Health Psychology

© 2021 American Psychological Association
ISSN: 0278-6133

2021, Vol. 40, No. 5, 316–325
https://doi.org/10.1037/hea0001067

Cardiovascular and Cortisol Responses to Experimentally-Induced Minority Stress

David M. Huebner[1], Larissa A. McGarrity[2], Nicholas S. Perry[3], Leigh A. Spivey[4], and Timothy W. Smith[5]

[1] Department of Prevention and Community Health, George Washington University
[2] Department of Physical Medicine and Rehabilitation, University of Utah
[3] Alpert Medical School, Brown University
[4] Department of Psychology, University of North Carolina, Chapel Hill
[5] Department of Psychology, University of Utah

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

Objective: Lesbian, gay, and bisexual (LGB) individuals who report greater minority stress (e.g., discrimination) are at an elevated risk for multiple health problems. However, few studies have examined physiological mechanisms that might link minority stress to health. This study tested how cardiovascular and cortisol responses to a laboratory-induced social stressor differed when that stressor contained an additional minority stress component. ***Method:*** LGB adults (n = 141; 51% male, 49% female) participated in a social stress task in which they were interviewed by a prerecorded confederate. Participants were randomized to receive information that their interviewer held either antigay or progay social/political beliefs. Cardiovascular reactivity and salivary cortisol were assessed at baseline, during the task, and during recovery. ***Results:*** All participants experienced significant task-related increases in heart rate (HR), systolic blood pressure (SBP), and diastolic blood pressure (DBP). However, participants in the antigay condition had greater increases in HR and SBP during the task and smaller decreases in SBP during recovery. Salivary cortisol increased significantly only in the antigay condition. High frequency heart rate variability (hfHRV) was constant throughout the stress task for participants in the progay condition but decreased significantly during the task for participants in the antigay condition. ***Conclusions:*** Minority stress has the potential to affect LGB individuals' health through cardiovascular and endocrine mechanisms. Moreover, its physiological signature may differ from other social stress in ways that have implications for health and emotion regulation more broadly.

Keywords: lesbian, gay, psychophysiology, minority stress, cardiovascular reactivity

For the past several decades, researchers have documented mental and physical health disparities experienced among lesbian, gay, and bisexual (LGB) individuals (for reviews, see Institute of Medicine, 2011; National Academies of Sciences, Engineering, and Medicine, 2020). It is now well established that LGB individuals suffer disproportionately from a variety of health problems, and both theoretical and empirical work suggests that these increased risks are likely attributable to experiences of discrimination and other minority stressors (for a review, see Lick et al., 2013). More recently, a relatively small group of researchers have begun incorporating physiological measurements into their exploration of these phenomena, with the aim of examining possible mechanisms underlying now well-documented health disparities (Flentje et al., 2019). However, the results of this emerging work examining physiologic markers of health has been much more mixed.

Research Comparing Physiology in LGB to Heterosexual Individuals

One category of research examining physiological outcomes are comparative studies that explore whether LGB individuals, when compared to heterosexuals, have more physiological markers of poorer health. For example, utilizing a nationally representative sample of 6,973 young adults, Hatzenbuehler and colleagues (2014) found that gay and bisexual men had higher levels of various cardiometabolic risk factors relative to heterosexual men, although they observed no differences by sexual orientation among women. Another study examining physiologic markers of

David M. Huebner https://orcid.org/0000-0001-6006-5146

This research was supported by a Presidential Scholar Award from the University of Utah to the first author.

David M. Huebner concieved the study together with Timothy W. Smith and Larissa A. McGarrity. David M. Huebner conducted the analyses and drafted the manuscript. Larissa A. McGarrity (who was not mentioned in the existing text) also lead the administration of the project and contributed a supporting role to writing-review and editing. Nicholas S. Perry contributed a supporting role to project administration and to writing-review and editing. Leigh A. Spivey contributed a supporting role for writing-review and editing. Timothy W. Smith (in addition to co-conceiving the study), contributed a supporting role to writing-review and editing, and also to supervision.

Correspondence concerning this article should be addressed to David M. Huebner, Department of Prevention and Community Health, George Washington University, 950 New Hampshire Avenue NW, 3rd floor, Washington, DC 20052, United States. Email: davidhuebner@gwu.edu

allostatic load among 12,969 adults revealed that bisexual men had some poorer physiological health indicators (higher A1c and systolic blood pressure), relative to heterosexual men (Mays et al., 2018). However gay men had fewer overall physiological indicators of high allostatic load than heterosexual men. As with the younger sample, no differences were observed among women. Finally, one study of diurnal cortisol patterns among 1,670 young adults found no differences by sexual orientation for either men or women (Austin et al., 2016).

Findings on allostatic load and cortisol obtained in these large, national data sets closely parallel the results from work conducted by Juster and colleagues in which a convenience sample of 87 Canadian adults received extensive assessments of physiologic indicators of health (Juster et al., 2013, 2015, 2016, 2019). They found that gay and bisexual men, but not lesbian or bisexual women, had lower scores on a comprehensive measure of allostatic load, relative to heterosexuals, but that there were no differences by sexual orientation for men or women in overall daily cortisol output (Juster et al., 2013). Participants' physiologic responses to the Trier Social Stress Test (Kirschbaum et al., 1993) revealed that lesbian and bisexual women had higher cortisol reactivity and marginally higher mean arterial blood pressure compared to heterosexual women (Juster et al., 2015, 2019). Gay men had lower cortisol levels throughout the testing period (unrelated to task reactivity) and higher heart rate reactivity to the task compared to heterosexual men (Juster et al., 2015, 2019).

To summarize, extant research finds little evidence of sexual orientation disparities in tonic physiologic health indicators among women and some mixed evidence in men. Emerging research from one study of physiologic reactivity to a social stressor revealed no clear pattern (Juster et al., 2015, 2019) but suggested that some markers of reactivity may be higher for LGB individuals, whereas other markers are lower or no different.

Within-Group Research on Correlates of Health-Relevant Biomarkers in LGB Individuals

In addition to these studies exploring differences between LGB and heterosexual individuals in physiologic outcomes, a small number of studies have focused within sexual minority populations and examined how stress or support predict physiologic outcomes. One study of 77 young LGB individuals found that those raised in states with less favorable laws for LGB people had less cortisol reactivity to the Trier Social Stress Test (Hatzenbuehler & McLaughlin, 2014). However, a separate analysis of the same data showed that LGB individuals with more family support also had a lower cortisol response (Burton et al., 2014), raising the question of which kind of cortisol response (higher or lower) was more adaptive in this population. A different study of 62 LGB young adults examined diurnal cortisol patterns and found that individuals who reported more LGB identity stress had a flatter slope from waking to evening, indicating greater overall cortisol output over the course of the day (Parra et al., 2016). Finally, three studies examining disclosure of sexual orientation found mixed associations with cortisol. In a study of 73 gay and bisexual men, Huebner and Davis (2005) found that men who were more open about their sexual orientations at work had higher levels of salivary cortisol throughout a workday compared to men who were more closeted. In contrast, a study of 58 LGB men and women found that greater disclosure overall and greater disclosure to family were both associated with reduced cortisol output throughout a typical day (Manigault et al., 2018). Finally, a subgroup analysis of 43 LGB individuals from a larger study found that participants who had disclosed their sexual orientations had lower waking levels of salivary cortisol, relative to those who had not disclosed (Juster et al., 2013). Thus, similar to the literature looking at physiological differences between sexual orientation groups, studies looking within LGB samples for associations between various naturally occurring minority stressors and physiology (all cortisol) also reveal few clear patterns.

