# Hunger sensitivity: How high interoceptive awareness of hunger impacts eating behaviors and body mass index in those over 40

Hunger sensitivity: How high interoceptive awareness of hunger impacts eating behaviors and body mass index in those over 40

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# Abstract

The present study examined the concept of hunger sensitivity as theorized in a study conducted by Walker et al. (2015a), who determined that hunger sensitivity could be assessed using their newly developed Hunger Sensitivity Scale. This present study continued their work and used the Hunger Sensitivity Scale to determine what effects high hunger sensitivity had on individual BMI and maladaptive eating patterns in a sample of participants between the ages of 40-65. Participants completed a Qualtrics survey that included demographic data, the Hunger Sensitivity Scale and the Three-Factor Eating Questionnaire R18V2. For the first research question, a two-tailed Pearson correlation and an independent samples t-test were used to determine whether or not high hunger sensitivity was related to higher BMI in adults within the sample age group. Results showed no relationship between the two variables. For the second research question, a two-tailed Pearson correlation was used to determine whether or not high hunger sensitivity was related to higher scores on the Three-Factor Eating Questionnaire R18V2. This measure is used to quantitatively score maladaptive eating patterns that are divided up into three different domains (uncontrolled eating, cognitive restraint, emotional eating) as well as a total score. The results of this analysis showed that high hunger sensitivity had a small correlation with the TFEQ-R18V2 total score and the uncontrolled eating and emotional eating domains. There was no correlation found for the cognitive restraint domain. Test scores were calculated using Microsoft Excel and all statistical analysis was completed using IBM SPSS Statistics. Discussion of the study

results include comparison to the results of the Walker et al. (2015a) study, as well as discussion of ANOVA and multiple linear regression results for demographic data. Study limitations and directions for future research are also discussed.

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# Chapter I.

## Introduction

Bodily sensitivity is conceptualized as the individual ability to detect physiological signals and sensations (Boswell et al., 2015). Some individuals detect these sensations more easily and intensely than the average individual within a population. This sensitivity can be thought of on a continuum with individuals ranging from a low ability to perceive physiological sensations to those with very high ability to perceive the same sensations. Often referred to as interoceptive awareness, this sensitivity has been investigated in many forms in the psychology literature and is found to be associated with increased emotional or behavioral reactions that can lead to the development of various types of psychopathology (Boswell et al., 2015).

For clarity, one might describe the process in this way: (1) an individual experiences a high level of interoceptive awareness to a certain physiological signal within the body; (2) for some, this high degree of sensitivity creates anxiety as the individual experiences these sensations that they interpret as unpleasant, uncomfortable, or more harmful than they actually are, a concept known as catastrophizing (Esteve et al., 2012); and (3) this anxiety then results in emotional or behavioral reactions, such as avoidance behaviors (Fulton et al., 2012), in response to the discomfort experienced.

As psychological inquiry has expanded our understanding of how different types of high interoceptive awareness leads to behaviors such as catastrophizing and avoidance, researchers published in the Canadian Journal of Behavioral Science developed a scale to measure a previously unresearched form of interoceptive awareness for the physiological feelings of hunger (Walker et al., 2015a). Their Hunger Sensitivity Scale (HSS) was used to measure how hunger sensitivity influenced eating patterns and obesity as assessed using BMI (Walker et al., 2015b). Using anxiety and disgust sensitivity as precedents, they theorized that those who experience high hunger sensitivity might be more prone to catastrophizing that the feelings of hunger they experienced were more detrimental to the body than they truly are; resulting in behaviors aimed at avoiding feelings of hunger. These behaviors could be eating when not hungry, eating frequently, and consuming more calories; all behaviors that could potentially lead to weight gain (Walker et al., 2015a). The Walker et al. (2015a) study was important in that the HSS was shown to be a reliable measure of hunger sensitivity.

This study then used the HSS to examine a population of undergraduate college students to determine if high hunger sensitivity was related to BMI or maladaptive eating behaviors that could potentially lead to weight gain. Their research provided evidence that high hunger sensitivity was positively correlated with certain eating behaviors but there was no significant relationship found between hunger sensitivity and BMI in this population. These results were unexpected and created space for further research to clarify the nature of these relationships and to examine how interoceptive processes impact eating behaviors.

## Interoception vs. Interoceptive Awareness

Body awareness and many types of sensitivity, including hunger sensitivity as discussed by Walker et al. (2015a), would be considered types of interoceptive awareness (I.A.). At one time, the term *interoception* may have been defined similarly to what researchers more recently would term *interoceptive awareness*. As research in the area of body awareness and sensitivity has progressed, evidence has clarified some of the neurological and developmental questions concerning interoception and interoceptive awareness revealing important distinctions. The term interoception refers to the body's neurological process by which it receives sensory information from within the body and interprets that information in relation to itself and the outside world (Paulus et al., 2019). The specific neurological pathway is referred to as the 'interoceptive cortex' (Murphy et al., 2017) and includes the anterior insula and anterior cingulate cortex. These areas are vital in the individual's ability to consciously perceive physiological signals (Brewer et al., 2021). *Interoception* has thus become a general term referring to this neurological process.

It is now recognized that the process of interoception has both unconscious and conscious elements (Khoury et al., 2018). Interoception can be unconscious/implicit when internal regulation of the body results in changes to behavioral, neurological or physical responses of which the individual is not consciously aware. Evidence suggests the development of implicit interoception is present early in infancy (Murphy et al., 2017). Interoception can also be conscious/explicit. The conscious awareness of bodily signals is more specifically referred to as *interoceptive awareness* and would be the type of interoception most relevant when discussing the topic of bodily awareness or bodily sensitivity. It is unclear at which point this awareness develops and is recognized by the individual (Murphy et al., 2017) but would include an individual's ability to perceive internal sensations such as hunger, thirst, satiety, heart rate, temperature, touch, gastrointestinal and bladder sensations and many more (Brewer et al., 2021; Murphy et al., 2017). Interoceptive awareness occurs on a continuum in which some individuals have an atypically low ability to perceive internal signals while some individuals have an atypically high ability to perceive internal signals (Brewer et al., 2021). It is important to note here that this may be a somewhat simplistic explanation as Brewer et al. (2021) indicate that it is possible that individuals may vary on their ability to perceive internal signals dependent on which signal is being perceived. For example, an individual may be able to perceive hunger and thirst with what would be considered normal ability; however, they may have atypically low ability to perceive other sensations such as heart rate or touch.

Different researchers also distinguish the level of consciousness experienced by the individual. Brewer et al. (2021) theorize that interoceptive awareness may occur when an individual is aware when an interoceptive state has changed but may not be able to label the change, only recognizing that it is unusual. But a higher level of conscious perception is required to recognize when an interoceptive state has changed and label the new state. Likewise, Garfinkel et al. (2015) delineate two types of interoceptive sensitivity: Objective interoceptive sensitivity is defined as the individual's ability to accurately perceive their bodily state while subjective interoceptive sensitivity encompasses the individual's beliefs about the accuracy of their perception.

It is not known why individuals differ in their ability to perceive these signals. Some ideas have been suggested. There could be a difference in individual nervous system arousal, meaning some individuals actually feel sensations differently or the central nervous system processes those signals differently (Murphy et al., 2017). Others have suggested the possibility that neurological changes occur due to a conditioned response by negative reinforcement (Cusack et al., 2022). Research also suggests that childhood adversity could account for some of the differences seen in individual interceptive awareness. Various types of maltreatment, including abuse, neglect or difficult familial environments are associated with neurological changes to the insula and anterior cingulate cortex, the same regions of the brain identified as the "interoceptive pathway," as well as increased rates of psychopathology (Teicher et al., 2014). It is suggested that the relationship between adverse childhood experiences and psychopathology are mediated by interoception possibly through hindering the neurological processes in some way or by the individual using body dissociation to ignore or distrust the interoceptive signals they are experiencing (Schmitz et al., 2023).

The interoceptive signals related to hunger and satiety travel from the stomach to the insula via the vagus nerve. According to some neurological models, once this information reaches the insula, it takes the information received from these signals about the body's state and compares them to expected homeostatic states.[1] Differences between the two are encoded as errors within the insula and are used to predict the expected needs of the body, which tells the other areas of the body to perform the required functions to return the body to homeostasis, thus implicating the insula in both processes (interoception and homeostatic regulation; Simmons and DeVille, 2017).

This process is important in understanding how interoceptive sensitivity to hunger might lead to obesity and maladaptive eating patterns in individuals who are more sensitive to these cues. The body is always trying to return itself to a homeostatic state. Interoceptive signals alert the body to what is needed to achieve homeostasis in an effort

[1] This is an incredibly simplified explanation of the Embodied Predictive Interoception Coding (EPIC) model as explained by Simmons & DeVille (2017). Please refer to their 2017 article for a more detailed explanation of the neurological process involved.

to motivate the organism either consciously or unconsciously to do whatever is required for homeostatic balance. This need for balance can increase the body's reward value of any substance used to achieve this, a concept known as positive alliesthesia. This is well documented in addiction studies and could possibly play a role in obesity as well. An individual who is hypersensitive to signals of hunger may have an increased positive alliesthesia for food to achieve homeostasis, leaving any attempts at restriction of food intake much more difficult (Simmons & DeVille, 2017).

## Interoceptive Awareness in Emotion Processing and Psychopathology

Being able to accurately detect physical signals within the body is necessary in the individual development and identification of emotional states. Schachter and Singer developed a model from which many modern theories on emotions are based that suggest emotions are both "awareness of physiological arousal" and "cognitive appraisals of contextual cues" (as cited in Brewer et al., 2021). This interpretation identifies interoception and interoceptive awareness as necessary for an individual to accurately detect their own bodily signals to identify emotional states and to accurately understand and interpret their own emotional experience. Interoceptive awareness is correlated with emotional stability, regulation, and intensity, and it appears vital for appropriate socio-emotional functioning (Füstös et al., 2013). Likewise, interoceptive awareness is necessary for an individual to develop the ability to recognize and understand, or empathize, with the emotions experienced by another individual (Brewer et al., 2021).

The idea that healthy emotional development necessitates appropriate interoceptive abilities has led researchers to suggest that an individual's ability to attend to their own internal sensations may have far reaching impacts on the development of psychopathology. Atypical interoceptive awareness has been suggested as the ‘p-factor,’ a susceptibility or vulnerability to psychopathology (Brewer et al., 2021; Murphy et al., 2017). Brewer et al. (2021) even suggest that many symptoms of various psychopathologies are a result of atypical interoceptive awareness, rather than distinct disorder characteristics.

Some of the earliest associations between atypical interoceptive awareness and certain health conditions has been found in Feeding and Eating Disorders. A study of 327 patients diagnosed with anorexia nervosa, bulimia nervosa or obesity (some with binging/purging behaviors and some without) found that those with more problematic eating patterns scored higher in interoceptive awareness (Fassino et al., 2004). In support of this finding, atypical function of the insula and anterior cingulate cortex has been observed in those with many psychopathologies including eating disorders (Brewer et al., 2021). Neuro-imaging suggests a positive association between increased insula activity and a tendency to eat in response to external cues rather than internal hunger sensations in a study of overweight adolescents (Mata et al. 2015). Individuals who are unable to accurately detect or interpret bodily signals of hunger and satiety are more likely to either restrict food intake if food is less rewarding and overeat or binge eat if food is more rewarding (Monteleone et al., 2018). A study of 165 normal weight and obese individuals showed that obese individuals have a more difficult time with emotion regulation and interoception in relation to those who are not obese (Willem et al., 2019) and abnormal interoceptive awareness is related to increased emotional eating (Young et al., 2017).

