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Examining the Relationship of Interoception, Self-Regulation, Eating Domains, and Eating Outcomes in College Students

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EXAMINING THE RELATIONSHIP OF INTEROCEPTION, SELF-REGULATION, EATING DOMAINS, AND WEIGHT STATUS IN COLLEGE STUDENTS

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To: Dean Stanislaw F. Wnuk
College of Public Health and Social Work

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We have read this dissertation and recommend that it be approved.

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DEDICATION

I would like to dedicate this dissertation to my husband, Micael, who has always shown unwavering love and support for me throughout this process. I also dedicate this dissertation to my son, Micah. Your presence has pushed me to become the best I can be in order to lead by example. I also would like to dedicate this dissertation to my mom, Maxine, for always offering her unconditional love to keep pushing forward.

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ABSTRACT OF THE DISSERTATION

EXAMINING THE RELATIONSHIP OF INTEROCEPTION, SELF-REGULATION, EATING DOMAINS, AND WEIGHT STATUS IN COLLEGE STUDENTS

by

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College student weight gain has steadily increased throughout the past decades. Issues resulting from overweight and obesity can lead to chronic disease and increased mortality risk. Inability to maintaining a healthy weight status may be attributable to unhealthy eating behaviors that often lead to poor diet quality and overeating. Recently, cognitive behaviors such as interoception and dietary self-regulation have been of great interest in order to better understand the processes of eating behaviors and their relationship with obesity.

The purpose of this study is to examine the associations of interoception, self-regulation, eating domains and body mass index (BMI) in college students. Furthermore, longitudinal associations between interoception, self-regulation, non-purposeful eating domain behaviors, and BMI were assessed. Lastly, we sought out to examine the mediated role of eating behaviors on relationships of interoception and self-regulation on BMI. This study was a longitudinal, repeated measures research study that collected data over 3 timepoints (1 timepoint per month) through the course of a single academic semester. There were 229 females who completed baseline measures and 104 participants who completed all 3 timepoints. Participants completed 7 validated questionnaires to assess interoception, self-regulation, and various eating behaviors and provided self-report of anthropometrics for body mass index (BMI) assessment.

Baseline study results indicated a positive association between interoception and self-regulation. Also, interoception and self-regulation both had a significant negative association with the purposeful and non-purposeful eating domains. The non-purposeful eating domain had a positive association with BMI. Longitudinally, there were significant changes in interoceptive responsiveness, external, and uncontrolled eating throughout the study timepoints. Also, there were significant causal relationships between interoception, self-regulation, the non-purposeful eating domain behaviors, and BMI. Lastly, intuitive eating significantly mediated the relationships of interoception on BMI, as well as self-regulation on BMI.

In conclusion, this research study has provided empirical evidence on the associations between interoception, self-regulation, purposeful and non-purposeful eating domains, and weight status. Future studies assessing long-term observation on interoception, self-regulation, and non-purposeful eating behaviors are needed to explore the processes that may affect college student's weight status and overall lifestyles.

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INTRODUCTION

Obesity rates have rapidly increased over the last few decades, as over 400 million people are considered obese, worldwide (Simmons & DeVille, 2017). Young adults are not spared from this epidemic. In fact, obesity rates have doubled as students move from adolescence to emerging adulthood and consistently increase further into adulthood (Gordon-Larsen, The, & Adair, 2010). Since college can be such an important time for the development of health habits, health professionals regularly investigate the etiology of college student obesity to provide solutions for excess weight gain and disease prevention (Young et al., 2017). In recent years, researchers have examined interoception and self-regulation to better understand the physical and cognitive processes around one's eating patterns and behavior that influence weight change and associated risk factors. Interoception, the ability to sense and respond to one's internal sensations, has emerged as a significant measurement of individual awareness and responsiveness to their hunger and satiety levels (Craig, 2008). Self-regulation, defined as the ability to suppress "lower-level" desires to achieve "higher-level" goals, is commonly associated with interoception when analyzing eating style behaviors and patterns (Johnson, Pratt M & Wardle, 2012). Within those eating style patterns, some college students exhibit "purposeful eating domain" behaviors defined as a mix of cognitive restraint and mindfulness of their food choices. While other students exhibit "non-purposeful eating domain" behaviors where they are predominantly utilizing either emotion or external prompts as the driving force to regulate eating behaviors, potentially leading to adverse dietary choices. In the non-purposeful eating domain, college students ignore their natural internal signals guided by interoception and self-regulation to formulate eating behaviors. The purpose of this study is to determine how a college student's interoception, self-regulation, and eating domain influence their body mass index (BMI). Furthermore, we would like to determine

the longitudinal effects between interoception and self-regulation on non-purposeful eating domain behaviors, as well as their effects on one's BMI. Lastly, we would like to examine the indirect effects of multiple eating styles on the associations of interoception on BMI, as well as self-regulation on BMI.

Interoception and Self-Regulation:

Interoception allows for better interpretation of one's internal awareness and responsiveness to their internal signals (Oswald, Chapman & Wilson, 2017; Young et al., 2017). Previous research describes interoception as a moderator between the body and the brain, therefore, serving as an important connector linking one's cognitive and physical awareness (Craig, 2008; Van Dyck et al., 2016). Interoception is the ability to process multiple organ systems signals including the gastrointestinal system to assess the individual's own regard for their bodily sensations and needs, such as hunger and satiety (Craig, 2008, Critchley & Garfinkel, 2017; Herbert & Pollatos, 2014). Interoceptive sensibility is categorized as one's self-report of perceived interoception regarding their ability to feel and respond to their body's sensations (Oswald, Chapman & Wilson, 2017; Young et al., 2017). Self-regulation is highly dependent on one's interoceptive sensibility as an individual with low interoceptive sensibility may have difficulty in monitoring their eating behaviors, therefore, potentially leading to inappropriate response to their internal cues (Oswald, Chapman & Wilson, 2017; Young et al., 2017). For effective self-regulation, consistent interoceptive abilities are required to maintain healthy eating habits and weight maintenance, especially in high stress environments such as attending college.

Purposeful vs. Non-purposeful Eating Domains:

The eating habits and behaviors of college students can be composed into 2 specific eating domains: purposeful and non-purposeful eating. It is predicted that the purposeful eating domain includes both cognitive restraint and intuitive eating styles. The cognitive restraint eating

style is defined as the deliberate restriction of food intake, often used in effort to lose weight (Anglé et al., 2009). Intuitive eating is a novel, non-diet approach encompassed around mindfulness and awareness of hunger and satiety cues. Although both eating styles are vastly different from each other, they share a commonality of self-control, "eating for purpose", and require high interoception and self-regulation.

On the other hand, the non-purposeful eating domain includes eating styles that are more capricious, whereas the individual lacks self-control and awareness over their decision-making regarding food choices. Behaviors within the non-purposeful eating domain share traits of external, emotional, and uncontrolled eating styles. External eating is described as consuming food after stimulated by external temptations (Sung, K. Lee, Song, M. Lee, & D. Lee, 2010). For example, external eaters are more prone to eat foods that captivate the senses, such as the sight or smell of food (Sung et al., 2010). Another eating style that is incorporated in the "non-purposeful" eating domain is emotional eating, defined as eating in response to emotional cues as a strategy to cope with negative emotions (Anglé et al., 2009; Bennett, Greene, Schwartz-Barcott, 2013; Verzijl, Ahlich, Schlauch, & Rancourt, 2018). Lastly, uncontrolled eating is described as the complete loss of control when eating, often leading to excessive overeating (Hawks, Madanat, Smith & Cruz, 2008; Vainik, Neseliler, Konstabel, Fellows & Dagher, 2015). These eating styles encompassed by the non-purposeful eating domain are solely motivated by external factors causing an underutilized self-regulation, and interoceptive awareness and responsiveness.

Weight Status

Eating outcomes such as BMI among college students are often influenced by food resources on campus. In the college environment, there is an overabundance and easy availability of negative food choices. Students need to be able to have high levels of self-regulation and interoception in order to make better food choices while on campus. However, on-campus food resources are not sole contributors to unhealthy weight gain. Students' eating domain behaviors

may also impact BMI in various ways. The purposeful eating domain may theoretically be related to a healthy BMI status. Whereas the non-purposeful eating domain may promote adverse eating outcomes such as increased daily energy consumption and poor diet quality, thus leading to higher BMI status and a heightened risk of obesity (Nolan & Geliebter, 2012). Conversely, college students with a purposeful eating domain may have the necessary levels of interoception and self-regulation to mindfully eat for adequate energy requirements and maintain healthy weight status.

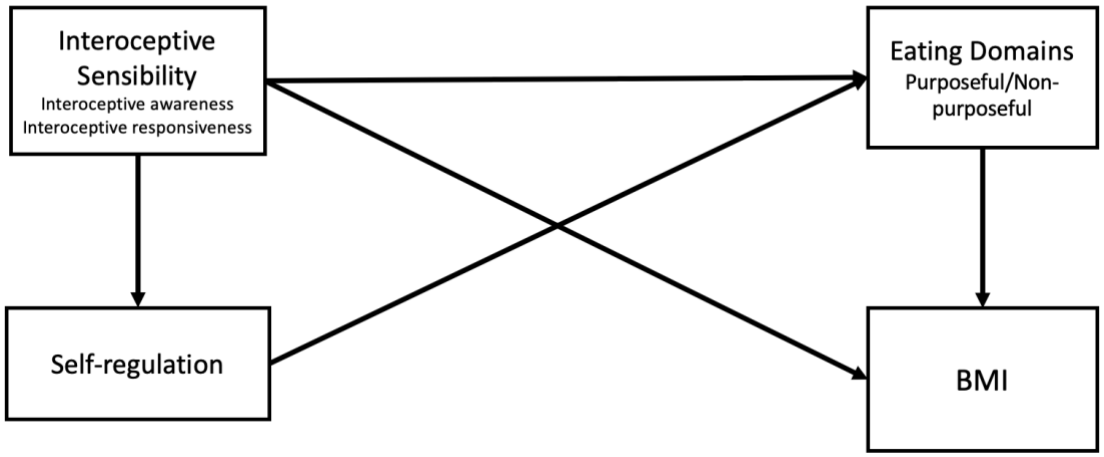
In conclusion, there are multiple contributing factors that may influence obesity in college students including interoception, self-regulation, eating domains, and BMI. Furthermore, there may be significant longitudinal changes among the associations between the cognitive factors of interoception and self-regulation and external behaviors such as emotional, external, and uncontrolled eating that may also affect BMI over time. Specifically, in college, individual eating behaviors are forming into long-lasting habits, but little is known on how specific eating styles indirectly effect the associations of interoception and self-regulation on BMI throughout time.

Significance of study

This study is important because currently, there is insufficient evidence that indicates how interoceptive sensibility affects self-regulation, purposeful and non-purposeful eating domains, and BMI among college students. We proposed a theoretical model on the associations of interoception, self-regulation, purposeful and non-purposeful eating domain behaviors and BMI (Figure 1). Also, the longitudinal associations between the cognitive factors (interoception and self-regulation) and non-purposeful eating behaviors have yet to examined along with their causal effects of BMI. Moreover, little is known regarding how specific eating behaviors mediate the relationship of interoception on BMI, and self-regulation on BMI throughout time. For college students, there is an overabundance of food accessibility that may affect their food

choices, and weight status. Interoceptive sensibility and self-regulation provides a clear indication of an individual's awareness and responsiveness of detecting their bodily signals regarding hunger and satiety. By collecting data at multiple timepoints over a long period of time, study outcomes can provide empirical evidence to further describe both internal and external eating behavior changes.

Figure 1. Theoretical Model



Specific Aims and Hypotheses

1. To examine the relationship between interoception, self-regulation, purposeful and non-purposeful eating domains, and BMI.
    a. Hypothesis #1: Cognitive restraint and intuitive eating will significantly factor onto the "purposeful" eating domain and external, emotional, and uncontrolled eating will significantly factor onto the "non-purposeful" eating domain.
    b. Hypothesis #2: Individuals with high interoceptive sensibility will have higher self-regulation, purposeful eating domain behaviors and healthy BMI status.
    c. Hypothesis #3: Individuals with reduced interoceptive sensibility will have reduced self-regulation, higher non-purposeful eating domain behaviors and overweight/obese BMI status.

2. To determine longitudinal associations between interoception, self-regulation, the non-purposeful eating domains, and BMI over time.
    a. Hypothesis #4: There will be significant changes within interoception, self-regulation, non-purposeful eating behaviors, and BMI over time.
    b. Hypothesis #5: Individuals with higher interoception will have increased self-regulation, a negative relationship with non-purposeful eating domain behaviors, and healthy BMI over time.
3. To determine if there is a significant mediating effect of specific eating styles on interoception on BMI and self-regulation on BMI.
    a. Hypothesis #6: Individuals with increased interoception and self-regulation will have decreased BMI through purposeful eating domain behaviors (cognitive restraint and intuitive eating).
    b. Hypothesis #7: Individuals with increased interoception and self-regulation will have increased BMI through non-purposeful eating domain behaviors (emotional, external, and uncontrolled eating).

CHAPTER II

LITERATURE REVIEW

Obesity among College Students

In 2016, the Center for Disease Control and Prevention (CDC) reported that nearly 40% of U.S. adults or 93 million people were considered obese (Hales, Carrol, Fryar & Ogden, 2017). Of those obese adults, an estimated 24% of U.S. college students, aged 18-24, were categorized as obese (Bennett, Greene & Schwartz-Barcott, 2013; Bryan, 2016). Increased obesity rates in college students have led to greater mortality risk, thus predicting a shorter lifespan than that of their parents and past generations (Anglin, 2012; Bennett et al., 2013; Bryan, 2016; Mathews, Mathias, Thomas, Williams & Noronha, 2015; Olshansky et al., 2005). Obesogenic causes among this population are predominantly derived from increased energy consumption and poor diet quality (Bryan, 2016; Brunt, Rhee & Zhong, 2008).

College is the first time many young adults live independently and make their own choices regarding their dietary habits (Brunt, Rhee & Zhong, 2008). Students often are limited to dining halls, fast food restaurants, and convenience stores located on campus for their nutritional resources. Where highly palatable, processed foods are frequently accessible, many students on-campus consume these food items out of convenience or cost (Skelton & Evans, 2020). Over time, eating pattern outcomes may lead to increased weight gain. College student weight gain has been trending in recent years, so much that “Freshman 15” was coined after college students were gaining up to an average of 15 pounds in their first year of college (Smith-Jackson & Reel, 2012). While 15 pounds of weight gain per year may not be experienced by all, several studies did show that most college students (70%) gained approximately 12 pounds (5.3kg) in weight in a 4-year timespan (Gropper, Simmons, Connell & Ulrich, 2012; Zagorsky & Smith, 2011). Unhealthy eating habits such as a diet low in fruits and vegetables, and high in saturated fat, sodium, and sugar are known to contribute to weight gain and obesity (Brunt et al., 2008). Decisions regarding

on-campus food choices affect a young adults' weight and risk for obesity. Long-term diet behaviors often lead to excess weight gain and poor health, over time. In a climate where students are deciphering their independence, knowledge surrounding preventative strategies against obesity such as nutrition and eating behaviors are needed to aid in healthy weight management.

Interoception and Self-regulation

Interoception is the body-to-brain axis of sensation where measurements of internal body signals can be quantified (Garfinkel, Seth, Barrett, Suzuki & Critchley, 2015; Oswald et al., 2017; Young et al., 2017). If a person is interoceptively aware, the individual can detect internal changes in the body such as feelings of temperature, pain, and hunger (Craig, 2002, Garfinkel et al., 2015). In theory, a person can objectively feel when they are hungry or satiated by tuning into their internal gastric signals and adequately respond to those signals (Craig, 2008; Critchley & Garfinkel, 2017; Herbert & Pallatos, 2014). "Interoceptive sensibility" is the self-reported measure to detect and respond to the internal signaling of the body (Barret, Quigley, Bliss-Moreau & Aronson, 2004; Garfinkel et al., 2014; Oswald et al., 2017; Zamariola, Vlemincx, Corneille & Luminet, 2018). This mode of interoceptive testing utilizes validated questionnaires to indicate perceptions of one's internal sensations such as hunger and satiety (Barrett et al., 2004). Interoceptive awareness and responsiveness are two subgroups that make up interoceptive sensibility. Interoceptive awareness is described as the general ability to detect the internal sensations within the body (Oswald et al., 2017). Interoceptive responsiveness indicates the subjective response after detection of the internal signaling (Oswald et al., 2017). There are many studies that have found interoception as a significant measure in body awareness, internal decision making, and emotional recognition.

Multiple studies have reviewed interoception and optimal eating styles like intuitive eating (Dunn et al., 2010; Francis & Stevenson, 2011; B. Herbert, C. Herbert, Matthias, Blechert & Hautzinger, 2013; Herbert & Pollatos, 2014; Oswald et al., 2017;). For example, in a cross-

sectional study of 111 college females, interoception was assessed to detect its association with eating behaviors and BMI (B. Herbert et al., 2013). Increased levels of interoception were positively associated with mindfulness and intuitive eating, while also negatively associated with BMI (B. Herbert et al., 2013). In the overweight/obese population, similar findings were also found in a cross-sectional research study that examined interoception in college students with various weight classifications (normal/overweight/obese) (Herbert & Pollatos, 2014). In overweight and obese students, there was a significantly positive relationship between interoception and food consumption regulation, however, both measures were lower in overweight/obese students when compared to normal weight students (Herbert & Pollatos, 2014).

Self-regulation is highly dependent on the awareness and responsiveness of an individual's body signals (Annesi, Mareno & McEwen, 2016; Young et al., 2017). Self-regulation consists of being aware and actively monitoring the processes of the body to achieve a specific "goal" (Young et al., 2017). Self-regulation is utilized in many research studies to assess the capabilities of one's control regarding food choice decisions and behaviors that may affect weight status. In past research, individuals with high levels of self-regulation resulted in better food choices and healthy weight maintenance (Annesi et al., 2016; Kliemann, Beeken, Wardle, & Johnson, 2016; Mullan, Allom, Brogan, Kothe & Todd, 2014). For example, in a recent observational research study, 481 college freshmen were assessed to examine the associations between self-regulation, dietary intake, and weight change over time (Kliemann et al., 2016). After the 6-month follow-up, results indicated that overweight students with high self-regulation had a reduction of weight (Kliemann et al., 2016).

Both interoception and self-regulation hold promise for accurate measurement and improvement of decision-making regarding food choices that may affect overall BMI. Theoretically, increased interoception and self-regulation can allow for long-term healthy eating habits and behaviors, however, both interoception and self-regulation have not been tested among

multiple eating styles and domains fully determine their benefits on eating behavior and weight management in college students.

Eating Domains: Purposeful vs Non-purposeful

Purposeful Eating Domains:

"Purposeful eating domains" seek to describe eating patterns that are performed with intention and are predominantly cognitive-driven. In theory, these eating styles require increased self-regulation and interoception to guide oneself to make decisions on food choices. Cognitive restraint and intuitive eating styles both contribute to the purposeful eating domain in many ways. This eating domain is hypothesized to provide positive decision-making regarding food choices and healthy weight maintenance.

Cognitive Restraint Eating

Cognitive restraint eating is often known as intentional self-regulation, where a person is highly aware of their internal signals yet overrides hunger cues to purposefully restrict one's intake (Anglé, 2009). For instance, restrained eaters restrict themselves from eating even if hungry in order to consume less calories than desired to meet adequate daily requirements (Anglé, 2009; Schur, Cumming, Callahan & Foster- Schubert, 2008; Racine, 2018). This eating style is most similar to traditional dieting, where a person actively controls their food intake to achieve specific goals such as weight loss (L. Anderson, Reilly, Schaumberg, Dmochowski, & D. Anderson, 2016; Racine, 2018; Shur et al., 2008). Therefore, this eating style is reliant on high levels of consistent motivation to reduce the risk of relapsed maladaptive behavior (L. Anderson, et al., 2016; Racine, 2018; Shur et al., 2008).

Researchers who have studied cognitive restraint among college students have concluded that when participants obtain cognitive control, positive associations regarding healthy food choices were made (Houben, Roefs & Jansen, 2012; Meule, Lutz, Vögele & Kübler, 2012;

Racine, 2018; Veenstra & de Jong, 2010). Three research studies, in particular, have examined food intake and purposeful eating measures such as intention, motivation, and self-regulation in cognitive restraint eaters (Meule et al., 2012; Racine, 2018; van Koningsbruggen, Stroebe, Papies & Aarts, 2011). Conclusions indicated that intention and goal setting were primary predictors among the studies on cognitive restraint eating (Meule et al., 2012; Racine, 2018; van Koningsbruggen, Stroebe, Papies & Aarts, 2011). Van Koningsbruggen et al. (2011) and Racine et al. (2018) stated that restrained eaters were mostly successful due to self-control and long-term goal seeking. Results suggested that successful restrained eaters were eligible to resist highly palatable foods and control their eating behavior over time (Meule et al., 2012; Racine, 2018; van Koningsbruggen et al., 2011). More specifically, Meule et al. (2012) argued that palatable food craving scores were lowered among successful restraint eaters, compared to unsuccessful eaters.