Present Study

The present study is grounded broadly in minority stress theory (Meyer 2003), together with models that articulate the ways in which individuals' physiological responses to threatening and/or challenging situations can influence their physical health (O'Connor et al., 2021). Minority stress theory posits that LGB individuals are exposed to a variety of "distal" stressors unique to their status as a stigmatized minority (e.g., exposure to prejudicial attitudes, experiences of discrimination) and that these activate "proximal" stress processes within individuals (e.g., expectations of rejection, a desire to conceal sexual orientation), and together these accumulate to affect health.

Considering the specific nature of these minority stressors, a number of physiological reactions might be expected based on models of physiological stress responses generally (Brosschot et al., 2017) and responses to social stressors in particular (Slavich, 2020). Broadly, perceptions of social situations as challenging, or requiring effort to influence others, increase heart rate and blood pressure (Seery, 2013). More specifically, social-evaluative threat involving possible negative judgments by others also increases blood pressure and heart rate (Bosch et al., 2009) and appears to be particularly salient in producing cortisol responses (Dickerson & Kemeny, 2004). Such threats can be based on "undesirable characteristics or identities (e.g., stigmatizing conditions)" (Dickerson, 2008, p. 1363). Both the possibility of rejection (i.e. loss of acceptance or inclusion) and devaluation (i.e. loss of status) can also evoke this combination of cardiovascular and neuroendocrine reactivity (Smith & Jordan, 2015). Perceptions of social situations as unsafe or threatening commonly produce parasympathetic withdrawal (Brosschot et al., 2016; 2017; Porges, 2003), measured as a decrease in vagally-mediated heart rate variability (e.g., high-frequency heart rate variability). Lower parasympathetic activity can contribute to adverse health outcomes directly and can potentiate sympathetically-mediated cardiovascular and neuroendocrine reactivity (Brosschot et al., 2017). Thus, several components of the minority stress experience likely produce physiological stress responses.

Given these theoretical links between minority stress and physiology, it is surprising that previous studies have not shown more consistent associations between sexual orientation, sexual orientation-related stress, and physiological outcomes. This might be due to the fact that the observational methods employed by most existing research make it difficult to control for confounding variables. For example, in explaining why gay men had lower allostatic load than heterosexual men, Mays et al. (2018) noted that several of their indicators of allostatic load were sensitive to body weight. The authors suggested that social pressures within the gay male community to maintain physical fitness might result in fewer men showing evidence of high allostatic load, despite the probability

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

that they do experience greater social stress than their heterosexual peers. Assessing discrimination-related stress is itself a challenge, as it requires participants to recall and reflect on events (e.g., receiving poor service at a restaurant) and then determine whether the event was the result of discrimination or some other cause (Crocker et al., 1991). If discrimination occurs but is not recognized or reported by an individual, this itself can have negative health consequences. Indeed, a number of studies observe better health outcomes among individuals who acknowledge experiencing some discrimination, relative to those who deny any at all (Huebner & Davis, 2007; Krieger & Sidney, 1996, 1997). This suggests that the subjectivity inherent in self-reports of discrimination can confound its association with health. Finally, findings from previous research might be unclear simply because LGB health disparities may not be mediated by physiological stress responses but rather by other factors, such as mental health or health behaviors (e.g., greater substance use or less preventive screening).

Experimental designs can address some of the challenges confronting existing observational research on these phenomena. By manipulating exposure to some element of minority stress and examining subsequent changes in physiology, an experimental paradigm has the potential to reduce the impact of confounders, eliminate the subjectivity in reports of discrimination-related stress, and thereby make a clearer case for the impact of that stress on physiological outcomes. For example, research looking at the effects of race-related stress has utilized experimental paradigms to uncover a host of physiological sequalae of racism (for reviews, see Berger & Sarnyai, 2015; Harrell et al., 2003). We are aware of no previous study that has utilized such methods with LGB individuals.

The present study utilized an experimental paradigm in which we exposed participants to a social evaluative stressor task that either did or did not include an additional sexual minority stress element. We then explored changes in blood pressure, heart rate, heart rate variability, and salivary cortisol. We selected these outcomes because of their well-documented responsivity to psychological stressors and their associations with subsequent health (Lovallo, 2015; Lovallo & Buchanan, 2017; Smith et al., 2020). We hypothesized that exposure to social evaluative stress would result in increases in blood pressure, heart rate, and cortisol and decreases in high frequency heart rate variability and that these changes would be more pronounced in the condition with minority stress, suggesting an additive effect of minority stress on physiological stress responses.

Method

Participants

Participants were recruited through targeted Facebook advertising and by contacting individuals who had expressed interest in participating in research at the local LGBT pride festivals. To be eligible for the study, participants had to be between the ages of 18–60 and identify their sexual orientation as gay, lesbian, bisexual, or queer. Individuals identifying as bisexual or queer were asked additional screening questions and were included if they either indicated that their most recent romantic partner was of the same-sex or that their current sexual attractions were greater toward individuals of the same sex than the opposite sex.[1] Participants were excluded if they had a history of cardiovascular disease, were allergic to electrodes, bandages, or other adhesives, or were taking medication likely to impact cardiovascular function or cortisol response (e.g., cardiovascular medications, steroids, benzodiazepines). In total 141 participants screened into the study. Seven participants were removed from analyses because they indicated significant suspicion about the manipulation prior to debriefing (four from the antigay condition and three from the progay condition). The final analytic sample included 134 individuals (69 in the antigay condition, 65 in the progay condition).

Participants ranged in age from 18–58 years (M = 25.8, *SD* = 7.0) and were predominately White (85%). Sex assigned at birth was 51% male and 49% female; five participants reported currently identifying their gender as something other than their sex assigned at birth. Most self-identified their sexual orientation as "gay" (52%) or "lesbian" (34%), with smaller percentages identifying as "bisexual" (8%) or some other nonheterosexual identity (7%). Forty-two percent had a college education or higher, and 50% reported annual household income of less than $35,000.

Procedures

The University of Utah IRB approved all study procedures. The study was carried out in 2015. During screening participants were led to believe that they were being assessed for two separate studies: (a) a brief, online survey study about LGB individuals' childhood and adult experiences and (b) a lab-based study about the health effects of social interactions between diverse individuals, for which anyone was eligible, regardless of sexual orientation. We framed the studies as separate so that information relevant to participants' sexual orientations could be collected without revealing that the actual focus of the laboratory study was also on the effects of LGB minority stress. In reality, participants had to agree to complete both studies to be enrolled. Individuals who agreed to participate first completed the online questionnaire, lasting 30–45 minutes and then were subsequently scheduled for the laboratory session. Data from the two studies were linked with unique participant identifiers.

Procedures for the laboratory portion of the study were adapted from our team's previous work utilizing similar tasks to elicit and study stress responses among healthy individuals (Cundiff et al., 2016). Participants were instructed to avoid eating, drinking (other than water), exercising, or smoking for two hours prior to arrival. Participants arrived at the laboratory and were informed that they were the first of two participants to arrive and that they would each be seated in separate adjacent rooms. In reality there was no second participant, only a gender-matched, prerecorded confederate. The participant was escorted to their room, seated, and told that the purpose of the study was "to examine how diverse individuals interact

[1] Pilot work revealed that some individuals who identifyied as "bisexual" or "queer" did so in the absence of any significant same-sex romantic experience or current attractions. For example, one middle-aged pilot participant was currently heterosexually married for over 10 years. Because this was the first application of our paradigm to this population, we had concerns about the capacity for our manipulation to generate stress in individuals whose sexual identity label was based strictly on historic attractions or experiences, or whose recent everyday lives were indistinguishable from individuals with a heterosexual identity. Thus, individuals reporting a bisexual or queer identity were included only if they reported significant same-sex attraction, or a recent same-sex relationship.

