

The Role of Stress on Black Women's Food Motivation and Food Choice

By  
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The Role of Stress in the Eating Behaviors and Food Choice Among Black Women

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## Abstract

The highest rates of obesity in the U.S. are among black women with a prevalence of 54.8%. Stress has been associated with differences in eating behaviors, such as emotional eating which can lead to obesity over time. Stress from racism, has also been proposed as contributors to this disparity, but the mechanisms are unclear. The objectives of these studies are to understand the relationship between perceived stress, race related stress, neurological markers of food motivation and food choice. **Methods: Study 1** Twenty women with a body mass index (BMI) between 18.5 and 40 were recruited. Self-reported stress was measured using the Perceived Stress Scale and food motivation was measured by examining brain activation to visual food cues when fasted. **Study 2** Sixteen women come in fasted for two appointments, randomized to the order of stress exposure in a within subject design. Images from two validated picture sets, intended to induce negative affect, were matched on valence and arousal. Images were classified as race-related and non-race related. Food choice and food demand tasks were completed pre- and post-stress exposure. **Results: Study 1** No brain regions were found that showed a positive correlation between food motivation and stress. No significant differences were found in food motivation or stress between healthy weight and obese women. **Study 2** Stress after viewing NRR images decreased compared to RR images. Preferences for low fat food increased after viewing RR images. **Conclusion:** Overall, results of the current study suggest that increased levels of perceived stress are not related in increased activation in a brain region related to food motivation and self-regulation. Different types of stress are associated with changes in food choice in black women.

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## Table of Contents

Chapter 1: Introduction .....	1
Literature Review.....	4
<i>Stress and the Brain</i> .....	4
<i>Food and the Brain</i> .....	5
<i>Stress and Food</i> .....	6
<i>Food and Race</i> .....	7
<i>Race and Stress</i> .....	7
<i>Race Related Stress</i> .....	8
Chapter 2: Research Hypotheses .....	10
Aim 1: Examine the relationship between perceived stress, hormonal response and food motivation among black women.....	11
<i>Summary of Relevant Literature</i> .....	11
<i>Gap in the Literature</i> .....	11
<i>Statement of Hypotheses</i> .....	12
Aim 2: Examine the relationship between race related stress and food choice among black women.....	12
<i>Summary of Relevant Literature</i> .....	12
<i>Gap in the Literature</i> .....	12
<i>Statement of Hypotheses</i> .....	13
Chapter 3: Study 1 Aim 1 .....	14
Methods.....	15
<i>Participants</i> .....	15
<i>Inclusion and exclusion criteria:</i> .....	15
<i>Procedures</i> .....	15
<i>fMRI Procedures</i> .....	16
<i>Self Report Measures</i> .....	18
<i>Data Analysis</i> .....	18
Results.....	19
<i>Sample Characteristics</i> .....	19

<i>fMRI Data and Ghrelin</i> .....	19
Chapter 4: Study 2 Aim 2 .....	22
Methods.....	23
<i>Participants</i> .....	23
<i>Inclusion and Exclusion Criteria</i> .....	23
<i>Procedures</i> .....	24
<i>Self- Report Measures</i> .....	24
<i>Outcome Measures</i> .....	25
<i>Data Analysis</i> .....	26
Results.....	26
<i>Sample Characteristics</i> .....	26
<i>Outcome Measures</i> .....	27
Chapter 5: Discussion .....	32
Discussion of Hypotheses .....	33
<i>Study 1</i> .....	33
<i>Study 2</i> .....	34
Limitations .....	36
Summary .....	36
References.....	38

## List of Figures

Figure 1 Participant Schedule .....	16
Figure 2 fMRI Paradigm.....	17
Figure 3 Avg % Ghrelin Change by Group .....	20
Figure 4 Change in Ghrelin Over Time .....	21
Figure 5 Consort Diagram .....	23
Figure 6 Example Food Choice Task.....	25

## List of Tables

Table 1 Descriptive Characteristics .....	20
Table 2 Age and BMI distribution of Sample.....	28
Table 3 Socioeconomic Descriptives of Sample .....	28
Table 4 Post Hoc Tukey LS means of Outcome Variables .....	30
Table 5 Spearman Partial Correlation Coefficients IRRS v. Outcome Measures .....	30
Table 6 Spearman Partial Correlation Coefficients BMI v. Outcome Measures.....	30
Table 7 Spearman Partial Correlation Coefficient BMI v. IRRS and PSS .....	31

## Chapter 1: Introduction



Weight gain occurs when daily total energy intake (TEI) is greater than total energy expenditure (TEE) over a period of time (Swinburn et al., 2009). The storage of this excess energy is deposited as fat, which evolutionarily protects against episodes of famine (Levine, Eberhardt, & Jensen, 1999). Storage of some fat is necessary for optimal biological functioning, but excessive accumulation disrupts several physiological processes, thus increasing risk of disease (Redinger, 2007). Body Mass Index (BMI), approximates the level of excessive fat tissue and is the standard measure of classifying weight status in relation to disease risk, with a BMI  $\geq 30\text{kg/m}^2$  defining obesity ("Executive Summary," 1998).

Currently over one-third of adults in the United States are obese, and by 2030 that number is expected to rise to 51% (Finkelstein et al. (2012); a number already surpassed among black women. Black women have the highest prevalence of obesity in the United States at 54.8%; whereas white women have an obesity prevalence of 34.8% (Hales CM (2020). Genetics, socioeconomic, and psychosocial factors, such as stress have been proposed as contributors to the disproportionate rate of obesity in black women (Byrd, Toth, & Stanford, 2018).

Twin studies provide evidence of heritable genetic factors that increase risk of obesity in adulthood (Silventoinen, Rokholm, Kaprio, & Sørensen, 2010). Additionally, differences in genetic expression of regulatory fatty acid synthesis metabolism and appetite hormones (e.g. adiponectin, leptin, ghrelin, and peptide YY) have been found between racial groups. In black populations, certain single nucleotide polymorphisms and copy number variants have been associated with obesity (Monda et al., 2013; Zhao et al., 2012). Adiponectin is associated with fatty acid metabolism and is has been found to be lower among individuals with obesity (Heid et al., 2006). Leptin is a hormone that induces satiety and the desensitization of leptin has been linked to obesity (Pan, Guo, & Su, 2014). Similarly impaired regulation of ghrelin, which

induces hunger, and peptide YY (PYY) which induces satiety, may contribute to altered hunger cues and obesity (Batterham et al., 2002; David E Cummings et al., 2001). There is some evidence of Blacks compared to Whites having lower adiponectin (S. S. Cohen et al., 2011) and PYY levels as well as lower levels of ghrelin suppression (Bacha & Arslanian, 2006) and lower expressions of leptin regulators (Mou et al., 2015). Gene expression, however, can be regulated by the environment, and genetic variation alone cannot explain obesity risk. The differences in obesity risk between foreign born Black people, and those born in the United States, suggest that there are environmental factors that influence genetic risk (Barrington, Baquero, Borrell, & Crawford, 2010). Those born in the US were more likely to be obese than those born in other countries, with foreign born Blacks having similar, or even decreased risk of obesity compared to US born Whites (Barrington et al., 2010). These differences varied across socioeconomic status (SES), an environmental factor which can influence genetic susceptibility to obesity.

