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Capturing the cardiac effects of racial discrimination: Do the effects "keep going"?

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Abstract

Racial discrimination negatively impacts cardiac functioning, but few studies examine the more distal cardiac effects of racial discrimination experiences. The present study examined the momentary and prolonged impact of lab-based intergroup and intragroup racial discrimination on heart rate variability (HRV) and heart rate (HR) in a sample (N = 42) of African American (AA) women across two days. On day one, the women were exposed to simulated racial discrimination from either a European American (EA) or AA confederate in the lab. On day two, the women returned to the lab for additional physiological recording and debriefing. Women insulted by the EA confederate exhibited lower HRV on day one and marginally lower HRV on day two. These women also exhibited marginally higher HR on day two. The HRV and HR effects on day two were not mediated by differences in perseveration about the stressor. The findings indicate that racial discrimination – particularly intergroup racial discrimination – may have both momentary and prolonged effects on cardiac activity in AAs.

Keywords

Racial discrimination; Heart rate variability; Heart rate; Perseverative cognition; Ecologically valid approaches; African Americans

1. Introduction

A strong corpus of research documents the damaging effects of racial discrimination on African American (AA) mental and physical health. Racial discrimination has been associated with a host of negative outcomes, including elevated blood pressure and

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hypertension, increased heart rate (HR), decreased heart rate variability (HRV), and risk for cardiovascular diseases, cellular aging, and dysregulation of the HPA axis (Brondolo et al., 2008, 2011; Chae et al., 2014; Dorr et al., 2007; Hill et al., 2007; Paradies, 2006; Pascoe and Smart Richman, 2009; Williams and Mohammed, 2013). Yet, researchers have little understanding of the pathways through which racial discrimination contributes to changes in physiological systems and poorer health outcomes (Harrell et al., 2011).

Exaggerated "fight or flight" processes are initiated when AA individuals perceive that an event is racially discriminatory (Clark et al., 1999). While scholars note that these responses, governed largely by the sympathetic nervous system, may continue long after a racially discriminatory event occurs (Dorr et al., 2007; Harrell, 2000; Utsey et al., 2013), few studies examine the longer-term effects of racial discrimination (see Hoggard et al., 2015, for an exception). For instance, Dorr et al., 2007 found that AAs who inhibited their anger following a racist or nonracist debate with a European American (EA) confederate experienced delayed total peripheral resistance recovery during a 10-minute recording period. Conversely, AAs who expressed their anger experienced delayed blood pressure, HR, cardiac output, and HRV recovery during the 10-minute recording period. As this study illustrates, the impact of race-related stimuli on cardiovascular functioning may continue to unfold after an initial exposure. We believe the inclusion of longer recovery periods (e.g., beyond a brief lab session) is imperative as prolonged, not momentary, "fight or flight" responses to stressful events lead to disease and premature death (Brosschot et al., 2006). In the present study, we assess AAs' cardiac activity on two consecutive days, during two lab sessions.

Perseverative cognition is a potential mechanism by which individuals experience extended or prolonged physiological responses to stressors (Brosschot et al., 2005, 2006). Perseverative cognition refers to repeated or chronic activation of the cognitive representations of psychological stressors. As a deviation from stress and coping models that tend to focus on the short-term effects of stressors, Brosschot et al. (2006) proposed the Perseverative Cognition Hypothesis, arguing that prolonged physiological responses to stressors – both stressors that have already occurred as well as stressors that are anticipated – ensue when repeated and/or prolonged representation of stressors occurs. Moreover, the theorists assert that perseverative cognition mediates the link between these stressors and somatic illness. As it is possible that AAs' responses to racial discrimination events unfold over time (e.g., across multiple days) such that the longer or more frequently they perseverate over these events, the longer their physiological recovery, we adopt the Perseverative Cognition Hypothesis as a framework for understanding the lingering physiological effects of racial discrimination.

In this investigation, we acknowledge that the momentary and prolonged effects of racial discrimination on cardiac activity may depend on the *race of the perpetrator*. However, few studies disentangle the unique influences of *intergroup* and *intragroup* racial discrimination on the health and well-being of AAs. One notable exception is a study wherein AAs who listened to racial discrimination vignettes reported significantly higher levels of distress and disgust when the perpetrator was EA than when the perpetrator was AA (Rucker et al., 2014). In another study, AAs viewed scenes depicting an unjust arrest for shoplifting or an

encounter with a rude and threatening EA or AA highway patrolman. Surprisingly, there was no effect of officer/patrolman race on the AAs' blood pressure and pulse rate reactivity (Morris-Prather et al., 1996). Given these discrepant findings, additional research is needed to elucidate whether the consequences of intergroup and intragroup racial discrimination are comparable. In particular, do AAs exhibit differential patterns of physiological activity following racial discrimination (e.g., being treated as if intellectually inferior, being avoided) when the perpetrator is EA versus AA?

In many studies examining race-related stress in the lab context, AA participants are often instructed to *imagine* that they are experiencing racial discrimination or to *view* scenes of individuals experiencing racial discrimination (e.g., Morris-Prather et al., 1996; Neblett and Roberts, 2013; Rucker et al., 2014). Although these approaches provide useful insights, they remain limited as there are likely to be discrepancies between how individuals think they will emotionally and behaviorally respond to a situation and their emotional and behavioral responses *in vivo* (Lazarus, 1995; Lepore et al., 2006; Robinson and Clore, 2001). Moreover, vicarious racial discrimination experiences (e.g., viewing scenes) and direct racial discrimination experiences likely differ with regard to their impact on cardiac activity. Compared to these more traditional approaches, we employ an innovative experimental paradigm by focusing on cardiac responses to direct racial discrimination that *actually* unfolds in the lab context via the use of confederates.

