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Perceived Control and Reactivity to Acute Stressors: Variations by Age, Race, and Facets of Control

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Abstract

Greater perceived control is associated with better health and well-being outcomes, possibly through more adaptive stress processes. Yet little research has examined whether facets of perceived control (personal mastery and perceived constraints) predict psychological and physiological stress reactivity. The present study evaluated the associations of personal mastery and perceived constraints with changes in subjective stress and cortisol in response to acute laboratory stressors, with age and race as potential moderators. In the Midlife in the United States Refresher Study (*N* = 633 adults aged 25–75), participants completed a baseline perceived control measure and were subsequently recruited to participate in the laboratory stress protocol. The protocol consisted of completing two mental stress tasks (mental arithmetic and Stroop) as well as providing saliva samples and subjective stress ratings. Race moderated the association between perceived constraints and subjective stress reactivity, such that higher constraints predicted greater subjective stress responses in White participants, but no association was observed in Black participants. Higher personal mastery and perceived constraints each predicted greater increases in cortisol in response to the stress tasks (AUC_i) among younger but not older adults. These findings suggest that older adults were buffered against the association between facets of control and cortisol stress reactivity. Discussion on potential racial differences in the link between constraints and stress reactivity are elaborated further, as well as considerations for future work to distinguish between facets of control and examine age and racial differences.

Keywords: stress, perceived control, constraints, mastery, cortisol reactivity, laboratory stressors

Perceived Control and Reactivity to Acute Stressors: Variations by Age, Race, and Facets of Control

A large body of evidence has demonstrated that maintaining a sense of control throughout adulthood is associated with better health and well-being, in addition to facilitating adaptation under stressful life conditions (Hülür et al., 2017; Infurna & Mayer, 2015; Lachman et al., 2011; Prenda & Lachman, 2001). *Perceived control*—defined as the perception of one's ability to exert influence over life circumstances—has been proposed to influence health and aging-related outcomes through physiological and behavioral mechanisms (Lachman, 2006b; Lachman et al., 2011; Robinson & Lachman, 2017). Stress reactivity, in particular, has been hypothesized to link individual differences in control beliefs with future health outcomes. People who perceive greater control over their lives may exhibit more adaptive psychological and physiological responses to stressful situations, which in turn may result in less wear-and-tear on physiological stress systems over time (Elliot, Mooney, et al., 2018; Lachman et al., 2011).

Findings from both experimental and ecological studies have found greater perceived control to be protective against physiological and affective stress responses (Agrigoroaei et al., 2013; Bollini et al., 2004; Diehl & Hay, 2010; Neupert, Almeida, & Charles, 2007). Compared to those with less perceived control (e.g., assessed using the Perceived Control Scale; Lachman & Weaver, 1998), people with greater perceived control show lower levels of stressor-related anxiety (Ong, Bergeman, & Bisconti, 2005), engage in more adaptive coping strategies (Lachman & Andreoletti, 2006), and are less emotionally reactive to daily stressors (Neupert et al., 2007). Findings from several laboratory studies suggest that individuals with greater control beliefs may be less psychologically and physiologically reactive to acute lab-based stressors (Bollini et al., 2004; Sanz & Villamarín, 2001). According to the social self-preservation theory, threats to one's social value, esteem, and status would evoke psychological (e.g., negative emotions and cognitions) and physiological (e.g., increased biological markers of stress) changes to cope with the threats (Dickerson et al., 2004). The theory posits that the magnitude of stress responses depends, in part, on the person's degree of control over the stressors (Dickerson et al., 2004). Thus, perceived control may protect against the psychological and physiological effects of stress.

Stress produces a cascade of glucocorticoid hormones via activation of the hypothalamic-pituitary-adrenal (HPA) axis, including secretion of cortisol. Cortisol plays key roles for regulating multiple physiological systems (Sapolsky, Romero, & Munck, 2000). Dysregulated patterns of salivary cortisol are associated with poorer health (e.g., allostatic load) and elevated mortality risk (Charles et al., 2020; Kumari et al., 2011). Controllability is an important dimension of stress that is known to increase or diminish HPA axis activity (for reviews, see Dickerson & Kemeny, 2004 and Miller, Chen, & Zhou, 2007). Laboratory studies have shown that motivated performance stress tasks (i.e., active performance tasks that demand immediate overt or cognitive responses from participants, such as giving a speech) which contain elements of uncontrollability elicit greater cortisol responses, compared to controllable acute stressors or passive tasks that do not require cognitive responses (e.g., noise exposure or watching a film; Dickerson & Kemeny, 2004). Moreover, perceptions of control over the situation have been shown to attenuate cortisol responses to laboratory stressors (Abelson et al., 2008; Bollini et al., 2004). For example, among participants who believed control could be exerted over a laboratory stressor, those with higher trait control beliefs exhibited relatively smaller increases in cortisol and reported less subjective stress (Bollini et al., 2004).

Much of this past research has focused on experimentally-manipulated controllability and cortisol stress reactivity (Dickerson & Kemeny, 2004), whereas less research has focused on trait-like control beliefs as predictors of cortisol responses to standardized stressors. Individual differences in trait perceived control may be an important predictor of stress reactivity as it is indicative of a person's general belief in their ability to overcome potential challenges in their lives. For example, Neupert and colleagues (2007) found that younger adults who reported lower levels of trait perceived control had greater psychological distress when faced with interpersonal stressors, compared to those with higher perceived control. In another study, participants with higher general (trait) control beliefs exhibited relatively greater cortisol responses when faced with a low-control scenario (Agrigoroaei et al., 2013). Taken together, higher levels of control may be protective during stressful situations (e.g., Lachman & Andreoletti, 2006), but may also detrimental under certain contexts (e.g., Agrigoroaei et al., 2013).

To our knowledge, only several studies (e.g., Agrigoroaei et al., 2013; Bollini et al., 2004) have examined individual differences in trait perceived control and cortisol stress reactivity. These studies, as well as others focusing on perceived control and diurnal cortisol (e.g., Zilioli, Imami, & Slatcher, 2017), have reported no main effects for the link between perceived control and cortisol outcomes, suggesting that a more nuanced relationship exists. Given that perceived control and cortisol profiles have been found to differ between racial (e.g., Assari, 2017; Cohen et al., 2006) and age groups (e.g., Drewelies et al., 2017; Roelfsema et al., 2017), further examination of the facets of perceived control and conceptually-relevant contextual moderators (specifically, race and age) is warranted to advance our understanding of the link between perceived control and stress processes (Infurna & Mayer, 2015; Lachman, Neupert, & Agrigoroaei, 2011). Although several studies have separately examined the roles of age (Agrigoroaei et al., 2013; Diehl & Hay, 2010; Neupert et al., 2007) or race (Bruce & Thornton, 2004; Miller et al., 1995; Peterson et al., 2020; Sastry & Ross, 1998) in the association between perceived control and stress, to our knowledge no research on this topic has focused on the intersection of age and race.

Facets and Moderators of Perceived Control

Facets of Perceived Control

Perceived control is composed of multiple dimensions, including the facets of *personal mastery*, or beliefs about one's abilities to reach desired goals, and *perceived constraints*, or beliefs regarding obstacles that may interfere with goal attainment (Lachman & Firth, 2004). Past research on perceived control and stress has typically examined perceived control as a single construct (Bollini et al., 2004; Lachman & Andreoletti, 2006; Ong et al., 2005). Although mastery and constraints are (inversely) correlated, some evidence suggests that facets of perceived control may have different implications on mental and physical health (Elliot, Turiano, Infurna, et al., 2018; Infurna & Mayer, 2015), as well as stress reactivity (Neupert et al., 2007).

Personal mastery reflects a sense of competence and self-efficacy, which may be derived from an individual's motivation and behaviors associated with goal attainment. Mastery can be an important psychological resource for coping with major stressors: For example, mastery has been shown to attenuate the link between lifetime trauma exposure and mortality risk (Elliot, Turiano, et al., 2018). Perceived constraints, on the other hand, may capture external circumstances in one's environment that limit personal control. Constraints encompass potent elements of psychological stress—including beliefs about limitations due to uncontrollable factors (Infurna & Mayer, 2015)—which have been shown to evoke the greatest cortisol responses (Dickerson & Kemeny, 2004). Thus, both facets of perceived control have implications for stress, but no research has directly compared their implications for subjective versus physiological stress responses.

