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Multi-Ethnic Variation in the Ties That Bind Rumination and Heart Rate Variability:
Implications for Health Disparities

THESIS

submitted in partial satisfaction of the requirements for the degree of

MASTER OF ARTS

in Social Ecology

by

Vida Pourmand, M.S.

Thesis Committee:
Assistant Professor DeWayne P. Williams, Chair
Professor Belinda Campos
Distinguished Professor Julian F. Thayer

2023

DEDICATION

To

my family

Thank you for your constant support and uplifting me regardless of what I am pursuing. Through everything we have been through this year, I am grateful for us to still all be together.

my friends, peers, and cohort mates

Thank you for being my support system in Irvine. You all keep me sane and human throughout the roller coaster that is graduate school.

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ABSTRACT OF THE THESIS

Multi-Ethnic Variation in the Ties That Bind Rumination and Heart Rate Variability:

Implications for Health Disparities

by

Vida Pourmand, M.S.

Master of Arts in Social Ecology

University of California, Irvine, 2023

Assistant Professor DeWayne P. Williams, Chair

Higher self-reported rumination, a common form of trait perseverative cognition, is linked with lower resting heart rate variability (HRV), which indicates poorer cardiac function and greater disease risk. A prior meta-analysis and systematic review indicates that in samples with fewer European Americans, the association of rumination with both heart rate and blood pressure was stronger. Thus, trait rumination may be more strongly associated with HRV among ethnically minoritized populations, but few studies exist. The current study therefore investigated whether differences in the association of self-reported rumination with resting HRV varied by ethnicity in a sample ($N = 513$; $M_{age} = 19.41$; 226 Women) of self-identified African Americans ($n = 110$), Asian Americans ($n = 84$), and European Americans ($n = 319$). Participants completed a 5-min baseline period to assess resting HRV, followed by the Ruminative Responses Scale, which contains three facets of rumination including brooding, depressive, and reflective rumination. On average, Asian Americans reported higher levels of rumination relative to European Americans. African Americans had higher average HRV than Asian Americans. Adjusting for covariates, higher self-reported rumination was significantly associated with lower HRV in both African and

Asian Americans, but not significantly so in European Americans. This finding was consistent for brooding and reflective, but not depressive rumination. Overall, this study lends insight into a psychological mechanism – rumination – that may impact health disparities among ethnically minoritized individuals, contributing to an understanding of how stress gets under the skin among such populations.

INTRODUCTION

Stress can manifest physiologically, dysregulating one's body, increasing risk for poor health, and ultimately contributing to health disparities that burden members of minoritized ethnic groups. Through perseverative cognition, defined as the repetitive and sustained focus on past and future distressing thoughts and/or stimuli, stress can prolong physiological activation and negatively affect health (Brosschot et al., 2006). Rumination, a common form of perseverative cognition, is the process of having intrusive and repetitive thoughts about negative emotions and/or past/present stressors (Brosschot et al., 2006; Nolen-Hoeksema et al., 2008). Higher perseverating via rumination has been linked with lower resting heart rate variability (HRV)¹, a reliable index of cardiovascular functioning (Williams et al., 2017). A prior meta-analysis and systematic review indicated that in samples with fewer European Americans relative to other ethnic groups, the strength between rumination and both heart rate and blood pressure was stronger (Ottaviani et al., 2016). Although results were not significant for HRV, most studies did not have adequate sample sizes of minoritized ethnic groups, thereby warranting further study. The goal of the current study was to examine ethnic differences in trait (i.e., self-reported) rumination and HRV, as well as whether the association of rumination with HRV varied as a function of ethnicity in a sample of African American, Asian American, and European American² young adults. Additionally, we explored the association of the various types of rumination

¹ Resting heart rate variability will hereafter be referred to as "HRV."

² Term preferences vary and can change. In this paper, we aimed to use terms that highlight the ethnic and racial background of our participants and are widely recognized by members of the respective groups.

(brooding, depressive, reflection) with HRV, and if those associations were moderated by ethnic background.

Perseverative Cognition: Implications for Cardiovascular Health

Prolonged stress responses have been implicated in disease and overall poorer health (Ottaviani et al., 2016). It has been suggested that through perseverative cognition, stress can prolong physiological activation and negatively affect health (Brosschot et al., 2006; Gerin et al., 2012; Ottaviani, 2018). Therefore, those who perseverate about distressing past or future thoughts/stimuli may be at risk for worse cardiovascular health. Perseverative cognition is made up of mainly two facets, rumination and worry (Brosschot et al., 2006). The current report focuses on rumination, which can be thought of as the process of passively focusing on one's negative thoughts about a prior stressor (Nolen-Hoeksema, et al., 2008; Treynor et al., 2003). Given that rumination is considered a maladaptive strategy for coping with stress (Treynor et al., 2003), higher levels of rumination are associated with a wide range of physical health outcomes such as worse endocrine, autonomic, and cardiovascular function (Ottaviani et al., 2016).

Individuals of minoritized ethnic backgrounds undergo unique stressful experiences that may elicit ruminative tendencies, a potential means through which psychosocial stress can contribute to cardiovascular health disparities. For example, in the U.S., people of African, Asian, and Latino background report more discrimination (LeBrón et al., 2020; McMurtry et al., 2019; Salomon & Jaguszyn, 2008) which has been linked with rumination among African Americans (Williams, Pandya, et al., 2019). This maladaptive psychophysiological cycle may perpetuate ethnic disparities that exist in health.

Specifically, African Americans have increased risk for cardiovascular risk factors such as

diabetes and hypertension, and thus, increased prevalence of cardiovascular disease, than their European American counterparts (Carnethon et al., 2017). Among Asian Americans, although the research is minimal, growing evidence suggests higher rates of cardiovascular disease relative to their European American counterparts (Jose et al., 2014). To highlight the scarcity of this literature, to our knowledge only one recent study demonstrated that Asian Americans have increased risk for undiagnosed hypertension as compared to their European American counterparts (Morey et al., 2022). It may be that the prevalence of cardiovascular disease in this population is underdiagnosed (Narayan et al., 2010) and therefore warrants further study. Taken together, in ethnically minoritized people, a “running dialogue” of stress might be particularly detrimental for cardiovascular function and associated outcomes relative to individuals of European background given vast differences in societal experiences.

