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An Exploration of Assessments, Predictors, and Models of Uncontrolled Eating in Youth

A dissertation submitted in partial satisfaction of the requirements for the degree

Doctor of Philosophy

in

Clinical Psychology

by

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The dissertation of Michael Anthony Manzano is approved, and it is acceptable in quality and form for publication on microfilm and electronically.

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DEDICATION

This dissertation is dedicated to my grandmother, Gloria Reyes Manzano, without whom I would not be the researcher, clinician, or person I am today. Her unwavering support of my passions and immense pride in my academic pursuits will never be forgotten.

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ABSTRACT OF THE DISSERTATION

An Exploration of Assessments, Predictors, and Models of Uncontrolled Eating in Youth

by

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Rationale: Overeating is a significant driver of current pediatric obesity rates; however, overeating encompasses a range of behaviors. Moreover, many overeating assessments are conceptualized as assessing distinct constructs simply because they use differing terminology. The uncontrolled eating model proposes a framework by

which a variety of related overeating behaviors can be subsumed under the spectrum of "uncontrolled eating," which ranges from normative overeating to loss of control (LOC) eating but has not been validated in youth.

Methods: This 3-paper dissertation evaluated the concordance of several measures of the least severe form of uncontrolled eating (*i.e.,* cue responsive eating) in school-age youth, explored the frequency and predictors of a range of uncontrolled eating behaviors in adolescents utilizing ecological momentary assessment, and evaluated a model of uncontrolled eating in pediatric samples.

Results: Study 1 (published; *N*=111; mean age=10.6, 70% female) evaluated the psychometric properties of and concordance among five measures of cue responsive eating in school age youth with overweight/obesity (OW/OB) and found little concordance. Study 2 (*N*=157; mean age=14.9, 57.2% female) demonstrated cue responsive eating and LOC, particularly the former, are common in adolescents with OW/OB, and found that neither negative affect nor stress consistently predicted uncontrolled eating behaviors. Study 3 (*N*=458) provided preliminary validation of a model of uncontrolled eating in youth with OW/OB, with models in school age youth (*N*=310; mean age=10.0, 53.2% female; $\chi^2 = 6476.2$, df = 2481, $p < .001$, RMSEA = .072) and adolescents (*N*=148; mean age=14.9, 56.8% female; $\chi^2 = 4827.7$, df = 2770, $p < .001$, RMSEA = .068) demonstrating good model fit.

Discussion: This research contributes to the literature by questioning the construct validity of several well-established measures said to capture aspects of cue responsive eating, in addition to questioning the extent to which negative affectivity precedes the range of uncontrolled eating behaviors, including LOC, in adolescents.

This also contributes to the literature by providing the first preliminary validated model of uncontrolled eating in youth with OW/OB and underscores the interconnected nature of “distinct” overeating behaviors. This work highlights that adult models of eating behavior may not fit for youth and may inform clinical practice by providing a greater understanding of the range of uncontrolled eating behaviors in youth.

INTRODUCTION

While recognized as a public health crisis for decades, the prevalence of pediatric obesity in the United States remains unabated, with rates of 17.9% and 20.6% found in school-age children and adolescents, respectively, and even further insult demonstrated as the result of the SARS-CoV-2 pandemic (Ogden et al., 2018; Yusuf et al., 2019; Ogden et al., 2020; Browne et al., 2021; Lange et al., 2021). This is concerning given obesity in youth most often persists into adulthood (Kumar & Kelly, 2017). Moreover, adults with obesity are at greater risk for hypertension, type 2 diabetes mellitus, hypercholesterolemia, lower overall physical fitness, and all-cause mortality (Darsini et al., 2020; Veronese et al., 2016). Whereas young children are infrequently diagnosed with many of these physical health ailments due to the time necessary for chronic conditions to manifest, differences in physical and mental health outcomes for youth with obesity are known to emerge throughout development, particularly in adolescence (Mak et al., 2010; Kumar & Kelly, 2017; Twig et al., 2019; Rankin et al., 2016). Despite advances in understanding the genetic and endocrine factors that influence body weight, the role of eating behaviors remains incontrovertible (Santos & Cortés, 2020; Russo et al., 2010; Begg & Woods, 2013).

The Role of Eating Behaviors in Obesity

Eating behaviors are known to develop early in the life course (Birch & Fisher, 1998; Oliveira et al., 2015; Story et al., 2002; Kral & Rauh, 2010). While a variety of eating behaviors have been studied, overeating (*i.e.,* excessive caloric consumption) remains the primary behavior associated with obesity (Romieu et al., 2017; Hill et al., 2008) and weight gain (van Strien et al., 2012; Drapeau et al., 2003). Moreover, it has

also long been demonstrated that children of higher weight statuses, as compared with children of a healthy weight, have a decreased ability to regulate energy intake (Johnson & Birch, 1994; Kininmonth et al., 2021). Thus, early identification of maladaptive eating behaviors in youth with obesity is critical so as to intervene when behaviors are susceptible to change (Magarey et al., 2016; Scaglioni et al., 2011).

Current Issues with Overeating Terminology

A lack of clear operationalizations of constructs has long plagued the study of overeating. The following are just some of the terms for specific forms of overeating that have been proposed to date: *external eating, food cue responsiveness, reward-based eating, hedonic eating, emotional eating, loss of control eating, binge eating, food cravings, disinhibited eating, emotional eating,* and *food addiction*. Subsequently, dozens of assessments were developed to assess these purportedly distinct forms of overeating. However, most measures were developed in adult populations and empirical evaluation of the uniqueness, or not, of these overeating constructs in youth remains to be seen. The limited work that has explored the convergent and discriminant validity of these measures in adults has found that questionnaires assessing the above mentioned constructs are typically correlated at or above r>.50 (Vainik et al., 2015; Price et al., 2015; A. E. Mason et al., 2017). Interestingly, Vainik et al. (2019) points out that despite r>.50 being used as a standard threshold for the convergent validity of new measures, when this threshold is met or far exceeded newly developed measures still mistakenly claim to be assessing something novel. Thus, it is possible that eating behavior measurement developers have fallen prey to the “jangle fallacy,” which is the erroneous assumption that two things are different because they have a different name

(Vainik & Meule, 2018). Taken together, many of these measures may not be measuring different constructs, and very few have been tested for reliability and validity in youth. The evaluation of construct validity is particularly difficult if clear operational definitions of latent constructs are not available.