Age Differences in Perceived Control

Compared to younger adults, older adults have similar levels of personal mastery but higher perceived constraints, potentially due to increased physical limitations with advancing age (Drewelies et al., 2018; Lachman, 2006a). It is unknown whether control beliefs are more strongly related to health earlier or later in life. Two perspectives have emerged regarding the role of age in control beliefs. The first perspective is that perceived control may be more protective for health and well-being in late adulthood when people face greater declines in health, compared to early or middle adulthood (Infurna, Gerstorf, & Zarit, 2011; Lachman, 2006; Lachman & Agrigoroaei, 2010). Evidence for this perspective comes from longitudinal studies demonstrating stronger links between higher levels of perceived control and fewer changes in the number of health conditions (e.g., arthritis, hypertension; Infurna et al., 2011), as well as better functional health (Lachman & Agrigoroaei, 2010) in older adults, compared to younger and midlife adults.

The other perspective suggests that fostering control beliefs earlier in the lifespan is important for setting a person on a better health trajectory, possibly by influencing mechanisms such as adaptive stress responses or better health behaviors (Infurna, Ram, Gerstorf, 2013; Infurna & Mayer, 2015). In support of this latter perspective, daily diary studies have found stronger associations between control beliefs and stress reactivity for younger adults than for older adults (Diehl & Hay, 2010; Neupert et al., 2007). Lifespan theories of emotions and aging posit that as people grow older, they develop expertise and motivation for regulating emotions (Carstensen, Isaacowitz, & Charles, 1999; Charles, 2010). Older adults are more likely than younger adults to use attentional, appraisal, and behavioral strategies that mitigate emotional and physiological reactivity to stressors (Charles, 2010; Charles & Carstensen, 2010). Indeed, studies using adult lifespan samples have demonstrated stronger associations between low perceived control and emotional or subjective stress responses in younger adults compared to older adults, such as greater daily negative affect (Diehl & Hay, 2010) and self-reported increases in physical symptoms (Neupert et al., 2007). However, it remains unknown whether the previously-observed age differences in the links between perceived control and stress responses in daily life (as indicated by affect and physical symptoms) will extend to standardized laboratory stressors and to cortisol stress reactivity.

Racial Differences in Perceived Control

In addition to age, race is an important sociodemographic factor that is related to different levels of perceived control. Compared to White individuals, racial minorities in the United States—including Black/African American, Latinx, and Asian American individuals—report lower control beliefs on average (Kang et al., 2013; Mirowsky, Ross, & Van Willigen, 1996; Sastry & Ross, 1998; Shaw & Krause, 2001). Racial differences extend to the facets of perceived control as well: Black individuals have reported lower mastery (Ward, 2012) and greater constraints (Zahodne et al., 2017), compared to White individuals.

Racial inequity in the distribution of power, privilege, and resources (as evidenced in healthcare, education, housing, criminal justice, and other social systems) has been hypothesized as an explanation for racial differences in control beliefs, as perceptions of discrimination or exclusion can erode feelings of control (Assari, 2018; Jang et al., 2008). Race has been shown to moderate the link between socioeconomic factors (e.g., education and income) and health, such that Black individuals do not show the same degree of health gains from higher socioeconomic status than their White counterparts (El-Sheikh et al., 2016; Williams et al., 2016). This moderating role of race is evident for perceived control as well: Racial minorities (including Black and Asian individuals) have shown weaker or no associations of perceived control with psychological outcomes (e.g., psychological distress, depressive symptoms; Sastry & Ross, 1998) and physical health outcomes (e.g., functional health, mortality risk; Assari, 2017; Bruce & Thornton, 2004), relative to White individuals. It is possible that trait perceived control is less beneficial for racial minorities than for White individuals due to pervasive constraints in the lives of minorities, stemming from uncontrollable factors that include institutional and cultural discrimination, toxic residential and occupational environments, and intergenerational and lifetime experiences of trauma (for reviews, see Assari, 2018; Sastry & Ross, 1998; Williams et al., 2016).

Racial differences in subjective and physiological stress responses have been observed in previous research. For example, one study found that Black participants reported higher psychological distress than White participants during a laboratory speech task (Lepore et al., 2006). In a study examining race and age moderation, Black individuals showed greater age-related decreases in heart rate variability in response to acute stressors, compared to White participants (Fuller-Rowell et al., 2013). Although perceived control has been shown to *mediate* the link between racial exclusion and greater cortisol reactivity to a social laboratory-based stressor (Peterson et al., 2020), the question of whether race *moderates* the association between perceived control and stress reactivity remains unanswered.

Intersection of Age and Race

A large body of research has examined the interaction of age and race psychological and physiological health (Bellizzi et al., 2012; House et al., 1990; Jackson et al., 2010; Quittner et al., 2010; Yao & Robert, 2008). To our knowledge, however, only one study has evaluated both race and age variations in control beliefs. Specifically, age was inversely associated with control beliefs in the Americans' Changing Lives Study, and this trajectory was largely similar for White and Black individuals (Shaw & Krause, 2001). Yet, different factors influenced this relationship in the two racial groups: Education, in particular, was more strongly associated with control beliefs in White than in Black individuals (Shaw & Krause, 2001). That study focused on control beliefs as an outcome, but it is unknown whether the association between perceived control and stress reactivity differs by both age and race. The intersection of age and race for perceived control is important to understand due to its implications for racial disparities in adult development and aging. For instance, younger White adults may show the greatest benefit from control beliefs, given that younger age is related to less-effective emotion regulation (Charles, 2010) and greater psychological stress reactivity (Neupert et al., 2007), in addition to being afforded more opportunities and fewer constraints in their daily lives, compared to Black individuals (Assari, 2018). If that is indeed the case, then this information could be valuable for tailoring interventions for stress management (e.g., Reich & Zautra, 1990), while considering differences based on age and race.

Current Study

The overarching purpose of the current study was to examine individual differences in facets of perceived control (personal mastery and perceived constraints) as predictors of subjective stress and salivary cortisol responses to standardized laboratory-based stressors. Our data came from a national U.S. sample of adults ages 25-75 in the Midlife in the United States (MIDUS) Refresher Study, which enabled us to evaluate age and race as hypothesized moderating factors. Participants in the current study completed a baseline questionnaire and subsequently engaged in a laboratory stress protocol as part of the MIDUS Refresher Biomarker Sub-study an average of 22 months later (*SD* = 9.13). The first aim of the study was to examine whether individual differences in trait-like mastery and constraints were differentially related to changes in subjective stress and in cortisol levels in response to acute stress tasks. Based on findings demonstrating stronger associations between mastery and psychological outcomes, and between constraints and physical health (Infurna & Mayer, 2015), we hypothesized that higher mastery would be associated with smaller increases in subjective stress, whereas higher constraints would be associated with greater increases in salivary cortisol. The second aim was to evaluate age as a moderator of the association between perceived control and stress reactivity. Based on lifespan developmental theories of emotions (e.g., Charles, 2010) and previous evidence from observational studies (e.g., Diehl & Hay, 2010; Neupert et al., 2007), we predicted that the associations between facets of perceived control and stress reactivity would be stronger for younger adults than for older adults. Drawing on past evidence indicating race moderation in the link between perceived control and health and well-being (e.g., Assari, 2017; Peterson et al., 2020; Sastry & Ross, 1998), the third aim was to test our hypothesis that facets of perceived control would be more predictive of stress reactivity for White than for Black participants. Lastly, on an exploratory basis, we sought to integrate the potential moderating effects of age and race to examine whether they interact to moderate the links between perceived control and stress responses.

Method

Participants and Design

The Midlife in the United States Refresher (MIDUS-R) Study (N = 3,577) is a national study designed to examine the roles of psychosocial factors in aging and health (Kirsch et al., 2019). Our data came from a substudy of MIDUS-R called the Biomarker Project, which consisted of 863 adults ages 25-75 who participated in a standardized acute stress protocol. Participants were excluded from the current analysis for the following reasons: did not complete the acute stress protocol (n = 32), provided insufficient saliva to assay (n = 108), or did not complete the perceived control measure (n = 1). We further excluded non-Black minority participants due to insufficient sample size in each of the racial/ethnic groups. Specifically, a total of 89 participants were excluded for missing data on race (n = 6) or if they identified as Native American (n = 19), Asian (n = 11), Native Hawaiian/Pacific Islander (n = 2), or “Other” regarding their racial identity (n = 51). Thus, our final analytic sample was composed of 633 participants who self-identified as White (n = 510, 81%) or Black (n = 123, 19%). Compared to the 230 participants that were excluded from analyses, the analytic sample of 633 participants did not differ in age (t = 0.36, p = .72), personal mastery (t = -0.44, p =.66), perceived constraints (t = 0.50, p = .62), education attainment (t = -0.65, p = .51), number of chronic conditions (t = 1.31, p = .19), nor body mass index (t = .06, p = .95).