In a recent study by Poovey et al. (2022), they examined eating disorders as they relate to hunger sensitivity specifically, as opposed to earlier studies looking at eating disorders and the relationship to interoceptive sensitivity as a whole across all bodily sensations. Using survey data from 213 university student participants, they found that interoceptive sensitivity to hunger was the largest predictor of binge eating, purging and cognitive restraint but was not predictive of restricting behaviors. This may indicate the importance of looking at hunger sensitivity specifically when evaluating the effect interoceptive processes have on various types of disordered eating.

Eating disorders share some similarities with anxiety disorders in that the continued maintenance of both of these disorders is due to the extreme sensitivity of the physiological sensations experienced by the individual (Cusack et al., 2022). Often there is an assumption in the research on the topic of atypical interoceptive awareness that psychopathology arises when the atypicality is due to lowered interoceptive ability (Brewer et al., 2021), and indeed this is sometimes the case, for example, in very common and well-researched conditions such as depression, schizophrenia and even certain developmental disabilities such as autism. However, in the case of eating disorders and anxiety disorders the pathology appears to be present due to hypersensitivity rather than hyposensitivity (Cusack et al., 2022). Neuro-imaging studies seem to confirm this as well. Scans of the insula in people with major depressive disorder show the insula is hypoactive, whereas those with anxiety disorders show the insula to be hyperactive (Khoury et al., 2018).

Two examples in the literature by which this process has been demonstrated are anxiety sensitivity and disgust sensitivity. Individuals who have high interoceptive awareness to the physiological sensations associated with anxiety, termed anxiety sensitivity, were first researched due to its association as a possible risk factor for anxiety disorders. Evidence suggests this is the case and now researchers have expanded the list of psychopathology of which anxiety sensitivity is now thought to be a risk factor, including substance use disorder, depression, borderline personality disorder and eating disorders (Fulton et al., 2012). Anxiety Sensitivity has also been associated with increased fear of pain, a fear that worsens the actual experience of pain, resulting in catastrophic interpretations of pain and pathological avoidance behaviors (Ocañez et al., 2010). The second example is disgust sensitivity, which is an individual predisposition to experience disgust in an elevated way to either physical substances or moral judgments. High disgust sensitivity has been studied as a risk factor in the development (Kot et al., 2021) and severity (Troop et al., 2000) of certain eating disorders.

In the case of eating disorders, high disgust sensitivity has been found more often in women with eating disorders than in women without an eating disorder and is significantly correlated with the severity of the eating disorder experienced (Troop et al., 2000). There is also evidence that abnormalities in the insula—thought to control disgust—result in the development of anorexia nervosa (Kot et al., 2021). A recent study by Kot et al. (2021) found higher levels of disgust sensitivity and self-disgust in individuals with anorexia nervosa, though it is important to note here that the researchers acknowledge prior studies have had mixed results.

Other theories on the development of eating disorders look at the interoceptive awareness involved in emotional development and how individuals with eating disorders may have difficulty in identifying or interpreting certain emotional experiences and confuse them with certain physical sensations they experience within the body. A paper by Cusack et al. (2022) gives the example that an individual may have a feeling of guilt or shame—a common emotional state for those with eating disorders (Troop et al., 2000)—but have difficultly appropriately understanding the feeling of guilt. They also experience the feeling of bloating but misinterpret bloating for guilt indicating a difficulty in differentiating between emotional and physical sensations. The behavioral result is disordered eating in response to guilt they misinterpret from the feeling of bloating. This example illustrates the complex relationship atypical interoceptive awareness has in emotional processing and the development of disordered eating behaviors.

Anxiety sensitivity, a form of interoceptive awareness where an individual is atypically hypersensitive to the physiological sensations related to anxiety and interprets them in a negative way (Reiss et al., 1986), has also been linked to the development of psychopathology. It was first associated with the development of many anxiety disorders, most notably in panic and PTSD (McNally, 2002), but upon further examination has been thought to extend beyond the realm of anxiety. Anxiety sensitivity could be linked to disordered eating through the mediating variable of experiential avoidance (Fulton et al., 2012). Anxiety sensitivity leads to avoidance behaviors in anxiety-producing situations (Walker et al., 2015a). It also results in catastrophizing and avoidance behaviors in individuals that leads to worse patient experience and lower functional status in pain patients (Esteve et al., 2012).

Hunger sensitivity is a concept based on the evidence that suggests disgust sensitivity and anxiety sensitivity may lead to the development of psychopathology, including disorders related to eating. It is possible other forms of bodily sensitivity, including hunger, may also result in maladaptive eating patterns as a result of the anxiety produced by the discomfort of the sensation.

## Catastrophizing and Avoidance Behaviors

As currently theorized, atypical sensitivity to certain interoceptive signals within the body results in a similar behavioral pattern within the individual. Individuals who experience those signals more sensitively can either interpret the signals adaptively, which would not result in any significant issue in terms of pathology; however, for some individuals, these signals are interpreted as unrealistically harmful, problematic or disconcerting. This maladaptive interpretation is known as catastrophizing (Khoury et al., 2018). Catastrophizing or catastrophic thinking is a psychological concept in which individuals tend to, as the saying goes “make a mountain out of a molehill.”

Catastrophizing can be done with any life event, feeling, disappointment or stressor, but in the discussion of interoceptive awareness would refer to the maladaptive interpretation of physiological signals. An individual mistakenly interprets that the sensations they are experiencing within the body are harmful or are experienced more severely than would be expected. What makes catastrophic thinking so maladaptive is that this type of cognitive misappraisal of events often leads to persistent worry, rumination and anxiety (Psychology Today, n.d.). It is also thought to have a causal relationship with many forms of psychopathology, including several anxiety disorders (Gellatly & Beck, 2016).

In some individuals, if a catastrophic maladaptive interpretation of a physiological signal occurs, the anxiety experienced from this hypersensitivity can lead to avoidance behaviors. These are behaviors adopted by the individual in an attempt to prevent the feared or unpleasant sensations from occurring (Christian & Levinson, 2022). Avoidance behaviors are often a maladaptive response to anxiety because they maintain the anxious state by reinforcing the association between the sensation and the anxiety produced (Christian & Levinson, 2022) and do not allow the individual to develop the skills necessary to cope with the unpleasant sensations in adaptive ways. A close examination of the neurological activity during avoidance of aversive events implicates the same region within the brain associated with interoception, the insula, as well the amygdala which is the region involved in fear conditioning. There is evidence to suggest that once this avoidance behavior becomes habitual, there is a shift in the neural circuitry involved and it is much more resistant to treatment (Christian & Levinson, 2022).

Anxiety has long been thought to be associated with obesity though the nature of this association is still unclear. A large review of the literature, including 346,298 participants, determined a moderately significant positive association between anxiety and obesity though the association is stronger in those with severe obesity (BMI>35; Gariepy et al., 2010). This review also acknowledges an important point; it may not be the physiological aspects of obesity leading to anxiety disorders, but perhaps anxiety disorders leading to obesity through a variety of mechanisms (Gariepy et al., 2010).

Kivimäki et al. (2009) found the latter to be the case. In their 2009 study, results showed that the direction of the association indicated that anxiety and depression were a risk factor for obesity and that the more repeated episodes of these disorders resulted in increased risk. Later, Kivimäki et al. (2018) completed a longitudinal study looking at the common mental disorders of depression and anxiety across the adult lifespan and found that the association between these disorders and obesity is stronger as the person ages and confirmed what other studies suggest that this is equally true of both depression and anxiety. This directional link could support the idea that hypersensitivity to hunger and associated anxiety may result in maladaptive behaviors leading to increased weight gain.

## Hunger Sensitivity and Weight Gain

The process of catastrophizing and avoidance behaviors due to interoceptive hypersensitivity outlined above has been documented in disgust sensitivity and anxiety sensitivity. First theorized by Walker et al. (2015a), the interoceptive signal of hunger or, more specifically, hunger sensitivity, may lead to the same catastrophic interpretation that leads to anxiety and maladaptive avoidance behaviors. The feeling of hunger can be a source of anxiety for some individuals (Boswell et al., 2015). But hunger is a sensation within the body that is subjective, and individuals vary widely in their ability to perceive hunger signals. There is wide variability between individuals in their ability to determine when hunger ceases and satiation begins. Palascha et al. (2021) conducted a study using water volume tests to determine individual differences in feelings of hunger and satiation. A sample of 113 participants, starting with an empty stomach, were asked to drink water from identical 1.5 L cups. Participants were instructed to drink from a straw until they experienced the first feeling of satiation. The amount of water consumed was noted and participants would then continue drinking until they experienced maximum stomach capacity. Results indicated participant differences in volume threshold to feel initial satiation reaching up to 5X more water consumed than other participants.

To further clarify the differences in hunger perception, Stevenson et al. (2023) conducted a study to determine if individuals differ in their feelings of hunger and if so, how are their individual experiences different? The study used data from 191 university students who had no history of eating disorders. These students were asked to complete a survey while hungry about the physical sensations they were experiencing and to what extent. They were also asked questions about their beliefs about what was happening in the body while hungry (e.g., low blood sugar, nutrient deficiency). Due to results showing great variation in the types of physical sensations experienced as well as the intensity of those sensations, the study authors concluded that interoceptive hunger cues are “multidimensional” (Stevenson et al., 2023). This study also found that beliefs about hunger may impact how their hunger sensations are interpreted and how those beliefs trigger the act of food consumption. Though the body typically has substantial energy supply and rarely is low, belief that hunger signals indicate an individual is running low on energy stores may cause an individual to respond to those cues by eating in an effort to ensure the body has its needs met. However, if an individual believes that internal hunger signals are triggered by environmental causes, they may not respond to the signals by eating as they would not perceive these cues to be an important signal of body state (Stevenson et al. 2023).

Walker et al. (2015a) first conceptualized hunger sensitivity as an interoceptive signal that had the potential to impact health and wellbeing. They argue that certain sensations surrounding hunger can be unpleasant, for example, difficulty concentrating, stomach discomfort or irritability. An individual may have an atypical hypersensitivity to these sensations that result in the individual engaging in catastrophic thinking and avoidance behaviors. Behaviors to avoid the sensations of hunger might include eating more frequently so as not to reach a point of hunger or to eat larger amounts. They may also not use hunger as a cue to eat but use social or other cues outside the body as reference for when to eat. All of these behaviors could result in eating behaviors that are maladaptive (Walker et al., 2015a).

Individuals may also interpret the signals of hunger as more serious or harmful than they truly are in the cognitive distortion of catastrophizing. If hunger signals are interpreted in this way, normal hunger sensations may be interpreted as pathology or damaging to the body. They may also result in individuals experiencing anxiety around signals of hunger resulting in rumination or being triggered to eat at very slight indications of hunger causing overeating (Walker et al., 2015a). An individual with a very low hunger sensitivity might not even notice these signals or realize they are hungry, making overeating less likely. Walker et al. (2015a) theorized that if hunger sensitivity results in maladaptive eating behaviors there may be some association between high hunger sensitivity and weight gain.

