PERCEIVED CONTROL AND REACTIVITY TO ACUTE STRESSORS: VARIATIONS BY AGE, RACE, AND FACETS OF CONTROL

by

Jin-Hui Wen

B.A., Chapman University, 2015

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

in

THE FACULTY OF GRADUATE AND POSTDOCTORAL STUDIES

(Psychology)

THE UNIVERSITY OF BRITISH COLUMBIA

(Vancouver)

August 2020

The following individuals certify that they have read, and recommend to the Faculty of Graduate and Postdoctoral Studies for acceptance, the thesis entitled:

Perceived control and reactivity to acute stressors: Variations by age, race, and facets of control

submitted by Jin-Hui Wen in partial fulfillment of the requirements for

the degree of Master of Arts

in Psychology

Examining Committee:

Nancy L. Sin
Supervisor

Anita DeLongis
Supervisory Committee Member

Christiane Hoppmann
Supervisory Committee Member

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 global perceived control, as well as its facets of personal mastery and perceived constraints, predict psychological and physiological stress reactivity. Thus, the goal of the present study was to evaluate the associations of perceived control and its facets with changes in subjective stress and cortisol in response to acute laboratory stressors. In addition, we considered the moderating roles of age and race. In a sample of 735 U.S. adults ages 25–75 (71% White, 18% Black, 11% Other/Unknown Races), participants completed a measure of perceived control at baseline and subsequently underwent two lab-based acute stress tasks. Subjective stress and salivary cortisol were collected pre- and post-stressors. Perceived control was related to smaller increases in subjective stress, but did not directly predict cortisol responses. Age and race interacted to moderate the associations between facets of perceived control and stress reactivity. Specifically, greater personal mastery predicted lower subjective stress responses in White older adults, and higher perceived constraints predicted greater cortisol reactivity among White younger adults, whereas no association was found among racial minorities. These findings suggest that, among Whites, older adults garner the stress-protective benefits of mastery and are buffered against the link between constraints and cortisol stress reactivity. Future research on the role of perceived control in stress and health should distinguish between facets of control as well as consider the importance of age and racial differences.

Lay Summary

People who believe they have more control over life circumstances tend to have better mental and physical health. Stress responses are one potential pathway linking control beliefs with health. The purpose of this study was to examine the influences of age and race on the relationships between perceived control and its subcomponents (personal mastery and perceived constraints) with subjective stress ratings and cortisol responses to laboratory stress tasks. Findings indicated that greater mastery predicted lower subjective stress responses in White older adults, and higher constraints predicted greater cortisol reactivity among White younger adults. No associations were observed between perceived control and stress reactivity among racial minorities. Thus, among White adults only, older adults garner the stress-protective benefits of mastery and are buffered against the link between perceived constraints and cortisol stress reactivity. Findings suggest that perceived control may not be a psychosocial resource for minorities as it is for Whites.

Preface

I am the primary author of the work presented in this thesis. I identified the research question and created plans for data analysis. This study used publicly-available data from the Midlife in the United States Refresher Study (http://midus.wisc.edu/). I was responsible for study conception, data analysis, data interpretation, and manuscript writing. Dr. Nancy L. Sin acted as supervisory author by providing guidance and feedback on concept formation, data analysis and interpretation, and manuscript revisions. The study procedures were approved by The University of British Columbia's Behavioural Research Ethics Board (certification #H19-01215, "MIDUS-R: Perceived Control and Stress Reactivity").

Earlier versions of this research were presented at the 2019 Meeting of the American Psychosomatic Society and the 2019 Meeting of the Gerontological Society of America. The conference abstracts were published in *Psychosomatic Medicine* and *Innovation in Aging,* respectively:

Wen, J. H., & Sin, N. L. (2019, May). Self-control as a predictor of physiological reactivity to acute stressors. *Psychosomatic Medicine*, 81(4), A9-A9.

Wen, J. H., & Sin, N. L. (2019, Nov). Perceived control and cortisol stress reactivity: Variations by age, race, and facets of control. *Innovation in Aging*, 3(Suppl 1), S854.

Table of Contents

List of Tables

List of Figures

Acknowledgements

Firstly, I would like to thank my advisor, Dr. Nancy L. Sin, for continually supporting, encouraging, and challenging me as a researcher throughout my Master's degree. Her mentorship and guidance have been invaluable to my thesis research, and, more broadly, my professional development.

I would also like to give special thanks and acknowledgements to my supervisory committee members. Thank you to Dr. Anita Delongis and Dr. Christiane Hoppmann for their insightful feedback on my thesis project, and generally on helping me navigate the health psychology program and broadening my research perspective.

Thank you to all my colleagues and research assistants at the UPLIFT Health Lab for their encouragement and support on my project. In particular, thank you to our previous lab manager, Kevin Chi, for his feedback on the initial drafts of my thesis.

Additionally, I am grateful for the funding generously provided by the UBC Faculty of Arts, UBC Department of Psychology, and the Social Sciences and Humanities Research Council of Canada, which helped support me during the course of my Master's program.

Finally, I would like to thank my mom and dad, as well as my friends, who have supported me in my pursuit of a graduate degree. Notably, I'd like to thank Dr. Britt-Marie Ljung for helping me develop the skills needed to pursue graduate studies and opening opportunities that has led me to succeed in academia.

Introduction

A large body of evidence has demonstrated that maintaining a sense of control across adulthood is associated with better aging-related health and well-being outcomes (Lachman, Neupert, & Agrigoroaei, 2011), including greater life satisfaction (Prenda & Lachman, 2001), better functional health (Infurna & Mayer, 2015) and lower 20-year mortality risk (Hülür et al., 2017). Perceived control—defined as the perception of one's ability to exert influence over life circumstances—has been conceptualized to influence aging-related outcomes and performance (e.g., health, well-being, cognition) in a multidirectional manner through mechanisms that include affect, motivation, health behaviors, and physiology (Lachman, 2006; Lachman, Neupert, & Agrigoroaei, 2011). Aging-related outcomes and performance, in turn, are postulated to subsequently influence control beliefs. Moreover, this reciprocal process occurs within the context of background factors such as age and race.

Perceived Control and Stress Reactivity

Stress reactivity has been proposed as a potential pathway by which control beliefs may influence aging-related outcomes (Lachman, 2006; Robinson & Lachman, 2017). Experimental and daily diary studies have provided support for greater perceived control as a protective factor against physiological and affective stress responses (Agrigoroaei et al., 2013; Bollini, Walker, Hamann, & Kestler, 2004; Diehl & Hay, 2010; Neupert, Almeida, & Charles, 2007). Compared to those with less perceived control, 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), are less emotionally reactive to daily stressors (Neupert et al., 2007), as well as are less psychologically and physiologically reactive to acute lab-based stressors (Bollini et al., 2004; Sanz & Villamarín, 2001).

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, Mogle, Piazza, Karlamangla, & Almeida, 2020; Kumari, Shipley, Stafford, & Kivimaki, 2011). Controllability is an important dimension of stress that may activate or diminish HPA axis activity (for reviews, see Dickerson & Kemeny, 2004 and Miller, Chen, & Zhou, 2007). Laboratory studies show that motivated performance stress tasks (i.e., active performance tasks that demand immediate overt or cognitive responses from participants, such as mental arithmetic or 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).

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. To our knowledge, only several studies (Agrigoroaei et al., 2013; Bollini et al., 2004) have examined individual differences in 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.

Further examination of the facets of perceived control and conceptually-relevant contextual moderators (e.g., 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, Campbell, Farran, Kaufman, & Davis, 1995; 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. The current study seeks to bridge this gap in the literature by evaluating the associations between facets of perceived control with subjective and physiological stress responses, as well as consider the combined influences 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, recent evidence suggests that facets of perceived control may have different implications on mental and physical health, as well as stress reactivity (Elliot, Mooney, Infurna, & Chapman, 2017; Elliot, Mooney, Infurna, & Chapman, 2018; Elliot, Turiano, Infurna, Lachman, & Chapman, 2018; Infurna & Mayer, 2015).

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 may 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

Two competing perspectives have emerged regarding the role of age on control beliefs. One perspective is that perceived control may be more protective for health and well-being in late adulthood when people facing 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, Gerstorf, & Zarit, 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 lifelong mechanisms such as health behaviors (Infurna, Ram, Gerstorf, 2013; Infurna & Mayer, 2015). Longitudinal research has shown that greater control beliefs in adolescents were associated with lower psychological stress, reduced risk of obesity, and better self-rated health 20 years later (Gale, Batty, & Deary, 2008; Moffitt et al., 2011).

Following from the latter perspective, perceived control may be more robustly associated with stress reactivity in younger adults than in older adults. 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 consistently 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 both facets of perceived control and to cortisol stress reactivity.