Rumination and Heart Rate Variability (HRV)

Higher perseverating via rumination is increasingly understood to be linked with impaired cardiovascular health (Manigault & Zoccola, 2020). Specifically, it is associated with lower HRV, a reliable index of cardiovascular functioning (Williams et al., 2017). In particular, HRV represents parasympathetic nervous system functioning which in times of stress, acts on the heart to maintain adaptive physiological regulation. HRV indicates the heart’s ability to flexibly soothe the mind and body during distress, and is a reliable index of self-regulation abilities (Appelhans & Luecken, 2006; Thayer & Lane, 2009). This idea is supported by imaging studies, which have linked brain regions responsible for self-regulation (e.g., prefrontal cortex) with HRV directly (Thayer et al., 2012). As such, lower HRV is indicative of lesser adaptive self-regulatory abilities, both physiologically (e.g.,

increased allostatic load; Thayer & Sternberg, 2006) and psychologically (e.g., rumination; Williams et al., 2017).

While literature examining the association of rumination with HRV has been somewhat mixed (Aldao et al., 2013; Key et al., 2008), converging evidence has suggested higher levels of rumination are linked with lower HRV (Ando et al., 2020; Ottaviani et al., 2016; Ottaviani et al., 2009). As such, a meta-analysis suggested higher rumination was associated with lower HRV (Ottaviani et al., 2016). Other examples of the negative association of rumination with HRV include a study which found that higher work-related rumination was associated with lower HRV (Cropley et al., 2017) and another which found that in women that are more prone to depression, higher levels of brooding rumination were associated with lower HRV (Woody et al., 2014). In various other studies and under a variety of conditions, higher state and trait ruminative thoughts have been associated with lower HRV (Gerteis & Schwerdtfeger, 2016; Kocsel et al., 2019; Plate et al., 2020; Woody et al., 2014; Williams et al., 2017). While research has shown rumination to be negatively linked with HRV, studies to date have rarely, if not ever, considered ethnic differences in these constructs.

Rumination and HRV: Ethnic Differences

Members of marginalized ethnic groups might be especially vulnerable to stress due to unique circumstances and social inequities in the U.S., which has been linked with increased perseverative cognition (e.g., Williams et al., 2019; Williams, Joseph, et al., 2019; Williams et al., under review). Nonetheless, there is minimal research that has examined ethnic differences in rumination. The few studies have suggested differences in rumination amongst Asian and European Americans, such that Asian Americans report higher levels of

rumination than European Americans (De Vaus et al., 2018; 6/8/2023 1:24:00 AM; Kwon et al., 2013). Another investigation suggested no significant difference between African Americans and European Americans on average group levels of rumination (Williams, Pandya, et al., 2019). Yet in this same study, higher discrimination was significantly associated with higher rumination. This link highlights the fact that unique challenging experiences, such as higher levels of perceived discrimination, are linked with higher levels of rumination. However, less is known about the possible differential association of rumination with HRV among ethnically minoritized groups.

Similar to reported ethnic differences in rumination, there is a growing body of literature suggesting ethnic differences in HRV. Research has found that African Americans demonstrate higher HRV than European Americans (Hill et al., 2015; Hill et al., 2017; Hoggard et al., 2015). This is paradoxical considering higher HRV should be cardio-protective, yet African Americans remain at an elevated risk for cardiometabolic disease compared with European Americans (Thayer et al., 2020). Here, it has been proposed that higher HRV signals compensation for their negative social experiences (i.e., higher levels of emotion regulation is needed; Hill et al., 2015). Furthermore, on average, Asian Americans demonstrate lower HRV than European Americans do (Pourmand et al., *in prep*; Yoo et al., 2021), although the intersection between ethnicity and gender may play a role (Hall et al., 2013). It remains that very few studies have investigated ethnic differences in HRV among these groups and results are mixed.

Importantly, given that ethnic differences in both rumination and HRV exist, the established association of rumination with HRV may be moderated by ethnicity. To our knowledge, there is no research examining this potential differential association. A recent

meta-analysis by Ottaviani and colleagues (2016) points to the possibility that the association of rumination with HRV may vary as a function of one's ethnic background. Specifically, it indicated that ethnicity moderated the association of perseverative cognition with heart rate in studies that consisted of samples with fewer European American participants compared to that of studies consisting of samples with a majority of European American participants. Although ethnicity did not moderate the association of perseverative cognition with HRV, this may be due to the fact that most of the reported HRV studies consisted of mainly European American participants. The authors suggest that ethnicity could play a crucial part in the association of rumination with cardiovascular responses, but that no study to date has examined that association. We sought to address this gap in the literature by examining how the association of rumination with HRV might differ among a sample of African Americans, Asian Americans, and European Americans.

The Current Study

The current study empirically investigated mean differences in rumination and HRV between ethnicities, and whether the association of rumination with HRV varied by ethnic group among African Americans, Asian Americans, and European Americans. This study also explored the association of the different facets of rumination (brooding, depressive, reflection) with HRV moderated by ethnicity. We hypothesized that:

- 1) African Americans and Asian Americans would report greater rumination relative to European Americans, and we explored differences on associated subscales.

- 2) in line with prior research, African Americans would have higher HRV than European Americans (Hill et al., 2015), who would have higher HRV than Asian Americans (Yoo et al., 2021).
- 3) higher levels of total rumination would be associated with lower HRV, and ethnicity would moderate this association such that this pattern would be particularly strong among minoritized ethnic groups (i.e., in the African American and Asian American samples). We explored associated subscales independently.