Major Constructs Related to Overeating

There are a variety of overlapping constructs related to varying aspects of overeating identified in the literature. As described earlier, these domains are presently considered *distinct*, with a myriad of terminology used to describe overeating behaviors. This section will operationalize each major overeating construct, describe the overlap between constructs, and detail the assessment measures for each major construct.

Table I.1: Overview of Major Constructs Related to Overeating and Related Assessments in Youth

Construct	Definition	Related Assessments
Cue Responsive Eating	Eating in response to the physiological and/or psychological arousal that result from food cues.	Child Eating Behavior Questionnaire (Wardle et al., 2001)
Emotional Eating	Eating in response to negative emotions.	Emotional Eating Scale-Child (Tanofsky-Kraff et al., 2007)
Food Craving	Eating driven by physiological and/or psychological motivational states that promote consumption.	Food Craving Questionnaire-Trait (Cepeda-Benito et al., 2000)
Hedonic Eating	Eating due to the anticipated pleasure that will result from eating, driven in part by the increased reinforcing value of food.	Child- Power of Food Scale (Laurent, 2015)
Loss of Control Eating	Eating is response to a pathological drive to eat that is experienced as an inability to control consumption.	Youth- Eating Disorder Examination (Goldschmidt et al., 2007)
Reward-Based Eating	Eating driven by the predicted anticipated reward from eating, typically accompanied by a preoccupation with food and/or lack of satisfaction.	Reward-Based Eating Drive Scale (Epel et al., 2014)

Cue Responsive Eating. Broadly, cue responsive eating is characterized by eating in response to food cues, such as the sight or smell of food. Using this definition, the term food cue responsive (FCR) eating falls under this domain and is used in the literature. FCR is defined as eating in response to the physiological and/or psychological arousal that results from being exposed to food cues (Kanoski & Boutelle, 2022). Psychological arousal includes cognitive responses, such as memories of past eating events, increased attention bias toward food cues, or food preoccupation (Parent et al., 2022; Hou et al., 2011; Hardman et al., 2013). Physiological responses include changes in cardiac, endocrine, and gastrointestinal functioning as the result of food cues (Lasschuijt et al., 2020; Smeets et al., 2010).

The behavioral susceptibility theory of obesity proposes FCR as a central appetitive mechanism which results from the interaction of genetic and environmental factors and is a known risk factor for the development and maintenance of obesity (Carnell & Wardle, 2007; Boutelle et al., 2020; Larsen et al., 2012; van den Akker et al., 2014; Schüz et al., 2015). Heightened FCR has been demonstrated in young children and is stable throughout childhood (Carnell & Wardle, 2008; Northstone & Emmett, 2008). Indeed, FCR is known to emerge as early as infancy, with maternal-reported measures of FCR in infants as young as 3-months being predictive of subsequent weight gain (Llewellyn et al., 2011; van Jaarsveld et al., 2011), in addition to being associated with an increased preference for food versus non-food stimuli (Buvinger et al., 2017). Moreover, heightened FCR is posited as a moderating factor that interacts with the modern “obesogenic” environment leading to excess calorie consumption in youth (Carnell & Wardle, 2008; Sadler et al., 2021).

While genetic predispositions greatly influence individuals' *risk* for engaging in overeating behaviors, *responsiveness* to food cues is learned and develops through Pavlovian and operant conditioning when the presence of food, memories of foods, advertisements, or even situational factors such as time of day or location become conditioned stimuli that elicit physiological, psychological, and neurological changes that promote increased food intake (Belfort-DeAguiar & Seo, 2018; Boutelle & Bouton, 2015; Jansen et al., 2003). Cephalic phase responses are particularly relevant and include innate physiological responses (*e.g.,* heart rate variability, salivation, endocrine changes) to sensory signals related to food that prepare the gastrointestinal tract for digestion (Smeets et al., 2010; van der Waal et al., 2021; Verastegui-Tena et al., 2017). Research has linked FCR to increased cephalic phase responses and neural activation of motivation and reward circuitry (Ferriday & Brunstrom, 2011; Bruce et al., 2010).

Two questionnaires have been developed to assess cue responsive eating in youth. Jane Wardle and colleagues developed the Child Eating Behavior Questionnaire (CEBQ)(Carnell & Wardle, 2007; Wardle et al., 2001), which utilizes parent report of their child's eating behaviors across eight domains- food responsiveness, enjoyment of food, emotional overeating, desire to drink, satiety responsiveness, slowness in eating, emotional undereating, and food fussiness. The Eating in the Absence of Hunger Questionnaire for Children and Adolescents (EAH-C) measures beginning or continuing to eat when physically sated, and includes three subscales- negative affect, external eating, and fatigue boredom (Tanofsky-Kraff et al., 2008). The EAH-C is said to indirectly assess cue responsive eating given all eating is said to take place when not

physiologically hungry, indicating the eating is driven by external factors, in addition to there being an explicitly defined external eating subscale.

In addition to questionnaires, behavioral paradigms have also been utilized to assess cue responsive eating. One of the earliest assessments of cue responsive eating is the eating in the absence of hunger (EAH) ad libitum eating paradigm (Fisher & Birch, 2002; Faith et al., 2006; Shomaker et al., 2010). While methodologies differ slightly, the task is generally set up as a pseudo taste test task. Children are given a meal and told to eat until comfortably full, then following a break are given free access to several highly palatable foods. These foods are weighed, and the outcome is number of calories consumed, types of foods consumed, or both. Physiological drive (*i.e.,* state-hunger) is controlled for as children are sated as part of this task. While informative, the time and resources required to administer the EAH task has restricted its use to exclusively academic research laboratories, limiting the ability of the measure to be used more broadly.

