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Rumination Moderates the Association between Resting High-Frequency Heart Rate Variability and Perceived Ethnic Discrimination

RUNNING HEAD: Resting Heart Rate Variability, Rumination, and Ethnic Discrimination

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Abstract

Ethnic discrimination (ED) is both an unfortunate and uncontrollable phenomenon that uniquely impacts African Americans (AAs) and other individuals of ethnic minority status. Perceived ethnic discrimination (PED), defined as the degree to which an individual consciously perceives a negative event as discriminatory and threatening, largely determines the impact that ED can have on target individuals. However, research has not yet considered how individual differences in both emotion regulation abilities, as indexed by resting high frequency heart rate variability (HF-HRV), and rumination, a maladaptive emotion regulation strategy, may predict PED in AAs. The following investigation examined this relationship in a sample of 101 college-aged students (45 AAs and 56 Caucasian Americans). Resting HF-HRV was assessed via electrocardiogram during a 5-minute-resting period. Rumination was assessed using the ruminative responses scale and everyday PED was assessed using the perceived ethnic discrimination questionnaire. Results showed a significant negative relationship between resting HF-HRV and PED in AAs only. Rumination significantly moderated this relationship, such that lower HF-HRV was related to higher PED only in AAs who reporter moderate to higher (β=.417 (.125), $p<.01$) levels of trait rumination. These results suggest that greater HF-HRV and lesser ruminative tendencies are key factors in reducing PED and therefore possibly, negative consequences associated with ED.

Keywords: *heart rate variability, perceived ethnic discrimination, rumination, emotion regulation*

Introduction

Ethnic discrimination (ED), defined as the negative treatment of an individual based on their ethnic background, remains a major societal concern and can produce negative outcomes for health in the target group. For example, converging evidence links ED with physiological outcomes such as poorer autonomic function (e.g., blood pressure (BP); Merritt, Bennett, Williams, Edwards, & Sollers, 2006), psychological outcomes such as depression (e.g., Noh & Kasper, 2003) and self-esteem (Major, Quinton, & Schmader, 2003), and health status such as cardiovascular disease (see Williams & Mohammad, 2009, for review). As ED is both an unfortunate and uncontrollable phenomenon that uniquely impacts African Americans (AAs) and other individuals of ethnic minority status (Kessler, Mickelson, & Williams, 1999; Landrine & Klonoff, 1996), converging evidence suggests that ED is associated with poorer health in these individuals particularly (Pascoe & Richman, 2009; Todorova, Falcón, Lincoln, & Price, 2010; Williams & Mohammed, 2009; Sellers & Shelton, 2003). In comparison to Caucasian American (CAs), AAs are at elevated risk for morbidity and mortality from the leading causes of death in America, including cardiovascular and other diseases (Karlamangla, Merkin, Crimmins, & Seeman, 2006; Mozaffarian et al., 2016). Given the aformentioned negative impact ED can have on health and well-being in AAs, many propose that ED contributes to such health disparities (see Williams & Mohammad, 2009, for review).

Perceived ED (PED) is defined as the degree to which an individual consciously perceives a negative event as discriminatory and threatening (Sellers & Shelton, 2003). It is important to note that ED can be considered detrimental to the target, even if it is not *consciously* perceived (Allison, 1998; Clark, Anderson, Clark, & Williams, 1999; Landrine & Klonoff, 1996; Sellers & Shelton, 2003). For example, one study demonstrated increased blood pressure in AAs

following manipulated ED under both blatant (explicit and conscious) and subtle (ambiguous and *unconscious*) experimental conditions (Merritt et al., 2006). Nevertheless, *everyday* PED may be characterized by individual differences independent of ED, that is, the same ED event may be perceived as either threatening or non-threatening depending on the individual (i.e., more or less PED; Sellers & Shelton, 2003). In this regard, research has primarily focused on social psychological factors as individual differences in PED, such as racial identity and stigma sensitivity (see Major et al., 2002).