On average, the perceived control measure was completed 22.4 months (SD = 9.1 months) before participants took part in clinic visits spanning two days. The mental stress protocol began at approximately 9:00am on the second day of clinic visits, following an overnight stay in the clinical research unit at one of 3 research sites (i.e., UCLA, University of Wisconsin, Georgetown University) based on the region in which the participants lived. Participants were instructed to avoid caffeine and nicotine after midnight the night before their clinic visit. Upon arrival, participants provided their first subjective stress rating and saliva sample before beginning an 11-minute seated resting period. The end of the resting period, another subjective stress rating and saliva sample were collected; this was considered the baseline measure for the current analyses. Next, participants engaged in one of the two randomized mental stress tasks (i.e., mental arithmetic, Stroop color-word task) followed by a 6-minute recovery period; subjective stress ratings were reported immediately after the stressor and after the recovery period. This procedure was repeated for the second mental stressor. A third saliva sample was collected following the recovery period of the second cognitive stressor. Participants rated their subjective stress and provided a fourth saliva sample 30 minutes later. The final subjective stress rating and saliva sample was collected 60 minutes after the completion of both cognitive stressors (Love et al., 2010).

Mental Stress Tasks

Mental Arithmetic. For six minutes, participants were presented with a series of addition and subtraction problems on a computer screen, each followed by an answer (Turner et al., 1986). They were instructed to press a key to indicate whether each answer was correct or incorrect, working as quickly and accurately as possible. The problem difficulty varied across five levels, starting at medium difficulty and became more or less difficult depending on response accuracy.

Stroop Color-Word Task. For six minutes, participants were presented with one of four color names (*blue, green, yellow, red*) on a computer screen in a font color that was either congruent or incongruent with the name. They were instructed to press a key that corresponded with the color of the target word. Stimuli were presented at a speed that varied based on task performance. Greater accuracy led to more rapid presentation of subsequent stimuli, whereas poorer accuracy led to a slower presentation rate. Participants were asked to complete the trials quickly and accurately (Love et al., 2010). Prior research has suggested that both mental stress tasks are effective in evoking a psychological and HPA axis stress response (Skoluda et al., 2015).

Measures

Perceived Control

Perceived control was assessed by a self-reported questionnaire as part of the main MIDUS-R study. The perceived control scale ($\alpha = 0.88$) consisted of two subscales, personal mastery and perceived constraints (Lachman & Weaver, 1998). Personal mastery was measured using 4 items that assessed self-efficacy in realizing goals (e.g., "When I really want to do something, I usually find a way to succeed at it"; $\alpha = 0.74$). Perceived constraints were assessed with 8 items tapping into beliefs about obstacles beyond one's control that interfere with goal attainment (e.g., "What happens in my life is often beyond my control"; $\alpha = 0.87$). Participants rated their agreement with each statement using a 7-point scale (1 = *strongly agree,* 7 = *strongly disagree*). Personal mastery and perceived constraints items were coded such that higher values reflected higher levels of each construct. Ratings were averaged across the items within each subscale to obtain mastery and constraints scores. Prior research has suggested that perceived control remains relatively stable over time (e.g., across 15 years) but begins to decline in late life, particularly with poorer health (Drewelies et al., 2017; Lachman & Firth, 2004).

Subjective Stress Rating

Subjective stress ratings were assessed at six time points during the acute stress protocol: (1) baseline immediately before stressor exposure, (2-3) immediately after each of the two stress tasks, (4-5) 6-min following each stress task, and (6) 30-min post stressor exposure. Participants rated their subjective stress on a scale from 1 (*Not stressed at all*) to 9 (*Extremely stressed*). The order of the stress tasks was randomized and counterbalanced. Post-stressor subjective stress was computed as the average of two stress ratings, one assessed after the Stroop task and the other assessed after the mental arithmetic task. Change scores for subjective stress were created by subtracting the baseline stress rating from the average post-stressor rating.

Salivary Cortisol

Salivary cortisol was collected using Salivettes (Sarstedt, Nümbrecht, Germany) at four time points: (1) baseline immediately before stressor exposure, (2) immediately after both stress tasks were completed, (3) 30-min post-stressors, and (4) 60-min post-stressors. Concentrations of free cortisol were determined from saliva samples using radioimmunoassays (MP Biomedicals, Solon, OH). Based on prior research (Khoury et al., 2015), we focused specifically on salivary cortisol assessments collected from baseline, immediately post-stressors, and 30-min post-stressors. We computed two indices using the trapezoidal formulas from Pruessner et al. (2003). First, area under the curve with respect to ground (AUC_g) served as a measure of total cortisol output. Second, area under the curve with respect to increases or decreases (AUC_i) was used to capture changes in cortisol relative to the baseline level (Fekedulegn et al., 2007; Khoury et al., 2015). Salivary cortisol values (nmol/L) were approximately normally distributed; thus, AUC calculations were made using raw non-transformed values.

Data Analysis

Analyses were conducted using R version 4.0.1 (R Core Team, 2021). Separate multiple regression analyses were performed using the *stats* R package (R Core Team, 2021) to evaluate facets of perceived control (personal mastery and perceived constraints) as predictors of change in subjective stress ratings and salivary cortisol levels from baseline to post-stressor exposure, respectively. To evaluate age and race as potential moderators, the models included interactions between perceived control and its facets by age (as a continuous variable) and by race (coded as White or Black).

For significant interaction effects, a *region of significance* analysis was conducted to examine the region of age over which the slope of the association between perceived control and subjective or cortisol stress responses significantly differ from zero (Preacher, Curran, & Bauer, 2006). All models covaried for sex, education (1 = some college or higher, 0 = high school education or lower), number of chronic conditions and symptoms (from list of 20 conditions, e.g., heart disease, high blood pressure, high cholesterol), body mass index (kg/m^2; calculated from height and weight measured during clinic visit), and current use of cortisol-altering medications (e.g., corticosteroids, steroid inhalers, hormone therapy, oral contraceptives) with the exception of topical applications of corticosteroids. We also controlled for baseline measures of optimism and self-esteem from the 6-item Life Orientation Test ($\alpha = .82$; Scheier et al., 1994) and the 7-item Self-Esteem Scale ($\alpha = .77$; Rosenberg, 1995), respectively, to account for the influence of other stress-related individual resources. An assessment interval variable was also included to account for the time interval between participating in the initial MIDUS-R survey and Biomarker Project. In the model predicting subjective stress reactivity, we controlled for baseline subjective stress because it was inversely correlated with the magnitude of change. All continuous predictors and covariates were centered at the grand means. Bootstrap resampling (5000 repetitions) was used to calculate bias-corrected confidence intervals.

Lastly, prior studies have found that 40% of participants do not show increased cortisol in response to mental stress tasks such as the Stroop and mirror tracing, but cortisol responders were at greater risk for coronary artery calcification (Hamer et al., 2010) and cellular aging (Steptoe et al., 2017) than cortisol nonresponders. Thus, as a secondary analysis, we ran a logistic regression model to evaluate facets of perceived control and its interactions with age and race as predictors of the odds of being a cortisol responder (i.e., any increase in cortisol relative to baseline).

Results

Descriptives and Correlations

Descriptive statistics by race are shown in Table 1. The final sample was composed of 633 adults (50% female) with an average age of 50.62 years (*SD* = 13.08). Overall, 84% of the sample completed at least 1-year of college or more. Participants reported an average of four chronic conditions and symptoms, and 41% of the sample reported taking cortisol-altering medications. On a 1–7 scale, average scores on personal mastery and perceived constraints were 5.71 (*SD* = 1.01) and 2.54 (*SD* = 1.15), respectively. Compared to White participants, Black participants had a higher proportion of females to males (68.3% vs. 45.7%), were on average younger (46.2 years vs. 51.7 years) and had a higher body mass index (33.1 vs. 29.6). Furthermore, Black participants differed from White participants in the proportion of individuals that had some college education (68.5% vs. 88.0%). There was no difference between White and Black participants in any of the subjective stress measures (i.e., baseline, post-stressor, reactivity). However, on average, Black participants had relatively lower total cortisol output (AUC_g) and decreases in cortisol in response to the stress tasks (negative AUC_i), whereas White participants had increases in cortisol (positive AUC_i). Mean levels of perceived control and its facets did not differ by race. Bivariate correlations among study variables were included in Supplementary Table S1.