Another behavioral assessment of cue responsive eating is a food exposure paradigm that measures cephalic phase responses to the presentation of highly palatable foods (Nederkoorn et al., 2000; Boutelle et al., 2015). Participants are told to sit quietly for three brief intervals; 1) baseline phase-where the participant sits quietly, 2) exposure phase-where food is presented and the participant holds and smells the food, and 3) recovery phase-where the food is taken away and the participant sits quietly. Self-reported cravings are rated by the participant every 30 seconds during the exposure phase. Changes between food and nonfood intervals can be used as an indicator of physiological responsiveness to the food, with heart rate and heart rate

variability indices (*e.g.,* power frequencies, beat to beat R-R interval time series derived values) often being used (Nederkoorn et al., 2000; Kuoppa et al., 2016). Similar to the EAH task, the time and resources this paradigm requires have made the assessment tool informative but limited in use.

Hedonic Eating. Hedonic eating is considered eating driven by pleasure (Lowe & Butryn, 2007). More specifically, hedonic eating is defined as eating due to the *anticipated* pleasure that will result from eating, driven in part by the reinforcing value of food. Using this operationalization, reward-based eating falls under this major construct. Reward-based eating is defined as eating characterized by an excessive drive to eat outside of homeostatic hunger that is coupled with preoccupation with food and/or feelings of lack of satisfaction or satiation (Epel et al., 2014). Epel et al. (2014) acknowledged this behavior's overlap with hedonic eating, while also attempting to create a new term that emphasized neural findings implicating reward circuitry in hedonic eating. Given the significant overlap between currently accepted definitions of hedonic eating and reward-based eating, the terms can be used interchangeably. The term hedonic eating will be used to encompass both moving forward.

Hedonic eating in adolescents has been prospectively associated with unhealthy eating and drink consumption broadly, in addition to being specifically associated with increased consumption of foods high in fat and starch (Mason et al., 2020; Bejarano & Cushing, 2018). Moreover, in a sample of youth ages 8-17 years old, increases in hedonic eating were associated with increases in age and sex adjusted body weight values (Fox et al., 2021). A recent mechanistic study found higher levels of hedonic

eating were associated with increased weight status in adolescents, with this pathway being mediated by increased caloric consumption (Kaur & Jensen, 2022).

There exist three self-report measures to assess this construct. First, the Power of Food Scale (PFS) was developed by Michael Lowe shortly after proposing his conceptualization of hedonic eating (Lowe et al., 2009; Lowe & Butryn, 2007). A child specific adaptation was later created that used more developmentally appropriate language (Laurent, 2015; Stone et al., 2020). The PFS has 3 subscales indicating differing levels of proximity to food, including food available, food present, and food tasted. The Food Craving Questionnaire (FCQ) is another self-report questionnaire which assesses cravings for food, which is defined as food-cue elicited expectations for the pleasure that accompanies consumption of a desired food (Cepeda-Benito et al., 2000). The FCQ has 8 subscales, including intentions/plans to consume food, anticipation of positive reinforcement from eating, anticipation of relief from negative states around eating, lack of control over eating, cognitive preoccupation with food, craving as a physiological state, emotions around food cravings or eating, cues that may trigger food cravings, and guilt from cravings. While developed in adults, there has been initial validation of the measure in a sample of 5th grade students with a mean age of 10 years old (Jeong et al., 2017). Lastly, the Reward-Based Eating Scale (RED; Epel et al., 2014) was developed using items drawn from existing, older questionnaires including the Three Factor Eating Questionnaire (Stunkard & Messick, 1985), the Dutch Eating Behavior Questionnaire (van Strien et al., 1986), and the Binge Eating Scale (Gormally et al., 1982). The RED was developed to assess individuals' susceptibility to overeating due to the reinforcing nature of food more broadly than the PFS. The RED

scale has 3 subscales- lack of control, lack of satiation, and preoccupation with food. The RED has not been validated in pediatric samples.

Emotional Eating. Emotional eating was originally described as eating solely due to negative emotions, with more recent work suggesting emotional eating can also occur in response to positive emotions as well (Cardi et al., 2015). However, for the present study, emotional eating is defined as eating in response to negative emotions, given the direction of emotional eating in response to positive emotions remains unclear (van Strien et al., 2013). Emotional eating is believed to emerge during childhood and adolescence (Nguyen-Rodriguez et al., 2009) and has been implicated as an important potential mediator between emotional states and both overeating and loss of control eating (see below) (Michels et al., 2012; Goossens et al., 2009). Moreover, emotional eating has been associated with obesity and weight gain (Faith et al., 1997; Koenders & van Strien, 2011), with this relationship also emerging during childhood (Belcher et al., 2011; Geliebter & Aversa, 2003).

Several assessments measuring emotional eating in youth have been developed. The Emotional Eating Scale (EES) was developed for use in adult populations assessing eating in response to negative affect, but was later validated in pediatric samples (Arnow et al., 1995; Tanofsky-Kraff et al., 2007). While not the sole focus of the measure, the Child Eating Behavior Questionnaire (Wardle et al., 2001) contains an emotional eating subscale which assesses eating due to negative emotions. Similarly, the Eating in the Absence of Hunger Questionnaire for Children and Adolescents (EAH-C) includes a negative affect subscale, including eating when sad/depressed, angry/frustrated, and anxious/nervous (Tanofsky-Kraff et al., 2008).

Loss of Control Eating. Of all the currently described major overeating constructs, loss of control eating has been the most well defined, in large part due to operational definitions that are needed for the diagnosis of eating disorders in the American Psychiatric Associations Diagnostic and Statistical Manual (American Psychiatric Association, 2022). Loss of control eating is a disordered eating behavior characterized by feeling unable to stop or control how much one is eating (Fairburn & Wilson, 1993). Loss of control eating is present in approximately 25-30% of youth living with overweight and obesity and is a well-established risk factor for the development of binge eating disorder and obesity in adulthood (He et al., 2017; Tanofsky-Kraff et al., 2020).

