THESIS

AGE GROUP DIFFERENCES IN RESPONSES TO LABORATORY STRESSORS: TASK APPRAISALS AND AFFECT REACTIVITY

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ABSTRACT

AGE GROUP DIFFERENCES IN RESPONSES TO LABORATORY STRESSORS: TASK APPRAISALS AND AFFECT REACTIVITY

Several theories of lifespan socioemotional development posit that adults become more adept at regulating their emotions during stressful situations as they age. However, mixed findings in the literature do not yet provide clear support for this assumption. Cognitive appraisals have been found to influence affective reactivity to stressors, but few studies have directly examined their role in explaining age-group differences in affective reactivity. Additionally, there is limited information available for how trajectories of adaptation in affective reactivity and cognitive appraisals in response to equivalent stressor exposures may vary across adult age-groups. To address these gaps in the literature, the current study used a structural equation modeling framework to examine younger (n = 138) and older adults' (n = 106) trajectories of affective reactivity and cognitive appraisals in response to three exposures to the Trier Social Stress Test. We then investigated the extent to which, over time, changes in cognitive appraisals accounted for age-group differences in changes of affective reactivity. Older adults reported attenuated reductions in negative affective reactivity, smaller decreases in appraisals of task-difficulty, and reduced improvements in appraisals of task-performance, relative to younger adults. Additionally, older adults' appraisals of the task as relatively more difficult over time accounted for their comparatively elevated levels of negative affective reactivity across assessments. Together, these findings suggest that older adults, compared to younger adults, may

show attenuated trajectories of adaptation to repeated stressor exposures when the stressor is novel, uncontrollable, or especially threatening to older adults.

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CHAPTER 1: INTRODUCTION

Throughout human development, there exists the joint occurrence of both growth and decline (Baltes, Staudinger, & Lindenberger, 1999). With respect to adult development, remarkable stability or even gains in overall affective well-being (i.e., the ratio of positive to negative emotional experiences) are reported by older adults despite age-normative declines in cognitive and physiological functioning (Burr, Castrellon, Zald, Samanez-Larkin, 2021; Carstensen et al., 2011). Although this "paradox of aging" has received considerable attention from researchers over the past three decades, there is yet little consensus on whether older adults are able to more effectively manage or regulate their emotions *during* stressful situations relative to their younger counterparts (Isaacowitz, 2022). One potential contributing factor for this ongoing debate is that previous research has largely attempted to either group qualitatively different stressor-type responses (e.g., daily hassles, chronic stressors, and life events) or extrapolated single stressor exposure responses to characterize general response patterns (Epel et al., 2018). Given the current state of the literature on this topic, the present study aims to address these outstanding issues by examining differences between younger and older adults' changes in affective (i.e., emotional) reactivity to three equivalent, laboratory-based stressor exposures. We then investigate the extent to which stressor appraisals (i.e., evaluations of the stressor) mediate age-related differences in trajectories of affective reactivity to these repeated stressor exposures.

Stressor Affect-Health Links

Stress occurs when a person perceives the demands of a situation to outweigh their resources to adequately manage or mitigate those demands (Folkman & Lazarus, 1984). Today, there is widespread agreement among researchers that stress has the potential to adversely impact numerous health and well-being outcomes (see reviews by Almeida, Piazza, Stawski, & Klein, 2011; Charles, Piazza, Mogel, Sliwinsky, & Almeida, 2013; Cohen, Gianaros, & Manuck, 2016; DeSteno, Gross, & Kubzansky, 2013; Epel et al., 2018; Schneidermann, Ironson, & Siegel, 2005). The situations that produce stress (i.e., stressors) come in a wide variety of forms ranging from major life events (e.g., divorce) to daily hassles (e.g., getting stuck in traffic). Additionally, stress may occur over various timescales. Acute stressors are typically short-lived events (i.e., experienced over minutes or hours) that have a beginning, end, and recovery period, whereas chronic stressors are persistent and pervasive events that cause distress over an indefinite amount of time (see review by Crosswell & Lockwood, 2020). Despite the range of forms that stressors may take, there are core similarities in the psychological and physiological processes commonly observed in response to stressor exposures (i.e., stress responses).

Due to their transient nature, acute stressor exposures offer researchers the ability to closely examine how stress response processes unfold on a momentary basis. There are a multitude of separate processes that interact in bidirectional and dynamic ways upon stressor exposure, but these processes are often grouped into two overarching components: a) psychological responses; and b) physiological responses (for a full review of these processes see review by Epel et al., 2018). Of particular relevance to the present study are the psychological processes of cognitive appraisals (discussed below) and affective reactivity.

Affective experiences are the subjective experience of emotions within the moment (e.g., I feel frustrated), whereas affective reactivity represents the magnitude of change in these affective experiences in response to a stressor (Smyth et al., 2018). These affective responses typically consist of increased negative affect (NA) and decreased positive affect (PA), which trigger cascading bidirectional interactions between psychological response processes and multisystem physiological processes (McEwen, 2007). When repeatedly activated in response to stressors over time, the cumulative strain placed on these physiological systems often contribute to increased disease prevalence and all-cause mortality risk (Sapolsky, 2007). It is important to note that not everybody who is exposed to stress develops poor health outcomes. However, this relationship seems to be exacerbated for people who exhibit relatively more affective reactivity to stress (Almeida, 2005; Charles et al., 2013; Chiang, Turiano, Mroczek, & Miller, 2018; DeSteno et al., 2013; Piazza et al., 2013; Schilling & Diehl, 2014). Thus, understanding which processes contribute to variability in affective reactivity outcomes across individuals may also help to explain differential vulnerability to stressor affect-health linkages.

Appraisals Mediate Stress Reactivity

The definition of stress utilized by the current study (see above) is adopted from Folkman and Lazarus's (1984) theory of stress and coping. An integral part of this conceptualization is that stressor exposure is not solely determined by the objective characteristics of the situation itself, but by the individual's subjective evaluations (i.e., cognitive appraisals) of the stressor and their personal resources to cope with the stressor. At the most fundamental level, appraisals are the mechanism by which we make sense of the world around us (Barret, Mesquita, Ochner, & Gross, 2007). For example, appraising a situation as threatening may evoke concerns of potential harm or loss and induce a stress response (Blascovich & Mendes, 2010; Lazarus, 1991).

Within the context of stress responses, there is considerable evidence for the causal role of cognitive appraisals in determining individual differences in physiological and affective reactivity (Luong & Charles, 2014; Jameison, Hangen, Lee, & Yaeger, 2018; Maier, Waldstein, & Synowski, 2003; Moors, Ellsworth, Scherer, & Frijda, 2013; Siemer, Mauss, & Gross, 2007). Additionally, research has found predictive qualities of cognitive appraisals for more distal outcomes related to stressor exposure including the development of chronic disease (Miller, Chen, & Parker, 2011), increased risk of breast cancer (Fischer, Ziogas, & Anton-Culver, 2018), the development of psychopathology (Grant et al., 2014), differential resilience to major life events (Luhmann et al., 2020), and even biological aging (Rentscher et al., 2019). Although there is well documented evidence for the role of cognitive appraisals' influence on affective reactivity and other stress-related outcomes, there is also substantial between-person variability in affective reactivity and appraisals that may be explained by person-level factors (Epel et al., 2018). One such factor that has previously been identified in the literature is age-group membership (Charles & Carstensen, 2010).