Interestingly, Berger and Sarnyai (2014) reviewed articles that provided both direct and indirect evidence that chronic exposure to ED may impair executive brain region (e.g., the prefrontal cortex; PFC) function. Executive brain regions, particularly the PFC, is responsible for proper emotion regulation (ER), defined as a process by which individuals can modify their emotional experiences and expressions (for review, see both Etkin, Egner, & Kalisch, 2011; and Lane, McRae, Reiman, Chen, Ahern, & Thayer, 2009). Thus, the researchers proposed that the negative impact ED can have on executive brain region function may lead to a subsequent heightened stress response for additional ED (i.e., PED) or other general threat (Berger & Sarnyai, 2014). Therefore, given the role of executive function in regulating emotions, it would be important to consider how ER abilities, as determined by executive brain function, may serve as an individual difference factor in PED.

Vagally Mediated Heart Rate Variability as a Psychophysiological Indicator of Emotion Regulation Abilities

A key mechanism for successful ER is inhibitory control – individuals must inhibit inappropriate emotional responses and instead encourage more acceptable, appropriate, and desirable ones (Lane et al., 2009; Thayer, Ahs, Fredrikson, Sollers, & Wager, 2012). Executive

brain regions including the PFC exert an inhibitory influence on subcortical brain structures such as the amygdala, allowing the individual to adaptively respond to demands from the environment, and organize their emotional and behavioral responses effectively (Etkin et al., 2011; Lane et al., 2009). These core set of brain structures are also structurally and functionally linked with autonomic nervous system (ANS) regulation. The ANS dually innervates peripheral organs including the heart, and in a resting state, ANS influence is characterized by a relative dominance of the parasympathetic nervous system (PNS) over influences of the sympathetic nervous system (SNS; Thayer et al., 2012; Thayer & Lane, 2009). PNS activity is thought to reflect executive brain activity, whereas SNS activity is thought to reflect amygdala activity (see Thayer et al., 2012, for review). The vagus nerve is the primary nerve of the PNS responsible for regulating physiological functions (e.g., immune, inflammatory, and cardiac function; Thayer & Sternberg, 2006; Weber et al., 2010) via inhibitory control. Therefore, resting high frequency heart rate variability (HF-HRV), defined as variability between heartbeats mediated by the vagus, is considered an index of both (cardiac) PNS activity and executive brain function (Thayer et al., 2012), in addition to overall ER abilities. This idea is not without behavioral evidence, as many studies have linked decreased resting HF-HRV with poorer ER (e.g., Appelhans & Luecken, 2006; Melzig, Weike, Hamm, & Thayer, 2009; for review, see Thayer & Lane, 2009; Williams, Cash, Rankin, Bernardi, Koenig, & Thayer, 2015). Overall, resting HF-HRV is a measure of the degree to which the brain's "integrative" system for adaptive regulation provides flexible control over both the periphery (Thayer et al., 2012) and self-regulatory processes (e.g., ER; Kemp & Quintana, 2013).

Understanding the relationship between ED/PED and resting HF-HRV is both warranted and important, but this relationship has not been studied extensively. A handful of investigations

have shown the impact of experimentally manipulated ED on phasic changes in HF-HRV, having shown decreased HF-HRV in individuals following the experience of ED (e.g., Hoggard, Hill, Gray, & Sellers, 2015; Neblett & Roberts, 2013). However to our knowledge, only one study has examined the direct relationship between *resting* HF-HRV and everyday PED (Hill, Hoggard, Richmond, Gray, Williams, & Thayer, 2017). This study showed higher self-reported PED was associated with lower resting HF-HRV, concluding that repeated exposure of ED may lead to decreased PNS activity overtime (Hill et al., 2017). However, research has not yet considered how resting HF-HRV, as an index of ER abilities, potentially influences the likelihood that an individual perceives everyday negative events as both discriminatory and threatening (i.e., PED).