Child and adolescent loss of control eating can be assessed using a host of validated assessment instruments. The most commonly used instrument is the Eating Disorder Examination (EDE), which exists in both clinical interview and self-report questionnaire (EDE-Q) formats (Fairburn & Wilson, 1993; Fairburn & Beglin, 1994). Shortly after they were originally developed, the EDE and EDE-Q were adapted for use among children and adolescents (Bryant-Waugh et al., 1996). Notably, loss of control eating is assessed dichotomously in these measures, with outcomes being a frequency of days in which loss of control is present or not. The Questionnaire on Eating and Weight Patterns-5 (QEWP-5) is a screening measure which asks items that parallel each of the Diagnostic and Statistical Manual-5th edition (DSM-5) criteria for binge eating disorder, and was adapted for use in youth (Yanovski et al., 2015; Altman et al., 2020). The Loss of Control Eating Scale (LOCES) is a 24-item self-report scale assessing various thoughts, behaviors, and feelings around loss of control eating, which

was later truncated and validated for use in early-adolescents (Latner et al., 2014; Vannucci & Ohannessian, 2018).

Binge Eating. A binge is a specific subtype of overeating, which includes loss of control while consuming an objectively large amount of food. The DSM-5 diagnostic criteria for binge eating disorder includes binge eating episodes at least one time a week for 3 months, and is accompanied by associated features including secrecy, guilt or distress around eating, or eating in the absence of hunger (American Psychiatric Association, 2022). Given binge eating represents a certain presentation of loss of control eating, the same measures are typically used to assess both, with binge eating requiring a large amount of food consumed along with loss of control. It should be noted that while the current diagnostic criteria for binge eating disorder includes a volume of food requirement, it remains to be elucidated whether this particular aspect of binge eating is clinically relevant or important to distinguish, particularly in children and adolescents (Pratt et al., 1998; Marcus & Kalarchian, 2003; Shomaker, Tanofsky-Kraff, Elliott, et al., 2010; Bohon, 2019).

Together, cue responsive eating, hedonic eating, emotional eating, loss of control eating, and binge eating are all important aspects of overeating that have key similarities and differences. However, the lack of clear operational definitions of many of these constructs up to this point, in addition to the lack of conceptual models that explain the relationships among these related constructs, has plagued overeating measure development. Thus, alternate assessment approaches that clearly define terminology, rigorously evaluate assessments' reliability and validity, and include the full range of overeating behaviors may be helpful in advancing our understanding of

overeating, particularly with respect to how these various types of overeating are related in pediatric samples.

Alternate Assessment Approaches and Considerations

Current questionnaires, interviews, and behavior paradigms described above suffer from a variety of reliability and external validity issues. With respect to reliability, eating behaviors are highly variable given their frequency; thus, an assessment at a single timepoint is unlikely to fully capture this variability. With respect to validity, individuals of all ages are notoriously poor reporters of their own eating behavior (Archer et al., 2013; Ioannidis, 2013; Archer et al., 2015). While no methodological approach is likely to account for all of the variance in overeating, ecological momentary assessment (EMA) holds great promise in addressing many of the current assessment concerns. The potential utility of EMA in assessing overeating behaviors, in addition to more broad reliability and validity considerations will be further described.

Ecological Momentary Assessment (EMA)

EMA is an assessment approach that utilizes iterative, naturalistic data collection in an effort to gather data that are potentially more representative of phenomena than a single administration of a self-report measure and allows for closer examination of within person effects (Shiffman et al., 2008; Stone & Shiffman, 1994). Thus, EMA is characterized by three main factors: (1) data are collected in individuals' natural environment, (2) assessments are repeatedly administered over a specified time period, and (3) assessment items must ask about current or very recent states. In addition to potential benefits to assessment reliability and validity, EMA allows for a more nuanced

exploration of associations between constructs, including the analysis of temporal associations among constructs (Shiffman et al., 2008; Shiffman, 2009).

Temporal Effects of Affect and Stress on Overeating Behaviors. EMA allows for modelling of within person variability that enables comparison of individuals to themselves, in effect functioning as their own "control" over time (Russell & Gajos, 2020). This allows for greater causal inference than traditional between subject approaches, which can be greatly informative in identifying predictors of overeating behaviors. EMA studies in adults have consistently found negative affect as a predictor of loss of control eating (Berg et al., 2015; Goldschmidt et al., 2012; Smith et al., 2018; Berg et al., 2014; Goldschmidt et al., 2014). However, there remains a dearth of definitive empirical data surrounding momentary antecedents of loss of control eating in youth. A recently proposed developmental framework for binge eating based on loss of control eating names negative affectivity (*e.g.*, negative emotions and stress) as an antecedent to loss of control eating in youth (Tanofsky-Kraff et al., 2020). Interestingly, although few EMA studies have investigated loss of control eating in youth, these studies have failed to demonstrate this relationship (Goldschmidt et al., 2018; Hilbert et al., 2009; Ranzenhofer et al., 2014). Moreover, these EMA studies excluded both older adolescents (*i.e.,* teens older than 14 years of age) and males, limiting generalizability. This highlights that while EMA has many benefits, issues of sample representativeness and not imposing findings in adults onto pediatric samples without empirical evidence, which exists across methodologies, remains important to consider with EMA.

Few prospective studies have investigated the associations between various overeating behaviors, affect, and stress in youth. Cross-sectionally, negative affect and

social stress are more prevalent in youth who experience loss of control eating (Byrne et al., 2019; Shomaker, Tanofsky-Kraff, Elliott, et al., 2010) and higher levels of social stress and anxiety were associated with increased food intake during a laboratory test meal (Shank et al., 2017). EMA studies that allow for nuanced investigation of temporal associations between affect, stress, and eating are greatly needed in pediatric samples to more fully understand causality among these domains that are known to interact. Moreover, greater understanding of the temporal associations between these domains can inform which should be targeted when attempting to decrease resulting uncontrolled eating behaviors, specifically in pediatric samples.