The present study examines AAs' cardiac responses, both in the moment and over time, to *actual* racial discrimination involving an EA (intergroup racial discrimination) or AA (intragroup racial discrimination) perpetrator. To assess cardiac activity, we focus on HRV as it reflects the dynamic beat-to-beat influence of the parasympathetic nervous system and is thought to reflect individual differences in the capacity to navigate changing demands in the environment (Appelhans and Luecken, 2006; Berntson et al., 2009; Brosschot et al., 2003; Task Force, 1996). Indeed, in their neurovisceral integration model of health disparities, Thayer and Friedman (2004) suggest that anticipation, worry, and rumination – all perseverative psychological states that may result from experiencing racism – disrupt the functioning of the parasympathetic nervous system in reducing stress responses to a race-related stressor. We also focus on HR as it is dynamically regulated by both the sympathetic and parasympathetic nervous systems (Verkuil et al., 2014). Finally, we examine cognitive perseveration as a mechanism (mediator) by which AAs may experience prolonged HRV and HR responses to the lab stressor.

The present study investigates three research questions: First, do AAs experience lower HRV and higher HR activity following an *actual* intergroup versus intragroup race-related stressor in the relative short-term (on day one)? Second, do the aforementioned differences in HRV and HR activity persist over time (on day two)? Third, are the potential differences in HRV and HR responses to the *actual* intergroup and intragroup race-related stressors on day two mediated by cognitive perseveration? We expect that: (1) AAs will experience lower HRV and greater HR after experiencing intergroup racial discrimination than after experiencing intragroup racial discrimination on day one; (2) the comparatively lower HRV and greater HR activity for intergroup racial discrimination will persist during the lab session on day two; and (3) the intergroup racial discrimination will lead to more

perseveration than the intragroup racial discrimination which will, in turn, lead to comparatively longer physiological activation periods. We focused on AA women as AA men and women may differ with regard to the frequency with which they experience racial discrimination and the types of race-related events most commonly experienced (e.g., Banks et al., 2006; Sellers and Shelton, 2003; Sidanius and Veniegas, 2000). For instance, AA men may be more likely to be treated with fear and suspicion, and to be overtly harassed (Evans, 2011) whereas AA women may be more likely to be ignored in social, legal, political, and academic contexts (Purdie-Vaughns and Eibach, 2008). Moreover, AA women may be more vulnerable to the consequences and impact of racial discrimination (e.g., anxiety) (Banks et al., 2006; Greer et al., 2009). Furthermore, we focus on AA women in the present study as scholars have documented gender differences in HRV with women typically exhibiting higher HRV (e.g., Sztajzel et al., 2008). Finally, we wanted to maximize our sample size (our experimental samples are typically 55–65% women) while also matching the experimenter, confederate, and participants with respect to gender. We note that while women are the sample of choice, we selected a race-related stressor that is equally likely to be experienced by AA women and men: Being treated as if intellectually inferior (Evans, 2011).

2. Method

2.1. Participants

Forty-two AA female college students (M_{age} = 19.83 years, SD = 2.10) were recruited at a large public university in the Midwest. Exclusionary criteria for the study were as follows: not being female; being less than 18 years of age; having participated in a study that was previously conducted in the lab; having major medical conditions or currently using medications for cardiovascular disease; and currently being pregnant. Participants were instructed to refrain from eating, drinking anything other than water, consuming caffeine, smoking, and engaging in physical activity for an hour prior to both research appointments. Participants were randomly assigned to experimental condition (e.g., EA or AA perpetrator) using an online random number generator (http://www.randomizer.org/form.htm). Twenty-four participants were randomly assigned to the condition in which they interacted with the EA perpetrator and 18 participants were randomly assigned to the condition in which they interacted with the AA perpetrator.

Participants earned $20 for their participation in the two-day experiment. The present study was conducted in compliance with the university Institutional Review Board.

2.2. Procedure

2.2.1. Overview—During recruitment, participants were informed that they would participate in a two-day study examining the relationship between mood, thoughts, and physiological activity. Upon arrival to the lab on day one, participants were greeted by an EA female experimenter who remained present in the experimental room with the exception of the manipulation and spontaneous processing periods (detailed below). Electrodes were applied to measure the participants' electrocardiogram (ECG) activity. After a physiological baseline recording and a brief questionnaire completion period, the participant sat quietly for

a pre-manipulation period. The participant then witnessed a scripted interaction between the experimenter and an EA or AA female confederate (perpetrator) meant to convey that the participant is intellectually inferior because of her race (detailed below). Participant ECG activity was recorded during the interaction as well as during a 5-minute period immediately afterward, during which the experimenter was not present in the room. Upon the experimenter's return, the participant had her ECG activity recorded for two additional post-manipulation periods. On the following day, the participant returned to the lab to provide additional resting ECG data, indicate whether she had experienced any stressful events outside of the lab between the two lab sessions, report on her grade point average (GPA), and answer questions regarding her interaction with the perpetrator on the previous day. The data were collected with the following timeline: Baseline (10 minutes), pre-manipulation (3 minutes in length; 5 minutes after baseline), manipulation (1.5 minutes in length; 8 minutes after baseline); spontaneous processing (5 minutes in length; 11 minutes after baseline); post-manipulation 1 (3 minutes in length; 19 minutes after baseline); post-manipulation 2 (3 minutes in length; 24 minutes after baseline); day two baseline (10 minutes in length); stressful experiences, GPA, cognitive perseveration, and manipulation check assessments (day two); debriefing (day two).

2.2.2. Tasks—After the participant arrived individually to the experimental room, the experimenter greeted her and instructed her to sit down at a desk with a computer. After the participant provided informed consent, the experimenter applied the ECG electrodes and baseline recording began. Next, the participant completed a demographics questionnaire. Following the demographics questionnaire, the pre-manipulation recording period ensued to minimize potential carryover effects related to the completion of the questionnaires.