Racial Differences in Perceived Control

In addition to age, race is an important sociodemographic factor that can influence levels of perceived control. Racial minorities in the United States—including Blacks/African Americans, Hispanic/non-White Latino Americans, and Asian Americans—report lower control beliefs compared to White Americans (Kang, Chang, Chen, & Greenberger, 2013; Mirowsky Ross, van Willigen, 1996; Sastry & Ross, 1998; Shaw & Krause, 2001). Importantly, there are also likely to be meaningful differences between racial groups in how perceived control is conceptualized. Whereas greater perceived control is a health-protective factor among Whites, racial minorities tend to show less benefit from high levels of perceived control. Lower perceived control likely captures the greater constraints and uncontrollability in the lives of racial minorities and may reflect a healthy sensitivity to their environments (Assari, 2017; Bruce & Thornton, 2004; Sastry & Ross, 1998). In particular, racial minorities—compared to Whites—show 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).

Racial minorities may also differ from Whites in their psychological and physiological stress responses. For example, one study found that Black participants reported higher psychological distress than White participants during a laboratory speech task (Lepore et al., 2006), although research is currently limited regarding racial differences in subjective stress reactivity in laboratory settings. In addition, Blacks have flatter diurnal cortisol patterns (Karlamangla, Friedman, Seeman, Stawski, & Almeida, 2013) and show greater age-related decreases in heart rate variability responses to acute stressors (Fuller-Rowell et al., 2013), compared to Whites. Given the racial differences in perceived control and in stress responses, race may moderate the associations of perceived control and its facets with subjective and cortisol stress responses, although this has not been examined in past research. Furthermore, race and age may interact to predict stress responses, as older adults tend to show more pronounced increases in cortisol in response to standardized acute stressors compared to younger adults (Gotthardt et al., 1995; Kudielka, Buske-Kirschbaum, Hellhammer, & Kirschbaum, 2004; Seeman & Robbins, 1994).

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 Refresher Study, which enabled us to evaluate age and race as hypothesized moderating factors. The first aim of the study was to examine whether individual differences in trait-like mastery versus 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, 2011) and previous evidence from daily diary studies (Diehl & Hay, 2010; Neupert et al., 2007), we predicted that the association between perceived control and stress reactivity would be stronger for younger adults than for older adults. Drawing on past evidence demonstrating racial differences in perceived control and in stress reactivity, our third aim was to test our hypothesis that perceived control and its facets would be more predictive of subjective stress and cortisol stress reactivity for Whites than for Blacks and other racial minorities. Finally, 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. Specifically, mastery and constraints were expected to be associated with subjective and cortisol stress reactivity, respectively, in younger White participants, with relatively weaker associations among older White participants and the weakest or no associations for racial minorities of any age.

Method

Participants and Design

The Midlife in the United States Refresher (MIDUS-R) Study (N = 3,577) is a national longitudinal study designed to examine the roles of psychosocial factors in aging and health (Radler, 2014). 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. To examine race interactions, participants were categorized into one of three groups: White (71%), Black (18%), and Other/Unknown Races (11%). The Other/Unknown Races group (n = 83) was comprised of participants who identified as Native American (n = 19), Asian (n = 11), Native Hawaiian/Pacific Islander (n = 2), as well as participants that who indicated "Other" regarding their racial identity (n = 51). 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 = 89), did not complete the perceived control measure (n = 1), or missing survey response about race (n = 6). Our final analytic sample consisted of 735 participants who completed the perceived control questionnaire in MIDUS-R and who subsequently completed the acute stress tasks in the Biomarker Project with no missing data. Compared to the 128 participants that were excluded from analyses, the analytic sample of 735 participants did not differ in age (t = 1.20, p = .23), perceived control (t = -0.31, p =.76), education attainment (t = -0.58, p = .56), number of chronic conditions (t = 1.37, p = .17), nor body mass index (t = .31, p = .75).

The laboratory-based acute stress protocol began at approximately 9:00am during a clinic visit. The protocol consisted of an 11-min baseline resting period and two computerized cognitive stress tasks (mental arithmetic and Stroop color-word interference task; 6 min each), with 6-min recovery periods following each stressor. 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. Subjective stress ratings were assessed at six time points: (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 (Love, Seeman, Weinstein, & Ryff, 2010).

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 items were reverse-coded such that higher values reflected greater mastery. Ratings were averaged across the items within each subscale to obtain mastery and constraints scores, and averaged across all 12 items for the overall perceived control score.

Subjective Stress Rating

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 the stress ratings assessed after each stress task.

Salivary Cortisol

Concentrations of free cortisol were determined from saliva samples using radioimmunoassays (MP Biomedicals, Solon, OH). Salivary cortisol values (nmol/L) were approximately normally distributed; thus, analyses were performed using raw non-transformed values. To examine stress reactivity, we focused specifically on salivary cortisol assessments collected from baseline, immediately post-stressors, and 30-min post-stressors. Based on previous research indicating that cortisol levels may be elevated for 21-40 minutes following acute stressor exposure (Dickerson & Kemeny, 2004), we considered participants' peak cortisol to be their highest cortisol level collected either immediately post-stressors or 30-min post-stressors.

Data Analysis

Separate multiple regression analyses were performed to evaluate perceived control and its facets (personal mastery and perceived constraints) as predictors of change in subjective stress ratings and salivary cortisol levels from baseline to post-stressor exposure. Change scores for subjective stress were created by subtracting the baseline stress rating from the average post-stressor rating. Change scores for cortisol were computed by subtracting the cortisol level at baseline from the peak post-stressor cortisol level. Higher values in the change scores indicated greater increases in subjective stress or in cortisol levels in response to the acute stress tasks. 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, Black, or Other/Unknown Races). As a sensitivity analysis, the change score outcomes were replaced with post-stressor subjective stress ratings and peak cortisol values, while controlling for baseline stress ratings and cortisol values, respectively.

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 (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 or past use of any cortisol-altering medications (e.g., oral corticosteroids, respiratory medications, hormone therapy, oral contraceptives) with the exception of topical applications of corticosteroids. All continuous predictors and covariates were centered at their respective means. Bootstrap resampling (5000 repetitions) was used to calculate bias-corrected confidence intervals.

Results

Descriptives and Correlations

Descriptive statistics by race are shown in Table 1. The final sample was composed of 735 adults (51% female) with an average age of 50.84 years (*SD* = 13.41). Eighty-four percent of the sample completed at least 1-year of college or more (54% attained a 4-year degree or higher). Participants reported an average of four chronic conditions and symptoms, and 75% of the sample reported having ever taken some form of cortisol-altering medication (including 44% who have taken prednisone). On a 1–7 scale, the mean perceived control score was 5.54 (*SD* = 0.99); average scores on personal mastery and perceived constraints were 5.71 (*SD* = 1.03) and 2.56 (*SD* = 1.17), respectively. Control scores did not significantly differ between age or racial groups (all *p*-values > .05). On a 1-9 scale, average subjective stress ratings were 1.74 (*SD* = 1.22) at baseline and 4.07 (*SD* = 1.79) at post-stressor. Whites were observed to have significantly greater subjective stress reactivity compared to Other/Unknown Races (p = .004) but not compared to Blacks (p = .25). Similarly, Blacks had marginally higher subjective stress reactivity than Other/Unknown Races (p = .09). Peak cortisol values for 60% of participants (n = 440) were found immediately following the stress tasks, whereas the remaining participants (n = 295) exhibited their highest cortisol levels at 30-min post-stressors. The mean salivary cortisol level at baseline was 15.38 nmol/L (*SD* = 6.84) and increased to 16.64 nmol/L (*SD* = 7.42) at the peak level. Notably, 323 participants (44%) showed a decrease in cortisol (mean decrease among these participants = -3.40 nmol/L, *SD* = 3.44) in response to the acute stressors. Of the participants that showed an increase in cortisol (n = 412), the average cortisol increase was 4.92 nmol/L (*SD* = 5.27). Black participants showed smaller (i.e., less-increased) cortisol stress responses compared to Whites and Other/Unknown Races, whereas White and Other/Unknown Races participants did not differ in their mean cortisol reactivity.

Bivariate correlations among all study variables are provided in Table 2. Age was inversely correlated with perceived constraints (r = -0.09, *95% CI* = [-0.16, -0.03], p < .01), but was not correlated with the full scale (r = 0.05, *95% CI* = [-0.01, 0.12], p = .12) nor personal mastery (r = -0.05, *95% CI* = [-0.11, 0.02], p =.16). Age was not significantly correlated with baseline subjective stress, post-stressor subjective stress, or subjective stress reactivity (*p's* > .05). Age was positively correlated with both baseline cortisol (r = 0.08, *95% CI* = [0.004, 0.15], p = .04) and peak cortisol (r = 0.09, *95% CI* = [0.02, 0.16], p = .01), but not cortisol reactivity.