Age Group Differences in Affective Reactivity and Appraisals

Almost three decades ago, a burgeoning pattern of findings in the developmental psychology literature began to show remarkable stability, or even gains, in affective well-being throughout adulthood and into the 7^{th} or 8^{th} decade of life (see review by Carstensen, 2021). As researchers explored potential mechanisms, several emergent theories posited that older adults were better at regulating their emotions, allowing them to maintain high levels of affective well-being despite age-related losses and challenges (see review by Charles & Carstensen, 2010). However, mixed evidence across numerous studies of age differences in affective reactivity to stressor exposures does not yet provide clear support for this assertion (Isaacowitz, 2022).

Age Group Differences in Daily Life Affective Reactivity

Although older adults generally experience higher levels of overall affective well-being in their day to day lives relative to younger adults (see review by Charles & Carstensen, 2010), research examining age-related differences in affective reactivity to daily life stressors has produced inconsistent results (see review by Stawski et al., 2019). While some studies have shown age-related decreases in affective reactivity to daily life stressors (Birditt, 2013; Charles, Piazza, Luong, & Almeida, 2009; Scott, Ram, Smyth, Almeida, & Sliwinski., 2017; Uchino, Berg, Smith, Pearce, & Skinner et al, 2006), others have found age-related increases (Mroczek & Almeida, 2004; Sliwinski, Almeida, Smyth, & Stawski, 2009; Wrzus, Luong, Wagner, & Riediger, 2015; Wrzus, Muller, Wagner, Lindenberger, & Riediger, 2013), or no age-related differences (Diehl & Hay, 2010; Schilling & Diehl, 2014; Stawski, Sliwinski, Almeida, & Smyth, 2008). These mixed findings may be a result of methodological challenges associated with daily life studies including difficulties accounting for influences from contextual factors (e.g., duration of the stressor or distinguishing between stressor domains), differences in how stressors are defined or measured, and variability in measurement assessment windows (i.e., proximity of the assessment to the stressor exposure; see review by Stawski et al., 2019).

Age Group Differences in Laboratory Affective Reactivity and Appraisals

Research designs that utilize laboratory paradigms to examine age differences in affective reactivity and appraisals have several methodological advantages including the ability to control for contextual variability that is commonly experienced in daily life scenarios (Allen et al., 2017). Additionally, standardizing the stressor across individuals allows researchers to examine age differences to equivalent stressors, or to investigate hypothesized effects of qualitatively different tasks (i.e., controlled variation), as well as allowing study conditions to be replicated (see review by Falk & Heckman, 2009). Another major advantage of laboratory-based designs is that there is significant control over assessment windows to measure stress response processes immediately preceding and following exposure in order to minimize recall biases from retrospective reports (Epel et al., 2018). This final consideration is especially relevant for examining age group differences in affective experiences and appraisals due to older adults' proclivity to recall events progressively more favorably as the time from the stressor exposure increases (Charles et al., 2016).

Although laboratory-based research on age group differences in affective reactivity and appraisals offers significant amounts of control relative to daily life studies, there are also mixed findings in the literature. However, upon closer inspection of the paradigms used across these studies, there appears to be a consistent age pattern based on the nature of the lab tasks. In studies that have utilized interpersonal conflict scenarios, older adults have shown reduced affective reactivity compared to younger adults (Charles & Carstensen, 2008; Luong & Charles, 2014; Uchino, Birmingham, & Berg, 2010). Luong and Charles (2014) also found that older adults' relatively more benign appraisals of the task mediated age group differences in negative affect (NA) reactivity, pulse rate reactivity, and positive affect (PA) recovery (i.e., posttask increases in PA). Older adults' relative advantage in effectively navigating interpersonal stressors has been a consistent finding in the literature (Charles, 2010). This age effect has been hypothesized to be a result of increased life experience in maintaining long-term social partners (Blanchard-Fields, 2007), and the fact that interpersonal stressors are the most commonly experienced daily life stressors (Almeida, 2005).

Conversely, studies that have asked younger and older adults to react to emotionally-charged film clips have either found age similarities in NA reactivity (Tsai, Levenson, & Carstensen, 2000), or even age-related increases in NA reactivity in response to films specifically relevant to older adults (e.g., bereavement or Alzheimer's disease; Kunzmann & Gruhn, 2005; Kunzmann & Richter, 2009; Seider, Shiota, Whalen, & Levenson, 2011). Interestingly, although both of the Kunzmann and colleagues (2005; 2009) studies used appraisal theory as justification for their hypothesized results and actual results, neither study directly assessed age differences in situational appraisals. Similarly, Seider and colleagues (2011) hypothesized that age differences in appraisals were partly responsible for their findings but noted that a major limitation of the study was that they did not directly test these effects. However, the vast majority of laboratory-based research has only examined single stressor exposures, which may not accurately characterize how individuals adapt to similar stressor exposures over time.

Adaptation to Equivalent Stressor Exposures

Generally speaking, adaptation to successive exposures to equivalent stressors (i.e., habituation) refers to a pattern of reduction in the magnitude of psychological, physiological, or behavioral reactivity over time (Grissom & Bhatnagar, 2008). Although the majority of stress habituation research has primarily focused on patterns of physiological reactivity, parallel psychological processes (e.g., affect reactivity and appraisals) have also been found to display similar trajectories of adaptation as a function of prior exposures to functionally similar stressors (Epel et al., 2018; Lazarus, 1991; Rankin et al., 2008). Given the multitude of empirical findings on age-related differences in affective reactivity and cognitive appraisals (see review by Charles & Carstensen, 2010), it is surprising that relatively little is known about how trajectories of adaptation to repeated stressor exposures may vary across adulthood (Rohleder, 2019).

The strength and vulnerability integration model (SAVI; Charles, 2010) may offer a predictive framework for age differences in psychological response trajectories across repeated exposures to equivalent stressors. SAVI posits that although older adults may benefit from increased life experience, allowing them to successfully avoid or navigate relatively minor stressors, these age-related strengths may be attenuated or even reversed in highly arousing or repeated stressor exposures due to reduced physiological flexibility (Charles, 2010). However, to our knowledge, there have been no formal evaluations of this assumption as it relates to differential trajectories of affective reactivity and cognitive appraisals to repeated equivalent exposures to a validated and standardized laboratory-based stressor across multiple days. Thus, additional research is needed to not only fill important gaps in the literature, but also to refine current theoretical assumptions.