After the pre-manipulation inter-task rest period, an EA or AA perpetrator (confederate) knocked on the door, interrupting the experiment. The experimenter exited the room, purposefully leaving the door ajar to ensure that the participant could hear what transpired. Upon entering the hallway, the experimenter and perpetrator conducted a scripted interaction during which the perpetrator claimed to want to recruit the current participant for another study involving a problem-solving task. After reluctantly agreeing to help, the experimenter allowed the perpetrator to enter the lab room to invite the participant to take part in the problem-solving study. After looking at the participant, the perpetrator paused and remarked "oh…never mind" and walked out of the room. Another scripted interaction took place out in the hallway during which the experimenter inquired about the perpetrator's quick exit. The perpetrator responded, "Well, students must have a high GPA to be eligible to participate, you know, that is part of the criteria for the study, and she probably won't meet our standards so it's not worth it. But thanks anyway." The perpetrator then left. A similar task involving actual racial discrimination has been previously employed by Hoggard et al. (under review), and has been shown to elicit negative emotional responses.

Immediately following the manipulation, the experimenter returned to the room and said "I am so sorry. That was really weird". Next, the experimenter instructed the participant to sit quietly for another inter-task rest period and then left the room, leaving the participant to spontaneously process the preceding event. The experimenter returned to the room five

minutes later and was present for the remainder of the study. The participant was then instructed to sit quietly for two final post-manipulation inter-task recording periods.

We note that research assistants were trained to enact contingency plans (i.e., debriefing participants following the interaction with the perpetrator) in the event that participants appeared to be particularly bothered by the interaction with the perpetrator. One participant was debriefed immediately following the manipulation and two were debriefed immediately following the spontaneous processing period.

On the following day, the participant arrived for the second experimental session during which baseline cardiac activity was again recorded. Thereafter, the participant was instructed to reflect on her interaction with the perpetrator on the previous day and her not being selected to participate in the problem-solving study. Next, the participant completed the stressful event, GPA, cognitive perseveration, and manipulation check assessments. The experimenter then removed the electrodes and provided a full debriefing. The participant was given the debriefing form and was verbally informed that the perpetrator from the previous day was a confederate who was assisting with the study.

2.3. Apparatus and physiological measures

Cardiovascular data were recorded using the BioNomadix ECG module and MP150 Acquisition System (Biopac, Goleta, CA) and a lab PC. The ECG signal was obtained using a modified lead II configuration at a sampling rate of 1 kHz. The data were segmented based on experimental time point: baseline, pre-manipulation, manipulation, spontaneous processing, post-manipulation 1, post-manipulation 2, and day two. Prior to analysis, interbeat intervals were visually inspected and evaluated by an artifact detection algorithm implemented in a custom software package for the analysis of HRV (Mindware Technologies, Gahanna, OH). Consistent with Task Force guidelines and recommendations, we employed the square root of the mean squared differences in successive R-R intervals (RMSSD) as a short-term index of high frequency HRV (Task Force, 1996). While there remains ongoing debate regarding the need to control for respiration in the analysis and interpretation of HRV data, RMSSD has been argued to be less susceptible to respiratory influences (Hill and Siebenbrock, 2009; Verkuil et al., 2014). Using the software package for the analysis of HRV, HR was calculated in beats per minute (BPM). Whereas higher HR generally can reflect relative changes in both parasympathetic and sympathetic nervous system activation, higher RMSSD reflects greater parasympathetic nervous system activity (Verkuil et al., 2014).

2.4. Measures

2.4.1. Real-life stressor—At the beginning of the second lab session, the participants reported on whether they had experienced a stressful event after leaving the lab on day one or before coming into the lab on day two. If the participants had experienced a stressful event(s), they described the event(s) in their own words. Responses were coded as 0 = No, 1 = Yes. An example of a stressful event is “I took a test in biology!”

2.4.2. GPA—The participants in the present study reported on their cumulative GPA on a 4.0 scale. At most United States colleges and universities, GPA is calculated by dividing the total amount of grade points earned by the total amount of credit hours attempted. GPAs may range from 0.0, the lowest grade (equivalent to the letter grade "F"), to a 4.0, the highest grade possible (equivalent to the letter grade "A"). A higher cumulative GPA is indicative of greater academic performance.

2.4.3. Perseveration—Participants completed a modified version of the Impact of Event scale (Horowitz et al., 1979) during the second lab session. The original scale assesses the psychological impact of a variety of traumas, including violence, accidents, and illness (Sundin and Horowitz, 2002). More recently, the scale was utilized to assess the extent to which AAs perseverated about racist incidents (Henson et al., 2013). The Impact of Event scale assesses two common responses to stressful events: intrusion and avoidance. The modified scale utilized in the present study consisted of 15 items that assessed the extent to which the participants had intrusive thoughts ($\alpha = .84$) about the stressor over the last day and the extent to which they attempted to avoid these thoughts over the last day ($\alpha = .80$). A sample item for the intrusion subscale is "I thought about it when I didn't mean to". A sample item for the avoidance subscale is "I tried not to think about it". Responses to all items were assessed on a 4-point Likert-type scale ranging from 1 (*not at all*) to 4 (*often*). Finally, participants responded to the following item: "How much did you think about the event after it happened?" The response to the item was assessed on a 4-point Likert-type scale ranging from 1 (*not at all*) to 4 (*a lot*).

2.4.4. Manipulation checks—During the second lab session, participants responded to the following two manipulation checks. First, participants were asked: "what race did you assign to the other researcher for the other study?" Second, participants indicated the extent to which they agreed or disagreed that race was the reason they were not invited to participate in the other study. Responses to the item were based on a 7-point Likert-type scale ranging from 1 *(strongly disagree)* to 7 *(strongly agree).* A higher score on this item is indicative of more agreement that race was the reason for the unfair treatment.