Oxytocin influences metabolic regulation, appetite and stress responses, which are all involved in obesity risk. Those of low SES are more likely to report higher levels of depression, social isolation, and chronic life stress (Hemingway & Marmot, 1999). In children, low SES is associated with genetic variations in oxytocin receptors that increase susceptibility to obesity (Bush et al., 2017). Among Black women, weight gain over time and obesity are associated with neighborhood SES, more than individual SES. Those living in lower SES neighborhoods, irrespective of individual educational attainment and income, were more likely to be obese than those living in more affluent neighborhoods. Living in a low SES neighborhood was associated with increased levels of C-reactive protein (CRP) a marker of inflammation associated with increased levels of stress and obesity (Aronson et al., 2004; Cozier et al., 2016). Compared to White women, Black women do not have as strong or as consistent inverse relationship between

socioeconomic status and rates of obesity (Jackson et al., 2013). Additionally, Black women have higher average BMI's across the socioeconomic spectrum compared to their White counterparts (Chang & Lauderdale, 2005). Other factors, aside from SES should be explored as, SES is not as strong of a protective factor against obesity for Black women. Data suggests that neighborhood stress influences these findings, as Black women are more likely to live in disadvantaged neighborhoods even with similar levels of education and income as Whites (Krieger, Rowley, Herman, Avery, & Phillips, 1993).

## **Literature Review**

### *Stress and the Brain*

The physiologic stress response occurs when stimuli disrupt and overwhelm homeostasis of an organism. Psychological stress can be defined as “stimuli that threaten the current state and are perceived in an anticipatory condition e.g., aversive environmental stimuli, predator-related cues and failure to satisfy internal drives” (Dayas, Buller, Crane, Xu, & Day, 2001). Markers of physiological stress, like neuroendocrine hormones (i.e. cortisol) and inflammatory cytokines (i.e. IL-1 $\beta$ , IL-6, TNF-a) change consistently in response to psychological stress (Sinha & Jastreboff, 2013).

In animal models, repeated social stress has been associated with modifications in expression of proteins in the hippocampus (Carboni et al., 2006), which is involved in attention, learning and memory. Reduction of stress, measured via the Perceived Stress Scale (PSS) has been associated with decreases in density of the amygdala; a region involved in detection of stress and coping mechanisms (LeDoux, 2000). Induction of psychological stress via the Montreal Imaging Stress Task (MIST) was associated with deactivation in the medio orbitofrontal cortex and anterior cingulate cortex; correlating to increases in release of cortisol

(Pruessner et al., 2008). These aforementioned regions are involved in reward processing, executive functioning, cognitive control which when altered can affect behavior and decision making (Baxter & Murray, 2002; Porcelli, Lewis, & Delgado, 2012).

### *Food and the Brain*

Control of eating is modulated by the hypothalamus in response to dynamic changes in energy stores via hormones like leptin, ghrelin and PYY (Saper, Chou, & Elmquist, 2002). Satiety results from changes in the gastrointestinal system (i.e. gastric distension) modifying release of hormones (leptin) to send signals to the brain upon feeding. Hunger results from disruption in homeostatic energy signals, signaling the release of hormones (ghrelin) to stimulate appetite (David E. Cummings & Overduin, 2007). Exogenous administration of ghrelin in response to visual food cues is associated with increased self-reports of hunger, and brain regions involved in reward processing and appetite (Malik, McGlone, Bedrossian, & Dagher, 2008).

The regions of the brain associated with response to food cues, the appetitive network, has been studied using functional MRI (fMRI) to understand neural responses for food motivation (Dagher, 2012). Dopaminergic signaling from the midbrain stimulates the appetitive network, which alters emotion and reward processing while viewing images of food. This is correlated to food preference, caloric intake, and weight gain (Demos, Heatherton, & Kelley, 2012; Mehta et al., 2012; M. S. Tryon, C. S. Carter, R. Decant, & K. D. Laugero, 2013). Changes in appetite hormones, as mentioned above, modulate the activity of neural networks involved in understanding the reward value of food. Higher fasting levels of ghrelin, are associated with increased subjective rating of appetite, and increased food cue reactivity in reward regions of the brain (Kroemer et al., 2013). Activity of higher order cognitive

processing of food reward, via imaging of the dorsolateral prefrontal cortex, has been related to the desire to purchase foods at difference prices (Plassmann, O'Doherty, & Rangel, 2007).

The reinforcing nature of food intake has been compared to the neural processing of drugs via dopaminergic pathways. In rats, consumption of highly palatable foods can cause addiction like behaviors, resulting in compulsive eating and weight gain (Kenny, 2011). Lack of access to these foods, can induce states similar to drug withdrawal, mediated by altered levels of neural dopamine receptors (P. M. Johnson & Kenny, 2010).

### *Stress and Food*

The hypothalamic pituitary-adrenal axis (HPA), is involved in modulating the effects of stress associated with changes in food behaviors (Mary F. Dallman et al., 2003). The effects of ghrelin on neural circuitry have been associated with mediating stress induced food reward in animal models, and in humans. Psychosocial stress can be induced in mice by repeated subordination of individuals with lower social status (i.e. smaller, timid), by those in a higher social status (i.e. larger, more aggressive). The exposure of mice to prolonged periods of psychosocial stress, is associated with increased plasma ghrelin and increased intake of high fat food (Chuang et al., 2011; Moles et al., 2006).

In humans high reactivity social stress, along with high cortisol levels, potentially leads to increased consumption of calories and highly palatable foods (Epel, Lapidus, McEwen, & Brownell, 2001). Higher reported stress levels have been associated with increased activation in brain regions involving reward and motivation when shown pictures of high calorie foods (Martin et al., 2010; Matthew S Tryon, Cameron S Carter, Rashel DeCant, & Kevin D Laugero, 2013). Women are especially susceptible to this as they have been typically found to score higher

on measures of emotional eating (Grunberg & Straub, 1992; van Strien, Frijters, Bergers, & Defares, 1986).

### *Food and Race*

Diet quality and food preference differ among racial groups; which can partially be explained by cultural and historical factors (James, 2004). The institutions of slavery and segregation, led to restrictions on the availability of certain foods to Black Americans, which influenced techniques in food preparation that is still common in modern cuisine (Kittler, Sucher, & Nelms, 2011). This history, could be a contributor in Black Americans more likely to have an obesogenic diet, which is high in calories and fat, low in fruit, vegetable and fiber intake (Basiotis, Carlson, Gerrior, Juan, & Lino, 2004).

Black children have a greater preference of sweet tasting food compared to their White counterparts, a risk factor for obesity in adulthood (Dodd, Briefel, Cabili, Wilson, & Crepinsek, 2013; Schiffman, Graham, Sattely-Miller, & Peterson-Dancy, 2000). This finding is similar in adults, with more Black mothers and their children preferring sweet tasting food, compared to White mothers and their children. This was irrespective of socioeconomic differences (Pepino & Mennella, 2005). Some of these discrepancies can be attributed to stress, with Blacks having higher levels of stress and greater preference for sweet tasting food compared to Whites (Mary F Dallman et al., 2003; Schiffman et al., 2000).