To test this theory, their 2015 study tested the validity of their newly developed Hunger Sensitivity Scale (Walker et al., 2015b). Results showed that of the original 29 items included on the scale, 13 were both reliable and valid and should be retained (Appendix 1). Using the scale’s remaining 13 items to determine hunger sensitivity scores, they conducted another study examining eating behaviors and BMI in college-aged students using survey data. Results indicated some associations between maladaptive eating behaviors and high hunger sensitivity. High hunger sensitivity resulted in a higher likelihood of engaging in binging and purging, a lack of cognitive control over eating, eating due to social cues and higher levels of general hunger. What the study did not show, however, was a correlation between high hunger sensitivity and increased BMI.

Upon first glance this may seem to indicate that high hunger sensitivity does not play a role in weight gain even though there is evidence to suggest it does result in a higher likelihood of behaviors that could lead to weight gain. However, it is possible that a population of undergraduate college students used to collect the data may not be suitable for assessing weight gain. This incompatibility may be for several reasons. Kuk et al. (2009) reviewed published research on weight and fat distribution in aging and found that weight gain is most evident between the ages of 40-66 and then tapers off. They also found that total fat mass increases with age with women gaining abdominal fat at a faster rate than men. Other research looking into body composition determined that there are changes in body composition as a person ages. Adults lose muscle mass and strength as they age, which is true regardless of gender or ethnicity (Goodpaster et al., 2006). These findings suggest that weight gain may not be as evident in a younger population even if maladaptive eating patterns due to hunger sensitivity have already developed.

## Significance of Study

Research into interoception has produced significant evidence to the importance of the awareness of bodily sensations in healthy emotional development, and that when atypical perception is present it is associated with psychopathology. When an individual is hypersensitive to the sensations within their body, catastrophic thinking, anxiety, and avoidance behaviors are a possible response. This response has been shown in the case of anxiety sensitivity and disgust sensitivity. It is reasonable to conclude that there may be other types of interoceptive sensations that could result in the same behavioral pattern. Walker et al. (2015a) recognized this and formed their research on hunger sensitivity.

While Walker et al. (2015a) did not find a significant relationship between scores on the Hunger Sensitivity Scale and increase in BMI among a university undergraduate population, there is sufficient evidence suggesting that further research into hunger sensitivity looking at an older population could show a relationship between hunger sensitivity and BMI that was not found in their initial research. So before psychological science could dismiss the idea that hunger sensitivity had no association with developing higher BMI, this researcher determined that testing these theories in a more appropriate age cohort is necessary.

There is sufficient evidence to suggest that high hunger sensitivity could be a misunderstood aspect of the interconnected nature of anxiety and obesity. Both of these conditions plague the developed world at high rates and current treatment approaches to both conditions have yet to really have any significant impact in reversing these trends. Initial data suggesting a relationship would lead to further research in this area and possibly result in better treatment approaches. Approaches like interoceptive exposure or other cognitive treatments, that have had success in reducing anxiety sensitivity (Boettcher et al., 2015) might be impactful in reducing hunger sensitivity. Other approaches that target the neurological processes involved in interoception, like vagus nerve stimulation, are other possible effective treatments for reducing hunger sensitivity or other conditions related to abnormal interoception.

## Chapter II.

## Method

This study is seeking to answer the following questions:

1. Is there is a positive association between high hunger sensitivity as assessed by the Hunger Sensitivity Scale and BMI in a population between the ages of 40 and 65? My hypothesis is there will be a positive correlation between high hunger sensitivity and increased BMI within this population.
2. Do individuals within the same population between the ages of 40-65 who have high hunger sensitivity as determined by the Hunger Sensitivity Scale also exhibit more maladaptive eating behaviors as assessed by the Three-Factor Eating Questionnaire? These behaviors are categorized into three domains: uncontrolled eating, cognitive restraint, and emotional eating. My hypothesis is there will be higher rates of these maladaptive eating behaviors in participants with high hunger sensitivity as compared to those with low hunger sensitivity scores.

### Participants

Participants for this study were a voluntary response sample obtained through Prolific, a website with pre-screened individuals who are interested in participating in survey-based research. It was determined using G*Power analysis that a minimum sample size of 138 participants was needed for sufficient statistical power. The participants opted to participate in the survey and were paid $2 for their time through the Prolific website. These individuals needed to be between the ages of 40 and 65, as well as reside within the United States. There were no requirements for other demographic information with the intent of recruiting participants from diverse backgrounds. Initially, 144 individuals completed the survey; however, five of the surveys were not completed accurately and had to be removed from the sample. This left a final sample size of 139 participants whose data were analyzed.

## Measures

The study design required a numerical score for quantitative analysis for each of the research questions. Several measures were used to calculate a numerical score for each survey item.

### Hunger Sensitivity Scale

The Hunger Sensitivity Scale (HSS) is a 13-item questionnaire developed by Walker et al. (2015b) that assesses sensitivity to hunger-related body sensations. Study results showed scale score reliability to be .95, 95% confidence interval (Walker et al., 2015a) using Cronbach's alpha. Rating of each question is done using a Likert scale of 0-6 (strongly disagree to strongly agree) with a total score being the sum of all items (range: 0-174; see Appendix 1). Approval for use was not required because the HSS is not under copyright.

### Three-Factor Eating Questionnaire, 18-item, v2

The Three-Factor Eating Questionnaire (TFEQ-R18V2) is an 18-item questionnaire used to assess certain eating behaviors. These behaviors are divided into three domains: uncontrolled eating, cognitive restraint, and emotional eating. Each question is assigned a domain and each item in the domain is scored separately from the other items. A total score for the entire questionnaire is also calculated. Items are reverse scored. Further details on scoring are included in Appendix 2. Approval for use was obtained.

### Body Mass Index

Body Mass Index (BMI) is used as a measure to assess healthy weight. Adult BMI lower than 18.5 is considered underweight, 18.6 to <25 is considered to be healthy weight, BMI of 25 to <30 is considered overweight, while BMI greater than 30 is considered to be obesity (Centers for Disease Control, n.d.). Participants provided height and weight information for the purposes of calculating BMI. To calculate BMI, the formula BMI = weight (lbs.)/height$^2$ (inches) * 703. This is the standard calculation and is the same formula used in the Walker et al. (2015a) study.

## Procedures

A voluntary response sample was recruited through the Prolific website. Individuals who volunteered to participate needed to be between the ages of 40-65 and reside within the United States. Qualified volunteers were sent a link to a Qualtrics survey. Due to possible discomfort with answering survey questions regarding weight and eating behaviors, anonymity of the survey was vital. To acquire consent while also keeping the survey anonymous, participants were asked to agree to the consent form by entering in their unique Prolific ID to proceed. The 15-minute survey included demographic information, including sex, race, zip code, and age, as well as height and weight for BMI calculation. After demographic information was completed, participants were directed to the Hunger Sensitivity Scale and the Three-Factor Eating Questionnaire. A total of 144 participants completed the survey but 5 were removed due to insufficient data, leaving 139 participants in the final sample. After the survey was reviewed for completeness, the participant was paid $2 for their time. Survey results were compiled within the Qualtrics platform.

## Data Analysis

After initial review of the data in Qualtrics to ensure completeness, all survey information that was deemed complete and appropriate by the researcher was included and converted to an Excel spreadsheet for score calculation ($n$=139).

### Body Mass Index

To calculate BMI scores for all participants, self-reported height and weight information was used in the formula BMI = weight (lbs.)/height$^2$ (inches) * 703. Then each BMI score was given a label of either Underweight, Healthy, Overweight or Obesity as determined by the CDC guidelines. Mean BMI for all participants was $\bar{x}$ = 28.14 (*SD* = 6.828).

Table 1. Frequency Table of BMI Category for All Participants.

| BMI Category | Frequency | Percent | Cumulative percent |
|---|---|---|---|
| Healthy | 45 | 32.4 | 32.4 |
| Obesity | 42 | 30.2 | 62.6 |
| Overweight | 49 | 35.3 | 97.8 |
| Underweight | 3 | 2.2 | 100 |
| Total | 139 | 100 | |

*Frequency count and percentage of the total number of participants in each of the BMI categories.*

Hunger Sensitivity Scale

Excel was also used to calculate individual scores on the Hunger Sensitivity Scale. The HSS uses a 7-point Likert scale (0-strongly disagree, 1-disagree, 2-somewhat disagree, 3-neutral, 4-somewhat agree, 5-agree, 6-strongly agree) and HSS scoring is a sum total of all items with item 11 reverse scored. (Possible scores range from 0-78.) The mean score for all participants was $\bar{x}$ = 34.49 (*SD* = 13.546). Composite scores ranged from 3 to 66.

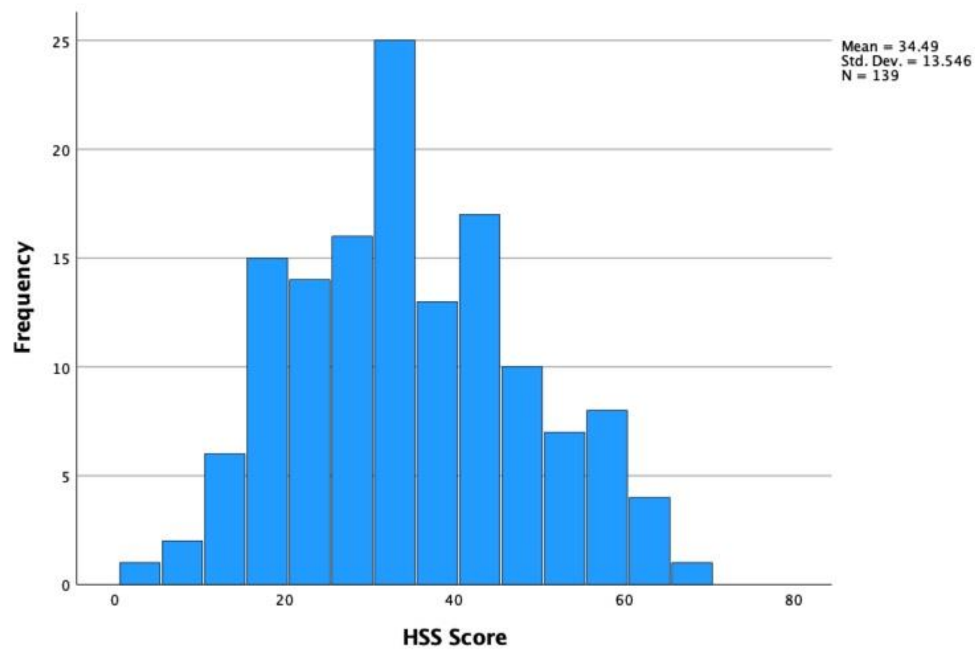


Figure 1. Histogram of HSS Score Results.

Three-Factor Eating Questionnaire, 18-item, v2 (TFEQ-R18V2)

Scores for each participant were calculated for each of the three domains on the Three-Factor Eating Questionnaire, as well as a composite score including all items on the questionnaire. The TFEQ-R18V2 uses a 4-point Likert scale (1-Definitely true, 2-Mostly true, 3-Mostly false, 4-Definitely false) with items 1-16 reverse scored. (Possible composite scores range from 8-72.) The mean composite score for all participants was $\bar{x}$ = 37.17 (*SD* = 9.613) with scores ranging from 19 to 62.