2.5. Overview of analysis

In assessing differences in cardiac activity following an intergroup versus intragroup race-related stressor in the short-term (i.e., on day one), it was important to avoid independence violations, inflated Type 1 error rates, and biased parameter estimates while summarizing the patterns emerging from repeated observations of cardiac activity over time. Multilevel growth curve models therefore were employed to estimate trajectories of HRV and HR among participants who experienced intergroup and intragroup race-related stressors using *Stata 12*. This approach has several strengths that make it appropriate for the present study. A primary strength of multilevel modeling is that it allows one to appropriately estimate effects when time between assessments is unevenly spaced (Raudenbush and Bryk, 2002). We therefore were able to model HRV and HR in terms of time since baseline (in minutes) and capture trajectories of cardiac activity for participants who experienced intergroup and intragroup race-related stressors. Our statistical approach appreciates dependence in cardiac activity across time, allows us to draw conclusions about differences at various time points,

and allows us to assess the extent to which trajectories of cardiac activity differ by race of perpetrator.

We estimated our models using a maximum likelihood estimation strategy in order to assess improvement in model fit. Experimental time points were modeled in terms of minutes since baseline (coded 0) as follows: pre-manipulation (5 minutes after baseline); manipulation (8 minutes after baseline); spontaneous processing (11 minutes after baseline); post-manipulation 1 (19 minutes after baseline); post-manipulation 2 (24 minutes after baseline). Thus, intercepts depicted in Fig. 1 represent model-implied cardiac activity at baseline and slopes represent the estimated change in cardiac activity per time point. We calculated intra-class correlation (ICC) coefficients for both RMSSD and HR by first estimating a random effects analysis of variance (empty model), with *ICC RMSSD* = .833 and *ICC HR* = .833. The ICC may be interpreted as follows: On average, for any given participant, observations of cardiac activity (e.g., RMSSD) across experimental tasks are correlated at about .83, demonstrating the dependence in cardiac activity across time and further demonstrating that multilevel growth curve analyses were warranted. We then regressed RMSSD and HR onto minutes since baseline, experimental condition (time invariant predictor), the cross-product between minutes since baseline and experimental condition, and GPA (standardized). In this random-intercepts model, GPA served as the sole control variable included in the model, and z-scores were used to estimate GPA as a grand-mean centered predictor. The inclusion of the cross-product, time-by-experimental condition, facilitated our ability to test a *conditional growth model* that predicts differences in baseline and rate of change in cardiac activity. We conducted a likelihood ratio test comparing models with and without the cross-product in order to assess whether the inclusion of this interaction term significantly improved model fit. Details of the model are provided in Table 1.

We tested our research questions pertaining to day two using ordinary least squares regression. Specifically, to test for the presence of lingering effects for the intergroup versus intragroup race-related stressor, RMSSD and HR on day two were regressed onto experimental condition, the day one baseline cardiac activity covariate (i.e., standardized RMSSD/HR from day one), GPA (standardized), and whether participants had experienced a stressful event outside of the lab. We tested for a mediating effect of cognitive perseveration by linking $X \rightarrow M \rightarrow Y$, where X is the experimental condition, cognitive perseveration is the mediator (M), and cardiac activity (i.e., RMSSD and HR) is the outcome (Y) after adjusting for day one baseline cardiac activity, GPA, and whether participants had experienced a stressful event outside of the lab. This required us to estimate two sets of coefficients: one in which the mediator (M) is modeled as the dependent variable, and another in which the outcome (Y) is modeled as the dependent variable (Preacher and Hayes, 2008). The effect of X on Y is mediated by M if the product of the $X \rightarrow M$ coefficient (referred to as path a) and the $M \rightarrow Y$ coefficient (referred to as path b) produces a bootstrapped coefficient (ab) whose confidence interval (CI) does not contain zero. Operationalizing perseverative cognition as intrusion, avoidance, and having thought about the race-related stressor, all three mediation effects were estimated at once for each dependent variable. CIs were estimated using 10,000 bootstrap replications with replacement.

2.5.1. Missing data—Of the 42 recruited participants in our sample, 38 participated in the study across both days. Three of the 42 participants, two in the EA perpetrator condition and one in the AA perpetrator condition, did not participate on day two because they were bothered by the interaction with the confederate and were debriefed prematurely. As the experimental protocol for these three participants differed from that of the other participants, their data were not included in the statistical analysis. Finally, one participant canceled her day two appointment because of a scheduling conflict and therefore had no data for day two.

3. Results

3.1. Preliminary analyses

Descriptive statistics (means, standard deviations and correlations) for all self-report and baseline cardiac data are presented in Table 2. Generally, participants reported not having or rarely having intrusive thoughts (M = 1.632, SD = .657) about the event since its occurrence on the previous day, not trying to avoid thinking about the event (M = 1.803, SD = .721), and thinking about the event very little (M = 2.026, SD = .854). Not surprisingly, the perseveration measures were positively correlated. Overall, correlations between baseline RMSSD and baseline HR were inverse and only significant on day 2 (r = −.625, p < .001).

3.2. Manipulation checks

All participants correctly identified the race of the perpetrator. Moreover, there was no evidence that the participants in the EA perpetrator condition (M = 5.261, SD = 1.94) experienced the event as being more racially discriminatory than the participants in the AA perpetrator condition (M = 5.267, SD = 2.05), $F(1,36) < .001$, p = .993, $\eta^2 < .001$. Approximately 78% of the participants in the EA perpetrator condition made race-based attributions for the insult whereas 67% of the participants in the AA confederate perpetrator made race-based attributions for the insult.

3.3. Cardiac activity on day one

We expected different trajectories for RMSSD and HR across conditions such that AAs who experienced intergroup (i.e., EA perpetrator) racial discrimination would exhibit lower RMSSD and higher HR than AAs who experienced intragroup (i.e., AA perpetrator) racial discrimination. In support of this prediction, results revealed a significant interaction between time and experimental condition on RMSSD, γ = −.841, p = .033. This coefficient represents the difference in the slope for the trajectory of RMSSD over time (.84 milliseconds) across experimental conditions. GPA was marginally associated with RMSSD, implying that AAs who reported higher GPAs tended to have lower RMSSD, γ = −6.301, p = .059. Results of the likelihood ratio test revealed that the inclusion of the time-by-experimental condition interaction significantly improved model fit, $\chi^2_{(2)} = 4.48$, p = .034. This interaction explained 2.32% of the RMSSD within-person variance.