### *Race and Stress*

Allostatic load is a measure used to estimate levels of stress, via physiological changes that reflect the disruption of homeostasis (McEwen, 2000). A study measuring allostatic load, using National Health and Nutrition Examination survey data, found that Blacks on average have

a higher allostatic load score compared to Whites, even when adjusting for socioeconomic status (Geronimus, Hicken, Keene, & Bound, 2006). Whites living in poverty were less likely than Blacks not living in poverty to have high allostatic load scores. Black women had the highest allostatic load scores, no matter their economic indicators compared to all groups (Geronimus et al., 2006). Non-poor Black women were two times as likely to have a high allostatic load compared to White women (Geronimus et al., 2006). In overweight and obese women completing a weight loss intervention, Black women reported greater average levels of stress (via PSS) than White women.

### *Race Related Stress*

Increased levels of stress are associated with increased risk for obesity, via a variety of physiological mechanisms that influence food behaviors. Women, are more likely than men to participate in maladaptive behaviors, such as emotional eating that are used to cope with high levels of stress, putting them at greater risk for obesity (van Strien, Peter Herman, & Verheijden, 2012). The Perceived Stress Scale (PSS) is the most widely used tool for measuring stress levels, with scores correlating to physiological markers of stress (Pruessner, Hellhammer, & Kirschbaum, 1999; Tull, Sheu, Butler, & Cornelious, 2005; Van Uum et al., 2008). This tool however is not able to differentiate the influence of specific stressors. Black women have the highest rates of obesity among any demographic group, as well as high levels of stress. These data suggests that race related stress could account for the disparities in obesity rates in Black women, not accounted for by measuring general stress levels alone (Mwendwa et al., 2011).

Race related stress (RRS) can be defined as “transactions between individuals or groups and their environment that emerge from the dynamics of racism, and that are perceived to tax, or exceed existing individual and collective resources or threaten well being” (Harrell, 2000).

Perceived discrimination has been associated with physiological outcomes such as cortisol regulation (Zeiders, Hoyt, & Adam, 2014) visceral fat levels, (Lewis, Kravitz, Janssen, & Powell, 2011), inflammation (Lewis, Aiello, Leurgans, Kelly, & Barnes, 2010) and allostatic load (Brody et al., 2014). There is also evidence linking experience of racism to health behaviors such as poor sleep and alcohol use (Borrell, Kiefe, Diez-Roux, Williams, & Gordon-Larsen, 2013; Cozier et al., 2014; Lewis et al., 2013).

The risk factors for obesity span inherent genetic differences that can occur between and within populations. Differences in environment, such as socioeconomic factors can modulate genetic expression to increase or decrease one's individual risk. Increased susceptibility is related to varying physiological differences, such as alteration in neural networks, and disrupted regulatory appetite hormones. These processes are meant to maintain homeostasis in an organism, but stress can create dysfunction in these tightly controlled processes, promoting maladaptive eating behaviors. Stress from racism has been proposed to be involved in this complex interaction between psychological and physiological risk factors for obesity.



## Chapter 2: Research Hypotheses

**Aim 1: Examine the relationship between perceived stress, hormonal response and food motivation among black women.**

*Summary of Relevant Literature*

Increased levels of stress have been associated with increases in neural reward reactivity in response to food (Born et al., 2010). Alterations in cognitive control regions, such as the dorsolateral prefrontal cortex, are related to increased levels of stress (Coletta et al., 2009). Differing levels of regulatory appetite hormones, such as ghrelin have been associated to differences in perceived stress level (Dickson et al., 2011). Women are more susceptible to emotional eating in response to stress with black women being the most susceptible (Epel et al., 2001). This could be due to dysregulation of homeostasis in appetitive hormones from stress because of the increased likelihood black women experiencing stress.

*Gap in the Literature*

Much of the literature exploring the relationship between stress and eating behaviors lack representation of black participants. A 2017 study exploring the relationship of acute stress on neural processing of food cues in those with bulimia, were predominately White with no Black women in the group of healthy controls (Collins et al., 2017). A 2009 study assessing brain activity of restrained vs unrestrained eaters when exposed to foods of varying palatability, had only 1 Black participant out of 29 person sample (Coletta et al., 2009). In several studies cited previously in the section on stress, neuroimaging and food, race was not reported at all in their participant characteristics (Epel et al., 2001; Matthew S Tryon et al., 2013). As Black women are 70% more likely to be obese compared to White women (Agyemang & Powell-Wiley, 2013), the lack of representation in neuroimaging research of this domain, does not allow for an adequate representative sample.

### *Statement of Hypotheses*

1. Individuals who report higher levels of stress will have increased activation in brain regions related to food motivation when exposed to food stimuli in the MRI while fasted. It is expected that those with an obese BMI would a) have a higher PSS scale score and b) more strongly react to food stimuli than those with a HW BMI.
2. Those with high PSS scores will have lower levels of ghrelin suppression post prandially than those with lower PSS scores. It is expected that those with an obese BMI would have the lower levels of ghrelin suppression post prandially compared to those with a HW BMI.

**Aim 2: Examine the relationship between race related stress and food choice among black women.**

### *Summary of Relevant Literature*

The examination of the relationship between racism and health outcomes, is a growing field of research that attempts to elucidate the unique stressors that minority populations face. As previously mentioned, in animal models, psychological stress can be induced via subordination to individuals of higher social status (Chuang et al., 2011). There is also evidence that stress can be transmitted via social interaction (Sterley et al., 2018). Neuronal activity of mice that were not stressed mimicked the findings of mice that were stressed, after coming into with the stressed mice (Sterley et al., 2018). These findings suggest that differences in social hierarchy can precipitate stress, which could be transmitted to those within the same social group, resulting in similar negative health outcomes.

### *Gap in the Literature*

Perceived discrimination as a risk factor has been associated with emotional eating in small samples of Black women (Diggins, Woods-Giscombe, & Waters, 2015; Hayman,

McIntyre, & Abbey, 2015). These studies have primarily assessed discrimination by surveying participants about past experiences of racism (Diggins, Woods-Giscombe, & Waters, 2015; P. Johnson, Risica, Gans, Kirtania, & Kumanyika, 2012). These studies are observational and can provide correlational data yet cannot provide real-time responses to different stress states. Acute stress has been shown to increase energy intake compared to neutral non-stressful conditions at rest (Born et al., 2010). Experimental manipulation that induces stress acutely can provide stronger evidence for the relationship between race-related stress and energy intake.

### *Statement of Hypotheses*

1. Exposure to race related stressors (e.g. photos of racially charged scenes) compared to non-race related stressors (e.g. photos of stress related scenes that are not racially charged) will be associated with decreased healthy food selection.
2. Those with higher levels of self-reported race related stress will be more likely to have higher BMI's
3. Those with higher BMI's will be more likely to have select higher quantities of unhealthy food following stress exposure (e.g. photos of stressful scenes). This finding would be most pronounced following the race-related stressful images.

## Chapter 3: Study 1 Aim 1

## Methods

### *Participants*

Participant data was collected from a food motivation fMRI study conducted by Hoglund Brain Imaging Center. Twenty participants completed all study procedures and were included in the analysis.