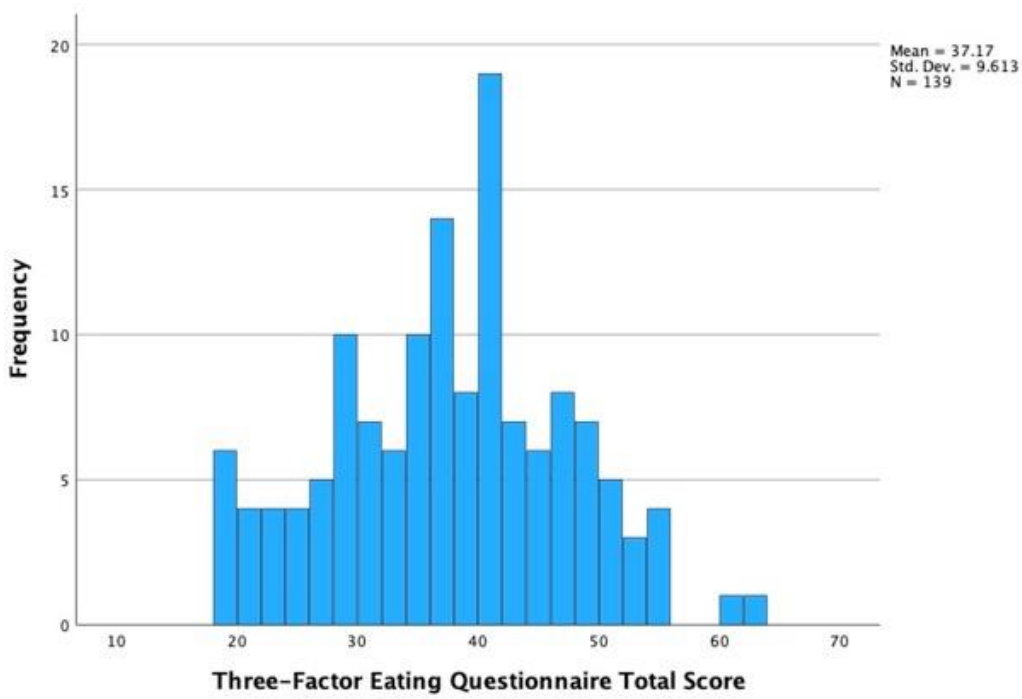


Figure 2. Histogram of TFEQ-R18V2 Total Score.

Results for all three domains within the TFEQ-R18V2 were also calculated for each participant. The three domains are Uncontrolled Eating, Cognitive Restraint and

Emotional Eating. The first domain, Uncontrolled Eating, is defined as the tendency to eat more than would be typical due to personal loss of control and includes questionnaire items (3, 6, 8, 9, 12, 13, 15, 19, 20). The second domain, Cognitive Restraint, is defined as the conscious decision to reduce the amount of food consumed to lose weight and includes items (1, 5, 11, 17, 18, 21). Lastly, the third domain, Emotional Eating, is defined as eating more than would be typical due to mood and includes items (2, 4, 7, 10, 14 ,16; Cappelleri et al., 2009).

Table 2. Descriptive Statistics for all Three Domains on TFEQ-R18V2.

| Domain | *N* | Minimum | Maximum | Mean | *SD* |
|---|---|---|---|---|---|
| Uncontrolled Eating | 139 | 9 | 33 | 18.14 | 5.287 |
| Cognitive Restraint | 139 | 3 | 11 | 6.42 | 2.290 |
| Emotional Eating | 139 | 6 | 24 | 12.60 | 4.771 |
| Total | 139 | | | | |

*This table shows the minimum and maximum scores, mean, and standard deviation for each domain on the Three-Factor Eating Questionnaire.*

# Chapter III.

# Results

Upon completion of score calculations, all statistical analysis was conducted using IBM SPSS Statistics with a significance level of $\alpha = .05$. The demographic requirements for this study were only that the participants be between the ages of 40-65 and reside within the United States. This left open the possibility of participants with demographic diversity.

## Sex

Out of 139 participants, 55.4% identified as female and 44.6% identified as male. An independent samples t-test for HSS scores was calculated by sex (male, female) and found that between the two groups the mean score for females ($n = 77$) was $\bar{x} = 36.97$ ($SD = 14.145$). For males ($n = 62$), the mean score was $\bar{x} = 31.40$ ($SD = 12.180$). T-test results indicated that the mean difference between males and females was significant ($t(137) = 2.454$, $p = .015$) with females reporting higher mean HSS scores (Table 3).

Table 3. Mean HSS Score by Sex.

| | Sex | *N* | Mean | *SD* | Std. Error Mean |
|---|---|---|---|---|---|
| HSS Score | Female | 77 | 36.97 | 14.145 | 1.612 |
| | Male | 62 | 31.40 | 12.180 | 1.547 |

Race

The self-identified racial make-up of the participants included 79.1% White (*n* = 110), 8.6% Black or African American (*n* = 12), 7.9% Multiracial (*n* = 11), 2.2% Asian (*n* = 3), 1.4% American Indian or Alaska Native (*n* = 2), and .7% Other (*n* = 1). Asians had the highest mean HSS score at $\bar{x}$ = 39.00 (*SD* = 19.287) as compared to the other race categories (Table 4).

Table 4. Mean HSS Score by Race.

| Race | *N* | Mean | *SD* | Std. Error | Minimum | Maximum |
|---|---|---|---|---|---|---|
| Am. Indian or AK Native | 2 | 31.00 | 19.799 | 14.00 | 17 | 45 |
| Asian | 3 | 39.00 | 19.287 | 11.136 | 25 | 61 |
| Black/African American | 12 | 33.67 | 9.089 | 2.624 | 19 | 55 |
| Multiracial | 11 | 34.91 | 15.469 | 4.664 | 3 | 58 |
| Other | 1 | 17.00 | | | 17 | 17 |
| White | 110 | 34.64 | 13.707 | 1.307 | 7 | 66 |
| Total | 139 | 34.49 | 13.546 | 1.149 | 3 | 66 |

Age

Participant age ranged from 40-65 with a sample mean of $\bar{x} = 49.79$ (*SD* = 7.56). Out of 139 participants, the majority were in their 40’s (*n*=75), and those in their 50’s were quite a bit less (*n*=44). There were 20 participants in their 60’s. Participation rates trended down as age went up (Figure 3). A correlation between age and HSS score as well as age and participant BMI showed no significance.

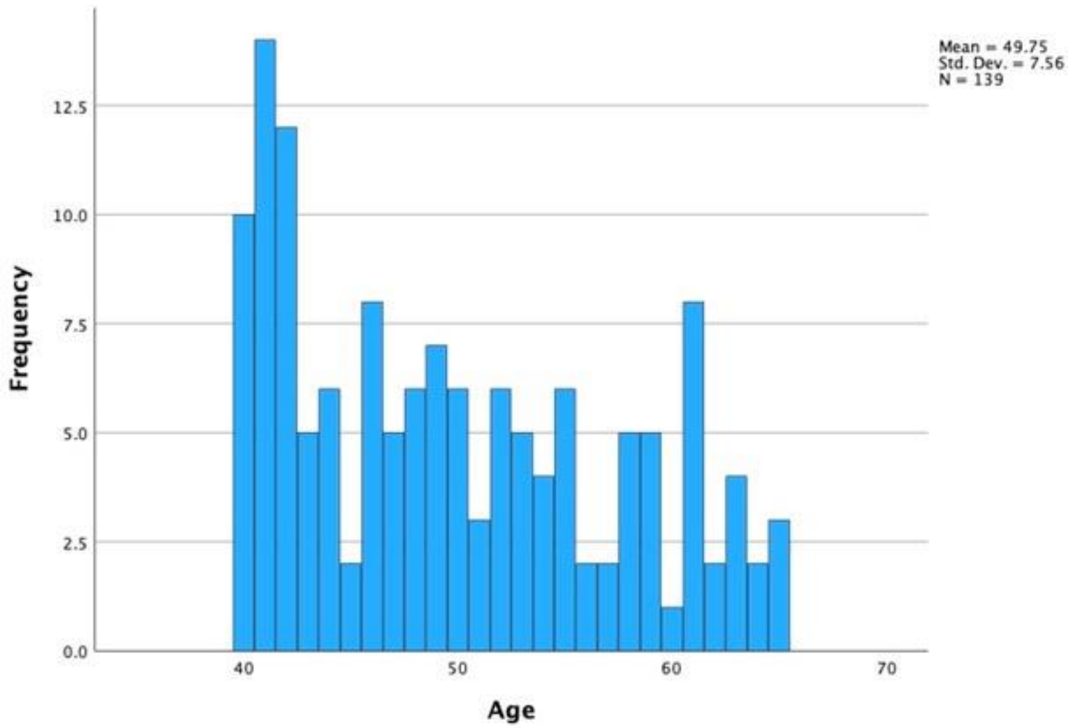


Figure 3. Histogram of Participant Age.

Region

Participants were required to reside within the United States and all regions were represented. The United States is divided into five regions: Northeast, Southeast, Midwest, Southwest, and West. The zip codes collected from each participant were categorized into one of these regions. Twelve participants were not included in the calculations based on region because of incomplete zip codes listed (*n* = 127). The Southeast region of the United States was represented the most at 33.8% (*n* = 47) of respondents residing there. Following was the Midwest at 22.3% (*n* = 31), West at 15.8% (*n* = 22), Southwest at 12.9% (*n* = 18), and Northeast at 6.5% (*n* = 9).

Average HSS scores by region were also calculated. The highest mean scores were in the Northeast region with a sample mean of $\bar{x}$ = 39.67 (*SD* = 11.597). while the West region had the lowest sample mean of $\bar{x}$ = 32.45 (*SD* = 11.995) Refer to Table 5 for the sample means from all regions within the United States.

Table 5. Mean HSS Score by Region.

| Region | N | Mean | SD | Std. Error | Minimum | Maximum |
|---|---|---|---|---|---|---|
| Midwest | 31 | 35.03 | 11.496 | 2.065 | 11 | 63 |
| Northeast | 9 | 39.67 | 11.597 | 3.866 | 17 | 56 |
| Southeast | 47 | 34.64 | 14.805 | 2.160 | 10 | 66 |
| Southwest | 18 | 34.56 | 16.314 | 3.845 | 3 | 62 |
| West | 22 | 32.45 | 11.995 | 2.557 | 7 | 56 |
| Total | 127 | 34.70 | 13.513 | 1.199 | 3 | 66 |

*This table shows mean Hunger Sensitivity Scale scores by region of the United States as determined by the US Census Bureau.*

There was no significant correlation found between the region in which the participant resides and HSS score or BMI. To compare the means of BMI and HSS scores by region, I ran a One-Way ANOVA with a 95% confidence interval. Tests for Homogeneity of Variance were met. Results showed that there was no statistically significant difference between groups for BMI ($F(4, 122) = 1.049$, $p = .385$) or HSS score ($F(4, 122) = .453$, $p = .770$).

