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Research Article

Implications of Cumulative Life Event Stress for Daily Stress Exposure and Cardiovascular Reactivity Among Black and White Americans

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Abstract

Objectives: Daily stress and cardiovascular reactivity may be important mechanisms linking cumulative life event stress with cardiovascular health and may help to explain racial health disparities. However, studies have yet to examine links between exposure to life event stress, daily stress exposure, and cardiovascular reactivity. This study assessed links between trajectories of life event stress exposure, daily stressors, and cardiovascular reactivity among Black and White individuals.

Methods: Participants are from the Stress and Well-being in Everyday Life Study in which 238 individuals (109 Black 129 White; ages 33–93), drawn from the longitudinal Social Relations Study, reported life event stress in 1992, 2005, 2015, and 2018. Of those individuals, 169 completed an ecological momentary assessment study in which they reported stress exposure every 3 hr, and 164 wore a heart rate monitor for up to 5 days.

Results: Latent class growth curve models revealed 2 longitudinal trajectories of life event stress: moderate-increasing and low-decreasing. Individuals in the moderate-increasing stress trajectory reported greater daily stress exposure and links did not vary by race. Black individuals in the low-decreasing trajectory and White individuals in the moderate-increasing trajectory showed positive associations between daily stress and heart rate (i.e., were reactive to daily stress exposure). The link between daily stress and heart rate was not significant among Black individuals in the moderate-increasing trajectory and White individuals in the low-decreasing trajectory.

Discussion: Individuals who experience more life events across the adult life course report greater daily stress exposure which has important implications for daily cardiovascular health. Black individuals with moderate-increasing life event stress show evidence of blunted daily stress reactivity (nonsignificant association between daily stress and heart rate) whereas Black individuals with low-decreasing life event stress show evidence of stress reactivity (positive association between daily stress and heart rate). White individuals showed the opposite pattern (albeit marginally). These findings expand the weathering hypothesis and indicate that chronic life event stress may be associated with blunted stress reactivity among Black individuals.

Keywords: Cardiovascular health, Daily stress, Ecological momentary assessment, Racial health disparities

Extreme racial health disparities exist in the United States with Black individuals having greater likelihood of hypertension and cardiovascular disease than White individuals (Benjamins et al., 2017; Wadhera et al., 2021). Theories of structural racism indicate that these disparities are the result of race differences in exposures to stress across the life course (Phelan & Link, 2015; Williams et al., 2019). Indeed a burgeoning literature shows that greater cumulative lifetime stress (e.g., childhood adversity, work stress, discrimination, and lower socioeconomic status) is associated with increased hypertension and cardiovascular disease (Hicken et al., 2014; Morenoff et al., 2007; Steptoe & Kivimäki, 2013; Williams et al., 2003). Daily stress processes may provide an important window into the links between lifetime stress and health, as theory and research suggest that because daily events occur more frequently than major life events, daily stress may have even greater implications for health and well-being than life events (Almeida, 2005). Further, daily stress exposure and stress reactivity and, in particular, daily cardiovascular reactivity (e.g., heart rate [HR] reactions to stress) are hypothesized to be major factors linking cumulative life stress and cardiovascular health, as it predicts increased risk of cardiac events and mortality (Kamarck et al., 2004; Schnall et al., 1998; Treiber et al., 2003). Understanding how cumulative life stress and daily stress contribute to within-person variability in cardiovascular health in daily life may provide important clues to how cumulative lifetime stress affects health and provide

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a better understanding of how stress contributes to racial disparities in cardiovascular health.

The purpose of the present study was to examine links between longitudinal assessments of life event stress, daily stress exposure, and daily cardiovascular reactivity among Black and White individuals. To examine cumulative life event stress, we identified longitudinal trajectories of life event stress and then assessed whether they were associated with daily stress exposure and cardiovascular reactivity.

Theoretical Background

The rationale for examining life event stress, daily stress exposure, daily stress reactivity, and race emerge from the Exposure Reactivity Model (Almeida, 2005) and the Weathering Hypothesis (Geronimus et al., 2006). The Exposure Reactivity Model emphasizes the importance of examining lifetime (e.g., life events such as death of close others and job loss) and daily stress (e.g., daily interpersonal and noninterpersonal stressors) as well as examining whether stressors are experienced (number or frequency of exposures) and the link between exposure and poor well-being/physiological stress (reactivity; Almeida, 2005). Exposure is the likelihood of experiencing the stressor, whereas reactivity is how the individual reacts emotionally or physically to the stressor. Daily stress may have even greater implications for health than life events as daily events occur more frequently than major life events and may accumulate over time (Lazarus, 1999). Long-term experiences of stress or chronic stress may increase the likelihood of being exposed to more daily stressors. This is a concept often referred to as stress proliferation whereby stress experienced in one domain may cause new additional stressors to occur in either the same domain or a different domain (Pearlin et al., 1997). Further overall experiences of stress may increase reactivity to those stressors by reducing individuals' resources. This is often referred to as the sensitivity hypothesis (Hammen et al., 2000). According to the Exposure Reactivity model, sociodemographic, psychosocial, and health factors affect both exposure and reactivity to stress. This study focuses on the influence of exposure to life events over the adult life course and race on daily stress exposure and reactivity.

The Weathering hypothesis suggests stress exposure and its effects on health are particularly pernicious among Black individuals. Indeed, the Weathering hypothesis (Geronimus, 1992) broadly suggests that due to structural racism and greater lifetime stress, Black individuals experience accelerated aging and greater health problems than White individuals (Geronimus et al., 2006, 2010; Simons et al., 2021; Williams, 2012). The physiological wear and tear as a result of chronic stress, barriers and hardship (Geronimus et al., 2006), and accelerated age are hypothesized to cause dysregulation of the stress response which may lead to increased or blunted stress reactivity, both of which are associated with poor health outcomes (McEwen, 1998; Turner et al., 2020).