Researchers have also considered the cognitive restraint eating style as a beneficial practice for healthy weight management. For instance, in a cross-sectional study of 715 college women (ages 18-24), researchers examined the relationship of healthy weight maintenance practices such as purchasing fruit and vegetables and maintaining a balanced diet among cognitive restraint eaters (Hayes & Napolitano, 2012). Using validated questionnaires, researchers found that individuals with increased healthy weight maintenance practices were significantly associated with higher levels of cognitive restraint, compensatory behaviors, and physical activity among all weight classification groups (Hayes & Napolitano, 2012). Research in this eating style has been heavily studied among female-only, college-student populations (Anderson et al., 2016; Hayes & Napolitano, 2012; van Koningsbruggen et al., 2011). However, similar results were also found in an observational research study assessing college males and females (Rocks, Pelly, Slater & Martin, 2016). Results suggested that males who were successful cognitive restraint eaters had reduced levels of energy intake and were primarily seeking weight loss (Rocks et al., 2016). Limitations arose in this study due to a small male sample size (n=12)

and many were nutrition majors (Rocks et al., 2016). More research is needed to better understand college male cognitive restraint eaters and its effects on food choices and weight management.

Intuitive Eating

Intuitive eating solely focuses on the individual's internal signals of hunger and satiety to indicate whether it is time to eat (Anglin, 2012). Intuitive eating is the non-diet approach that is centered around the individual's body signaling response such as their hunger and satiety cues (Anderson et al., 2016; Anglin 2012; Oswald et al., 2017; van Koningsbruggen, 2011). In order to effectively practice intuitive eating, individuals must be able to accurately identify and respond to their internal hunger cues via interoception (Anglin 2012; Nolan & Geliebter, 2012; Oswald et al., 2017). Intuitive eating requires heightened interoceptive awareness and responsiveness levels to aid in healthy decision-making regarding feeding choices to be recognized and accepted (Anglin, 2012; Bryan, 2016; Oswald et al., 2017).

There has been promising promotion of intuitive eating utilized as a successful eating style as most studies have shown positive correlations in weight maintenance and healthy eating patterns through mindfulness (Anglin, 2012; Warren, Smith & Ashwell, 2017). In college men and women, Hawks et al. (2005) and Gast et al. (2012) assessed the associations between intuitive eating and positive health outcomes such as weight management and healthy eating behaviors. Lowered BMI was significantly correlated with increased scoring of intuitive eating measures. It was also stated that intuitive eaters were more intrinsically motivated to practice healthy eating behaviors, whereas weight loss was not an incentive for implementation (Gast et al., 2012; Hawks et al., 2005).

Regarding healthy eating patterns, Anderson et al. conducted a cross-sectional research study to examine the associations of weight status, and intuitive eating when compared to other eating styles (Anderson et al., 2016). The study had a sample size of 125 college students

consisting of mostly females (64%) with normal weight status (Anderson et al., 2016). Participants completed eating behavior questionnaires and consumed food to assess hunger/satiety levels during their visit (Anderson et al., 2016). Hunger scores were calculated and used as a measure of interoceptive awareness, where a person can effectively assess their internal hunger and satiety signals (Anderson et al., 2016). Significant positive associations were made between intuitive eating and hunger scores that suggested participants with high intuitive eating scores ate adequate amounts of food based on their hunger scoring (Anderson et al., 2016). Other researchers, like Barad et al. (2019) and Smith and Hawks have found similar findings among college students. Similarly, Smith and Hawks (2006) also found that those who were intuitive eaters had more diversity in food choice and lower BMI statuses.

Both cognitive restraint and intuitive eating were positively related to increased awareness and diet adherence (Anglin, 2012; Bryan, 2016; Oswald et al., 2017). Both purposeful eating domain behaviors were positively associated with weight loss or healthy weight maintenance in many research studies. These subgroups of the purposeful eating domain may better delineate its effects on eating outcomes, especially in maintaining health weight status.

Non-purposeful Eating Domain

The "non-purposeful" eating domain consists of eating styles that are motivated by external factors such as one's emotions or environment. Eating habits in this domain are not suited for a specific purpose, but rather utilized as a response to an external factor. The non-purposeful eating domain is predominantly emotional-driven and lessens one's control over their decisions regarding food choices. This eating domain is composed of emotional, external and uncontrolled eating styles.

Emotional Eating and Obesity

Emotional eating is generally defined as eating in response to certain emotional cues as a coping mechanism (Annesi et al., 2016; Bennett et al., 2013; Lazarevich, Marco, María del, & María Esther, 2016). According to previous studies, emotional eaters have a difficult time recognizing their emotions and, simultaneously, regulating their eating patterns (Bennett et al., 2013). Stress, anxiety, frustration, and anger are prominent mood patterns that often lead to emotional eating (Anderson et al., 2016; Lazarevich et al., 2016; Oswald et al. 2017). More commonly, emotional eating is associated with overeating, thus, leading to excessive weight gain and obesity (Anderson et al., 2016; Bennett et al., 2013; Lazarevich et al., 2016). Several studies reviewed below have indicated positive associations with negative emotions and psychological conditions such as depression, the increased consumption of overall food intake, and higher body mass index (BMI) (Konttinen, Silventoinen, Sarlio-Lähteenkorv, Männistö & Haukkala, 2010; Lazarevich et al., 2016; Mooreville et al., 2014).

In a previous cross-sectional research study with 1,463 first-year college students, the relationships between emotional eating, negative mood patterns, and weight gain were assessed (Lazarevich et al., 2016). It was found that emotional eating had a significant mediating effect on mood and weight status. In fact, approximately 1/3 of college students responded with 'yes' to the question: "Do you overeat in response to emotions?" (Lazarevich et al., 2016). Study findings connected emotional eating to weight gain by indicating the reduced self-regulatory skills when experiencing negative emotions (Annesi et al., 2016; Lazarevich et al., 2016). With dysfunctional coping strategies to negative emotions, it is postulated that an individual may unsuccessfully become aware or responsive to their internal signals (Lazarevich et al., 2016).

Among college students, emotional eating has become more prevalent due to various stressors like financial and academic stress, presenting students at a greater risk of gradual weight gain (Anglé et al., 2009). Bennett and colleagues found that different gender groups had notably

different identifiers during emotional eating (Bennett et al., 2016). In females, results indicated that stress was the most predominant predictor for emotional eating, whereas, in males, boredness and anxiety were predictors prompting emotional eating (Bennett et al., 2016). As a result, multiple studies have found that college students who are emotional eaters often have dysfunctional coping strategies to stress such as increased food consumption and unhealthy food choice (Anderson et al., 2016; Annesi et al., 2016; Lazarevich et al., 2016). Students often later develop abnormal eating patterns and behaviors in the effort to reduce their negative mood status (Anderson et al., 2016; Annesi et al., 2016; Lazarevich et al., 2016). Moreover, being extrinsically motivated to eat via emotion, interoception and self-regulation are theorized to become reduced over time.

In order to reduce emotional eating behaviors, individuals are recommended to self-regulate by eating for physical needs, rather than for temporary comfort (Anderson et al., 2016). More specifically, in women, negative eating patterns due to emotional eating or other psychological deterrents, resulted in conditioning themselves to ignore their natural messages, leading to blocked internal cues over time (Brunt et al., 2008; Bryan, 2016; Simmons & DeVille, 2017). In males and females, self-regulation is often reduced when combined with increased stress or emotions, resulting in a stimulus response of negative eating behaviors as coping mechanisms (Bryan, 2016; Simmons & DeVille, 2017). Weight maintenance treatments for emotional eaters have to consider the multiple stressors and mediators such as depression and self-regulation in order to receive successful outcomes.

External Eating and Obesity

External eating is eating in response to an external food-related stimulus like the sight or smell of food, regardless of having feelings of hunger or satiety (Mooreville et al., 2014; Van Strien et al., 1986). External eaters are known to have less conscientiousness (interoception) over their eating behaviors (Heaven et al., 2001). As a result, external eaters may also experience a

reduction in self-regulatory abilities when eating, thus leading to increased episodes of overeating (Brogan & Hevey, 2013; Heaven et al., 2001). The behaviors and outcomes of external eating have not been well studied in the college environment, however, there were few studies that have reviewed the associations of external eating with dietary consumption and food cravings in various populations.

Past studies have provided empirical evidence on the effects of external eating (Anschutz, Van Strien, Van De Ven & Engels, 2009; Brogan & Hevey, 2013; Heaven et al., 2001). In a population of both men and women (n=124, ages 21-70), external eating traits were positively correlated with increased energy intake (Burton, Smit & Lightowler, 2007). In fact, external eating was a significant predictor of increased food cravings and weight status, although there were differences among food craving types between males and females (Burton, Smit & Lightowler, 2007). Male external eaters had increased cravings for fast food, fats, and carbohydrates, whereas females had more cravings for sweets and carbohydrates only (Burton, Smit & Lightowler, 2007). Outcomes were similar among overweight/obese weight classifications, also. Specifically in an obese sample, 57 men and women (aged 16-70) were assessed to explore the relationships between unhealthy eating patterns and external eating. Researchers examined those factors to identify how external eating was associated to food choices and snacking frequency (Brogan & Hevey, 2013). Study results indicated a positive association between external eaters and emotional response to food (Brogan & Hevey, 2013).

Overall, external eating had significant associations with increased daily caloric intake among college women, which may increase risk of obesity (Anschutz et al., 2009). Furthermore, there were few studies that examined these factors on both males and females, however, it was conducted in a general adult population (Brogan & Hevey, 2013, Burton et al., 2007). Clearly, there are gender differences when assessing external eating behaviors, but more research is necessary on college men and women to draw definitive conclusions.

Uncontrolled Eating

Uncontrolled eating, described as the loss of control while consuming food, is associated with increased BMI and risk of obesity in both men and women (Anglé et al., 2009; Vainik et al., 2015; Verzijl et al., 2014). Uncontrolled eating shares many traits with other eating styles like emotional and external eating, but can become more frequent, and lead to full loss of self-regulation and control (Vainik et al., 2015; Verzijl et al., 2014). It is theorized that uncontrolled eating is viewed more so as a continuum that starts from eating impulsivity to overeating behaviors (Vainik et al., 2015; Verzijl et al., 2014). Few studies have assessed the uncontrolled eating style with other personality attributes to try to deduce the reasoning for overeating and risk of obesity (Pérez-Fuentes et al., 2019; Vainik, García-García & Dagher, 2019). As a result, researchers explained uncontrolled eating can be a means for individuals to achieve emotional relief, thus becoming similar to emotional eating, however, the frequency of consumption differs between the 2 eating styles (Oomen, Gro, Spronk, Booth & Fox, 2018; Pérez-Fuentes et al., 2019).

In fact, Vainik et al. (2015) defined uncontrolled eating as more of a continuum consisting of eating impulsivity on one side and disinhibition on the more severe side of the spectrum. In a previous study, researchers examined uncontrolled eating and its relationship to cognitive control. Participant sample size consisted of 62 college males and females who were assessed on the relationship between uncontrolled eating and cognitive performance (Calvo, Galioto, Gunstad & Spitznagel, 2014). Self-reported questionnaires and performance tasks such as inhibitory and working memory tasks were completed during the participant visit (Calvo, Galioto, Gunstad & Spitznagel, 2014). As a result, Calvo and colleagues revealed that uncontrolled eating was significantly associated with reduced inhibitory control and working memory levels among college students (Calvo, Galioto, Gunstad & Spitznagel, 2014). Furthermore, cognitive control was lowered among individuals considered overweight or obese,

when compared to normal weight participants (Calvo, Galioto, Gunstad & Spitznagel, 2014). Also, self-report of uncontrolled eating was also more prominent among overweight and obese students (Calvo, Galioto, Gunstad & Spitznagel, 2014). It is suggested that inhibitory mechanisms counteract one's control over their cognitive functioning, leading to individuals to participate in impulsive behaviors and lose control (Calvo, Galioto, Gunstad & Spitznagel, 2014).

In 2019, another cross-sectional study of 400 college students was conducted to assess potential associations between uncontrolled eating and influential factors that affect eating behaviors like cognitive, behavioral, and emotional characteristics of an individual (Aoun et al., 2019). Researchers collected data using self-reported questionnaires regarding eating behaviors, emotion and weight status. Study results indicated that weight status and feelings of anxiety were significantly associated with uncontrolled eating in male students (Aoun et al., 2019). However, lack of cognitive control was significantly associated with eating habits in females (Aoun et al., 2019).

Interoception and Self-regulation of Eating Behaviors and Weight Status in College students: A Structural Equation Modeling Analysis

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ABSTRACT

Interoception and self-regulation are prominent cognitive-behavioral skills used to examine one's internal regulation. Poor internal regulation can lead to unhealthy eating habits and excessive weight gain. Understanding these processes may help us better understand the physical and cognitive practices surrounding one's eating patterns and their association to obesity risk. The purpose of this study was to determine the associations between interoception, self-regulation, purposeful and non-purposeful eating domains, and BMI among college students. Participants included 229 female undergraduate students, predominantly classified as Hispanic/Latinx (75%). Participants completed 7 validated questionnaires to assess interoception, self-regulation, and various eating behaviors which were later grouped into purposeful or non-purposeful eating domains. Self-report of anthropometrics were provided to calculate body mass index (BMI) for assessment. Cross-sectional data were analyzed using confirmatory factor analyses and a 2-step structural equation model analyses. Study results signified a positive relationship between interoception and self-regulation. Also, interoception and self-regulation was negatively associated with purposeful eating domain. Similarly, interoception and self-regulation was negatively associated with non-purposeful eating, also. Lastly, only the non-purposeful eating domain had a positive relationship with BMI. Overall, this study provided empirical evidence on the associations between interoception, self-regulation, purposeful and non-purposeful eating domains, and weight status. Furthermore, it highlighted the influences of both purposeful and non-purposeful eating domains and their influences on the other factors, which may serve as an integral addition to nutrition interventions and future research.

Keywords: Self-regulation, Interoception, Eating behaviors, College students, Body Mass Index, Structural Equation Modeling

1. INTRODUCTION

Obesity rates have rapidly increased over the last few decades, as over 400 million people are considered obese, worldwide (Simmons & DeVille, 2017). Similarly, obesity rates among college students have continued to increase throughout the recent years. In fact, obesity rates double as students move from adolescence to emerging adulthood and consistently increase further into adulthood (Gordon-Larsen, The, & Adair, 2010). Since college can be such an important time for the development of health habits, health professionals regularly investigate the etiology of college student obesity to provide solutions for excess weight gain and disease prevention (Young et al., 2017).

In recent years, researchers have examined interoception and self-regulation to better understand the physical and cognitive processes around one's eating patterns that influence weight change and associated risk factors. Interoception, the ability to sense and respond to one's internal sensations, has emerged as a significant measurement of individual awareness and responsiveness to their hunger and satiety levels (Craig, 2008). In theory, a person can objectively feel when they are hungry or satiated by tuning into their internal gastric signals and should act by responding to those signals (Craig, 2008; Critchley & Garfinkel, 2017; Herbert & Pallatos, 2014). "Interoceptive sensibility" is the self-reported measure to detect and respond to the internal signaling of the body and is made up of two subcategories: interoceptive awareness and interoceptive responsiveness (Oswald, Chapman, & Wilson, 2017; Garfinkel, Seth, Barrett, Suzuki, Critchley, 2015). Interoceptive awareness is described as the general ability to detect the internal sensations within the body (Oswald et al., 2017). Interoceptive responsiveness indicates the subjective response after detection of the internal signaling (Oswald et al., 2017). Self-regulation, defined as the ability to suppress "lower-level" desires to achieve "higher-level" goals, is highly dependent on the awareness and responsiveness of an individual's body signals (Young

et al., 2017; Annesi, Mareno, & McEwen, 2016). In past research, individuals with high levels of self-regulation reported better food choices and healthy weight maintenance (Annesi et al., 2016; Kliemann, Croker, Johnson, & Beeken, 2018; Mullan, Allom, Brogan, Kothe, & Todd, 2014).

Self-regulation is commonly associated with interoception when analyzing eating style behaviors and patterns (Johnson, Pratt, & Wardle, 2012). To exhibit self-regulation related to interoception, an individual must be purposeful in their eating meaning they are aware of what they are choosing and are able to make a conscious decision to consume or not consume certain food items. Two eating styles might fit within the purposeful eating domain: cognitive restraint and intuitive eating styles. The cognitive restraint eating style is defined as the deliberate restriction of food intake, often used in effort to lose weight (Anglé et al, 2009), whereas intuitive eating is a novel, non-diet approach encompassed around mindfulness and awareness of hunger and satiety cues (Warren, Smith, & Ashwell, 2017). Although both eating styles are vastly different from each other, they share a commonality of self-control, "eating for purpose", and require high interoception and self-regulation. Non-purposeful eating behaviors, on the other hand, are exhibited when individuals are predominantly utilizing either emotion or external prompts as the driving force to regulate eating behaviors, potentially leading to adverse dietary choices. In the non-purposeful eating domain, individuals ignore or disregard internal signals guided by interoception and self-regulation. The non-purposeful eating domain includes eating styles that are more capricious, whereas the individual lacks self-control and awareness over their decision-making regarding food choices. Behaviors within the non-purposeful eating domain include the external, emotional, and uncontrolled eating styles. External eating is described as consuming food after being stimulated by external temptations (Sung, K. Lee, Song, M. Lee, & D. Lee, 2010). For example, external eaters are more prone to eat foods that captivate the senses, such as the sight or smell of food (Sung et al., 2010). Another eating style is emotional eating which is defined as eating in response to emotional cues as a strategy to cope with negative

emotions (Anglé et al, 2009). Lastly, uncontrolled eating is described as the complete loss of control when eating, often leading to excessive overeating (Hawk, Madanat, Smith, & Cruz, 2008). These non-purposeful eating domain behaviors are solely motivated by external factors which may underutilize self-regulation, and interoceptive awareness and responsiveness.

Over time, eating style outcomes may lead to poor diet and increased weight gain. College student weight gain has been trending in recent years, so much that "Freshman 15" was coined after college students were gaining up to an average of 15 pounds in their first year of college (Smith-Jackson & Reel, 2012). Students who exhibit higher levels of interoception and self-regulation are more likely to maintain a healthy weight in their college years (Annesi et al., 2016; Herbert, Blechert, Hautzinger, Matthias, & Herbert, 2013). Also, college students that are more purposeful in their eating were shown to have the necessary levels of interoception and self-regulation to mindfully eat and maintain healthy weight status. Both cognitive restraint and intuitive eating styles have been negatively correlated with BMI. When cognitive restraint eaters obtain cognitive control, they are more likely to make healthy food choices and maintain healthy weight status (Racine, 2018; Houben, Roefs, & Jansen, 2012; Meule, Lutz, Vögele, & Kübler, 2012; Veenstra & de Jong, 2010). Hawks et al. (2005) and Gast et al. (2012) found that lowered BMI was significantly correlated with higher levels of intuitive eating. Non-purposeful eating behaviors may provide long-term consequences through excessive weight gain, leading to obesity and obesity-related health risks. Previous research has shown that eating styles like emotional eating may lead to weight gain due to the inability to maintain adequate self-regulatory skills when experiencing negative emotions (Annesi et al., 2016; Lazarevich, Marco, María del, & María Esther, 2016). External eating was a significant predictor of increased food cravings and weight status in another study of college students (Burton, Smit, & Lightowler, 2007). Finally uncontrolled eating which is categorized as a full loss of self-regulation and control has been correlated with increased BMI (Vainik, Neseliler, Konstabel, Fellows, & Dagher, 2015). Despite

previous research on eating behaviors, this study contributes to the literature by determining if eating behaviors can be categorized into purposeful and non-purposeful eating domains. Classifying eating behaviors into these domains will allow us to examine the interplay between one's cognitive factors (interoception and self-regulation), eating behaviors and weight status in college students.

The purpose of this study is to 1. Confirm the two-factor structure of purposeful and non-purposeful eating domains and 2. Examine the associations between interoception, self-regulation, purposeful and non-purposeful eating domains, and BMI in college students. We hypothesize that cognitive restraint and intuitive eating will share observed similarities within the "purposeful" eating domain and that external, emotional, and uncontrolled eating behaviors will create the "non-purposeful" eating domain. We also predict that individuals with interoceptive sensibility will have higher levels of self-regulation, purposeful eating domain behaviors, and healthy BMI status. In support of our hypothesis, we have developed a theoretical model to better understand the associations of interoception, self-regulation, eating domains and BMI (Figure 1). Study outcomes can provide empirical evidence to further describe the association between cognitive behaviors such as interoception and self-regulation with eating behaviors, and weight status.

[insert Figure 1 here]

2. METHODS

2.1 Participant Recruitment and Procedures

Participants were recruited from a 4-year university located in the southern region of Florida. Participants were predominantly recruited through the university psychology research participation pool online system, SONA. Participants eligible for this study were undergraduate college students. Exclusion criteria included taking medications that suppress or increase appetite, previously diagnosed eating disorders or mood disorders, pregnant or planning to become

pregnant, and/or student athletes. Males (n=13) were excluded post-hoc due to inadequate sampling. Study protocols were reviewed and approved by the university's Institutional Review Board.

This study utilized baseline measures from a repeated-measures, longitudinal research study. At baseline, participants completed an online survey to provide self-reported demographic information, anthropometrics, and completed measures using validated questionnaires.