Method

Participants

Participants were recruited through the Research Experience Program (REP) at the Ohio State University and data was pooled across ten studies that included variables of interest; a portion of these data have been published elsewhere (Williams et al., 2015; Williams et al., 2019; Williams, Tracy, et al., 2019; Williams et al., 2022). Students who participated received partial course credit for a psychology course. Participants who were recruited apart from the REP pool received monetary compensation, funded by The Ohio State University College of Social and Behavioral Sciences and College of Arts and Sciences. Data was collected from a total of 513 undergraduate students (226 women, 287 men, $M_{age} = 19.41 (2.16)$, 110 African Americans, 84 Asian Americans, 319 European Americans) across ten studies. Each individual participated in only one of the ten studies. Participants who were outliers due to physiological noise were removed from analyses. Participants were asked to avoid smoking, vigorous physical activity, and caffeine six hours prior to the

experiment. Studies were approved by the university's institutional review boards and each participant provided informed consent.

Procedures

Participants were directed to a soundproof experimental room that was equipped with a camera and microphone for safety and instructional purposes as well as a high-definition TV for stimuli presentation. Each participant was given detailed explanations of the study procedures without indication of any hypotheses or manipulations that were being tested and applied. Electrocardiogram (ECG) leads (three-figure configuration) were attached to the subjects. In a separate control room, experimenters led subjects through the initial phases of the experiment. Participants completed a five-minute baseline period while sitting in a resting position with the TV displaying a blank, gray screen. They were instructed not to move or fall asleep during the baseline period in order to avoid spontaneous breathing. Following the baseline period, participants completed a set of self-report questionnaires either before or after completing an experimental task, which are not relevant to this study.

Measures

Rumination

Rumination was assessed using the 22-item Ruminative Responses Scale (RRS; Nolen-Hoeksema & Morrow, 1991). The scale asked participants to report the frequency with which they ruminate. The RRS contains three subscales, including brooding (wallowing and sulking; 5-items), depressive (sadness and despair; 12-items), and reflective (analytical thinking; 5-items) rumination. A sample item from the brooding subscale asks participants how often they “think about a recent situation, wishing it had

gone better,” a statement from the depressive subscale asks how often participants “think about how sad [they] feel,” and an item from the reflective subscale probes the frequency with which they “write down what you are thinking and analyze it.” Participants rated each statement on a 5-point Likert scale from 1 (*almost never*) to 4 (*almost always*). Items were summed to produce a total score for each subscale as well as a total overall rumination score such that higher scores represented higher trait rumination. The RRS has demonstrated high reliability and validity (Nolen-Hoeksema & Morrow, 1991; Treynor et al., 2003; Topper et al., 2014).

Resting Heart Rate Variability (HRV)

Cardiac data was recorded via an electrocardiogram at a 1000 Hz sampling rate using a Mindware™ 2000D (MW2000D) Impedance Cardiograph package. HRV during baseline was calculated using the variability between successive R-spikes as identified by electrocardiogram recordings. Participants’ successive inter-beat-intervals, measured in milliseconds, were extracted using HRV 2.51 Analysis software, written in a text file, and analyzed using Kubios HRV analysis package 2.0 (Tarvainen et al., 2014). Artifacts (differing abnormal inter-beat-intervals from the mean inter-beat-intervals) within the R-to-R series were visually detected and corrected by an artifact correction level that differentiates and removes artifacts using a piecewise cubic spline interpolation method. We obtained two measures of HRV, High-frequency HRV (HF-HRV; 0.15–0.4 Hz), and root mean-squared successive differences between adjacent normal R-R intervals. These time- and frequency-domain measures are valid and stable measures of HRV (Task Force, 1996). HF-HRV and root mean-squared successive differences are highly correlated measures of HRV ($r = .91, p < .001$). For the purposes of this study, we used HF-HRV as our main

measure of HRV³. As such, values were converted to their natural log (ln) to fit assumptions of linear data for analyses.

Data Analytic Plan

All analyses were conducted in SPSS (ver. 28, IBM Chicago, IL, USA) and R (ver. 4.0.3). First, we conducted planned comparisons (i.e., two-tailed *t*-tests), to examine whether there were differences between our three ethnic groups (African American, Asian American, European American) on all key study variables⁴. Next, we conducted zero-order Pearson's *r* correlation analyses between study variables to determine whether our key study variables were associated with one another. To assess these associations while accounting for covariates, we conducted partial *r* correlations. Lastly, to test the effect of total rumination levels on HF-HRV moderated by ethnic background, regression models were conducted. To better understand the effects of each of the different types of rumination (total, brooding, depressive, reflective) on HF-HRV as a function of ethnicity, we ran Johnson-Neyman analyses. In each of the separate models, we switched the predictor and moderator variables so that ethnicity was the predictor variable and rumination was the moderator variable, satisfying the assumptions of the Johnson-Neyman analyses; we probed regions of significance in which ethnicity predicted HRV at varying levels of rumination. Each of the regression models contained covariates including age (years), gender (men/women), and body mass index (BMI; Kg/M²), all of which are related to HRV (Koenig & Thayer, 2016; Koenig et al., 2014; Voss et al., 2015). We calculated effect sizes as

³ Results using RMSSD as the measure of HRV were similar in both direction and magnitude of the effect and thus, only HF-HRV results are presented.

⁴ We also conducted omnibus one-way ANOVA tests.

r values using the Practical Meta-Analysis Effect Size Calculator (Lipsey & Wilson, 2001), and report 95% confidence intervals of associated r values.