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

and evaluate one another in interview situations, and how those interactions affect health." They then completed written informed consent.

Participants next completed a series of neuropsychological tests lasting approximately 10–15 minutes. We have separately published the effects of our experimental manipulation on cognitive outcomes (McGarrity et al., 2020), and as such, they will not be reported further here. Electrodes and a blood pressure cuff were attached to participants and tested for correct function. Participants then did a 10-minute minimally engaging baseline task that involved looking at pairs of nature photographs and selecting which was more appealing (e.g., Smith et al., 2000). After this baseline task, participants completed initial measures of state affect.

A research assistant next explained that participants would be engaging in a social interaction task in which one person would be assigned to the role of interviewer and one to the role of interviewee. The interviewer would ask the interviewee a series of four prespecified questions and based on their answers would evaluate the interviewee's intelligence, competence, and likeability. These evaluative domains were chosen because they produce significant physiological responses (Smith & Jordan, 2015). The interviewee was instructed to disclose as much or little personal information about themselves as they wanted. Participants were told that they were separated from their interaction partner in a different room so that attractiveness and other visual cues would not affect the results, but that they would meet their interaction partner at the end of the task. A sham lottery was then conducted in which the participant was always assigned to the role of interviewee.

To experimentally manipulate whether the interviewer held antigay or progay attitudes, the research assistant provided participants with a "Q&A" form, ostensibly completed by their interaction partner. Participants were instructed to read over the form so they would "have some information about the person about to interview them." The form contained four typewritten questions, and corresponding handwritten answers to the questions. The final question asked, "What are one or two political issues that you are passionate about? What is your position on those issues and why?" Exposure to antigay attitudes was manipulated by varying responses to this question. In the antigay condition, the response read, "As a straight person, I hope that increased support for gay marriage does not lead to more rights in other areas for gay people, such as teaching in schools. It's not a healthy lifestyle that we want to promote." In the progay condition, it read, "Even though I'm straight, I hope that increased support for gay marriage leads to more rights in other areas for gay people, such as teaching in schools. It's good to promote diversity." The remaining questions asked about neutral topics (e.g., hobbies) and had identical responses across conditions. All other participant experiences were identical across conditions (e.g., the same gender-matched confederate recording was used for participants across conditions). Research assistants were blind to participant condition.

After the manipulation, participants were given more explicit instructions for the interview task (for details, see McGarrity et al., 2020), which generally involved the prerecorded confederate asking a question, followed by a 90-s period in which the participant spoke their response into a microphone, followed by a 90-s period in which the participant remained silent and prepared their answer to the next question while the interviewer ostensibly evaluated the participant's last response. This question-answer sequence proceeded for four rounds.

Participants then spent 5–10 minutes completing immediate posttask questionnaires (e.g., state affect) and physiology readings during the first five-minutes of this period functioned as the recovery assessment. A posttask cognitive battery was administered. Participants next completed items checking for manipulation effectiveness and were questioned verbally to assess suspicion of the manipulation. Finally, participants were thoroughly debriefed, provided with $75 compensation, and dismissed.

Measures

Participant Characteristics

Participants self-reported their age, race/ethnicity, income, and education. Body mass index (BMI) was calculated from self-reported height and weight.

Cardiovascular Reactivity

Using a Critikon Dinamap occillometric monitor (model 100), mean systolic (SBP) and diastolic blood pressure (DBP) readings were calculated for each epoch to increase the reliability of these assessments (Kamarck et al., 1992). Readings were taken every 60 seconds during the 10-minute baseline, and the last five readings were averaged to form baseline values. Readings were taken eight times during the discussion task, 30 seconds after the beginning of each 90-s speaking or listening turn. The participant took four turns speaking and four turns listening—speaking and listening were averaged separately. A MindWare Technologies 2000 D Impedance Cardiograph was used along with spot electrodes placed in the tetra polar configuration (Thayer et al., 2008), and raw electrocardiography (ECG) data were visually inspected for artifacts and abnormal beats (Berntson et al., 1990). Heart rate was calculated as the average of the continuous ECG readings across each of the resting, speaking, listening, and recovery periods. High-frequency heart rate variability (hfHRV) analysis software, Version 5.2 (MindWare Technologies, Gahanna, OH) was derived from the ECG data and defined as the range .15 to .40 Hz and analyzed as the natural log (ln) of the high-frequency power (ms2/Hz) and was similarly averaged across study periods.

Salivary Cortisol

Given the timing of salivary cortisol responses to psychosocial stressors (Dickerson & Kemeny, 2004), we collected samples immediately following the baseline task and 5 and 15 minutes after completion of the interview task (reflecting task cortisol and recovery cortisol, respectively). Samples were collected with Sarstedt cortisol salivettes, stored using standard procedures, and analyzed at the Technical University of Dresden using immunoassays (IBL-International) with well-documented sensitivity (.2 nmol/L), reliability (intra- and interassay coefficients of variation 5%), and validity (Miller et al., 2013).

Perceptions of Confederate/Manipulation Check

Once all study procedures and primary measures had been completed, participants responded to two series of questions to test manipulation effectiveness. Participants completed several single-

item face valid measures of their perceptions of the confederate's attitudes toward gay people (e.g., "How negatively does your interaction partner feel about gay people?"; with 5-point response scales). To assess participants' cognitive and emotional responses to the confederate, we administered a 32-item version of the Impact Message Inventory (IMI-C; Kiesler & Schmidt, 1983, 2006). The IMI-C assesses how an individual is perceived during an interaction along a series of eight related dimensions: dominant, hostile-dominant, hostile, hostile-submissive, submissive, friendly-submissive, friendly, and friendly-dominant. Cronbach's alphas in the present sample were good for all dimensions (<.76).

Analysis

Analyses were conducted using SPSS 26.0 for Windows. To test the effects of experimental condition on physiological outcomes, we conducted a series of repeated measures ANOVAs with time as a within-subjects factor (baseline, talk phase of the task, recovery) and condition (progay, antigay) as a between-subjects factor. Within these models, the linear main effect of time represents how much participants increased or decreased overall from baseline through the rest of the experiment (task and recovery averaged), and the quadratic (or curvilinear) effect of time represents the degree to which that measure curved or "peaked" from baseline to task to recovery, versus maintaining a constant slope. Consistent with previous research utilizing similar tasks, we expected physiological responses to increase from baseline to task and then decrease from task to recovery, which would be represented by a significant quadratic effect of time. To test our primary hypotheses that experimental condition would impact these overall patterns of response, we included interaction terms of condition with both the linear and quadratic effects of time. Significant interactions were then further probed with simple comparisons to identify the specific ways in which those overall patterns differed (i.e. within each condition, examining the differences between baseline and task, and baseline and recovery). Participant age, sex assigned at birth, and BMI were used as covariates in analyses of cardiovascular outcomes. Participant age, sex assigned at birth, and time of day were used as covariates in analysis of cortisol.

We used the same ANOVA frameworks to separately analyze cardiovascular outcomes during the waiting (nonspeaking) phases of the tasks, to test the possibility that differences in speech patterns across conditions might contribute to some effects. We report these results as footnotes only in cases where the findings differ substantively from those during the active (talking) portions of the task.

Results

Manipulation Check

Perception of Partner's Attitudes Toward LGB People

When asked in open-ended format what they remembered about their interaction partner from the information sheet, only 8 participants (6%) did not mention information about the confederate's position on gay rights. In close ended questions, participants in the antigay condition reported that their interaction partner held more negative attitudes toward gay people, $M = 3.6$ versus 1.2; $t(146) = 14.8$, $p < .001$, less positive attitudes toward gay people, $M = 1.8$ versus 2.8; $t(147) = -6.8$, $p < .001$, and that they had less interest in becoming friends with their interaction partner, $M = 1.9$ versus 4.0; $t(146) = -12.0$, $p < .001$.