Psychometric Properties

Testing the reliability and validity of assessment measures is critical to ensuring assessments are both statistically precise and measuring their intended constructs (Mead, 2019). Moreover, reliability and validity are not to be tested once, but rather they must be tested whenever the measure is being applied to a new population (*e.g.,* age, disease population, racial/ethnic identity). This step is often neglected, which has further implications on later model testing. Undefined measurement error increases the amount of unexplained model error, which limits the predictive validity of a given model. Thus, the goal of every measure is one that limits unexplained error while maintaining its construct validity. Although EMA holds promise, based on its iterative data structure, the reliability and validity of EMA data are challenging to assess.

Taken together, EMA is uniquely able to investigate predictors of overeating behaviors, particularly with respect to how negative affect and stress influence these behaviors. However, two issues persist. Findings from EMA studies in adult samples

have not been replicated in youth and thus require further investigation. Additionally, while predictors of overeating behaviors have been explored, associations among related overeating behaviors and how to conceptualize these associations remain to be explored and empirically tested.

Combining Overeating Concepts

Beyond assessment considerations, current models of overeating behaviors have failed to make clear the relationships between related eating behaviors. A recently described model of *uncontrolled eating* has been proposed that may represent an important step forward in conceptualizing and defining related overeating behaviors, as well as clarifying how these behaviors are related.

Model of Uncontrolled Eating

As has been described, a myriad of purportedly unique overeating behaviors have been proposed, and related measures have been developed to capture the range of these behaviors in youth. An burgeoning model of “uncontrolled eating” suggests these overeating behaviors may represent differing levels of *severity* or *intensity* of the singular, higher order construct (Vainik et al., 2015, 2019). Vainik’s uncontrolled eating model holds promise in both clinical and research domains. Clinically, providers and patients alike could conceptualize related behaviors as one construct as opposed to several. From a research perspective, elucidating an overarching construct could facilitate simplified terminology and allow for the use of greater shared language among researchers studying related appetitive concepts.

In this framework, uncontrolled eating represents a spectrum of behaviors, starting with “impulsive” eating which is marked by occasional and perhaps normative

overeating. “Power of food” and “emotional eating,” represent increased levels of severity due to the fact that pleasure and emotions influence these eating constructs independent of true physiological hunger. The most severe end of the spectrum includes “disinhibition” and “binge eating,” which is characterized by loss of control eating and binge eating episodes. Thus, this model of uncontrolled eating captures the range of normative overeating to binge eating, and all overeating behaviors in between.

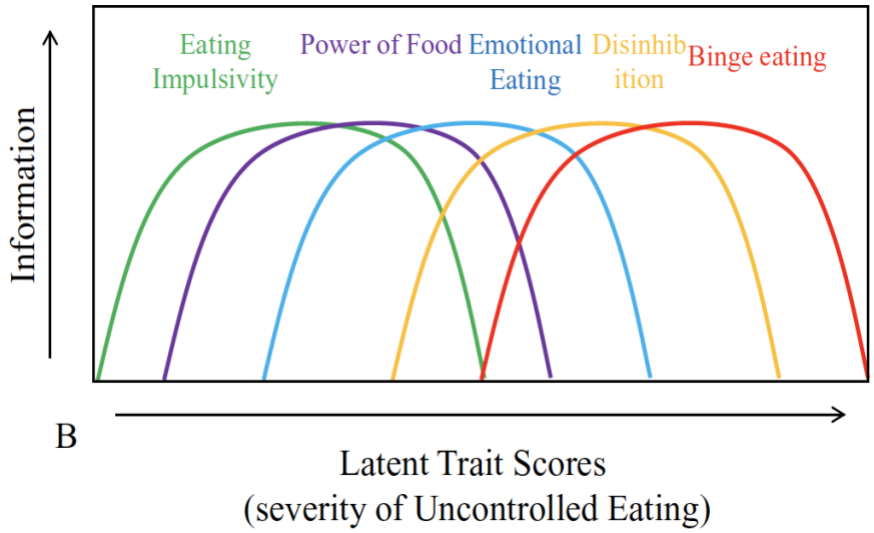

Figure I.1: Visual depiction of the uncontrolled eating model, from Vainik et al. (2015).

Drawing upon past work (Appelhans, 2009; Alonso-Alonso & Pascual-Leone, 2007; Hofmann et al., 2009), Vainik conceptualized eating behaviors as the result of a “dualistic interplay between a bottom-up, hedonic appetitive system and top-down, goal-driven control” (Vainik et al., 2013). Said another way, overeating is the result of an increased appetite for food that overrides self-control mechanisms. The differing levels of severity were meant to include the full range of reasons uncontrolled eating occurred (*i.e.,* due to food cues, food cognitions, emotions, and psychopathology). Additionally, while exploratory in nature, after initial development of his model of uncontrolled eating, Vainik went on to propose psychological constructs he conceptualized as being related

and/or predictive of uncontrolled eating behaviors, with negative emotionality (*e.g.,* psychological stress and negative affect) as one of the predictive constructs. Similarities and differences between each of these levels of severity will be further described.