### *Inclusion and exclusion criteria:*

- 1.) Inclusion Criteria: 1) Self-identified African American Females 2) Age 21 to 55 year-old 3) BMI 18.5 - 24.9 (HW) or 30.0 - 44.9 (Ob).
- 2.) Exclusion Criteria: 1) Left Handedness, 2) conditions that prevent MRI scanning (e.g. pacemaker, metal implants, etc), 3) participating in a research study involving weight loss or physical activity in the past 6 months, 4) Currently smoking, 5) currently on a restricted or special diet, 6) currently on medications that affect metabolism or appetite, 7) scores suggesting disordered eating behavior via screeners (Eating attitudes test, Binge Eating Scale) depression, or drug addiction, 8) metabolic diseases that affect energy balance (i.e. diabetes), 9) pregnant or breastfeeding during the previous 6 months, 10) weight fluctuations +/-4.5 kg within the past 3 months, 11) serious medical diagnoses such as DM1, cancer, recent cardiac event, 12) alcohol consumption over 3 drinks a day.

### *Procedures*

Standard meals were provided for the subjects. The energy content of the dinner and breakfast meals was based of the total daily energy need for each individual subject. The dinner meal was calculated to be approximately 45% of the total daily energy need for each subject. The breakfast meal was 35% of the total daily energy need. Participants were instructed to eat dinner between 5pm and 7pm the day before testing with nothing else besides water. Participants were

to eat breakfast four hours before arriving to their appointment at the testing center. After arriving to the testing center, blood samples were drawn at the beginning of the appointment. A continuous catheter was inserted, and blood samples were taken every 30 minutes for four hours for total ghrelin, leptin, adiponectin and insulin levels. After the first blood draw participants completed an MRI while fasted. In the fMRI participants viewed a series of images of food, animals and baseline blurred images. A standard lunch meal was given to each participant, with instructions to consume the meal within a 20-minute window. A post meal fMRI was then collected. Following the fMRI, self-report surveys were collected, along with the blood samples, until the end of the appointment. A workflow diagram of the participant appointment is below:

*fMRI Procedures*

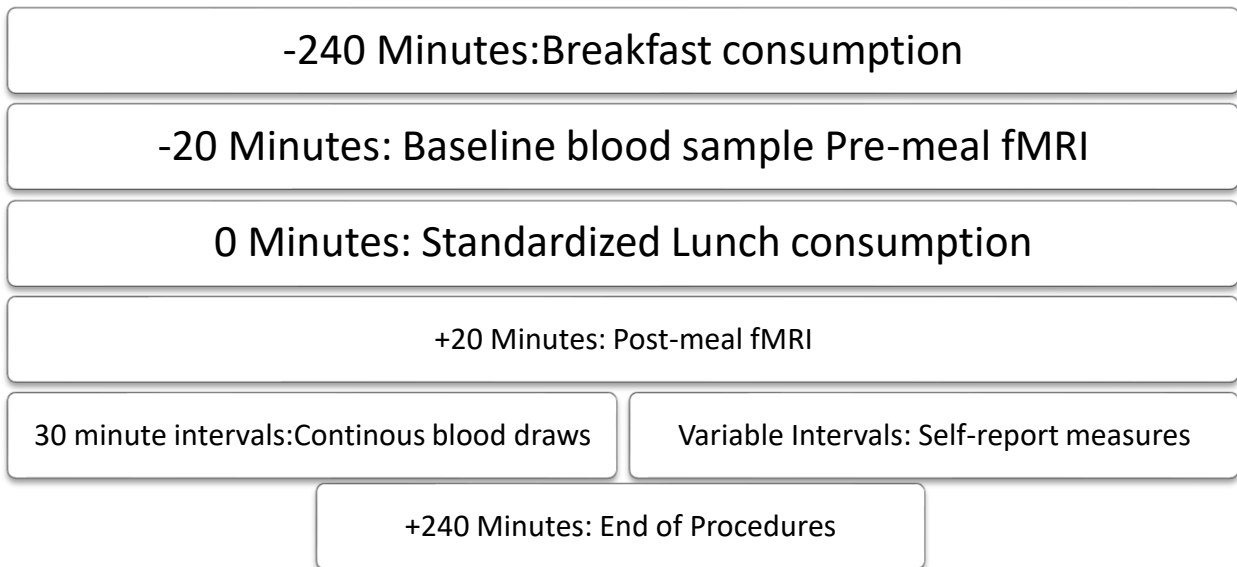


Figure 1 Participant Schedule

Participants viewed pictures of food, animals, and Gaussian-blurred low-level baseline control images during two scanning sessions: 1) after fasting for four hours (pre-meal) and 2) immediately after eating a small uniform meal (post-meal). Animals were used as control stimuli in order to control for general interest and visual richness. Animals that are reminiscent of food

(i.e., fish) were removed from the stimuli pool to prevent the possible confusion between animal/food categorizations. Each participant saw each image only once.

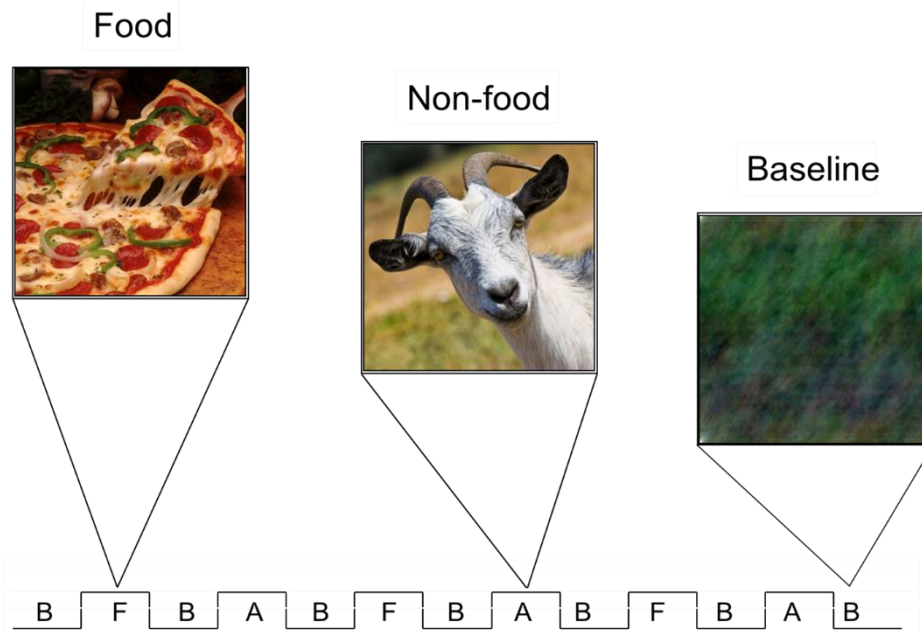


Figure 2 fMRI Paradigm

Each functional scan had three repetitions of each block of each stimulus condition type (i.e., food, animal), alternated randomly with blocks of blurred images. Visual stimuli were presented electronically using the E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA). Each image was shown for 2.5 seconds with a 0.5 second interval between. Within each of the two functional scans there was a total of 13 blocks of stimuli presentation; within each block, 10 images are presented. The order of category presentation was counterbalanced across participants.