CHAPTER 2: THE CURRENT STUDY

Previous studies examining age differences in affective reactivity to stress have produced inconsistent results (see review by Isaacowitz, 2022). These discrepant findings in the literature may be partially due to methodological limitations in comparing reactions to qualitatively different stressors encountered in daily life (see review by Stawski et al., 2019). Laboratory-based research designs offer a reliable method of controlling for contextual variability, but prior research has predominantly generalized findings from single stressor exposures, which discounts the potential for substantial within-person heterogeneity in affective reactivity and appraisals to successive exposures (e.g., Lazarus 1991). Thus, there is currently limited evidence available on how and why people's affective reactions to a stressor may fluctuate over time, and if these trajectories of change unfold differently across adulthood (Rohleder, 2019).

Although the strength and vulnerability integration model (SAVI; Charles, 2010) predicts that repeated exposures to a highly arousing or personally relevant stressor may result in relatively elevated levels of affective reactivity over time for older adults, compared to younger adults, these assumptions have rarely been directly tested in a laboratory setting. The current study addresses these gaps in the literature by examining younger adults' (i.e., 18 years – 35 years of age) and older adults' (i.e., 60+ years of age) affective reactivity (e.g., positive affect reactivity and negative affect reactivity) and task-appraisals (e.g., task-enjoyment, task-difficulty, and task-performance) in response to three equivalent exposures to the Trier Social Stress Test (TSST; Kirshbaum, Pirke, & Hellhammer, 1993) over a 5-day period. The TSST combines elements of novelty, uncontrollability, and social evaluation to reliably produce a stress response in adults of all ages (Allen et al., 2017), thereby allowing the current study to investigate age-group differences in trajectories of affective reactivity, and the extent to which task-appraisals account for these differences.

Research Questions

The current study will address three primary research aims. *Research aim 1*: Are there age-group differences in trajectories of affective reactivity across the three stressor exposures? *Hypothesis 1*: Based on predictions from SAVI that age-related advantages in affective well-being will be attenuated or reversed under repeated stressor conditions (Charles, 2010), we hypothesize that older adults will exhibit relatively elevated levels of affective reactivity across the three stressor exposures, compared to younger adults. *Research aim 2*: Are there age-group differences in trajectories of task-appraisals across the three stressor exposures? *Hypothesis 2*: We predict that the novelty and unpredictability of the TSST will not allow older adults to leverage their increased life experience to appraise the tasks favorably (e.g., Blanchard-Fields, 2007), resulting relatively less benign task-appraisals over time (e.g., appraisals of the task as less enjoyable, more difficult, and lower ratings of performance), compared to younger adults. *Research aim 3*: To what extent do changes in task-appraisals over time explain age-group differences in trajectories of affective reactivity across successive stressor exposures? *Hypothesis 3*: We hypothesize that age-group differences in trajectories of affective reactivity over time will be accounted for by complementary changes in task-appraisals across stressor exposures. We formed this prediction on the basis of our previous hypotheses, a substantial base of literature substantiating the causal role of appraisals in shaping affective responses to stress (Epel et al., 2018; Lazarus & Folkman, 1984), and further evidence demonstrating the mediating effect of appraisals on age-group differences in affective reactions to stress (Hart & Charles, 2013; Luong & Charles, 2014).

CHAPTER 3: METHODS

Participants

Participants in the Health and Daily Experiences (i.e., HEADE) study were recruited from the Fort Collins, Colorado area. A variety of recruitment strategies were used including the Colorado State University human subjects pool (younger adults only), community and residential flyer postings, community presentations, local newspaper advertisements, social media and message board posts, electronic mailing list distributions, and word-of-mouth recruitment. Prospective participants were screened for eligibility based on four main inclusion criteria: 1) age groups were defined for younger (18 – 35 years old) and older adults (60+ years old); 2) ability to speak, read and write English fluently; 3) only participants with no current or recent (i.e., within the past year) psychological disorders and/or arrhythmias or other heart conditions; and 4) prospective participants over the age of 60 years old were screened for cognitive impairment using the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975). Individuals who met these inclusion criteria were added to a prospective participant list and then contacted to schedule laboratory session times as they became available. Younger adults who were recruited though the Colorado State University human research subject pool received course credit for their participation. Community participants were compensated up to $200 for full completion of all study procedures.

A total of 244 participants were recruited to participate in the Health and Daily Experiences (i.e., HEADE). The final sample included in the study (N = 244) included 138 younger adults (18 – 35 years old, m_{age} = 22.8 years, SD = 5.2) and 106 older adults (60 – 90 years old, m_{age} = 69.8 years, SD = 6.6). The sample was 58.2% female, 75.8% White (non-

Hispanic), 18.9% Hispanic/ LatinX, and 5.3% 'other'. Younger adults were predominantly single/never married (73.2%), had highest education levels of some college, but no degree (60.1%), and reported annual incomes of less than $20,000 (66.4%). Older adults reported higher annual incomes and had more formal education on average, with nearly one half having attained a Master's degree or higher (49.1%), and annual incomes of more than $50,000 (49.5%). Additionally, the majority of older adults were either currently married and cohabitating with their spouse (50%) or divorced (26.4%).

Procedures

The Health and Daily Experiences (HEADE) study included two main protocols: laboratory sessions and ecological momentary assessments. The current study focuses only on the laboratory sessions. Participants were scheduled for a total of five lab sessions at Colorado State University: a 1-hr study overview session on Thursday; three 1-hr laboratory sessions on the following Monday, Wednesday, and Friday; and a 30-minute equipment return and debriefing session on the next Tuesday.

Study Overview Session

During the overview session, participants were told they were in a study examining how health and daily experiences are related across adulthood. All participants provided informed consent at this time. Research assistants delivered a PowerPoint presentation which included information on what to bring to their laboratory sessions, how to use study equipment, and how they would be compensated for completing the study procedures. Each of the three laboratory sessions were scheduled for the same time slots on Monday, Wednesday, and Friday to avoid potential time-of-day effects on within-person changes over time (see review by Hines, 2004).

Laboratory Stressor Sessions

Each of the three laboratory sessions consisted of three distinct periods: pretask; task; and posttask periods. Laboratory sessions were video, and audio recorded with consent from the participants.

Pretask period. During the pretask period, participants completed self-report measures including demographic questionnaires (e.g., age, gender, race, ethnicity, income, and education) and their current affective experience (i.e., baseline or pretask affect) alone in an observation room. After the participant completed their baseline questionnaire packet, research assistants placed electrodes on the participant to measure their electrocardiogram data (e.g., heart rate variability and impedance cardiography) via mobile collection device (Mindware, 2022). However, these physiological data are beyond the scope of the current study.