2.2 Participant Measures

2.2.1 Interoceptive Awareness and Responsiveness

Multidimensional Assessment of Interoceptive Awareness (MAIA) is a 32-item questionnaire that indicates and assesses eight components of interoceptive awareness (Young et al., 2017; Zamariola, Vlemincx, Corneille, & Luminet, 2018). Topics such as emotional awareness, self-regulation, and body listening scales are included to assess perceived levels of interoception. It is scored based on the average responses using a Likert scale of 0 (never) to 5 (always). The reliability of the questionnaire ranged from 0.54-0.91, including the 8 subscales, indicating an adequate internal consistency.

Body Responsiveness Scale (BRS) is a 7-item scale that measures how a participant's internal sensations are appreciated or reviewed (Oswald et al., 2017). The assessment indicates the person's eagerness to respond to their internal cues. The questionnaire's responses are measured on a 7-point Likert scale indicating 1 as 'not at all true' and 7 as 'always true of me'. Higher point scores are indicative of increased interoceptive responsiveness. BRS resulted with a reliability of $\alpha = 0.75$.

2.2.2 Self-regulation

The Self-Regulation of Eating Behavior Questionnaire (SREBQ) is a validated questionnaire used to assess the participant's perceived self-regulation on one's own eating behaviors (Kliemann, Beeken, Wardle, & Johnson, 2016). It is a 5-item questionnaire that

assesses an individual's self-regulation capacity. Items are scored using a Likert scale using 1 (Never) to 5 (Always). The questionnaire's internal consistency for the total score was $\alpha = 0.69$.

2.2.3 Purposeful and Non-purposeful eating domains

Dutch Eating Behavior Questionnaire (DEBQ) is a 33-item questionnaire that contains three subscales of Emotional eating, External eating, and Restrained eating (Van Strien, Frijters, Bergers, & Defares, 1986). The assessment indicates a person's eating behavior based on three main psychological theories (Van Strien et al., 1986) For the purposes of this study, the researchers only utilize the Emotional eating and External eating subscales. The questionnaire items are scored on a Likert scale ranging from 1 (seldom) to 5 (very often). The DEBQ has a high internal consistency at $\alpha = 0.95$ and 0.85 for Emotional eating and External Eating, respectively.

Three-factor Eating Questionnaire (TFEQ-R18) is an 18-item assessment that measures eating behavior concepts of Cognitive Restraint, Uncontrolled and Emotional eating (Anglé et al., 2009). Originating from obesity research, the questionnaire is set to identify eating behaviors that are deemed higher in overeating (Anglé et al., 2009). Only the Cognitive Restraint and Uncontrolled eating subscales were utilized in the current study. The questionnaire is scored using a four-point scale of 1-4, with the higher values signifying for more of the behavior. The TFEQ-R18 demonstrates a good internal consistency at $\alpha = 0.89$ and 0.79 for Uncontrolled eating and Cognitive Restraint eating, respectively.

Intuitive eating focuses on the individual's response to their body signaling such as their hunger and satiety cues (Tylka & Kroon, 2013). The Intuitive Eating Scale-2 (IES-2) is a 23-item questionnaire that assess the individual's ability to adhere to their internal hunger and satiety cues, regarding when to eat (Tylka & Kroon, 2013). The questionnaire is scored using a Likert scale of 1 (strongly disagree) to 5 (strongly agree). In the current study, the scale had a Cronbach's alpha of 0.87 representing good internal consistency.

2.2.4 Weight Status

Participant weight was self-reported via an online survey. At each timepoint, participants were asked to weight themselves and record their weight while completed the other questionnaires. BMI was calculated using the individual's baseline height and weight using the formula (weight (kg) / [height (m)]^2 ("About Adult BMI", 2021). BMI were classified into 4 categories using the Center for Disease Control guidelines: Underweight (BMI<18.5), Healthy weight (18.5-24.5), Overweight (25.0-29.9), and Obesity (BMI>=30.0) ("About Adult BMI", 2021).

2.3 Statistical Analysis

Collected data were analyzed on SPSS Statistics v26.0 and SPSS AMOS v26.0. Both, one-factor and two-factor Confirmatory factor analyses (CFA) were used to examine the construct structure of interoceptive sensibility along with purposeful and non-purposeful eating domains indicated in our path diagram. A 2-step Structural Equation Modeling (SEM) analysis was conducted (Anderson & Gerbing, 1988). A measurement model was utilized to assess constructive model fit between the proposed variables. Then, SEM was conducted to assess how self-regulation, purposeful and non-purposeful eating domains, and weight status are related to interoception. Maximum Likelihood (ML) estimation was performed when estimating the paths of the diagram, Global fit statistics (eg. chi-square, chi-square/degrees of freedom ratio, CLI, TFI and RMSEA statistics) and local fit statistics were employed to test the well-fit the items are to the overall model. Chi-square statistics indicated any potential significant misfit in the model. However, as the current literature has indicated, the chi-square test is highly dependent on sample size where larger sample sizes often lead to a significant measure (Bentler & Bonett, 1980). Since our study consists of a large sample size, we utilized the chi-square/degrees of freedom ratio as the more accurate measure. This measure indicates a good model fit if the ratio is lower than the recommended value of 5 (Hu & Bentler, 1999). CFI and TLI testing are recommended when

assessing the fit of a single model (Hu & Bentler, 1999). CFI and TLI represents 'goodness of fit', where the >0.95 indicated good model fit. Lastly, RMSEA is a measure that goodness of fit at 0.06 or below (MacCallum, Browne, & Sugawara, 1996). For local fit statistics, standardized residuals were examined for any absolute value greater than 4, which would be indicative for a poor item fit to the overall model.

3. RESULTS

3.1 Participant Demographics

At baseline, there were 229 female participants who completed the questionnaires. Participants were predominantly classified as Juniors (51.1%), majored in social sciences (including anthropology, economics, political science, psychology, sociology; 65.5%), identified as White Hispanics (75.1%), were never married (88.2%), lived off-campus (94.8%), and many lived with their parents (54.6%). Participants had a mean age of 23.39 (SD=6.312) and mean BMI of 25.45 (SD=5.48), which is classified as overweight. All participant demographic information is included in Table 1.

[insert Table 1 here]

3.2 Correlations

Means, standard deviations and correlations between all the study variables can be found in Table 2. BMI was positively associated with emotional eating ($r=0.291$, $p<0.001$), uncontrolled eating ($r=0.167$, $p=0.011$), and cognitive restraint ($r=0.180$, $p=0.006$). BMI was negatively associated with MAIA-Trusting ($r=-0.190$, $p=0.004$), BRS ($r=-0.157$, $p=0.017$), and self-regulation ($r=-0.170$, $p=0.010$).

[insert Table 2 here]

3.3 SEM Model Analysis

3.3.1 Confirmatory Factor Analysis (CFA) for Eating Domains and Interoceptive Sensibility.

A 2-factor CFA was conducted based on our proposed theory that eating behaviors can be categorized as purposeful or non-purposeful eating domains. The model fit indices (Table 3) were examined, and an adequate model fit was considered. Most factor loadings were considered strong with the exception of the cognitive restraint loading on the purposeful eating domain. However, a strong inverse association between cognitive restraint and intuitive eating were indicated within the factor analysis. All factor loadings are in Figure 2. R^2 correlations were examined and all the loadings excluding cognitive restraint were favorable. Overall, the researchers decided to keep it in the model to signify the imposed duality within the purposeful eating domain.

[insert Figure 2 here]

A confirmatory factor analysis was conducted to test the model fit of interoceptive sensibility. Goodness of fit indicators indicated adequate model fit with a chi-square of 56.825 ($p<0.001$), chi-square/degrees of freedom of 2.71, CLI and TLI scores of 0.94 and 0.90, respectively and an RMSEA of 0.086. All model fit indices are found in Table 3. Factor loadings were predominantly considered favorable. All factor loadings can be found in Figure 3. Also, R^2 correlations were assessed to further understand any potential poor fit within the model. All the factors indicated a strong explained variance to the data.

[insert Figure 3 here]

3.3.2 Measurement Model

A 2-step process was utilized to confirm model fit in the SEM analysis. First, a measurement model was tested by creating latent variables out of all the proposed model variables, then correlating them altogether to create a saturated model (Figure 4). From there, the

model fit was assessed to determine good model fit in the SEM analysis (Table 3). This analysis provided sufficient evidence to move forward in examining the proposed SEM model.

[insert Figure 4 here]

3.3.3 Full SEM Model Parameter Estimates

The analysis of the full SEM model was conducted after achieving good model fit in the measurement model (Figure 5). Table 4. indicates the path relationships. The fit indices indicated an adequate model fit and similar statistical significance as the measurement model (Table 3). Local fit statistics were also assessed using the standardized residuals. There were no indications of poor fit between the items in the model. Interoceptive sensibility was found to have a significant negative association with both purposeful (b=-0.37, p-value=0.039) and non-purposeful (b=-0.21, p=0.003) eating domains and a significantly positive correlation with self-regulation (b=0.51, p<0.001). Self-regulation had a marginal negative association with purposeful (b=-0.22, p=0.054) and significant negative association with non-purposeful (b=-0.45, p<0.001) eating domains. Lastly, the non-purposeful eating domain had a positive association with weight status (b=0.29, p=0.003).

[insert Table 3 here]

[insert Table 4 here]

[insert Figure 4 here]

4. DISCUSSION

The study's aim was to determine the two-factor structure of multiple eating behaviors onto two categories: purposeful and non-purposeful eating domains and examine the effects of interoception and self-regulation on one's eating domain and weight status in college students. Significant differences between the two factors were found when eating behaviors were categorized into the purposeful and non-purposeful eating domains. Study findings indicated a good model fit for our proposed SEM model that interoception and self-regulation may influence

one's eating style and BMI. Results indicated a strong positive association between self-regulation and interoception. Furthermore, there were significant negative associations between the cognitive factors of interoception and self-regulation and the behaviors of both purposeful and non-purposeful eating domains. Lastly, it was found that the non-purposeful eating domain had a positive association with BMI.

The two-factor confirmatory factor analysis presented distinct differences between the purposeful and non-purposeful eating domain behaviors. Within the purposeful eating domain, intuitive eating loaded significantly onto the domain. Intuitive eating has been popularized for its reliance on hunger and satiety cues, thus leading to more purposeful eating habits (Tylka, 2006). Cognitive restraint was not indicative as a strong measure onto the purposeful eating domain, however, an inverse association with intuitive eating was shown. The current literature supports this contrary behavior, cognitive restraint is commonly utilized to regulate eating habits such as overeating (Karlsson, Persson, Sjöström, & Sullivan, 2000). Conversely, emotional, external, and uncontrolled eating were found to have strong loadings onto the non-purposeful eating domain. Our review of the literature supports this relationship in that these eating styles share a common "reactivity" toward external stimuli that, in turn, affect their eating behaviors (van Strien, Herman & Verheijden, 2012; Anglé et al., 2009). Future research in purposeful and non-purposeful eating domains can provide a useful perspective when dealing with the complexities of understanding one's eating behaviors.

High levels of interoception were associated with higher self-regulation scores. This was consistent with current literature as the cognitive influences of interoception can affect one's active decision-making when attempting to self-regulate (Young et al., 2017; Annesi et al., 2016). Other researchers have used objective measures of interoception and found that individuals with increased interoceptive skills were inherently more precise when following body cues and were able to better regulate themselves based on their hunger and satiety levels (Young, Gaylor, de

Kerckhove, Watkins, & Benton, 2019). The significance of this association indicates that both interoception and self-regulation can have a potential relationship with the proposed eating domains.

Interoception and self-regulation were negatively correlated with both purposeful and non-purposeful eating domains. It was proposed that interoception and self-regulation would have an inverse association with the non-purposeful eating domain due to its high reactivity to environmental stimuli (ie. emotional reactions, the sight or smell of food) however, not with purposeful eating since both high interoception and self-regulation are required to effectively be considered a 'cognitive restraint' or 'intuitive' eater. However, the findings of the current study did not support this hypothesis. The purposeful eating domain had a negative association with both interoception and self-regulation. This may be due to the self-reported nature of the cognitive skills. Participants may believe that they have higher levels of interoception and self-regulation than they may actually possess. In a previous study by Seth and colleagues, similarities were found showing distinct discrepancies between how a person views themselves interoceptively and their actual physical behaviors (Seth, Dienes, Cleeremans, Overgaard, & Pessoa, 2008). Nevertheless, the findings may also be due to the unique characteristics within the eating behaviors. For instance, the act intuitive eating is to become more conscious with one's body and follow its hunger and satiety cues, thus mimicking the interoceptive behavior. However, the given "autonomy" that intuitive eating provides as a result may often lead people to do the opposite of what the behavior intends, which is ignoring internal cues and consuming more. The thought behind cognitive restraint is similar. Those who are considered cognitive restraint eaters may indeed restrain themselves at times, but then later indulge ignoring both interoceptive and self-regulative skills (Ogden & Wardle, 1990). Both considerations are speculative therefore more research is needed to further understand their mechanisms.

Lastly, it was found that non-purposeful eating had a significantly positive association with BMI. Again, this confirmed our hypothesis as it was presumed that those who scored higher on the non-purposeful eating domain would also have higher BMI scores. In fact, in an intervention study, the associations between non-purposeful eating domain behaviors such as emotional eating and BMI were assessed at pre- and post-intervention among women with obesity (Annesi et al., 2016). Results signified that emotional eaters were more at risk for reduced self-regulation and weight-loss failure. However, at post-intervention, reduced incidences of emotional eating were significantly correlated with weight loss, thus indicating the positive influence that emotional eating has on BMI. (Annesi et al., 2016). Similar findings were found in uncontrolled and external eating (Verzijl, Ahlich, Schlauch, & Rancourt, 2018; Burton et al., 2007). Given the previous research on this relationship, additional research utilizing our proposed eating domains may lend addition support for weight loss research and interventions.

Although the study provided empirical information on the related topics, there are a few limitations that should be addressed. First, although it was not the intention of the researchers, this study was female-only due to insufficient recruitment of male participants (n=13). The lack of male representation limits the generalizability of the study and does not provide the needed knowledge of the male perspective regarding cognitive behaviors, eating styles and weight status. Associations may differ within the male population as it has in similar previous research studies (Bennett, Greene, Schwartz-Barcott, 2013). For example, a previous study found that nearly 60% of females, compared to the 43% of males, participated in emotional eating and overeating episodes (Oliver & Wardle, 1999).

Also, our study population was predominantly Hispanic (75%) which can create potential issues when attempting to generalize to the general college student population. The social and cultural experiences surrounding eating behaviors may differ when compared to other ethnicities. Past research has shown that this population is considered the most at-risk for obesity and

obesity-related issues (Karabulut, Romero, Conatser, & Karabulut, 2018). However, it is acknowledged that the differences in eating behaviors in the Hispanic community have been ineffectively studied since it has often been only compared to the 'American' or western diet which may pose an inaccurate consideration of a healthy diet. Lastly, all the measures utilized in this study were self-reported by the participant which may also lead to potential inaccuracies in data. Even with the limitations of the study, there were also significant strengths. We employed 2 sets of CFAs and a 2-step SEM model analysis to validate our hypotheses. Furthermore, we were able to utilize those eating styles to identify two eating domains: purposeful and non-purposeful to further explain the associations between college students and their eating behaviors.

5. CONCLUSION

Overall, this research study provided empirical evidence on the associations between interoception, self-regulation, purposeful and non-purposeful eating domains, and weight status in college students. The overall college experience may affect students' behaviors and weight status; therefore, it is important to continually decipher the largest influences on weight status to mitigate obesity. The information gathered can be used in interventions to create healthy strategies when eating to lessen obesity risk. Also, future longitudinal studies on this topic are needed to further determine the long-term effects of interoception, self-regulation, eating domains and weight status in college students.

6. ACKNOWLEDGEMENTS

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7. DECLARATION OF INTEREST

The authors report no conflict of interest

8. DATA SHARING STATEMENT

Due to the sensitive information collected from participants, the data from this study will remain confidential and unshared, as promised to our participants.

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MAIN TABLES AND FIGURES:

Figure 1. Theoretical Model on the Associations of Cognitive Skills, Eating Domains and BMI.

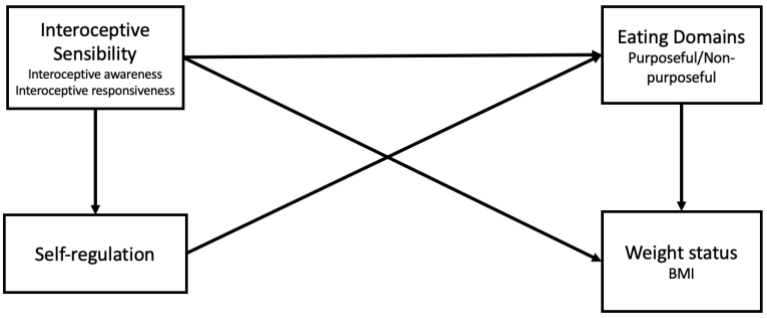


Figure 2. Confirmatory Factor Analysis for Purposeful and Non-purposeful Eating Domains

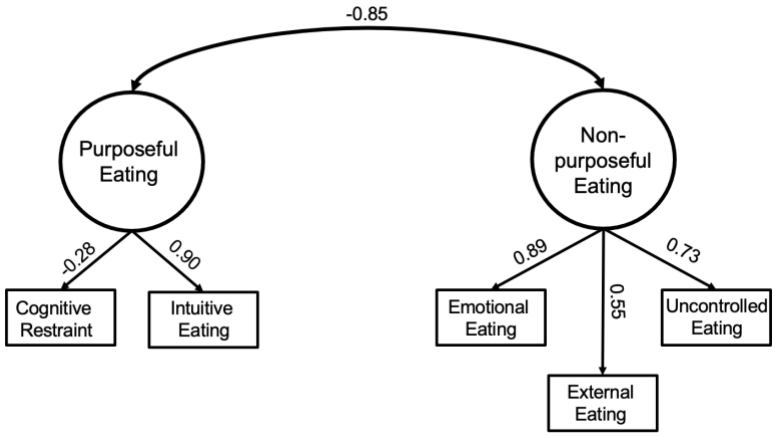


Figure 3. Confirmatory Factor Analysis for Interoceptive Sensibility

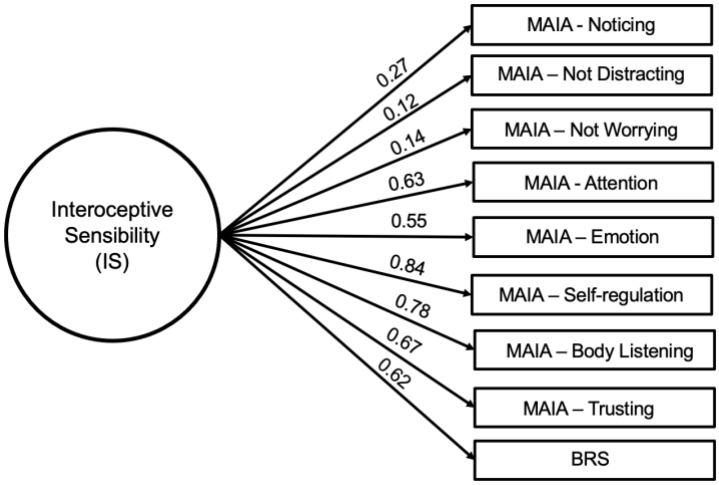
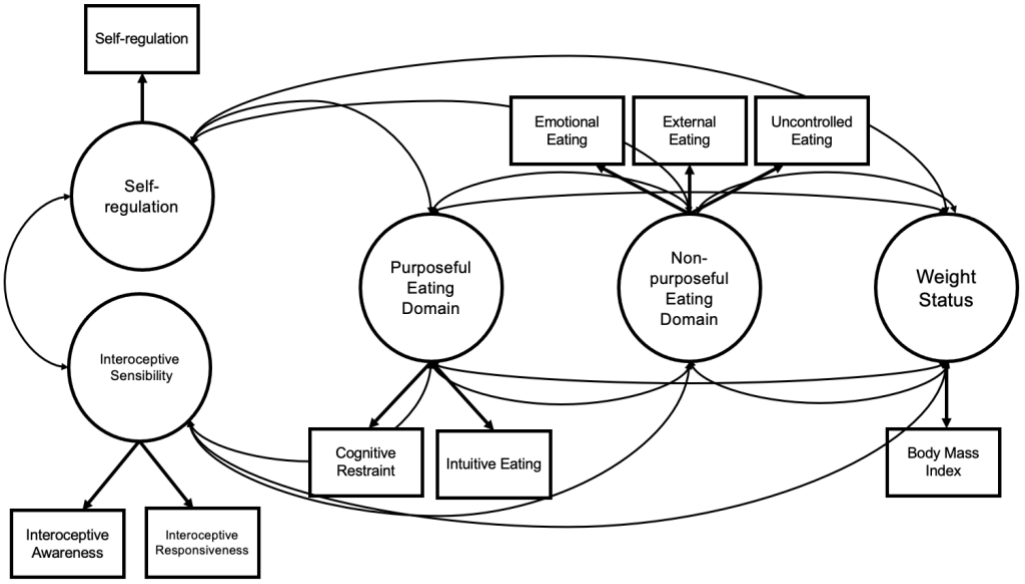
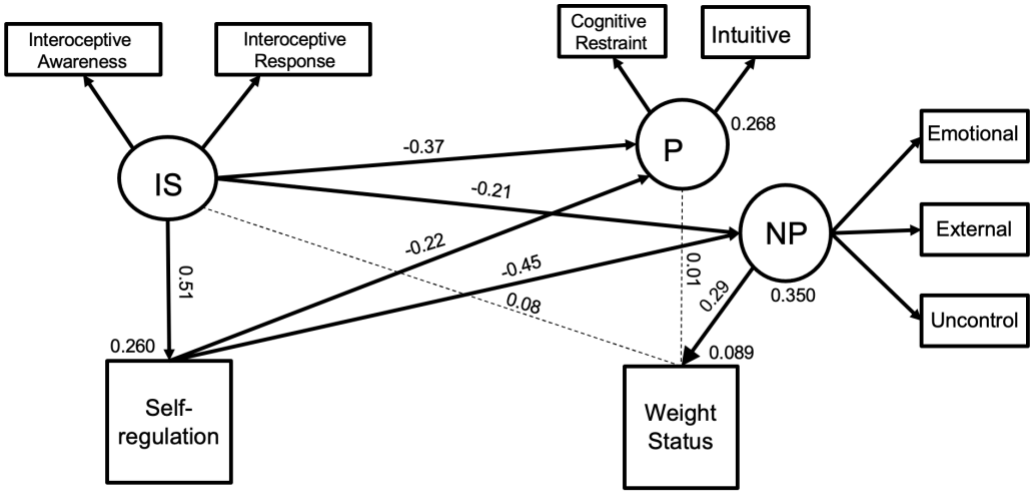


Figure 4. Measurement Model on the Associations of Cognitive Skills, Eating Domains and BMI.