Life Event Stress, Daily Stress Exposure, and Cardiovascular Reactivity to Stress

Greater lifetime stress (e.g., childhood adversity, work stress, discrimination, and lower socioeconomic status) is associated with increased hypertension and cardiovascular disease (Dar et al., 2019; Hicken et al., 2014; Morenoff et al., 2007; Steptoe & Kivimäki, 2013; Williams et al., 2003). Rosengren et al. (2004) found that chronic stress predicted cardiovascular disease (CVD) equivalently to other risk factors. Two potential mechanisms linking lifetime stress to CVD are daily stress exposure and dysregulated cardiovascular stress reactivity (either exaggerated or blunted).

Research examining links between lifetime stress and reactivity to stress experienced in daily life has revealed links between daily exposure and stress reactivity but has not examined cardiovascular reactivity. Serido et al. (2004) examined chronic stress and links between daily stress and self-reported distress. They found that individuals who reported chronic stress reported greater distress on days in which they reported more daily stressors. Stawski (2008) examined associations between global perceived stress and daily exposure and reactivity to daily stress (using negative affect). They found that greater perceived stress was associated with greater exposure and reactivity to stress in daily life.

Research examining links between lifetime stress and cardiovascular reactivity has usually examined cardiovascular reactivity in the laboratory with some studies finding increased reactivity and others finding blunted reactivity. For instance, Lepore et al. (1997) found that individuals exposed to greater chronic stress in the previous 9 months were more reactive to an arithmetic stress task showing greater blood pressure and HR. Other studies have found that lifetime stress is associated with blunted reactivity (Uchino & Garvey, 1997). Matthews et al. (2001) found that young and middle-aged men and women, who reported high levels of chronic stress, showed lower blood pressure reactivity to arithmetic and public speaking tasks. Carroll et al. (2017) examined links between life events reported in the last 2 years and reactivity to an arithmetic task among middle-aged and older cohorts. They found that participants who rated their life events as having a greater impact (i.e., more stressful) showed less blood pressure reactivity.

Studies have also revealed that moderate levels of stress may cause lower cardiovascular reactivity and greater recovery than both high and low levels of stress due to improved resilience or "toughness" (Chatkoff et al., 2010). Chatkoff et al. (2010) examined undergraduate students and the links among reports of overall perceived stress in the past 30 days and cardiovascular reactivity to an arithmetic task and a stress recall task. Women who reported moderate levels of stress were less reactive to the stress task (showing less blood pressure reactivity) compared to those reporting low or high levels of stress but this link was not found among men. Similarly, Seery et al. (2013) examined links between lifetime adversity (whether respondents had ever experienced a series of stressful life events) and cardiovascular reactivity to a computer-based intelligence test among undergraduate students. Individuals who reported moderate levels of lifetime adversity exhibited higher levels of resilience during the test (as indicated by higher cardiac output and lower total peripheral resistance) compared to those who reported high and no lifetime adversity (Seery et al., 2013).

Although reactivity to stress in the laboratory provides useful information, it is also important to examine stress in daily life as it may be more representative of the types of stress individuals are exposed to than laboratory stressors and hence more ecologically valid (Almeida, 2005). Daily stress also allows for the examination of within-person variability and within-person links between changes in daily exposure and well-being. Further, research shows that daily stress is associated with cardiovascular reactivity in daily life, including HR and blood pressure (Kamarck et al., 2005; Schoenthaler et al., 2010). Indeed, women with coronary artery disease were more likely to suffer from CVD events when they reported chronic daily marital tension (Orth-Gomér et al., 2000). The present study used EMAs every 3 hr, which provides even more fine-grained information regarding within-person links between daily exposure and heart outcomes. We were able to examine whether stress experienced in each 3-hr period was related to HR in those same 3-hr periods.

Race Differences in Exposure and Reactivity to Stress

Stress exposure and reactivity may vary by race as a function of long-term experiences of stress. A burgeoning literature shows that due to structural racism, Black Americans are exposed to greater stress across the life course than White Americans (Phelan & Link, 2015). Studies of race differences in daily stress exposure show that after controlling for covariates such as socioeconomic status, White and Black individuals report similar levels of daily stress exposure (Birditt et al., 2011; Cichy et al., 2012) but that Black individuals are more reactive to daily stress reporting more physical symptoms, greater negative affect, and exhibiting higher cortisol in response to daily stress exposure compared with White individuals (Birditt et al., 2011; Cichy et al., 2012).

Studies have also suggested that cardiovascular stress reactivity varies by race with some research showing evidence of blunting as well as increased reactivity but these studies have examined stress reactivity in the laboratory. Cavanagh and Obasi (2021) examined Black individuals ages 18–22 and whether reports of chronic stress across the life span and coping styles were associated with reactivity to laboratory stress (i.e., trier social stress test). They found that greater chronic stress was associated with blunted HR reactivity to stress but only among women and not men. Richman et al. (2007) examined links between past experiences of discrimination and reactivity to a laboratory task among Black and White adults ages 18–50. They found that greater past experiences of discrimination were associated with greater cardiovascular reactivity among individuals who were low in cynicism and high in optimism and that the associations were stronger among Black participants than White participants.

Other Factors

This study considers a multitude of other factors that are known to be associated with stress exposure and reactivity including demographic factors of gender, age, education, and marital status. Research has suggested that women report greater exposure and reactivity to lifetime and daily stress (Almeida & Kessler, 1998). Older individuals report less exposure and reactivity to stress (Almeida & Horn, 2004; Stawski et al., 2008). Greater education (Grzywacz et al., 2004) and being married often confer health benefits (Almeida et al., 2005; Roy et al., 1998). Well-being factors including self-rated health and depressive symptoms that are associated with daily stress and reactivity were included as covariates. Heart medication and heart disease were included as potential covariates as they are associated with variability in cardiovascular outcomes. We considered several psychosocial factors that may account for the links between lifetime stress and daily stress exposure and reactivity including discrimination, emotional support, health behaviors, and coping. Discrimination is an important life stressor that varies by race and has important implications for health (Williams et al., 2019). Research shows that emotional support may buffer stress reactivity (Southwick et al., 2016; Uchino & Garvey, 1997). Health behaviors including exercise and alcohol use are associated with stress and health (Umberson et al., 2008). Finally, we consider coping strategies as studies have shown that coping moderates the effects of stress on well-being (Gross & John, 2003).