Perception of Partner's Interpersonal Impact

A repeated measures ANOVA was conducted to determine if scores on each of the IMI-C dimensions differed as a function of experimental condition. Results revealed a significant condition by dimension interaction, $F(7, 120) = 5.18$, $p < .001$, indicating that the effect of condition on participants' perceptions of the confederate's interpersonal behavior differed across dimensions. Simple comparisons revealed that in the antigay condition, the confederate rated higher in hostility, hostile dominance, hostile submissiveness, and submissiveness and lower on friendliness (all ps $< .05$). No effects of condition were found for the other dimensions. These results suggest that participants' differing experience of the antigay and progay confederates extended to their perceptions of the confederate's interpersonal impact, despite the fact that confederate behavior was identical in each condition (i.e. both conditions utilized the exact same confederate recording).

Experimental Effects on Physiology

SBP

The two-way mixed effects ANOVA predicting SBP from time and condition revealed a significant quadratic effect for time, $F(1, 121) = 17.06$, $p < .001$, consistent with participants showing increases in SBP from baseline to task, and then a decrease in SBP to recovery. We also observed a significant condition by time interaction for the linear effect of time, $F(1, 121) = 4.06$, $p = .046$, indicating differences by condition in the overall degree of increase in SBP from baseline to task and recovery. Figure 1 illustrates this pattern. Analysis of simple effects revealed significant SBP increases from baseline to task for both conditions, with the antigay condition yielding a greater increase ($M_{diff} = 22.72$, 95% CI [19.75, 25.68]) than the progay condition ($M_{diff} = 18.78$, 95% CI [15.61, 21.95]). Ongoing differences in SBP from baseline to recovery were present for participants in the antigay condition ($M_{diff} = 7.00$, 95% CI [4.24, 9.76]) but not the progay condition ($M_{diff} = 2.85$, 95% CI [−.10, 5.74]).

DBP

The two-way mixed effects ANOVA predicting DBP from time and condition revealed a significant quadratic effect for time, $F(1, 210) = 26.03$, $p < .001$, consistent with task-related increases in DBP, followed by recovery. However, no interactions with condition were present, indicating that experimental condition did not alter the nature of DBP increase or recovery.

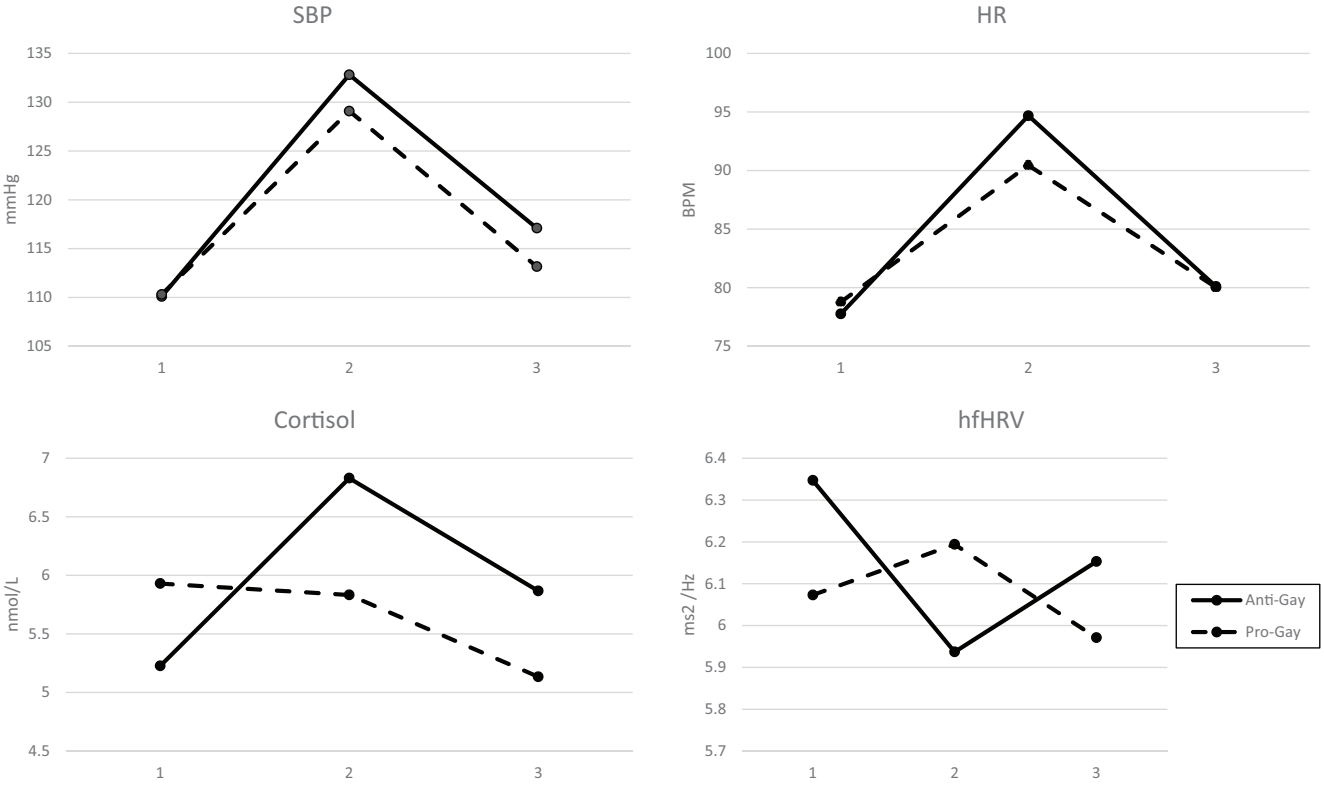
Heart Rate

The two-way mixed effects ANOVA predicting heart rate from time and condition revealed a significant quadratic effect for time, $F(1, 123) = 25.66$, $p < .001$, consistent with task-related increases in heartrate, followed by recovery. We also observed significant interactions by condition with the quadratic effect of time, $F(1, 123) = 8.39$, $p = .004$, indicating that the antigay group showed a different overall pattern of activation and recovery, relative to the progay group (see Figure 1). Simple effects tests indicated that participants in the progay condition had elevations in heart rate from

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

Figure 1

Systolic Blood Pressure (SBP), Heart Rate (HR), Cortisol, and High-Frequency Heart Rate Variability (hfHRV) Over Time by Experimental Condition



This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

baseline to task (M_{diff} = 11.66, 95% CI [9.10, 14.23]) and then recovered, but with some residual differences from baseline (M_{diff} = 1.24, 95% CI [.16, 2.32]). Participants in the antigay condition had larger increases in heartrate from baseline to task (M_{diff} = 16.88, 95% CI [14.41, 19.34]) and then also remained elevated over baseline at recovery (M_{diff} = 2.34, 95% CI [1.30, 3.37]).

hfHRV

The two-way mixed effects ANOVA predicting hfHRV from time and condition revealed no overall significant main effect of time across conditions at either the linear, $F(1, 123) = 2.04$, *ns*, or quadratic levels, $F(1, 123) = 1.07$, *ns*. However, there was a significant interaction of condition with the quadratic effect for time, $F(1, 123) = 9.43$, $p = .003$. This suggests a qualitatively different pattern of hfHRV response across the two experimental groups (see Figure 1). Simple effects analysis revealed that participants in the progay group maintained steady hfHRV across the study, with no significant increases from baseline to task (M_{diff} = −.12, 95% CI [−.36, .24]) or remaining differences from baseline to recovery (M_{diff} = −.10, 95% CI [−.24, .36]). However, in the antigay group, participants showed significant decreases in hfHRV from baseline to task (M_{diff} = −.41, 95% CI [−.64, −.18]) and that at recovery hfHRV still remained well below baseline (M_{diff} = −.19, 95% CI [−.33, −.06]). For hfHRV, results of analyses examining the waiting/thinking portion of the task differed somewhat from those examining the speaking portion of the task. For waiting/thinking, we observed a significant quadratic effect of time, $F(1, 123) = -5.02$, $p = .027$, consistent with increases in hfHRV from baseline to wait/think, and then subsequent decreases in hfHRV to recovery. However, there was no interaction with condition, suggesting that participants in both the antigay and progay group had similar patterns of hfHRV when they were in the waiting/thinking portion of the task.[2]