Research Question 1. Hunger Sensitivity and BMI

A two-tailed Pearson Correlation using the level of significance α = .05 was used to determine whether or not there was an association between high hunger sensitivity and BMI in individuals between the ages of 40-65 ($n$ = 139). Results showed a correlation coefficient of $r(137) = .014$, $p = .871$ indicating no correlation between an individual's level of hunger sensitivity and BMI. An independent samples t-test was also calculated by dividing participants into groups based on BMI. Those with a BMI less than 25 were categorized as Group 1 and those with a BMI greater than 25 were categorized as group 2. Results indicated no significant difference in Hunger Sensitivity Scale scores between the two groups $t(137) = .743$, $p = .459$.

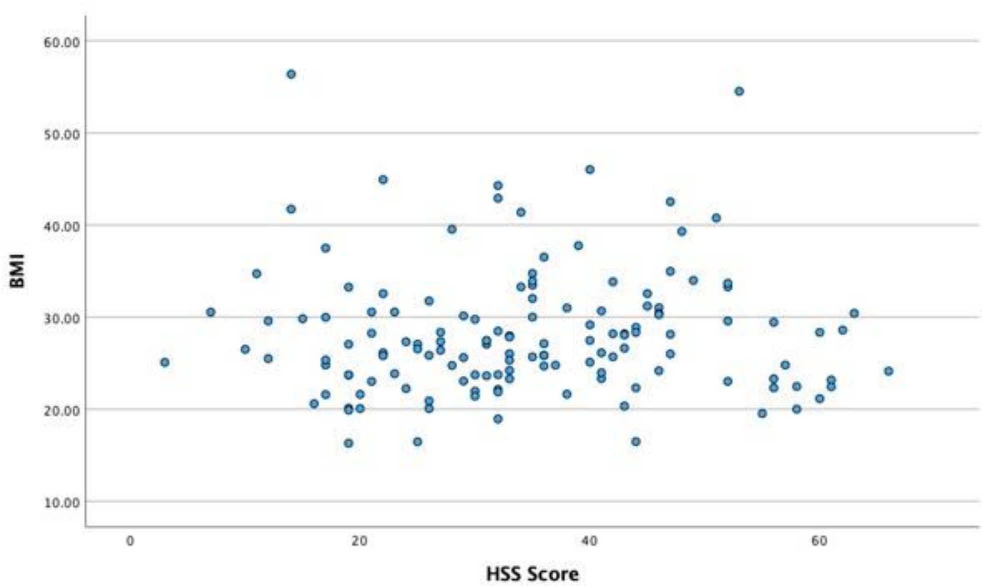


Figure 4. Scatterplot of Correlation Between HSS Score and BMI.

*This Scatterplot is showing no correlation between the two variables.*

Hunger sensitivity scores were also shown to not be significantly correlated with any of the demographic data collected, with the exception of sex. Therefore, it does not appear there is any relationship between high hunger sensitivity and age, race, or what region within the United States the participant resides.

## Research Question 2. Hunger Sensitivity and Eating Behaviors

To assess whether or not high hunger sensitivity is correlated with increased maladaptive eating behaviors, a 2-tailed Pearson Correlation using the level of significance of $\alpha = .05$ was conducted. The same survey sample of 40-65-year-olds was used for both research questions ($n = 139$). First, a correlation was used to determine a relationship between the total composite score of the Three-Factor Eating Questionnaire (TFEQ-R18V2), Hunger Sensitivity Scale score, and participant BMI. Results showed a correlation coefficient of $r(137) = .415$, $p = <.001$ indicating a small positive correlation between TFEQ-R18V2 total score and HSS score. Results also showed that the TFEQ-R18V2 total score showed a small correlation ($r(137) = .387$, $p = <.001$) with BMI (See Table 6).

Table 6. Correlation of TFEQ-R18V2 Total Score with HSS Score and BMI.

| | | HSS Score | BMI | TFEQ Total Score |
|---|---|---|---|---|
| HSS Score | Pearson Correlation | 1 | .014 | .415** |
| | Sig. (2-tailed) | | .871 | <.001 |
| | N | 139 | 139 | 139 |
| BMI | Pearson Correlation | .014 | 1 | .387** |
| | Sig. (2-tailed) | .871 | | <.001 |
| | N | 139 | 139 | 139 |
| Three-Factor Eating Questionnaire Total Score | Pearson Correlation | .415** | .387** | 1 |
| | Sig. (2-tailed) | <.001 | <.001 | |
| | N | 139 | 139 | 139 |

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation table showing the small correlation between TFEQ-R18V2 total score and HSS Score and TFEQ-R18V2 total score and participant BMI.*

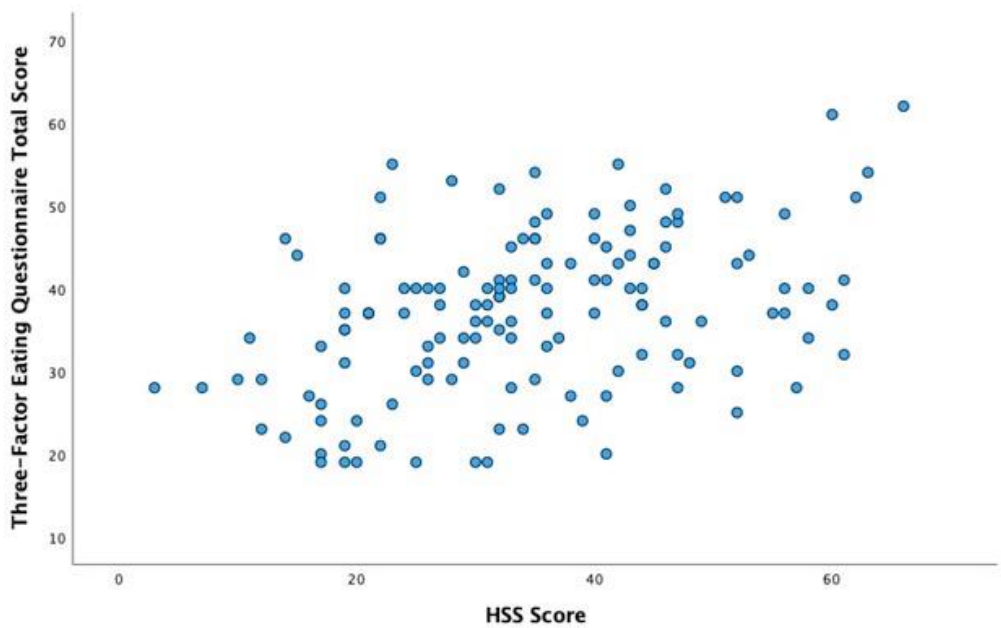


Figure 5. Scatterplot of Correlation Between HSS Score and TFEQ-R18V2.

*This scatterplot is showing a small positive correlation between the two variables.*

Next, a 2-tailed Pearson Correlation was used to compare HSS Score and BMI to each of the three domain categories on the TFEQ-R18V2.

Uncontrolled Eating

For the Uncontrolled Eating domain, the correlation coefficient for HSS score was *r*(137) = .419, *p* = <.001 indicating a small positive correlation. A significant correlation was also calculated between Uncontrolled Eating and participant BMI (*r*(137) = .318, *p* = <.001; See Table 7).

Table 7. Correlation of Uncontrolled Eating Domain with HSS Score and BMI.

| | | HSS Score | BMI | Uncontrolled Eating Score |
|---|---|---|---|---|
| HSS Score | Pearson Correlation | 1 | .014 | .419** |
| | Sig. (2-tailed) | | .871 | <.001 |
| | N | 139 | 139 | 139 |
| BMI | Pearson Correlation | .014 | 1 | .318** |
| | Sig. (2-tailed) | .871 | | <.001 |
| | N | 139 | 139 | 139 |
| Uncontrolled Eating Score | Pearson Correlation | .419** | .318** | 1 |
| | Sig. (2-tailed) | <.001 | <.001 | |
| | N | 139 | 139 | 139 |

***Correlation is significant at the 0.01 level (2-tailed).*

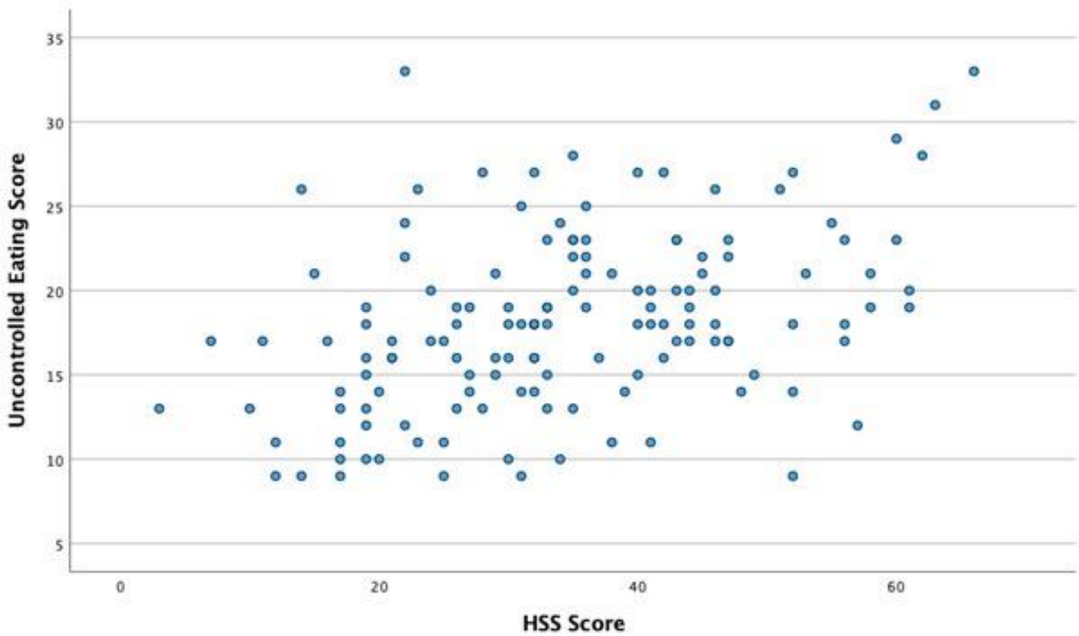


Figure 6. Scatterplot of Correlation Between HSS Score and Uncontrolled Eating.

*This scatterplot is showing the small positive correlation between the variables.*

Cognitive Restraint

For the Cognitive Restraint domain, the correlation coefficient was $r(137) = -.023$, $p = .785$ indicating no correlation with HSS score. There was also found to be no correlation between Cognitive Restraint and participant BMI ($r(137) = .013$, $p = .875$) (See Table 8). These results differ from the Walker et al. (2015a) study which did find that a lack of cognitive control was associated with HSS score.[2]

[2]It is important to note that the Walker et al. (2015a) study used a different measure to assess cognitive restraint. They used the Eating Inventory (EI), a 51-item measure developed by Stunkard & Messick (1985).