The Present Study

Overall research has revealed inconsistent findings regarding whether lifetime stress is associated with increased or decreased stress reactivity. The literature to date has often examined retrospective reports of lifetime stress and cardiovascular reactivity to laboratory stress. Studies examining reactivity to stressors experienced outside of the laboratory have examined psychological reactivity rather than physiological reactivity. These studies have also lacked racial diversity. In the present study, we focus specifically on cardiovascular reactivity by measuring the link between stress exposure and HR. Individuals may show either exaggerated or blunted cardiovascular reactivity to stress and both are associated with a myriad of health problems (Turner et al., 2020).

This study moves the field forward by examining longitudinal reports of lifetime stress and its associations with daily stress exposure and cardiovascular reactivity among Black and White individuals. To do this, we incorporated an examination of daily exposure and daily stress reactivity into a longitudinal study to understand how long-term patterns of life event stress are associated with daily stress exposure and cardiovascular reactivity and whether those links vary by race. Due to different life experiences (i.e., structural racism), Black and White individuals may show different cardiovascular responses to lifetime stress and daily stress. The purpose of this study was to examine the following research questions:

1) Does daily stress exposure vary by life event stress exposure and do those links vary by race?

We hypothesized that greater life event stress across the adult life course would be associated with greater daily stress exposure (i.e., proliferation) and that these links would be stronger among Black individuals than White individuals.

2) Does cardiovascular reactivity to daily stress exposure vary by life event stress exposure and do those links vary by race?

We hypothesized that greater life event stress exposure would be associated with dysregulated cardiovascular stress reactivity to daily stress (either greater or blunted) and that these links would be stronger among Black individuals than White individuals.

Method

Participants

The participants are from the Stress and Well-being in Everyday Life (SWEL) Study, which was conducted in 2018 and included 238 (129 White, 109 Black ages 33–93) participants from the longitudinal Social Relations Study (SRS; T. Antonucci, PI). They were asked to complete a baseline phone interview followed by 4–5 days during which they completed ecological momentary assessments (EMAs) and wore an electrocardiogram (ECG) monitor. To be included in the sample selection, participants had to have completed at least one wave of the SRS study. The SWEL sample was selected from the total number of eligible Black SRS participants (N = 298) who were matched to one or two potential White SRS participants (N = 364) on key characteristics including gender, education, age, social network size, and hypertension status using propensity scores (Guo & Fraser, 2014). The goal of the SWEL study was to enroll 300 participants (150 Black and 150 White), but the data collection was halted due to coronavirus disease 2019 (COVID-19). A total of 109 Black individuals and 129 White individuals participated in the SWEL study. Of the 662 eligible SRS participants, considered for the SWEL study 92 had no attempts, 125 had no contact, 75 refused, 93 resistant, 7 died, and 11 were permanently disabled. A total of 332 cases were considered nonfinal and 92 had no attempts. We divided 238 by the total contacted and eligible respondents (n = 427) which is a 55% response rate. This response rate is lower due to COVID-19. We achieved 238 of the goal of 300 which is 79% of the target.

The original SRS study includes three waves of data (1992, 2005, and 2015; see Supplementary Materials 1 for additional details). The Wave 1 SRS sample was drawn from the tri-county Detroit metropolitan area of individuals who completed face-to-face interviews (N = 1,703; response rate = 72% in 1992; ages 7–93). Wave 2, completed in 2005, using both telephone and face-to-face interviewing, included 1,076 of the original participants with 320 identified as deceased (N = 1,076, response rate = 78% of eligible respondents). Wave 3, completed in 2015, using telephone interviews, included 720 of the original participants with 63 deceased, 25 disabled, and 2 incarcerated (response rate = 73% of eligible respondents). Gender composition for the three waves was as follows: %women: 58, 60, and 62; Racial/ethnic composition: %White: 70, 71, and 72; %Black: 29, 27, and 24. We used computer-assisted interviews to collect Wave 2 and 3 data. Research indicates few data quality differences using the face-to-face and phone interviews (Herzog & Rodgers, 1988; Soldo et al., 1997).

Of the 238 SWEL participants who completed the baseline interview, a total of 169 had EMA data regarding daily stress and 164 provided HR data. Thus, the sample size varied depending on the outcome of interest. Respondents showed high response rates completing an average of 17.2 (72%) of the EMAs (69% for Black and 74% for White). The total number of EMAs completed was 2,905 (Black = 1,326 and White = 1,579). The range was 1–26 EMAs; 19.5% had less than 4 days, 76.9% had 4 days, and 3.6% had 5 days.

We compared the 238 enrolled participants with baseline data to the 424 potential participants who were not recruited into the study. The 238 participants did not differ significantly from those not recruited on age, race, education, gender, marital status, network size, self-rated health, or depressive symptoms.

We also compared the 169 who completed the EMA study with the 69 who completed the baseline only and found that the EMA sample was significantly younger (b = −0.06, standard error [SE] = 0.01, p < .001) and had more years of education (b = 0.17, SE = 0.08, p < .05). They did not differ on race, gender, marital status, network size, self-rated health, or depressive symptoms. We compared the 164 heart outcomes sample with the five who had EMA only and there were no significant differences.

Further, because some of the participants were related (from the same households), we conducted additional analyses to account for potential correlated error in the analyses. These are discussed in the post hoc section of the analyses section.