Fit indices: chi-square =175.950, p<0.001; chi-square/df = 2.095; CFI = 0.927; TLI = 0.882; RMSEA = 0.069

Figure 5. SEM model with Standardized Estimates on the Associations of Cognitive Skills, Eating Domains and BMI.



Fit indices: chi-square =179.599, p<0.001; chi-square/df = 2.07; CFI = 0.928; TLI = 0.885; RMSEA = 0.069

Note: IS = Interoceptive Sensibility, P = Purposeful Eating, NP = Non-purposeful Eating
Note: Bolded lines indicate significant paths; Dashed lines indicate non-significant paths.

Table 1. Baseline Participant Demographic Information

		Sample	***Percentage (%)***
Race	American Indian or Native American	1	0.4
	Asian or Pacific Islander	6	2.6
	Black or African American	34	15
	White or Caucasian	126	55
	Other or Mixed	62	24
Ethnicity	Hispanic	172	75
	Non-Hispanic	57	25
Classification	Freshman	11	4.8
	Sophomore	38	17
	Junior	117	51
	Senior	63	28
BMI Category	Underweight	6	2.6
	Normal	125	55
	Overweight	60	26
	Obese	38	16
College Transfer	Started here	83	36
	Transferred	146	64
Major	Biological/Life Sciences	10	4.4
	Business	5	2.2
	Communication	2	0.9
	Education	1	0.4
	Engineering	1	0.4
	Health-related fields (nursing, physical therapy)	7	3.1
	Humanities	1	0.4
	Physical sciences (physics, chemistry)	1	0.4
	Pre-professional (pre-dental, pre-medical)	5	2.2
	Public administration	3	1.3
	Social sciences (anthropology, psychology)	150	66
	Visual and performing arts	1	0.4
	Other	11	4.8
Marital Status	Never Married	202	88
	Married	18	7.9
	Divorced	3	1.3
	Separated	6	2.6
Living location	On-campus housing	12	5.2
	Off-campus housing	217	95
Living arrangements	Living alone	14	6.1
	With other students	17	6.1
	My family (spouse or children)	35	14
	Parents	125	55
	Other relatives	7	3.0
	Other	7	3.0

Table 2. Baseline Correlation Matrix with Means and Standard Deviations of Cognitive Skills, Eating Domains and BMI.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. MAIA-N	1	-.061	-.044	.341**	.385**	.215**	.208**	.108	.096	.011	-.040	.118	.063	.039	.077	.016
2. MAIA-ND		1	.107	-.103	.038	.146*	.073	.102	.201**	.177**	-.100	-.126	-.140*	-.175**	.115	.002
3. MAIA-NW			1	.149*	-.106	.159*	.017	.102	.157*	.158*	-.187**	-.155*	-.196**	.007	.171**	-.026
4. MAIA-A				1	.297**	.514**	.490**	.454**	.408**	.235**	-.168*	-.097	-.097	.071	.285**	-.024
5. MAIA-E					1	.455**	.481**	.357**	.277**	.097	-.020	.072	.029	.089	.068	-.069
6. MAIA-SR						1	.653**	.556**	.524**	.232**	-.163*	-.047	-.100	.065	.265**	-.075
7. MAIA-B							1	.507**	.411**	.135*	-.033	.018	.019	.044	.085	-.054
8. MAIA-T								1	.647**	.399**	-.274**	-.085	-.216**	-.096	.412**	-.190**
9. BRS									1	.567**	-.422**	-.241**	-.384**	.003	.585**	-.157*
10. SREBQ										1	-.432**	-.387**	-.505**	.075	.460**	-.170**
11. DEBQ-Em											1	.518**	.641**	.220**	-.681**	.291**
12. DEBQ-E												1	.636**	.085	-.350**	.106
13. TFEQ-U													1	.152*	-.579**	.167*
14. TFEQ-C														1	-.249**	.180**
15. IES															1	-.246**
16. BMI																1
Mean	**3.68**	**3.09**	**2.92**	**3.12**	**3.85**	**3.17**	**2.94**	**3.66**	**31.38**	**3.19**	**35.24**	**31.94**	**19.62**	**14.60**	**3.42**	**25.69**
Standard Deviation	**0.79**	**0.90**	**0.84**	**0.87**	**0.84**	**1.08**	**1.09**	**1.14**	**7.86**	**0.72**	**15.56**	**7.66**	**6.10**	**3.90**	**0.63**	**5.47**

Note: *Correlations significant at the 0.01 level (two-tailed), **Correlations significant at the 0.05 level (two-tailed).

Note: MAIA-N: Multidimensional Assessment of Interoceptive Awareness-Noticing
MAIA-ND: Multidimensional Assessment of Interoceptive Awareness-Not Distracting
MAIA-NW: Multidimensional Assessment of Interoceptive Awareness-Not Worrying
MAIA-A: Multidimensional Assessment of Interoceptive Awareness-Attention Regulation
MAIA-E: Multidimensional Assessment of Interoceptive Awareness-Emotional Awareness
MAIA-SR: Multidimensional Assessment of Interoceptive Awareness-Self-Regulation
MAIA-B: Multidimensional Assessment of Interoceptive Awareness-Body Listening
MAIA-T: Multidimensional Assessment of Interoceptive Awareness-Trusting
BRS: Body Responsiveness Scale
DEBQ-Em: Dutch Eating Behavior Questionnaire-Emotional Eating
DEBQ-E: Dutch Eating Behavior Questionnaire-External Eating

TFEQ-U: Three-factor Eating Questionnaire-Uncontrolled Eating
TFEQ-C: Three-factor Eating Questionnaire-Cognitive Restraint Eating
IES: Intuitive Eating Scale
SREBQ: Self-Regulation of Eating Behavior Questionnaire
BMI: Body Mass Index

Table 3. Model Fit Indices for All Model Analyses.

Model	Chi-Square	P-value	χ^2/df	CFI	TLI	RMSEA
Interoceptive Sensibility CFA	56.83	<0.001	2.71	0.94	0.90	0.086
Eating Domains CFA	9.71	0.021	3.24	0.98	0.92	0.099
Measurement Model	175.95	<0.001	2.10	0.93	0.88	0.069
SEM Model	179.60	<0.001	2.07	0.93	0.89	0.069

Table 4. SEM Model Path Relationships and Hypotheses.

Relationships	Standardized Regression Coefficients	P-value	Hypothesis Supported
IS → Self-regulation	0.510	p<0.001	Supported
IS → Purposeful	-0.372	0.039	Not Supported
IS → Non-purposeful	-0.215	0.003	Supported
IS → Weight Status	0.008	0.909	Supported
Self-regulation → Purposeful	-0.218	0.054	Not Supported
Self-regulation → Non-purposeful	-0.453	p<0.001	Supported
Non-purposeful → Weight Status	0.294	0.003	Supported
Purposeful → Weight Status	0.012	0.867	Supported

The Causal Associations Between Interoception, Self-regulation, Non-purposeful Eating behaviors, and Weight Status in College Students: A Longitudinal Cross-lagged Model Analysis

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ABSTRACT

College student weight gain has led to increased obesity and mortality risk among emerging adults. Issues with maintaining a healthy weight status may be attributed to unhealthy eating behaviors that often lead to poor diet quality and overeating. However, there is a gap in literature that identifies the causal relationship between cognitive skills such as interoception and self-regulation, non-purposeful eating behaviors, and weight status and how these effects fluctuate over the course of a typical academic semester for college females. The study's purpose was to determine the longitudinal changes and causal effects among interoception, self-regulation, the non-purposeful eating domain behaviors, and weight status among college students. Data was collected over 3 timepoints (1 timepoint per month) during a typical academic semester. Subjects included 104 participants who completed all 3 timepoints. Study results indicated that there were significant changes in interoceptive responsiveness, external, and uncontrolled eating throughout the semester. Also, there were significant causal effects between interoception, self-regulation, the non-purposeful eating domain behaviors, and weight status. Overall, the research study provided foundational evidence that utilize regulatory skills to help prevent unhealthy eating behaviors and increased weight status in college students. In the future, long-term studies regarding interoception, self-regulation, non-purposeful eating behaviors and weight status are needed to explore the processes that may affect college student's weight status and overall lifestyles.

Keywords: interoception, self-regulation, emotional eating, external eating, uncontrolled eating

INTRODUCTION

It is estimated that approximately 24% of college students, aged 18-24, are categorized as obese (Bennett, Greene & Schwartz-Barcott, 2013; Bryan, 2016). Increased obesity rates in college students are correlated with a greater mortality risk. Consequently, some researchers have predicted a shorter lifespan for the current generation of college students than that of their parents and past generations (Anglin, 2012; Bennett et al., 2013; Bryan, 2016). For many students, college is the first time that they are making diet choices on their own and many students engage in unhealthy eating behaviors that often lead to poor diet quality and excessive weight gain over time. Several factors within the college environment may impact these poor dietary behaviors including the food environment on campus which many times includes 'all you can eat' dining options which sometimes results in uncontrolled eating, dietary social pressures to eat which can be related to external eating habits and academic stress which has been linked to emotional eating (Sogari, Velez-Argumedo, Gómez & Mora, 2018). Internal regulatory skills including interoception and self-regulation may provide a mechanism to combat poor eating behaviors and prevent college weight gain. However, not much is known about how these variables change or relate to one another over the course of a typical college semester.

Interoception and self-regulation have been theorized as indicators of the cognitive-behavioral skills used to make decisions regarding food choices that may influence weight status in college students. Interoception is considered the body-to-brain axis of sensation where measurements of internal body signals can be quantified (Craig, 2002; Young et al., 2017). In theory, a person can objectively feel when they are hungry or satiated by tuning into their internal gastric signals and adequately respond to those signals (Craig, 2008; Critchley & Garfinkel, 2017; Herbert & Pollatos, 2014). Self-regulation is highly dependent on the awareness and responsiveness of an individual's body signals (Annesi, Mareno & McEwen, 2016; Young et al., 2017). Thus, interoception may have a direct effect on self-regulation as individuals with high

interoception may be more apt to effectively self-regulate over time. Self-regulation consists of actively monitoring the processes of the body to achieve a specific "goal" (Young et al., 2017). It is postulated that those with higher interoception and self-regulation skills may be more purposeful with the eating behaviors. However, if one has reduced levels of either interoception or self-regulation, they may become less purposeful in their eating leading to more reactive behaviors and weight gain.

Non-purposeful eating styles, described as eating without conscious decision-making, can lead to unhealthy eating behaviors and a heightened sensitivity to external stimuli. Examples of non-purposeful eating include emotional, external, and uncontrolled eating styles. Emotional eating is generally defined as eating in response to certain emotional cues as a coping mechanism (Annesi et al., 2016; Bennett et al., 2013). External eating is eating in response to an external food-related stimulus like the sight or smell of food, regardless of having feelings of hunger or satiety (Van Strien, Frijters, Bergers & Defares, 1986). Uncontrolled eating, described as the loss of control while consuming food, shares many traits with other eating styles like emotional and external eating, but can become more frequent and can exhibit a full loss of self-control when presented with food (Vainik, Neseliler, Konstabe, Fellows & Dagher, 2015; Verzijl, Ahlich, Schlauch & Rancourt 2018). Higher levels of non-purposeful eating behaviors have been associated with reduced interoception and self-regulation, and increased weight gain, which was found particularly among individuals classified as overweight or obese. (Geliebter & Aversa, 2003; Herbert & Pollatos, 2014; Vainik et al., 2019).

To date, most of the research on internal regulatory variables and eating behaviors has examined cross-sectional associations between these variables in college students. It is unclear if interoception, self-regulation, and non-purposeful eating behaviors fluctuate over the course of a typical academic semester for college females. In addition, longitudinal studies are needed to examine the mechanisms by which these factors may impact one another. Thus, the primary aim

of this study was to determine how interoception, self-regulation, the non-purposeful eating domain behaviors (emotional, external, and uncontrolled eating) and body mass index (BMI) change over the course of a typical academic semester. Our secondary aim was to examine the causal relationships between interoception, self-regulation, non-purposeful eating domain behaviors and BMI over time. We predict that there will be significant changes between interoception, self-regulation, non-purposeful eating behaviors and BMI within an academic semester. Also, we hypothesize that the cognitive skills of interoception and self-regulation will have a reciprocal positive effect among each other throughout time. Furthermore, both interoception and self-regulation will have a negative effect with non-purposeful eating domain behaviors and BMI over time. Lastly, the non-purposeful eating domain behaviors will have a positive effect with BMI throughout time.

METHODS

Participant Recruitment and Procedures

Participants were recruited from a 4-year university in South Florida. Exclusion criteria for participation included taking medications that suppress or increase appetite, previously diagnosed eating disorders or mood disorders, pregnant or planning to become pregnant, and/or student athletes. The researchers excluded males (n=13) during data analysis process due to an inadequate sample size. Study protocols were reviewed and approved by the university's Institutional Review Board. There were 279 participants that were recruited for the study, however with participant drop-out and the removal of male participants, there were 229 (82%) females who completed baseline measures. This study was a longitudinal, repeated measures research study that collected data over 3 timepoints (1 timepoint per month). At the end of the study (timepoint 3), there were 104 females that completed study measures (45% retention within study).

To investigate this proposed method, we have employed a cross-lagged model using 4 variables over 3-month period (1 timepoint per month) (Figure 1). The 3-month timeframe was utilized to assess measures during a typical academic semester with Timepoint 1 conducted at the start of the semester, Timepoint 2 during the middle of the term where mid-term examinations are prominent, and Timepoint 3 at the end of the semester where students are completing their coursework and final examinations. Study outcomes can provide empirical evidence to describe the longitudinal causal effects between cognitive practices such as interoception and self-regulation with non-purposeful eating domain behaviors and BMI using a longitudinal cross-lagged model design.

[insert Figure 1 here]

Measures

Interoception

Body Responsiveness Scale (BRS) is a 7-item scale that measures how an individual responds to their bodily sensations (Oswald, Chapman & Wilson, 2017). The questionnaire's responses were based on a 7-point Likert scale indicating 1 as 'not at all true' and 7 as 'always true of me'. Increased scoring demonstrates higher levels of interoceptive responsiveness. BRS was found to have a good reliability of 0.75, 0.80, and 0.78 for Timepoints 1, 2, and 3, respectively.

Self-regulation

The Self-Regulation of Eating Behavior Questionnaire (SREBQ) is a 5-item questionnaire that assesses an individual's self-regulation capacity (Kliemann, Beeken, Wardle, & Johnson, 2016). A Likert scoring system of 1 (Never) to 5 (Always) was used. The questionnaire's internal consistency was $\alpha = 0.69$, 0.73, and 0.68 for Timepoints 1, 2, and 3, respectively.

Non-purposeful eating domain

Dutch Eating Behavior Questionnaire (DEBQ) is a 33-item questionnaire that includes the subscales of Emotional eating, External eating, and Restrained eating (Van Strien et al., 1986). For this study, the researchers used the Emotional eating and External eating subscales. A Likert scale scoring between 1 (seldom) to 5 (very often) was utilized. The DEBQ had a high reliability of 0.95, 0.96, and 0.98 for Emotional eating and 0.85, 0.86, and 0.90 for External Eating, for Timepoints 1,2, and 3, respectively.

Three-factor Eating Questionnaire (TFEQ-R18) is an 18-item questionnaire that measures cognitive restraint, uncontrolled and emotional eating (Anglé et al., 2009). For the purposes of this study, the researchers utilized the Uncontrolled eating subscale. A four-point scale of 1-4 was used, with increased behavior signified by higher scorings. The TFEQ-R18 was found to have a good reliability of 0.89, 0.68, and 0.71 for Uncontrolled eating at Timepoints 1,2, and 3, respectively.

Weight Status

Participant weight was self-reported via an online survey. At each timepoint, participants were asked to weight themselves and record their weight while completing the other questionnaires. BMI was calculated using the individual's height and weight using the formula (weight (kg) / [height (m)]^2 ("About Adult BMI", 2021). BMI were classified into 4 categories using the Center for Disease Control guidelines: Underweight (BMI<18.5), Healthy weight (18.5-24.5), Overweight (25.0-29.9), and Obesity (BMI>=30.0) ("About Adult BMI", 2021).

Statistical Analysis

Data were analyzed using SPSS Statistics v26.0 for descriptive statistics and repeated measures ANOVA analyses. SPSS AMOS v26.0 was also utilized for longitudinal cross-lagged model analysis. Because significant differences were found over the course of the semester for the primary variables, we conducted the cross-lagged model analysis to determine how the

variables influenced one another. Separate models were run for each of the non-purposeful eating variables resulting in 3 models to indicate specific relationships with each of the eating behaviors. To determine if our proposed model had good model fit, we assessed multiple global fit tests (chi-square, chi-square/degrees of freedom (df) ratio, CLI, TLI, and RMSEA). Chi-square statistics indicated any potential significant misfit in the model, where any significance may specify potential misfit in the model. Due to the sensitivity of have a large sample size, chi-square was deemed less reliable model fit assessment (Bentler & Bonett, 1980). Therefore, we have also utilized the chi-square/df ratio as another measure of model fit, utilizing a value lower than 5 to indicate good model fit (Hu & Bentler, 1999). CFI and TLI are both considered as 'goodness of fit' measures, where the >0.95 designated good model fit (Hu & Bentler, 1999). Lastly, RMSEA is another widely used measure that depicts good model fit at 0.06 or below (MacCallum, Browne, & Sugawara, 1996). Local fit statistics were also used to ensure that the items within the model were well fit. An analysis using standardized residual covariances were used and an indication of an absolute value greater than 4 was deemed a poor fit of an item.

RESULTS

Participant Characteristics

Participants were predominantly identified as White Hispanics (75.1%) with an average age of 23.39 (SD=6.312) and BMI average of 25.45 (SD=5.48) at baseline. They were mostly classified as Juniors (51.1%), majored in social sciences (including anthropology, economics, and psychology; 65.5%), were never married (88.2%), and lived off-campus (94.8%) with their parents (54.6%). Table 1 includes all participant demographic information.

[Insert Table 1 here]

Repeated Measures ANOVA Analysis

Table 2 provides the means and standard deviations of the study variables at each timepoint along with any significant differences within the variables between timepoints 1, 2, and

3. Significant were found for interoceptive responsiveness (F=5.443, p=0.006), external eating (F=3.779, p=0.026), and uncontrolled eating (F=9.778, p<0.001). Post-hoc analyses using the Bonferroni method were conducted on the significant findings to determine where the significance specifically occurred. Pairwise correlations were assessed. In interoceptive responsiveness, it was found that there was a significant increase from Timepoint 1 to 2 (mean difference = -1.615, p=0.006) and Timepoint 1 to 3 (mean difference = -1.500, p=0.017). Within external eating, there was a significant decrease from Timepoint 2 to 3 (mean difference = 1.510, p=0.048). Lastly, in uncontrolled eating, significant increases were found from Timepoint 1 to 2 (mean difference = -1.865, p<0.001) and Timepoint 1 to 3 (mean difference = -1.519, p=0.001).

[Insert Table 2 here]

Cross-lagged Model Analysis

Model fit

In all models, the fit indices signified an overall good fit. The chi-square/df ratios were all below the recommended value of 5. CFI and TLI statistics ranged from 0.991 to 0.998 and 0.899 to 0.978, respectively, indicating a good model fit for all models. RMSEA showed an adequate fit as it was 0.058, 0.120, and 0.070 for emotional, external, and uncontrolled eating models, respectively. Model fit indices are found in Table 3. Local fit statistics utilizing the standardized residuals of the variables were also examined for each model and all values were below the recommended value of 4, showing that the items fit the models well.

[Insert Table 3 here]

Path Estimates

The cross-lagged models of emotional, external, uncontrolled eating had several significant path relationships. All autoregressive path effects were found statistically significant in each model. Among all models, interoceptive responsiveness (Timepoint 1) positively predicted self-regulation (Timepoint 2). All non-purposeful eating behaviors (Timepoint 1)

negatively predicted self-regulation (Timepoint 2) and positively predicted BMI (Timepoint 2). BMI (Timepoint 1) negatively predicted all non-purposeful eating behaviors (Timepoint 3). BMI (Timepoint 2) negatively predicted interoceptive responsiveness (Timepoint 3) and positively predicted all non-purposeful eating behaviors (Timepoint 3).