Task period – Trier Social Stress Test (TSST). After the pretask period, the experimenter returned to the room to describe the procedures for the Trier Social Stress Test (TSST; Kirschbaum et al., 1993), which consisted of a spontaneous public speaking task followed by a mental arithmetic task. The TSST is a standardized psychosocial stressor which reliably elicits affective stress responses in adults of all ages (Allen et al., 2017). Participants were informed that they would deliver a 5-minute uninterrupted speech in front of an evaluator who had special training in observing human behavior. In fact, this evaluator was a trained research assistant who was instructed to remain neutral and provide no positive feedback or non-verbal cues (e.g., smiling or nodding their head). After the experimenter read the speech task instructions, they gave the participants 5 minutes to prepare their speech using a pen and piece of paper with the speech prompt written on it. Participants completed one of three unique speech prompts (e.g., interview for a volunteer position, describe a shameful or embarrassing experience, and discuss major shortcomings as an individual), in a counter-balanced order across the three lab sessions. The evaluator entered the observation suite after the 5-minute preparation period was over in a white lab coat and carrying a clipboard, asked the participant for their preparation materials, and then instructed the participant to begin their speech. During the speech, the evaluator took notes on a clipboard and held frequent eye contact with the participant when not writing. If the participant stopped speaking before the five minutes were completed, the evaluator prompted the participant to continue using predetermined statements (e.g., "you should talk for the whole time," "there is still time remaining," "you need to keep talking," or "the task is not yet complete"). After the 5-minute speech, the evaluator told the participant they can stop with the task and then read instructions for the mental arithmetic task.

The mental arithmetic task involved participants mentally subtracting a subtrahend from a larger starting number serially until they reached zero. These instructions included an example of a starting number of 1000 and subtracting 5's, with the evaluator stating the first several correct responses aloud (e.g., 1000, 995, 990, 985, and so on). Like the speech prompts, there were three versions of the math task that participants also completed in counter-balanced order (e.g., 1032 minus 9's, 1027 minus 7's, and 990 minus 8's). Additionally, participants were instructed that they needed to complete the task as quickly and accurately as they could. If the participant made a mistake, the evaluator would correct them, and they would need to start over from the original starting number. If the evaluator determined that the participant was unable to complete the original task, they could switch to an easier version of the task (e.g., 333 minus 3's) for the remainder of the time. Participants worked on the mental arithmetic task for 5 minutes, at which point, the evaluator concluded the TSST procedures and left the room. Immediately following the TSST procedures, the experimenter returned to the room and gave the participant another questionnaire packet. The questionnaire included measures related to their current affective experiences (e.g., positive and negative affect) and task-appraisals (e.g., subjective rating of task difficulty, performance, and enjoyment).

Posttask period. The participants completed a final questionnaire packet regarding unrelated questionnaires (e.g., personality traits, cultural values, or chronic health conditions) before the end of the session. Experimenters then stopped the video and physiological data recording and asked if the participant had any questions regarding their next laboratory session. The pretask, task, and posttask procedures were repeated for each of the three laboratory stressor sessions, with some variation in global questionnaires administered across sessions. After the third laboratory stressor session, participants returned the following week for the debriefing session.

Debriefing Session

During the debriefing session, participants were informed of the true nature of the study. Specifically, the study was designed to examine how people physically, emotionally, and behaviorally respond to stress across adulthood, and how these responses affect health and well-being outcomes. Participants were also given the option to omit their data from any future analyses. However, no participants elected to omit their data.

Measures

Demographic Information

Participants reported their demographic background, including age, gender, race/ethnicity, highest education attained, and annual income, among other information.

Positive and Negative Affective Reactivity

Current affective experiences were assessed using a modified version of the Emotion Sampler (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000). Participants were asked to rate the degree they were currently experiencing each of eight positive emotion items (e.g., pride, accomplishment, joy, contentment, calm, interest, relaxed, and excitement) and seven negative emotion items (e.g., anger, sadness, fear, anxiety/ worry, frustration, embarrassment, and boredom) on a 7-point Likert scale ranging from 1 (*not at all*) to 7 (*extremely*). Composite scores for positive affect (PA) and negative affect (NA) were calculated by using the average of the related emotion items for each assessment period (i.e., baseline and task periods), respectively. The difference between baseline and task period affect were then used to determine PA and NA reactivity scores for each lab session. Greater magnitude in affective reactivity scores indicated greater increases in NA and greater decreases in PA as a result of the TSST procedure. Specifically, larger positive NA reactivity scores indicated greater negative affect during the task vs pretask periods, whereas larger negative PA reactivity scores indicated lower positive affect during the task vs pretask periods.

Task Appraisals

Questions regarding participants' appraisals of the TSST were adapted from a previous study that also examined three dimensions of laboratory task-appraisals (e.g., Luong & Charles, 2014) using a 5-point Likert scale from 1 (*strongly disagree*) to 5 (*strongly agree*). Participants rated their level of agreement for statements about *task-difficulty* (three items for each task; e.g., "I found the task to be easy," "the task was difficult for me," and "working on the task was a challenge for me"), *task-performance* (seven items for each task; e.g., "I did a great job on the task," "I completed the task successfully," "I am proud of how I performed on the task," "I did the best I could on the task," "I performed well on the task," "I wanted to complete the task to the best of my ability," and "I wanted to complete the task as instructed by the experimenter"), and *task-enjoyment* (two items for each task; e.g., "I enjoyed working on the task" and "I would not want to work on this task again"). Participants reported on these task-appraisals separately for the speech and math task at each laboratory session. Composite scores for each of the three appraisal dimensions (task-difficulty, task-performance, task-enjoyment) were calculated by averaging the relevant items across the math and speech tasks for each lab session, independently.

Data Analytic Plan

Longitudinal Growth Curve Modeling (i.e., LGCM) was used to analyze the data. Prior to inclusion in the LGCM, all affective reactivity (i.e., PA and NA) and appraisal variables (i.e., task-difficulty, task-performance, and task-enjoyment) were rescaled (standardized) based on the means and standard deviations obtained at the first lab session. Each of these variables were then analyzed, independently, in a series of univariate LGCMs in a stepwise procedure, fitting in order (a) an intercept-only model, (b) an intercept and linear slope model, and (c) an intercept and latent basis slope model (Grimm & Ram, 2018).

The intercept only model, also commonly referred to as a "no-growth model", represents stable individual differences in a variable across assessments. Adding the linear slope with equidistant item-slope loadings (i.e., 0,1, and 2 for the first, second, and third lab sessions respectively) captures linear change across measurement occasions, accounting for differences in person level averages. The latent basis model also captures change across occasions, but instead of a linear slope, this model allows for changes between measurement occasions to be freely estimated, depending on how item-slope loadings are constrained. Here, we fixed the loadings for the first and third lab sessions to 0.00 and 1.00 respectively, allowing the loading for the second lab session to be freely estimated. This means that the amount of change between sessions one and two and between sessions two and three was allowed to differ, as may happen due to adaptation effects when the majority of change may occur between the first and second stressor exposures (Rankin et al., 2009; Rohler, 2019).

All structural equation models were estimated using the R statistical software, version 4.1.2 (R Core Team, 2021) and Lavaan package (Roseel, 2012). We tested changes in model fit based on deviance (i.e., change in chi-square vs. change in degrees of freedom) to determine the best parameterization for each variable. Absolute fit was determined using the comparative fit index (i.e., CFI; Bentler, 1990), the root mean square error of approximation (i.e., RMSEA; Kenny, Kaniskan, & McCoach, 2014), and the standardized root mean squared residual (i.e., SRMR; Bentler, 1995). Desirable threshold values for model fit statistics are: CFI at or above .90; RMSEA at or below .10; and SRMR at or below .08 (Hu & Bentler, 1999).