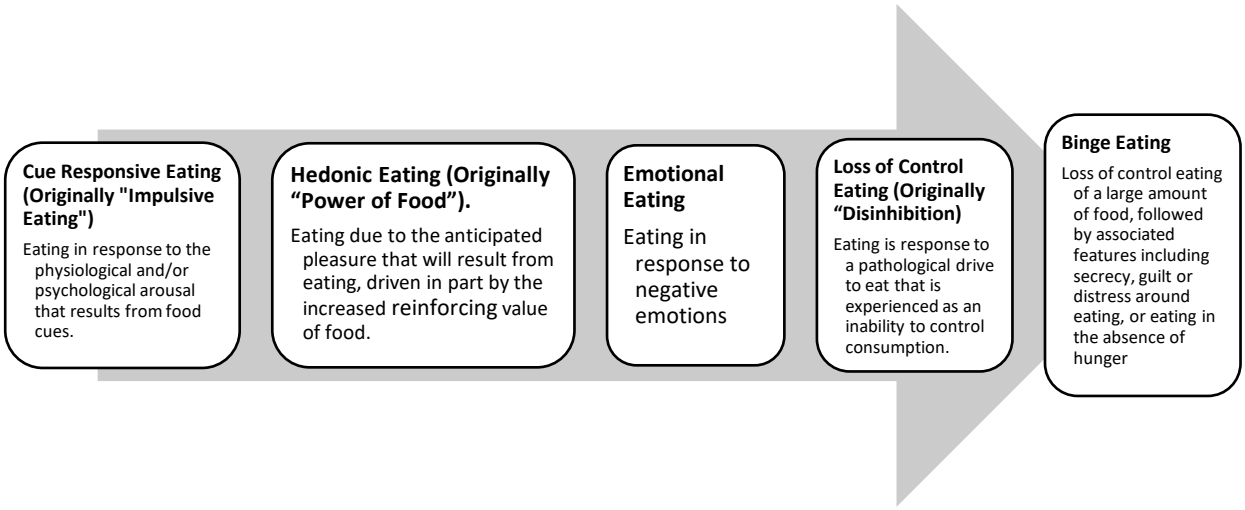

Figure I.2: Conceptual depiction of the continuous nature of the uncontrolled eating model, adapted from Vainik et al. (2015), including definitions of subdomains.

Cue Responsive Eating (Originally: "Impulsive Eating"). While not included as a label in the original Vainik et al. (2015) model of uncontrolled eating, in his subsequent uncontrolled eating paper Vainik et al. (2019) goes on to move away from using the phrase "impulsive eating" to describing the least severe form of uncontrolled eating as behaviors caused by external factors such as cue responsive eating. Thus, the term cue responsive eating will used moving forward as the least severe form of uncontrolled eating.

Hedonic Eating (Originally "Power of Food"). While also not included as a label in the original Vainik et al. (2015) model of uncontrolled eating, the author of the Power of Food Scale explicitly states in the measure development paper that the assessment is meant to assess hedonic eating (Lowe et al., 2009; Lowe & Butryn,

2007). Thus, the term hedonic eating will be said to capture the second form of uncontrolled eating. Hedonic eating is similar to cue responsive eating in that consumption is driven by external factors, and a recent longitudinal study of 3268, 9th graders defined hedonic eating as an “extreme responsiveness to food” (Mason et al., 2020). However, hedonic eating is distinct from the previous level of severity, due to the conditioning observed in cue responsive eating being largely outside of an individuals’ consciousness, while hedonic eating is said to be more cognitively intrusive. Hedonic eating has also been characterized as being related to emotional eating given hedonic or pleasurable goals are often maintaining mechanisms for emotionally driven eating. Nevertheless, hedonic eating is distinct from the next level of uncontrolled eating severity, emotional eating, due to hedonic eating being driven by the anticipated pleasure of eating, while emotional eating is driven by a desire to influence experienced affectivity irrespective of pleasure. Indeed, emotional eating has been described as a strategy to “numb” ones emotional experience (Litwin et al., 2017; Lev-ari et al., 2021).

Emotional Eating. Emotional eating is distinct from both hedonic eating and loss of control eating (originally “disinhibition), as emotions are the *primary* driver of overeating in emotion eating, in contrast to negative emotions co-occurring with overeating as is the case with many overeating behaviors. Emotional eating is also distinct from the next level of uncontrolled eating severity, loss of control eating, due to individuals experiencing emotional eating maintaining some subjective level of control during their overeating which is not the case with loss of control eating.

Loss of Control Eating (Originally “Disinhibition). Recent studies that purport to be measuring *disinhibited* eating in youth, continue to use the term interchangeably

with loss of control eating (Kelly et al., 2020; Byrne et al., 2021). Given loss of control eating has a long history of having a clear operationalization, the term loss of control will be said to capture the fourth form of uncontrolled eating. Loss of control eating is similar to emotional and binge eating in that all three are often coupled with guilt, shame, or secretive eating after the overeating stops. Loss of control eating is distinct from the next and final level of uncontrolled eating severity, binge eating, solely due to the quantity of food consumed.

Binge Eating. Binge eating represents the most severe form of uncontrolled eating and is distinct from all other overeating behaviors described due to it being the only behavior which would warrant an eating disorder diagnosis if this behavior occurs at least approximately once a week (*e.g.,* binge eating disorder, bulimia nervosa).

Altogether, Vainik's model of uncontrolled eating puts forth a model by which anchors of uncontrolled eating are clearly defined and the relationship between subconstructs is proposed, with a continuous spectrum of behaviors ranging from cue responsive eating to binge eating resulting. While this model makes theoretical sense, given that terminology to date has been fluid with respect to distinguishing or not between subdomains of uncontrolled eating, empirical tests of the psychometric concordance between related assessments remains to be explored. For example, even in Vainik et al. (2019), levels of uncontrolled eating severity are conflated, with Vainik describing "external eating, hedonic hunger, [and] reward-based eating drive" as eating due to "exposure to appetizing food." Given the overlap between terminology, empirical tests of the associative strength among purportedly related measures are vital in

ensuring terms are used interchangeably when appropriate but distinguished if they warrant distinction.

Importance of Validating the Uncontrolled Eating Model in Children and Adolescents

To date, no work has validated Vainik's model of uncontrolled eating in youth (Vainik et al., 2015, 2019), which is important to empirically evaluate given the emergence of uncontrolled eating behaviors during childhood. Furthermore, recent investigations of eating behaviors in youth continue to struggle with using consistent terminology, as exemplified by "maladaptive eating," "disinhibited eating," "uncontrolled eating" and "eating behaviors in obesity" all used to describe the range of major constructs of overeating behaviors (Calcaterra et al., 2020; Hampton-Anderson & Craighead, 2021; Alberga et al., 2022; Swanson et al., 2022). Thus, validating Vainik's model of uncontrolled eating in youth could serve as an important step forward in bringing the most up to date research into clinical practice, allowing providers to classify overeating behaviors, with clear definitions, on a spectrum that can be used to target clinical care.