Multiple Regression Analyses for Perceived Control and Acute Stress Reactivity

Subjective Stress Reactivity

Table 3 shows results from three separate regression models for perceived control, personal mastery, and perceived constraints as predictors of subjective stress reactivity. Individuals with higher scores on the full perceived control scale showed smaller subjective stress responses to the acute stressors. Participants with higher scores on the perceived constraints subscale showed larger increases in subjective stress, whereas there was no main effect for personal mastery. Compared to Whites, participants of Other/Unknown Races exhibited smaller increases in subjective stress from baseline to post-stressor. As shown in Figure 1, there was a significant 2-way interaction between Perceived Constraints X Black, such that constraints were related to subjective stress reactivity among Whites only (*Est.* = 0.21, *SE* = 0.06, p = .001), whereas no significant association was observed among Blacks (*Est.* = -0.06, *SE* = 0.1, p = .52) or Other/Unknown Races (*Est.* = 0.17, *SE* = 0.13, p = .21). No other 2-way interactions were found between race or age and perceived control measures.

There were no significant 3-way interactions for Perceived Control or Perceived Constraints x Age x Race. However, there was a marginally significant interaction for Personal Mastery x Age x White Race (p = .07). Simple slope analyses (Figure 2) revealed that among White participants, older adults with higher personal mastery showed smaller changes from the baseline stress rating to the post-stressor stress ratings (simple slope for older adults at 65 years old: *Est.* = -0.18, *SE* = 0.09, p = .06); no significant slopes were observed in younger (i.e., 30 years old) and middle-aged (mean age of 51) White participants, or among Blacks and Other/Unknown Races of any age group. Region of significance tests indicated that among White adults, personal mastery was not associated with changes in subjective stress for participants younger than 53 years old.

As a sensitivity analyses, we evaluated the post-stressor subjective stress score as the outcome (rather than the change score), while controlling for baseline subjective stress. Using this approach, the 3-way Personal Mastery X Race X Age interaction was no longer marginally significant. All of the other main effects and 2-way interaction for Perceived Constraints x Black remained significant.

Cortisol Stress Reactivity

Results from the multiple regression models for cortisol reactivity to acute stressors are shown in Table 4. There were no main effects of perceived control or its facets with cortisol stress reactivity (i.e., changes in salivary cortisol from baseline to the peak post-stressors level). Age and race separately did not moderate the associations of perceived control or its facets with cortisol stress reactivity.

There was a significant 3-way Perceived Constraints x Age x White Race interaction (unstandardized B = -0.04; *95% CI* = [-0.08, -0.003]; $p = .04$). Bootstrapped confidence intervals were similar to those found in the primary analysis (*95% CI* = [-0.09, -0.004]). Simple slope analyses were conducted separately by racial group, comparing the slopes of younger (30 years), middle-aged (mean age of 51), and older adults (65 years). As shown in Figure 3, among White participants, younger adults with higher perceived constraints exhibited significant increases in cortisol (simple slope for younger adults: *Est.* = 1.23, *SE* = 0.48, $p = .01$), whereas perceived constraints were not associated with cortisol reactivity for middle-aged adults (simple slope: *Est.* = 0.40, *SE* = 0.25, $p = .11$) or older adults (simple slope for older adults: *Est.* = -0.19, *SE* = 0.37, $p = .61$). The region of significance analysis indicated that perceived constraints were not associated with cortisol stress reactivity for participants older than 49 years of age. No significant associations between perceived constraints and cortisol reactivity were observed at any of the age slopes in the Black or Other/Unknown Races groups.

The 3-way Perceived Constraints x Age x Race interaction remained statistically significant (b = -0.05, *95% CI* = [-0.08, -0.01], $p < 0.01$) in our sensitivity analysis that used post-stressor cortisol levels rather than change scores as the outcome. Simple slope analyses revealed the same pattern of results.

Discussion

The current study investigated the associations of perceived control and its facets (i.e., personal mastery, perceived constraints) with subjective and cortisol stress reactivity to acute standardized stressors in a national U.S. sample of adults. In addition, we examined age, race, and their intersection as potential moderators of the links between perceived control and stress reactivity. Regarding subjective stress responses, we found that higher personal mastery was marginally associated with lower subjective stress reactivity in older White adults, but not in younger White adults or in participants who were Black or Other/Unknown Races. Additionally, higher perceived constraints were significantly related to greater subjective stress reactivity among Whites, but not Blacks or Other/Unknown Races. Regarding cortisol stress responses, higher perceived constraints predicted greater cortisol reactivity among younger White adults, whereas no significant association was observed among older White adults or Black and Other/Unknown Race participants of any age. Overall, these finding demonstrate that facets of perceived control interact with age and race to determine stress reactivity.

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. Our hypothesis was partially supported, such that mastery marginally predicted smaller increases in subjective stress ratings (among older White adults only). Contrary to our expectations, however, constraints showed stronger associations with subjective stress than did mastery: higher constraints predicted greater increases in subjective stress in White participants but not related to subjective stress responses in Black or Other/Unknown Races participants. Because constraints capture personal or environmental limitations and elements of uncontrollability, it may be more relevant for stress responses in-the-moment than mastery. Yet, given past research linking mastery to better outcomes among people who have experienced more trauma (Elliot, Turiano, et al., 2018), it is possible that mastery may be consequential for major stressors or long-term coping strategies. Future research is warranted to examine the differential contributions of facets of control for other forms of stress and other aspects of stress responses.

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. In line with our hypothesis as well as past research linking perceived control to stress reactivity in younger adults (Diehl & Hay, 2010; Neupert et al., 2007), we found that higher perceived constraints predicted greater cortisol reactivity for adults younger than 49 years old, although this effect was only evident among Whites. However, contrary to our expectations, higher mastery was marginally associated with lower subjective stress reactivity among older but not younger White adults. Taken together, our findings indicate that control beliefs have different implications for stress processes as people age, such that older adults show more benefit from mastery and are buffered against the link between constraints and cortisol reactivity.

We were unable to pinpoint the reasons why older adults appeared to derive more benefit from control beliefs. It is possible that older adults with higher mastery may have more favorable stress appraisals or more confidence in their ability to perform the tasks, compared to those with lower mastery or to younger adults. For example, the Strength and Vulnerability Integration Model posits that older adults are more effective than younger adults at employing emotion regulation strategies (e.g., attentional disengagement, reappraisal) and thus show less-pronounced increases in negative affect and physiological arousal in response to emotion-eliciting situations (Charles, 2010). In addition, the acute stressors were computerized cognitive tasks, which may have posed more threat for older adults with lower mastery. Indeed, older adults, compared to younger adults, have been found to make stronger attributions to internal uncontrollable factors (e.g., ability, genetics) that influence their performance on cognitive memory tasks (Blatt-Eisengart & Lachman, 2004). A next step for future research on this topic would be to examine whether the age-related benefits of mastery would replicate (as this was only a marginally significant effect) and whether the finding would extend to social stressors.

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 Whites—compared to Blacks and people of Other/Unknown Races—would show a stronger association between perceived control and stress reactivity. We did not find support for this hypothesis when examining the overall perceived control scale. However, there was a significant 2-way interaction of Perceived Constraints X Black for subjective stress responses, indicating that Blacks significantly differed from Whites in their association between constraints and subjective stress reactivity. As mentioned previously, significant 3-way interactions for Race x Age x Facets of Control were observed, such that personal mastery was related to lower subjective stress reactivity among White older adults only, and perceived constraints was related to greater cortisol stress reactivity among White younger adults only.

On average, there was no increase in cortisol levels as well as lower variability in cortisol stress reactivity for Black participants compared to White participants, which may have contributed to difficulties in detecting a link between perceived control and cortisol responses among Blacks. The lack of cortisol stress reactivity in Blacks is indicative of wear-and-tear or dysregulated HPA axis functioning, which has also been found in other studies of cortisol in Black Americans (McEwen & Seeman, 1999; Seeman, Merkin, Karlamangla, Koretz, & Seeman, 2014). Because our results are in line with past research showing weaker relationships of perceived control with health and well-being outcomes in racial minorities compared to Whites (Assari, 2017), it is likely that the null effects for Blacks and racial minorities in our study are attributable to substantive rather than statistical (e.g., lower variability in cortisol) reasons. Thus, our findings extend the previous evidence by showing that perceived control is protective for stress processes for Whites but not for racial minorities.

The findings of the current study also highlight the need for further research to identify psychological resources for racial minorities. Considering that most research on psychological resources have been conducted in largely White samples, it may be incorrect to assume that the protective benefits of perceived control (or other psychological resources) will extend to racial minorities. Social environmental factors, such as low socioeconomic status, may limit the ability for racial minorities to garner and maintain psychological resources (e.g., dispositional optimism; Boehm, Chen, Williams, Ryff, & Kubzansky, 2015; Matthews & Gallo, 2011). Thus, future research should strive to use more diverse samples when investigating the benefits of potential psychological resources on health and well-being.