To determine whether successive exposures to the Trier Social Stress Test (i.e., TSST; Kirshbaum et al., 1993) differentially influenced affective reactivity and task-appraisals across age groups, we also conducted structural regression analyses (i.e., regressing latent slope parameters onto age group membership). Change in these regression analyses was parameterized according to the better fitting slope parameterization (linear vs. latent basis) from the initial analyses. We concurrently tested for baseline differences in each variable across age groups (by regressing intercepts onto age groups).

Finally, to examine whether changes in task-appraisals mediated the effects of age differences on changes in affective reactivity, we ran a series of structural models with age group as a dichotomous predictor, changes in the three task-appraisal variables as mediators, and changes in PA and NA reactivity as outcomes. We ran a total of six mediation models, sequentially testing each mediator/outcome combination. For the mediation models, affective reactivity and task-appraisal change variables were calculated by subtracting participant's responses at the first lab session from their responses at the second lab session for the respective measures. The decision to use simple change scores in the mediation models was based on results from the aforementioned univariate latent change analyses (see below) and further informed by work comparing residualized change (i.e., ANCOVA) vs. differences score approaches (Castro-Schilo & Grimm, 2017) for analyzing group differences in pre-post change when groups differ at baseline (as we anticipated given that our groups were defined by age differences). All mediation models were again run using the Lavaan package (Roseel, 2012) within the R statistical software, version 4.1.2 (R Core Team, 2021).

CHAPTER 4: RESULTS

Descriptive Statistics

Table 1 lists the means and standard deviations for each of the affective reactivity and task-appraisal variables across each of the three lab sessions for younger and older adults.

Table 1

Descriptive Statistics of Key Study Variables by Age Group

	Mean (SD) by Wave					
	Lab Session 1		*Lab Session 2*		*Lab Session 3*	
Measure	YA	OA	YA	OA	YA	OA
Affective Reactivity						
PA Reactivity	-.57 (1.37)	-.42 (1.19)	.03 (1.13)	-.24 (.97)	.09 (1.03)	.005 (.96)
NA Reactivity	.99 (1.07)	.85 (.98)	.17 (.69)	.58 (.82)	.07 (.68)	.32 (.63)
Task-Appraisals						
Task-Difficulty	3.75 (.69)	3.78 (.79)	3.27 (.72)	3.53 (.80)	3.15 (.79)	3.69 (.70)
Task-Performance	3.19 (.71)	3.43 (.54)	3.57 (.70)	3.65 (.59)	3.79 (.79)	3.61 (.53)
Task-Enjoyment	2.59 (1.03)	2.92 (.99)	2.90 (.94)	2.92 (1.06)	2.85 (1.01)	2.94 (1.04)

Note. SD = standard deviation; YA = younger adults; OA = older adults; PA = positive affect; NA = negative affect. All means and standard deviations are in raw unstandardized metrics.

Results from Univariate Trajectory Models

Model Fit Statistics

Tests of chi-square changes in model fit (Table 2) showed that the latent basis model best fit the data for all five variables (3 appraisals and 2 affect reactivity variables). Absolute fit criteria further showed that the latent basis parametrization captured the data well: CFI ranged from 0.92 to 1.00, RMSEA was < .01 for four variables and .09 for the fifth, and SRMR ranged from .01 to .04.

Table 2

Model Fit Statistics of Univariate Longitudinal Growth Curve Models

Model	$\chi^2(df)$	$\Delta\chi^2$	CFI	RMSEA [CI95%]	SRMR
PA Reactivity					
Intercept-only	57.09 (6)		0.00	0.19 [0.14, 0.23]	0.25
Linear Slope	6.95 (3)	50.14 ***	0.86	0.07 [0.00, 0.15]	0.07
Latent Basis	1.79 (2)	5.16 *	1.00	0.00 [0.00, 0.12]	0.04
NA Reactivity					
Intercept-only	176.36 (6)		0.00	0.34 [0.30, 0.39]	0.25
Linear Slope	27.68 (3)	148.68 ***	0.50	0.18 [0.13, 0.25]	0.07
Latent Basis	5.95 (2)	21.73 ***	0.92	0.09 [0.00, 0.18]	0.04
Task-Difficulty					
Intercept-only	72.21 (6)		0.58	0.21 [0.17, 0.26]	0.09
Linear Slope	19.08 (3)	53.13 ***	0.90	0.15 [0.09, 0.22]	0.04
Latent Basis	0.59 (2)	18.49 ***	1.00	0.00 [0.00, 0.08]	0.01
Task-Performance					
Intercept-only	104.65 (6)		0.53	0.26 [0.22, 0.30]	0.10
Linear Slope	9.44 (3)	95.21 ***	0.97	0.09 [0.03, 0.16]	0.03
Latent Basis	0.53 (2)	8.91 **	1.00	0.00 [0.00, 0.09]	0.01
Task-Enjoyment					
Intercept-only	21.51 (6)		0.94	0.10 [0.06, 0.15]	0.04
Linear Slope	9.02 (3)	12.49 ***	0.98	0.09 [0.03, 0.16]	0.02
Latent Basis	0.45 (2)	8.57 **	1.00	0.00 [0.00, 0.08]	0.01

Note. PA = positive affect; NA = negative affect; *df* = degrees of freedom; χ^2 = Chi-Square; $\Delta\chi^2$ = change in chi-square from previous model; *CFI* = comparative fit index; *RMSEA* = root mean square error of approximation; CI = confidence interval; *SRMR* = standardized root mean squared residual. * $p < .05$. ** $p < .01$. *** $p < .001$.

Parameter Estimates

Table 3 shows the parameter estimates from the best fitting (i.e., latent basis) models. Changes in participants' task appraisals and affect reactivity across lab sessions were statistically significant in all analyses. Because observed items were scaled in standardized units (*Z*), and because latent basis loadings were fixed at 0.00 at the first lab session and 1.00 at the final session, estimated slopes (B_{slope}) from the latent basis models reflect overall change in standardized units from first to last assessment. Estimates of the item-slope loadings at the

Table 3

Parameter Estimates for the Latent Basis Univariate Longitudinal Growth Curve Models