Manipulation Check

Average subjective stress ratings increased from baseline to post-stress tasks (Table 1). A paired samples t-test confirmed that baseline and post-stressor subjective stress ratings were significantly different ($t(632) = -36.29$, $p < .001$).

For descriptive purposes, we considered participants' peak cortisol value to be their highest cortisol level collected either immediately post-stressor or 30-min post-stressor, given prior work showing that cortisol levels may be elevated 21–40 minutes following acute stressor exposure (Dickerson & Kemeny, 2004). On average, the mean salivary cortisol level at baseline was 15.47 nmol/L ($SD = 6.91$) and significantly increased to 16.64 nmol/L ($SD = 7.27$) at its peak level ($t(632) = -4.96$, $p < .001$). Peak cortisol values for 60% of participants were found immediately following the stress tasks, whereas the remaining participants had their highest cortisol levels at 30-min post-stressors. However, 276 participants (44%) showed no change or a decrease in cortisol in response to the acute stressors (mean cortisol change among these participants = -3.40 nmol/L, $SD = 3.53$). Of the participants that showed an increase in cortisol (n = 357), the average cortisol increase was 4.71 nmol/L ($SD = 4.94$).

Facets of Perceived Control and Stress Reactivity

Subjective Stress Reactivity

Aim 1 (Main effects). Table 2 shows the results from a regression model of personal mastery and perceived constraints as predictors of subjective stress reactivity. In contrast to our hypothesis that mastery would be associated with lower subjective stress reactivity, there was no main effect of mastery. However, participants with higher perceived constraints showed larger increases in subjective stress in response to the stressors (effect size $\eta^2 = .01$); this main effect of constraints was moderated by race (described below for Aim 3 results).

Aim 2 (Age moderation). Neither personal mastery nor perceived constraints interacted with age to predict subjective stress reactivity, contrary to our expectations.

Aim 3 (Race moderation). In line with our prediction that facets of perceived control would be more strongly associated with stress reactivity in White participants than in Black participants, there was a significant 2-way interaction between perceived constraints and race (Figure 1; $\eta^2 = 0.03$). Bootstrapped confidence intervals were similar to those in the primary analysis (*95% CI* = [-.71, -0.10]). Specifically, perceived constraints predicted increases in subjective stress among White participants only (simple slope: *Est.* = 0.28, *SE* = 0.09, $p = .002$, $\beta = 0.12$) but not among Black participants (simple slope: *Est.* = -0.14, *SE* = 0.12, $p = 0.24$, $\beta = -0.06$). However, personal mastery did not interact with race to predict subjective stress reactivity.

Exploratory Aim (Age x Race moderation). Our exploratory analyses revealed no significant three-way interactions of personal mastery or perceived constraints with age and race.

Cortisol Reactivity

Aim 1 (Main effects). Table 3 reports the findings from the regression models for personal mastery and perceived constraints as predictors of total cortisol output (AUC_g) and changes in cortisol in response to the stress tasks (AUC_i). We had expected only perceived constraints to be related to greater cortisol stress reactivity. However, we found that neither personal mastery nor perceived constraints predicted cortisol stress responses.

Aim 2 (Age moderation). Age moderated the association between personal mastery and cortisol AUC_i ($\eta^2 = 0.01$; bootstrapped 95% CI = [-5.05, -0.46]). Simple slope analyses were conducted separately by age, comparing the slopes of younger (30 years), middle-aged (mean age of 51), and older adults (65 years). As shown in Figure 2, personal mastery was associated with cortisol AUC_i in younger adults (simple slope for age 30: *Est.* = 57.42, *SE* = 26.48, $p = .03$,

β = 2.22) but not middle-aged (simple slope for age 51: *Est.* = 9.63, *SE* = 14.62, *p* = .51, β = 0.03) or older adults (simple slope for age 65: *Est.* = -24.50, *SE* = 21.73, *p* = .26, β = -1.53). However, the direction of this association did not align with our expectations. In particular, the results revealed that younger adults with higher personal mastery showed greater increases in cortisol in response to the stressors. The region of significance analysis indicated that personal mastery was not associated with cortisol AUC_i for participants older than 38 years of age. There were no 2-way interaction effects for Age by Facets of Perceived Control in the model predicting cortisol AUC_g.

As hypothesized, age moderated the association between perceived constraints and cortisol stress reactivity (AUC_i; η^2 = 0.02; bootstrapped 95% CI = [-5.53, -0.40]), although this pattern was not evident for total cortisol output (AUC_g). As depicted in Figure 3, higher constraints predicted greater cortisol AUC_i among younger adults (simple slope for age 30: *Est*. = 61.17, *SE* = 26.12, *p* = .02, β = 0.18), but not among middle-aged adults (simple slope for age 51 [sample mean age]: *Est.* = 17.14, *SE* = 15.50, *p* = .27, β = 0.07) or older adults (simple slope for age 65: *Est.* = -14.33, *SE* = 21.65, *p* = .51, β = -0.04). The region of significance analysis revealed that this association between perceived constraints and cortisol AUC_i was not significant for participants older than 42 years of age.

Aim 3 (Race moderation). In contrast to our predictions, race did not interact with either personal mastery or perceived constraints to predict cortisol AUC_g nor AUC_i.

Exploratory Aim (Age x Race moderation). There were no 3-way interactions for Facets of Perceived Control x Age x Race for either cortisol AUCi or AUCg.

Secondary Analysis for Cortisol Responders vs. Cortisol Nonresponders

The logistic regression model predicting the odds of any increased cortisol in response to the stress tasks (Supplementary Table S2) produced findings that were similar to the AUC_i analysis. Specifically, there were no main effects of personal mastery or perceived constraints on the odds of being a cortisol responder. Age significantly interacted with personal mastery (*OR* = 0.98, *95% CI* = [0.96, 1.00], $p = .02$, $\eta^2 = 0.08$) and perceived constraints (*OR* = 0.98, *95% CI* = [0.97, 1.00], $p = .03$, $\eta^2 = 0.07$), such that higher personal mastery and higher perceived constraints were independently associated with greater odds of being a cortisol responder among younger adults, but not among middle-aged and older adults. The region of significance analyses indicated that the facets of perceived control were significantly predictive of greater odds of being a cortisol responder only for individuals under the age of 35 (for personal mastery) and 39 (for perceived constraints).

Discussion

The current study investigated the associations of facets of perceived control (personal mastery and perceived constraints) with subjective and cortisol stress reactivity to acute standardized stressors, in addition to the potential moderating roles of age and race. In a national U.S. sample of adults in the MIDUS Refresher Study, we found that greater perceived constraints were associated with higher subjective stress reactivity. This association was moderated by race, such that higher perceived constraints were related to greater subjective stress reactivity among White participants but not among Black participants. In analyses for cortisol reactivity, age moderated the associations of personal mastery and perceived constraints with change in cortisol in response to the stress tasks (AUC_i). In particular, higher mastery and higher constraints independently predicted greater increases in cortisol among younger adults only. No association was observed between mastery and subjective stress reactivity, and neither mastery nor constraints predicted total cortisol output (AUC_g). Below, we have organized the discussion based on the three primary research aims.

Facets of perceived control

Our first aim was to examine differences between personal mastery versus perceived constraints in their associations with psychological and physiological stress reactivity. The findings more consistently support the role of perceived constraints in stress responses. In particular, constraints predicted greater subjective stress reactivity among White participants but not among Black participants, as well as greater increases in cortisol among younger adults only. Because trait perceived constraints reflect barriers in one's environment (e.g., reduced access to resources) as well as elements of uncontrollability that interfere with goal attainment, individuals with higher perceived constraints may be more sensitive to the psychological and physiological effects of stressors. Previous research using daily diaries have produced similar findings, such that individuals with higher constraints had higher negative affect and physical symptoms on days when stressors occurred vs. on nonstressor days (Neupert et al., 2007). It is possible that when individuals with higher perceived constraints encounter a stressor, they may perceive it as an additional barrier that limits their control and thus exhibit a stronger stress response.