Procedure

Participants completed baseline interviews in their homes or over the phone (if they lived more than 50 miles away or the interview was conducted during the pandemic). Following the baseline interview, interviewers trained the respondents (either in person or over the phone) to complete EMAs on a study smartphone and to wear the Body Guardian (BG) HR monitor. After the training, participants wore the BG monitor and completed six EMAs daily for 4–5 consecutive days. Participants were paid $50 for completing the baseline interview and $150 for completing the EMA portion of the study.

Baseline Measures

Race

Adult participants from Wave 1 of the SRS were asked: "Are you White, Black, Native American, Asian, Hispanic or another race?" If participants indicated more than one race, they were asked "Which do you feel best describes your race?" Child participants from Wave 1 had their race coded by interviewers via observation (n = 44). Core network members, who only completed Wave 3 of the SRS and not Wave 1 (n = 10), were asked an open-ended question, "What is your ancestry or ethnic origin?." Responses were coded by the study team. For this study, race was recoded to White (−1) or Black (1).

Life event stress

Participants were asked (in 1992, 2005, 2015, and 2018) whether they had experienced any of 10 life events over the past year: (1) Has there been any change in your health, such as an illness or injury? (2) Has a member of your family been ill or badly injured? (3) Has there been trouble between you and your relatives? (4) Has there been a negative change in your position or conditions of work? (5) Has your income decreased? (6) Have you had a substantial amount of unexpected expenses? (7) Have you moved to a new residence? (8) Has your spouse died? (9) Has any close family member died? (10) Has a close friend died? (Holmes & Rahe, 1967). For each item, participants responded yes (coded as 1) or no (coded as 0). Items were summed and truncated at four due to the skew in the data. We also considered the proportion of life events across waves by summing the number of life events reported in each wave and dividing by the total number of life events possible for each participant.

Covariates included self-reported gender (dichotomous −1 = male; 1 = female), age based on the year of birth (continuous), years of education (continuous), marital status (dichotomous 1= married/living with partner; −1 = widowed, never married, and divorced), heart trouble (dichotomous 1 = yes; −1 = no), and heart medication (dichotomous 1 = yes; −1 = no). Self-rated health was continuous and assessed from 1 (excellent) to 5 (poor) and reverse coded so that higher scores represented better health. Depressive symptoms were assessed with the eight-item Center for Epidemiological Studies—Depression scale ($\alpha = 0.81$) (Radloff, 1977). Because heart trouble and heart medication were correlated at $r = 0.73$, the models presented in the results control for heart trouble only. We include models controlling for heart medication in the post hoc section of the Results. Finally, we estimated additional post hoc models controlling for discrimination, emotional support, health behaviors, and coping. To assess discrimination, participants were asked how often they are treated with less respect than others, they receive poorer service than others at stores, people act afraid of them, they are threatened or harassed, and they are followed around in stores on a scale from (1) never to (6) almost every day (Williams et al., 1997). These items were averaged to create a scale ($\alpha = 0.60$). To assess emotional support, participants were asked to report how much emotional support they received from each of their network members on a scale from (1) not at all to (5) a great deal (Antonucci, 1986). To assess health behaviors, participants were asked to report whether they drank alcohol in the last 3 months and the average number of drinks they had per week as well as the frequency of vigorous and moderate exercise with two items on a scale from never (1) to three or more times per week (5) which were tested separately (Jenkins et al., 2008). To assess coping, we asked participants to report every 3 hr to what extent they kept their emotions to themselves and tried to control feelings by thinking about something else on a scale from (1) not at all to (5) a great deal (Gross & John, 2003). These coping items were examined separately.

Daily Measures

Heart rate

The BG heart monitor is a portable ECG monitor worn by participants for 24 hr a day for 4–5 days. It adheres to the chest via an adhesive strip and is small, and comfortable to wear. The monitor comes with its own mobile phone and transmits data via Bluetooth to the phone, which then transmits data to a secure server via the 5G cell network. The company that produces the monitor provides measures of HR. The system reports an average HR which is derived by detecting the R wave component of the QRS complex for both normal and premature ventricular complexes. The system calculates the interval between R waves (R–R interval) and processes this information to derive an average HR value every 10 s. Median HR was calculated for each 3-hr period.

Daily stress exposure

Every 3 hr, participants reported how many social interactions they had: "How many people have you interacted with in the last 3 hours? (*Interactions can include in person, phone, text, email, social media or video chat*)." Participants were then asked about whether those interactions were negative, specifically asking: "Of the interactions you had in the last 3 hours, which ones were irritating, hurtful, annoying or stressful?" and "Which interactions were ones in which you could have felt irritated or annoyed but decided not to?" The number of irritating interactions was recoded as 0 = none or 1 = 1 or more, and the number of avoided irritating interactions was recoded as 0 = none or 1 = 1 or more. Participants were also asked whether anything else happened that they would consider stressful, coded as 0 = none or 1 = 1 or more. Then, these three items were summed to create a score of daily stress exposure ranging from 0 to 3 ($\alpha = 0.55$). The alpha was relatively low, but the exposure items are not expected to be highly correlated. These items are adapted from existing assessments of daily stressful events as well as social interactions (Almeida et al., 2002; Birditt, 2014; Birditt et al., 2018).

Positive interactions

We considered positive interactions in follow-up models. Positive interactions were assessed with the following question: "Of the interactions you had in the last 3 hours, which ones were positive/enjoyable?" The number of positive interactions was recoded as 0 = none or 1 = 1 or more.

Analysis Strategy

The morning survey did not ask questions about stress in the previous 3 hr and therefore data from that survey were not included in this analysis. This resulted in a total of 2,491 surveys for analysis. Of these, 2,382 had HR for the corresponding 3-hr period. Means (*M*) and standard deviations (*SD*) were calculated followed by *t* tests and chi-square tests to assess whether there were significant race differences in covariates, lifetime (proportion and each type) and daily stress, and HR.