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). Furthermore, laboratory-based stress tasks differ from stressful situations in real life, and physiological responses to experimental stress tasks have been shown to be weakly correlated to physiological stress reactivity in daily life (Kamarck, Schwartz, Janicki, Shiffman, & Raynor, 2003). It is unknown whether the findings of this study would extend to more potent experimental stressors (e.g., social-evaluative stress tasks) or to stress processes outside of the laboratory.

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. Moreover, the MIDUS Refresher sample had a small and racially heterogeneous subset of non-Black racial minorities, making it is difficult to draw conclusions about the Other/Unknown Races group. 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 Whites (Sastry & Ross, 1998), future work should examine these differences in larger subsamples of 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 subjective and cortisol stress reactivity only among White adults but not among Blacks and other racial minorities. Specifically, higher constraints predicted greater subjective stress reactivity in Whites (regardless of age) and greater cortisol reactivity in White younger and midlife adults. In addition, a marginally-significant association was found between mastery and lower subjective stress reactivity among White older adults. Thus, among White participants only, older age was a protective factor for both subjective and cortisol responses to stressors. Considering the prevalent socially- and institutionally-imposed restrictions in the lives of Blacks and other racial minorities, perceived control likely captures different aspects of life circumstances for racial minorities than for Whites (Assari, 2017). Perceived control may not be a psychological resource for racial minorities to the same extent as for White adults. Our findings support the value of distinguishing between mastery and constraints, as well as considering their intersections with age and race, to understand the role of perceived control in stress processes.

Table 1

Descriptives and Group Differences in Key Variables by Race

Variable	Overall Sample (N=735)	White (n=522)	Black (n=130)	Other/Unknown Races (n=83)	Chi-Square/ One-Way ANOVA
Sex					
Females (%)	373 (50.7%)	238 (45.6%)	87 (66.9%)	48 (57.8%)	**$X_2(2) = 22.09$ $p < .001$**
Age					
Mean (SD) years	50.035 (13.296)	51.621 (13.261)	46.385 (11.717)	45.783 (13.916)	**$F(2, 732) = 13.29$ $p < .001$**
Education					
Some College (vs. Less)	616 (83.8%)	459 (87.9%)	89 (68.5%)	68 (81.9%)	**$X_2(2) = 36.65$ $p < .001$**
Body mass index					
Mean (SD)	30.280 (7.578)	29.668 (7.063)	33.243 (8.467)	29.487 (8.209)	**$F(2, 732) = 12.48$ $p < .001$**
Total # of Chronic Symptoms					
Mean (SD)	4.063 (3.144)	4.094 (2.975)	3.985 (3.389)	3.988 (3.756)	$F(2, 732) = 0.09$ $p = .92$
Corticosteroid Use					
Yes (vs. No)	550 (74.8%)	395 (75.7%)	101 (77.7%)	54 (65.1%)	**$X_2(2) = 6.33$ $p = .04$**
Perceived Control (Full Scale)					
Mean (SD)	5.536 (0.992)	5.546 (0.969)	5.564 (1.034)	5.428 (1.066)	$F(2, 732) = 0.57$ $p = .55$
Personal Mastery (Subscale)					
Mean (SD)	5.708 (1.030)	5.692 (1.011)	5.829 (1.065)	5.620 (1.088)	$F(2, 732) = 1.27$ $p = .28$

Table 1 (cont.)

Descriptives and Group Differences in Key Variables by Race

Variable	Overall Sample (N=735)	White (n=522)	Black (n=130)	Other/Unknown Races (n=83)	Chi-Square/ One-Way ANOVA
Perceived Constraints (Subscale)					
Mean (SD)	2.563 (1.169)	2.527 (1.093)	2.639 (1.342)	2.668 (1.330)	$F(2, 732) = 0.86$ $p = .42$
Baseline Stress Rating					
Mean (SD)	1.743 (1.219)	1.759 (1.187)	1.662 (1.211)	1.771 (1.426)	$F(2, 732) = 0.36$ $p = .70$
Average Post-Stressor Stress Rating					
Mean (SD)	4.067 (1.786)	4.171 (1.690)	3.931 (2.028)	3.627 (1.914)	$\boldsymbol{F(2, 732) = 3.82}$ $\boldsymbol{p = .02}$
Subjective Stress Reactivity[a]					
Mean (SD)	2.324 (1.655)	2.413 (1.582)	2.269 (1.934)	1.855 (1.571)	$\boldsymbol{F(2, 732) = 4.18}$ $\boldsymbol{p = .02}$
Baseline Cortisol (nmol/L)					
Mean (SD)	15.396 (6.837)	15.736 (6.984)	14.807 (6.635)	14.180 (6.046)	$F(2, 732) = 2.45$ $p = .09$
Peak Cortisol (nmol/L)[b]					
Mean (SD)	16.658 (7.426)	17.305 (7.795)	14.667 (5.654)	15.705 (6.884)	$\boldsymbol{F(2, 732) = 7.46}$ $\boldsymbol{p < .001}$
Cortisol Reactivity[c]					
Mean (SD)	1.261 (6.150)	1.568 (6.441)	-0.140 (4.465)	1.525 (6.314)	$\boldsymbol{F(2, 732) = 4.14}$ $\boldsymbol{p = .02}$

Table 1 (cont.)
Descriptives and Group Differences in Key Variables by Race

Note. **Bolded values** represent significant findings. Body mass index was calculated using height and weight (kg/m^2). Perceived Control (Full Scale) was a composite of the Personal Mastery subscale (items reverse-coded) and Perceived Constraints subscale. Personal Mastery and Perceived Constraints were rated on a scale of 1–7. Items were coded so that higher scores reflect higher standing in each dimension. Subjective Stress was rated on a scale of 1–9 (1 = *not stressed at all*, 9 = *extremely stressed*).
[a]Subjective Stress Reactivity was calculated by subtracting the baseline stress score from the post-stressor stress score.
[b]Peak Cortisol represents the highest cortisol value collected either immediately after the stressor or 30-minutes post-stressor.
[c]Cortisol Reactivity was calculated by subtracting the baseline cortisol value from the peak cortisol value.

Table 2

Correlations among study variables

Variable	Age	Edu	BMI	No. of Chron Cond	Med Use	Perc. Control	Mast-ery	Const	BL Cort	Peak Cort	Cort React	BL Stress	Post Stress
Age													
Education	-.06												
Body mass index	.00	-.19**											
No. of Chronic Conditions	.48**	-.03	.12**										
Corticosteroid Med Use	.03	-.01	.04	.24**									
Perceived Control (Full Scale)	.07	.18**	-.13**	-.08*	.02								
Personal Mastery (Subscale)	-.04	.04	-.06	-.10**	.02	.75**							
Perceived Constraints (Subscale)	-.11**	-.23**	.17**	.05	-.02	-.92**	-.49**						
Baseline Cortisol	.08*	-.05	.01	.05	-.04	.01	-.01	-.02					
Peak Cortisol	.08*	-.02	.02	.04	-.07*	-.02	-.01	.02	.63**				
Cortisol Reactivity	.01	.03	.01	-.00	-.04	-.04	-.00	.04	-.35**	.51**			
Baseline Stress Rating	-.03	-.03	-.04	.10**	.04	-.11**	-.10**	.09**	.03	.13**	.13**		
Post-Stressor Rating	.04	.02	-.03	.11**	.11**	-.15**	-.11**	.15**	-.01	.03	.06	.44**	
Subjective Stress Reactivity	.07	.05	-.01	.05	.10**	-.08*	-.04	.09*	-.04	-.06	-.03	-.26**	.75**

Table 2 (cont.)
Correlations among study variables

Note. Bolded values represent significant findings. Edu = education. BMI = body mass index. No. of Chron Cond = total # of chronic conditions. Med Use = cortisol-altering medication use. Perc. Control = Perceived Control (Full Scale). Mastery = Personal Mastery (Sub-Scale). Const = Perceived Constraints (Sub-Scale). BL Cort = Baseline Cortisol. Peak Cort = Peak Cortisol. Cort React = Cortisol Reactivity. BL Stress = Baseline Stress. Post Stress = Post-Stressor Stress. Cortisol Reactivity = Peak Cortisol – Baseline Cortisol. Subjective Stress Reactivity = Post-Stressor Rating – Baseline Stress.
* indicates $p < .05$. ** indicates $p < .01$.