Mastery was not associated with psychological stress reactivity, but it was instead predictive of *greater* cortisol stress reactivity among younger adults. Although these results were not aligned with our predictions based on previous work (Infurna & Mayer, 2015), several past studies have nonetheless documented a link between overall perceived control (not focusing on mastery specifically) and *lower* cortisol reactivity (Agrigoroaei et al., 2013; Bollini et al., 2004). One potential explanation is that younger adults with higher trait mastery may have exhibited more effort in these motivated performance tasks. Their greater effort was perhaps reflected in the increased cortisol reactivity, but this effort did not translate to greater (or lesser) changes in subjective feelings of stress.

Age moderation

The second aim of this study was to test the hypothesis that there would be relatively stronger associations between perceived control and subjective and cortisol stress reactivity for younger adults. Contrary to our expectations, age did not moderate the association between either facet of perceived control (i.e., mastery and constraints) and subjective stress reactivity; the age moderation effects were found only for cortisol responses. The lack of age moderation for perceived control and subjective stress was inconsistent with findings from previous daily diary studies, in which younger adults with lower perceived control showed greater stressor-related increases in negative affect or psychological distress (Diehl & Hay, 2010; Neupert et al., 2007). Because these previous studies focused on naturally-occurring stressors in daily life, it is possible that the laboratory-based stress tasks in our study lacked the personal relevance and daily life contexts in which age differences in perceived control and subjective stress would be more likely to emerge.

With regard to cortisol responses, we found that higher personal mastery and perceived constraints predicted greater cortisol AUC_i for younger and early midlife adults (up to approximately age 42) but not for older ages. It is possible that middle-aged and older adults were buffered from the consequences of higher perceived constraints on cortisol stress reactivity due to age-related differences in employing emotion regulation strategies, such as attentional disengagement or reappraisal (Charles, 2010). Adaptive emotion regulation strategies, in turn, predict more favorable psychological and physiological responses to stressors (Gross, 2001; Mauss et al., 2007), including lower cortisol response to stressors (Carlson et al., 2012; Gaab et al., 2003). Indeed, compared to younger adults, older adults are more effective at employing emotion regulation strategies which have been associated with less-pronounced increases in negative affect and physiological arousal in response to emotion-eliciting situations (Charles, 2010). A next step for future research on this topic would be to directly evaluate age-related patterns in emotion regulation strategies that may mediate the link between control beliefs and cortisol stress reactivity.

The unexpected finding that younger adults with higher personal mastery exhibited *greater* cortisol stress reactivity is intriguing. As mentioned previously, these results may be an indication of more effort exerted by younger adults with high mastery. Past research suggests that stressor domain is important to consider when examining age differences in mastery and stress responses. In particular, high mastery was protective in buffering against increases in physical symptoms in response to work stressors for younger and older adults, as well as for offsetting emotional reactivity to social network stressors in middle-aged adults (Neupert et al., 2007). Our findings add to this literature by raising the possibility that, among younger individuals, higher personal mastery may be related to greater cortisol responses—albeit transient and not reflected in subjective feelings of stress—in situations that demand attention and performance.

Of note, the age moderation results for cortisol AUC_i did not extend to AUC_g. This was unsurprising, however, as these two indices capture different information (Pruessner et al., 2003). Because AUC_i is sensitive to acute changes in cortisol, it was most aligned with our focus on stress reactivity in the laboratory context.

Race moderation

Given past research showing that the associations between control beliefs and health outcomes differed between racial groups (Mirowsky et al., 1996; Sastry & Ross, 1998; Shaw & Krause, 2001), our third hypothesis focused on whether White participants would show a stronger association between perceived control and reactivity to acute laboratory stressors compared to Black participants. We found support for this hypothesis only when examining perceived constraints and subjective stress reactivity, but not personal mastery or cortisol responses. Specifically, constraints predicted greater subjective stress reactivity in White participants, whereas no association was found among Black participants. Although speculative, it is possible that the lack of association may reflect differences in stress thresholds between Black and White individuals. Previous work has suggested that earlier and more frequent stressor exposure may enable Black individuals and other racial/ethnic minorities to develop more effective coping strategies and to be less perturbed by relatively minor stressors (Lewis et al., 2015; Williams et al., 2010). Indeed, an analysis of the Health and Retirement Study suggests that despite Black and Hispanic participants reporting more chronic stressors, they have lower stress appraisals (i.e., less upset by the stressors) compared to White participants (Brown et al., 2020). Thus, due to potential racial differences in stress thresholds, Black participants may have had less severe stress appraisals when engaging in the computerized stress tasks compared to White participants.

Contrary to our expectations, race did not moderate the association between perceived control and cortisol reactivity. One explanation may be that the stress tasks were not potent enough to reveal race-related differences in cortisol reactivity. Prior research suggests that stressors that include elements of explicit racial or ethnic discrimination elicit larger cortisol responses among racial minorities (Korous et al., 2017; Peterson et al., 2020). For example, a previous study found that Latinx participants had greater cortisol reactivity to a social-evaluative stressor when confederates made discriminatory remarks about a Latino classmate, compared to the neutral comments about the classmate (Huynh et al., 2017). Moreover, based on our exploratory analyses, age and race did not intersect to moderate the links between facets of perceived control and stress reactivity (i.e., no 3-way interactions). Despite these null findings, further research is necessary given that race-related differences in life circumstances (e.g., socioeconomic status, early life environment; Yao & Robert, 2008) could contribute to differences in perceived control and in health disparities across the lifespan.

Limitations and future directions

Limitations of the current study should be considered when interpreting the findings. First, we did not have a context-specific or state measure of perceived control during the stress tasks and therefore were unable to compare the roles of state versus trait-like perceived control in stress responses. Because past research has indicated that state and trait perceived control may interact and show differential associations with stress responses (Agrigoroaei et al., 2013; Bollini et al., 2004), future research should consider distinguishing between situation-specific versus more global forms of mastery and constraints when examining their relationships with stress.

Second, this study used computerized mental stressors, specifically a Stroop task and mental arithmetic. Notably, these acute stress tasks did not include a social-evaluative component (e.g., public speaking) and thus would have elicited smaller cortisol responses compared to social-evaluative stressors (Dickerson & Kemeny, 2004). We also found that 44% of the sample showed no change or a decrease in cortisol in reaction to the acute stress tasks, and that Black participants were less likely to exhibit increases in cortisol, compared to White participants. Although it was unclear why Black participants were relatively less likely to show cortisol responses to the acute stress tasks in the present study, future investigations using laboratory-based stress tasks should consider elements of stressors that are most psychologically and physiologically evocative for Black individuals, such as experiences of discrimination (Korous et al., 2017).

Third, most of the Black participants in the MIDUS Refresher study were recruited from Milwaukee, which limits whether the findings can be generalized to Black communities elsewhere in the U.S. Furthermore, considering that the associations between control beliefs and well-being outcomes have been found to differ between non-Black racial minorities such as Asian Americans compared to White Americans (Sastry & Ross, 1998), future work should examine these differences among non-Black racial minority groups.

Finally, control beliefs vary based on life domain (e.g., work, health, marriage) and different domains become more salient across the life course (Lachman et al., 2011; Neupert et al., 2007). Thus, future research could examine whether perceived control and its facets are related to stress reactivity for valued life domains, such as work-related stressors for younger and midlife adults and health-related stressors for older adults (Lachman & Firth, 2004).

Conclusion

To conclude, individual differences in personal mastery and perceived constraints were associated with stress reactivity to acute laboratory-based stressors, but these associations were modified by age and race. Our findings suggest that constraints were more consistently associated with stress responses (i.e., increases in both subjective stress and cortisol) compared to mastery, Whites and Blacks differed in the role of constraints on subjective stress responses, and older age buffered against the association between constraints and lab-based cortisol stress reactivity. Younger adults and White participants tended to show stronger associations between facets of perceived control and stress responses, compared to older adults and Black participants, respectively. Our findings support the value of distinguishing between mastery and constraints, in addition to considering their interactions with age and race, to understand the role of perceived control in stress processes.