Table 8. Correlation of Cognitive Restraint Domain with HSS score and BMI.

| | | HSS Score | BMI | Cognitive Restraint Score |
|---|---|---|---|---|
| HSS Score | Pearson Correlation | 1 | .014 | -.023 |
| | Sig. (2-tailed) | | .871 | .785 |
| | N | 139 | 139 | 139 |
| BMI | Pearson Correlation | .014 | 1 | .013 |
| | Sig. (2-tailed) | .871 | | .875 |
| | N | 139 | 139 | 139 |
| Cognitive Restraint Score | Pearson Correlation | -.023 | .013 | 1 |
| | Sig. (2-tailed) | .785 | .875 | |
| | N | 139 | 139 | 139 |

*Correlation table showing no correlation between HSS Score and the Cognitive Restraint domain of the TFEQ-V18R2.*

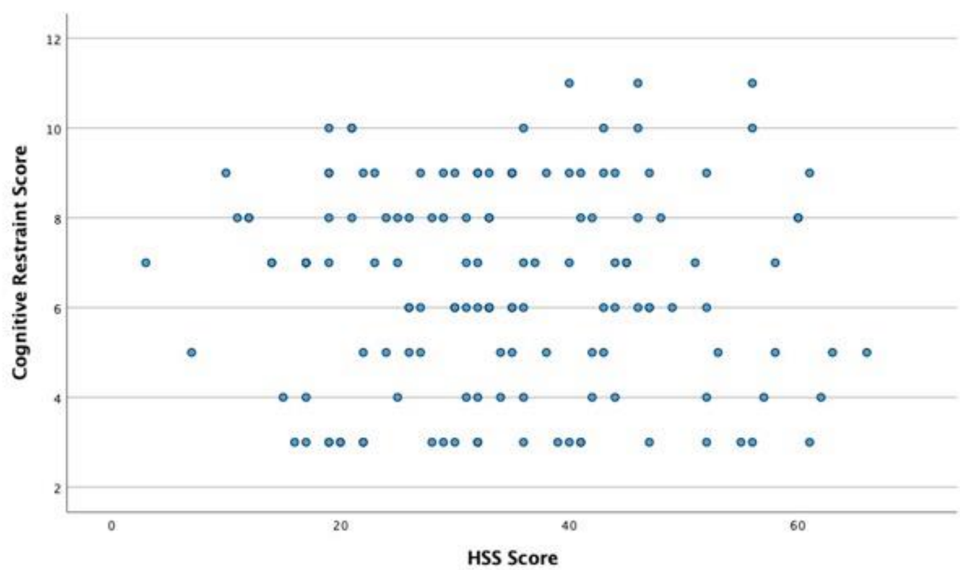


Figure 7. Scatterplot of Correlation Between HSS Score and Cognitive Restraint.

*This scatterplot is showing no correlation between the variables.*

Emotional Eating

For the Emotional Eating domain, the correlation coefficient for HSS score was *r*(137) = .384, *p* = <.001 indicating a small positive correlation. A small positive correlation was also found between Emotional Eating and participant BMI (*r*(137) = .421, *p* = <.001; See Table 9).

Table 9. Correlation of Emotional Eating Domain with HSS Score and BMI.

| | | HSS Score | BMI | Emotional Eating Score |
|---|---|---|---|---|
| HSS Score | Pearson Correlation | 1 | .014 | .384** |
| | Sig. (2-tailed) | | .871 | <.001 |
| | N | 139 | 139 | 139 |
| BMI | Pearson Correlation | .014 | 1 | .421** |
| | Sig. (2-tailed) | .871 | | <.001 |
| | N | 139 | 139 | 139 |
| Emotional Eating Score | Pearson Correlation | .384** | .421** | 1 |
| | Sig. (2-tailed) | <.001 | <.001 | |
| | N | 139 | 139 | 139 |

*** Correlation is significant at the 0.01 level (2-tailed).*

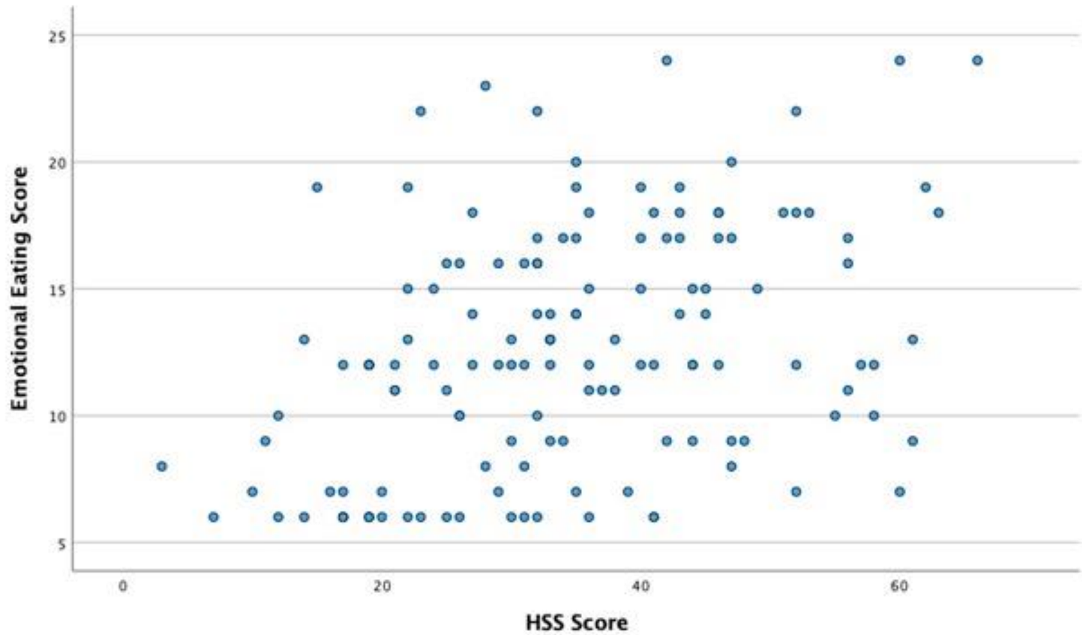


Figure 8. Scatterplot of Correlation Between HSS Score and Emotional Eating.

*This scatterplot is showing a small correlation between the variables.*

Mean scores on the TFEQ-R18V2 were also compared to the participant BMI category. The calculation included the TFEQ-R18V2 total score as well as the mean scores for each of the three domain categories. Each participant was categorized by BMI as determined by CDC criteria. The four categories are underweight, healthy, overweight and obesity. Results showed that for the total score and domain scores for Uncontrolled Eating and Emotional Eating (which were all significantly correlated with HSS scores), the mean scores increased as BMI increased. This was not the case for the mean scores for the Cognitive Restraint domain (which was also not correlated with HSS scores).

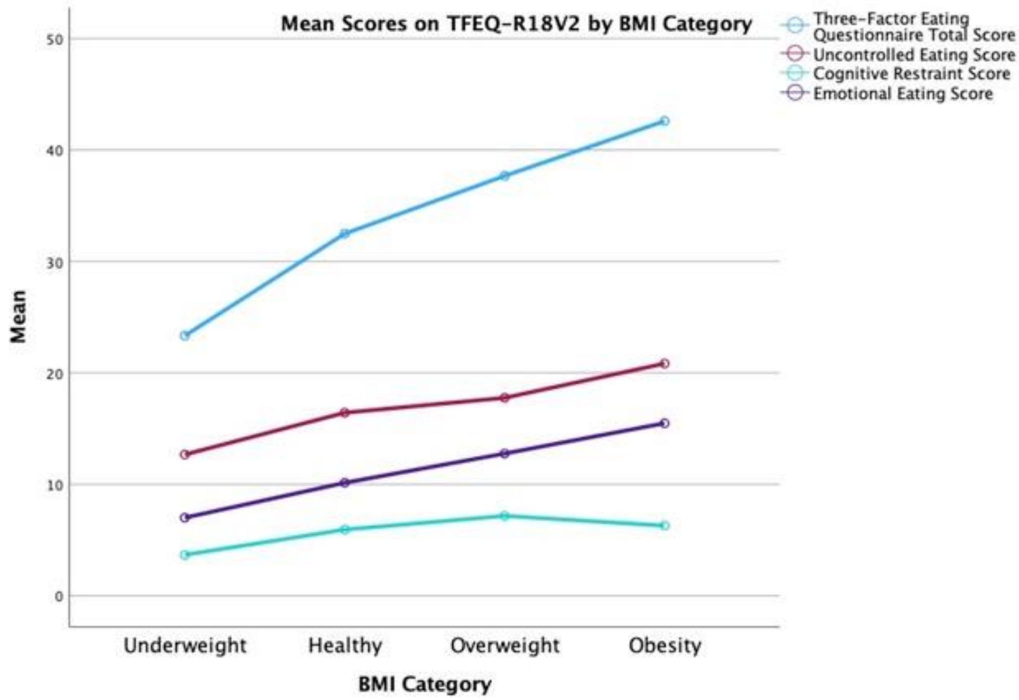


Figure 9. Mean Scores on TFEQ-R18V2 by BMI Category.

*This line graph shows how the mean scores for the Three-Factor Eating Questionnaire total scores and domain scores increase as participant BMI increases.*

# Chapter IV.

# Discussion

Interoceptive awareness is an individual's ability to recognize the internal sensations that occur within the body. An individual's ability to perceive these signals (bodily sensitivity) falls on a spectrum between those who have abnormally low inability to perceive them and those who have an abnormally high ability to perceive them (Brewer et al., 2021). Prior research has shown that those individuals who fall toward the two extremes of the spectrum may be at higher risk of unhealthy emotional development and psychopathology (Brewer et al., 2021; Murphy et al., 2017), including disordered eating. Though some psychopathology is linked to an inability to detect internal signals, patients who have issues with various eating abnormalities tend to score higher in their abilities to detect these signals (Fassino et al., 2004). This hypersensitivity may then result in increased anxiety around these sensations, thereby reinforcing any catastrophizing thoughts or behavior responses to these sensations.

The purpose of the present study was to determine if an individual's hypersensitivity to hunger resulted in a similar process and to continue the research first completed by Walker et al. (2015a) regarding hunger sensitivity by clarifying any relationships between BMI, hunger sensitivity and maladaptive eating patterns. The original study completed by Walker et al. (2015a) developed a new scale to score hunger sensitivity in individuals and compared those scores to BMI and other eating patterns. Their study was completed using participants who were undergraduate college students and results showed no significant relationship between hunger sensitivity and BMI within this population. It did, however, show that high hunger sensitivity was associated with certain maladaptive eating patterns. These included engaging in binging and purging behavior, a lack of cognitive control over eating, eating due to social cues, and higher levels of general hunger.

The current study evaluated similar relationships between BMI, hunger sensitivity and maladaptive eating patterns. However, the basis for the hypotheses being tested resulted from questions about whether the results of the Walker et al. (2015a) study would be repeated in a different age group. Prior research by Kuk et al. (2009) determined that weight gain in individuals was most evident between the ages of 40-66 and that fat mass increases with age. Adults also lose muscle mass and strength as they age (Goodpastor et al., 2006). This suggests that weight gain may not be as evident in a younger population, even if maladaptive eating patterns have already developed, and could explain the Walker et al. (2015a) study's results. Therefore, two questions were asked in this study:

1. Is there an association between high hunger sensitivity as assessed on the HSS to increased measures of BMI in a population over 40 years of age?
2. Are individuals within the same sample of participants between the ages of 40 and 65 more likely to have maladaptive eating patterns?

## Demographics

Individuals who participated in this study were reasonably representative of the population of the United States at large. Representation of various groups was ensured by limiting recruitment criteria as much as possible, while still meeting the population parameters necessary. After a review of demographic data, some interesting trends emerged.