We estimated latent class growth analysis (LCGA) models for the SWEL baseline sample ($n = 238$) using Mplus version 7 to determine the trajectories of life events from 1992 to 2018. These models use full-information maximum-likelihood to handle missing data. The exploratory nature of this analytic framework allowed us to find subsets of participants that may follow one model as opposed to another; compared with a more traditional regression-type model that forces all subjects to follow the same set of betas. We used this method instead of simply summing up the number of events because these types of analyses allow for the simultaneous modeling of mean differences as well as change over time.

To identify trajectories of life events, we started by estimating unconditional univariate latent growth curve models to determine the shape of the average life event trajectory. The first indicator of the slope factor was fixed at zero so the intercept would represent the initial level of life events in 1992. The remaining three indicators were fixed to the number of years passed since baseline, divided by 100 to decrease issues associated with large variances (0.13, 0.23, and 0.27). The cubic trajectory model fit better than the linear and quadratic models based on lower Akaike information criterion and Bayesian information criterion values and an adequate comparative fit index (0.87) and root-mean-square error of approximation (0.09). Results of the cubic trajectory model showed a significant intercept ($M = 1.75$, $p < .001$), significant linear slope ($M = 18.13$, $p < .001$), significant quadratic slope ($M = -160.52$, $p < .001$), and a significant cubic slope ($M = 360.13$, $p < .001$). There was significant variance around the intercept only (0.47, $p < .001$).

Next, using the cubic trajectory model we examined LCGAs to identify heterogeneity in life event trajectories. We used the following criteria to determine the number of latent classes: lower Bayesian information criterion (BIC) statistic, high entropy, significant bootstrap Lo, Mendell, and Rubin (LMR) test, and substantive interest of the classes. We also included a post hoc analysis examining the proportion of life events over time and report that in the post hoc analysis section of the Results. The proportion was used rather than a sum because not all participants were interviewed in all four waves.

Models were then estimated to examine whether life event trajectories varied by race and all of the other covariates. To examine race and other covariate differences in life event trajectories, the auxiliary option in Mplus was used (Vermunt, 2010). This method allows for the most likely class to be regressed on the predictor variable without affecting the original latent class trajectories but includes misclassification when obtaining the most likely class membership.

We saved the most likely class membership for each participant and used those trajectory classes as predictors of daily stress exposure and HR using SAS 9.4. Multilevel models for continuous outcomes with random intercepts were estimated to examine the associations between life event trajectories and daily stress exposure and whether there were race differences in those associations. Maximum-likelihood estimation was used for these models to handle missingness in the outcome. Because we were not examining change over time in the EMAs we did not have a variable for time. Next, we examined whether there were associations between lifetime stress, cardiovascular stress reactivity, and whether those links varied by race. All baseline continuous variables were grand-mean centered and all time-varying continuous variables were person-mean centered. In the interest of parsimony, only linear effects (and not quadratic) were considered for continuous variables. We examined correlations with the outcome variables to determine the covariates to include in each model only including those that were significantly correlated (Rovine et al., 1988). Covariates for the model predicting stress exposure included gender, marital status, age, self-rated health, depressive symptoms, and education. Covariates for the model predicting HR included gender, marital status, age, self-rated health, depressive symptoms, and heart trouble. Education was not included as it was not significantly related to HR.

We estimated a series of post hoc models. We conducted a series of models with additional covariates to determine the robustness of the associations. These models included controlling for life events as reported in 2018, heart medication rather than heart trouble, discrimination, emotional support, health behaviors (alcohol use and exercise), and coping. We examined whether there were age or gender differences by examining interactions with age and gender in the models.

Results

Descriptive Statistics

There were no race differences in age, self-rated health, marital status, depressive symptoms, heart trouble, or heart medication status. Black individuals reported fewer years of education compared with White individuals (Table 1, sample descriptives).

Black individuals reported a higher proportion of life events over time ($M = 0.23$, $SD = 0.12$) compared with White individuals ($M = 0.20$, $SD = 0.10$; $t = 2.15$, $p = .032$). As for the types of events, Black individuals were more likely to experience a decrease in income in at least one wave (61.5%) compared with White individuals (43.4%; chi-square = 7.71, $p < .01$). White individuals were more likely to experience the

Table 1. Sample Descriptives (n = 238)

	Black (n = 109)			White (n = 129)			Sig diff	Cohen's d
	Mean	*SD*	Range	Mean	*SD*	Range		
Age	55.21	13.95	33–93	57.10	14.54	34–91	ns	0.13
Education	13.78	1.90	9–17	14.46	2.06	9–17	**	0.34
Self-rated health	3.59	0.89	1–5	3.70	1.00	1–5	ns	0.12
Depressive symptoms	6.60	4.73	0–22	5.60	4.83	0–19	ns	0.21
Life events (1992)	1.67	1.54	0–4	1.78	1.34	0–4	ns	0.08
Life events (2005)	2.53	1.27	0–4	1.93	1.44	0–4	**	0.44
Life events (2015)	1.97	1.20	0–4	1.69	1.24	0–4	ns	0.23
Life events (2018)	2.06	1.40	0–4	2.00	1.30	0–4	ns	0.04
Proportion life events	0.23	0.12	0–0.6	0.20	0.10	0–0.5	*	0.28
	%	*n*		%	*n*			
Female	67.9	74		65.1	84		ns	—
Married/Live with partner	46.8	51		59.7	77		ns	—
Heart trouble	13.8	15		13.2	17		ns	—
Heart medication	11.9	13		10.1	13		ns	—
	Mean[a]	*SE*		Mean[a]	*SE*			
Daily stress exposure[b]	0.37	0.04	0–3	0.45	0.04	0–3	ns	—
Heart rate[c]	84.91	1.19	53–202	84.34	1.12	47–183	ns	—

Notes: diff = difference; EMA = ecological momentary assessment; ns = non significant; *SD* = standard deviation; *SE* = standard error.
[a]Mean is least square mean from SAS Proc mixed.
[b]Daily stress exposure is reported for participants who completed EMAs (n = 169).
[c]Heart rate is calculated for participants who wore the BodyGuardian heart monitor (n = 164).
* $p < .05$. ** $p < .01$.