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Table 1

Descriptives and Group Differences in Key Variables by Race

Variable	Full Sample (N = 633)	White (n = 510)	Black (n = 123)	Chi-square or t-test
Sex, N (%) female	318 (50.1%)	232 (45.7%)	84 (68.3%)	< **.001**
Age, mean (SD) years	50.62 (13.08)	51.68 (13.23)	46.24 (11.48)	< **.001**
Some College Education vs. Less, N (%)	532 (84.3%)	447 (88.0%)	85 (68.5%)	< **.001**
Body Mass Index, mean (SD)	30.25 (7.34)	29.57 (7.04)	33.06 (7.91)	< **.001**
No. of Chronic Conditions, mean (SD)	4.07 (3.06)	4.09 (2.96)	3.984 (3.44)	.72
Cortisol-Altering Medication Use (Yes), N (%)	258 (40.9%)	219 (43.1%)	39 (31.7%)	**.02**
Optimism, mean (SD)	23.06 (5.82)	23.11 (4.92)	22.84 (8.60)	.64
Self-Esteem, mean (SD)	37.38 (7.98)	37.25 (7.58)	37.93 (9.46)	.40
Perceived Control (Full Scale), mean (SD)	5.56 (0.98)	5.56 (0.96)	5.56 (1.06)	.97
Personal Mastery (Subscale), mean (SD)	5.71 (1.01)	5.845 (1.08)	5.73 (1.03)	.17
Perceived Constraints (Subscale), mean (SD)	2.54 (1.15)	2.52 (1.09)	2.65 (1.37)	.23
Baseline Subjective Stress Rating, mean (SD)	1.73 (1.18)	1.76 (1.18)	1.63 (1.20)	.30
Post-Stressor Subjective Stress Rating, mean (SD)	4.14 (1.76)	4.18 (1.69)	3.96 (2.03)	.20
Subjective Stress Reactivity, mean (SD)[a]	2.40 (1.66)	2.42 (1.58)	2.32 (1.97)	.54
Baseline cortisol (nmol/L), mean (SD)	15.47 (6.91)	15.64 (7.00)	14.78 (6.70)	.219
Post-stressor cortisol (nmol/L), mean (SD)	15.67 (6.97)	16.14 (7.19)	13.71 (5.58)	< **.001**
30-min post-stressor cortisol (nmol/L), mean (SD)	15.08 (6.74)	15.44 (6.94)	13.59 (5.63)	**.006**
Cortisol AUC_g (Total cortisol output)[b]	1064.44 (503.41)	1112.27 (514.62)	866.91 (399.04)	< **.001**
Cortisol AUC_i (Change in cortisol)[c]	1.34 (299.38)	14.21 (315.01)	-51.83 (216.59)	**.028**

Note. Bolded p-values represent significant differences between racial groups. Optimism was computed as the sum of 6 items rated on a scale from 1–5 (1 = *a lot disagree*, 5 = *a lot agree*). Self-Esteem was computed as the sum of 7 items rated on a scale from 1–7 (1 = *strongly disagree*, 7 = *strongly agree*). Perceived Control (Full Scale) was an average of the Personal Mastery subscale (items reverse-coded) and Perceived Constraints subscale. Personal Mastery and Perceived Constraints were rated on a scale from 1–7. Items were coded such that higher scores reflected higher standing in each facet. Subjective Stress was rated on a scale from 1–9 (1 = *not stressed*

at all, 9 = *extremely stressed*).
[a]Subjective Stress Reactivity was calculated by subtracting the baseline subjective stress rating from the average post-stressor ratings.
[b]Cortisol AUC_g = area under the curve with respect to ground.
[c]Cortisol AUC_i = area under the curve with respect to increase (or decrease).

Table 2

Personal Mastery, Perceived Constraints, and their Interactions with Age and Race as Predictors of Subjective Stress Reactivity

	Subjective Stress Reactivity		
Predictors	*B estimate*	*95% CI*	*p-value*
Intercept	2.30	1.95 – 2.66	**<.001**
Stress Baseline	-0.35	-0.45 – -0.25	**<.001**
Age	0.003	-0.01 – 0.01	.548
Sex (Ref = Female)	-0.33	-0.57 – -0.09	**.007**
Race (Ref = White)	-0.11	-0.43 – 0.20	.481
Education (ref = High School Diploma or less)	0.28	-0.05 – 0.61	.095
Body mass index	-0.01	-0.02 – 0.01	.541
No. of Chronic Conditions	0.01	-0.03 – 0.05	.599
Medication Use (Ref = No)	0.07	-0.18 – 0.33	.582
Time between Baseline and Laboratory Visit	0.01	-0.01 – 0.02	.403
Optimism	-0.01	-0.03 – 0.02	.699
Self Esteem	0.0004	-0.02 – 0.02	.968
Age x Race	0.01	-0.01 – 0.03	.432
Personal Mastery	0.09	-0.07 – 0.26	.255
Personal Mastery x Race	-0.22	-0.52 – 0.08	.154
Personal Mastery x Age	-0.01	-0.02 – 0.001	.081
Personal Mastery x Race x Age	0.01	-0.02 – 0.03	.615
Perceived Constraints	0.28	0.11 – 0.45	**.001**
Perceived Constraints x Race	-0.41	-0.68 – -0.15	**.002**
Perceived Constraints x Age	-0.01	-0.02 – 0.004	.233
Perceived Constraints x Race x Age	-0.00	-0.02 – 0.02	.690
R^2 / R^2 adjusted	0.106 / 0.081		

Note. Regression coefficients were unstandardized. Continuous predictors were mean-centered. Subjective stress reactivity was operationalized as the change score in subjective stress from pre- to post-stressors. *p*-values <0.05 were **bolded**.

Table 3

Regression Models for Personal Mastery, Perceived Constraints, and their Interactions with Age and Race Predicting Salivary Cortisol AUC_g *and* AUC_i

	Total Cortisol Output (AUC_g)			Change in cortisol (AUC_i)		
Predictors	*B*	*95% CI*	*p-value*	*B*	*95% CI*	*p-value*
Intercept	992.80	872.63 – 1112.97	**<0.001**	-74.51	-149.70 – 0.69	.052
Age	1.40	-2.29 – 5.08	0.456	0.46	-1.85 – 2.77	.695
Sex (Ref = Female)	180.25	102.00 – 258.50	**<0.001**	41.41	-7.56 – 90.37	.097
Race (Ref = White)	-137.61	-246.39 – -28.84	**0.013**	-35.13	-103.19 – 32.93	.311
Education (ref = High School Diploma or less)	21.69	-88.73 – 132.12	0.700	77.57	8.47 – 146.67	**.028**
Body mass index	-3.71	-9.11 – 1.70	0.178	-0.16	-3.54 – 3.22	.925
No. of Chronic Conditions	14.77	-0.15 – 29.68	0.052	-0.28	-9.62 – 9.05	.953
Medication Use (Ref = No)	-5.29	-87.85 – 77.27	0.900	-9.25	-60.91 – 42.41	.725
Time between Baseline and Laboratory Visit	-9.73	-13.98 – -5.47	**<0.001**	2.18	-0.48 – 4.84	.108
Optimism	3.77	-4.57 – 12.11	0.375	-0.82	-6.04 – 4.40	.758
Self Esteem	-4.31	-10.80 – 2.18	0.192	0.31	-3.75 – 4.38	.879
Age x Race	3.06	-5.36 – 11.49	0.475	1.15	-4.12 – 6.42	.669
Personal Mastery	42.00	-10.33 – 94.33	0.115	15.09	-17.66 – 47.83	.366
Personal Mastery x Race	-48.42	-149.31 – 52.47	0.346	-28.08	-91.21 – 35.05	.383
Personal Mastery x Age	0.73	-2.95 – 4.40	0.698	-2.65	-4.95 – -0.35	**.024**
Personal Mastery x Race x Age	3.24	-5.32 – 11.80	0.458	1.94	-3.42 – 7.30	.477
Perceived Constraints	-0.31	-55.64 – 55.02	0.991	21.70	-12.92 – 56.32	.219
Perceived Constraints x Race	0.30	-86.48 – 87.07	0.995	-23.50	-77.80 – 30.80	.396
Perceived Constraints x Age	-1.59	-5.22 – 2.04	0.389	-2.51	-4.78 – -0.24	**.030**
Perceived Constraints x Race x Age	3.76	-3.39 – 10.91	0.302	2.12	-2.35 – 6.60	.352
R^2 / R^2 adjusted		0.130 / 0.103			0.037 / 0.007	

Note. Regression coefficients were unstandardized. Continuous predictors were mean-centered. *p*-values <0.05 were **bolded**.