Table 3

Regression Models for Perceived Control, Personal Mastery, Perceived Constraints, and Their Interactions with Age and Race as Predictors of Subjective Stress Reactivity

	Unstandardized B (95% CI)		
	Outcome: Change Score in Subjective Stress Ratings		
Parameter	**Perceived Control Full Scale**	**Personal Mastery Subscale**	**Perceived Constraints Subscale**
Intercept	**2.271 (1.833, 2.709)***	**2.316 (1.878, 2.754)**	**2.246 (1.807, 2.684)***
Sex (ref = Female)			
Male	**-0.370 (-0.625, -0.115)**	**-0.363 (-0.619, -0.108)**	**-0.364 (-0.619, -0.110)**
Age	0.006 (-0.005, 0.017)	0.004 (-0.007, 0.015)	0.006 (-0.005, 0.017)
Education (ref = High school diploma or less)			
Some college or more	**0.288 (-0.024, 0.599)t**	0.245 (-0.063, 0.552)	**0.309 (-0.005, 0.623)t**
Race (ref = White)			
Black	-0.111 (-0.427, 0.205)	-0.121 (-0.444, 0.202)	-0.110 (-0.424, 0.205)
Black X age	0.012 (-0.012, 0.036)	0.013 (-0.012, 0.037)	0.011 (-0.013, 0.035)
Other/Unknown Race	**-0.487 (-0.870, -0.104)***	**-0.528 (-0.912, -0.144)**	**-0.463 (-0.850, -0.077)***
Other/Unknown Race X age	0.010 (-0.016, 0.036)	0.007 (-0.019, 0.033)	0.011 (-0.016, 0.037)
No. of chronic conditions	0.0004 (-0.039, 0.040)	0.003 (-0.036, 0.042)	-0.0002 (-0.039, 0.039)
Corticosteroid medication use (1 = yes)	0.089 (-0.212, 0.390)	0.068 (-0.235, 0.371)	0.097 (-0.203, 0.397)
Body mass index	-0.001 (-0.016, 0.014)	0.001 (-0.014, 0.017)	-0.002 (-0.017, 0.013)
Perceived control	**-0.184 (-0.324, -0.043)***	---	---
Perceived control X Black	**0.267 (-0.039, 0.573)t**	---	---
Perceived control X Other/Unknown	0.127 (-0.498, 0.244)	---	---
Perceived control X age X White (ref)	-0.005 (-0.015, 0.005)	---	---

Table 3 (cont.)

Regression Models for Perceived Control, Personal Mastery, Perceived Constraints, and Their Interactions with Age and Race as Predictors of Subjective Stress Reactivity

	Unstandardized B (96% CI)		
	Outcome: Change Score in Salivary Cortisol (nmol/L)		
Parameter	**Perceived Control Full Scale**	**Personal Mastery Subscale**	**Perceived Constraints Subscale**
Perceived control X age X Black	0.010 (-0.013, 0.033)	---	---
Perceived control X age X Other/Unknown	-0.010 (-0.038, 0.017)	---	---
Personal mastery	---	-0.043 (-0.175, 0.088)	---
Personal mastery X Black	---	-0.007 (-0.293, 0.280)	---
Personal mastery X Other/Unknown	---	-0.172 (-0.532, 0.188)	---
Personal mastery X age X White (ref)	---	**-0.009 (-0.018, 0.001)ŧ**	---
Personal mastery X age X Black	---	0.008 (-0.016, 0.031)	---
Personal mastery X age X Other/Unknown	---	-0.001 (-0.029, 0.026)	---
Perceived constraints	---	---	**0.202 (0.076, 0.327)****
Perceived constraints X Black	---	---	**-0.297 (-0.545, -0.050)***
Perceived constraints X Other/Unknown	---	---	0.039 (-0.267, 0.346)
Perceived constraints X age X White (ref)	---	---	0.001 (-0.008, 0.011)
Perceived constraints X age X Black	---	---	-0.008 (-0.027 0.011)
Perceived constraints X age X Other/Unknown	---	---	0.011 (-0.012 0.034)

Note. Regression coefficients are unstandardized. Continuous predictors were mean-centered. Subjective stress reactivity was operationalized as the change score in baseline stress levels to average post-stressors levels.
ŧ$p < 0.10$, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table 4

Regression Models for Perceived Control, Personal Mastery, Perceived Constraints, and Their Interactions with Age and Race as Predictors of Salivary Cortisol Response (nmol/L)

	Unstandardized B (96% CI)		
	Outcome: Change Score in Salivary Cortisol (nmol/L)		
Parameter	**Perceived Control Full Scale**	**Personal Mastery Subscale**	**Perceived Constraints Subscale**
Intercept	0.351 (-1.417, 2.120)	0.518 (-1.246, 2.282)	0.293 (-1.478, 2.064)
Sex (ref = Female)			
Male	**1.378 (0.365, 2.392)****	**1.394 (0.377, 2.412)****	**1.368 (0.357, 2.378)****
Age	-0.013 (-0.058, 0.031)	-0.016 (-0.061, 0.028)	-0.012 (-0.057, 0.033)
Education (ref = High school diploma or less)			
Some college or more	0.355 (-0.917, 1.627)	-0.279 (-0.979, 1.538)	0.388 (-0.895, 1.670)
Race (ref = White)			
Black	**-1.364 (-2.663, -0.065)***	**-1.458 (-2.791, -0.125)***	**-1.340 (-2.630, -0.051)***
Black X age	0.024 (-0.076, 0.124)	0.027 (-0.076, 0.129)	0.025 (-0.074, 0.124)
Other/Unknown	0.194 (-1.352, 1.741)	0.308 (-1.234, 1.850)	0.192 (-1.383, 1.766)
Other/Unknown X age	0.020 (-0.085, 0.124)	0.033 (-0.072, 0.137)	0.020 (-0.087, 0.126)
No. of chronic conditions	0.001 (-0.169, 0.171)	0.015 (-1.074, 1.308)	-0.005 (-0.175, 0.164)
Corticosteroid medication use (1 = yes)	0.212 (-0.974, 1.398)	0.117 (-0.154, 0.184)	0.231 (-0.950, 1.413)
Body mass index	0.024 (-0.038, 0.085)	0.025 (-0.036, 0.087)	0.022 (-0.040, 0.084)
Perceived control	-0.333 (-0.893, 0.226)	---	---
Perceived control X Black	0.146 (-1.079, 1.371)	---	---
Perceived control X Other/Unknown	0.849 (-0.629, 2.326)	---	---
Perceived control X age X White (ref)	0.029 (-0.012, 0.071)	---	---

Table 4 (cont.)

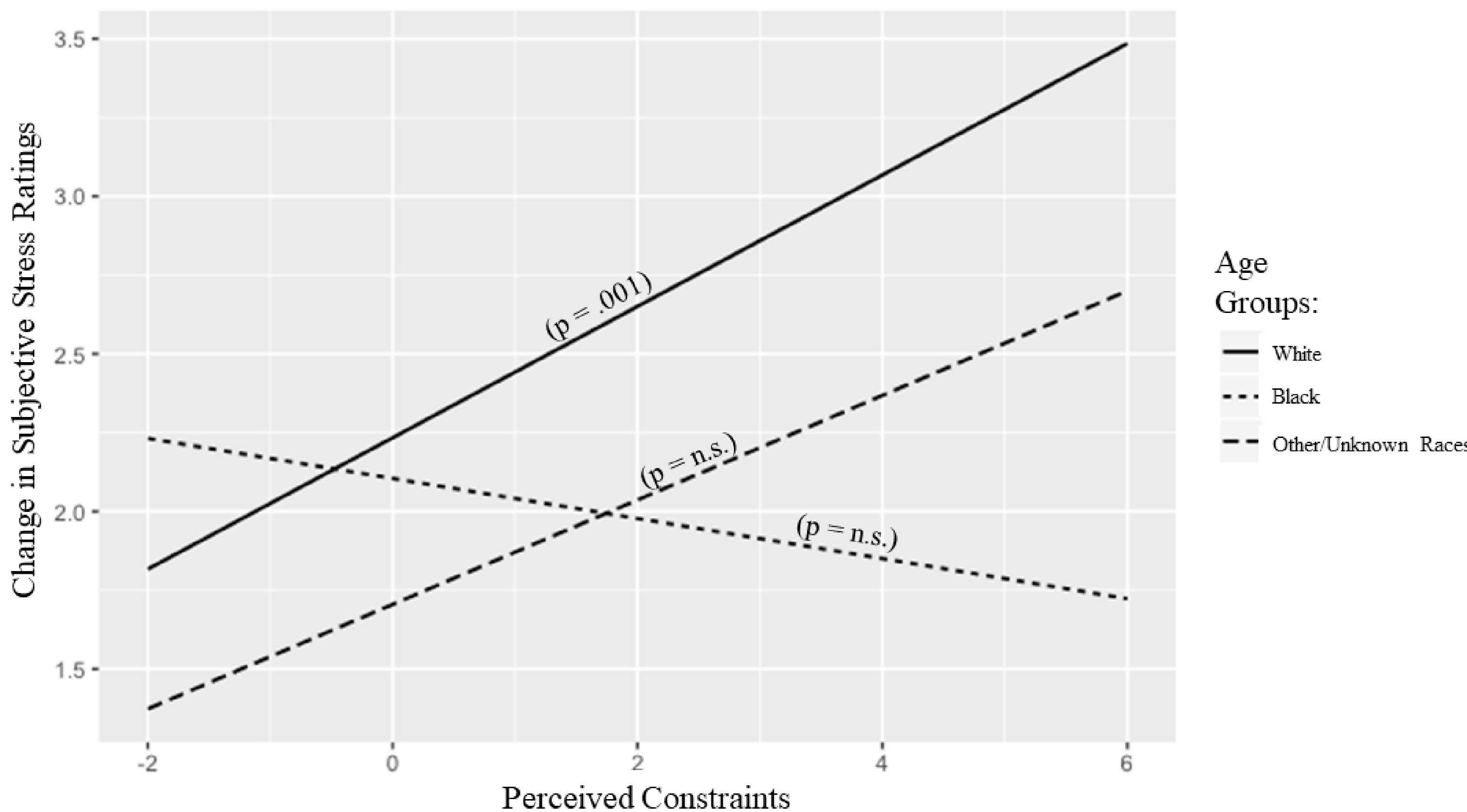
Regression Models for Perceived Control, Personal Mastery, Perceived Constraints, and Their Interactions with Age and Race as Predictors of Salivary Cortisol Response (nmol/L)