There were also differences between the non-purposeful eating behavior models. In the emotional eating model, interoceptive responsiveness (Timepoint 1) negatively predicted emotional eating (Timepoint 2) and self-regulation (Timepoint 1) positively predicted interoceptive responsiveness (Timepoint 2). Emotional eating (Timepoint 2) negatively predicted self-regulation (Timepoint 3). In the uncontrolled model, uncontrolled eating (Timepoint 2) negatively predicted BMI (Timepoint 3). All significant relationships for the emotional, external, and uncontrolled models are found in Figure 2, 3, and 4, respectively.

[insert Figure 2 here]

[insert Figure 3 here]

[insert Figure 4 here]

DISCUSSION

The primary purpose of this study was to examine the longitudinal changes within interoception, self-regulation, the non-purposeful eating domain behaviors (emotional, external, and uncontrolled eating) and BMI. Our secondary aim was to explore the cause-and-effect relationships of cognitive processes such as interoception and self-regulation with eating behaviors categorized under the non-purposeful eating domain and BMI. First, we predicted there would be significant changes that occurred within the study variables. Then, it was hypothesized that interoception and self-regulation would have a significant positive cross-lagged effect among each other over time, and both interoception and self-regulation would have a negative effect on non-purposeful eating domain behaviors and BMI throughout time. Furthermore, it was hypothesized that there would be positive predictions between the non-purposeful eating domain

behaviors and BMI. Study results indicated significant changes in interoceptive responsiveness, external eating, and uncontrolled eating throughout the time of a usual semester. For the cross-lagged model analyses, all models were considered to achieve an adequate model fit. Also, among all models, there were indeed significant causal relationships between interoception, self-regulation, the non-purposeful eating domain behaviors, and BMI throughout time.

Among the 3 timepoints, significant changes were found within the study variables. Interoceptive responsiveness and uncontrolled eating increased between Timepoint 1 to 2 and Timepoint 1 to 3, and external eating decreased from Timepoint 2 to 3. Interoceptive responsiveness increased significantly throughout the study, indicating that female college students became more aware of their bodily sensations throughout the course of the semester. This finding was not expected. However, based on the Body Responsiveness Scale survey questions which were focused on general responsiveness to bodily sensations, it is presumed that participants may have had an overall increased response to their bodily cues over time instead of specifically on hunger or satiety cues. A recent review found varying types of internal responsiveness such as food cue responsiveness and satiety responsiveness that, when increased, present more risk to unhealthy eating behaviors like non-purposeful eating (Boutelle, Manzano & Eichen, 2020). Uncontrolled eating also increased over time. Adverse eating behaviors including uncontrolled eating are often heightened in response to external stimuli such as stress, workload and burnout (Annesi et al., 2016; Baghurst & Kelley, 2014, Simmons & Deville, 2017). In fact, it was found that increased uncontrolled eating occurs as a way for some people to obtain emotional relief when experiencing negative feelings (Pérez-Fuentes et al., 2019). On the other hand, external eating significantly decreased from Timepoint 2 to 3, which suggested that between the middle of the semester where students are taking mid-term examinations to the end of the semester when final examinations are common, students were less likely to consume foods regardless of their hunger or satiety signals. With increased external stimuli, some people may

cope with their negative feelings and stress by abstaining from food. Also, it is possible that as students adjusted to their surroundings over the course of the semester, they became less impacted via the external stimuli. However, future research is needed to confirm those assumptions.

In support of our hypotheses, interoception at timepoint 1 positively predicted self-regulation at timepoint 2 in all cross-lagged models. Also, only in the emotional eating model, self-regulation at timepoint 1 was directly related to interoceptive responsiveness at timepoint 2, which indicated the reciprocal causal effect between the 2 variables. This suggested that, throughout time, individuals who had high interoceptive responsiveness were also more apt to have increased self-regulation skills and vice versa. The broader theory of interoception and self-regulation has been recently emerging in various research study populations. For example, Dunn et al. (2010) explains how the process between mind (interoception) and body (self-regulation) processes aid to better decision-making and emotional regulation (Dunn et al., 2010). However, this study is the first-known study to indicate the longitudinal associations between interoceptive responsiveness and self-regulation to determine how cognitive processes may affect one's overall behavior over time.

The emotional cross-lagged model indicated a unique relationship where it signified that emotional eating (Timepoint 2) was negatively predicted by interoceptive responsiveness (Timepoint 1). Therefore, lowered interoceptive awareness at baseline was indicative of increased emotional eating by the middle of the semester. Longitudinal studies on this association are scarce and only found in children and adolescent girls (Dakanalis et al., 2014; Koch & Pollatos, 2014). However, this was consistent in previous observational research that have found reduced interoception as a negative predictor of emotional overeating occurrences (Bullock & Goldbacher, 2021; Robinson, Marty, Higgs & Jones, 2021; Van Strien, Engels, Van Leeuwe & Snoek, 2005). It is important to note that differing results were found with the use of interoceptive

objective testing, suggesting that emotional eaters had increased levels of interoception via the heartbeat perception task in young adults (Young et al., 2017). Although, when the participants of the study provided self-reported perception of their interoceptive skills, lower interoception was predictive of higher levels of emotional eating (Young et al., 2017). As another note, our cross-lagged models have only indicated this association between Timepoints 1 and 2, therefore, it is not fully understood if this association remains stable throughout an entire college semester. Further research is needed to test long-term effects between interoception and emotional eating.

Self-regulation was found to be significantly influenced by non-purposeful eating domain behaviors. Emotional, external, and uncontrolled eating at timepoint 1 negatively influenced self-regulation at timepoint 2. Also, long-term effects were indicated when emotional eating at timepoint 2 negatively affected self-regulation at timepoint 3. These findings were supportive of our hypotheses suggesting that non-purposeful eaters were less likely to maintain adequate self-regulation skills throughout the school semester. Prior to this study, non-purposeful eating behaviors positioned as the causal indicator on self-regulation had yet to be studied. Although, associations of reduced self-regulatory skills were often found among individuals with increased unhealthy eating behaviors like frequently consuming highly palatable food items (Kliemann, Croker, Johnson & Beeken, 2018; Mullan, Allom, Brogan, Kothe & Todd, 2014).

There were many longitudinal associations with BMI. Our study found inverse effects on relationship between BMI and interoceptive responsiveness. BMI at Timepoint 2 predicted reduced interoceptive responsiveness at Timepoint 3. The results suggested that college students with increased weight status did not accurately respond to their internal bodily signals by the end of the semester, which can be presumed that overweight or obese individuals were more reactive to external cues rather than following their internal signals. In fact, reduced adherence to interoception among students with overweight and obesity were noted to have decreased perception of hunger and satiety cues (Herbert & Pollatos, 2014). Thus, individuals with

increased BMI may be less mindful and partake in unhealthy eating behaviors like emotional, external, and uncontrolled eating. It is also important to note that the timeframe of Timepoints 2 and 3 were usually in the middle and end of the term where students may be more susceptible to suppress internal responsiveness during examinations, especially in students who are considered overweight or obese (Antonopoulou et al., 2020). Long-term associations were found among non-purposeful eating domain behaviors and BMI. Non-purposeful eating domain behaviors at timepoint 1 positively predicted BMI at timepoint 2 and BMI at timepoint 2 positively predicted non-purposeful eating domain behaviors at timepoint 3. It can be interpreted that there is a long-term reciprocal effect that occurs over the 3-month period. Non-purposeful eaters at the beginning of the semester were more likely to be considered overweight or obese at mid-term, while those individuals considered overweight or obese at midterm were more likely to non-purposeful eaters at the end of the semester. The was consistent in past observational research, where emotional eating is associated with overeating, thus, leading to excessive weight gain and obesity (Anderson et al., 2016; Bennett et al., 2013; Lazarevich et al., 2016). External eating was a significant predictor of increased food cravings and weight status (Burton, Smit & Lightowler, 2007). Also, due to the lack of control in uncontrolled eating, impulsive behaviors commonly found in this eating style also has led to increased BMI status (Calvo, Galioto, Gunstad & Spitznagel, 2014). Study results presented a good indicator of how exactly non-purposeful eating behaviors effect weight status and thus, how susceptible those individuals are to continue these eating style behaviors over time. Long-term observational studies are needed to further disentangle the cause-and-effect relationships between eating behaviors and weight status over time.

Lastly, BMI at timepoint 1 negatively predicted emotional, external, and uncontrolled eating at timepoint 3. This relationship was not expected, however, there are a few suggestions that may explain this relationship. First, it is assumed that participants were at healthier BMI in the beginning of the semester. Students may have stayed home for the break which may indicate

healthier dietary habits from consuming foods that their parents prepare (Papadaki, Hondros, Scott & Kapsokefalou, 2007). However, within the term, those individuals were more susceptible to becoming non-purposeful eaters and consume more comfort foods by the end of the semester. This may be due to the external factors such as stress, living away from home, and forming social groups that can influence individuals with both healthy and overweight BMI status to become an emotional, external, or uncontrolled eater. To further explain this relationship, participants who were classified as overweight or obese at timepoint 2 positively predicted non-purposeful eating at timepoint 3, which possibly suggests that study participants may have had some weight gain between timepoints 1 and 2, all potentially due to the non-purposeful eating behaviors. Taken together, the researchers of this study presume that there was a unique cause-and-effect relationship that occurred between non-purposeful eating behaviors and the weight status in college students. However, further longitudinal research needs to be done before making such assumptions.

Overall, our study provided useful applications to assess the longitudinal changes and causal relationships between interoception, self-regulation, non-purposeful eating domain behaviors and BMI. Although, it is important to discuss a few notable limitations within the study. First, this study was conducted on a large sample size of college students, however, it was a female-only sample. Due to the utilization of convenient sampling, the researchers were unable to adequately recruit male participants in the study. Therefore, the results of this study cannot be generalized. Also, the use of self-reported data can potentiate bias within our findings, however validated questionnaires were utilized to reduce this bias.

There were significant strengths within this study, also. Our study utilized 3 timepoints to examine the relationships between interoception, self-regulation, non-purposeful eating styles and BMI within a usual academic semester. This gave us the ability to detect potential differences within the term where students may be experiencing a variety of different influencing external

factors that may affect their weight over time. The real-time, longitudinal relationships should also be further tested using the proposed cross-lagged models. Future research with additional timepoints is necessary to consider the causal effects throughout the entire academic year.

CONCLUSION

Overall, our study has provided useful, empirical evidence on the longitudinal associations among cognitive functions such as interoception and self-regulation, unhealthy eating behaviors, and BMI. Non-purposeful eating domain behaviors were indicative of several relationships between interoception, self-regulation, and BMI in college students. Future long-term studies on this topic are needed to further determine its' effects on college students during their academic careers. Furthermore, to continue to identify the factors that influence these relationships, additional research assessing factors that may impact a college student's behavior such as stress, academic workload, and finances are needed.

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DECLARATION OF INTEREST

The authors report no conflict of interest

DATA SHARING STATEMENT

Due to the sensitive information collected from participants, the data from this study will remain confidential and unshared, as promised to our participants.

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MAIN TABLES AND FIGURES:

Table 1. Baseline Participant Demographic Information

		Sample	***Percentage (%)***
Race	American Indian or Native American	1	0.4
	Asian or Pacific Islander	6	2.6
	Black or African American	34	15
	White or Caucasian	126	55
	Other or Mixed	62	24
Ethnicity	Hispanic	172	75
	Non-Hispanic	57	25
Classification	Freshman	11	4.8
	Sophomore	38	17
	Junior	117	51
	Senior	63	28
BMI Category	Underweight	6	2.6
	Normal	125	55
	Overweight	60	26
	Obese	38	16
College Transfer	Started here	83	36
	Transferred	146	64
Major	Biological/Life Sciences	10	4.4
	Business	5	2.2
	Communication	2	0.9
	Education	1	0.4
	Engineering	1	0.4
	Health-related field (nursing, physical therapy)	7	3.1
	Humanities	1	0.4
	Physical sciences (physics, chemistry)	1	0.4
	Pre-professional (pre-dental, pre-medical)	5	2.2
	Public administration	3	1.3
	Social sciences (anthropology, psychology)	150	66
	Visual and performing arts	1	0.4
	Other	11	4.8
Marital Status	Never Married	202	88
	Married	18	7.9
	Divorced	3	1.3
	Separated	6	2.6
Living location	On-campus housing	12	5.2
	Off-campus housing	217	95
Living arrangements	Living alone	14	6.1
	With other students	17	6.1
	My family (spouse or children)	35	14
	Parents	125	55
	Other relatives	7	3.0
	Other	7	3.0

Table 2. Means, Standard Deviations and F-test statistics of the Cognitive Skills, Non-purposeful Eating and BMI at each Timepoint

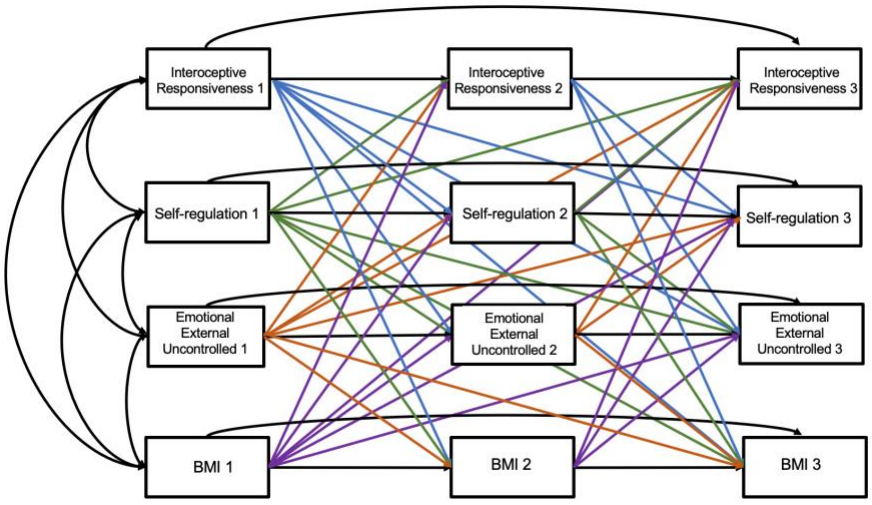
Variable	N	Timepoint 1	Timepoint 2	Timepoint 3	F-value	P-value
BRS	104	31.85 (8.11)	33.46 (8.26)	33.45 (7.70)	5.443	0.006*
Self-regulation	104	3.25 (0.70)	3.19 (0.74)	3.38 (0.67)	1.989	0.142
Emotional Eating	104	33.73 (16.00)	33.06 (15.91)	32.63 (16.79)	0.533	0.577
External Eating	104	31.23 (7.73)	31.14 (8.10)	29.63 (8.58)	3.776	0.026*
Uncontrolled Eating	104	19.33 (6.38)	21.19 (4.48)	20.85 (4.51)	9.778	<0.001*
BMI	104	25.31 (4.68)	25.50 (5.32)	25.34 (4.60)	0.265	0.768

Note: * indicates a statistically significant result

Table 3. Model Fit Indices for Cross-lagged Analyses

Model	Chi-Square	P-value	χ^2/df	CFI	TLI	RMSEA
Emotional Model	8.075	0.233	1.346	0.998	0.978	0.058
External Model	14.867	0.021	2.478	0.991	0.899	0.120
Uncontrolled Model	9.039	0.171	1.507	0.997	0.967	0.070

Figure 1. Proposed Cross-lagged Model with 3 Timepoints



Note. Blue paths indicate the relationships predicted by interoceptive responsiveness. Green paths indicate the relationships predicted by self-regulation. Orange paths indicate the relationships predicted by the non-purposeful eating domain. Purple paths indicate the relationships predicted by BMI.

Figure 2. Cross-lagged Model with Emotional Eating

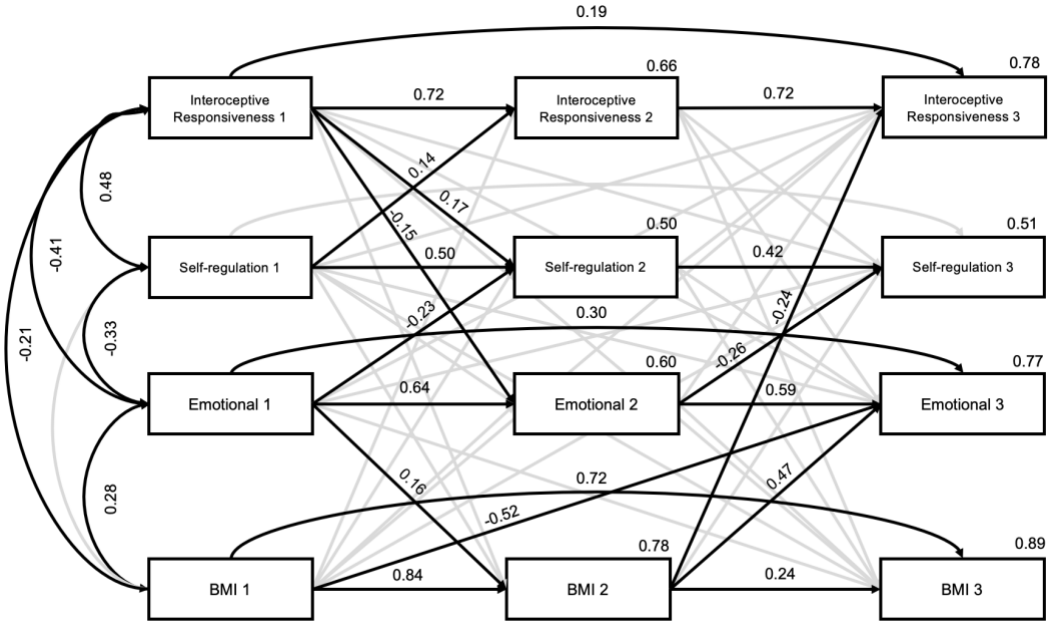


Figure 3. Cross-lagged Model with External Eating

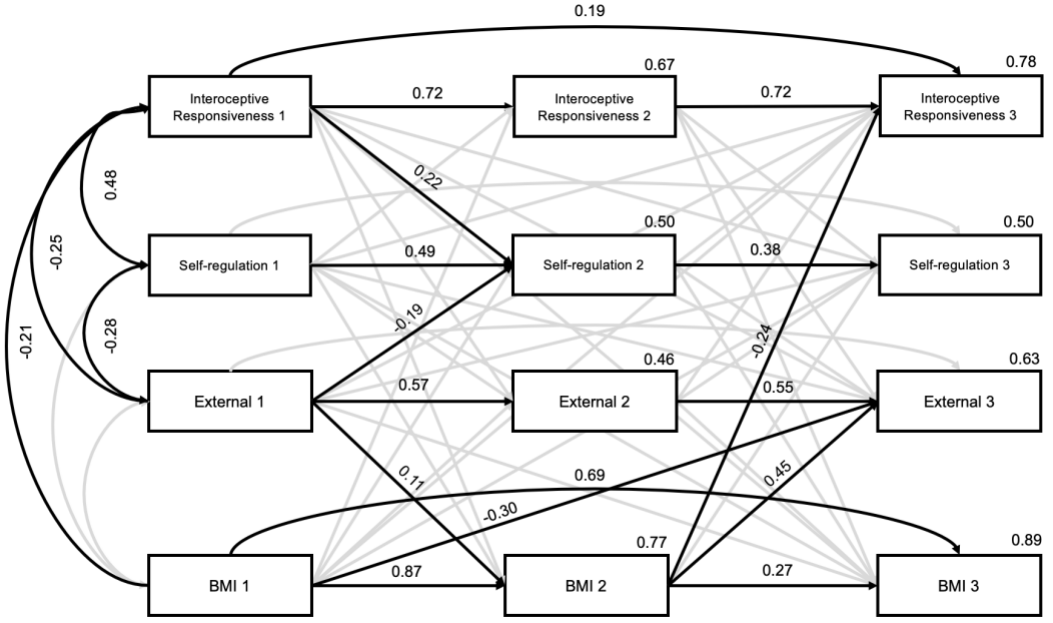
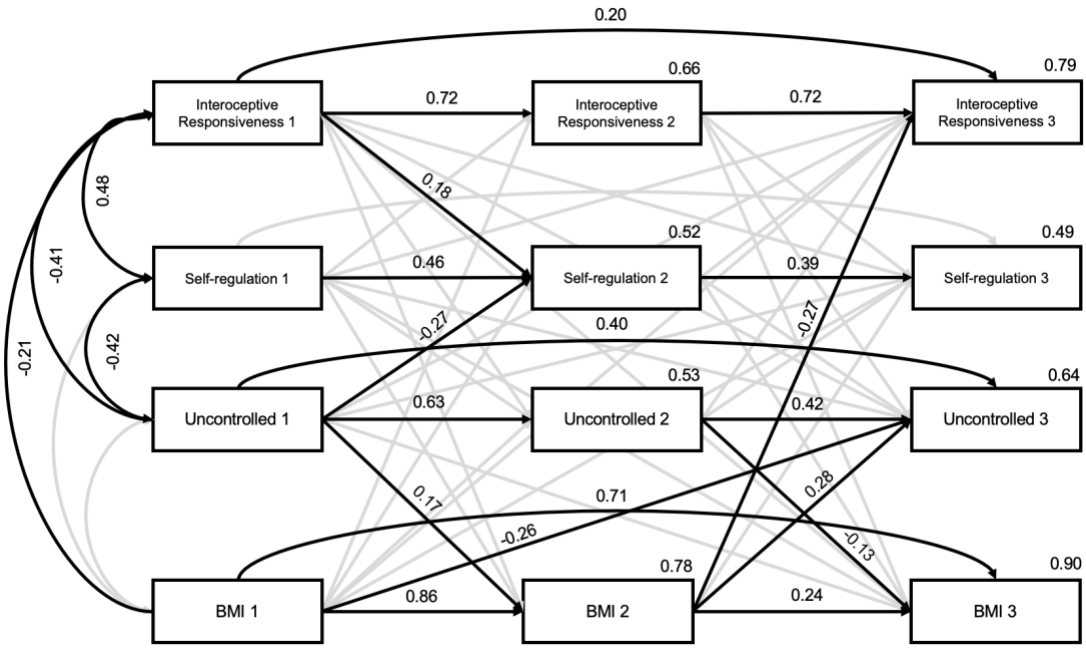


Figure 4. Cross-lagged Model with Uncontrolled Eating


0.20
0.66
0.79
Interoceptive Responsiveness 1
0.72
Interoceptive Responsiveness 2
0.72
Interoceptive Responsiveness 3
0.48
0.18
0.52
0.49
-0.41
Self-regulation 1
0.46
Self-regulation 2
0.39
Self-regulation 3
-0.27
-0.27
0.40
-0.21
-0.42
0.53
0.64
Uncontrolled 1
0.63
Uncontrolled 2
0.42
Uncontrolled 3
0.17
0.71
0.28
-0.26
-0.13
0.78
0.90
BMI 1
0.86
BMI 2
0.24
BMI 3

The Mediating Effect of Eating Behaviors on Interoception, Self-regulation and Weight Status among College Students

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ABSTRACT

Obesity among college students have been consistently high in the recent decades. Interoception and self-regulation have been studied to identify certain health behaviors that lead to weight gain. Reduced interoception and self-regulation may lead to increased body mass index (BMI), however, various eating styles may indirectly affect this relationship. Because both interoception and self-regulation possess multiple benefits towards one's weight status, it is important to understand which eating styles best explains the relationship between interoception and self-regulation on BMI. There were 104 female participants that completed study measures. Study result indicated that intuitive eating significantly mediated the relationships of interoception on BMI, as well as self-regulation on BMI. Overall, this study was set to determine which eating style most importantly explained the relationship of interoception on BMI and self-regulation on BMI. Intuitive eating was the only eating style that was found to be a significant mediator within both analyses. It is theorized that both interoception and self-regulation are practiced among college students who intuitively eat, thus providing it eligible to accurately explain the associations on BMI. The study has provided foundational evidence on the indirect effect of eating behaviors on one's relationship of interoception and self-regulation on BMI and can be useful in future interventions regarding college students and their associated risk for obesity.