Memory was tested following the scanning session to ensure that participants were actively processing stimuli. From each of the food and animal groups, approximately 50% of the images used in the scanning session (30 images) were presented for memory testing. Participants



completed a recognition memory task outside the scanner, immediately following each scanning session (Szabo-Reed et al., 2015).

MRI scanning was performed on a 3-Tesla head-only Siemens Allegra scanner (Siemens, Erlangen, Germany). Participants were positioned in the scanner so that the angle of the anterior commissure to posterior commissure was at a 17° and 22° angle in scanner coordinate space, verified with a localization scan, to minimize artifact in the orbitofrontal cortex and ensure similar head positioning for participants of varying BMIs. The anatomical scan consisted of a T1-weighted 3D MPRAGE sequence (TR/TE = 2300/3.06 ms, flip angle = 8°, FOV = 192 × 100 mm, matrix = 192 × 192, slice thickness = 1 mm) and was used for co-registration with the functional scan and spatial normalization. The functional scans consisted of two gradient echo blood oxygen level dependent (BOLD) scans acquired in 43 contiguous oblique axial slices at a 40° angle (repetition time/echo time [TR/TE] = 3000/30 ms, flip angle = 90°, field of view [FOV] = 220 mm, matrix = 64 × 64, slice thickness = 3 mm, 0.5 mm skip, in-plane resolution = 3 × 3 mm, 130 data points)

### *Self Report Measures*

*The Perceived Stress Scale (PSS)* (S. Cohen, Kamarck, & Mermelstein, 1994) was administered to estimate levels of stress.

### *Data Analysis*

Whole-brain analyses and Spearman correlations were used to identify regions that correlated the PSS and food motivation (i.e. Food-Nonfood). Average ghrelin change over time were calculated for both HW and Ob groups. Percent ghrelin change was calculated from baseline to post meal. Spearman partial correlation coefficients were calculated to determine the relationship between PSS scores and percent ghrelin change. Analyses of covariance were

conducted with post-hoc comparisons using Tukey HSD to determine any differences in percent ghrelin change between HW and OB participants.

## **Results**

### *Sample Characteristics*

Twenty participants completed study procedures fMRI imaging. The average age of the overall sample was 37.11 years. Table 1 contains the descriptive characteristics of the sample. Much of the sample had some level of college education. The OB group was older (40.0 yrs) on average than the HW group (34.8 yrs). Mean PSS scores for both groups were 12.8, corresponding to “low” stress on the scale (S. Cohen, Kamarck, & Mermelstein, 1983). PSS scores did not differ significantly between the two groups.

### *fMRI Data and Ghrelin*

*Hypothesis 1: Individuals who report higher levels of stress will have increased activation in brain regions related to food motivation when exposed to food stimuli in the MRI while fasted.* There were no significant whole brain positive correlations between PSS scores and food response.

*Hypothesis 2: Those with high PSS scores will have lower levels of ghrelin suppression post prandially than those with lower PSS scores.* Healthy weight participants had a significantly greater percent change of ghrelin post prandially than obese participants ( $p < 0.05$ , eta squared = 0.53). Obese participants on average had a 5 percent change in ghrelin, and healthy weight participants had an average of a 48 percent change. Perceived stress scale scores were not correlated to fasting levels of ghrelin or change in ghrelin level.

Table 1 Descriptive Characteristics

Characteristic (M±SD)	Overall (n=20)	HW (n=11)	OB (n=9)
Age(yrs)	37.11+/-9.83	34.8+/- 8.65	40.0+/- 11.02
BMI(kg/m <sup>2</sup> )	29.18+/- 7.54	23.0+/- 1.51	36.61+/- 4.36
PSS	12.8+/- 5.81	12.45+/- 5.99	13.22.18+/- 5.93
Annual Family Income			
Under \$25,000	4		
\$25,000 to \$49,999	8		
\$50,000-99,999	8		
Education Level			
College 1-3 Years	9		
College Graduate	7		
Graduate Degree	2		