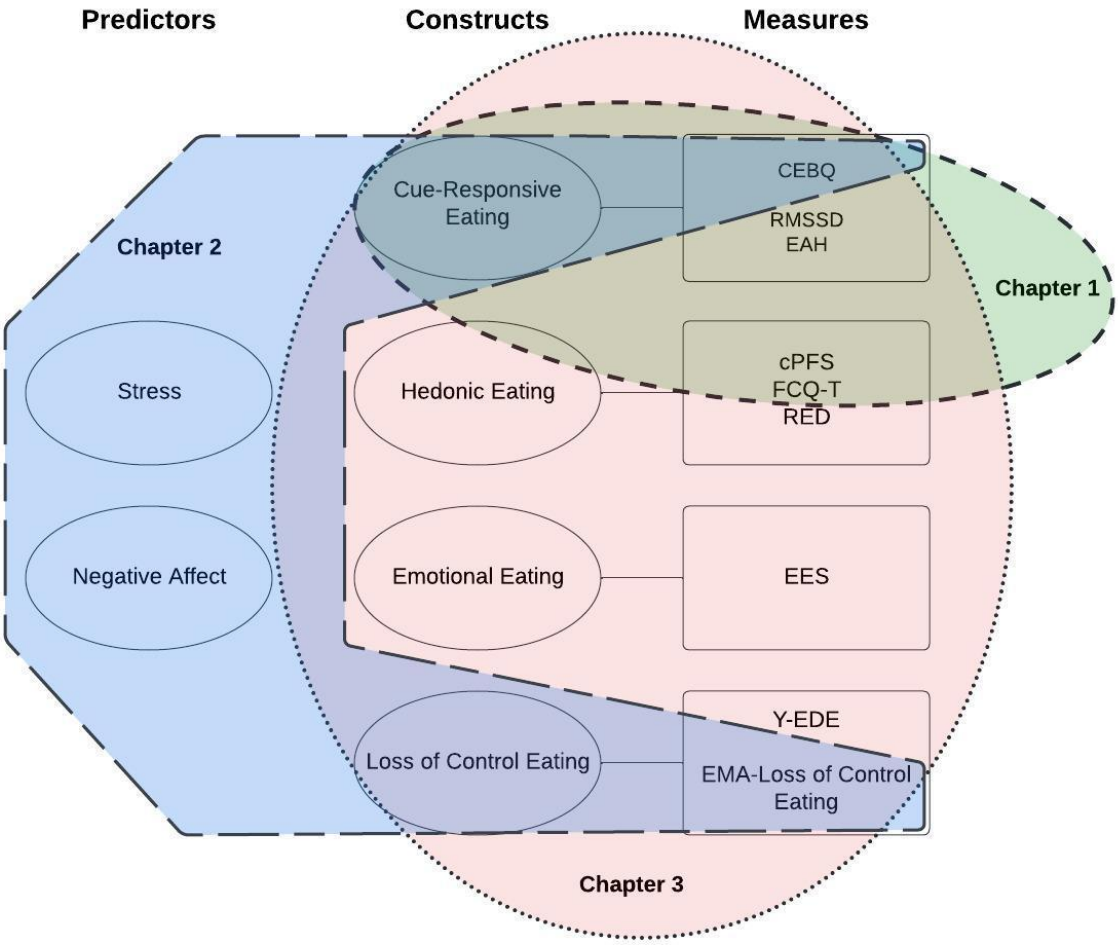

Figure I.3: Graphical representation of aspects of uncontrolled eating that are being investigated in each chapter of this dissertation, with Chapter 1 in green, Chapter 2 in blue, and Chapter 3 in red.

In sum, there are currently a myriad of measures aiming to assess a range of uncontrolled eating domains in youth, including cue responsive eating, hedonic eating, emotional eating, loss of control eating, and binge eating. Despite the fact that many of these instruments measure related if not identical constructs, little work has been done to determine the construct validity of such measures. Additionally, no conceptual models of eating behavior to date explain the expected relationships among these measures in youth. Beyond measurement, further work is needed to identify a model

which elucidates the temporal associations between uncontrolled eating behaviors and known associated factors such as stress and negative affect. Given the demonstrated associations between uncontrolled eating behaviors and both excessive caloric consumption and obesity emerge early in development, assessment and model evaluation in pediatric samples is vitally needed. In this way, the current dissertation fills these gaps in the literature through having (1) evaluated the concordance between five measures of cue responsive eating, which has historically been the least clearly operationally defined uncontrolled eating behavior; (2) utilized EMA to elucidate the temporal associations between uncontrolled eating behavior intensity, affect, and stress; and (3) evaluated Vainik's model of uncontrolled eating in samples of children and adolescents.

CHAPTER 1: Discordance Between Assessments of Food Cue Responsiveness: Implications for Assessment in Youth with Overweight/Obesity

Chapter 1, in full, is a reprint of the material as it appears in Appetite, 2023, Manzano, Michael; Strong, David; Rhee, Kyung; Liang, June; Boutelle, Kerri. The dissertation author was the primary investigator and author of this paper.

Abstract

Objectives: Food cue responsiveness (FCR), broadly defined as behavioral, cognitive, emotional and/or physiological responses to external appetitive cues outside of physiological need, contributes to overeating and obesity among youth and adults. A variety of measures purportedly assess this construct, ranging from youth- or parent-report surveys to objective eating tasks. However, little research has assessed their convergence. It is especially important to evaluate this in children with overweight/obesity (OW/OB), as reliable and valid assessments of FCR are essential to better understand the role of this critical mechanism in behavioral interventions.

Methods: The present study examined the relationship between five measures of FCR in a sample of 111 children with OW/OB (mean age=10.6, mean BMI percentile=96.4; 70% female; 68% white; 23% Latinx). Assessments included: objectively measured eating in the absence of hunger (EAH), parasympathetic activity when exposed to food, parent reported food responsiveness subscale from the Child Eating Behavior Questionnaire (CEBQ-FR), child self-reported Power of Food total score (C-PFS), and child self-reported Food Cravings Questionnaire total score (FCQ-T).

Results: Statistically significant spearman correlations were found between EAH and CEBQ-FR (ρ=0.19, p<0.05) and parasympathetic reactivity to food cues with both

C-PFS (ρ=-0.32, p=0.002) and FCQ-T (ρ=-0.34, p<0.001). No other associations were statistically significant. These relationships remained significant in subsequent linear regression models controlling for child age and gender.