Fig. 1 shows the simple slope of the trajectory of RMSSD from baseline to the final day one experimental time point (post-manipulation 2) for AAs who were insulted by either an EA or AA perpetrator. As depicted by the solid line, the trajectory of RMSSD is positive and significant, indicating increasing HRV for AAs who were insulted by the AA perpetrator, γ

= .714, p = .016. Conversely, the slope of the dashed line is not significant, γ = −.127, p = .629. We also probed the condition-based differences in RMSSD at each of the six time points on day one. In Fig. 1, the knots along each of the simple slopes represent experimental time points. Not surprisingly, there were no differences in RMSSD across conditions at baseline, γ = −3.198, p = .691, or at the pre-manipulation time point (5 minutes after baseline) (γ = −7.405, p = .303). There was also no difference across conditions during the manipulation (8 minutes after baseline) (γ = −9.930, p = .150). By the spontaneous processing time point (11 minutes after baseline), however, participants exhibited marginally significant differences in RMSSD across conditions, γ = −12.454, p = .068. At the post-manipulation 1 time point (19 minutes after baseline), differences among participants in the two conditions were significant, γ = −19.185, p = .011. Specifically, RMSSD is approximately 19 milliseconds higher among participants who were insulted by an AA perpetrator, compared to an EA perpetrator. At the post-manipulation 2 time point (24 minutes after baseline), we see that this difference persists, γ = −23.392, p = .006.

Surprisingly, the results did not reveal a significant interaction between time and experimental condition for HR, γ = .057, p = .347, suggesting that there were not different HR trajectories across the experimental conditions.

3.4. Cardiac activity on day two

We expected the race of perpetrator effects to persist on day two. Compared with AAs who experienced intragroup racial discrimination on day one, we expected that AAs who experienced intergroup racial discrimination on day one would exhibit lower HRV and higher HR. Results revealed marginally significant results in support of this prediction, b = −21.00, p = .061, sr^2 = .120. On day two, RMSSD was marginally lower among participants insulted by the EA perpetrator. Race of perpetrator accounted for approximately 12% of the variance in RMSSD. No other predictors were significant.

Results for HR on day two revealed that participants insulted by the EA perpetrator had an estimated HR that was nearly 7 BPM higher than participants insulted by the AA perpetrator (marginally), b = 6.77, p = .052, sr^2 = .100. Race of perpetrator accounted for approximately 10% of the variance in HR. With the exception of baseline HR on day one (b = .52, p = .005, sr^2 = .230), no other predictors were significant.

3.5. Perseverative cognition mediation

We hypothesized that perseverative cognition would mediate the effects of race of perpetrator on cardiac activity. When specifying RMSSD as an outcome variable, results did not support this mediation hypothesis, as the bootstrapped CIs straddled zero for intrusion (a_1b −1.08, Bias-Corrected 95% CI [−5.76, 22.35]), avoidance (a_2b = −6.10, Bias-Corrected 95% CI [−25.71, 1.10]), and having thought about the race-related stressor (a_3b = −1.43, Bias-Corrected 95% CI [−11.81, 21.69]). Using HR as an outcome, results did not support this hypothesis for intrusion (a_1b = −.43, Bias-Corrected 95% CI [−7.30, 2.64]), avoidance (a_2b = 2.15, Bias-Corrected 95% CI [−.07, 7.23]), or having thought about the race-related stressor (a_3b = −1.69, Bias-Corrected 95% CI [−12.45, 1.96]). Models estimating path a and path b for indirect effects are shown in Table 3 for RMSSD and Table 4 for HR.

Interestingly, the analyses revealed that avoidance was associated with higher HR activity on day two (b = 4.95, p = .022; see Table 4). Surprisingly, RMSSD was higher (23.55 milliseconds) and HR was lower (8.04 BPM) for participants who experienced a stressful event outside of the lab than for those who did not experience a stressful event outside of the lab (see Tables 3 and 4). However, these results should be interpreted with caution as only eleven of the participants reported experiencing a stressful event.

4. Discussion

In the present study, we examined AA women's momentary and lingering HRV and HR responses to a relatively *in vivo* racial discrimination experience. We found that AAs who experienced intergroup racial discrimination exhibited significantly lower HRV on day one as well as marginally lower HRV and marginally higher HR on day two than AAs who experienced intragroup racial discrimination. Importantly, there was no evidence for differences in participants' race-based attributions for the scripted manipulation, regardless of the race of the perpetrator. This was the case despite the omission of any explicit mention of race by the perpetrator during either her interactions with the participant or the experimenter. Given the widespread stereotypes that exist about AAs with regard to intellectual ability (e.g., stupid, lazy, etc.), it is reasonable to assume that these stereotypes became salient for the participants during and/or following the interaction with the perpetrator. Indeed, the large literature on stereotype threat has proposed and found support for the notion that race-related cues in the environment can activate domain-relevant or domain-specific stereotypes about one's racial group (e.g., Steele, 1997). During the debriefing process, several participants indicated that the paradigm was very similar to instances of racial discrimination that they experienced on the university campus, suggesting that the paradigm closely approximates events that AAs experience in real life.