	Unstandardized B (96% CI)		
	Outcome: Change Score in Salivary Cortisol (nmol/L)		
Parameter	**Perceived Control Full Scale**	**Personal Mastery Subscale**	**Perceived Constraints Subscale**
Perceived control X age X Black	-0.028 (-0.125, 0.070)	---	---
Perceived control X age X Other/Unknown	-0.002 (-0.111, 0.108)	---	---
Personal mastery	---	0.003 (-0.524, 0.529)	---
Personal mastery X Black	---	-0.065 (-1.228, 1.097)	
Personal mastery X Other/Unknown	---	0.704 (-0.687, 2.096)	
Personal mastery X age X White (ref)	---	-0.009 (-0.047, 0.029)	---
Personal mastery X age X Black	---	-0.002 (-0.100, 0.095)	---
Personal mastery X age X Other	---	0.037 (-0.070, 0.144)	---
Perceived constraints	---	---	0.402 (-0.095, 0.900)
Perceived constraints X Black	---	---	-0.328 (-1.309, 0.653)
Perceived constraints X Other/Unknown	---	---	-0.650 (-1.891, 0.590)
Perceived constraints X age X White (ref)	---	---	**-0.039 (-0.076, -0.003)***
Perceived constraints X age X Black	---	---	0.039 (-0.041, 0.118)
Perceived constraints X age X Other/Unknown	---	---	0.022 (-0.071, 0.114)

Note. Regression coefficients are unstandardized. Continuous predictors were mean-centered. Cortisol stress reactivity was operationalized as the change score in salivary cortisol levels from pre-stressors to the peak level post-stressors.
$_{t}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Figure 1

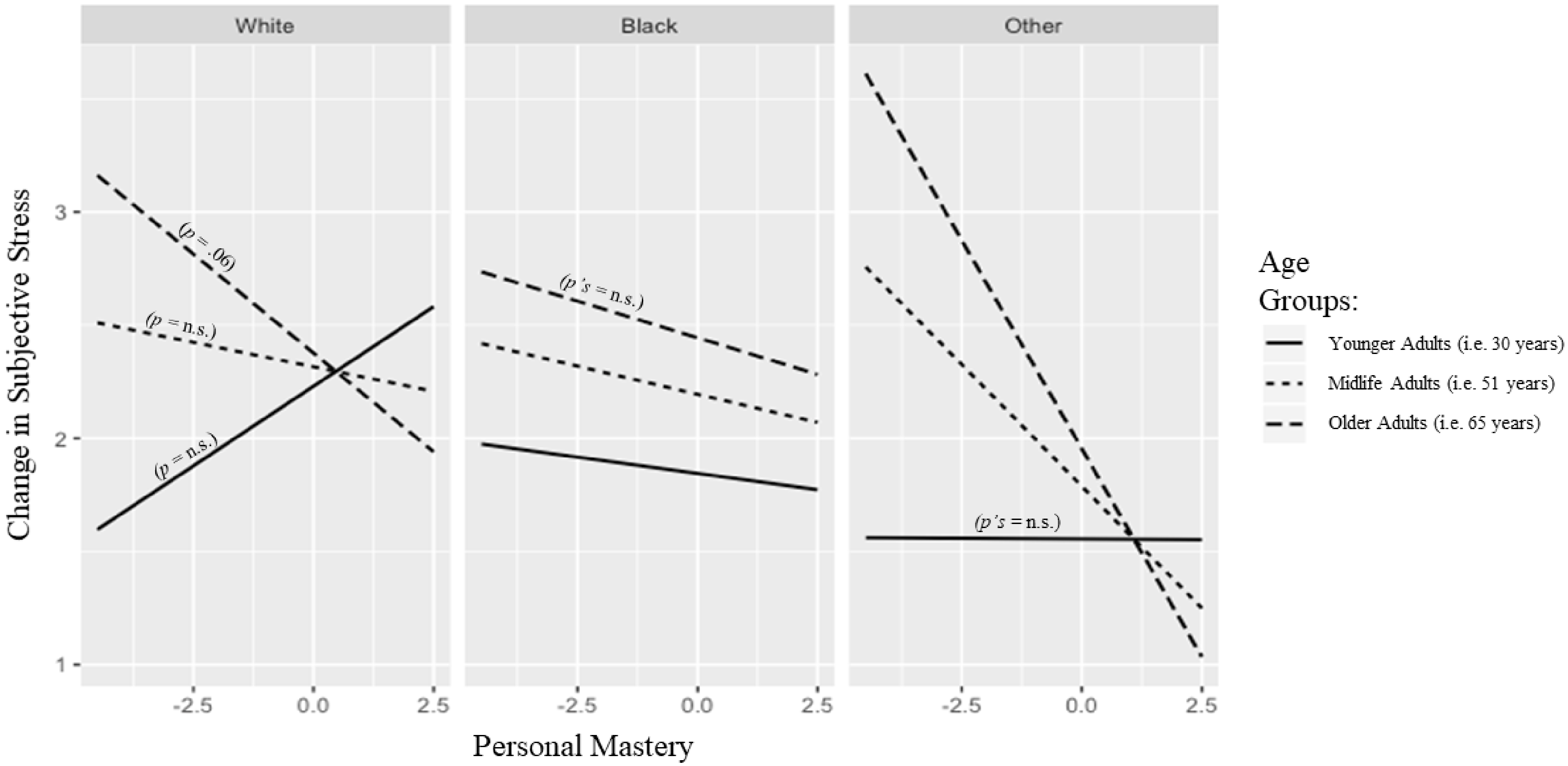
Perceived Constraints and Subjective Stress Reactivity by Race



Note: Black Race (vs. White Race) significantly moderated the association between perceived constraints and changes in subjective stress ratings from pre- to post-stressors. Simple slope analyses revealed a significant association only among White participants, whereas no association was found among Black or Other/Unknown Races participants. Perceived constraints were mean-centered in this figure.