Parameter	Estimate	S.E.	Z-score	*p*
Latent Basis Coefficients				
PA Reactivity	0.799	0.160	4.980	<.001
NA Reactivity	0.798	0.078	10.272	<.001
Task-Difficulty	1.001	0.132	7.561	<.001
Task-Performance	0.742	0.081	9.136	<.001
Task-Enjoyment	1.161	0.286	4.056	<.001
Means				
Intercept of PA Reactivity	-0.003	0.063	-0.045	.964
Slope of PA Reactivity	0.420	0.073	5.726	<.001
Intercept of NA Reactivity	0.003	0.064	0.041	.967
Slope of NA Reactivity	-0.716	0.068	-10.536	<.001
Intercept of Task-Difficulty	-0.001	0.064	-0.019	.985
Slope of Task-Difficulty	-0.505	0.068	-7.375	<.001
Intercept of Task-Performance	0.001	0.064	0.020	.984
Slope of Task-Performance	0.632	0.064	9.796	<.001
Intercept of Task-Enjoyment	-0.001	0.064	-0.022	.982
Slope of Task-Enjoyment	0.197	0.054	3.655	<.001
Variances				
Intercept of PA Reactivity	0.433	0.133	3.249	.001
Slope of PA Reactivity	0.161	0.183	0.878	.380
Intercept of NA Reactivity	0.637	0.110	5.781	<.001
Slope of NA Reactivity	0.441	0.117	3.768	<.001
Intercept of Task-Difficulty	0.481	0.086	5.566	<.001
Slope of Task-Difficulty	0.068	0.113	0.601	.548
Intercept of Task-Performance	0.585	0.097	6.009	<.001
Slope of Task-Performance	0.179	0.136	1.315	.188
Intercept of Task-Enjoyment	0.677	0.081	8.361	<.001
Slope of Task-Enjoyment	0.071	0.064	1.106	.269
Covariances				
Intercept ~ Slope of PA Reactivity	-0.262	0.131	-2.002	.045
Intercept ~ Slope of NA Reactivity	-0.477	0.098	-4.892	<.001
Intercept ~ Slope of Task-Difficulty	0.032	0.076	0.421	.674
Intercept ~ Slope of Task-Performance	-0.034	0.089	-0.378	.705
Intercept ~ Slope of Task-Enjoyment	-0.049	0.053	-0.929	.353
Residual Variances				
PA Reactivity	0.549	0.068	8.030	<.001
NA Reactivity	0.353	0.043	8.163	<.001
Task-Difficulty	0.513	0.049	10.412	<.001
Task-Performance	0.399	0.052	7.666	<.001
Task-Enjoyment	0.321	0.032	9.936	<.001

Note. PA = positive affect; NA = negative affect; S.E. = standard error; ~ designates a covariance. Intercept and slope estimates are in standardized Z-units.

second assessment (λ_2) can similarly be interpreted as the proportion of that overall change that occurred between the first and second assessments.

Participants' positive affect (PA) reactivity increased 0.42*Z* from the first to third sessions (B_{slope} = .42, *SE* = .07, $p < .001$), with 79.9% of this change occurring between the first and second sessions (λ_2 = .80, *SE* = .16, $p < .001$). Additionally, participants' negative affect (NA) reactivity decreased 0.72*Z* between the first and third sessions (B_{slope} = .72, *SE* = .07, $p < .001$), with 79.8% of this overall change occurring between the first and second sessions (λ_2 = .80, *SE* = .08, $p < .001$). Appraisals of task-difficulty decreased by 0.51Z (B_{slope} = -0.51, *SE* = 0.07, $p < .001$), from the first to final sessions, with 100% of this change taking place between the first and second sessions (λ_2 = 1.00, *SE* = 0.13, $p < .001$). Appraisals of task-performance increased 0.63*Z* between the first and final lab sessions (B_{slope} = *0.63*; *SE* = 0.07, $p < .001$), 74.2% of which occurred between the first and second sessions (λ_2 = 0.74, *SE* = .08, $p < .001$). Finally, task-enjoyment appraisals increased 0.2*Z* between the first and last sessions (B_{slope} = 0.20, *SE* = 0.05, $p < .001$), with 116.0% of that change reported by the second session (λ_2 = 1.16, *SE* = .29, $p < .001$), indicating a regression to the mean between the second and third sessions.

Age-Group Differences in Changes Over Time (Table 4)

With respect to affective reactivity, intercepts for NA and PA reactivity, and change in PA reactivity over time, did not differ significantly across age-groups. However, older adults did show attenuated reductions in NA reactivity across assessment compared to younger adults (Est. = .46; *SE* = .13; $p < .001$). With respect to appraisals, older adults rated their baseline (i.e., intercept) task-performance more positively than did younger adults (B = .41; *SE* = .12; $p < .001$). There were no significant age group differences in baseline appraisals of task-enjoyment or task-difficulty. Additionally, older adults reported smaller increases in ratings of task-performance (Est. = -0.58; *SE* = .13; *p* < .001) and smaller reductions in appraisals of task-difficulty (Est. = .63; *SE* = .15; *p* < .001) over time, relative to younger adults. Changes in task-enjoyment did not differ significantly between age-groups.

Table 4

Results of Univariate Longitudinal Growth Curve Models Regressed on Age Group

Model	Estimate	S.E.	Z-score	*p*
PA Reactivity				
Intercept-only	0.098	0.127	0.769	.442
Slope	-0.238	0.136	-1.746	.081
NA Reactivity				
Intercept-only	-0.109	0.133	-0.822	.411
Slope	0.455	0.132	3.452	.001
Task-Difficulty				
Intercept-only	0.014	0.133	0.102	.918
Slope	0.629	0.154	4.092	<.001
Task-Performance				
Intercept-only	0.406	0.120	3.389	.001
Slope	-0.580	0.127	-4.572	<.001
Task-Enjoyment				
Intercept-only	0.194	0.128	1.519	.129
Slope	-0.126	0.091	-1.393	.164

Note. PA = positive affect; NA = negative affect; S.E. = standard error. All estimates are in standardized Z-units.

Results from Appraisal Mediation Models

Results from the mediation models are provided in table 5. As noted above, changes in NA and PA reactivity and task-appraisals were calculated by subtracting responses at the first lab session from their responses at the second lab session. We focused on changes across these first two sessions because results from the univariate trajectory models with latent basis slopes indicated that overwhelming majority of change occurred by the second lab session.

Positive Affect (PA) Reactivity Outcome Models

The first set of mediation models examined if change in each of the three task-appraisal variables (tested separately) mediated the effects of age-group differences on change in PA reactivity. The direct effect (path *c*) and total effect (paths *ab* + *c*) of age-group differences on change in PA reactivity were non-significant irrespective of mediator. The indirect effect of age on change in PA reactivity (path *ab*) was also non-significant across analyses: For mediation by change in task-difficulty, *B* = -0.032, *SE* = 0.027; for mediation by change in task-enjoyment, *B* = -0.054, *SE* = 0.040; and for mediation by change in task-performance, *B* = -0.081, *SE* = 0.051. However, changes in two of the task-appraisals