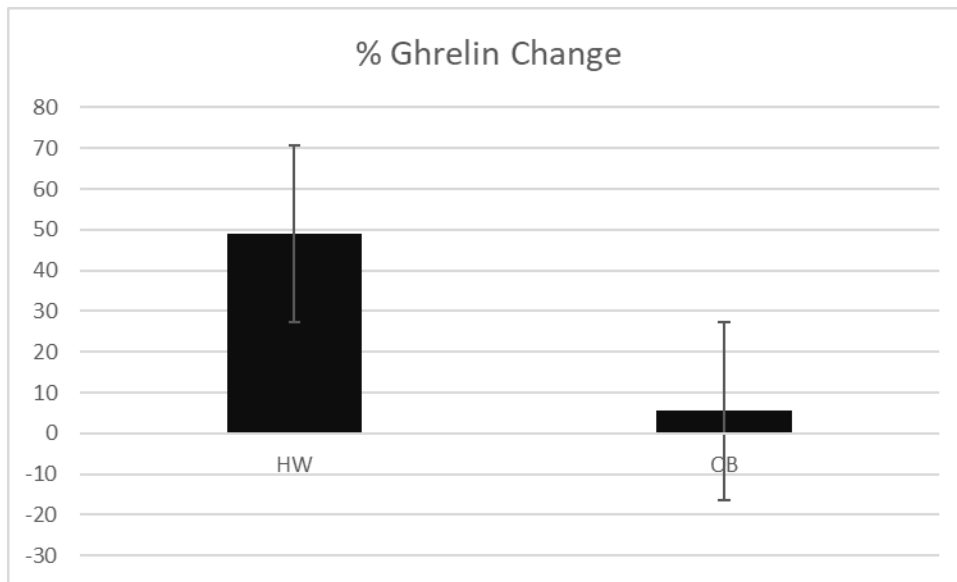


Figure 3 Avg % Ghrelin Change by Group

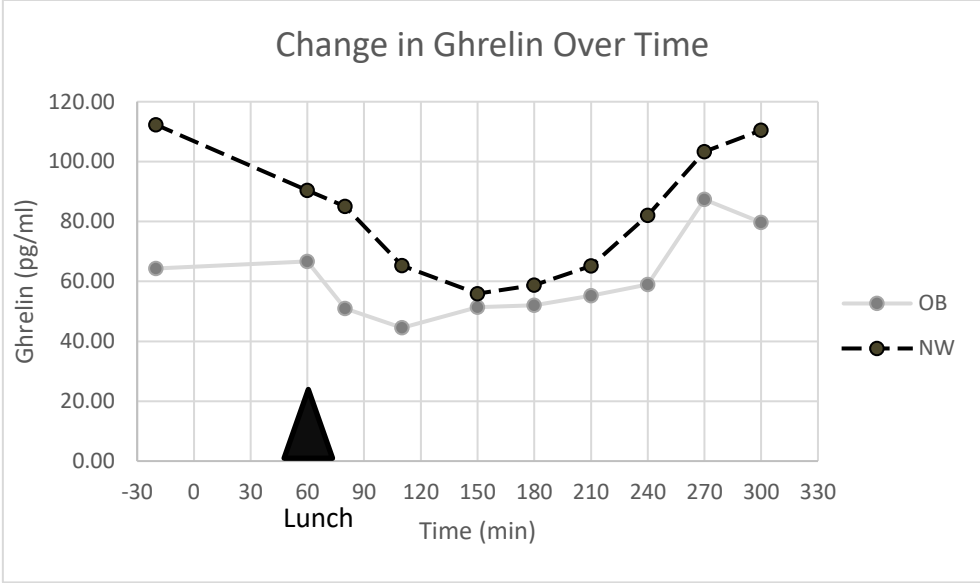


Figure 4 Change in Ghrelin Over Time

## Chapter 4: Study 2 Aim 2

## Methods

### Participants

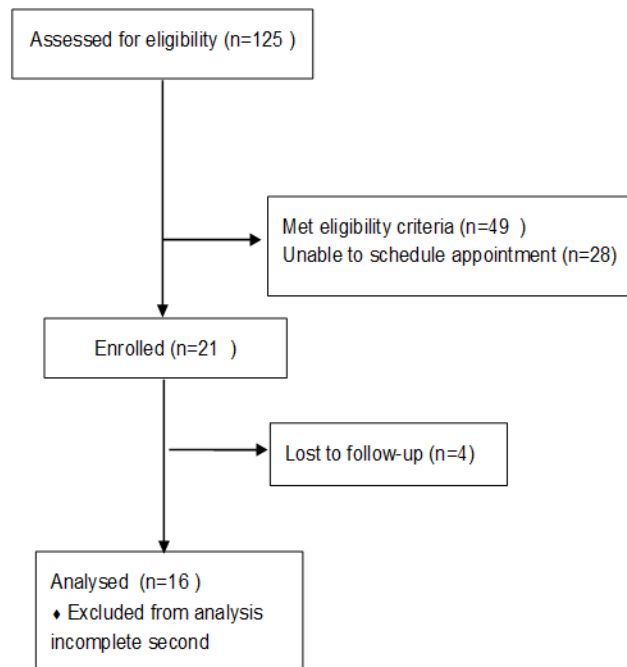


Figure 5 Consort Diagram

Twenty-one participants were enrolled in the study. Participants were recruited from a HERON data base search from the Pioneer’s participant registry for the eligibility criteria below and from flyers at local clinics, and online. Sixteen participants completed both appointments and are included in the analysis (see Consort Diagram in Figure 5).

#### *Inclusion and Exclusion Criteria*

Inclusion criteria: 1) Self-identified African American females; 2) BMI of 18-55 kg/m<sup>2</sup>; 3) 18-45 years of age; 4) not currently dieting or attempting to lose weight.

Exclusion criteria: 1) non-African American 2) males 3) pregnant/breast feeding women; 4) diagnosis of conditions that may affect eating behaviors such as a) diabetes b) hypertension c) eating disorders such as bulimia, anorexia nervosa or binge eating disorder d) food allergies e) gastrointestinal disorders such as Celiac’s disease, gallstones or ulcers.

### *Procedures*

Study participants were randomized prior to their appointment condition of the types of images seen. Images were selected from the International Affective Picture System (IAPS) (Lang, Bradley, & Cuthbert, 1997) and the Socio-Moral Image Database (SMID) (Lang et al., 1997) and either contain racially charged images (e.g. Ku Klux Klan) or non-racially charged scenes (e.g. aggressive dog). Other methods of stress induction have been used in previous studies such as the Trier Social Stress Test (Kirschbaum, Pirke, & Hellhammer, 1993). For race related stress, several unvalidated methods have been used, usually inducing feelings of exclusion (Hayman Jr, McIntyre, & Abbey, 2015). The IAPS and SMID are both validated picture sets that have been selected to induce negative affect. Using these images allowed us to match the two conditions carefully and provide a consistent stress induction measure that could not be possible with other methods. Images across conditions were matched on valance, dominance, and arousal. Each stress conditions consisted of 40 images, programmed to appear randomly on each viewing, with each picture appearing for 5 seconds.

### *Self- Report Measures*

Index of Race Related Stress Form-Brief (IRRS) (Utsey, 1999)A 22-item scale used to measure race related stress experienced by African Americans due to their personal experiences of racism.

The Perceived Stress Scale (S. Cohen et al., 1994)10-item measure to estimate levels of stress.

### *Outcome Measures*

**Food Choice Tasks:** (Epel et al., 2001) participants rated a series of foods on perceived health and taste. Then participants were presented with two food images and asked to indicate which image they prefer on a scale of 1-5. One image will always be an image that they previously rated as neutral on health and taste. The variables of interest are the proportion of high-fat and low-fat foods that were preferred over the participants' chosen neutral.

**Food Purchase Tasks:** In this task participants were asked how much food they would purchase in a day across a wide range of hypothetical prices (\$0.01 to \$35) on a scale of 0-100.



Figure 6 Example Food Choice Task

The value of interest is breakpoint of healthy and unhealthy food items- the first price in which the participant stated they would purchase zero of the given item.

**Ad lib food decision:** Participants were asked to fill out additional questionnaires in a room where snacks were available. The type and how much of the food items were taken were recorded. The variables of interest were: a) the proportion of healthy and unhealthy food items to the total number of items taken b) the total number of calories taken.



### *Data Analysis*

Acute stress was assessed via Wilcoxon Signed Rank Test for differences in demand items before and after viewing the images in each condition (Berry Mendes, Gray, Mendoza-Denton, Major, & Epel, 2007). The food choice task responses were converted from the five-point to binary responses (yes or no) indicating whether they preferred or did not prefer the presented item over the reference item. Responses that were neutral (rating of 3) were omitted from analysis. The proportion of choices were calculated for high fat and low fat foods (Foerde et al., 2018).

Analyses of covariance were conducted to report the outcome measures from the food choice task, food purchase task and ad lib food decision making. Multicollinearity of covariates (self-report measures) were assessed, and those with significant multicollinearity were removed to fit the model. Post-hoc comparisons using Tukey HSD test were assessed to determine any differences found between the two stress conditions (NRR and RR). Partial Spearman correlation coefficients were calculated to determine the relationship between the outcome measures, race related stress, and BMI.

## **Results**

### *Sample Characteristics*

Sixteen participants completed both appointments. Sample characteristics are presented in Table 2. The sample had a mean age of  $28.94 \pm 4.81$  years and a BMI of  $27.00 \pm 7.9$  kg/m<sup>2</sup>. Much of the sample had a normal BMI. Most participants had some degree of college education, were employed, and have never been married.

## *Outcome Measures*

*Hypothesis 1: Exposure to race related stressors (e.g. photos of racially charged scenes) compared to non-race related stressors (e.g. photos of stress related scenes that are not racially charged) will be associated with decreased healthy food selection.* Stress did not significantly increase for either condition. Participants had a significantly decreased level of stress after viewing the NRR images compared to the RR images ( $p < 0.05$ , effect size  $r = -0.557$ ). These results are shown in Figure 7. Exposure to race related stressors resulted in significant changes in preference (pre-post) for low fat foods in the food choice task ( $p < 0.05$ ). Preference for low fat foods increased after viewing RR images ( $M = -0.044$ ) and decreased after viewing NRR images ( $M = 0.066$ ). There was not a significant change in preference for high fat foods in the food choice task, breakpoint in the food purchase task, or the types of foods in the ad lib task. The summary of these values is listed in table 4.