Vagally Mediated Heart Rate Variability, Perceived Ethnic Discrimination, and Rumination

Rumination is a factor thought to prolong the negative impact ED can have on physiological arousal and psychological distress, particularly in AAs (Bennett, Merritt, Edwards, & Sollers, 2004; Merritt et al., 2006). Rumination can be defined as the perseverative thinking over stressors, and often predicts negative mental states such as depression and anxiety – making rumination a largely maladaptive coping strategy (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). However, little research has considered how the tendency to employ particular ER strategies such as rumination may influence determine everyday PED. Given the definition of PED (i.e., a *past* perception of ED), it is possible that individuals with a general tendency to ruminate, may create a "running dialogue" associated with their experiences of ED and thus, the negative threat ED can remain subjectively active/present (i.e., increased PED). Additionally, individuals with lower resting HF-HRV typically employ poorer ER *strategies* when regulating

negative emotions compared to those with higher resting HF-HRV (see Brosschot, Gerin, & Thayer, 2006, for review); indeed, rumination is considered a poor ER strategy characteristic of individuals with lower ER abilities, as indexed by lower resting HF-HRV (Brosschot, et al., 2006). However, ER *abilities* and *strategies* are conceptually different; ER strategies are thought to be context dependent, that is, some strategies may be more or less adaptive depending on both the individual (e.g., abilities) and the environment (e.g., motivations; Aldao & Nolen-Hoeksema, 2012). In contrast, ER ability is a more stable factor across situations (Thayer & Lane, 2000), and thus it would be helpful to understand how both ER abilities and strategies interact to determine PED. However to date, no study has examined how an individual's trait rumination can alter or *moderate* the association between resting HF-HRV and everyday PED.

The Present Study

Research on the relationship between resting HF-HRV and PED is warranted as to our knowledge, only one other study has investigated this link (Hill et al., 2017). From an ER perspective, research has yet to consider resting HF-HRV as an individual difference factor and in everyday PED. Furthermore, it would be important to investigate if trait rumination, a maladaptive ER strategy, moderates the link between ER abilities, as index by resting HF-HRV, and everyday PED. Thus, the present study sought to both (i) replicate previous findings that showed a negative association between resting HF-HRV and everyday self-reported PED (Hill et al., 2017) and (ii) assess how trait rumination may moderate this relationship. We hypothesized that (i) resting HF-HRV would be inversely related to PED, such that AAs with lower HF-HRV would report higher PED and that (ii) this relationship would be moderated by rumination, such that this relationship should be strongest in AAs who report greater trait rumination. We expected to observe no meaningful relationships in CAs. These hypothesized results would

suggest that both ER *abilities* (i.e., HF-HRV) and ER *strategies* (i.e., rumination) are important individual difference factors in reducing PED and thereby potentially minimizing the impact of actual ED. Finally, directionality is important, as we conceptualize resting HF-HRV as the independent variable rather than an outcome (dependent) variable as in previous work (Hill et al., 2017). Therefore, we also test the reverse of our proposed moderation model above, with PED as the independent variable, rumination as the moderating variable, and resting HF-HRV as the outcome variable.

Methods

General Procedure

We recruited 101 college-aged individuals (45 AAs, 72 female, mean age = 19.48 (SD: 2.26). The experiment was conducted at the Emotions and Quantitative Psychophysiology Lab (EQP) at the Ohio State University. Subjects were recruited from the Research Experience Program (REP) pool at The Ohio State University, allowing students to participate in research for partial class credit in an introductory level psychology course. Participants outside of the REP pool were also recruited and paid for their participation. We asked all participants not to smoke, undergo vigorous physical activity, or drink caffeine six hours prior to the experiment. The study was approved by the institutional review board, and all participants signed written informed consent.

All participants were placed in a soundproof experimental room, equipped with a camera and a microphone for safety and instructional reasons, and a high definition TV for stimuli presentation. Participants were given a detailed explanation of the procedures that would take place without indicating the specific hypothesis under study or manipulations applied. Electrocardiogram (ECG) leads were attached to the subjects and while in a separate control

room, the experimenter led the subjects to the initial phases of the experiment. First, participants completed a 5-minute resting baseline period, where participants sat in a resting (spontaneous breathing) position, and viewed a blank grey screen. Following this period, participants completed a series of self-report questionnaires.