Supplementary Table S1

Correlations Among Study Variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Age	1														
2. Some college (vs. less education)	-.06														
3. Black race (vs. white)	**-.16****	**-.21****													
4. Body mass index	01	**-.15****	**.19****												
5. No. of Chronic Conditions	**.47****	-.03	-.01	.12**											
6. Medication Use	**.11****	.07	**-.09***	.06	**.33****										
7. Optimism	**.12****	**.17****	-.02	-.05	**-.09***	.00									
8. Self-Esteem	**.14****	**.12****	.03	**-.08***	-.07	-.03	**.54****								
9. Perceived Control (Full Scale)	.04	**.19****	.00	**-.15****	**-.10***	-.02	**.55****	**.68****							
10. Personal Mastery	-.04	.08	.06	**-.10****	-.11**	-.02	**.36****	**.50****	**.77****						
11. Perceived Constraints	**-.08***	**-.24****	.05	**.17****	.07	.01	**-.56****	**-.57****	**-.92****	**-.52****					
12. Cortisol AUCg	**.15****	.04	**-.19****	-.08	**.10***	.00	.02	-.01	.03	.01	-.04				
13. Cortisol AUCi	.03	**.10***	**-.09***	-.03	.01	.00	-.01	-.01	-.01	-.00	.01	**.17****			
14. Baseline Stress Rating	-.02	.02	-.04	-.07	**.09***	.03	**-.08***	**-.13****	**-.09***	**-.12****	.06	**.16****	**.13****		
15. Post-Stressor Rating	.03	.04	-.05	-.04	**.09***	.07	**-.10***	**-.14****	**-.15****	**-.11****	**.13****	.03	**.10***	**.41****	
16. Subjective Stress Reactivity	.05	.02	-.02	.00	.03	.05	-.04	-.06	**-.09***	-.04	**.10***	**-.08***	.01	**-.27****	**.76****

Note. Bolded values represent significant correlations. * Indicates $p < .05$. ** Indicates $p < .01$.

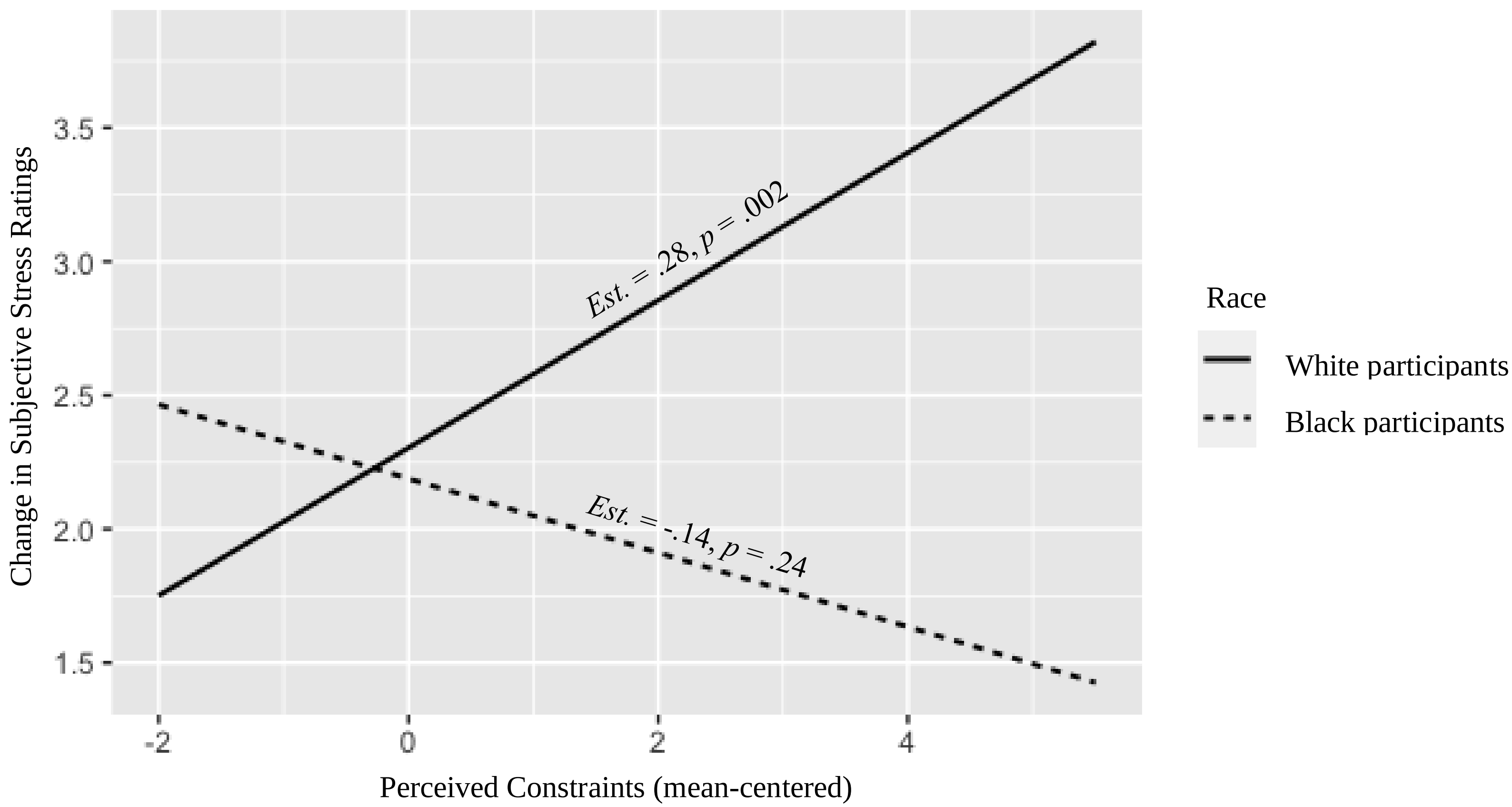
Supplementary Table S2*Personal Mastery, Perceived Constraints, and their Interactions with Age and Race Predicting Odds of Any Cortisol Increase in Response to Acute Stressors (i.e., Cortisol Responders)*

	Cortisol Responder (vs. Cortisol Non-Responder)		
Predictors	***Odds Ratio***	***95% CI***	***p-value***
Intercept	0.72	0.43 – 1.19	.205
Age	1.01	1.00 – 1.03	.178
Sex (Ref = Female)	1.53	1.10 – 2.13	**.012**
Race (Ref = White)	0.68	0.43 – 1.06	.091
Education (ref = High School Diploma or less)	1.76	1.10 – 2.81	**.018**
Body mass index	1.01	0.99 – 1.04	.286
No. of Chronic Conditions	0.99	0.93 – 1.06	.835
Medication Use (Ref = No)	0.88	0.62 – 1.26	.492
Time between Baseline and Laboratory Visit	1.01	0.99 – 1.03	.276
Optimism	0.98	0.94 – 1.01	.242
Self Esteem	1.01	0.98 – 1.03	.696
Age x Race	0.99	0.96 – 1.03	.642
Personal Mastery	1.01	0.80 – 1.28	.912
Personal Mastery x Race	1.10	0.71 – 1.71	.680
Personal Mastery x Age	0.98	0.96 – 1.00	**.023**
Personal Mastery x Race x Age	1.01	0.97 – 1.05	.689
Perceived Constraints	1.10	0.86 – 1.40	.452
Perceived Constraints x Race	0.98	0.68 – 1.42	.916
Perceived Constraints x Age	0.98	0.97 – 1.00	**.037**
Perceived Constraints x Race x Age	1.01	0.98 – 1.04	.509
Pseudo R^2		0.051	

Note. Continuous predictors were mean-centered. *p*-values <0.05 were **bolded**.