In support of our first hypothesis, we found that AAs who were insulted by the AA perpetrator actually exhibited an increase in HRV on day one whereas AAs who were insulted by the EA perpetrator demonstrated little change and even exhibited a very slight decline in HRV. These findings suggest that the AAs who were insulted by the AA perpetrator responded in a manner that was physiologically beneficial whereas those insulted by the EA perpetrator exhibited little physiological response or recovery on day one. We also note that the condition-based differences in RMSSD emerged at the spontaneous processing time point (marginally significant) and persisted until the post-manipulation 2 time point on day one (14.5 minutes after the manipulation). As the participants were randomly assigned to experimental condition and as there were no baseline differences in HRV, we are confident that the mean and slope differences in HRV across conditions were indeed a function of the race of perpetrator manipulation. Surprisingly, we found no evidence for condition-based differences in the mean or slope for HR on day one, indicating that the impact of the intergroup and intragroup racial discrimination was similar across conditions.

With respect to our second hypothesis, we found that the effect of race of perpetrator on day two cardiac activity approached significance. Specifically, compared with AAs who experienced intragroup racial discrimination, AAs who experienced intergroup racial

discrimination exhibited marginally lower RMSSD and marginally higher HR on day two. As others have noted, measures of variability derived directly from the beat-to-beat (i.e., interbeat) interval series specifically reflect parasympathetic activity (Verkuil et al., 2014). Thus, the trend for RMSSD is particularly suggestive of marginally lower parasympathetic activity on day two among women who experienced intergroup racial discrimination. While this pattern is further consistent with the marginally higher HR observed on day two, it is important to remember that both autonomic nervous system branches dynamically govern HR. Thus, in lieu of a measure of cardiac sympathetic nervous system activity, we can only speculate that sympathetic activity may also have been increased in these women on day two.

Because the women who experienced intergroup racial discrimination exhibited lower RMSSD at the end of the experimental session on day one, it would be tantalizing to conclude that their HRV remained diminished approximately 24 hours after the relatively explicit exposure to racial discrimination by the EA perpetrator. This interpretation is consistent with the notion that stressors can have a chronic and prolonged (i.e., suppressive) impact on cardiac activity. Alternatively, it is also possible that the women's cardiac responses returned to baseline after the lab session on day one, and that they experienced another 'shift' in cardiac autonomic activity upon their arrival at the lab on day two. This pattern would suggest that merely returning to the environment where an act of racial discrimination has taken place – cognitively re-experiencing the event or anticipating that another racially discriminatory event will occur – can be a sufficient trigger for changes in cardiac activity. This pattern also illustrates a more recurrent pathway through which perseverative stressors are argued to contribute to physiological dysregulation over time (Brosschot et al., 2006; Hicken et al., 2013; Sawyer et al., 2012). While we identify cognitive re-experiencing (i.e., rumination) and anticipatory stress as possible mechanisms by which discrimination may function as a perseverative stressor, we acknowledge that there are likely other mechanisms (e.g., disruption of sleep) through which discrimination impacts cardiac autonomic function.

We did not find evidence that the marginal condition-based differences in RMSSD and HR activity on day two were mediated by cognitive perseveration. It is plausible that we did not effectively assess perseveration, as other studies have utilized measures of trait worry and trait rumination to capture this phenomenon. We assessed the extent to which the participants ruminated about the race-based lab stressor, but did not assess the extent to which they were worried about future occurrences of race-related stressors or the extent to which they are prone to worrisome thinking more generally. However, we did find evidence that avoidance was associated with higher HR activity on day two (see Table 4). It is therefore a possibility that the participants who reported trying to avoid thinking about the stressor used avoidance as a strategy to cope with their ruminative thoughts about the discrimination, and that these ruminative thoughts were associated with changes in cardiac activity. Another explanation is that we were statistically underpowered due to the small sample size or that there actually was an indirect effect of perseverative cognition, but we were unable to capture this indirect effect as we did not measure the AAs' cardiac activity between the lab sessions (e.g., ambulatory recordings). A final possibility is that unconscious – not conscious – perseveration was the mechanism (mediator). Indeed, in a

more recent extension of the Perseverative Cognition Hypothesis, Brosschot and colleagues purport that a considerable – and perhaps the *most* significant portion of perseverative cognition – occurs unconsciously (Brosschot, 2010; Brosschot et al., 2010). Thus, it may be that the participants who were insulted by the EA perpetrator continued to perseverate about their experience throughout the remainder of day one and into day two. We did not employ measures or tasks to capture these critical, unconscious processes, and we believe that capturing these processes is an important aim that should be incorporated in future research on discrimination and perseverative cognition.

The present study builds upon previous studies of racial discrimination by investigating how AA women comparatively respond to intergroup and intragroup racial discrimination. To our knowledge, ours is the first study that has examined the impact of a lab race-based stressor on cardiac activity over a two-day period in AAs. In doing so, we demonstrated that intergroup racial discrimination may exceed the consequences of intragroup racial discrimination using an innovative method. This work sets the stage for future studies to further investigate specific instances of racial discrimination in the lab context while also preserving ecological validity. Our work also contributes to the interesting and growing literature examining the Perseverative Cognition Hypothesis. While we did not find evidence in mediation analysis, self-reported perseveration was positively associated with HR activity on day two. This provides modest support for the notion that discrimination has both an event-level and recurrent, accumulative impact on cardiovascular functioning and health in AAs.

There are some key limitations of the present study that may help to inform future studies of racial discrimination. First, there was no control group wherein the participants witnessed a benign conversation that was unrelated to race. The inclusion of this third group may have provided additional clarity with respect to the impact of the lab stressor. Second, we were unable to assess participants' physiological activity once they left the lab on day one. As such, we may not have fully captured the prolonged influence of the race-related stressor or the relation between cardiac activity and perseveration. Third, the sample size was small, and perseverative cognition scores were rather low and invariant, thereby possibly undermining statistical power to test the mediation for perseverative cognition. Relatedly, it is plausible that we did not effectively assess perseveration as other studies have used measures of trait worry and rumination to capture this phenomenon. Specifically, the Impact of Life Event Scale is typically used for traumatic stress and the one-question item "How much did you think about the event" may have been limited as it did not measure other important aspects of perseverative cognition, such as intensity and duration. Similarly, more recent work suggests that a considerable portion of perseveration occurs outside of conscious awareness and may be best assessed using non-traditional methods.