Cortisol

The two-way mixed effects ANOVA predicting cortisol from time and condition revealed a significant quadratic effect for time, $F(1, 127) = 4.26$, $p = .041$, which was qualified by an interaction with condition, $F(1, 127) = 4.12$, $p = .045$. In the progay group, participants showed no increases in cortisol from sample 1 (baseline) to sample 2 (5 minutes after task; M_{diff} = −.10, 95% CI [−1.12, 1.31]) or sample 3 (15 minutes after task; M_{diff} = −.80, 95% CI [−1.92, .33]). However, in the antigay group, participants' cortisol increased significantly from baseline to sample 2 (M_{diff} = 1.60, 95% CI [.44,

[2] For hfHRV, results of analyses examining the waiting/thinking portion of the task differed somewhat from those examining the speaking portion of the task. For waiting/thinking, we observed a significant quadratic effect of time, $F(1,123) = -5.02$, $p = 0.027$, consistent with increases in hfHRV from baseline to wait/think, and then subsequent decreases in hfHRV to recovery. However, there was no interaction with condition, suggesting that participants in both the anti-gay and pro-gay group had similar patterns of hfHRV when they were in the waiting/thinking portion of the task.

2.76]) and then recovered to levels similar to baseline by sample 3 (M_{diff} = .64, 95% CI [−.43, 1.72]; see Figure 1).[3]

Discussion

LGB individuals who engaged in a social-evaluative stressor task exhibited typical patterns of cardiovascular reactivity commonly observed in other studies of similar stressors (e.g., Cundiff et al., 2016; Smith & Jordan, 2015). However, when participants were interacting with an individual they believed to hold antigay attitudes, they had even greater SBP and heart rate reactivity to the task and were somewhat slower to recover on both measures, relative to participants who believed they were interacting with an individual who held progay attitudes. These findings are consistent with the idea that sexual-minority stress has an additive effect on cardiovascular reactivity, over and above the effects of typical social stressors. In contrast, cortisol responses were more notably different across minority stress conditions; individuals in the progay condition had no task-related elevations in cortisol, whereas individuals in the antigay condition did. Analyses of hfHRV revealed that individuals in the progay condition maintained steady hfHRV from baseline to task to recovery, whereas participants in the antigay condition had decreased hfHRV, consistent with vagal withdrawal in response to the stressor task.

These findings add to the extant body of knowledge regarding the possible effects of minority stress on LGB individual's physical health in several ways. Because virtually all previous research has been correlational in nature, it has been impossible to rule out alternate explanations for associations between LGB status, minority stress, and physical health (for example, that disparities are the result of comorbid health problems, such as HIV; that healthier individuals select more supportive environments; or that personality factors, such as neuroticism, confound self-reports of minority stress and health problems; for a review, see Lick et al., 2013). By experimentally manipulating exposure to minority stress and then observing objective physiological changes, our study addresses some of those concerns in the existing literature and documents a clear, causal link between minority stress and health-relevant physiological stress responses. It is notable that our experimental manipulation produced effects observable above and beyond the effects of an already stressful task. Moreover, our experimental manipulation was subtle—participants' experiences across conditions were virtually identical, differentiated only by information they received about the confederate in two hand-written sentences at the bottom of a long form. The fact that this subtle manipulation produced physiological differences in responses to an already significant stressor highlights the potential power for minority stress to impact health.

The nature of the stressor in the antigay condition could be characterized in two ways within Meyer's (2003) conceptualization of minority stress. First, reading the comment the confederate had written about gay marriage was a distal minority stressor—exposure to a prejudicial attitude. Once participants had this information about the confederate, they were then aware of the threat of discrimination in their interview and evaluation (a proximal minority stressor). Although our design makes it impossible to isolate which of those related phenomena operated to produce physiological responses, those forces are seldom uncoupled in the real world. Our goal in developing this experimental paradigm was to create a situation that had as much external validity as possible. Interviews and other social interactions with an evaluative component are relatively common. Moreover, sexual minority individuals commonly interact with individuals who might hold unsupportive attitudes toward LGBT issues in situations in which the threat of discrimination is ambiguous or subtle.

In that context, our study begins to identify mechanisms whereby minority stress might contribute to physical health problems. Elevations in blood pressure, heart rate, or cortisol can be adaptive short-term responses to stress, allowing individuals to meet the acute demands of challenging situations (Dienstbier, 1989; Seery, 2013). However, repeated exposures to such stress, and the attendant physiological changes that result, can accumulate to increase risk for cardiovascular disease, infectious disease, or perhaps even mortality (Chida & Steptoe, 2010; Cohen et al., 2002; Lovallo, 2015).

The fact that we observed different patterns of effects across physiological outcomes is notable. Whereas adding minority stress to a challenging interpersonal task had an additive effect on heart rate and blood pressure reactivity, it created a qualitatively different pattern for cortisol and hfHRV. Previous research has found that the degree of social evaluative threat present in a task is associated with the degree of cortisol reactivity (Dickerson & Kemeny, 2004). Despite the fact that participants in our study were told they were being evaluated for likeability, competence, and intelligence, we did not see a significant cortisol response when the interviewer was believed to hold progay attitudes but did when the evaluator held antigay attitudes. A number of possible explanations exist for this distinction. First, the degree of social evaluative threat present in our task might not have been large enough to elicit a cortisol response on its own, without the added presence of minority stress. Consistent with this notion, a separate study from our lab that manipulated the presence of the social evaluation during a similar stressor task found that cortisol was unresponsive to the manipulation of social evaluation alone (Cundiff et al., 2016). Rather, cortisol reactivity to our task was observed only when social evaluation was paired with certain personality characteristics in the confederate with whom participants interacted. In Dickerson's descriptive work about social-evaluative threat (Dickerson, 2008), she notes that this threat can arise from characteristics of a situation or because an individual in that situation possesses an undesirable or stigmatized characteristic that makes them more vulnerable to social judgment. Applied to our paradigm, it might be that our task only became stressful enough to produce a cortisol response when participants were confronted with the possibility that they could be negatively evaluated because of their LGB identity. An alternate explanation is that participants experienced something sufficiently supportive about the evaluator who expressed a progay belief to eliminate their cortisol responses to a task that would otherwise have elicited those responses. Although the interviewer exhibited no overtly supportive behaviors, the same recording was used across conditions, and

[3] An alternate approach to assessing cortisol effects involves examining the time-dependent change in total cortisol output over the experimental period (i.e. area under the curve increase; Pruessner et al., 2003). Utilizing this approach, we find the same pattern of results as reported in our primary analyses. Adjusting for age, sex, and time of day, individuals in the antigay condition report greater total cortisol output, relative to those in the pro-gay condition (M = 2649.30 vs. M = −446.05; $F(1, 126) = 4.01$, p = 0.047).

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

the expression of support for gay rights occurred before the interaction and before the confederate could have known anything about the participant's sexual orientation, the mere signal of support could be enough to increase the perceived safety of the situation, thereby reducing cortisol responses.