Keywords: Interoception, Self-regulation, Eating behaviors, Mediation, College students

INTRODUCTION

Obesity rates among college students have been a major topic of concern for several years. In 2021, approximately 38% of college students were considered overweight or obese (Bailey, Elmi, Hoban, Kukich & Napolitano, 2022). Issues that commonly stem from excessive weight gain and obesity consist of chronic diseases such as cardiovascular disease and diabetes, and increased mortality risk later in adulthood (Dietz, 2017). Since college is often considered the first time that most young adults make their own food choices and form eating behaviors, this timeframe may be highly influential on one's risk for obesity (Brunt, Rhee & Zhong, 2008). Cognitive processes like interoception and self-regulation have recently gained attention in obesity research to delineate how they are related to one's eating behaviors and, ultimately, weight status. Previous research has shown that reduced interoception and self-regulation may lead to increased body mass index (BMI) (Robinson, Foote, Smith, Higgs & Jones, 2021; Simmons & DeVille, 2017). However, various eating styles may indirectly affect this relationship. Tsakiris and De Preester (2018) define the act of eating as being the reflection of how in-tune a person is to their bodily needs and overall well-being. Therefore, eating styles may be an intermediate factor between one's level of cognitive skill and BMI. Because both interoception and self-regulation possess multiple benefits towards one's weight status, it is important to understand which eating styles best explains the relationship between interoception and self-regulation on BMI. With this knowledge, it is possible to further assess the contributing eating styles that would either hinder or benefit college students to maintain a healthy weight and prevent the rise in obesity.

Interoception is the perception of one's internal awareness and responsiveness to bodily signals (Young et al., 2017). It is often characterized as the communicative link between the body and the brain, which may serve to regulate one's hunger and satiety needs (Craig, 2008; Van Dyck et al., 2016). Individuals with high interoceptive responsiveness are more likely to

participate in healthy eating behaviors and lifestyle choices (B. Herbert, Blechert, Hautzinger, Matthias & C. Herbert, 2013). Researchers have found that there are 2 primary reasons for one's response to interoceptive signaling: 1. the effort to position the body back into a homeostatic energy balance, and 2. the reward value of food stimuli (Simmons & DeVille, 2017). Therefore, if interoception is altered, motivation for food consumption may be increased, leading to weight gain (Simmons & DeVille, 2017). Self-regulation is highly dependent on interoception where it represents the active monitoring of one's needs to achieve a specific goal (Jeune, Graziano, Campa & Coccia, 2022; Weiss, Sack, Henningsen & Pollatos, 2014). Self-regulatory processes allow for temporary suppression of "lower-order" cravings to accomplish "higher-order" purposes (Johnson, Pratt M & Wardle, 2012). Although self-regulation is understood to monitor one's behavior towards eating, there is very little known regarding the concrete process between self-regulation and eating styles. Furthermore, there is a gap in knowledge that clearly defines the role that self-regulation plays on one's BMI. Both cognitive processes have been commonly associated with healthier eating styles and may lead to a healthier BMI over time. Therefore, it is important to define how one's behavior may serve as a mediating variable on the relationship between a person's level of cognitive skill and their weight status, however, this has yet to be studied.

Over time, various eating styles may prevent or encourage unhealthy BMI status among college students. Non-purposeful eating behaviors include emotional, external and uncontrolled eating styles whereas purposeful eating behaviors include cognitive restraint and uncontrolled eating styles (Jeune, Graziano, Campa & Coccia, 2022). Emotional eating is generally defined as eating in response to certain emotional cues as a coping mechanism (Bennett, Greene, Schwartz-Barcott, 2013). Emotional eaters have a difficult time recognizing their emotions and, simultaneously, regulating their eating patterns (Bennett et al., 2013). More commonly, emotional eating is associated with overeating, thus leading to excessive weight gain and obesity over time

(Anderson et al., 2016; Bennett et al., 2013; Lazarevich et al., 2016). In order to reduce emotional eating behaviors, it is recommended to self-regulate by eating for physical needs, rather than for temporary comfort (Anderson et al., 2016). External eating is another eating style with similar eating behaviors. External eating is eating in response to an external food-related stimulus like the sight or smell of food, regardless of having feelings of hunger or satiety (Van Strien, Frijters & Bergers, 1986). External eaters are known to have less conscientiousness (interoception) over their eating behaviors (Heaven et al., 2001). As a result, external eaters may also experience a reduction in self-regulatory abilities when eating and consume more energy dense food items and overeating (Brogan & Hevey, 2013; Heaven et al., 2001). Uncontrolled eating, described as the loss of control while consuming food, is viewed more so as a continuum that starts from eating impulsivity to overeating behaviors (Vainik, Neseliler, Konstabel & Fellows, 2015). The nature of this eating style inhibits all interoceptive and self-regulative processes as the person navigates in a more sensitive and responsive state. Self-report of uncontrolled eating was found more prominent among students who were categorized as overweight and obese (Calvo, Galioto, Gunstad & Spitznagel, 2014).

On the other hand, in an effort to maintain control, college students may become more purposeful in their eating. Purposeful eating behaviors consist of cognitive restraint and intuitive eating styles. Cognitive restraint is most similar to traditional dieting, where a person is highly aware of their internal signals yet override hunger cues to purposefully restrict one's intake (Anglé, 2009). Restrained eaters were mostly successful in monitoring their overall eating habits due to increased self-regulation and long-term goal seeking (Racine, 2018). Another eating style that is said to utilize purposeful eating practices is intuitive eating. Intuitive eating is the non-diet approach that is centered around the individual's body signaling response such as their hunger and satiety cues (Oswald et al., 2017). To effectively practice intuitive eating, individuals must be able to accurately identify and respond to their internal hunger cues via interoception and regulate

their intake based on the guided cues (Anglin 2012; Nolan & Geliebter, 2012; Oswald et al., 2017). These eating styles accompany various amounts of interoception and self-regulation while simultaneously playing a role on BMI. Therefore, it is theorized that increased cognitive processes (interoception and self-regulation) help to maintain healthy BMI, when individuals have more purposeful eating styles such as cognitive restraint and intuitive eating. Inversely, it is suggested that reduced interoception and self-regulation leads to increased BMI among those with non-purposeful eating styles like emotional, external and uncontrolled eating.

Currently, it is unknown which of the eating styles indirectly effect the associations of interoception and self-regulation on BMI. In utilizing the 5 most popular eating styles, it is important to determine which eating style most prominently explains the association of interoception on BMI, as well as self-regulation on BMI. Taken one step further, the concept of time is also considered. Specifically in college students, assessing the mediating role of eating behaviors on the associations of interoception and self-regulation on BMI at three separate timepoints (beginning, mid-point, and end of the semester) can provoke a more detailed conversation. In order to determine the mechanistic effects between the variables, assessing each variable at a different timepoint should describe the potential influence that one variable may have on another. It is imperative to distinguish the foundational effects of the cognitive processes (interoception and self-regulation) at the beginning of the semester prior to any potential conflicting external factors that tend to happen within the term. Eating behaviors were assessed at Timepoint 2 to understand the students' typical behavior during the school term. Lastly, to determine the outcome effects by the end of one's term, BMI was assessed at Timepoint 3 to determine potential directionality of the associations. Taken together, the purpose of this study is to examine the indirect effects of multiple eating styles on the associations of interoception on BMI, as well as self-regulation on BMI. We predict that individuals with increased interoception and self-regulation will have decreased BMI through purposeful eating styles (cognitive restraint

and intuitive eating). We also predict that individuals with reduced interoception and self-regulation will have increased BMI through non-purposeful eating styles (emotional, external, and uncontrolled eating). (Figure 1 and Figure 2).

[insert Figure 1 here]

[insert Figure 2 here]

METHODS

Participant Recruitment and Procedures

Participants were recruited from a 4-year university in Southern Florida. The inclusion criteria were undergraduate male and female students. The exclusion criteria for this study consisted of taking medications that reduced or increased appetite, previously diagnosed eating disorders or mood disorders, pregnant or planning to become pregnant, and/or student athletes. At the end of the study, the researchers excluded male participants (n = 13) during the data analysis process due to an insufficient number of male participants. Study protocols were reviewed and approved by the university's Institutional Review Board. Study data was utilized from a repeated-measures, observational research study with 279 participants. After participant drop-out and the removal of male participants (n=13), there were 229 (82%) females who completed baseline measures. Data was collected over 3 timepoints (1 timepoint per month) within the timeframe of a typical academic semester. At the end of the study (timepoint 3), there were 104 females that completed study measures (45% retention within study).

Measures

Interoception

Interoceptive responsiveness, defined as the response to one's internal signaling was measured by the Body Responsiveness Scale (BRS). BRS is a 7-item scale that measures how an individual responds to their bodily sensations (Oswald et al., 2017). The questionnaire's responses were based on a 7-point Likert scale indicating 1 as 'not at all true' and 7 as 'always

true of me'. Increased scoring demonstrates increased interoceptive responsiveness. BRS was found to have a good reliability of 0.75, for Timepoint 1.

Self-regulation

Self-regulation was measured via the Self-Regulation of Eating Behavior Questionnaire (SREBQ). SREBQ is a 5-item questionnaire that assesses an individual's self-regulation capacity (Kliemann, Beeken, Wardle, & Johnson, 2016). A Likert scoring system of 1 (Never) to 5 (Always) was used. The questionnaire's internal consistency was $\alpha = 0.69$ for Timepoint 1.

Eating Behaviors

Eating behaviors were measured using 3 validated questionnaires: the Dutch Eating Behavior Questionnaire (DEBQ), the Three-factor Eating Questionnaire (TFEQ-R18), and the Intuitive Eating Scale-2 (IES-2). DEBQ is a 33-item questionnaire that contains three subscales of Emotional eating, External eating, and Restrained eating (Van Strien, Frijters, Bergers, & Defares, 1986). The assessment indicates a person's eating behavior based on three main psychological theories (Van Strien et al., 1986) For the purposes of this study, the researchers only utilize the Emotional eating and External eating subscales. The questionnaire items are scored on a Likert scale ranging from 1 (seldom) to 5 (very often). The DEBQ had a high reliability of 0.96 for Emotional eating and 0.86 for External Eating for Timepoint 2.

TFEQ-R18 is an 18-item assessment that measures eating behavior concepts of Cognitive Restraint, Uncontrolled and Emotional eating (Anglé et al., 2009). The Cognitive Restraint and Uncontrolled eating subscales were only utilized in this study. The questionnaire is scored using a four-point scale of 1-4, with the higher values signifying for more of the behavior. The TFEQ-R18 was found to have a good reliability of 0.89, 0.68, and 0.71 for Uncontrolled eating and 0.76for Cognitive Restraint Eating at Timepoint 2.

IES-2 is a 23-item questionnaire that assess the individual's ability to adhere to their internal hunger and satiety cues, regarding when to eat (Tylka & Kroon, 2013). The questionnaire

is scored using a Likert scale of 1 (strongly disagree) to 5 (strongly agree). In the current study, the scale had a Cronbach's alpha of 0.87 for Timepoint 2, representing good internal consistency.

Weight Status

Participant weight was provided via participant self-report on an online survey. At each timepoint, participants were asked to weight themselves and record their weight while completed the other questionnaires. BMI was calculated using the individual's baseline height and weight using the formula (weight (kg) / [height (m)]^2 ("About Adult BMI", 2021). BMI were classified into 4 categories using the Center for Disease Control guidelines: Underweight (BMI<18.5), Healthy weight (18.5-24.5), Overweight (25.0-29.9), and Obesity (BMI>=30.0) ("About Adult BMI", 2021).

Statistical Analysis

Data were analyzed using SPSS Statistics v26.0 for descriptive statistics, paired t-test statistics, and mediation analyses. Mediation analyses were conducted using the recommended PROCESS v3.4 system by Andrew Hayes (Hayes, 2017). First, direct associations between the variables were assessed, then, both total and specific indirect effects were examined to assess potential mediation. To signify indirect effect significance, the researchers performed the bootstrapping method. We utilized 5,000 samples with a 95% confidence interval to detect potential significance.

RESULTS

Participant Characteristics

Participants were predominantly identified as White Hispanics (75.1%) with an average age of 23.39 (SD=6.312) and BMI average of 25.45 (SD=5.48) at baseline. They were mostly classified as Juniors (51.1%), majored in social sciences (including anthropology, economics, and psychology; 65.5%), were never married (88.2%), and lived off-campus (94.8%) with their

parents (54.6%). Table 1 includes all participant demographic information. Table 2 includes the correlations, means and standard deviations of the study variables.

[insert Table 1 here]

[insert Table 2 here]

Mediation Analysis

In our interoception model, interoceptive responsiveness (T1) was negatively associated with emotional eating (T2) (path a1=-0.47, $p<0.001$), external eating (T2) (path a2=-0.35, $p<0.001$), uncontrolled eating (path a3=-0.39, $p<0.001$), and positively associated with intuitive eating (T2) (path a5=0.59, $p<0.001$). Intuitive eating (T2) was negatively associated with BMI (path b5=-0.32, p=0.026). There was a significant total indirect effect (-0.21, 95%CI [-0.373, -0.049]) and specific indirect effect of interoception (T1) on BMI (T3) through intuitive eating (T2) (-0.19, 95%CI [-0.394, -0.034]). All associations can be found in Figure 3.

[insert Figure 3 here]

In our self-regulation model, self-regulation (T1) was negatively associated with emotional eating (T2) (path a1=-0.49, $p<0.001$), external eating (T2) (path a2=-0.45, $p<0.001$), uncontrolled eating (path a3=-0.48, $p<0.001$), and positively associated with intuitive eating (T2) (path a5=0.53, $p<0.001$). Intuitive eating (T2) was negatively associated with BMI (path b5=-0.29, p=0.039). There was a significant specific indirect effect of self-regulation (T1) on BMI (T3) through intuitive eating (T2) (-0.15, 95%CI [-0.334, -0.026]). All associations can be found in Figure 4.

[insert Figure 4 here]

DISCUSSION

The study's purpose was to determine the indirect effects of specific eating styles on the relationships of interoception and BMI, as well as self-regulation and BMI. It was hypothesized that there would be a significant mediation of at least one eating style to determine which eating

style best explains the relationship between the cognitive processes (interoception and self-regulation) and BMI. The results of the study indicated that intuitive eating (T2) was the only eating style that significantly mediated the relationships of interoception (T1) on BMI (T3), as well as self-regulation (T1) on BMI (T3).

It was found that the intuitive eating significantly mediated the association of interoception and BMI. Therefore, intuitive eating was the only eating style that could account for the relationship between interoception and BMI in college students, thus indicating that those with increased interoception were more apt to have a reduced BMI, among individuals who were classified as intuitive eaters. To our knowledge, this study was the first to examine this relationship. Additionally, these associations were found within the different timepoints of a college semester, thus indicating directionality. Study results did not find a direct association between interoception and BMI, however there was a significant indirect effect of intuitive eating on the association. This suggests that individuals with increased interoception had decreased BMI through intuitive eating only. Based on previous knowledge, it is our theory that, when done correctly, intuitive eating may inherently posit interoceptive responsiveness in practice. The mind-body approach utilized in this eating style is set to allow the person to focus inward to their internal body signaling to guide them (Tylka, 2006). With greater interoceptive responsiveness via intuitive eating, individuals were likely to obtain decreased BMI by the end of the semester. Future longitudinal studies are needed to observe one's eating behavior, along with their usual intake to confirm our findings.

Similar to our outcomes in our interoception mediation analysis, our study results indicated consistent findings among self-regulation and BMI through intuitive eating. Although there was no direct association between self-regulation and BMI, it was confirmed that there was an indirect effect of intuitive eating on the relationship of self-regulation and BMI in college students. College students with increased self-regulation were more likely to have reduced BMI

when mediated by intuitive eating. Among all 5 eating styles, intuitive eating was the only significant eating style that had significant mediation. Our findings were consistent to a previous cross-sectional research study (Ruzanska & Warschburger, 2019). Conceptually, self-regulation is imbedded into the measures of intuitive eating. This eating style has 4 subcategories: Eating for Physical Rather Than Emotional Reasons, Unconditional Permission to Eat, Reliance on Hunger and Satiety Cues, and Body-Food Choice Congruence (Tylka & Kroon, 2013). Although not all subcategories were significant in the cross-sectional analyses, most of the subcategories operate through strengthening one's ability to regulate their feelings, hunger and satiety cues, and well-being (Tribole & Resch, 2003; Tylka & Kroon, 2013). Therefore, the behavior of self-regulation was practiced among intuitive eaters.

Overall, there were 5 eating styles that were assessed in the study; however, emotional, external, uncontrolled, and cognitive restraint eating did not significantly mediate the relationships of interoception and self-regulation on BMI. Although the non-purposeful eating styles were all associated with reduced interoception and self-regulation, these eating behaviors did show any sensitivity to BMI over time. For example, it was understood that emotional eaters were not necessarily classified as overweight or obese by the end of the semester. It was previously found that emotional eating during positive and negative states can lead to differing intake amounts (Geliebter & Aversa, 2003). Additionally, underweight, normal, and overweight participants were recognized to have individual differences between weight classifications (Geliebter & Aversa, 2003). In the overweight group, participants consumed more when feeling negative emotions, however, during positive emotional states, they consumed less (Geliebter & Aversa, 2003). Conversely, the underweight group consumed more during positive feelings and less during negative feelings (Geliebter & Aversa, 2003). Due to the variability within intake amount among the 3 weight classifications, the relationship between cognitive behaviors (interoception and self-regulation) and weight status can be hard to extrapolate from this eating

style. Similar findings were indicated with external eating. In a previous study assessing BMI trajectories in adolescents who externally eat, it was found that this eating style was not associated to any specific BMI trajectory. Therefore, it is suggested that the dysregulation of food consumption that occurs during external eating does not necessarily affect weight status. Uncontrolled eating has been commonly associated with weight gain and obesity in young adults, however, this eating style is explained as a concept that is based on a spectrum (Vainik, Neseliler, Konstabel, Fellows & Dagher, 2015). There are various subcategories from multiple questionnaires that vary in degree of severity (Vainik et al., 2015). Some of the categories are eating impulsivity which is considered a milder form of uncontrolled eating and binge eating, categorized as more severe (Vainik et al., 2015). Therefore, it may be explained that separate aspects of uncontrolled eating relate to BMI while others do not. Future research on this theory is needed to specifically identify which subcategories correlate to BMI.