4.1. Conclusions

In sum, this study is the first to directly compare cardiac responses to intergroup and intragroup racial discrimination over a two-day period in AAs. Collectively, we found evidence that racial discrimination involving an EA perpetrator had a greater immediate and marginally more prolonged impact on HRV than discrimination involving an AA

perpetrator. A likely explanation for these findings may be that intergroup racial discrimination makes apparent the uneven distribution of power that exists between EAs and AAs in the United States (Harrell, 2000; Harrell et al., 2011), and reminds AAs of their painful history. Another potential explanation is that racist behavior by an AA perpetrator against an AA victim may be less intense as this behavior may actually be self-directed – a manifestation of the AA perpetrators' internalization of negative stereotypes about his/her racial group. Others have characterized vagal withdrawal (a decrease in HRV) during exposure to discriminatory stimuli as a response to threat (Neblett and Roberts, 2013; Thayer and Friedman, 2004). Our findings are consistent with this interpretation and further suggest that simply thinking about a racially discriminatory act and/or returning to the environment where racial discrimination was experienced may have detrimental consequences on cardiovascular health. In consideration of the tremendous disparities in cardiovascular disease faced by AAs, future studies should examine how long the effects of racial discrimination and other race-based stressors linger following the initial experience.

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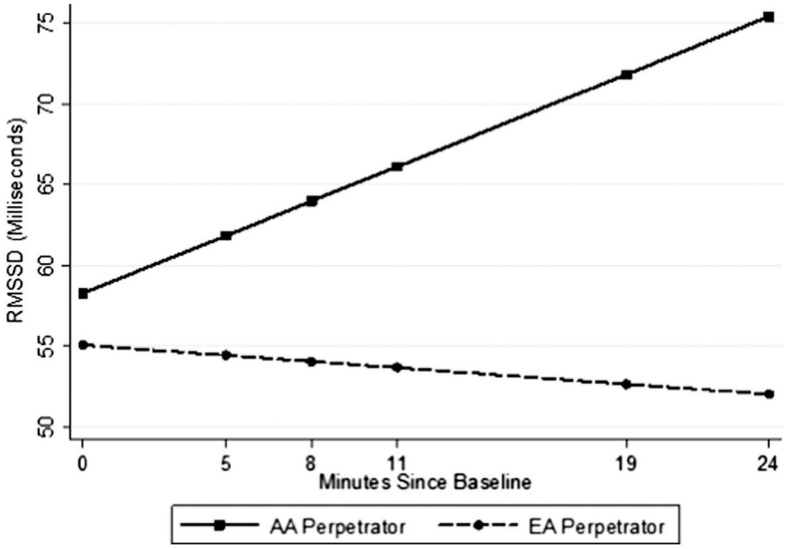

Fig. 1.

Model-implied intercepts and trajectories of RMSSD over time as a function of race of perpetrator.

Table 1

Variable description and treatment for conditional growth-curve model.

Criterion	Description and Variable Treatment
Focal Predictor	Time (Estimated as Minutes since Baseline)
Moderator Variable	Experimental Condition (0 = AA Confederate; 1 = EA Confederate)
Control Variable	Grade-Point Average (GPA scores were standardized. Therefore, GPA is grand-mean centered).
Statistical Notation for Random-Intercepts Model	$\gamma_{00} + \gamma_{01}$ (Condition) + γ_{02} (Grade Point Average) + γ_{10} (Time) + γ_{11} (Time*Condition) + $u_{0j} + r_{ij}$

Table 2

Descriptive statistics and correlations for Perseverative Cognition measures, HRV, and HR (N = 38).

		M(SD)	1	2	3	4	5	6	7	8	9	10	11	12
1	Age (yrs)	19.83 (2.10)	-											
2	BMI (kg/m^2)	24.9 (4.23)	.248	-										
3	GPA	3.08 (0.38)	−.307	−.198	-									
4	Race of Perp	-	.144	.126	.047	-								
5	Intrusion	1.63 (0.66)	−.160	.230	.196	.150	-							
6	Avoidance	1.80 (0.72)	−.058	.198	−.170	−.136	.338*	-						
7	Thinking about Stressor	2.03 (0.85)	−.076	.166	.113	−.089	.761**	.393*	-					
8	Baseline HR Day 1	76.12 (9.22)	−.229	−.319	−.103	.032	.082	.005	.105	-				
9	Baseline HR Day 2	75.02 (10.07)	−.048	−.142	−.222	−.307	.169	.231	.231	.478**	-			
10	Baseline RMSSD Day 1	55.98 (32.89)	−.023	−.100	−.159	−.110	.045	−.197	−.036	−.138	.152	-		
11	Baseline RMSSD Day 2	57.03 (27.93)	−.142	−.075	.138	.285	−.152	−.236	−.300	−.202	−.625**	.083	-	
12	Stressful Event	0.29 (0.46)	−.076	.292	.107	−.041	.222	.391*	.049	−.261	−.344*	.099	.275	-

Note. BMI = body mass index in kilograms/meters squared, GPA = self-reported grade point average, Race of Perp = exposure to discriminatory treatment by either an AA (0) or EA (1) confederate during the manipulation, Intrusion/Avoidance subscales from the Impact of Event Scale, Thinking about Stressor = participant self-reports of whether and how much they continued to think about the interaction from the manipulation from day 1 to day 2, HR = heart rate in beats per minute (BPM), RMSSD = root mean square of successive differences between adjacent R-R intervals in milliseconds (ms), Stressful Event = whether participant experienced a stressful outside of the lab.