With regard to differences in hfHRV, we observed that participants in the progay condition completed the interview task while maintaining hfHRV, whereas participants in the antigay condition experienced significant decreases. hfHRV is of interest because it is an indicator of the degree to which the vagus nerve is exerting a parasympathetic inhibitory influence on the heart (Berntson et al., 1993; Porges, 2003). Theoretical and empirical research suggests that confronting threat or lack of safety decreases vagal influence (Brosschot et al., 2016, 2017). While this response can be adaptive, given that it results in an efficient short-term increase in cardiac output (for a review, see Smith et al., 2020), habitual withdrawal of vagally mediated parasympathetic influence might be associated with less well-regulated interpersonal or emotional responses (Beauchaine et al., 2019; Beauchaine & Thayer, 2015). In contrast, increasing or maintaining hfHRV in the face of challenge suggests that an individual is engaging in self-regulatory effort (Roos et al., 2017). Future research should explore the possibility that the threat of minority stress in an already challenging situation (e.g., an interview) might engage or disengage physiological systems that have the potential to alter how people respond not only physiologically in those situations, but also emotionally and behaviorally. Previous research with sexual minority individuals indicates that experiences of stigma are associated with self-reported challenges in emotion regulation, which are then associated with riskier health behaviors and poorer adjustment (Burton et al., 2018; Pachankis et al., 2015). Our findings point to a possible physiological mechanism underlying associations between minority stress and self-regulation.

While this experimental study of minority stress advances the literature in multiple ways, it also carries limitations. First, within an experimental framework, it is difficult to comprehensively test the effects of multiple forms of minority stress at once. Some forms of minority stress, such as internalized homophobia, may not be amenable to experimental manipulation. Other forms, such as exposure to overt discrimination, can be manipulated, but the benefits of doing so must be weighed against the risks of harming participants. However, future research might explore other avenues for experimentally testing the effects of other minority stressors. For example, research on racial discrimination has utilized exposure to film or audio clips, as well as imagery tasks, as a means of simulating exposure to discriminatory experiences and then subsequently tested the effects of these exposures on psychosocial and health outcomes (Gibbons et al., 2010; Neblett & Roberts, 2013). Future research should also explore whether other minority stressors (e.g., rejection sensitivity; internalized homophobia) interact with laboratory-induced minority stress to impact physiology. Another limitation of our experimental design was that we did not have a truly neutral condition, as participants interacted with a participant who wrote about an explicitly antigay or progay political belief. We did this because we conducted the study in a politically conservative state, in which an interaction partner who communicated no attitude about gay rights might fairly be assumed to hold some antigay sentiment. Thus, in order to ensure a difference in experience across conditions, we specified a progay attitude in the control condition. However, this raises the possibility that differences between the groups might have been driven by some perception of support from the progay confederate, rather than minority stress associated with the antigay confederate.

As with most experimental studies, we utilized a convenience sample, which can introduce biases and threats to generalizability. We recruited participants who were comfortable identifying as sexual minorities either online (via our Facebook advertisements) or at a Pride Festival, and thus, it is unclear to what extent our findings generalize to individuals who are less comfortable with their sexual orientation. Our sample was generally young, and predominately white, and non-Hispanic, consistent with the demographics of our region. Future research must examine how sexual minority stress impacts people of color, including how the intersectional nature of being both a sexual minority and a racial or ethnic minority creates unique forms of stress and resilience (Bowleg, 2008) and how those forces are associated with physiology. With respect to age, older individuals have been shown to exhibit greater reactivity in SBP and HfHRV and less HR reactivity in response to laboratory stressors (Uchino et al., 2005, 2010). Our models control for age to adjust for this reality, but if our sample was not skewed young, we might expect to see even greater effects for SBP and HfHRV and smaller effects on HR. Future research will be required to determine whether those age-related effects hold for the specific influences of minority stressors. Regarding gender, although the sample was gender balanced, we were not powered to detect gender differences. Some observational research suggests that associations between sexual minority status and physiology differ by the biological sex and/or gender of participants (Hatzenbuehler et al., 2014; Mays et al., 2018), and future experimental studies should explore that possibility as well. We also utilized confederates who were gender-matched to participants, and so we were unable to test the possible moderating effects of gender of an interaction partner. Finally, the field is only just beginning to appreciate the role of expanded biological and social conceptualizations of gender on stress and physiological reactivity (Mueller, et al., 2018; Valentine & Shipherd, 2018), and future research on both heterosexual and sexual minority samples must begin to integrate nonbinary conceptualizations of gender.

This study represents one of the first attempts to experimentally manipulate exposure to minority stress for LGB individuals and assess its impact on physiological responses. Thus, it provides some of the strongest evidence to date for a causal link between sexual minority stress and physiological mechanisms linked to health. It also adds to a small, but growing, literature on the physiological mechanisms whereby minority stress operates to produce health disparities. As our understanding of these phenomena evolves, an important next step will be to examine potentially modifiable moderators of associations between minority stress, physiology, and health, with an eye toward identifying potential targets for interventions to reduce the health impacts of minority stress.

References

Austin, S. B., Rosario, M., McLaughlin, K. A., Roberts, A. L., Gordon, A. R., Sarda, V., Missmer, S., Anatale-Tardiff, L., & Scherer, E. A. (2016). Sexual orientation and diurnal cortisol patterns in a cohort of U. S. young adults. *Psychoneuroendocrinology*, *69*, 197–208. https://doi.org/10.1016/j.psyneuen.2016.04.012

Beauchaine, T. P., Bell, Z., Knapton, E., McDonough-Caplan, H., Shader, T., & Zisner, A. (2019). Respiratory sinus arrhythmia reactivity across empirically based structural dimensions of psychopathology: A meta-analysis. *Psychophysiology*, *56*(5), Article e13329. https://doi.org/10.1111/psyp.13329

Beauchaine, T. P., & Thayer, J. F. (2015). Heart rate variability as a transdiagnostic biomarker of psychopathology. *International Journal of Psychophysiology*, *98*(2 Part 2), 338–350. https://doi.org/10.1016/j.ijpsycho.2015.08.004

Berger, M., & Sarnyai, Z. (2015). 'More than skin deep': Stress neurobiology and mental health consequences of racial discrimination. *Stress: The International Journal on the Biology of Stress*, *18*(1), 1–10. https://doi.org/10.3109/10253890.2014.989204

Berntson, G. G., Cacioppo, J. T., & Quigley, K. S. (1993). Cardiac psychophysiology and autonomic space in humans: Empirical perspectives and conceptual implications. *Psychological Bulletin*, *114*(2), 296–322. https://doi.org/10.1037/0033-2909.114.2.296

Berntson, G. G., Quigley, K. S., Jang, J. F., & Boysen, S. T. (1990). An approach to artifact identification: Application to heart period data. *Psychophysiology*, *27*(5), 586–598. https://doi.org/10.1111/j.1469-8986.1990.tb01982.x

Bosch, J. A., de Geus, E. J. C., Carroll, D., Goedhart, A. D., Anane, L. A., Veldhuizen van Zanten, J. J., Helmerhorst, E. J., & Edwards, K. M. (2009). A general enhancement of autonomic and cortisol responses during social evaluative threat. *Psychosomatic Medicine*, *71*(8), 877–885. https://doi.org/10.1097/PSY.0b013e3181baef05

Bowleg, L. (2008). When Black + lesbian + woman ≠ Black lesbian woman: The methodological challenges of qualitative and quantitative intersectionality research. *Sex Roles*, *59*(5–6), 312–325. https://doi.org/10.1007/s11199-008-9400-z