Table 5

Results from Positive Affect Reactivity and Task Appraisal Mediation Models

	Mediator A: Task-Difficulty			Mediator B: Task-Performance			Mediator C: Task-Enjoyment		
Effects	Estimate	CI 95%	*p*	Estimate	CI 95%	*p*	Estimate	CI 95%	*p*
PA Reactivity Outcome Models									
Path a: Age group regressed on mediator	0.36	[0.09, 0.63]	0.01	-0.24	[-0.50, 0.03]	0.08	-0.16	[-0.39, 0.07	0.17
Path b: Mediator regressed on PA reactivity	-0.09	[-0.22, 0.04]	0.18	0.35	[0.20, 0.49]	0.00	0.33	[0.18, 0.49]	0.00
Path c: Age group regressed on PA reactivity	-0.27	[-0.60, 0.06]	0.11	-0.22	[-0.54, 0.10]	0.17	-0.25	[-0.56, 0.06]	0.12
Patch c': Indirect effect	-0.03	[-0.09, 0.02]	0.23	-0.08	[-0.18, 0.02]	0.11	-0.05	[-0.13, 0.03]	0.18
Total Effect	-0.30	[-0.63, 0.02]	0.07	-0.30	[-0.63, 0.02]	0.07	-0.30	[-0.63, 0.02]	0.07
NA Reactivity Outcome Models									
Path a: Age group regressed on mediator	0.36	[0.09, 0.63]	0.01	-0.24	[-0.50, 0.02]	0.07	-0.17	[-0.39, 0.06]	0.15
Path b: Mediator regressed on NA reactivity	0.21	[0.09, 0.33]	0.001	-0.35	[-0.47, -0.23]	0.00	-0.37	[0.52, -0.22]	0.00
Path c: Age group regressed on NA reactivity	0.46	[0.18, 0.74]	0.001	0.45	[0.18, 0.72]	0.001	0.47	[0.20, 0.74]	0.00
Patch c': Indirect effect	0.07	[0.01, 0.14]	0.03	0.09	[-0.01, 0.18]	0.09	0.06	[-0.23, 0.15]	0.17
Total Effect	0.53	[0.25, 0.81]	0.00	0.53	[0.25, 0.82]	0.00	0.53	[0.25, 0.82]	0.00

Note. PA = positive affect; NA = negative affect; CI = confidence interval. All estimates are in standardized Z-units. All mediators were tested individually in separate models significantly predicted changes in PA reactivity (path *b*): Increased task-enjoyment predicted increased PA reactivity ($B = 0.334$, $SE = 0.080$, $p < .001$), and increased task-performance predicted increased PA reactivity ($B = 0.345$, $SE = 0.074$, $p < .001$). Changes in task-difficulty were non-significantly negatively related to changes in PA reactivity ($B = -0.091$, $SE = 0.067$).

Negative Affect (NA) Reactivity Outcome Models

The second set of mediation models examined if change in each of the three task-appraisal variables (again tested separately) mediated the effects of age-group differences on change in NA reactivity. The direct effect (path *c*) and total effect (paths *ab* + *c*) of age group differences on change in NA reactivity were significant in all models. Unstandardized path coefficients for direct effects ranged from 0.447–0.471 ($p < .001$). The estimated total effect was the same in all models: 0.532 ($p < .001$). The indirect effect of age on changes in NA reactivity (path *ab*) was non-significant when the mediator was task-performance ($B = 0.085$, $SE = 0.050$) and when the mediator was task-enjoyment ($B = 0.061$, $SE = 0.044$). However, task-difficulty significantly mediated the association between age- group and change in NA reactivity, such that older age predicted less reduction in task-difficulty appraisals, which in turn predicted less reduction in NA reactivity (i.e., two positive associations), with $B_{ab} = 0.074$, $SE = 0.035$, $p = .032$). Change in each of the task-appraisals significantly predicted change in NA reactivity (path *b*): for task-difficulty, $B = 0.207$, $SE = 0.060$, $p < .001$; for task-performance, $B = -0.353$, $SE = 0.062$, $p < .001$); and for task-enjoyment, $B = -0.372$, $SE = 0.077$, $p < .001$.

CHAPTER 5: DISCUSSION

Contrary to consistent findings of age-related advantages in overall affective well-being (see review by Charles & Carstensen, 2010), the research on adult age-group differences in affective reactivity to stress has produced mixed results (Isaacowitz, 2022). However, few studies to-date have examined if younger and older adults differ in how they adapt to equivalent stressors over time; potentially due to methodological challenges in accounting for contextual variability in daily life (see review by Stawski et al., 2019). The current study aimed to address this gap in the literature by investigating age-group differences in trajectories of affective reactivity across three exposures to the Trier Social Stress Test (TSST; Kirshbaum et al., 1993), and the extent to which task-appraisals accounted for these age differences.

Age-Group Differences in Affective Reactivity

Our first research aim addressed the extent to which older adults, compared to younger adults, would show attenuated reductions in affective reactivity across repeated stressor exposures. In partial support of our hypotheses, results revealed that while there were no significant age-group differences in trajectories of positive affect (PA) reactivity, older adults reported relatively elevated levels of negative affect (NA) reactivity across successive exposures to the TSST, compared to younger adults. Although we only found older adults at a comparative disadvantage in their trajectories of NA reactivity, and not PA reactivity, these findings are in line with assumptions of the strength and vulnerability integration model (SAVI; Charles, 2010). SAVI predicts that older adults' general advantages in regulating their affective well-being in daily life may be attenuated (i.e., no significant age-group differences) *or* reversed (i.e., relative disadvantages for older adults) under highly arousing or repeated stressor exposure conditions

(Charles & Luong, 2014). Additionally, while it was not a primary focus of the current study, we did not find age-group differences in baseline levels (i.e., stable individual differences over time) of PA or NA reactivity. Consistent with predictions of SAVI, across all of these metrics, there were no detectable advantages in affective reactivity outcomes for older adults. These predictions may also partially account for the age-group differences found in participant's task-appraisals.

Age-Group Differences in Task-Appraisals

An additional aim of the current study was to examine potential differences in younger and older adults' trajectories of task-appraisals across the three TSST exposures. As we predicted, over time, older adults reported smaller increases in their appraisals of task-performance, and smaller decreases in their task-difficulty appraisals, relative to younger adults. This pattern of findings may be related to the nature of the TSST procedure because it incorporates elements of novelty and unpredictability to provoke a stress response (see review by Allen et al., 2017). A frequently cited theoretical assertion in the literature is that increased life experience is directly related to older adults' ability to effectively navigate commonly experienced minor stressors in daily life (e.g., daily hassles and interpersonal conflicts; Blanchard-Fields, 2007; Carstensen, 2021; Charles, 2010). Additionally, older adults may be better at avoiding highly arousing or stressful situations in daily life by carefully selecting the situations they take part in based on predictions of future outcomes, which are informed by previous experiences with similar situations (Sims, Hogan, & Carstensen, 2015; Urry & Gross, 2010).

In both cases, the TSST negates these potential life experience advantages for older adults by blinding participants to the inclusion of the TSST procedures prior to exposure, as well as having varied speech prompts and math tasks at each lab session (i.e., unpredictability).

Additionally, the experience of being surprised with a public speaking task immediately followed by a math task is unlikely to materialize in daily life (i.e., novelty). However, we did not find any age-group differences in appraisals of task-enjoyment – baseline or over time – potentially because prior research has found that appraisals of enjoyment were primarily related to PA reactivity (e.g., Luong & Charles, 2014), which we concurrently did not find age-group differences in. Interestingly, we did find that older adults' baseline levels of task-performance were higher than younger adults', even though older adults fared relatively worse over time. We suspect that these seemingly contrasting findings may be due to older adults rating their initial performance relatively more favorably (e.g., Luong & Charles, 2014) with comparable ratings over time, whereas younger adults' appraisals of their performance increased with each successive lab session. However, additional analyses are needed to confirm these assumptions.