Figure 2

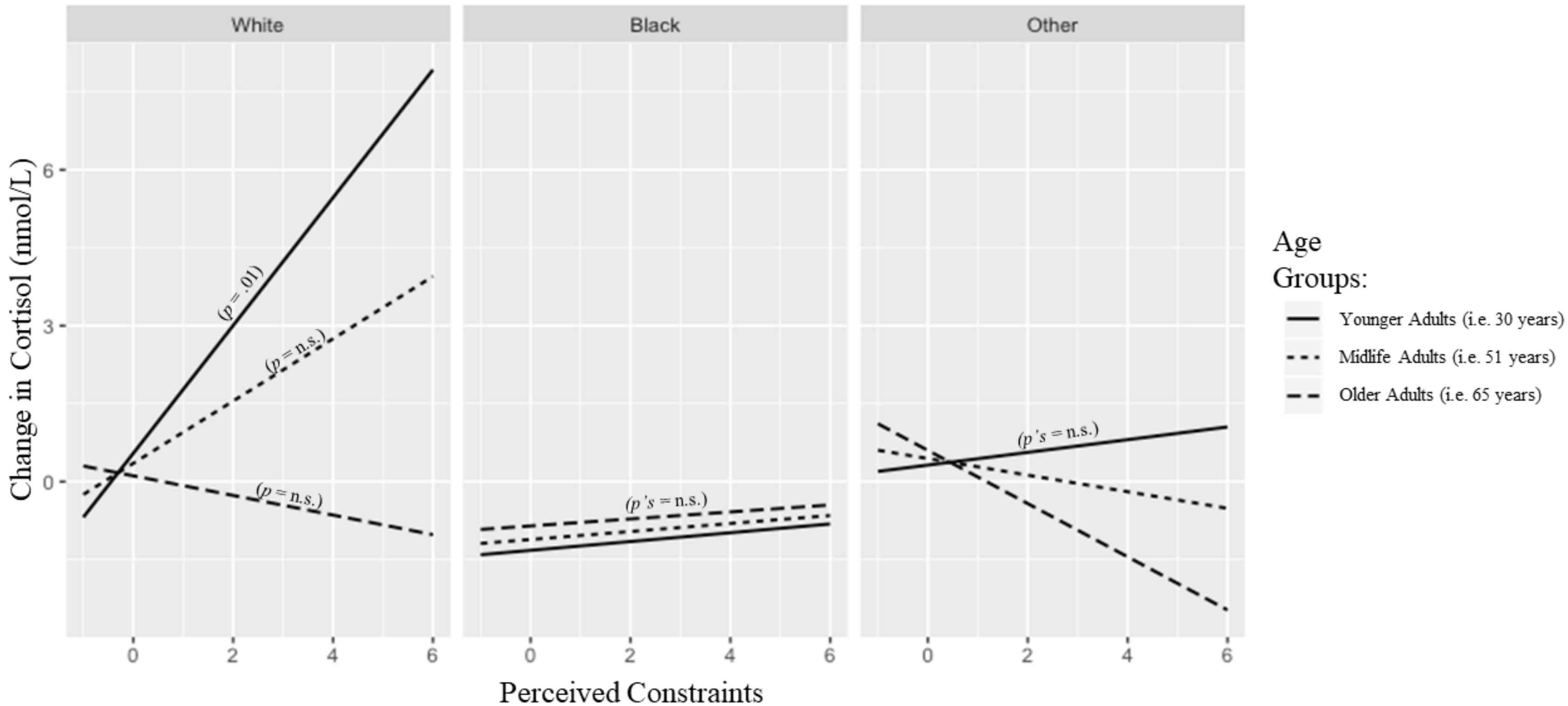
Personal Mastery and Subjective Stress Reactivity by Race and Age



Note. There was a marginally significant Age x Race interaction in the association between personal mastery and changes in subjective stress ratings from pre- to post-stressors. Simple slope analyses and a region of significance test revealed that among White participants, adults older than 53 years of age showed a marginally significant association between higher mastery and smaller increases in subjective stress. Mastery was not associated with changes in subjective stress at any age among participants that were Black or Other/Unknown Races. Personal Mastery was mean-centered in the current figure.

Figure 3

Perceived Constraints and Cortisol Stress Reactivity by Race and Age



Note. There was a significant Age x Race interaction in the association between perceived constraints and changes in cortisol levels from pre- to post-stressors. Simple slope analyses revealed that among White participants, younger adults showed a significant association between higher constraints and greater increase in cortisol levels; a region of significance test indicated that the association was no longer significant for participants older than 49 years of age. Constraints were not associated with changes in cortisol reactivity at any age among participants that were Black or Other/Unknown Races. Perceived constraints were mean-centered in the current figure.

References

Agrigoroaei, S., Polito, M., Lee, A., Kranz-Graham, E., Seeman, T., & Lachman, M. E. (2013). Cortisol response to challenge involving low controllability: The role of control beliefs and age. *Biological Psychology, 93*(1), 138–142. https://doi.org/10.1016/j.biopsycho.2013.01.003

Assari, S. (2017). Race, sense of control over life, and short-term risk of mortality among older adults in the United States. *Archives of Medical Science*, *13*(5), 1233–1240. https://doi.org/10.5114/aoms.2016.59740

Blatt-Eisengart, I., & Lachman, M. E. (2004). Attributions for memory performance in adulthood: Age differences and mediation effects. *Aging, Neuropsychology, and Cognition*, *11*(1), 68–79. https://doi.org/10.1076/anec.11.1.68.29364

Boehm, J. K., Chen, Y., Williams, D. R., Ryff, C., & Kubzansky, L. D. (2015). Unequally distributed psychological assets: Are there social disparities in optimism, life satisfaction, and positive affect? *PLoS ONE*, *10*(2), 1–16. https://doi.org/10.1371/journal.pone.0118066

Bollini, A. M., Walker, E. F., Hamann, S., & Kestler, L. (2004). The influence of perceived control and locus of control on the cortisol and subjective responses to stress. *Biological Psychology*, *67*(3), 245–260. https://doi.org/10.1016/j.biopsycho.2003.11.002

Bruce, M. A., & Thornton, M. C. (2004). It’s my world? Exploring black and white perceptions of personal control. *Sociological Quarterly, 45*(3). https://doi.org/10.1111/j.1533-8525.2004.tb02305.x

Carstensen, L. L., Isaacowitz, D. M., & Charles, S. T. (1999). Taking time seriously: A theory of socioemotional selectivity. *American Psychologist*, *54*(3), 165–181. https://doi.org/10.1037/0003-066X.54.3.165

Charles, S. T. (2010). Strength and vulnerability integration: A model of emotional well-being across adulthood. *Psychological Bulletin*, *136*(6), 1068–1091. https://doi.org/10.1037/a0021232

Charles, S. T., & Carstensen, L. L. (2010). Social and emotional aging. *Annual Review of Psychology*. https://doi.org/10.1146/annurev.psych.093008.100448

Charles, S. T., Mogle, J., Piazza, J. R., Karlamangla, A., & Almeida, D. M. (2020). Going the distance: The diurnal range of cortisol and its association with cognitive and physiological functioning. *Psychoneuroendocrinology*, *112*(April 2019), 104516. https://doi.org/10.1016/j.psyneuen.2019.104516

Dickerson, S. S., & Kemeny, M. E. (2004). Acute stressors and cortisol responses: A theoretical integration and synthesis of laboratory research. *Psychological Bulletin*, *130*(3), 355–391. https://doi.org/10.1037/0033-2909.130.3.355

Diehl, M., & Hay, E. L. (2010). Risk and resilience factors in coping with daily stress in adulthood: The role of age, self-concept incoherence, and personal control. *Developmental Psychology*, *46*(5), 1132–1146. https://doi.org/10.1037/a0019937

Dienberg Love, G., Seeman, T. E., Weinstein, M., & Ryff, C. D. (2010). Bioindicators in the MIDUS National Study: Protocol, measures, sample, and comparative context. *Journal of Aging and Health*, *22*(8), 1059–1080. https://doi.org/10.1177/0898264310374355

Elliot, A. J., Mooney, C. J., Infurna, F. J., & Chapman, B. P. (2017). Associations of lifetime trauma and chronic stress with C-reactive protein in adults ages 50 years and older: Examining the Moderating Role of Perceived Control. *Psychosomatic Medicine*, *79*(6), 622–630. https://doi.org/10.1097/PSY.0000000000000476

Elliot, A. J., Mooney, C. J., Infurna, F. J., & Chapman, B. P. (2018). Perceived control and frailty: The role of affect and perceived health. *Psychology and Aging*, *33*(3), 473–481. https://doi.org/10.1037/pag0000218

Elliot, A. J., Turiano, N. A., Infurna, F. J., Lachman, M. E., & Chapman, B. P. (2018). Lifetime trauma, perceived control, and all-cause mortality: Results from the Midlife in the United States Study. *Health Psychology*, *37*(3), 262–270. https://doi.org/10.1037/hea0000585

Fuller-Rowell, T. E., Williams, D. R., Love, G. D., McKinley, P. S., Sloan, R. P., & Ryff, C. D. (2013). Race differences in age-trends of autonomic nervous system functioning. *Journal of Aging and Health*, *25*(5), 839–862. https://doi.org/10.1177/0898264313491427

Gale, C. R., Batty, G. D., & Deary, I. J. (2008). Locus of control at age 10 years and health outcomes and behaviors at age 30 years: The 1970 british cohort study. *Psychosomatic Medicine*. https://doi.org/10.1097/PSY.0b013e31816a719e

Gotthardt, U., Schweiger, U., Fahrenberg, J., Lauer, C. J., Holsboer, F., & Heuser, I. (1995). Cortisol, ACTH, and cardiovascular response to a cognitive challenge paradigm in aging and depression. *American Journal of Physiology - Regulatory Integrative and Comparative Physiology*. https://doi.org/10.1152/ajpregu.1995.268.4.r865

Hülür, G., Heckhausen, J., Hoppmann, C. A., Infurna, F. J., Wagner, G. G., Ram, N., & Gerstorf, D. (2017). Levels of and changes in life satisfaction predict mortality hazards: Disentangling the role of physical health, perceived control, and social orientation. *Psychology and Aging*, *32*(6), 507–520. https://doi.org/10.1037/pag0000187

Infurna, F. J., Gerstorf, D., & Zarit, S. H. (2011). Examining dynamic links between perceived control and health: Longitudinal evidence for differential effects in midlife and old age. *Developmental Psychology*, *47*(1), 9–18. https://doi.org/10.1037/a0021022