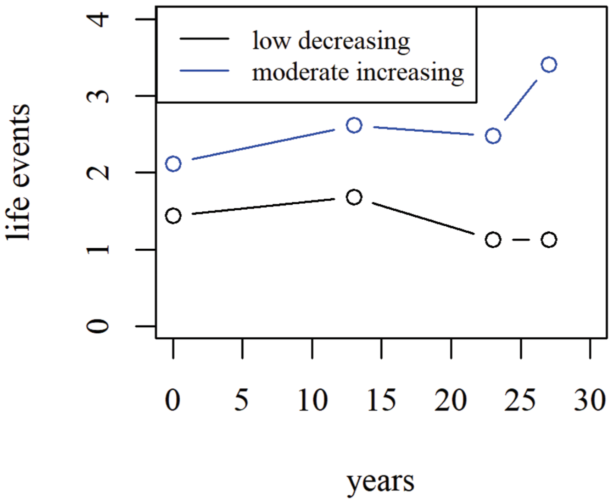

Figure 1. Life event trajectories over four waves (1992, 2005, 2015, and 2018).

death of a spouse (6.2%) compared with Black individuals (0.9%; chi-square = 4.53, $p < .05$), which is most likely due to the lower marriage rates among Black individuals. There were no other significant race differences in individual life events (see Supplementary Table 1). There was no significant race difference in the number of daily stressors reported or HR.

Life Event Trajectories

The two-class life event trajectory solution had the best fit with a lower BIC compared with the three-class solution (2,819.13; 2,830.65), high entropy (0.79), and a significant bootstrap LMR test ($p < .001$; Figure 1). The first class which we called the moderate-increasing life event trajectory included 43% of the sample ($n = 103$) with a mean intercept of 2.12 ($p < .001$), a mean linear slope of 25.57 ($p < .001$), a mean quadratic slope of −233.51 ($p < .001$), and a mean cubic slope of 571.50 ($p < .001$). The second class which we called the low-decreasing life event trajectory included 57% of the sample ($n = 135$) and had a mean intercept of 1.44 ($p < .001$), a mean linear slope of 12.90 ($p < .05$), a mean quadratic slope of −108.89 ($p > .05$), and a mean cubic slope of 207.60 ($p > .05$). Because the cubic term was not significant, we ran the model again with the cubic slope fixed to zero, and discovered that the quadratic term was significant (estimate = −21.38, $p < .05$), indicating that for this class life events increased slightly in 2005 and then decreased in the last two waves. We recognize that the moderate-increasing group showed a significant cubic pattern and the low-decreasing group showed a significant quadratic pattern but we chose those labels in the interest of parsimony and because the level and overall increasing versus decreasing patterns were their most distinctive features.

There was no race difference in life event trajectory membership or significant associations between life event trajectories and gender, education, marital status, or age. There were significant associations between life event trajectories, self-rated health, and depressive symptoms. Individuals in the low-decreasing life event trajectory had better self-rated health ($b = 0.53$, $SE = 0.19$, $p < .01$) and lower depressive symptoms ($b = -0.14$, $SE = 0.05$, $p < .01$) compared with individuals in the moderate-increasing life event trajectory.

Table 2. Estimates From Multilevel Models Examining Daily Stress Exposure as a Function of Life Event Trajectories and Race ($n = 169$)

	b	*SE*
Step 1		
Age	−0.00*	0.00
Female	0.02	0.03
Black	−0.05	0.03
Married/live with partner	0.03	0.03
Education	0.01	0.02
Self-rated health	−0.01	0.03
Depressive symptoms	0.00	0.01
Life event trajectories	0.12*	0.06
−2 log likelihood	5,323.4	
Step 2		
Life event trajectories × race	−0.03	0.05
−2 log likelihood	5,323.0	

Notes: *SE* = standard error.
*$p < .05$.

Associations Between Life Event Trajectories and Daily Stress Exposure

Models examining links between life event trajectories and daily stress exposure revealed individuals in the moderate-increasing life event trajectory reported experiencing more daily stressors (i.e., greater stress exposure) than individuals in the low-decreasing life event trajectory ($b = 0.12$, $SE = 0.06$, $p < .05$; Table 2, Step 1). There was no significant race difference in this association as evidenced by the nonsignificant interaction term between race and life event trajectories predicting daily stress exposure.

Associations Between Life Event Trajectories and Cardiovascular Reactivity to Daily Stress Exposure

Models revealed that life event trajectories were not significantly associated with HR. However, reporting greater daily stress exposure was associated with a higher HR in the same 3-hr period ($b = 0.66$, $SE = 0.30$, $p < .05$; Table 3, Step 1). This was consistent with the Exposure Reactivity Model indicating that daily stress is an important predictor of daily well-being. The two-way interaction between life event trajectories and daily stress exposure predicting HR was not significant (Table 3, Step 2).

Models examining race differences in the link between life events, daily stress exposure, and HR revealed that the three-way interaction between life event trajectories, daily stress exposure, and race predicting HR was significant ($b = -1.22$, $SE = 0.61$, $p < .05$; Table 3, Step 3). For Black individuals in the low-decreasing life event trajectory, having more stressful daily events was associated with a higher HR ($b = 1.66$, $SE = 0.69$, $p < .05$, Figure 2). For White individuals in the moderate-increasing trajectory, greater daily stress exposure was associated with increased HR, albeit marginally ($b = 0.97$, $SE = 0.56$, $p = .082$). This finding indicates that greater lifetime stress may be associated with blunted stress reactivity among Black individuals and marginal increased reactivity among White individuals.