Results

Ethnic Group Difference Analyses

Pre-planned contrasts⁵ indicated that Asian Americans reported higher levels of total rumination than did European Americans ($t(510) = 2.98, p = .003, r = .13, 95\%CI [0.04, 0.22]$), with no other notable comparisons (each $p > .07$). For brooding rumination, Asian Americans also reported higher average levels of brooding than did European Americans ($t(510) = 3.77, p < .001, r = .17, 95\%CI [0.08, 0.25]$) as well as African Americans ($t(510) = 2.01, p = .045, r = .09, 95\%CI [0.00, 0.17]$). African Americans and European Americans did not differ in their average levels of brooding rumination ($t(510) = 1.55, p = .12, r = .07, 95\%CI [-0.02, 0.15]$).

Pre-planned contrasts showed that African Americans had higher HF-HRV than Asian Americans ($t(510) = -2.22, p = .03, r = .10, 95\%CI [-0.18, -0.01]$). There was no significant difference between African Americans and European Americans ($t(510) = 1.74, p = .08, r = .08, 95\%CI [-0.01, 0.16]$) or Asian Americans ($t(510) = -1.06, p = .29, r = -.05, 95\%CI [-0.13, 0.04]$) in their HF-HRV.

For depressive rumination, pre-planned contrasts showed that Asian Americans reported significantly higher average levels of depressive rumination than did European Americans ($t(510) = 2.03, p = .04, r = .09, 95\%CI [0.00, 0.18]$), with no other notable comparisons (each $p > .07$). For reflective rumination, pre-planned contrasts indicated that

⁵ Omnibus one-way ANOVA tests were conducted for all pre-planned contrasts on HF-HRV and rumination (total, brooding, depressive, reflective). There were statistically significant omnibus tests for HF-HRV, total rumination, and brooding rumination, but not depressive or reflective rumination.

Asian Americans reported significantly higher average levels of reflective rumination than European Americans did ($t(510) = 2.18, p = .03, r = .10, 95\%CI [0.01, 0.18]$), with no other notable comparisons (each $p > .12$). All means and standard deviations for above comparisons are available in Table 2.

Correlational Analyses

Pearson's r correlational analyses indicated that in the full sample, total rumination was negatively associated with HF-HRV ($r = -.14, p = .002, 95\%CI [-0.22, -0.05]$). Brooding rumination ($r = -.09, p = .04, 95\%CI [-0.17, -0.00]$) and depressive rumination ($r = -.17, p < .001, 95\%CI [-0.25, -0.08]$) were also negatively associated with HF-HRV, but reflective rumination was not ($r = -.06, p = .16, 95\%CI [-0.15, 0.03]$).

Stratified by ethnicity, in Asian Americans, total ($r = -.27, p = .01, 95\%CI [-0.46, -0.06]$), brooding ($r = -.27, p = .01, 95\%CI [-0.46, -0.06]$), depressive ($r = -.26, p = .02, 95\%CI [-0.45, -0.05]$), and reflective ($r = -.21, p = .06, 95\%CI [-0.40, 0.01]$) rumination were all significantly or marginally negatively associated with HF-HRV. In African Americans, only reflective rumination was negatively correlated with HF-HRV ($r = -.25, p = .01, 95\%CI [-0.42, -0.07]$). In European Americans, only depressive rumination was associated with HF-HRV ($r = -.14, p = .01, 95\%CI [-0.24, -0.03]$). For all zero-order correlations, please see Tables 2a and 2b. Results remained consistent adjusting for covariates in the full sample, with the exception that the association of reflective rumination with HF-HRV became stronger among Asian Americans ($r = -.24, p = .03, 95\%CI [-0.43, -0.03]$).

Moderation Analyses

After adjusting for covariates, results suggested a moderation effect of ethnicity on the association of total rumination with HF-HRV, ($R^2 = .04, b = -0.01, SE = .00, p = .04, r = -$

.09, 95%CI [-0.18, -0.00]). Conditional analyses showed that higher overall rumination was associated with lower HF-HRV in African Americans ($b = -0.02$, $SE = .00$, $p < .001$, $r = -.17$, 95%CI [-0.25, -0.08]), and Asian Americans ($b = -0.03$, $SE = .01$, $p < .001$, $r = -.15$, 95%CI [-0.23, -0.06]). However, for European Americans, the association of total rumination with HF-HRV was not statistically significant ($b = -0.01$, $SE = .00$, $p = .16$, $r = -.06$, 95%CI [-0.15, 0.03]). Johnson-Neyman analyses showed that at lower levels of total rumination (total score less than 26.47), African Americans and Asian Americans had *higher* HF-HRV relative to European Americans. At higher levels of total rumination (total score greater than 112.21), African Americans and Asian Americans had *lower* HF-HRV relative to European Americans. Please see Tables 3a and 3b for statistical details on moderation analyses.

There was a marginally significant moderating effect of ethnicity on the association of brooding rumination with HF-HRV ($R^2 = .02$, $b = -0.03$, $SE = .02$, $p = .058$, $r = -.08$, 95%CI [-0.17, 0.00]). Conditional analyses showed higher brooding rumination was associated with lower HF-HRV in African Americans ($b = -0.04$, $SE = .02$, $p < .001$, $r = -.13$, 95%CI [-0.21, -0.04]) and Asian Americans ($b = -0.08$, $SE = .03$, $p = .01$, $r = -.12$, 95%CI [-0.21, -0.03]), but not in European Americans ($b = -0.01$, $SE = .02$, $p = .54$, $r = -.03$, 95%CI [-0.11, 0.06]). Results remained consistent when adjusting for depressive and reflective rumination. Johnson-Neyman analyses showed that at lower levels of brooding rumination (brooding subscale score less than 7.45), African Americans and Asian Americans had higher HF-HRV relative to European Americans. At higher levels of brooding rumination (brooding subscale score greater than 20.41), African Americans and Asian Americans had lower HF-HRV relative to European Americans.