Vagally Mediated Heart Rate Variability

Cardiac data was recorded continuously throughout each experiment via a 3-lead electrocardiogram (ECG) at a 1,000 Hz sampling rate using a Mindware™ 2000D (MW2000D) Impedance Cardiograph package. Electrodes were placed (1) below the right clavicle, (2) on the left side of the abdomen (below the heart), and (3) on the right side of the abdomen. Variability between R-spikes in milliseconds was collected to calculate baseline HF-HRV for the full 5-minute rest period. Participants' successive IBIs (in milliseconds) were extracted using Mindware™ HRV Analysis software. IBIs were written in a text file and analyzed using Kubios HRV analysis package 2.0 (Tarvainen, Niskanen, Lipponen, Ranta-aho, & Karialainen 2014), allowing for the calculation of frequency-domain indices of resting HF-HRV. Artifacts within the R-to-R series were visually detected, and we applied an artifact correction level that would differentiate and remove artifacts (differing abnormal IBIs from the mean IBI; smoothing priors as a detrend method; see Tarvainen et al., 2014, for review) using a piecewise cubic spline interpolation method. Autoregressive estimates were calculated, yielding high-frequency power HRV (HF-HRV, 0.15-0.4 Hz) (Thayer et al., 2010; Task Force of the European Society of Cardiology, 1996). HF-HRV is a reliable and valid measure of cardiac vagal activity (i.e., HF-HRV; Thayer, Hansen & Johnsen, 2010). HF-HRV values were natural log transformed (ln) to fit assumptions of linear analyses. Additionally, high-frequency peak values (HF peak) were

obtained from the autoregressive analysis as a measure of respiration rate to control for potential bias (Thayer, Sollers, Ruiz-padial, & Vila, 2002).

Self-report questionnaires

Perceived Ethnic Discrimination: PED was assessed using the Perceived Ethnic Discrimination Questionnaire (PEDQ). The PEDQ is a 17-item questionnaire designed to assess subjective feelings of everyday ED (i.e., PED) and contains four subscales, including discrimination via exclusion and rejection (PED-Exclusion; $\alpha = .70$; source of reliability from the current data), discrimination via stigmatization and/or devaluation (PED-Stigma; $\alpha = .74$), discrimination at work and/or school (PED-Work; $\alpha = .69$), and discrimination via threat and/or aggression (PED-Threat; $\alpha = .80$) (Brondolo et al., 2005). Participants rate the frequency with which they experienced particular situations (sample item: *"Because of your ethnicity, have others threatened to hurt you"*) from 1 (*never*) to 7 (*very often*). Within the current sample, the PEDQ showed good overall internal consistency ($\alpha = .87$).

Trait Rumination: Rumination was assessed using the 22-item Ruminative Responses Scale (RRS; Treynor, Gonzalez, Nolen-Hoeksema, 2003). Participants answered on a scale from 1 (*almost never*) to 4 (*almost always*), (sample item: *How often do you think* about how alone you feel), with higher values representing higher trait rumination (Cronbach's $\alpha = .92$).

Statistics

All statistical tests were conducted using SPSS (ver. 19, IBM Chicago, IL, USA). Independent sample t-tests were also used to examine differences between CAs and AAs on all psychological and physiological variables. Split by ethnicity, Pearson's r zero-order correlation coefficients were calculated in order to illustrate the relationships between all variables.

An SPSS macro PROCESS was used (Hayes, 2012) to test if rumination moderated the relationship between resting HF-HRV and PEDQ scores in AAs *only*, as we did not expect to observe a significant relationship between in CAs. In the program PROCESS, "Model 1" was used to test a main effect of the independent variable (IV; resting HF-HRV), a main effect of the moderator (M; RRS scores), and an interaction effect of the two on the dependent variable (DV; PEDQ scores). We also tested an alternative version of this model that includes PEDQ scores as the IV, RRS scores as the M, and resting HF-HRV as the DV (see Figure 1A for hypothesized moderation model, and Figure 1B for alternative moderation model).