Of the purposeful eating styles, cognitive restraint did not significantly mediate the relationships between interoception and self-regulation on BMI. It is important to note that cognitive restraint was not significantly related to interoception, self-regulation, or BMI. Originally, the researchers of this study hypothesized that cognitive restraint was more purposeful in nature which leads to increased interoception and self-regulation and decreased BMI. However, there are mixed results on these factors in past literature. The dieting approach behind cognitive restraint lends it to have both advantages and disadvantages. In a previous study, cognitive restraint eaters who were flexible with their eating were associated with lower BMI (Westenhoefer, Stunkard & Pudel, 1999). Furthermore, those who were in a weight-loss program were more apt to be successful with flexible cognitive restraint eating (Westenhoefer, Stunkard & Pudel, 1999). On the other hand, college students who participated in restrained eating were more likely to be classified as overweight or obese (Ramírez-Contreras, Farrán-Codina, Izquierdo-Pulido & Zerón-Rugerio, 2021). This is due to the initial suppression of food consumption

followed by an uptake of unhealthy eating behaviors later, thus leading them more susceptible to obesity risk (Racine, 2018). So, considering all concepts, cognitive restraint eating simply may not relate to the relationship of one's interoception and self-regulation on BMI over time.

The study had significant strengths. First, the researchers of the utilized 3 different timepoints within the academic term to assess for potential mediation. The different points of the study were compared for a more detailed look on how college student eating behavior indirectly influence the relationship of interoception and self-regulation on BMI throughout the length of a typical semester. Although, future research assessing several longitudinal timepoints is needed to effectively deduce the relationship that various eating behaviors play on interoception and BMI, as well as self-regulation and BMI in college students.

Also, it is imperative to discuss a few of the study's limitations. First, the study utilized mediation analyses to examine the associations within interoception, self-regulation, eating behaviors, and BMI, therefore, a causal relationship between the variables cannot be considered. Also, the study included female participants only. Due to the insufficient sampling on male undergraduate students, the researchers of the study removed all males from analyses, thus the ability to generalize the study's results should be done with caution. Lastly, the study assessed self-reported measures of interoception, self-regulation, eating behaviors and BMI, therefore, it should be acknowledged that the study results are based on how the participants perceived their feelings and behaviors, rather than their physiological behavior.

Overall, this study was set to determine which eating style most importantly explained the relationship of interoception on BMI and self-regulation on BMI. Intuitive eating was not only found to be a significant mediator, but the only mediator that explained the associated relationships. The authors of this study presume that both interoception and self-regulation were both already practiced among college students who intuitively eat, thus providing it eligible to accurately explain the associations on BMI. This was the first-known study to assess 5 prominent

eating styles as mediators on the association of interoception and self-regulation on BMI. It is important to continue this research in the future to assess the long-term implications of interoception, self-regulation, eating styles on weight status in order to prevent the increase in obesity risk. Overall, the study has provided foundational evidence on the indirect effect of eating behaviors on one's relationship of interoception and self-regulation on BMI and can be useful in future interventions regarding college students and their associated risk for obesity

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DECLARATION OF INTEREST

The authors report no conflict of interest

DATA SHARING STATEMENT

Due to the sensitive information collected from participants, the data from this study will remain confidential and unshared, as promised to our participants.

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MAIN TABLES AND FIGURES:

Figure 1. Mediation Model with Interoceptive Responsiveness and BMI through Eating Behaviors.

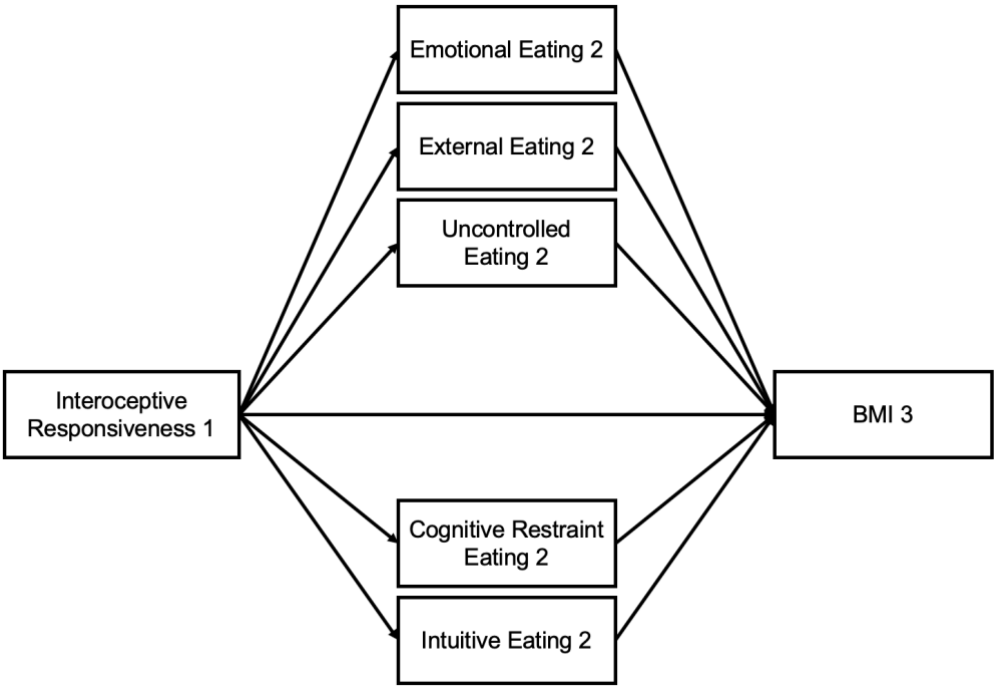


Figure 2. Mediation Model with Self-regulation and BMI through Eating Behaviors.

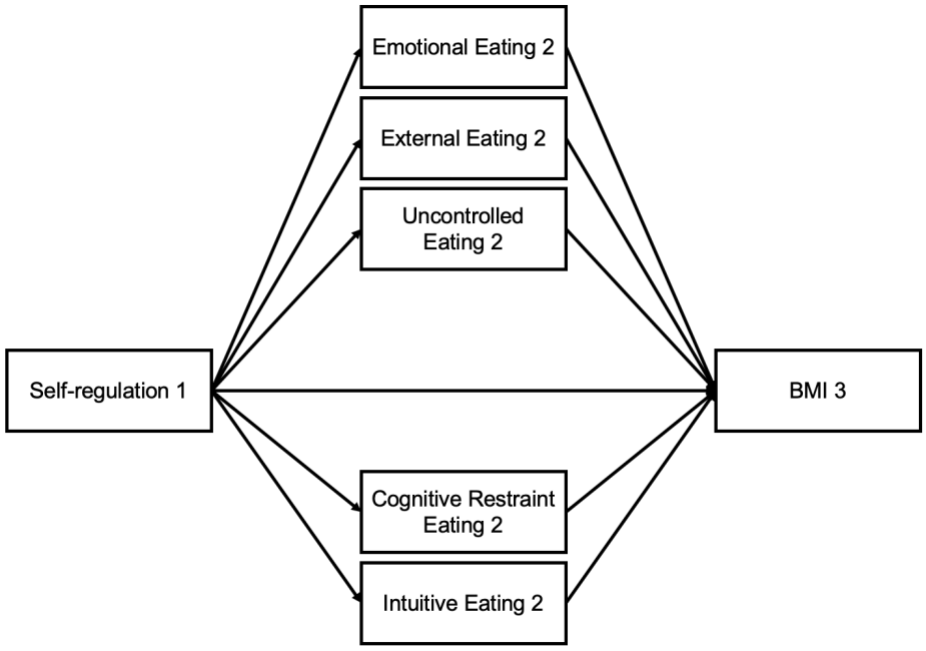
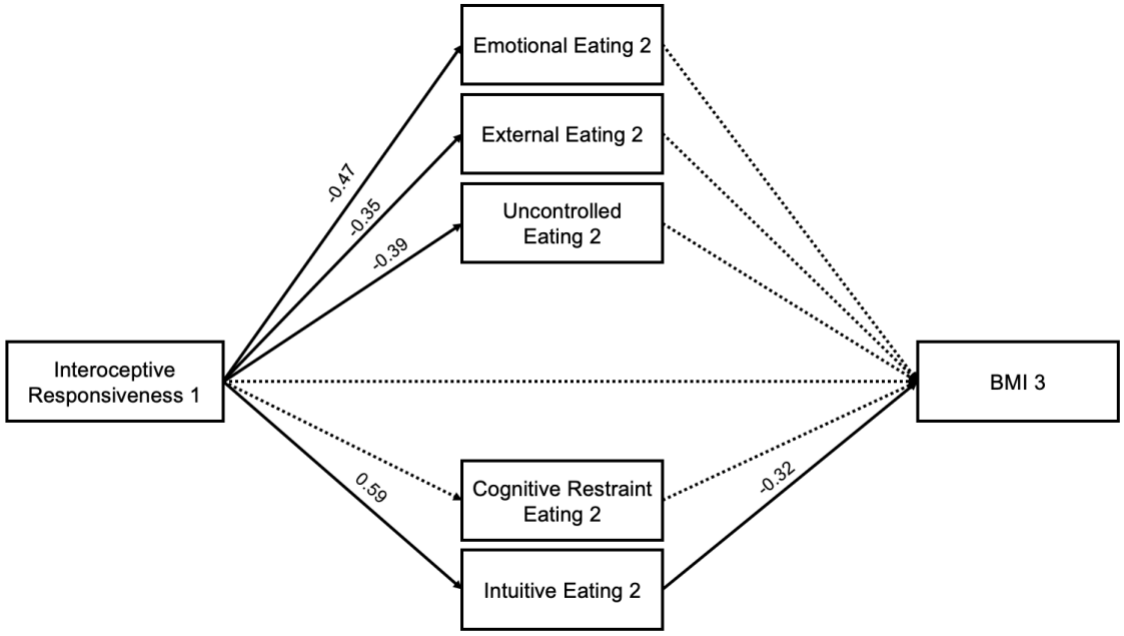
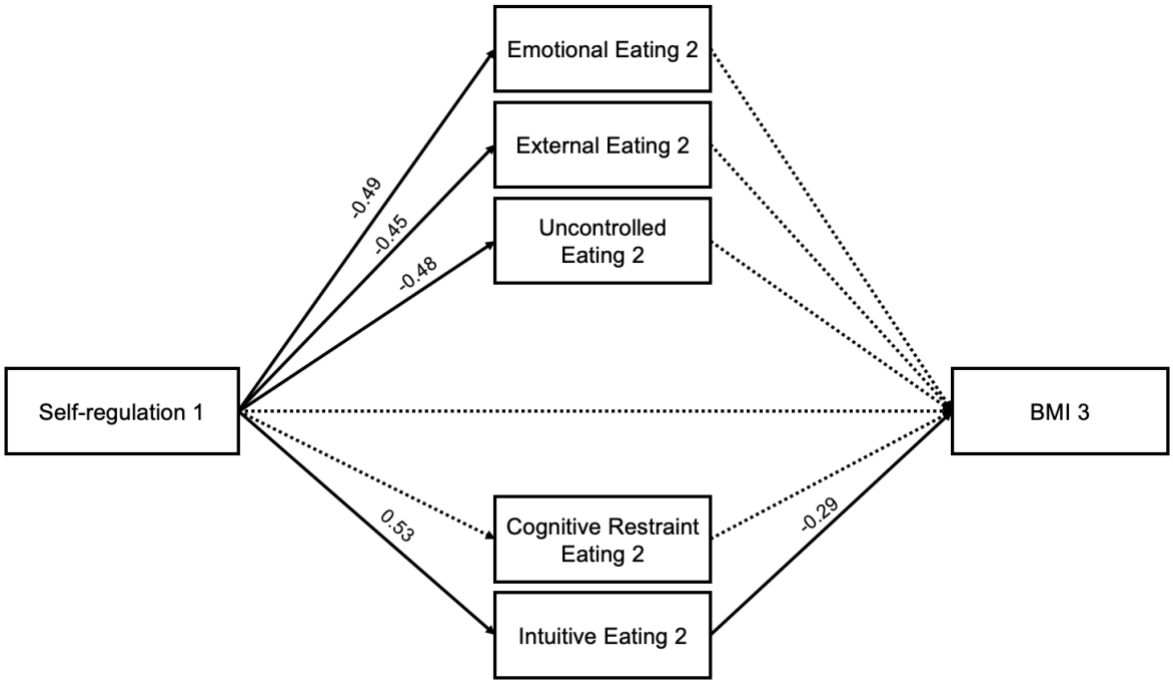


Figure 3. Interoceptive Responsiveness Mediation Model with Standardized Estimates



Note. Bolded lines are considered significant.

Figure 4. Self-regulation Mediation Model with Standardized Estimates



Note. Bolded lines are considered significant.

Table 1. Baseline Participant Demographic Information

		Sample	***Percentage (%)***
Race	American Indian or Native American	1	0.4
	Asian or Pacific Islander	6	2.6
	Black or African American	34	15
	White or Caucasian	126	55
	Other or Mixed	62	24
Ethnicity	Hispanic	172	75
	Non-Hispanic	57	25
Classification	Freshman	11	4.8
	Sophomore	38	17
	Junior	117	51
	Senior	63	28
BMI Category	Underweight	6	2.6
	Normal	125	55
	Overweight	60	26
	Obese	38	16
College Transfer	Started here	83	36
	Transferred	146	64
Major	Biological/Life Sciences	10	4.4
	Business	5	2.2
	Communication	2	0.9
	Education	1	0.4
	Engineering	1	0.4
	Health-related fields (nursing, physical therapy)	7	3.1
	Humanities	1	0.4
	Physical sciences (physics, chemistry)	1	0.4
	Pre-professional (pre-dental, pre-medical)	5	2.2
	Public administration	3	1.3
	Social sciences (anthropology, psychology)	150	66
	Visual and performing arts	1	0.4
	Other	11	4.8
Marital Status	Never Married	202	88
	Married	18	7.9
	Divorced	3	1.3
	Separated	6	2.6
Living location	On-campus housing	12	5.2
	Off-campus housing	217	95
Living arrangements	Living alone	14	6.1
	With other students	17	6.1
	My family (spouse or children)	35	14
	Parents	125	55
	Other relatives	7	3.0
	Other	7	3.0

Table 2. Correlations, Means, and Standard Deviations of Cognitive Skills, Eating styles, and BMI.

Variables	1	2	3	4	5	6	7	8
1.BRS	1	.567**	-.365**	-.307**	-.365**	-.103	.563**	-.246*
2. SREBQ		1	-.401**	-.350**	-.438**	-.031	.459**	-.309**
3. Emotional			1	.575**	.570**	.225**	-.654**	.294**
4. External				1	.680**	.103	-.377**	.164
5. Uncontrolled					1	.224**	-.329**	.219*
6. Cognitive Restraint						1	-.225**	.167
7. Intuitive							1	-.387**
8. BMI								1
Mean	**31.38**	**3.190**	**33.24**	**31.41**	**21.56**	**14.69**	**3.465**	**25.23**
Standard Deviation	**7.86**	**0.72**	**15.56**	**7.69**	**4.30**	**2.56**	**0.61**	**4.64**

*Note: *Significant at 0.05 level. **Significant at 0.01 level.*

CHAPTER V

CONCLUSION

The current study utilized a repeated-measures, observational research study design to explore the associations and causal relationships of interoception, self-regulation, purposeful and non-purposeful eating domain behaviors, and weight status in college students. College students exhibited significant differences in eating style behaviors that were categorized into purposeful and non-purposeful eating domains with the utilization of a 2-factor confirmatory factor analysis (CFA). When assessing the associations of the structural equation model (SEM), internal regulatory skills such as interoception and self-regulation were significantly correlated, whereas those with increased interoceptive abilities also had higher levels of self-regulation. Both interoception and self-regulation were found to have a negative association with both the purposeful and non-purposeful eating domains. This relationship was expected with the non-purposeful eating domain due to its reactivity to external cues. However, with the purposeful eating domain, it was assumed that the college student's perceived skill in interoception and self-regulation were inflated based on their actual behavior. Lastly, it was found that the non-purposeful eating domain had a significant positive relationship with BMI, whereas college students who participate in these eating behaviors were also more likely to be classified as overweight or obese.

Longitudinal changes among interoceptive responsiveness and uncontrolled eating in college students throughout the time of a typical academic semester were also examined. Interoceptive responsiveness declined significantly throughout the study, suggesting that adverse external factors may have possibly impacted the internal body signaling response over time. Uncontrolled eating also decreased throughout the study, it is possible that as they adjusted to the semester, students participated more in other eating behavior patterns. A cross-lagged model analysis signified that emotional eating (Timepoint 2) was negatively predicted by interoceptive

responsiveness (Timepoint 1), interoceptive responsiveness (Timepoint 1) significantly predicted a positive relationship with self-regulation (Timepoint 2), and self-regulation (Timepoint 2) predicted a significant negative association with external eating at (Timepoint 3), thus signifying the short-term (within 2 timepoints) and long-term (withing 3 timepoints) effects that cognitions played on non-purposeful eating behaviors in college students. Lastly, a mediation model analysis indicated that intuitive eating significantly mediated the relationship interoception on BMI, as well as self-regulation on BMI. Therefore, intuitive eating accounted for the relationship between interoception and self-regulation on BMI in college students, thus indicating that those with increased interoception and self-regulation were more apt to have a reduced BMI, among individuals who were classified as intuitive eaters.

Strengths and Limitations

This research study provided empirical evidence on the baseline and longitudinal associations between interoception, self-regulation, eating behaviors, and weight status in college students. However, there were a few limitations that should be considered. First, the study was assessed with a female-only sample. Due to the inability to recruit enough male participants, males were removed from the study. Potential gender differences were unable to be assessed, therefore generalizing the study's findings should be done with caution to prevent potential bias. Also, our study sample was predominantly with students from the Hispanic/Latino/a community. While this can bring unique revelations about their cognitive and eating behaviors, it continues to pose an issue with generalizability. Lastly, our study solely employed the usage of self-reported measures. The measures were validated and presented as reliable in many populations; however, this method is only formulated around one's perception of the behavior rather than obtaining objective measurements to quantify the behavior.

Despite the limitations, the study had several strengths. Multiple statistics were used to interpret the data. We utilized a 2-factor CFA to determine the behaviors of the purposeful and

non-purposeful eating domains. A SEM model was also conducted to signify the overall associations between interoception, self-regulation, eating domains and BMI at baseline. By choosing these assessments, the researchers of the study were able to uniquely classify 5 predominant eating behaviors and test those relationship among other factors that may influence BMI. Multiple time points allowed us to examine data over time. Furthermore, we employed a longitudinal cross-lagged model analyses to signify the causal relationship between the study variables. This method allowed the researchers to determine the "future based on the past" and statistically assess how time may affect the interrelationships between variables.

Future Research

Our research study has provided first-hand evidence of a college student's relationship with their cognitive skills (interoception and self-regulation), their behavior (purposeful and non-purposeful eating domains), and weight status throughout an academic semester. To improve on our current study's limitations, future research is needed among males and females to examine if sex differences in these relationships exist and to improve generalizability of the findings. Also, collecting data from diverse communities should also be considered. Being able to generalize results are valuable, however, providing the opportunity to detect unique differences between populations may share a vital viewpoint on specific communities. Therefore, it would be beneficial to stratify future interpretations based on participant characteristics to gain distinctive knowledge within that area. Lastly, conducting objective measures on the study's topics may allow for less bias during interpretation of future studies.

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APPENDICES

Appendix 1. Recruitment Flyer

Appendix 2. Consent Form

FIU IRB Approval:	12/11/2020
FIU IRB Expiration:	12/11/2023
FIU IRB Number:	IRB-20-0556

FIU | FLORIDA INTERNATIONAL UNIVERSITY

ADULT ONLINE CONSENT TO PARTICIPATE IN A RESEARCH STUDY
Examining the Relationship of Interoception, Self-Regulation, Environmental Stress, Eating Domain, And Eating Outcomes in College Students.

SUMMARY INFORMATION

This study seeks to determine how a college student's interoception (defined as the perception of internal body sensations), self-regulation, eating domain, and stress influence their eating outcomes like intake, diet quality and weight management. In addition, the study seeks to determine if weight classification and gender affect student's decision-making regarding their eating behaviors.

Things you should know about this study:

- **Purpose:** The purpose of the study is to examine how interoception and self-regulation influence eating behaviors and eating outcomes under various levels of stress.
- **Procedures**: If you choose to participate, you will be asked to provide demographic information, self-reported height and weight measurements, complete an online survey, and a 7-day food journal, one-time per month for 3 months.
- **Duration:** This will take approximately 2 hours per timepoint (6 hours over a 3-month period).
- **Risks**: The main risk or discomfort from this research is being asked about sensitive topics including coping behaviors due to stress, eating behaviors, and mental and physical health outcomes.
- **Benefits:** There are no direct benefits from this study.
- **Alternatives:** There are no known alternatives available to you other than not taking part in this study.
- **Participation:** Taking part in this research project is voluntary.

Please carefully read the entire document before agreeing to participate.

PURPOSE OF THE STUDY

The purpose of the study is to examine how interoception and self-regulation influence eating behaviors and eating outcomes under various levels of stress.

NUMBER OF STUDY PARTICIPANTS

FIU IRB Approval:	12/11/2020
FIU IRB Expiration:	12/11/2023
FIU IRB Number:	IRB-20-0556

If you decide to be in this study, you will be one of 216 people in this research study.