Table 3. Estimates From Multilevel Models Examining Daily Heart Rate as a Function of Life Event Trajectories and Race (n = 164)

	b	*SE*
Step 1		
Age	−0.16**	0.06
Female	1.13	0.76
Black	0.09	0.73
Married/live with partner	1.55*	0.76
Heart trouble	−4.74***	1.35
Self-rated health	−2.07*	0.88
Depressive symptoms	0.42*	0.18
Life event trajectories	1.26	1.55
Between person daily stress	1.19	2.01
Within-person daily stress	0.66*	0.30
−2 log likelihood	17,926.9	
Step 2		
Life event trajectories × daily stress	−0.22	0.60
−2 log likelihood	17,926.7	
Step 3		
Life event trajectories × race	−2.78*	1.40
Daily stress × race	0.75	0.45
Life event trajectories × daily stress × race	−1.22*	0.61
−2 log likelihood	17,918.7	

Notes: *SE* = standard error.
*$p < .05$. **$p < .01$. ***$p < .001$.

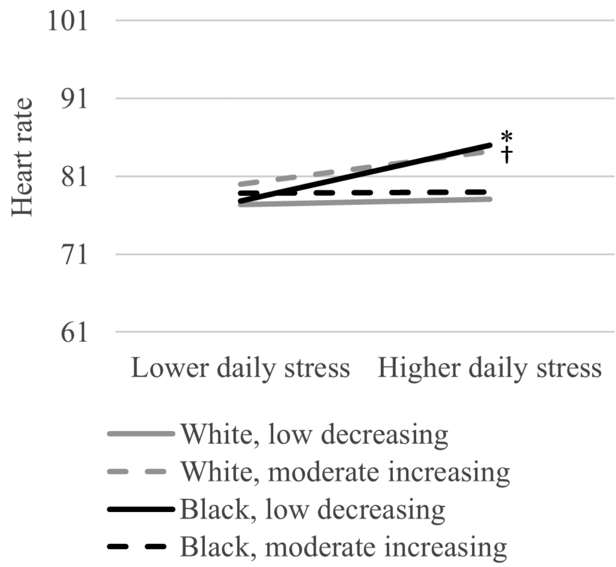

Figure 2. Heart rate as a function of life event trajectories, daily stress exposure, and race. †$p < .10$, *$p < .05$.

Post Hoc Analyses

We estimated models with the proportion of life events experienced over time instead of life event trajectories. We considered linear and quadratic effects in these models to examine the theory that perhaps moderate levels of stress have a resilience effect. There were no significant associations between these life event scores and daily stress exposure or reactivity to stress.

We estimated all models with HR medication as a covariate instead of having heart trouble and the findings remained the same. Findings also remained the same when controlling for emotional support, alcohol use, and moderate and vigorous exercise and discrimination. When controlling for life events reported in 2018, the models predicting HR remained the same but the model examining the link between life event trajectories and daily stress exposure became marginally significant. This indicates that the link between the moderate-increasing class and greater daily stress exposure may be due to the high level of life events reported in Wave 4. When we controlled for coping strategy items, the effect of life event trajectories predicting daily stress exposure and the effect of life event trajectories, daily stress, and race-predicting HR became marginal. Further exploration of this finding indicated that the coping strategies were both positively associated with the moderate-increasing life event trajectory group, greater daily stress exposure, and greater HR. Black individuals used coping strategies more than White individuals. This indicates that coping may represent an important causal factor in the links between life events and daily stress processes.

We also conducted follow-up analyses examining daily positive interactions. Life events were not associated with positive interactions and positive interactions were not associated with HR. There was an interaction between life event trajectories and positive interactions predicting HR. Among those in the low-decreasing life event class, having a positive interaction was associated with lower HR. There was no significant association for those in the moderate-increasing class. We also tested the three-way interaction between life event trajectories, positive interactions, and race, but it was not significant.

There were no significant gender or age interactions indicating that the findings were consistent across gender and age.

Finally, because there were 15 related dyads and 1 related triad in the study, we re-estimated all of the models with a random intercept at the dyad(triad) level. All of the findings remained the same.

Discussion

Overall, this study incorporated a short-term study of stress reactivity into a longitudinal study of stress to understand how life events and daily stress contribute to daily cardiovascular reactivity among White and Black individuals. Among both Black and White individuals, those who experienced more life event stress across the life span reported greater exposure to daily stressors. Interestingly, the link between daily stress exposure and HR varied by life event trajectories and race, showing that greater exposure to life events may be associated with blunted daily cardiovascular reactivity among Black individuals and increased daily stress reactivity among White individuals. This study makes significant advances in understanding how life event stress is associated with daily experiences and cardiovascular reactivity among Black and White adults. In particular, the use of both longitudinal data and ecological momentary assessment data allowed for an unprecedented examination of within-person associations between longitudinal patterns of life events experienced across the adult life course with within-person variations in daily stress exposure and cardiovascular reactivity.

Patterns of Lifetime Stress and Daily Stress by Race

The present study examined reports of life events over four waves from 1992 to 2018 and showed that two trajectories best described the empirical patterns of life event stress: A moderate-increasing trajectory that showed moderate levels of life event stress that increased over time; and a low-decreasing trajectory that showed low levels of life event stress over time. Further, individuals in the moderate-increasing life stress trajectory reported poorer self-rated health and greater depressive symptoms compared with individuals in the low-decreasing life stress trajectory. This is consistent with the research showing that greater life event stress is associated with both mental and physical health problems (Phelan et al., 2010; Thoits, 2011). Interestingly, there was no association between the lifetime trajectories and other demographic factors including race, gender, education, marital status, and age. However, when examining the total number of life events, Black individuals reported more life events than did White individuals, consistent with previous research showing that Black individuals tend to report greater stress across the life span than White individuals and consistent with the Weathering Hypothesis (Geronimus et al., 2006; Williams et al., 2019).