Figure 1

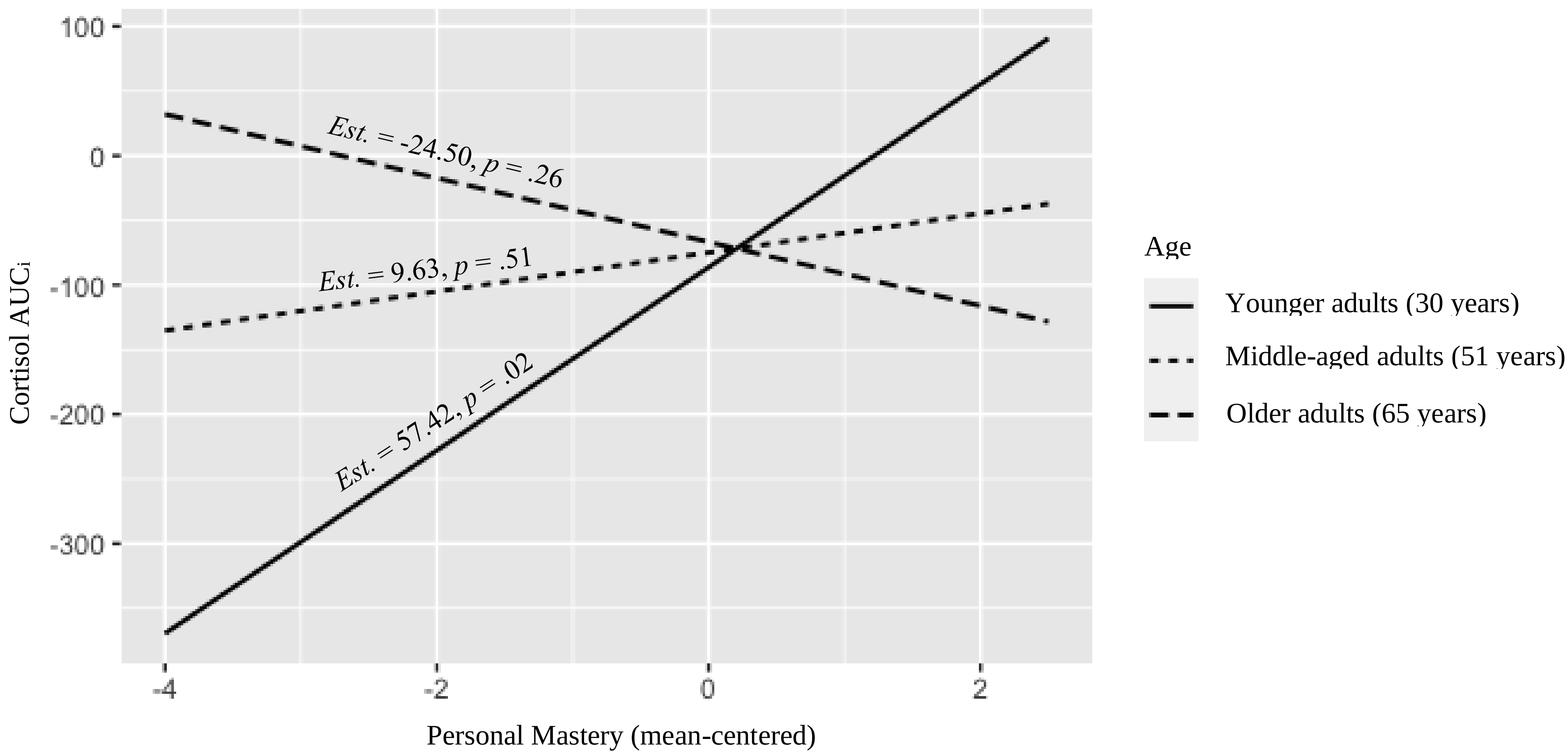
Race moderates the association between perceived constraints and subjective stress reactivity



Note. Black participants significantly differed from White participants in the association between perceived constraints and changes in subjective stress ratings from pre- to post-stressors. Simple slope analyses revealed that perceived constraints were positively associated with subjective stress reactivity among White participants, whereas no significant association was observed among Black participants.

Figure 2

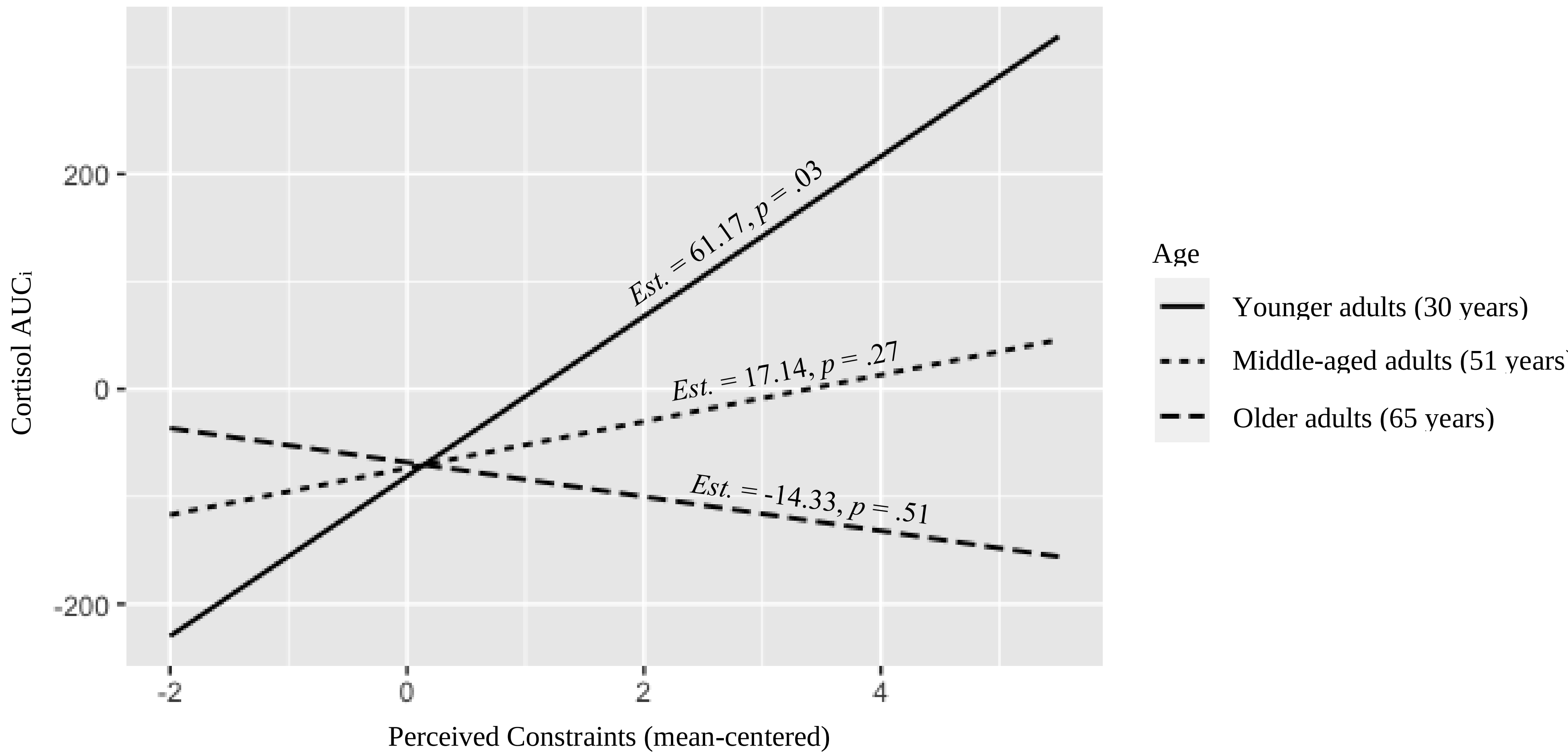
Age moderates the association between personal mastery and cortisol AUCi



Note. There was a significant Age x Personal Mastery interaction in predicting changes in cortisol levels (AUCi) from baseline to 30-minutes post-stressor. Simple slope analyses revealed that younger adults showed a significant association between higher mastery and greater increase in cortisol; a region of significance test indicated that the association was not significant for participants older than 38 years of age.

Figure 3

Age moderates the association between perceived constraints and cortisol AUC$_i$



Note. There was a significant Age x Perceived Constraints interaction in predicting changes in cortisol levels (AUCi) from baseline to 30-minutes post-stressor. Simple slope analyses revealed that younger adults showed a significant association between higher constraints and greater increases in cortisol; a region of significance test indicated that the association was not significant for participants older than 42 years of age.