*Hypothesis 2: Those with higher levels of self-reported race related stress will be more likely to have higher BMI's.* BMI and self-reported race-related stress were not significantly correlated. Increased levels of self-reported race related stress were correlated to increased preference of high fat foods ( $r = -0.43$ ,  $p < 0.05$ ). The summary of these values are listed in table 5.

*Hypothesis 3: Those with higher BMI's will be more likely to have select higher quantities of unhealthy food following stress exposure (e.g. photos of stressful scenes).* Increased BMI was associated with a greater percentage of healthy food choices and a decreased percentage of unhealthy food choices in the ad lib food task ( $r = 0.55$ ,  $r = -0.55$ ,  $p < 0.005$ ). BMI did not correlate to differences in breakpoint for the food purchase task, or preference for HF/LF foods in the food choice task. The summary of these values is listed in table 6.

Table 2 Age and BMI distribution of Sample

<b>Characteristic</b>	<b>M (SD)</b>	<b>N</b>	<b>% Sample</b>
Age	28.94 +/-4.81	16	100
BMI(kg/m <sup>2</sup> )	27.00+/- 7.96	16	100
Underweight (<18.5)		2	12.50
Normal (18.5-24.9)		7	43.75
Overweight (25.0-29.9)		3	18.75
Obese (>30)		4	25.00

Table 3 Socioeconomic Descriptives of Sample

	<b>N</b>	<b>%Sample</b>
<b>Annual Family Income</b>		
Under \$25,000	8	50.00
\$25,000 to \$49,999	4	25.00
\$50,000-99,999	3	18.75
Over \$100,000	1	6.25
<b>Education Level</b>		
Grade School	1	6.25
High School	4	25
Graduate/GED		
College 1-3 Years	2	12.5
College Graduate	7	43.8
Graduate Degree	2	12.5
<b>Employment Status</b>		
Employed for wages	11	68.8
Out of Work for Less than a Year	3	18.8
Student	4	25.0
Unable to work	0	0
<b>Marital Status</b>		
Married	0	0
Divorced	2	12.5
Widowed	1	6.3
Never Married	10	62.5
A member of an unmarried couple	4	25.0

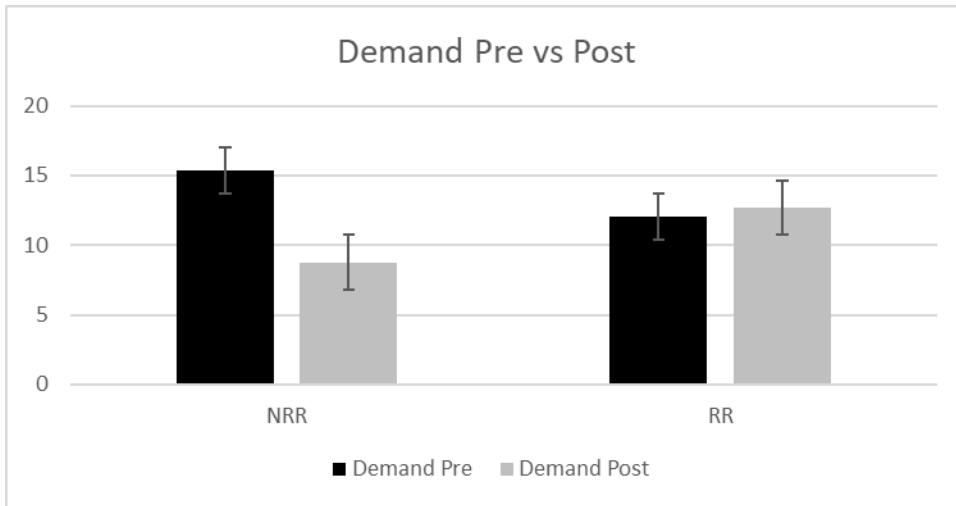


Figure 7 Demand Pre vs Post by Stress Condition

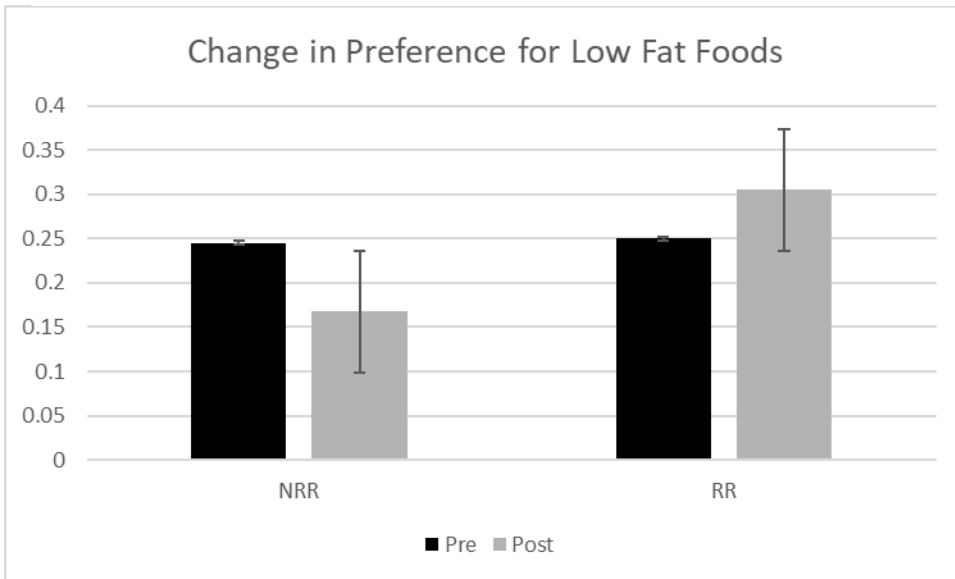


Figure 8 Change in Preference Pre vs Post by Stress Condition

Table 4 Post Hoc Tukey LS means of Outcome Variables

	% Healthy	%Unhealthy	Change Preference HF	Change Preference LF	Change Breakpoint Healthy	Change Breakpoint Unhealthy
NRR	47.47	52.53	0.068	0.066	-0.49	-0.32
RR	63.73	36.27	0.064	-0.044	1.05	0.26
P value	0.1101	0.1101	0.9320	0.0208*	0.0884	.4161
Effect Size (Eta- Square)	0.61	0.61	0.42	0.45	0.27	0.20

\* $p < .05$   
Adjusted for acute stress appraisal, hunger, impulsivity, BMI, PSS, IRRS and appointment order

Table 5 Spearman Partial Correlation Coefficients IRRS v. Outcome Measures

	BMI	%Healthy	%Unhealthy	Calories Taken	Change Breakpoint Healthy	Change Breakpoint Unhealthy	Change Preference HF	Change Preference LF
r	0.1908	0.37549	-0.37549	-0.2377	-0.35461	0.12424	-0.42374	-0.34103
P- value	0.3504	0.0587	0.0587	0.2422	0.0755	0.5454	0.0310*	0.0882