Ethnicity did not moderate the association of depressive rumination with HF-HRV ($R^2 = .04$, $b = -0.01$, $SE = .01$, $p = .20$, $r = -.06$, 95%CI [-0.14, 0.03]). Conditional analyses suggested that higher depressive rumination was associated with lower HF-HRV, with similar strength, among African Americans ($b = -0.03$, $SE = .01$, $p < .001$, $r = -.17$, 95%CI [-0.26, -0.09]), Asian Americans ($b = -0.04$, $SE = .01$, $p < .001$, $r = -.13$, 95%CI [-0.21, -0.04]) and in European Americans ($b = -0.02$, $SE = .01$, $p = .02$, $r = -.11$, 95%CI [-0.19, -0.02]). Results remained consistent when adjusting for reflective and brooding rumination. Johnson-Neyman analyses showed no notable regions of significance.

Ethnicity moderated the effect of reflective rumination on HF-HRV ($R^2 = .03$, $b = -0.05$, $SE = .02$, $p = .002$, $r = -.13$, 95%CI [-0.22, -0.05]). Conditional analyses suggested that higher reflective rumination was associated with lower HF-HRV in African Americans ($b = -0.05$, $SE = .02$, $p < .001$, $r = -.13$, 95%CI [-0.21, -0.04]), as well as in Asian Americans ($b = -0.10$, $SE = .03$, $p < .001$, $r = -.15$, 95%CI [-0.23, -0.06]). For European Americans, reflective rumination was not associated with HF-HRV ($b = -0.01$, $SE = .02$, $p = .59$, $r = .02$, 95%CI [-0.06, 0.11]). Results remained consistent when statistically adjusting for depressive and brooding rumination. Johnson-Neyman analyses demonstrated that at lower levels of reflective rumination (reflective subscale score less than 7.31) African Americans and Asian Americans had higher HF-HRV relative to European Americans. At higher levels of reflective rumination (reflective subscale score greater than 12.90), African Americans and Asian Americans had lower HF-HRV relative to European Americans.

Discussion

We examined ethnic differences in self-reported rumination, HRV, and the association of these two variables in a sample of African Americans, Asian Americans, and

European Americans. The current study yielded several notable findings. First, Asian Americans reported significantly higher levels of rumination than European Americans, and African Americans demonstrated higher HRV than Asian Americans. Novel findings showed higher total rumination was associated with lower HRV in African Americans and Asian Americans, but not in European Americans. Similar patterns emerged across both the brooding and reflective facets of rumination with HRV, whereas associations of depressive rumination with HRV were consistent across ethnicities. In other words, differential associations of total rumination with HRV appear to be driven by the specific facets of brooding and reflective, but not depressive, rumination. In sum, these findings make significant contributions to stress and health literature, indicating ethnic differences in both average levels of, and the link between, perseverative cognition (i.e., rumination) and associated physiological consequences (i.e., lower HRV).

Ethnic Differences in Rumination and HRV

In the current study, Asian Americans reported higher levels of rumination across all facets relative to European Americans, which is consistent with previous literature (De Vaus et al., 2018; Chang, 2010; Kwon et al., 2013). Emerging research suggests that emotion regulation strategies involving the thinking of negative emotions can vary in different cultural contexts (De Vaus et al., 2018), which can influence the degree of effectiveness. In particular, Asian Americans tend to moderate the expression of their emotions more than do European Americans (Ford & Mauss, 2015). In attempting to control the expression of their emotions, Asian Americans may internalize emotions, which might contribute to differences in self-reported rumination between these ethnic groups. Another likely explanation as to why Asian Americans self-report more rumination might

be due to unique societal unfair treatment in the U.S., for example, discrimination. Such unique and unfair treatment may, at least in part, play an important role in observed ethnic differences in trait rumination. In this regard, one study showed higher discrimination to be associated with higher rumination in African Americans but not European Americans, suggesting that discrimination is indeed linked with rumination in minoritized individuals (Williams, Pandya, et al., 2019). However, experiences of discrimination were not collected in the current investigation and thus, future research is needed to investigate these claims directly.

Differences between Asian Americans and both European Americans and African Americans in cardiovascular functioning remain understudied, and only a few studies have examined HRV in particular (Hall et al., 2013; Pourmand et al., *in prep*; Yoo et al., 2021). In the current study, Asian Americans demonstrated lower HRV relative to African Americans, but not statistically reliably different than with European Americans. Two prior empirical studies showed higher HRV in European Americans relative to Asian Americans (Yoo et al., 2021; Pourmand et al., *in prep*). In contrast, a prior investigation reported African American women and Chinese women to have greater HF-HRV during sleep relative to European American women (Hall et al., 2013). However, African American women and Chinese women did not differ in this investigation (Hall et al., 2013). The current data provide novel evidence of higher daytime-resting HRV in African Americans relative to Asian Americans in a young and apparently healthy sample. These conflicting results might be due to differences within Asian American ethnicities (e.g., Chinese American vs. Korean American vs. Japanese Americans) and thus, future studies should examine potential differential trends among varying East Asian ethnic groups. Additionally, circadian rhythm

effects (e.g., daytime vs. nighttime) and the intersection of gender and ethnicity (e.g., Asian American women and men compared to African American and European American women and men) may play a role in these conflicting results and thus stress the importance of continued research in this domain.

Furthermore, a cardiovascular paradox (i.e., *the Cardiovascular Conundrum*; Hill et al., 2015) exists, wherein African Americans have higher HRV (i.e., cardioprotective), yet also have elevated blood pressure and remain at an elevated risk for cardiovascular disease (Hill et al., 2015; Thayer et al., 2020). Given African Americans showed the highest HRV in our study, yet a stronger link with rumination relative to European Americans, rumination may be an important psychological mechanism underpinning this conundrum (i.e., linking higher HRV with higher blood pressure). However future research is needed to explore the potential complex link between rumination and other cardiac mechanisms in African Americans and other minoritized ethnic groups. Nonetheless, the *Cardiovascular Conundrum* is partially supported by the current study, as differences in HRV between African Americans and European Americans were not statistically significant but yielded an effect size in the same direction of prior meta-analytic evidence (Hill et al., 2015). As mentioned, the intersection of race and gender may play an important role here (Hall et al., 2013) and thus, continued investigations are warranted.