If the 2-way interaction is significant, it suggests that the relationship between the IV and DV changes at different levels of M, (see Hayes, 2012, for review). The nature of the interaction was determined using PROCESS' conditional effects, that is, *how* the IV-DV relationship changes at different levels of M and W. High and low values for the predictor variables are derived using +/- 1SD from the mean, allowing the program to yield predicted values of the DV at varying levels of the predictor variables via regions of significance and simple slope analyses (Hayes, 2012).

>*Insert Figure 1 Here*<

Statistics reported include, unstandardized beta (B) coefficients, standard errors (SE; in brackets), 95% confidence intervals, partial correlation coefficients (for interactions), and *p* values. Lastly, potential covariates of resting HF-HRV were controlled for in each model. These variables included respiration rate (HF peak values; Thayer et al., 2002), sex (Koenig & Thayer, 2016), body mass index (BMI; Koenig et al., 2014), and age (Jensen-Urstad, Storck, Bouvier, Ericson, Lindbland, Jensen-Urstad, 1997). All tests were two-tailed and significance levels were evaluated using an alpha of .05.

Results

Descriptive statistics, including age, BMI, baseline HR, baseline HF-HRV, PED, and rumination split by ethnicity are given in Table 1. The AA sample showed significantly higher PED in comparison to CAs (t (99) = -8.44, $p < .001$), and greater resting HR (t (99) = -2.28, $p < .05$) but did not differ significantly on any other variable (Table 1).

Table 1. Means and Standard Deviations of all Variables Split by Ethnicity

	n	Age	BMI	HR	Respiration	HF-HRV	PED	Rumination
AA	*45*	19.82 (2.48)	25.16 (5.42)	76.21 (8.16)	.27 (.04)	6.74 (.85)	30.02 (7.29)	41.82 (11.63)
CA	*56*	19.20 (2.05)	23.92 (3.16)	72.03 (9.85)	.26 (.05)	6.57 (1.05)	20.36 (4.05)	41.61 (10.65)
p		.168	.155	**.024**	.112	.370	**.001**	.924

Note: This table shows mean (standard deviation in brackets) values on baseline measures split between CAs and AAs. Age was calculated in years, heart rate (HR) in beats per minute, Body mass index (BMI) was calculated in kg/m2, and natural log high frequency heart rate variability (HF-HRV) was calculated in ms^2. Perceived ethnic discrimination PED was indexed using the perceived ethnic discrimination questionnaire (PEDQ) with higher scores reflect higher PED. Trait Rumination was indexed using the ruminative response scales (RRS), with higher reflecting higher trait rumination (significant p values bolded).

Within the AA group, results showed a significant negative association between resting HF-HRV and total PED scores (r = -.303, $p = .041$). Subscale results revealed a significant negative relationship between HF-HRV and PED-Stigma (r = -.402, $p < .01$) while the other subscales were not significant, but trending in the same direction (PED-Exclusion (r = -.241, $p = .107$); PED-Work (r = -.197, $p = .190$); PED-Threat (r = -.142, $p = .246$)). Total rumination was significantly positively associated with total PED (r = .299, $p = .025$). Total rumination was also significantly positively associated with PED-Threat (r = .442, $p = .002$). In CAs, no significant relationship between HF-HRV and PED (including all subscales) was found.

Additionally, no relationship between PED and total rumination was found in CAs (refer to Table 2 for correlations between all variables in both AAs and CAs).

Table 2. Correlations Coefficients between Variables Split by Ethnicity

African Americans	1	2	3	4	5	6	7
1. HF-HRV	--						
2. Rumination	.188	--					
3. PED-Total	**-.342***	**.299***	--				
4. PED-Exclusion	-.258	.018	**.711****	--			
5. PED-Stigma	**-.419****	.095	**.745****	**.549****	--		
6. PED-Work	-.213	.291	**.849****	**.507****	**.443****	--	
7. PED-Threat	-.193	**.442****	**.713****	.151	**.391****	**.536****	--

Caucasian Americans	1	2	3	4	5	6	7
1. HF-HRV	--						
2. Rumination	-.045	--					
3. PED-Total	-.173	.084	--				
4. PED-Exclusion	-.057	.217	**.605****	--			
5. PED-Stigma	-.203	**.299***	**.670****	**.595****	--		
6. PED-Work	-.048	-.090	**.598****	-.101	.177	--	
7. PED-Threat	-.184	-.063	**.819****	**.293***	**.317***	**.422****	--