Daily Stress Exposure as a Function of Lifetime Stress and Race

Individuals who experienced moderate levels of life event stress reported experiencing greater daily stress exposure than individuals in the low-decreasing life event stress group. This indicates that life event stress may generate more stress in daily life. This is consistent with the exposure reactivity model (Almeida, 2005) and a concept referred to as stress proliferation in the literature indicating that life events may lead individuals to experience more mundane daily stressors (Pearlin et al., 1997). These findings did not vary by race. We had expected the findings to be stronger among Black individuals due to greater lifetime stress and structural racism; however, it appears that the associations are similar for Black and White individuals.

Daily Stress Reactivity as a Function of Lifetime Stress and Race

This study revealed that daily cardiovascular health varied by daily stress exposure and the links between daily stress exposure and cardiovascular reactivity varied by life event stress and race. First, although life event stress did not predict HR, individuals who reported greater daily stress exposure within a 3-hr period also had a higher HR in those 3-hr periods. This is in line with the exposure reactivity model and research showing that daily stress has a greater impact on daily well-being than stressful life events (Almeida, 2005). This may be because these types of stressors occur more frequently and may accumulate over time (Lazarus, 1999).

Life event trajectories moderated the link between daily stress exposure and HR differently among Black individuals and White individuals. For Black individuals in the low-decreasing life event trajectory, those experiencing a greater number of daily stressful events within a 3-hr period had a higher HR in the same 3-hr period (i.e., greater reactivity). In contrast, there was no link between daily stress and HR among Black individuals in the moderate-increasing life event trajectory (i.e., blunted reactivity). These findings are consistent with the Weathering Hypothesis that suggests that greater lifetime stress is associated with dysregulated stress response particularly among Black individuals due to a lifetime of structural racism (Geronimus et al., 2006). It is also possible that this finding is consistent with the concept of resilience which suggests that moderate amounts of stress may be protective whereas experiencing no stress or high stress may be harmful (Seery et al., 2013). Moderate levels of lifetime stress may teach individuals to more effectively respond to daily stress. However, because we found that the moderate-increasing class was also exposed to more daily stress, and had poorer overall well-being, the findings appear to be more consistent with weathering.

Among White individuals in the moderate-increasing life event trajectory, greater daily stress exposure within a 3-hr period was associated with greater HR in that same 3-hr period (albeit marginally), whereas there was no significant link between daily stress and HR among White individuals in the low-decreasing life event trajectory. Thus, the findings for White individuals were consistent with exposure reactivity model and sensitivity hypothesis, which suggests that greater stress exposure over the life course increases sensitivity to stress exposure and its negative effects on well-being (Hammen et al., 2000). The fact that the findings were in the opposite direction for Black and White individuals may provide some clues as to why there are inconsistent findings in the literature regarding the implications of life event stress for stress reactivity. Individuals may develop different ways of responding to stress based on their life experiences and these findings may in part be due to variations in structural racism. Black individuals may experience greater wear and tear on their physiological stress response due to greater stress across the life course leading to blunted reactivity. Indeed, research shows that early life stress exposure is often associated with later blunted stress reactivity (Lovallo et al., 2019).

It is also important to note that the findings remained the same after controlling for several psychosocial factors including discrimination, emotional support, and health behaviors. Interestingly the findings varied somewhat when controlling for coping. Participants were asked the extent to which they kept their emotions to themselves and tried to control feelings by thinking about something else every 3 hr. When these were included in the model we found that life event trajectories no longer predicted daily stress exposure and that the links between life event trajectories, daily stress, and race predicting HR became marginal. Interestingly, Black individuals and individuals who experienced greater stress across the life course were more likely to use these strategies which were also associated with greater daily stress exposure and HR. Thus, consistent with previous research, coping may represent an important factor to consider when understanding links between cumulative life event stress and daily stress processes (Birditt et al., 2014; Gross & John, 2003). This also is a key finding as coping may represent a potentially modifiable risk factor for targeted interventions.

Limitations and Future Directions

There are several limitations to this study that should be addressed in future research. This study focused on life event stress that does not include the entire range of stressful events that individuals experience. One important limitation is that we did not include lifetime discrimination because it was only available in the 2015 and 2018 waves. Further, this study did not include other important sources of stress including early childhood trauma experiences (Montez & Hayward, 2014) or neighborhood stress both of which have important health implications (Robinette et al., 2021). The study includes four unevenly spaced waves and may not include important events that occurred between waves. Further, the daily study was conducted with White and Black individuals who were matched on demographics, potentially reducing some of the disparities typically found in the literature. We also have unmeasured variables that may moderate the associations including personality characteristics (e.g., neuroticism, cynicism, and optimism; Bolger & Zuckerman, 1995). Indeed, research has shown that low cynicism and high optimism are associated with greater reactivity (Richman et al., 2007).

Overall, this study makes an important contribution to the literature by examining how long-term life event stress exposure and daily stress exposure are associated with daily cardiovascular health. This study demonstrates that while greater life event stress was associated with greater cardiovascular stress reactivity among White individuals, it was associated with blunted stress reactivity among Black individuals. These conclusions provide some insight into the contrasting findings in the literature regarding the effects of stress on cardiovascular reactivity, indicating that the associations vary in important ways by race.

Supplementary Material

Supplementary data are available at *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences* online.

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Conflict of Interest

None declared.

Author Contributions

K. S. Birditt planned the study, supervised the data analysis, and wrote the first draft of the paper. A. Turkelson performed all statistical analyses and contributed to revising the paper. S. Javaid assisted with data collection, data analysis, and revising the paper. R. Gonzalez assisted with the supervision of data analysis and revisions of the paper. T. Antonucci is the PI on the longitudinal Social Relations study and contributed to revisions of the paper.

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