Sex

There was a participation rate for females (*n*=77) that was higher than for males (*n*=62). This is not surprising since females tend to participate in psychological research at higher rates than males (Dickinson et al., 2012; Otufowora et al., 2021). Females in this study were also more likely to have a higher score on the HSS than males. The mean difference between males and females for HSS scores was significant with a female mean score of $\bar{x}$ = 36.97 (*SD* = 14.145) and a male mean score of $\bar{x} =$ 31.40 (*SD* = 12.180). This is also consistent with prior research that indicates females tend to pay stronger attention to their internal bodily signals due to brain differences between the sexes, particularly in the anterior and posterior cingulate cortex as well as the insula (Longarzo et al., 2021). These regions are understood to be associated with interoceptive function. (Critchley et al., 2004; Murphy et al., 2017). Sex was the only demographic variable in the study that was significantly correlated with HSS scores.

Even though females were more likely to have higher HSS scores, this did not translate to them having higher mean BMI. Males had a slightly higher mean BMI at $\bar{x}$ = 28.66 (*SD* = 6.391) and females had a mean BMI of $\bar{x}$ = 27.72 (*SD* = 7.72). These results may be in contradiction to the hypothesis that high hunger sensitivity results in higher BMI because if the hypothesis were true, it would be expected that females would have a higher BMI than males due to their higher hunger sensitivity. There was negligible sex difference in the mean TFEQ-R18V2 total score or any of the three domain scores.

Race

Racial make-up for the study was diverse, however Caucasian individuals were slightly overrepresented based on United States Census Bureau (2020) data. In terms of racial representation, there were limitations with the Qualtrics platform that was not inclusive of all races represented within the United States. The survey question which asks participants to identify their race is a default choice question, meaning that Qualtrics provides the response choices for those filling out the survey. The default responses did not include an option for those who identify as Hispanic or Latinx except to select the "other" category and type in their racial designation manually. This seems odd since the United States Census Bureau (2020) concludes that just under 20% of the population would identify with those terms. If there were any participants who would identify themselves as Hispanic or Latinx, this lack of appropriate answer choice makes it difficult to know how those who identify in this racial group may have categorized themselves.

Race was not significantly correlated with HSS score or participant BMI. Those who identified as Asian had the highest mean HSS scores ($\bar{x}$ = 39, *SD* = 19.287) but in contrast had the lowest mean BMI ($\bar{x}$ = 21.09, *SD* = 4.013). This is in contrast to the hypothesis that high hunger sensitivity correlates to increase in BMI. For the hypothesis to be true, it would be expected that if those who identify as Asian had the highest mean HSS scores they would also have the highest BMI.

To compare the means of BMI and HSS scores by racial group, I ran a One-Way ANOVA with a 95% confidence interval. Tests for Homogeneity of Variance were met. Results showed that there was a statistically significant difference between groups for

BMI ($F(4, 133) = 3.359$, $p = .012$). A Tukey post hoc test determined that those who identify as Black or African American had a statistically significant lower BMI than those who considered themselves to be multi-racial ($p = .037$). There was no statistically significant difference between any of the other racial groups.

Though no positive or negative correlation was found between the HSS score and participant BMI by racial category, when the means of these two data points are graphed, they appear visually to be nearly inverse of each other.

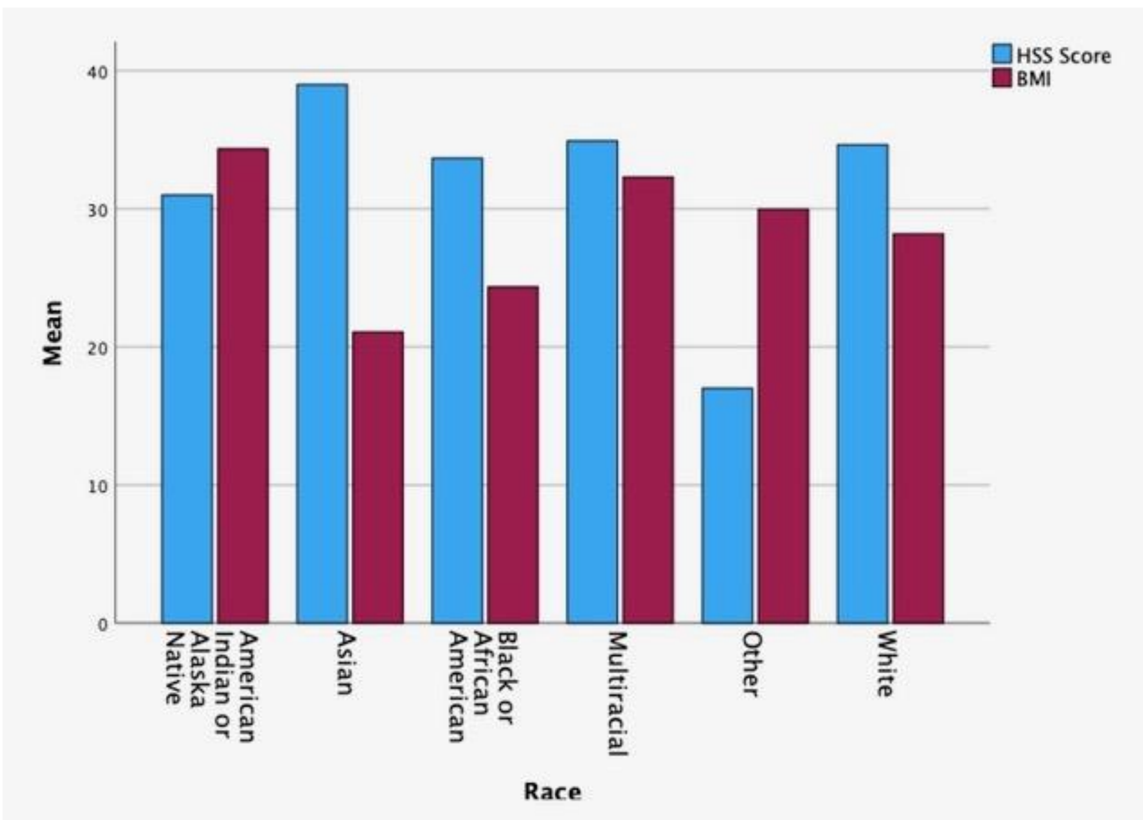


Figure 10. Mean HSS Compared with Mean BMI by Racial Group.

*The bar graph above is comparing the near inverse nature of the mean HSS score and the mean participant BMI by racial group.*

## Hunger Sensitivity and Eating Behaviors in Relation to BMI

The hypothesis of the first research question was that there would be a positive correlation between high hunger sensitivity and BMI in participants between the ages of 40-65. Results showed no correlation between HSS scores and BMI in this age group, reflecting the same results as the Walker et al. (2015a) study of undergraduates. This indicates that high hunger sensitivity may not result in weight gain as measured using BMI for either age group.

The hypothesis of the second research question was that there would be a positive correlation between high hunger sensitivity and maladaptive eating patterns as assessed using the TFEQ-R18V2. This study showed that high hunger sensitivity positively correlated with certain eating patterns that may increase an individual's BMI. There is a small correlation between total scores on the Three-Factor Eating Questionnaire and high hunger sensitivity as well as a small correlation between high hunger sensitivity and the domains of Uncontrolled Eating and Emotional Eating. The Cognitive Restraint domain did not show this relationship.

Distinguishing between these domains is important because they highlight how certain eating patterns differ in their impacts on individual health. The Cognitive Restraint domain includes questions that assess an individual's conscious decision to limit their intake or type of food consumed. The higher the score in this domain, the more likely an individual is to consciously restrain what or how much is eaten. When compared to the concept of high hunger sensitivity as defined in this study, in which an individual feels hunger sensations more intensely and therefore has increased emotional or behavioral reactions to the discomfort experienced (e.g. eating when not hungry, eating frequently, consuming more calories), it makes logical sense that high hunger sensitivity would not be correlated to cognitive restraint. Individuals with high hunger sensitivity would be expected to have less cognitive restraint in an attempt to lessen the anxiety their sensitivity for feelings of hunger is producing.

The Uncontrolled Eating domain includes questions that focused on an individual's tendency to eat without a sense of control or due to more intense feelings of hunger. A higher score in this domain would indicate an individual's lack of control over eating and therefore, is logically consistent with the concept of high hunger sensitivity, especially in the area of increased behavioral reactions due to the discomfort experienced from their more intense internal sensations. This may explain why the Uncontrolled Eating domain had a small significant correlation with hunger sensitivity.

Similarly, the Emotional Eating domain asks questions more indicative of eating behaviors in response to emotional state. A higher score in this domain would reveal a greater tendency to use eating as a comfort mechanism when experiencing negative emotion. Someone with high hunger sensitivity would potentially do this as well. The anxiety experienced from more intense hunger sensations, could result in using eating as a comfort mechanism to suppress those feelings. Though the Emotional Eating domain did not specifically focus solely on anxiety, but several different negative emotions, it was also correlated with HSS scores.

Though no correlation was found between HSS scores and BMI, there was a positive correlation that reached the level of $\alpha$=.01 significance between the TFEQ-R18V2 total score and participant BMI. This suggests that there is a relationship between certain maladaptive eating patterns and increase in participant BMI. However, this appears contradictory as HSS scores were also significantly correlated to TFEQ-R18V2 total scores. To look further into the relationship, multiple linear regression was used to determine if HSS score and TFEQ- R18V2 total score significantly predicted BMI. The overall regression was statistically significant ($R^2$ = .176, $F$(2,136) = 14.493, $p$ = <.001). It found that HSS score negatively predicted BMI (β = -.089, $p$ = .04) though that relationship was very small. It also found that TFEQ-R18V2 total score positively predicted BMI (β = .327, $p$ = <.001). Analysis also determined that neither of the two independent variables acted as a moderator.

## Limitations and Future Research

Inherent within the study design, were a couple of limitations that may have influenced the results. First, there may have been inaccuracies in the height and weight reported by participants. Due to the sensitive nature of the subject of weight and eating habits, it was important to maintain participant anonymity to receive data that were as accurate as possible. In order to do this, the study design required participants to self-report their height and weight. This presumably results in possible inconsistencies in the height and weight data. Each participant determined for themselves their own height and weight, possibly resulting in different methods used by each individual participant. It is possible some reported height and weight assumptions that may have been old information or rounded inaccurately. Some may have also adjusted height or weight information in a direction they would have deemed more positive, for example, based on societal values, males could have reported themselves as taller or females could have reported themselves as weighing less. If participants did in fact use measuring tapes and scales to determine height and weight, it is possible that small variations in these materials could have resulted in inconsistent data. Due to the nature of the BMI calculation, inconsistent data would result in possible inaccuracies or variations within the calculation.

Another possible limitation is using BMI as a measure for individual weight category. An objective measure of individual weight was necessary to evaluate a relationship with high hunger sensitivity and maladaptive eating patterns. However, there has long been debate about the accuracy of using BMI calculations. It is argued that those who are athletic and whose weight consists of lean muscle as opposed to body fat, can have a BMI calculation that is considered overweight or obese (Humphreys, 2010). This could skew data collection for this study because the high BMI in this case would presumably not be from high hunger sensitivity or maladaptive eating patterns. Also, the standard BMI categories commonly used are applied in every case for adults over the age of 20, regardless of race or age. This is problematic because different racial categories carry different proportions of fat mass for a given BMI (Humphreys, 2010). And especially relevant in this study, which is specifically looking at an age group of older adults between the ages of 40 and 65, studies suggest that the BMI categories need to be adjusted as people age. Optimal health for an older population would fall between a BMI of 25 and 35 (with minor adjustments for sex), as opposed to the currently used BMI calculation of 18.5 – 25 for healthy weight (Kiskac et al., 2022). BMI is criticized as being “one size fits all” when evidence suggests this is not the case.