\* $p < .05$   
Adjusted for Acute stress level, PSS, hunger, impulsivity, THQ, appointment order

Table 6 Spearman Partial Correlation Coefficients BMI v. Outcome Measures

Prob >  r  under H0: Partial Rho=0 BMI							
	%Healthy	%Unhealthy	Calories Taken	Change Breakpoint Healthy	Change Breakpoint Unhealthy	Change Preference HF	Change Preference LF
r	0.54607	-0.54607	-0.3248	-0.04956	-0.15484	0.26583	-0.25556
P- value	0.0026*	0.0026*	0.0917	0.8022	0.4314	0.1715	0.1893

*\*P<.05*

*Adjusted for Hunger, THQ, impulsivity, appointment order*

Table 7 Spearman Partial Correlation Coefficient BMI v. IRRS and PSS

<b>Prob &gt;  r  under H0: Partial Rho=0</b>		
	<b>IRRS</b>	<b>PSS</b>
<b>r</b>	-0.04920	-0.28471
<b>p-value</b>	0.8113	0.1586

*\*p<.05*

*Adjusted for THQ, GAD, BIS, Impulsivity*

## Chapter 5: Discussion

## **Discussion of Hypotheses**

### *Study 1*

Hypothesis 1: Individuals who report higher levels of stress will have increased activation in brain regions related to food motivation when exposed to food stimuli in the MRI while fasted.

The results were not consistent with the hypothesis, that food motivation was positively correlated to perceived stress. Previous literature supports a relationship in perceived stress altering neural functioning in higher order executive functioning regions. It was expected that, while in states of fasting, individuals would be more susceptible to visual food cues. This could alter neural activity that affect their real-world food choices. Those who are more stressed, could potentially be the most susceptible to these images. Perceived stress in this sample was low on average, which could affect neural processing of food cues. Those with lower levels of perceived stress could have more variable neural changes in response to food stimuli.

Hypothesis 2: Those with high PSS scores will have lower levels of ghrelin suppression post prandially than those with lower PSS scores.

These results were not consistent with the hypothesis. Absolute levels of ghrelin and post prandial changes of ghrelin were not correlated to scores on the Perceived Stress Scale. The PSS scores between HW and OB participants were not significantly different. OB participants on average had, lower levels of fasting ghrelin, and higher levels of ghrelin suppression (lower % change in ghrelin) than HW participants. The decreased change in ghrelin post prandially for obese participants, could blunt their appetite responsiveness, leading to overeating due to lack of post meal satiation. Healthy weight participants had a drastic drop in ghrelin levels, which could contribute to them feeling more quicker, decreasing the feeling of eating soon after meals.



Previous literature in animal models show that fasting ghrelin levels were higher in states of high stress. In humans, the data is less consistent, with no relationships or weak relationships between perceived stress and ghrelin. The data is more consistent with cortisol regulation and ghrelin regulation being correlated.

## *Study 2*

*Hypothesis 1:* Exposure to race related stressors (e.g. photos of racially charged scenes) compared to non-race related stressors (e.g. photos of stress related scenes that are not racially charged) will be associated with decreased healthy food selection.

These results were not consistent with the hypothesis. While acute stress did not increase significantly in either stress induction, after viewing the images NRR, acute stress decreased significantly. The change before and after RR was not significant, but there was a subgroup of participants who reported feeling more stressed after viewing the RR images. This suggests that after viewing NRR, individuals were able to cope better in contrast to the RR images. Further analyses of these differences should be explored to determine the factors contributing to these findings.

Following exposure to race-related stressors, participants had an increased preference for low fat food compared to non-race related stressors. All other outcome measures did not significantly differ between the two conditions. Previous literature suggests that following stress, individuals prefer highly palatable foods, which are normally high in fat and in sugar. More specifically, black women show higher preferences for sweet foods than white women. The foods in the food choice task, were separated primarily on their fat content, without subjective data from participants on the item's palatability. Further exploration of the data choices, with a "palatability score" could provide more consistent data.

Hypothesis 2: Those with higher levels of self-reported race related stress will be more likely to have higher BMI's

These data were not consistent with the hypothesis. Scores on the IRRS were not correlated to BMI. Previous literature shows a positive relationship between BMI and PSS. Most participants were of normal weight, which is not representative of black females in the United States. As previously stated, BMI and socioeconomic status are not as tightly correlated in black women, as other populations. The two main sources of research participants came from students at the medical center, and individuals who received care from a clinic that primarily serves low income black Americans. Interactions between socioeconomic status, BMI and self-reported stress should be explored in future analyses with a more robust sample size. Additionally, while all participants self-identified as black, further breakdown of origin was not assessed. Previous literature suggests there are differences in susceptibility to weight gain amongst US and foreign-born blacks. PSS and IRRS scores were not correlated. The lack of correlation between the IRRS and PSS scale provides support for race related stress not being accurately captured by more widespread self-report stress scales. The combined effects of the PSS and IRRS on eating behaviors should be explored in future analyses.

Hypothesis 3: Those with higher BMI's will be more likely to select higher quantities of unhealthy food following stress exposure.

These data do not support the hypothesis. Those with higher BMI's, chose a greater percentage of healthy foods and a lower percentage of unhealthy foods during the ad lib food choice task. Previous literature suggests that perception on healthiness of foods affects the amounts of food consumed. This study did not gather data on the perceived health of the ad lib food task. Further analyses should use the food choice task ratings to determine overall health

ratings for the foods in the task as a proxy. Previous literature suggests that obese/overweight individuals have a greater preference for all foods compared to those at a normal weight. Additionally, women with higher BMI's alter food intake based on social conditioning and societal pressure. Data on body perception and cultural ideals among body shape among black women should be incorporated into future studies.

### **Limitations**

There were several limitations involved in these studies. The sample sizes were both small, which could limit the strength of conclusions gathered from the data. The average BMI's of participants in both samples, did not accurately reflect the population. In study two most participants had a normal BMI. It is possible that eligibility criteria excluding diabetes and hypertension skewed potential participants towards a normal weight distribution. Future studies should attempt to gather a more representative sample.

Acute stress levels were not significantly higher in either group for study two, which could provide evidence for the failure of the stress induction methods.. In contrast to study 1, study 2 did not have a proxy for physiological changes which could provide stronger evidence for the conclusions found. Measurement of ghrelin to measure appetite changes, as well as cortisol levels could have provided a more complete understanding of the processes occurring during the experiment.

### **Summary**

Despite limitations the current pilot study was one of the first to examine the role of race, stress, and food choice/motivation using a combination of neuroimaging studies, self-reported stress, race related stress, and experimental manipulation of stress. This is an important first step for research related to racial stress and its effects on physiological and psychological functioning.

The literature suggests that there are influences apart from socioeconomic status, genetics and lifestyle factors that are contributing to the disparity in diseases related to diet. This knowledge will have an important positive impact because pinpointing race-specific determinants will advance development of more effective ways to prevent and treat obesity in high-risk populations. Most immediately, since data are limited in this field, this pilot study will produce more data to inform a larger study with more power.

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