Infurna, F. J., & Mayer, A. (2015). The effects of constraints and mastery on mental and physical health: Conceptual and methodological considerations. *Psychology and Aging*, *30*(2), 432–448. https://doi.org/10.1037/a0039050

Infurna, F. J., Ram, N., & Gerstorf, D. (2013). Level and change in perceived control predict 19-year mortality: Findings from the americans' changing lives study. *Developmental Psychology*, *49*(10), 1833–1847. https://doi.org/10.1037/a0031041

Kamarck, T. W., Schwartz, J. E., Janicki, D. L., Shiffman, S., & Raynor, D. A. (2003). Correspondence between laboratory and ambulatory measures of cardiovascular reactivity: A multilevel modeling approach. *Psychophysiology*, *40*(5), 675–683. https://doi.org/10.1111/1469-8986.00069

Kang, H. S., Chang, K. E., Chen, C., & Greenberger, E. (2013). Locus of control and peer relationships among caucasian, Hispanic, Asian, and African American adolescents. *Journal of Youth and Adolescence*, *44*(1), 184–194. https://doi.org/10.1007/s10964-013-0083-6

Karlamangla, A. S., Friedman, E. M., Seeman, T. E., Stawski, R. S., & Almeida, D. M. (2013). Daytime trajectories of cortisol: Demographic and socioeconomic differences-Findings from the national study of daily experiences. *Psychoneuroendocrinology*, *38*(11), 2585–2597. https://doi.org/10.1016/j.psyneuen.2013.06.010

Kudielka, B. M., Buske-Kirschbaum, A., Hellhammer, D. H., & Kirschbaum, C. (2004). HPA axis responses to laboratory psychosocial stress in healthy elderly adults, younger adults, and children: Impact of age and gender. *Psychoneuroendocrinology*. https://doi.org/10.1016/S0306-4530(02)00146-4

Kumari, M., Shipley, M., Stafford, M., & Kivimaki, M. (2011). Association of diurnal patterns in salivary cortisol with all-cause and cardiovascular mortality: Findings from the Whitehall II study. *Journal of Clinical Endocrinology and Metabolism*, *96*(5), 1478–1485. https://doi.org/10.1210/jc.2010-2137

Lachman, M. E. (2006). Aging-related declines adaptive beliefs and behaviors. *Current Directions in Psychological Science*, *15*(6), 282–286.

Lachman, M. E., & Agrigoroaei, S. (2010). Promoting functional health in midlife and old age: Long-term protective effects of control beliefs, social support, and physical exercise. *PLoS ONE*, *5*(10). https://doi.org/10.1371/journal.pone.0013297

Lachman, M. E., & Andreoletti, C. (2006). Strategy use mediates the relationship between control beliefs and memory performance for middle-aged and older adults. *Journals of Gerontology - Series B Psychological Sciences and Social Sciences*. https://doi.org/10.1093/geronb/61.2.P88

Lachman, M. E., & Firth, K. M. P. (2004). The adaptive value of feeling in control during midlife. *He John D. and Catherine T. MacArthur Foundation Series on Mental Health and Development. Studies on Successful Midlife Development. How Healthy Are We?: A National Study of Well-Being at Midlife*, 320–349. https://psycnet.apa.org/record/2004-00121-011

Lachman, M. E., Neupert, S. D., & Agrigoroaei, S. (2011). The relevance of control beliefs for health and aging. *Handbook of the Psychology of Aging*, 175–190. https://doi.org/10.1016/B978-0-12-380882-0.00011-5

Lachman, M. E., & Weaver, S. L. (1998). The sense of control as a moderator of social class differences in health and well-being. *Journal of Personality and Social Psychology*, *74*(3), 763–773. https://doi.org/10.1037/0022-3514.74.3.763

Lepore, S. J., Revenson, T. A., Weinberger, S. L., Weston, P., Frisina, P. G., Robertson, R., Portillo, M. M., Jones, H., & Cross, W. (2006). Effects of social stressors on cardiovascular reactivity in black and white women. *Annals of Behavioral Medicine*. https://doi.org/10.1207/s15324796abm3102_3

Matthews, K. A., & Gallo, L. C. (2011). Psychological perspectives on pathways linking socioeconomic status and physical health. *Annual Review of Psychology*, *62*(1), 501–530. https://doi.org/10.1146/annurev.psych.031809.130711

McEwen, B. S., & Seeman, T. E. (1999). Protective and damaging effects of mediators of stress: Elaborating and testing the concepts of allostasis and allostatic load. *Annals of the New York Academy of Sciences*, *896*(1), 30–47. https://doi.org/10.1111/j.1749-6632.1999.tb08103.x

Miller, B., Campbell, R. T., Farran, C. J., & Kaufman, J. E. (1995). Race, control, mastery, and caregiver distress. *Journals of Gerontology - Series B Psychological Sciences and Social Sciences*, *50 B*(6), S374–S382. https://doi.org/10.1093/geronb/50B.6.S374

Miller, G. E., Chen, E., & Zhou, E. S. (2007). If it goes up, must it come down? Chronic stress and the hypothalamic-pituitary-adrenocortical axis in humans. *Psychological Bulletin*, *133*(1), 25–45. https://doi.org/10.1037/0033-2909.133.1.25

Mirowsky, J., Ross, C. E., & Van Willigen, M. (1996). Instrumentalism in the land of opportunity: Socioeconomic causes and emotional consequences. *Social Psychology Quarterly*, 322-337.

Moffitt, T. E., Arseneault, L., Belsky, D., Dickson, N., Hancox, R. J., Harrington, H. L., Houts, R., Poulton, R., Roberts, B. W., Ross, S., Sears, M. R., Thomson, W. M., & Caspi, A. (2011). A gradient of childhood self-control predicts health, wealth, and public safety. *Proceedings of the National Academy of Sciences of the United States of America*. https://doi.org/10.1073/pnas.1010076108

Neupert, S. D., Almeida, D. M., & Charles, S. T. (2007). Age differences in reactivity to daily stressors: The role of personal control. *Journals of Gerontology - Series B Psychological Sciences and Social Sciences*, *62*(4), P216–P225.

Ong, A. D., Bergeman, C. S., & Bisconti, T. L. (2005). Unique effects of daily perceived control on anxiety symptomatology during conjugal bereavement. *Personality and Individual Differences*, *38*(5), 1057–1067. https://doi.org/10.1016/j.paid.2004.07.004

Preacher, K. J., Curran, P. J., & Bauer, D. J. (2006). Computational tools for probing interactions in multiple linear regression, multilevel modeling, and latent curve analysis. *Journal of Educational and Behavioral Statistics*. https://doi.org/10.3102/10769986031004437

Prenda, K. M., & Lachman, M. E. (2001). Planning for the future: A life management strategy for increasing control and life satisfaction in adulthood. *Psychology and Aging*. https://doi.org/10.1037//0882-7974.16.2.206

Radler, B. T. (2014). The Midlife in the United States (MIDUS) Series: A national longitudinal study of health and well-being. *Open Health Data*, *2*(1), 220–227. https://doi.org/10.5334/ohd.ai

Robinson, S. A., & Lachman, M. E. (2017). Perceived control and aging: A mini-review and directions for future research. *Gerontology*, *63*(5), 435–442. https://doi.org/10.1159/000468540

Sanz, A., & Villamarín, F. (2001). The role of perceived control in physiological reactivity: Self-efficacy and incentive value as regulators of cardiovascular adjustment. *Biological Psychology*. https://doi.org/10.1016/S0301-0511(01)00095-3

Sapolsky, R. M., Romero, L. M., & Munck, A. U. (2000). How do glucocorticoids influence stress responses? Preparative actions. *Endocrine Reviews*, *21*(1), 55–89.

Sastry, J., & Ross, C. E. (1998). Asian ethnicity and the sense of personal control. *Social Psychology Quarterly*, *61*(2), 101. https://doi.org/10.2307/2787064

Seeman, M., Stein Merkin, S., Karlamangla, A., Koretz, B., & Seeman, T. (2014). Social status and biological dysregulation: The “status syndrome” and allostatic load. *Social Science and Medicine*, *118*(C), 143–151. https://doi.org/10.1016/j.socscimed.2014.08.002

Seeman, T. E., & Robbins, R. J. (1994). Aging and hypothalamic-pituitary-adrenal response to challenge in humans. In *Endocrine Reviews*. https://doi.org/10.1210/er.15.2.233

Shaw, B. A., & Krause, N. (2001). Exploring race variations in aging and personal control. *Journals of Gerontology - Series B Psychological Sciences and Social Sciences*, *56*(2), S119–S124. https://doi.org/10.1093/geronb/56.2.S119

Zilioli, S., Imami, L., & Slatcher, R. B. (2017). Socioeconomic status, perceived control, diurnal cortisol, and physical symptoms: A moderated mediation model. *Psychoneuroendocrinology*, *75*, 36–43. https://doi.org/10.1016/j.psyneuen.2016.09.025