Brosschot, J. F., Verkuil, B., & Thayer, J. F. (2016). The default response to uncertainty and the importance of perceived safety in anxiety and stress: An evolution-theoretical perspective. *Journal of Anxiety Disorders*, *41*, 22–34. https://doi.org/10.1016/j.janxdis.2016.04.012

Brosschot, J. F., Verkuil, B., & Thayer, J. F. (2017). Exposed to events that never happen: Generalized unsafety, the default stress response, and prolonged autonomic activity. *Neuroscience and Biobehavioral Reviews*, *74*(Part B), 287–296. https://doi.org/10.1016/j.neubiorev.2016.07.019

Burton, C. L., Bonanno, G. A., & Hatzenbuehler, M. L. (2014). Familial social support predicts a reduced cortisol response to stress in sexual minority young adults. *Psychoneuroendocrinology*, *47*, 241–245. https://doi.org/10.1016/j.psyneuen.2014.05.013

Burton, C. L., Wang, K., & Pachankis, J. E. (2018). Does getting stigma under the skin make it thinner? Emotion regulation as a stress-contingent mediator of stigma and mental health. *Clinical Psychological Science*, *6*(4), 590–600. https://doi.org/10.1177/2167702618755321

Chida, Y., & Steptoe, A. (2010). Greater cardiovascular responses to laboratory mental stress are associated with poor subsequent cardiovascular risk status: A meta-analysis of prospective evidence. *Hypertension*, *55*(4), 1026–1032. https://doi.org/10.1161/HYPERTENSIONAHA.109.146621

Cohen, S., Hamrick, N., Rodriguez, M. S., Feldman, P. J., Rabin, B. S., & Manuck, S. B. (2002). Reactivity and vulnerability to stress-associated risk for upper respiratory illness. *Psychosomatic Medicine*, *64*(2), 302–310. https://doi.org/10.1097/00006842-200203000-00014

Crocker, J., Voelkl, K., Testa, M., & Major, B. (1991). Social stigma: The affective consequences of attributional ambiguity. *Journal of Personality and Social Psychology*, *60*(2), 218–228. https://doi.org/10.1037/0022-3514.60.2.218

Cundiff, J. M., Smith, T. W., Baron, C. E., & Uchino, B. N. (2016). Hierarchy and health: Physiological effects of interpersonal experiences associated with socioeconomic position. *Health Psychology*, *35*(4), 356–365. https://doi.org/10.1037/hea0000227

Dickerson, S. S. (2008). Emotional and physiological responses to social-evaluative threat. *Social and Personality Psychology Compass*, *2*(3), 1362–1378. https://doi.org/10.1111/j.1751-9004.2008.00095.x

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

Dienstbier, R. A. (1989). Arousal and physiological toughness: Implications for mental and physical health. *Psychological Review*, *91*(1), 84–100. https://doi.org/10.1037/0033-295X.96.1.84

Flentje, A., Heck, N. C., Brennan, J. M., & Meyer, I. H. (2019). The relationship between minority stress and biological outcomes: A systematic review. *Journal of Behavioral Medicine*, *43*, 673–694. https://doi.org/10.1007/s10865-019-00120-6

Gibbons, F. X., Etcheverry, P. E., Stock, M. L., Gerrard, M., Weng, C.-Y., Kiviniemi, M., & O'Hara, R. E. (2010). Exploring the link between racial discrimination and substance use: What mediates? What buffers? *Journal of Personality and Social Psychology*, *99*(5), 785–801. https://doi.org/10.1037/a0019880

Harrell, J. P., Hall, S., & Taliaferro, J. (2003). Physiological responses to racism and discrimination: An assessment of the evidence. *American Journal of Public Health*, *93*(2), 243–248. https://doi.org/10.2105/AJPH.93.2.243

Hatzenbuehler, M. L., & McLaughlin, K. A. (2014). Structural stigma and hypothalamic–pituitary–adrenocortical axis reactivity in lesbian, gay, and bisexual young adults. *Annals of Behavioral Medicine*, *47*(1), 39–47. https://doi.org/10.1007/s12160-013-9556-9

Hatzenbuehler, M. L., Slopen, N., McLaughlin, K. A., & McLaughlin, K. A. (2014). Stressful life events, sexual orientation, and cardiometabolic risk among young adults in the United States. *Health Psychology*, *33*(10), 1185–1194. https://doi.org/10.1037/hea000012610.1037/hea0000126.supp

Huebner, D. M., & Davis, M. C. (2005). Gay and bisexual men who disclose their sexual orientations in the workplace have higher workday levels of salivary cortisol and negative affect. *Annals of Behavioral Medicine*, *30*(3), 260–267. https://doi.org/10.1207/s15324796abm3003_10

Huebner, D. M., & Davis, M. C. (2007). Perceived anti-gay discrimination and physical health outcomes. *Health Psychology*, *26*(5), 627–634. https://doi.org/10.1037/0278-6133.26.5.627

Institute of Medicine. (2011). The health of lesbian, gay, bisexual, and transgender people: Building a foundation for better understanding. The National Academies Press.

Juster, R.-P., Doyle, D. M., Hatzenbuehler, M. L., Everett, B. G., DuBois, L. Z., & McGrath, J. J. (2019). Sexual orientation, disclosure, and cardiovascular stress reactivity. *Stress: The International Journal on the Biology of Stress*, *22*(3), 321–331. https://doi.org/10.1080/10253890.2019.1579793

Juster, R.-P., Hatzenbuehler, M. L., Mendrek, A., Pfaus, J. G., Smith, N. G., Johnson, P. J., Lefebvre-Louis, J.-P., Raymond, C., Marin, M.-F., Sindi, S., Lupien, S. J., & Pruessner, J. C. (2015). Sexual orientation modulates endocrine stress reactivity. *Biological Psychiatry*, *77*(7), 668–676. https://doi.org/10.1016/j.biopsych.2014.08.013

Juster, R.-P., Smith, N. G., Ouellet, É., Sindi, S., & Lupien, S. J. (2013). Sexual orientation and disclosure in relation to psychiatric symptoms, diurnal cortisol, and allostatic load. *Psychosomatic Medicine*, *75*(2), 103–116. https://doi.org/10.1097/PSY.0b013e3182826881

Juster, R.-P., Ouellet, É., Lefebvre-Louis, J.-P., Sindi, S., Johnson, P. J., Smith, N. G., & Lupien, S. J. (2016). Retrospective coping strategies during sexual identity formation and current biopsychosocial stress. *Anxiety, Stress, and Coping*, *29*(2), 119–138. https://doi.org/10.1080/10615806.2015.1004324

Kamarck, T. W., Jennings, J. R., Debski, T. T., Glickman-Weiss, E., Johnson, P. S., Eddy, M. J., & Manuck, S. B. (1992). Reliable measures of behaviorally-evoked cardiovascular reactivity from a PC-based test battery: Results from student and community samples. *Psychophysiology*, *29*(1), 17–28. https://doi.org/10.1111/j.1469-8986.1992.tb02006.x

Kiesler, D. J., & Schmidt, J. A. (1983). *The impact message inventory: Form IIA octant scale (IMI-C) version.*

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

Kiesler, D. J., & Schmidt, J. A. (2006). *Manual for the impact message inventory-circumplex (IMI-C)*.