Note: HF-HRV: high frequency heart rate variability (natural log transformed); Rumination: indexed using the ruminative responses scale; PED-Total: Perceived Ethnic Discrimination total scores – PED-Exclusion: discrimination via exclusion subscale; PED-Stigma: discrimination via stigma subscale; PED-Work: discrimination at work/school subscale; PED-Threat: discrimination via threat/aggression subscale. *p<.05 **p<.01

Controlling for aforementioned covariates, moderation results showed that rumination significantly moderated the relationship between resting HF-HRV and PED in the hypothesized model (Figure 1A; B= -.26 (.12), $r_{partial}$ = -.350, *p = .028*). Conditional effects analyses showed a

significant relationship between resting HF-HRV and PED in AAs with higher (B= -5.16 (1.61), $p = .003$) to moderate (B= -2.37 (1.14), $p = .04$) levels of trait rumination, but not in those with lower trait rumination (B= 0.42 (1.74), $p = .813$) suggesting that AA individuals with lower trait rumination report similar levels of PED despite levels of resting HF-HRV. Likewise, AA individuals with higher resting HF-HRV report similar levels of PED despite levels of trait rumination (B= -0.03 (0.14), $p = .835$). Moderation tests was not significant using the alternative model presented in Figure 1B (B= -.002 (.001), $r_{partial} = -.228$, $p = .164$).

>Insert Figure 3 Here<

Discussion

The current investigation sought to examine the relationship between resting HF-HRV, a psychophysiological index of ER abilities, and PED in AAs. Additionally, we sought to investigate how ruminative tendencies may moderate this association. In line with an earlier report (Hill et al., 2017), there was a significant and negative association between resting HF-HRV and PED in AAs but not CAs. Results also showed a significant negative association between trait rumination and PED in AAs only. Subscale analyses showed resting HF-HRV to be most related to the perception of discrimination via stigmatization as indicated by the respective subscale (PED-Stigma), however all subscales' correlations trended (although not significant) in a negative direction. Importantly, trait rumination significantly moderated the association between resting HF-HRV and PED, such that this relationship was only significant in AA individuals with moderate to higher levels of trait rumination. AAs with both lower resting HF-HRV and higher trait rumination showed higher PED compared to all other AAs. Overall, these data both (i) support the link between resting HF-HRV and PED in AAs, and (ii) presents trait rumination as an important moderating factor in this association.

Implications

It is important to note that moderation tests were only significant with resting HF-HRV as the independent variable and PED as the dependent variable (hypothesized model; Figure 1A), and not vice versa (alternative model; Figure 1B). This lends direct support for our novel idea that ER abilities, as indexed by resting HF-HRV, may differentiate AA individuals in everyday PED. Nevertheless, evidence has shown that following experimentally manipulated ED, AAs can also show decreased HF-HRV (e.g., Neblett & Roberts, 2013). Therefore, it is plausible to consider that in an environment where ED often occurs (Sellers & Shelton, 2003), repeated exposure may diminish the integrity of executive brain regions necessary to inhibit the effects of further ED or threat more generally (Berger & Sarnyai, 2014). Such decrements may lead to lower *resting* HF-HRV in AAs over time (Hoggard et al., 2013, Hill et al., 2017; Neblett & Roberts, 2013). Finally, as we suggest in the current report, chronic lower resting HF-HRV, especially when coupled with rumination, may further exaggerate PED in AAs thereby perpetuating a detrimental cycle of stress and disease. Therefore, we propose that resting HF-HRV and/or trait rumination are potential "first-steps" in minimizing both the impact of PED on psychophysiological processes, and psychophysiological processes on PED.