Ethnic Differences in the Link of Rumination with HRV

Higher total, brooding, and reflective rumination was associated with lower HRV in African Americans and Asian Americans, but not in European Americans. These findings lend evidence to the Perseverative Cognition Hypothesis (PCH; Brosschot et al., 2006) and the novel Generalized Unsafty Theory of Stress (GUTS; Brosschot et al., 2018). The GUTS

model builds on the PCH, and indicates that the physiological stress response remains active, and only until an individual perceives safety in their environment, does it cease. This harmful psychological processing can have negative and chronic downstream effects on health and well-being (Ottaviani et al., 2015). Rumination is indicative of an unconscious and/or conscious perception of unsafety (Brosschot, 2010). Our results suggest that these perceptions, especially in the form of brooding and reflective rumination, might be more detrimental for cardiac function in both African Americans and Asian Americans. Indeed, brooding rumination is typically conceptualized as maladaptive and involves wallowing and sulking, which could be heightened by unfair treatment among minoritized ethnic groups.

The reflective rumination subscale seemingly represents two core characteristics, including problem-solving and being analytical (Nolen-Hoeksema & Morrow, 1991). Ottaviani and colleagues (2017) showed that independently, perseverative cognition and problem-solving were both associated with increased blood pressure, but that only perseverative cognition was associated with higher blood pressure during recovery (i.e., when rumination is likely to occur). This provides direct evidence that rumination-based problem-solving is associated with similar negative cardiovascular effects as perseverative cognition, however these negative effects might conclude as problem-solving ends (see Ottaviani et al., 2017 for discussion). In so much that problem-solving does not persist, it may be that it is not as neutral as some research may conceptualize (Williams et al., 2017). It could be that for some groups such as European Americans, this neutrality may persist, whereas for groups such as African Americans and Asian Americans, higher levels of reflective rumination may be cardio harmful. Unfortunately, in a country where individual

and institutional unfair treatment often exists, higher levels of reflective rumination might be particularly harmful for African Americans, Asian Americans, as having a tendency to problem-solve through such treatment would be improbable and analyzing discriminatory experiences might be maladaptive. It may be that for ethnically minoritized groups they may have to continually problem-solve in order to navigate a likely hostile or inequitable environment. Because minimal studies have examined these associations, further study is warranted, and should be extended to other ethnic groups as well (e.g., Latino Americans). Lastly, from a neurophysiological perspective, meta-analyses find prefrontal activation to be associated with both the act of problem-solving (Bartley et al., 2018) and maintaining adequate levels of HRV (Thayer et al., 2012); investigation of ethnic differences here are warranted as it would provide a potential physiological and neurophysiological basis for our current findings.

In contrast, we found that higher depressive rumination was not associated with lower HRV differentially as a function of ethnicity. These findings are contrary to previous research that indicates similarities in the link between HRV and both depressive and brooding rumination (Williams et al., 2017). Depression is among the most prevalent disorders in the U.S. (Bailey et al., 2019) and rumination is a major component of many measures of depression (Nolen-Hoeksema, 2003). Prior studies have found that depression is linked with lower HRV (Beauchaine & Thayer, 2015), it is clear that greater depressive rumination is linked with lower HRV at least across the three ethnicities in the current study. Depression affects individuals from all ethnic backgrounds, and it could be that depressive rumination is more universally linked with HRV, regardless of ethnic background.

Furthermore, the decomposition of slopes for the interactions of total, brooding, and reflective rumination with HRV suggested that for African Americans and Asian Americans, ruminating at low levels relative to European Americans could be beneficial for their cardiovascular functioning as indicated by higher HRV relative to European Americans. In contrast, ruminating at high levels could be detrimental to their cardiovascular functioning as indicated by lower HRV, thereby highlighting the potential contribution to health disparities via decreased vagal tone. Lower rumination among minoritized ethnic groups might be particularly reflective of their resilience to stress, highlighted by higher HRV relative to their in- and out-group counterparts. It may be that having a tendency to engage in problem-solving aspects of perseverative cognition to some degree *may* be helpful to minoritized ethnic groups. Taken together, it remains important for African Americans and Asian Americans to engage in strategies that maintain minimal ruminative processes as a whole, as it may be an especially significant contributor to cardiovascular health disparities via lower HRV.

Limitations and Strengths

The findings of the current study should be considered in light of a few limitations. First, we were unable to examine how rumination is associated with HRV in other ethnically minoritized groups such as Latino and Middle Eastern Americans; the association of rumination with HRV may function differently in these other groups. Given that we could not consider interpersonal (e.g., everyday discrimination) and institutional factors (e.g., systemic racism) that may contribute to this association, future research is warranted in this domain. Additionally, the current study did not include state rumination, and previous research has indicated that trait and state rumination may be differentially

associated with HRV (Kocsel et al., 2019). Thus, it is important to examine *both* trait and state rumination in future studies. Lastly, the age range for the sample examined in this study was limited to young adults. Ruminative tendencies can decline with age (Nolen-Hoeksema & Aldao, 2011), therefore, warranting future research that studies a wider range of healthy adults to examine how rumination is differentially related to HRV by ethnicity.

Despite some limitations, the current study had several notable strengths. First, it examined the association of rumination with HRV in understudied and minoritized ethnic groups. To our knowledge, this is one of the first studies to examine ethnic differences in HRV in African Americans and Asian Americans, which allows us to gain insight to how stress may influence health differentially for ethnically minoritized groups. Importantly, this study explored the associations of the various facets of rumination (brooding, depressive, reflective) with HRV, and how they were differentially related across the different ethnic groups in our sample. This allowed us to gain a better understanding of the nuances of rumination that may emerge, and if all facets of rumination may be detrimental across ethnic groups. Lastly, given that it is difficult to obtain large sample sizes due to the nature of psychophysiological research amongst diverse samples, we propose another strength of our study is that we had a relatively large sample.