* $p < .05$,

** $p < .01$.

Table 3

Regression models estimating perseverative cognition mediators and day two RMSSD (when adjusting for perseverative cognition mediators).

	df	*b*	*SE*	*t*	*p*	95% CI Lower Bound	95% CI Upper Bound
R^2 = .112 for Path a_1: Intrusion	4, 27						
EA Perpetrator		−0.11	0.25	−0.42	0.676	−0.60	0.39
GPA (Standardized)		0.24	0.18	1.33	0.185	−0.11	0.59
Stressful Event		0.34	0.25	1.35	0.178	−0.15	0.83
Baseline RMSSD Day 1		0.00	0.00	0.18	0.858	−0.01	0.01
Intercept		**1.68**	**0.28**	**6.03**	**<0.001**	**1.13**	**2.23**
R^2 = .304 for Path a_2: Avoidance	4, 27						
EA Perpetrator		**0.48**	**0.25**	**1.96**	**0.050**	**0.01**	**0.97**
GPA (Standardized)		0.12	0.18	0.70	0.486	−0.22	0.47
Stressful Event		**0.73**	**0.25**	**2.96**	**0.003**	**0.25**	**1.22**
Baseline RMSSD Day 1		−0.01	0.00	−1.53	0.127	−0.01	0.00
Intercept		**1.64**	**0.27**	**6.00**	**<0.001**	**1.10**	**2.18**
R^2 = .165 for Path a_3: Thinking about Stressor	4, 27						
EA Perpetrator		0.52	0.32	1.64	0.101	−0.10	1.14
GPA (Standardized)		**0.52**	**0.22**	**2.30**	**0.021**	**0.08**	**0.96**
Stressful Event		0.15	0.32	0.46	0.642	−0.47	0.76
Baseline RMSSD Day 1		0.00	0.00	0.03	0.973	−0.01	0.01
Intercept		**1.74**	**0.35**	**4.99**	**<0.001**	**1.06**	**2.42**
R^2 = 320 for Path b: RMSSD on Day Two	7, 21						
EA Perpetrator		−17.41	11.33	−1.54	0.124	−39.61	4.79
GPA (Standardized)		−4.69	7.13	−0.66	0.511	−18.68	9.29
Stressful Event		**23.55**	**10.86**	**2.17**	**0.030**	**2.26**	**44.83**
Baseline RMSSD Day 1		0.01	0.13	0.06	0.953	−0.24	0.25
Intrusion		−10.20	13.19	−0.77	0.439	−36.06	15.66
Avoidance		−12.59	7.23	−1.74	0.082	−26.76	1.58
Thinking about Stressor		2.77	10.99	0.25	0.801	−18.76	24.31
Intercept		**95.02**	**16.78**	**5.66**	**<0.001**	**62.15**	**127.90**

Note. Significant coefficients are boldfaced. *Note*. EA Perpetrator Codes: 0 = AA Perpetrator, 1 = EA Perpetrator; Stressful Event: 0 = Participant did not experience a stressful event in between lab sessions, 1 = Participant did experience a stressful event in between lab sessions.

Table 4

Regression models estimating perseverative cognition mediators and day two heart rate (when adjusting for perseverative cognition mediators).

	df	*b*	*SE*	*t*	*p*	95% CI Lower Bound	95% CI Upper Bound
R^2 = .138 for Path a_1: Intrusion	4, 27						
EA Perpetrator		−0.08	0.26	−0.33	0.743	−0.59	0.42
GPA (Standardized)		0.25	0.18	1.40	0.162	−0.10	0.61
Stressful Event		0.40	0.27	1.47	0.143	−0.13	0.93
Baseline Heart Rate Day 1		0.01	0.01	1.04	0.301	−0.01	0.04
Intercept		0.68	1.03	0.66	0.511	−1.34	2.70
R^2 = .218 for Path a_2: Avoidance	4, 27						
EA Perpetrator		0.44	0.25	1.72	0.085	−0.06	0.93
GPA (Standardized)		0.13	0.18	0.74	0.457	−0.22	0.48
Stressful Event		**0.67**	**0.27**	**2.53**	**0.012**	**0.15**	**1.20**
Baseline Heart Rate Day 1		0.01	0.01	0.98	0.327	−0.01	0.04
Intercept		0.42	1.01	0.41	0.679	−1.57	2.41
R^2 = .205 for Path a_3: Thinking about Stressor	4, 27						
EA Perpetrator		0.57	0.32	1.80	0.072	−0.05	1.20
GPA (Standardized)		**0.55**	**0.22**	**2.43**	**0.015**	**0.11**	**0.98**
Stressful Event		0.27	0.34	0.82	0.415	−0.39	0.93
Baseline Heart Rate Day 1		0.02	0.02	1.19	0.233	−0.01	0.05
Intercept		0.25	1.28	0.19	0.848	−2.26	2.76
R^2 = 534 for Path *b*: Heart Rate on Day Two	7, 21						
EA Perpetrator		**6.73**	**3.40**	**1.98**	**0.048**	**0.06**	**13.40**
GPA (Standardized)		1.24	2.13	0.58	0.560	−2.93	5.42
Stressful Event		**−8.04**	**3.27**	**−2.46**	**0.014**	**−14.45**	**−1.64**
Baseline Heart Rate Day 1		**0.44**	**0.14**	**3.21**	**0.001**	**0.17**	**0.72**
Intrusion		5.07	3.95	1.29	0.199	−2.66	12.81
Avoidance		**4.95**	**2.15**	**2.30**	**0.022**	**0.72**	**9.17**
Thinking about Stressor		−2.94	3.34	−0.88	0.379	−9.49	3.61
Intercept		**28.95**	**10.97**	**2.64**	**0.008**	**7.44**	**50.46**

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Note. Significant coefficients are boldfaced. *Note*. EA Perpetrator Codes: 0 = AA Perpetrator, 1 = EA Perpetrator; Stressful Event: 0 = Participant did not experience a stressful event in between lab sessions, 1 = Participant did experience a stressful event in between lab sessions.