From a health standpoint, it is interesting to consider research showing that in comparison to CAs, AAs often show greater total peripheral resistance (TPR) and decreased BP at rest. However, a recent meta-analysis by our group showed that AAs have higher resting HF-HRV compared to CAs (Hill et al., 2015) – a paradoxical pattern that we named the *"cardiovascular conundrum"*. Here, we proposed that greater HF-HRV in AAs serves as a *compensatory mechanism*, such that AAs may need more ER abilities, and thus higher HF-HRV, to compensate for unique day-to-day stressors such as ED. In support of this idea a recent investigation showed that in 11,989 individuals, Black Brazilians showed greater resting HF-HRV in comparison to

both White Brazilians and mixed (Brown Brazilians) individuals, and this relationship was mediated by experiences of ED (i.e., darker skin tone associated with greater experiences of ED associated with higher resting HF-HRV; Kemp et al., 2016). Whereas Kemp et al. (2016) showed ED to be associated with higher resting HF-HRV *between* ethnic groups, the current results showed that *within* AAs only, greater PED was associated with lower resting HF-HRV but only in those AAs with a ruminative coping strategy. Overall, prior work suggests that ED serves as a mechanism underlying differences in resting HF-HRV *between*, and the current study suggests that higher resting HF-HRV *within* the AA group is especially important in minimizing PED.

Limitations and Future Directions

One major limitation of the current investigation is that it is correlational and thus, causation cannot be determined. Future research should use longitudinal techniques in an attempt to better understand causality. A second limitation of the current study is that socioeconomic status (SES) information was not collected. SES is proposed to be an influential variable in the experience of ED and thus, future studies should examine the current relationship while considering SES. A third limitation of the current study is that the sample consists of apparently healthy, young students. While we were able to provide evidence for an association of PED and HRV in this sample, future studies should examine this relationship on those with preexisting health problems and older subjects in general. Finally, although we required participants not to smoke, undergo vigorous physical activity, or drink caffeine six hours prior to the experiment, we did not verify that participants complied, and future investigations should ensure that this information is collected and considered.

Conclusions

The present study is the first to suggest that lower resting HF-HRV and trait rumination interact to negatively influence PED in AAs. We do not propose that higher resting HF-HRV and/or lower trait rumination can solve the core issues associated with ED. We are, however, proposing that these factors are of particular importance in AAs, as lower PED in a society where ED often occurs may potentially buffer the negative consequences of ED on health and well-being (Pascoe and Richman, 2009; Sellers and Shelton, 2003).

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Figure Ledgeds

Figure 1. Conceptual Proposed Moderation Model

Note: This figure represents the moderation models presented in the current investigation. Figure 1A – Hypothesized model: The independent variable is regarded as resting high frequency heart rate variability (HF-HRV; natural log transformed), the moderator as rumination (ruminative responses scale (RRS) scores), and the dependent variable as perceived ethnic discrimination (PED; indexed by perceived ethnic discrimination questionnaire (PEDQ) scores). Figure 2B – Alternative model: The independent variable is regarded as resting PED, the moderator as rumination, and the dependent variable as HF-HRV.

Figure 2. Scatterplot of Resting HF-HRV and Perceived Ethnic Discrimination

Note: figure A represents a scatterplot between resting natural log transformed (ln) high frequency heart rate variability (HF-HRV) and Perceived Ethnic Discrimination Questionnaire (PEDQ). This correlation was significant in African American participants only ($r = -.303$, $p < .05$). Figure B shows the correlation between PEDQ and Ruminative Response Scale (RRS) scores ($r = .299$, $p < .05$).

Figure 3. Conditional Effects of Rumination as a Moderation Variable

Note: This figure represents the conditional effects of rumination on the association between HF-HRV and Perceived Ethnic Discrimination Questionnaire (PEDQ) scores. Higher and lower estimates of resting natural log transformed (ln) high frequency heart rate variability derived from +/- 1SD from the mean (see Methods for details). Those who scored lower on the Ruminative Responses Scale (RRS) showed no association between resting HF-HRV and PEDQ scores. However, resting HF-HRV was significantly associated with PEDQ scores in those with higher trait rumination, such that lower resting HF-HRV was associated with greater PEDQ scores. AAs with lower HF-HRV and higher trait rumination reported the highest PED scores.