Conclusions

Overall, this study highlights the importance of considering ethnicity in better understanding how trait perseveration processes (i.e., rumination) may both relate to and influence cardiac autonomic functioning, indexed using HRV. We provide direct evidence that rumination is more strongly associated with HRV in minoritized ethnic groups, specifically African Americans and Asian Americans, relative to European Americans. Our

investigation also highlights nuances that may emerge when examining the link of various facets of rumination (brooding, depressive, reflective) with HRV among varying ethnic groups. We propose these findings are important for better identifying psychophysiological mechanisms underlying cardiac functioning and subsequent health disparities and may provide clues for potential interventions that better health profiles in ethnically minoritized individuals.

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APPENDIX

Table 1.

Descriptive Statistics of Key Study Variables

	Full Sample (N = 513)		African Americans (n = 110)		Asian Americans (n = 84)		European Americans (n = 319)	
	M/%	SD	M/%	SD	M/%	SD	M/%	SD
Age	19.45	2.12	19.55^{a,b}	1.79	19.71^a	1.90	19.34^b	2.27
Gender	55.9%/44.1%		61.8%/38.2%		51.2%/48.8%		55.2%/44.8%	
BMI	24.00	5.08	26.02	6.43	23.34	4.94	23.48	4.40
Total	43.61	12.19	43.82	12.22	47.06^c	12.18	42.63^c	12.04
Brooding	10.50	3.31	10.69	3.32	11.64^c	3.55	10.13^c	3.18
Depressive	9.47	3.32	23.10	7.26	24.94^c	6.82	23.30^c	6.90
Reflective	23.47	6.98	9.44	3.10	10.18^c	3.23	9.29^c	3.41
HRV	6.61	1.02	6.78^{a,b}	1.02	6.45^a	1.05	6.59^b	1.01

Note. BMI = Body Mass Index, Total = Total rumination, Brooding = Brooding Rumination, Depressive = Depressive Rumination, Reflective = Reflective Rumination, HRV = heart rate variability, as measured by high-frequency heart rate variability at rest. HRV values are log-transformed. Gender percentages represent women/men, respectively. Bolded values and associated subscripts represent non-trivial contrasts: ^a = African Americans vs. Asian Americans; ^b = African Americans vs. European Americans; ^c = Asian Americans vs European Americans

Tables 2a and 2b.

Pearson's r Zero-Order Correlations Between Study Variables

	1	2	3	4	5	6	7
1. Age	--	0.17	0.09	-0.08	0.12	0.16	-0.13
2. BMI	0.15**	--	0.12	0.01	0.11	0.14	-0.20*
3. Total Rumination	-0.00	0.08	--	0.82**	0.95**	0.80**	-0.18
4. Brooding Rumination	-0.08	0.04	0.85**	--	0.69**	0.52**	0.01
5. Depressive Rumination	0.01	0.08	0.95**	0.74**	--	0.67**	-0.17
6. Reflective Rumination	0.04	0.05	0.80**	0.57**	0.65**	--	-0.25**
7. Resting HRV	-0.06	-0.06	-0.14**	-0.09*	-0.17**	-0.06	--

Note. BMI = Body Mass Index, HRV = Heart rate variability, as measured by high-frequency heart rate variability. The above table represents Pearson's *r* correlations for the entire sample ($N = 513$) below the diagonal, and for African American participants ($n = 110$) above the diagonal. *** $p < .001$, ** $p < .05$, * $p < .10$.

	1	2	3	4	5	6	7
1. Age	--	0.16**	-0.03	-0.09	-0.03	0.02	-0.03
2. BMI	0.08	--	0.09	0.11	0.09	0.03	-0.07
3. Total Rumination	-0.04	0.00	--	0.86**	0.95**	0.80**	-0.08
4. Brooding Rumination	-0.13	-0.10	0.86**	--	0.76**	0.58**	-0.06
5. Depressive Rumination	0.02	0.04	0.95**	0.73**	--	0.64**	-0.14*
6. Reflective Rumination	-0.08	-0.01	0.80**	0.58**	0.66**	--	0.04
7. Resting HRV	-0.11	0.11	-0.27*	-0.27*	-0.26*	-0.21	--

Note. BMI = Body Mass Index, HRV = Heart rate variability, as measured by high-frequency heart rate variability. The above table represents Pearson's *r* correlations for the Asian American participants ($N = 84$) below the diagonal, and for European American participants ($n = 319$) above the diagonal. *** $p < .001$, ** $p < .05$, * $p < .10$.

Table 3a and 3b.

Effects of Rumination on HRV as a Function of Ethnicity

Predictor	Total Rumination on HRV					Brooding Rumination on HRV				
	<i>b</i>	<i>SE</i>	<i>t</i>	<i>p</i>	95%CI	<i>b</i>	<i>SE</i>	<i>t</i>	<i>p</i>	95%CI
Age	-0.02	0.02	-1.06	.290	[-0.06, 0.02]	-0.03	0.02	-1.23	.221	[-0.07, 0.02]
Gender	0.10	0.09	1.08	.281	[-0.08, 0.28]	0.09	0.09	0.96	.337	[-0.09, 0.27]
BMI	-0.01	0.01	-0.82	.410	[-0.03, 0.01]	-0.01	0.01	-1.06	.291	[-0.03, 0.01]
Rumination	0.00	0.01	0.44	.660	[-0.01, 0.02]	0.02	0.03	0.72	.471	[-0.39, 0.08]
Ethnicity	0.48*	0.23	2.11	.035	[0.03, 0.93]	0.39*	0.20	1.94	.054	[-0.01, 0.79]
Rum x Eth	-0.01*	0.00	-2.07	.039	[-0.02, -0.00]	-0.03	0.02	-1.90	.058	[-0.07, 0.00]
R ²	0.04*	--	--	.006	--	0.02	--	--	.055	--