DURATION OF THE STUDY

Your participation will involve approximately 2 hours per timepoint (6 hours for participation over a 3-month period).

PROCEDURES

If you agree to be in the study, we will ask you to do the following things:

1. Complete an online survey one time per month for 3 months. Questions will ask about your height and weight, your eating behaviors, and stress levels. The survey will take about an hour to complete.
2. Complete an online food journaling assignment for 7 days, one time per month for 3 months. Each journal entry will take approximately 30 per day to complete.

RISKS AND/OR DISCOMFORTS

The study has the following possible risks to you: there is minimal risk of becoming uncomfortable reflecting on the effects stress, your food access, and health behaviors, including mental and physical health.

BENEFITS

There are no direct benefits from this study.

ALTERNATIVES

There are no known alternatives available to you other than not taking part in this study. Any significant new findings developed during the course of the research which may relate to your willingness to continue participation will be provided to you.

CONFIDENTIALITY

The records of this study will be kept private and will be protected to the fullest extent provided by law. In any sort of report we might publish, we will not include any information that will make it possible to identify you. Research records will be stored securely and only the researcher team will have access to the records. However, your records may be inspected by authorized University or other agents who will also keep the information confidential.

USE OF YOUR INFORMATION

Identifiers about you might be removed from the identifiable private information and that, after such removal, the information could be used for future research studies or distributed to another

FIU IRB Approval:	12/11/2020
FIU IRB Expiration:	12/11/2023
FIU IRB Number:	IRB-20-0556

investigator for future research studies without additional informed consent from you or your legally authorized representative.

COMPENSATION & COSTS

You will be eligible to receive a total payment of $15 in a gift card and up to 6 SONA credit for your completed study participation. If you only complete the 1st appointment (baseline), you will be eligible for $1 gift card and 2 credits. If you complete baseline and the 2nd appointment, you will be eligible for $5 gift card and 4 credits. If you complete all 3 appointments, you will be eligible for the total payment of $15 and 6 credits. For those not participating in SONA, extra credit will be given instead of SONA credits. Extra credit amount will be at the professor's discretion. There are no costs to you for participating in this study.

RIGHT TO DECLINE OR WITHDRAW

Your participation in this study is voluntary. You are free to participate in the study or withdraw your consent at any time during the study. You will not lose any benefits if you decide not to participate or if you quit the study early. The investigator reserves the right to remove you without your consent at such time that he/she feels it is in the best interest.

RESEARCHER CONTACT INFORMATION

If you have any questions about the purpose, procedures, or any other issues relating to this research study you may contact Catherine Coccia Ph.D., R.D. at 11200 SW 8th Street. AHC5-316 Miami, FL 33174, 305-348-0194, ccoccia@fiu.edu.

IRB CONTACT INFORMATION

If you would like to talk with someone about your rights of being a subject in this research study or about ethical issues with this research study, you may contact the FIU Office of Research Integrity by phone at 305-348-2494 or by email at ori@fiu.edu.

PARTICIPANT AGREEMENT

I have read the information in this consent form and agree to participate in this study. I have had a chance to ask any questions I have about this study, and they have been answered for me. By clicking on the "consent to participate" button below I am providing my informed consent.

(Insert Consent to Participate Button Here on the Website)

Appendix 3. IRB Approval

FIU | FLORIDA INTERNATIONAL UNIVERSITY

Office of Research Integrity
Research Compliance, MARC 414

MEMORANDUM

To:	Dr. Catherine Coccia
CC:	Shante Jeune
From:	Elizabeth Juhasz, Ph.D., IRB Coordinator
Date:	December 11, 2020
Protocol Title:	"Examining the Relationship of Interoception, Self-regulation, Environmental Stress, Eating Domain, and Eating Outcomes in College Students"

The Social and Behavioral Institutional Review Board of Florida International University has approved your study for the use of human subjects via the **Expedited Review** process. Your study was found to be in compliance with this institution's Federal Wide Assurance (00000060).

IRB Protocol Approval #:	IRB-20-0556	**IRB Approval Date:**	12/11/20
TOPAZ Reference #:	109897	**IRB Expiration Date:**	12/11/23

As a requirement of IRB Approval you are required to:

1) Submit an IRB Amendment Form for all proposed additions or changes in the procedures involving human subjects. All additions and changes must be reviewed and approved by the IRB prior to implementation.
2) Promptly submit an IRB Event Report Form for every serious or unusual or unanticipated adverse event, problems with the rights or welfare of the human subjects, and/or deviations from the approved protocol.
3) Utilize copies of the date stamped consent document(s) for obtaining consent from subjects (unless waived by the IRB). Signed consent documents must be retained for at least three years after the completion of the study.
4) **Receive annual review and re-approval of your study prior to your IRB expiration date**. Submit the IRB Renewal Form at least 30 days in advance of the study's expiration date.
5) Submit an IRB Project Completion Report Form when the study is finished or discontinued.

HIPAA Privacy Rule: **N/A**

Special Conditions: **N/A**

For further information, you may visit the IRB website at http://research.fiu.edu/irb.

Appendix 4. Study Questionnaires

Multidimensional Assessment of Interoceptive Awareness (MAIA)

Below you will find a list of statements. Please indicate how often each statement applies to you generally in daily life.

	Circle one number on each line					
Never						**Always**
1. When I am tense I notice where the tension is located in my body.	0	1	2	3	4	5
2. I notice when I am uncomfortable in my body.	0	1	2	3	4	5
3. I notice where in my body I am comfortable.	0	1	2	3	4	5
4. I notice changes in my breathing, such as whether it slows down or speeds up.	0	1	2	3	4	5
5. I do not notice (I ignore) physical tension or discomfort until they become more severe.	0	1	2	3	4	5
6. I distract myself from sensations of discomfort.	0	1	2	3	4	5
7. When I feel pain or discomfort, I try to power through it.	0	1	2	3	4	5
8. When I feel physical pain, I become upset.	0	1	2	3	4	5
9. I start to worry that something is wrong if I feel any discomfort.	0	1	2	3	4	5
10. I can notice an unpleasant body sensation without worrying about it.	0	1	2	3	4	5
11. I can pay attention to my breath without being distracted by things happening around me.	0	1	2	3	4	5
12. I can maintain awareness of my inner bodily sensations even when there is a lot going on around me.	0	1	2	3	4	5
13. When I am in conversation with someone, I can pay attention to my posture.	0	1	2	3	4	5
14. I can return awareness to my body if I am distracted.	0	1	2	3	4	5

15. I can refocus my attention from thinking to sensing my body.	0	1	2	3	4	5
16. I can maintain awareness of my whole body even when a part of me is in pain or discomfort.	0	1	2	3	4	5

Please indicate how often each statement applies to you generally in daily life. Circle one number on each line

	Never					**Always**
17. I am able to consciously focus on my body as a whole.	0	1	2	3	4	5
18. I notice how my body changes when I am angry.	0	1	2	3	4	5
19. When something is wrong in my life I can feel it in my body.	0	1	2	3	4	5
20. I notice that my body feels different after a peaceful experience.	0	1	2	3	4	5
21. I notice that my breathing becomes free and easy when I feel comfortable.	0	1	2	3	4	5
22. I notice how my body changes when I feel happy / joyful.	0	1	2	3	4	5
23. When I feel overwhelmed I can find a calm place inside.	0	1	2	3	4	5
24. When I bring awareness to my body I feel a sense of calm.	0	1	2	3	4	5
25. I can use my breath to reduce tension.	0	1	2	3	4	5
26. When I am caught up in thoughts, I can calm my mind by focusing on my body/breathing.	0	1	2	3	4	5
27. I listen for information from my body about my emotional state.	0	1	2	3	4	5
28. When I am upset, I take time to explore how my body feels.	0	1	2	3	4	5

29. I listen to my body to inform me about what to do.	0	1	2	3	4	5
30. I am at home in my body.	0	1	2	3	4	5
31. I feel my body is a safe place.	0	1	2	3	4	5
32. I trust my body sensations.	0	1	2	3	4	5

Body Responsiveness Scale (BRS)

Not at all true — Always true of me

1 2 3 4 5 6 7

1. I am confident that my body will let me know what is good for me. _____
2. My bodily desires lead me to do things that I end up regretting. _____
3. My mind and body often want to do two different things. _____
4. I suppress my bodily feelings and sensations. _____
5. I 'listen' to my body to advise me about what to do. _____
6. It is important for me to know how my body is feeling throughout the day. _____
7. I enjoy becoming aware of how my body feels. _____

Self-Regulation of Eating Behavior Questionnaire (SREBQ)

Screening questions:

1. Do you find any of these foods tempting (that is, do you want to eat more of them than you think you should)? (Tick those which apply)

☐	Chocolate	☐	Fizzy drinks	☐	Pizza
☐	Crisps	☐	Biscuits	☐	Fried foods
☐	Cakes	☐	Sweets	☐	Chips
☐	Ice cream	☐	Popcorn	☐	Other foods
☐	Bread/toast	☐	Pastries	☐	I don't find any food tempting

If you have ticked other foods, please specify:

2. Do you intend NOT to eat too much of these foods you find tempting in the previous question?

☐ Yes
☐ No

3. Do you intend to have a healthy diet?

☐ Yes
☐ No

Self-Regulation of Eating Behaviour Questions:

4. Please read the following statements and tick the boxes most appropriate to you.
For the next few questions, please, understand that:
- 'Tempting foods' are any food you want to eat more of than you think your should.
- 'Eating intentions' refer to the way you are aiming to eat, for example you may intend to avoid tempting foods or eat healthy foods.

		Never	Rarely	Sometimes	Often	Always
1	I give up too easily on my eating intentions	□	□	□	□	□
2	I'm good at resisting tempting food	□	□	□	□	□
3	I easily get distracted from the way I intend to eat	□	□	□	□	□
4	If I am not eating in the way I intend to I make changes	□	□	□	□	□
5	I find it hard to remember what I have eaten throughout the day	□	□	□	□	□

Dutch Eating Behavior Questionnaire (DEBQ)

Questions	Seldom 1	2	3	4	Always 5
1. If you have put on weight, do you eat less than you usually do?					
2. Do you try to eat less at mealtimes than you would like to eat?					
3. How often do you refuse food or drink offered because you are concerned about your weight?					
4. Do you watch exactly what you eat?					
5. Do you deliberately eat foods that are slimming?					
6. When you have eaten too much, do you eat less than usual the following days?					
7. Do you deliberately eat less in order not to become heavier?					

8. How often do you try not to eat between meals because you are watching your weight?					
9. How often in the evening do you try not to eat because you are watching your weight?					
10. Do you take into account your weight with what you eat?					
11. Do you have the desire to eat when you are irritated?					
12. Do you have a desire to eat when you have nothing to do?					
13. Do you have a desire to eat when you are depressed or discouraged?					
14. Do you have a desire to eat when you are feeling lonely?					
15. Do you have a desire to eat when somebody lets you down?					
16. Do you have a desire to eat when you are cross?					
17. Do you have a desire to eat when you are approaching something unpleasant to happen?					
18. Do you get the desire to eat when you are anxious, worried or tense?					
19. Do you have a desire to eat when things are going against you or when things have gone wrong?					
20. Do you have a desire to eat when you are frightened?					
21. Do you have a desire to eat when you are disappointed?					
22. Do you have a desire to eat when you are emotionally upset?					
23. Do you have a desire to eat when you are bored or restless?					
24. If food tastes good to you, do you eat more than usual?					
25. If food smells and looks good, do you eat more than usual?					
26. If you see or smell something delicious, do you have a desire to eat it?					
27. If you have something delicious to eat, do you eat it straight away?					
28. If you walk past the baker do you have the desire to buy something delicious?					
29. If you walk past a snack bar or a cafe, do you have the desire to buy something delicious?					
30. If you see others eating, do you also have the desire to eat?					
31. Can you resist eating delicious foods?					
32. Do you eat more than usual, when you see others eat?					

33. When preparing a meal are you inclined to eat something?					

Three-factor Eating Questionnaire (TFEQ-R18)

Please read each statement and select from the multiple choice options the answer that indicates the frequency with which you find yourself feeling or experiencing what is being described in the statements below.

1. When I smell a delicious food, I find it very difficult to keep from eating, even if I have just finished a meal.
   Definitely true (4)/ mostly true (3)/ mostly false (2)/ definitely false (1)

2. I deliberately take small helpings as a means of controlling my weight.
   Definitely true (4)/ mostly true (3)/ mostly false (2)/ definitely false (1)

3. When I feel anxious, I find myself eating.
   Definitely true (4)/ mostly true (3)/ mostly false (2)/ definitely false (1)

4. Sometimes when I start eating, I just can't seem to stop.
   Definitely true (4)/ mostly true (3)/ mostly false (2)/ definitely false (1)

5. Being with someone who is eating often makes me hungry enough to eat also.
   Definitely true (4)/ mostly true (3)/ mostly false (2)/ definitely false (1)

6. When I feel blue, I often overeat.
   Definitely true (4)/ mostly true (3)/ mostly false (2)/ definitely false (1)

7. When I see a real delicacy, I often get so hungry that I have to eat right away.
   Definitely true (4)/ mostly true (3)/ mostly false (2)/ definitely false (1)

8. I get so hungry that my stomach often seems like a bottomless pit.
   Definitely true (4)/ mostly true (3)/ mostly false (2)/ definitely false (1)

9. I am always hungry so it is hard for me to stop eating before I finish the food on my plate.
   Definitely true (4)/ mostly true (3)/ mostly false (2)/ definitely false (1)

10. When I feel lonely, I console myself by eating.
    Definitely true (4)/ mostly true (3)/ mostly false (2)/ definitely false (1)

11. I consciously hold back at meals in order not to weight gain.
    Definitely true (4)/ mostly true (3)/ mostly false (2)/ definitely false (1)

12. I do not eat some foods because they make me fat.
    Definitely true (4)/ mostly true (3)/ mostly false (2)/ definitely false (1)

13. I am always hungry enough to eat at any time.
    Definitely true (4)/ mostly true (3)/ mostly false (2)/ definitely false (1)

14. How often do you feel hungry?
Only at mealtimes (1)/ sometimes between meals (2)/ often between meals (3)/almost always (4)

15. How frequently do you avoid "stocking up" on tempting foods?
Almost never (1)/ seldom (2)/ moderately likely (3)/ almost always (4)

16. How likely are you to consciously eat less than you want?
Unlikely (1)/ slightly likely (2)/ moderately likely (3)/ very likely (4)

17. Do you go on eating binges though you are not hungry?
Never (1)/ rarely (2)/ sometimes (3)/ at least once a week (4)

18. On a scale of 1 to 8, where 1 means no restraint in eating (eating whatever you want, whenever you want it) and 8 means total restraint (constantly limiting food intake and never "giving in"), what number would you give yourself?

Intuitive Eating Scale-2 (IES-2)

For each item, please circle the answer that best characterizes your attitudes or behaviors. (note to experimenter: use "check" in lieu of "circle" if survey is online)

1. **I try to avoid certain foods high in fat, carbohydrates, or calories.**

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

2. **I have forbidden foods that I don't allow myself to eat.**

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

3. **I get mad at myself for eating something unhealthy.**

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

4. **If I am craving a certain food, I allow myself to have it.**

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

5. **I allow myself to eat what food I desire at the moment.**

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

6. **I do NOT follow eating rules or dieting plans that dictate what, when, and/or how much to eat.**

1	2	3	4	5

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

7. **I find myself eating when I'm feeling emotional (e.g., anxious, depressed, sad), even when I'm not physically hungry.**

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

8. **I find myself eating when I am lonely, even when I'm not physically hungry.**

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

9. **I use food to help me soothe my negative emotions.**

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

10. **I find myself eating when I am stressed out, even when I'm not physically hungry.**

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

11. **I am able to cope with my negative emotions (e.g., anxiety, sadness) without turning to food for comfort.**

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

12. **When I am bored, I do NOT eat just for something to do.**

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

13. **When I am lonely, I do NOT turn to food for comfort.**

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

14. **I find other ways to cope with stress and anxiety than by eating.**

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

15. **I trust my body to tell me when to eat.**

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

16. **I trust my body to tell me what to eat.**

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

17. **I trust my body to tell me how much to eat.**

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

18. **I rely on my hunger signals to tell me when to eat.**

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

19. **I rely on my fullness (satiety) signals to tell me when to stop eating.**

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

20. **I trust my body to tell me when to stop eating.**

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

21. **Most of the time, I desire to eat nutritious foods.**

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

22. **I mostly eat foods that make my body perform efficiently (well).**

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

23. **I mostly eat foods that give my body energy and stamina.**

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Demographics Questionnaire

1. Age: _____
2. Gender:
    a. Male
    b. Female
    c. Non-binary/Third gender
    d. Other (Please specify): _____
3. What is your marital status?
    a. Never married
    b. Married
    c. Divorced
    d. Separated
    e. Widowed
4. What is your classification in college?
    a. Freshman
    b. Sophomore
    c. Junior
    d. Senior
    e. Graduate student
    f. unclassified
5. Did you begin college here or have you transferred from another college?
    a. Started here

b. Transferred

6. Where do you now live during the school year?
    a. dormitory or other campus housing
    b. residence (house, apartment, etc.) within walking distance of the institution
    c. residence (house, apartment, etc.) within driving distance
    d. fraternity or sorority house
7. With whom do you live during the school year? (Fill in all that apply)
    a. no one, I live alone
    b. one or more other students
    c. my spouse or partner
    d. my child or children
    e. my parents
    f. other relatives
    g. friends who are not students at the institution I'm attending
    h. other people (Please specify): _____
8. Which of these fields best describes your major, or your anticipated major? You may indicate more than one if applicable.
    a. Agriculture
    b. Biological/life sciences (biology, biochemistry, botany, zoology, etc.)
    c. Business (accounting, business administration, marketing, management, etc.)
    d. Communication (speech, journalism, television/radio, etc.)
    e. Computer and information sciences
    f. Education
    g. Engineering
    h. Ethnic, cultural studies, and area studies
    i. Foreign languages and literature (French, Spanish, etc.)
    j. Health-related fields (nursing, physical therapy, health technology, etc.)
    k. History
    l. Humanities (English, literature, philosophy, religion, etc.)
    m. Liberal/general studies
    n. Mathematics
    o. Multi/interdisciplinary studies (international relations, ecology, environmental studies, etc.)
    p. Parks, recreation, leisure studies, sports management Physical sciences (physics, chemistry, astronomy, earth science, etc.)
    q. Pre-professional (pre-dental, pre-medical, pre-veterinary)
    r. Public administration (city management, law enforcement, etc.)
    s. Social sciences (anthropology, economics, political science, psychology, sociology, etc.)
    t. Visual and performing arts (art, music, theater, etc.) Undecided
    u. Other, please specify: _____
9. Did either of your parents graduate from college?
    a. no
    b. yes, mother only
    c. yes, father only
    d. yes, both parents
    e. don't know
10. How many credit hours are you taking this term?
    a. 1-3

b. 4-6
c. 7-11
d. 12-14
e. 15 or more

11. Do you have a job?
    a. yes
    b. no
12. If yes, please specify: _____
13. If yes, how many hours do you work per week?
    a. 0-10
    b. 11-20
    c. 21-30
    d. 31-40
    e. 41 or above
14. If you have a job, how does it affect your school work?
    a. I don't have a job
    b. My job does not interfere with my school work
    c. My job takes some time from my school work
    d. My job takes a lot of time from my school work
15. What is your racial identification? (Fill in all that apply)
    a. American Indian or other Native American
    b. Asian or Pacific Islander
    c. Black or African American
    d. Caucasian
    e. Other (please specify): _____
16. Are you of Hispanic, Latino, or Spanish origin?
    a. yes
    b. no

For your reference, we have included an FIU student resource for those experiencing depression, anxiety, or any other associated feelings:

- Counseling & Psychological Services (CAPS)
    - 305-348-2277
    - MMC-SHC 270
    - BBC-WUC 320

VITA

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PRESENTATIONS AND PUBLICATIONS

Jeune SC, Coccia C, Graziano, P. The Role of Self-regulation on Eating Behavior and Obesity Risk: A Systematic Review. *J Health Psychol*. Under Review - Submitted April 2022.

Jeune SC, Dick A, Graziano P, Coccia C. The Healthy Eating Index and its' Association Between Mental Health and Eating Behaviors in College Students. Paper accepted at the annual AND Virtual Food & Nutrition Conference and Expo, October 2022.

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Coccia C, Jeune SC, Lovan P, Dick A, Graziano P. Family Food Insecurity and Child Nutrition During COVID-19: Examining Latino Families' Response to the Pandemic. Paper presented at the annual AND Virtual Food & Nutrition Conference and Expo, October 2021.

Jeune SC, Dick A, Graziano P, Coccia C. The Comparison of Healthy Eating Index (HEI) Scores Between Elementary School Children with and without Attention-Deficit/Hyperactivity Disorder (ADHD). Paper presented at the annual AND Virtual Food & Nutrition Conference and Expo, October 2021.

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Rivera CM, Jeune, SC, Frazier S, Coccia C. The Family Meal Project: Assessing the Relationship between Healthy Food Consumption and School Lunch Intake in Elementary School Children.

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Jeune SC, Hamil C, Frazier S, Coccia C. The Family Meal Project: Assessing the Relationship between Family Priorities and Routines to their Child's Eating Preferences. Paper presented at the annual SNEB Virtual Conference, July 2020.

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