Considering these limitations, and the limitations of thesis research, it is possible that there is more that can be studied regarding interoceptive awareness and the concept of hunger sensitivity. In recent research by Brewer et al. (2021) and Murphy et al. (2017) there is evidence to suggest that interoceptive awareness that falls to either of the two extremes (hyposensitive or hypersensitive), is a risk factor for the development of psychopathology. Healthy interoceptive awareness is necessary for individuals to identify and interpret their own emotions and develop empathy. Many symptoms of mental illness are because of abnormalities in interoception. Furthering the research in this area may give more clarity into the etiology of these conditions. This study focused solely on one type of awareness (hunger) but looking more deeply into relationships between other bodily sensations and interoception as a neurological process to the development or characteristics of mental illness, would further the knowledge of effective treatment of mental health for researchers and those working directly with patients. It appears as though current research is only scratching the surface on this topic and furthering our understanding of this link could potentially be seminal work.

Related work on the subject of abnormalities in interoception that would be important to study further, would be to look much more deeply at the causes of how these processes are disrupted in the first place. Individuals differ in interoceptive awareness. Are these differences inherent within the individual due to genetic or epigenetic differences? Are these processes disrupted by environmental factors as suggested by research on the impacts of traumatic childhood experiences (Schmitz et al., 2023), either through learned dissociation of bodily sensations or structural changes to the neurological structures involved? There is a sampling of research that examines the development of maladaptive interoceptive awareness but more clarity in the research is needed.

Confirming what was found by Longarzo et al. (2021), this study shows that females are more sensitive in their ability to identify internal signals than males. Further research could look at bodily sensations other than hunger to determine if females show more sensitivity in those areas as well. It could show whether these differences are for all bodily sensations or if there is a more nuanced ability. This could also be extended into looking at relationships between these sensitivities and mental illnesses more prevalent in females or perhaps in the distinct characteristics experienced by them.

This study also shows evidence that hunger sensitivity does have a positive relationship with maladaptive eating patterns, specifically those in the realms of emotional eating and uncontrolled eating. Further research is needed to understand if hunger sensitivity is a risk factor for the development of eating disorders, as has shown to be the case with disgust sensitivity. Poovey et al. (2022) found evidence that suggests hypersensitivity to hunger was the strongest predictor of developing certain disordered eating patterns, such as binging, in their study of 213 undergraduate students. If eating patterns are altered due to hunger sensitivity, it is possible that those with eating disorders experience this sensitivity to an extreme. If this relationship exists, it could assist in the development of better treatment approaches.

## Conclusion

The neurological processes that are involved in interoception are vital in human functioning. Abnormalities in this process have been shown to be related to the development of psychopathology with some researchers, such as Brewer et al. (2021) and Murphy et al. (2017), viewing the interoceptive abnormality as the psychopathology itself. When interoceptive processes result in individuals that are hypersensitive to their internal sensations, anxiety surrounding the conscious perception of these signals may result in behaviors that try to alleviate the discomfort experienced. This relationship has been shown in the development of eating disorders. Poovey et al. (2022) found that hypersensitivity to hunger specifically, as opposed to research examining interoceptive sensitivity generally across all body systems, was the strongest predictor of disordered eating behaviors.

Anxiety has also been associated with obesity, with some research indicating it is the former resulting in the latter. There are probably several reasons why this is the case, but certainly chief among them is that many people engage in emotional eating to alleviate negative feelings. As this present study showed, sensitivity to hunger sensations was significantly correlated with emotional eating and may be a result of the anxiety experienced with this hypersensitivity. Or as detailed by Simmons and DeVille (2017) it is possible that due to the insula's involvement in both interoception and homeostatic regulation of the body, any abnormalities in interoceptive functioning, may result in individuals who have developed positive alliesthesia that increases the body's reward system for food consumption, making it much more difficult to engage in long-term self-regulation. Whatever the case, teasing apart these specific relationship distinctions is not intuitive and requires further analysis.

The results of this study seem to reflect the results in the Walker et al. (2015a) study indicating no significant relationship between high hunger sensitivity and high BMI. Evidence of this include no correlation between the two variables and a very small negative relationship as determined by regression analysis. Also, females have significantly higher mean HSS scores than males, yet males have higher mean BMI, indicating a possible negative relationship. Participants who identify themselves as Asian have the highest mean HSS scores as compared to other racial categories, yet have the lowest mean BMI, indicating an inverse relationship. Therefore, results do not indicate that there is a significant relationship between high hunger sensitivity and increased BMI no matter the age group represented.

There is, however a significant relationship between maladaptive eating patterns and BMI as well as maladaptive eating patterns and high HSS scores. This may be an indication of what we already know…that weight gain is complicated. It had long been thought that weight gain (or loss) is a simple equation, however, more recently we are starting to understand the individual differences that exist. One person who develops maladaptive eating patterns may have a different result in weight gain than someone else due to other factors, like medication use, hormonal disorders, and genetics (Barsh et al., 2000).

This study was able to clarify relationships between high hunger sensitivity, BMI, and maladaptive eating patterns. As conceptualized as an extension of research into other forms of bodily sensitivity, hunger sensitivity shows evidence of being an impactful aspect of maladaptive eating patterns in individuals. This is similar to the process in which disgust sensitivity impacts the development of eating disorders and anxiety sensitivity impacts the development of anxiety disorders. Over time, interoceptive awareness that is considered to be on the extreme ends of the spectrum has been shown to be an important aspect in the development of psychopathology. However, more conclusive data regarding how these patterns develop is still necessary. There is evidence to suggest a neurological pathway that functions differently in individuals with these more extreme sensitivities. Or perhaps there are aspects of this relationship that are yet to be discovered, but no matter what future research tells us, interoceptive awareness is a complicated process in which future research endeavors on the topic are worth the effort.

Anxiety and obesity impact the world at alarming rates. Individuals with these conditions have reported lower quality of life and spend significant amounts of money to cover treatment of these conditions and that of other health issues that these conditions can create, and yet, those involved in their care have not found consistently effective treatments for either. Rates of both conditions continue to increase. Looking at them through the lens of interoceptive processes may give fresh perspective for understanding these conditions more completely, resulting in better, more effective treatment options.

Appendix 1.

Hunger Sensitivity Scale

PsycTESTS®

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**Hunger Sensitivity Scale**
**HSS**

Items

2. Feeling hungry makes me anxious.

6. I would rather eat something that is not very tasty immediately than wait to have a nicer meal later.

10. If I were trying to choose a diet, it would be extremely important to find one that would not result in frequent feelings of hunger.

*11. Feelings of hunger in day to day life are slightly inconvenient but they do not interfere with the things that I need to do.

12. Feeling hungry makes me cranky.

14. When I am hungry I keep thinking about how bad it feels.

15. When I am hungry I feel that I cannot go on.

16. Feeling hungry is awful.

19. I do everything I can to avoid being hungry.

21. When I am hungry I will choose to eat over another activity that I usually enjoy.

25. When I am hungry all I can focus on is the emptiness in my stomach.

26. When my stomach growls I feel anxious.

27. I dread feeling hungry because it gives me headaches.

*Note* . Response format is on 7-point Likert scales (0 = "*strongly disagree*", 3 = "*neutral*", 6 = "*strongly agree*"). Reverse-scored items are indicated by an asterisk.

Appendix 2.

Three-Factor Eating Questionnaire (TFEQ-R18V2)

The Three-Factor Eating Questionnaire Revised 18-Item (TFEQ-R18V2)

1. I deliberately take small helpings to control my weight. (1) Definitely true, (2) Mostly true, (3) Mostly false, (4) Definitely false
2. I start to eat when I feel anxious. (1) Definitely true, (2) Mostly true, (3) Mostly false, (4) Definitely false
3. Sometimes when I start eating, I just can't seem to stop. (1) Definitely true, (2) Mostly true, (3) Mostly false, (4) Definitely false
4. When I feel sad, I often eat too much. (1) Definitely true, (2) Mostly true, (3) Mostly false, (4) Definitely false
5. I don't eat some foods because they make me fat. (1) Definitely true, (2) Mostly true, (3) Mostly false, (4) Definitely false
6. Being with someone who is eating, often makes me want to also eat. (1) Definitely true, (2) Mostly true, (3) Mostly false, (4) Definitely false
7. When I feel tense or "wound up", I often feel I need to eat. (1) Definitely true, (2) Mostly true, (3) Mostly false, (4) Definitely false
8. I often get so hungry that my stomach feels like a bottomless pit. (1) Definitely true, (2) Mostly true, (3) Mostly false, (4) Definitely false
9. I'm always so hungry that it's hard for me to stop eating before finishing all of the food on my plate. (1) Definitely true, (2) Mostly true, (3) Mostly false, (4) Definitely false
10. When I feel lonely, I console myself by eating. (1) Definitely true, (2) Mostly true, (3) Mostly false, (4) Definitely false
11. I consciously hold back on how much I eat at meals to keep from gaining weight. (1) Definitely true, (2) Mostly true, (3) Mostly false, (4) Definitely false
12. When I smell a sizzling steak or see a juicy piece of meat, I find it very difficult to keep from eatingFeven if I've just finished a meal. (1) Definitely true, (2) Mostly true, (3) Mostly false, (4) Definitely false
13. I'm always hungry enough to eat at any time. (1) Definitely true, (2) Mostly true, (3) Mostly false, (4) Definitely false
14. If I feel nervous, I try to calm down by eating. (1) Definitely true, (2) Mostly true, (3) Mostly false, (4) Definitely false
15. When I see something that looks very delicious, I often get so hungry that I have to eat right away. (1) Definitely true, (2) Mostly true, (3) Mostly false, (4) Definitely false
16. When I feel depressed, I want to eat. (1) Definitely true, (2) Mostly true, (3) Mostly false, (4) Definitely false
17. (Not included in TFEQ-R18V2)
18. (Not included in TFEQ-R18V2)
19. Do you go on eating binges even though you're not hungry? (1) Never, (2) Rarely, (3) Sometimes, (4) At least once a week
20. How often do you feel hungry? (1) Only at mealtimes, (2) Sometimes between meals (3) Often between meals (4) Almost always
21. (Not included in TFEQ-R18V2)

The uncontrolled eating domain was composed of items 3, 6, 8, 9, 12, 13, 15, 19, 20. The cognitive restraint domain was composed of items 1, 5, 11, 17, 18, 21. The emotional eating domain was composed of items 2, 4, 7, 10, 14, 16. Before calculating the domain scores, items 1–16 should be reverse coded and item 21 should be recoded as follows: 1–2 scores as 1; 3–4 as 2; 5–6 as 3; 7–8 as 4. Note: Items 17, 18 and 21 are not part of the Three-Factor Eating Questionnaire revised 18-item, version 2 (TFEQR18V2).

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