Note. Rum x Eth = Rumination Type by Ethnicity interaction effect. *N*=511. **p*<.05, ***p*<.001

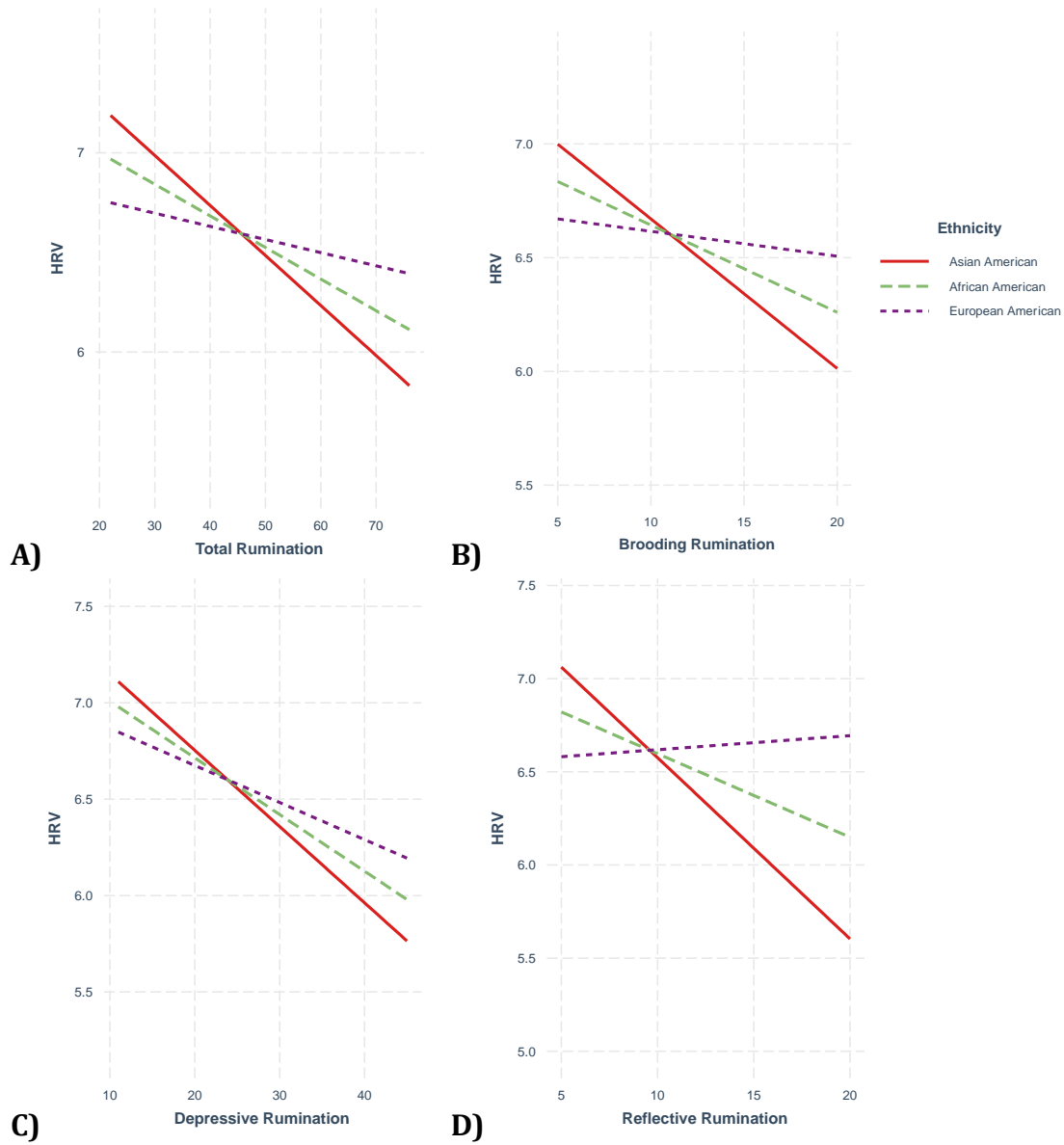
Effects of Rumination on HRV as a Function of Ethnicity cont.

Predictor	Depressive Rumination on HRV					Reflective Rumination on HRV				
	<i>b</i>	<i>SE</i>	<i>t</i>	<i>p</i>	95%CI	<i>b</i>	<i>SE</i>	<i>t</i>	<i>p</i>	95%CI
Age	-0.02					-0.02		-		
		0.02	-1.00	.318	[-0.06, 0.02]		0.02	1.03	.305	[-0.06, 0.02]
Gender	0.10	0.09	1.08	.283	[-0.08, 0.28]	0.10	0.09	1.08	.282	[-0.08, 0.28]
BMI	-0.01					-0.01		-		
		0.01	-0.74	.460	[-0.02, 0.01]		0.01	0.95	.344	[-0.32, 0.01]
Rumination	-0.01	0.01	-0.54	.593	[-0.04, 0.02]	0.06*	0.03*	2.11	.036	[0.00, 0.12]
Ethnicity	0.28	0.22	1.32	.188	[-0.14, 0.71]	0.55**	0.19**	2.93	.004	[0.18, 0.92]
Rum x Eth	-0.01					-0.06**		-		[-0.09, -
		0.01	-1.29	.199	[-0.03, 0.01]		0.02**	3.04	.003	0.02]
R ²	0.04**	--	--	.002	--	0.03*	--	--	.022	--

Note. Rum x Eth = Rumination Type by Ethnicity interaction effect. *N*=511. **p*<.05, ***p*<.001

Figure 1.

Conditional Effects of Rumination on HRV as a Function of Ethnicity



Note. The above figures represent the effect of A) total, B) brooding, C) depressive, and D) reflective rumination on resting HRV (as measured via HF-HRV) as a function of ethnicity in a sample of African, Asian, and European Americans.