Explaining Age-Group Differences in Affective Reactivity

The third and final research aim of the present study was to test the extent to which age differences in task-appraisals explained (i.e., mediated) changes in younger and older adults' affective reactivity over time. Contrary to our hypotheses, we did not find evidence that any of the three task-appraisal dimensions accounted for age-group differences in trajectories of PA reactivity. However, these findings are relatively unsurprising given that we did not find significant differences in trajectories of PA reactivity between younger and older adults. Additionally, we did not find statistically significant mediating effects for appraisals of task-performance or task-enjoyment for age-group differences in trajectories of NA reactivity. Similarly, trajectories of task-enjoyment did not meaningfully differ across age-groups, and thus were unlikely to produce a significant mediating effect for age-group differences in NA reactivity. However, our failure to identify a mediating effect for appraisals of task-performance on differential trajectories of NA reactivity between age-groups was unexpected. One potential explanation for this result is that appraisals of task-performance have been found to mediate age-group differences in PA reactivity (e.g., Luong & Charles, 2014), but we did not find the prerequisite age differences in trajectories of PA reactivity in this study. Another explanation is that specific appraisal dimensions may be more influential on eliciting discrete emotional reactions (e.g., appraisals of threat may provoke fear but not boredom; Young, Minton, & Mikels, 2021). Thus, appraisals of performance may have mediated specific affective reactions, but our utilization of valence-based composites of multiple affect items (i.e., PA and NA), rendered the effect of task-performance too diffuse to detect.

However, in support of our hypotheses, results revealed that age-group differences in task-difficulty appraisals fully accounted for differential trajectories of NA reactivity between younger and older adults. We propose several potential explanations for this finding. First, as Charles & Carstensen (2010) eloquently stated in their seminal review on social and emotional aging, "At no point in life does the need to feel embedded in a larger social group lessen, nor do the devastating consequences of isolation diminish" (p.384). While it is true that the TSST procedures contain elements of novelty and unpredictability, it has been hypothesized that the TSST predominantly induces a stress response through perceived threats to one's social status and negative social evaluation (i.e., social-evaluative threat; Allen et al., 2014). Although social-evaluative threat has been found to consistently elicit stress responses across adult age groups (see review by Epel et al., 2018), younger adults may encounter relatively more social-evaluative stressors in their daily lives as a function of school, work, and other peer group memberships (Almeida & Horn, 2004; Almedia et al., 2011; Charles & Carstensen, 2010). Thus, older adults' comparatively irregular exposure to social-evaluative threats may have amplified their appraisals of task-difficulty and NA reactivity over time, relative to younger adults.

Another plausible explanation for these results is that previous research has suggested that age-related increases in perceived self-efficacy to control or change negative aspects of stressful situations may be responsible for older adults' attenuated affective reactivity, relative to younger adults (e.g., Charles et al., 2009; Livingstone & Isaacowitz, 2019; Young & Mikels, 2020). However, the TSST is a largely uncontrollable stressor (i.e., attempts to materially change the situation cannot appreciably affect the outcomes; Byron, Khazanchi, & Nazarian 2010). Specifically, the evaluator in this study was trained to remain stoic and provided no positive feedback regardless of differences in participants' actual performance on the task. This inability to see any meaningful improvements across successive exposures to the TSST may have resulted in older adults' elevated appraisals of task-difficulty over time, compared to younger adults. Finally, previous research has suggested that when older adults find laboratory tasks or stressors especially relevant, they have exhibited increased levels of affective reactivity (e.g., Kunzmann & Gruhn, 2005; Kunzmann & Richter, 2009; Seider et al., 2011). The TSST is a cognitively demanding stressor that requires extensive working memory to complete the math portion while already under stress effects from the speech task (Allen et al., 2014). Given that threats of cognitive decline are more salient for older adults, this may have resulted in elevated appraisals of task-difficulty and NA reactivity over time, compared to younger adults.

Limitations and Future Directions for Research

Although there were numerous strengths to the current study design, there were also several limitations that may offer opportunities for future research to add additional context to our findings. First our sample was limited to relatively high functioning and healthy individuals with no cardiovascular disease, mental health disorders (e.g., anxiety, depression, or mood disorders), or cognitive impairments (e.g., Alzheimer's disease or dementia). However, many of these health concerns are prevalent in either younger or older adult populations and have been shown to meaningfully influence how people respond to stress (Chiang et al., 2018), thereby limiting the generalizability of our findings. Additionally, our relatively limited statistical power prevented our ability to add additional covariates that have been previously associated with stress response outcomes (e.g., gender, cultural background, and socioeconomic status; Almeida et al., 2011). As such, we cannot definitively rule out these potential confounds in the interpretation of our results. Further research may find those factors to be valuable predictors of stress outcomes.

Another caveat to the current study design is that we primarily focused on the specific processes of affective reactivity and cognitive appraisals. Although both processes have been found to be robust predictors of more distal health and well-being outcomes, they are only two parts of the overall psychological stress response (see review by Epel et al., 2018). Additional research may benefit from investigating mediating and moderating effects of emotion regulation strategy choices, motivation, and goals on age-group differences in stressor outcomes (e.g. Luong & Charles, 2014). The current study grouped specific affective reactivity items (e.g., sadness, joy, frustration) into positive and negative valence composites for increased reliability, but specific appraisals have been found to have differential influence on distinct emotional reactions (Young et al., 2021). Similarly, we aggregated participants' task-appraisals for the speech and math tasks, respectively, into a single task-appraisal measure. However, future research should investigate potential differences in how math or speech task-appraisals differentially influence affective reactivity outcomes. Finally, we posited that specific characteristics of the TSST (e.g., novelty, unpredictability, uncontrollability, and social-evaluative threat) were responsible for our results that attenuated or reversed any potential age-related regulatory advantages for older adults, but we did not directly assess participants' appraisals of those elements in the present study. Future research should include measures to quantify the extent to which each of these factors account for age-group differences in affective reactivity.

Conclusion

The current study makes several meaningful contributions to the socioemotional development literature. To start, our study is one of the first empirical evaluations of age-group differences in trajectories of adaptation to equivalent stressors, an area that has been largely unexplored until now (Rohleder, 2019). By utilizing a laboratory-based stressor that reliably produces a stress response in adults of all ages, we were able to find support for SAVI's predictions that highly arousing, unavoidable, and repeated stressor exposure conditions may eliminate or reverse regulatory advantages for older adults (Charles, 2010; Charles & Luong, 2013). Additionally, although there is a broad base of evidence for age-group differences in affective reactivity and appraisals (see review by Charles & Carstensen, 2010), relatively few studies have directly examined the extent to which appraisals account for age-group differences in affective reactivity. The current study has added increased specificity in this regard by showing that changes in appraisals of task-difficulty over time mediated differences in trajectories of NA reactivity between younger and older adults. Finally, the present study revealed several age-group differences in trajectories of affective reactivity and appraisals in response to equivalent stressors over time, providing a foundation for future research to build on in service of refining current theoretical assumptions and improving efforts to help adults of all ages deal with stress more adaptively.

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