Kirschbaum, C., Pirke, K. M., & Hellhammer, D. H. (1993). The 'Trier social stress test'—a tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology*, *28*(1–2), 76–81. https://doi.org/10.1159/000119004

Krieger, N., & Sidney, S. (1996). Racial discrimination and blood pressure: The CARDIA study of young Black and White adults. *American Journal of Public Health*, *86*(10), 1370–1378. https://doi.org/10.2105/ajph.86.10.1370

Krieger, N., & Sidney, S. (1997). Prevalence and health implications of anti-gay discrimination: A study of black and white women and men in the cardia cohort. *International Journal of Health Services*, *27*(1), 157–176. https://doi.org/10.2190/HPB8-5M2N-VK6X-0FWN

Lick, D. J., Durso, L. E., & Johnson, K. L. (2013). Minority stress and physical health among sexual minorities. *Perspectives on Psychological Science*, *8*(5), 521–548. https://doi.org/10.1177/1745691613497965

Lovallo, W. R. (2015). Can exaggerated stress reactivity and prolonged recovery predict negative health outcomes? The case of cardiovascular disease. *Psychosomatic Medicine*, *77*(3), 212–214. https://doi.org/10.1097/PSY.0000000000000173

Lovallo, W. R., & Buchanan, T. W. (2017). Stress hormones in psychophysiological research: Emotional, behavioral, and cognitive implications. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson (Eds.), *Handbook of psychophysiology* (4th ed., pp. 465–494). Cambridge University Press.

Manigault, A. W., Figueroa, W. S., Hollenbeck, C. R., Mendlein, A. E., Woody, A., Hamilton, K. R., Scanlin, M. C., Johnson, R. C., & Zoccola, P. M. (2018). When family matters most: A test of the association between sexual minority identity disclosure context and diurnal cortisol in sexual minority young adults. *Psychosomatic Medicine*, *80*(8), 717–723. https://doi.org/10.1097/PSY.0000000000000625

Mays, V. M., Juster, R.-P., Williamson, T. J., Seeman, T. E., & Cochran, S. D. (2018). Chronic physiologic effects of stress among lesbian, gay, and bisexual adults: Results from the National Health and Nutrition Examination Survey. *Psychosomatic Medicine*, *80*(6), 551–563. https://doi.org/10.1097/PSY.0000000000000600

McGarrity, L. A., Huebner, D. M., Smith, T. W., & Suchy, Y. (2020). Minority stress, emotion regulation, and executive function: An experimental investigation of gay and lesbian adults. *Personality and Social Psychology Bulletin*, *46*(3), 365–376. https://doi.org/10.1177/0146167219855047

Meyer, I. H. (2003). Prejudice, social stress, and mental health in lesbian, gay, and bisexual populations: Conceptual issues and research evidence. *Psychological Bulletin*, *129*(5), 674–697. https://doi.org/10.1037/0033-2909.129.5.674

Miller, R., Plessow, F., Rauh, M., Groschl, M., & Kirschbaum, C. (2013). Comparison of salivary cortisol as measured by different immunoassays and tandem mass spectrometry. *Psychoneuroendocrinology*, *38*(1), 50–57. https://doi.org/10.1016/j.psyneuen.2012.04.019

Mueller, S. C., Wierckx, K., Boccadoro, S., & T'Sjoen, G. (2018). Neural correlates of ostracism in transgender persons living according to their gender identity: A potential risk marker for psychopathology? *Psychological Medicine*, *48*(14), 2313–2320. http://hdl.handle.net/1854/LU-8542002. https://doi.org/10.1017/S0033291717003828

National Academies of Sciences, Engineering, and Medicine. (2020). *Understanding the Well-Being of LGBTQI+ Populations*. The National Academies Press. https://doi.org/10.17226/25877

Neblett, E. W., Jr., & Roberts, S. O. (2013). Racial identity and autonomic responses to racial discrimination. *Psychophysiology*, *50*(10), 943–953. https://doi.org/10.1111/psyp.12087

O'Connor, D. B., Thayer, J. F., & Vedhara, K. (2021). Stress and health: A review of psychobiological processes. *Annual Review of Psychology*, *72*, 663–688. https://doi.org/10.1146/annurev-psych-062520-122331

Pachankis, J. E., Rendina, H. J., Restar, A., Ventuneac, A., Grov, C., & Parsons, J. T. (2015). A minority stress—Emotion regulation model of sexual compulsivity among highly sexually active gay and bisexual men. *Health Psychology*, *34*(8), 829–840. https://doi.org/10.1037/hea0000180

Parra, L. A., Benibgui, M., Helm, J. L., & Hastings, P. D. (2016). Minority stress predicts depression in lesbian, gay, and bisexual emerging adults via elevated diurnal cortisol. *Emerging Adulthood*, *4*(5), 365–372. https://doi.org/10.1177/2167696815626822

Porges, S. W. (2003). The polyvagal theory: Phylogenetic contributions to social behavior. *Physiology & Behavior*, *79*(3), 503–413.

Pruessner, J. C., Kirschbaum, C., Meinlschmid, G., & Hellhammer, D. H. (2003). Two formulas for computation of the area under the curve represent measures of total hormone concentration versus time-dependent change. *Psychoneuroendocrinology*, *28*(7), 916–931. https://doi.org/10.1016/s0306-4530(02)00108-7

Roos, L. E., Knight, E. L., Beauchamp, K. G., Berkman, E. T., Faraday, K., Hyslop, K., & Fisher, P. A. (2017). Acute stress impairs inhibitory control based on individual differences in parasympathetic nervous system activity. *Biological Psychology*, *125*, 58–63. https://doi.org/10.1016/j.biopsycho.2017.03.004

Seery, M. D. (2013). The biopsychosocial model of challenge and threat: Using the heart to measure the mind. *Social and Personality Psychology Compass*, *7*(9), 637–653. https://doi.org/10.1111/spc3.12052

Slavich, G. M. (2020). Socail safety theory: A biologically based evolutionary perspective on life stress, health, and behavior. *Annual Review of Clinical Psychology*, *16*, 265–295. https://doi.org/10.1146/annurev-clinpsy-032816-045159

Smith, T. W., Deits-Lebehn, C., Williams, P. G., Baucom, B. R. W., & Uchino, B. N. (2020). Toward a social psychophysiology of vagally mediated heart rate variability: Concepts and methods in self-regulation, emotion, and interpersonal processes. *Social and Personality Psychology Compass*, *14*(3), e12516. https://doi.org/10.1111/spc3.12516

Smith, T. W., & Jordan, K. D. (2015). Interpersonal motives and social-evaluative threat: Effects of acceptance and status stressors on cardiovascular reactivity and salivary cortisol response. *Psychophysiology*, *52*(2), 269–276. https://doi.org/10.1111/psyp.12318

Smith, T. W., Ruiz, J. M., & Uchino, B. N. (2000). Vigilance, active coping, and cardiovascular reactivity during social interaction in young men. *Health Psychology*, *19*(4), 382–392. https://doi.org/10.1037/0278-6133.19.4.382

Thayer, J. F., Hansen, A. L., & Johnsen, B. H. (Eds.). (2008). Noninvasive assessment of autonomic influences on the heart: Impedance cardiography and heart rate variability. Sage Publications.

Uchino, B. N., Birmingham, W., & Berg, C. A. (2010). Are older adults less or more physiologically reactive? A meta-analysis of age-related differences in cardiovascular reactivity to laboratory tasks. *The Journals of Gerontology: Series B*, *65B*(2), 154–162. https://doi.org/10.1093/geronb/gbp127

Uchino, B. N., Holt-Lunstad, J., Bloor, L. E., & Campo, R. A. (2005). Aging and cardiovascular reactivity to stress: Longitudinal evidence for changes in stress reactivity. *Psychology and Aging*, *20*(1), 134–143. https://doi.org/10.1037/0882-7974.20.1.134

Valentine, S. E., & Shipherd, J. C. (2018). A systematic review of social stress and mental health among transgender and gender-non-conforming people in the United States. *Clinical Psychology Review*, *66*, 24–38. https://doi.org/10.1016/j.cpr.2018.03.003

Received June 4, 2020
Revision received December 10, 2020
Accepted December 16, 2020 ■