Discussion: The lack of concordance between measures assessing highly conceptually related constructs is of concern. Future studies should seek to elucidate a clear operationalization of FCR, examine the associations between FCR assessments in children and adolescents with a range of weight statuses, and evaluate how to best revise these measures to accurately reflect the latent construct being assessed.

Introduction

The ubiquity of highly palatable, energy-dense foods in today's food environment is a driver of current epidemic rates of obesity (Townshend & Lake, 2017; Lakerveld et al., 2018). Indeed, while ambiguity regarding the extent to which genetic and other biological mechanisms influence eating behaviors remains, the role of excessive eating in the development of obesity is undisputed. (Santos & Cortés, 2020; Russo et al., 2010; Begg & Woods, 2013). Moreover, given that differences in appetitive traits and overeating behaviors are known to emerge early in the life course (Birch & Fisher, 1998), better understanding of these phenomena and their relationship to obesity in youth is critical. One important facet of eating in today's environment is responsiveness to appetitive cues, both internal and external. Internal appetitive cues include gastrointestinal and endocrine signals of physiological hunger that initiate consumption, such as cholecystokinin, glucagon-like peptide 1, ghrelin, leptin, and peptide YY, which were traditionally studied as the main drivers of appetite regulation (D'Agostino et al., 2016; Anderberg et al., 2017; Al Massadi et al., 2017; Barrios-Correa et al., 2018;

Manning & Batterham, 2014; Delzenne et al., 2010). External appetitive cues include environmental signals that can influence eating, such as the presence and palatability of food as well as increased attention to food and food cues (Herman & Polivy, 2008; Brignell et al., 2009).

While a variety of terms are in use to characterize the phenomenon of eating in response to external appetitive cues, food cue responsiveness (FCR) is used for the present investigation as FCR is considered a conceptual and pragmatic term that can encompass other related terms (Mela, 2006; Price et al., 2015). The Behavioral Susceptibility Theory of obesity posits FCR as a central appetitive mechanism which is highly genetically determined and can lead to increased risk for the development and maintenance of obesity (Carnell & Wardle, 2007; Boutelle et al., 2020; van den Akker et al., 2014). Heightened FCR has been found in young children and is stable throughout childhood (Carnell & Wardle, 2008; Northstone & Emmett, 2008). Indeed, FCR is known to emerge as early as infancy, with maternal-reported measures of FCR in infants as young as 3-months being predictive of subsequent weight gain (Llewellyn et al., 2011; van Jaarsveld et al., 2011). It is also associated with an increased preference for food versus non-food stimuli (Buvinger et al., 2017). Moreover, heightened FCR is posited as a moderating factor which interacts with the modern “obesogenic” environment leading to excess caloric consumption in youth (Carnell & Wardle, 2008; Sadler et al., 2021).

Furthermore, while genetic predispositions greatly influence an individuals’ risk for engaging in overeating behaviors, responsiveness to food cues is learned and develops through Pavlovian and operant conditioning. The presence of food, memories of foods, advertisements, or even situational factors such as time of day or location can

become conditioned stimuli that elicit physiological, psychological, and neurological changes that promote increased food intake (Belfort-DeAguiar & Seo, 2018; Boutelle & Bouton, 2015; Jansen et al., 2003). Research has linked FCR to increased cephalic phase responses and neural activation of motivation and reward circuitry (Ferriday & Brunstrom, 2011; Bruce et al., 2010). Taken together, understanding this multifaceted appetitive construct is vital to elucidating mechanisms that lead to and maintain excessive weight gain, with investigation in children being particularly salient given that individual differences emerge early in the life course.

For the present investigation, FCR is defined as cognitive, emotional, and/or physiological changes that result from exposure to food cues and lead to overeating (Kanoski & Boutelle, 2022). Over the past three decades, a variety of assessments using a myriad of methodologies were developed that were said to assess FCR, including: the eating in the absence of hunger ad libitum eating paradigm, parasympathetic activity during a food exposure paradigm, Child Eating Behavior Questionnaire, Child Power of Food Scale, and Food Craving Questionnaire. Of note, this includes two behavioral paradigms, two child-report questionnaires, and one parent-report questionnaire. These measures capture a variety of FCR antecedents in addition to objective overeating, all of which are important facets of FCR.

One of the earliest assessments of FCR was the eating in the absence of hunger (EAH) ad libitum eating paradigm (Fisher & Birch, 2002; Faith et al., 2006; Shomaker et al., 2010). While methodologies differ slightly, the task is generally set up as a pseudo taste test task where children are initially provided a meal, told to eat until comfortably full, and are then given free access to several highly palatable foods. The EAH task

allowed for an ecologically valid understanding of overeating beyond physiological needs; however, given the outcome of this behavioral measure is simply calories consumed while overeating, it is unclear whether the EAH task is assessing FCR specifically or overeating more broadly. Additionally, the EAH task is typically administered once and is influenced by mood, so its utility for measuring overeating as a trait is in question (Lansigan et al., 2015). Thus, while informative, the time and resources required to administer the EAH task restricts its use to predominantly academic research laboratories, limiting the dissemination of this measure to assess this important construct.

Another assessment of FCR is a food exposure paradigm that measures cephalic phase responses to the presentation of highly palatable foods (Nederkoorn et al., 2000; Boutelle et al., 2015). This task assesses FCR more directly. Physiological changes are measured when food is present or absent, and differences in physiological metrics between the non-food and food presentation periods can be used as an indicator of physiological FCR. Of note, since actual food consumption is prevented in this paradigm, only physiologic responsiveness and resulting self-reported craving responses are assessed. Like the EAH task, the time and resources needed to administer and score this psychophysiological assessment have made the assessment tool informative but limited in use.

In addition to more objective measures, a variety of questionnaires have been developed to assess FCR. The Child Eating Behavior Questionnaire (CEBQ) (Carnell & Wardle, 2007; Wardle et al., 2001) measures a parent's report of their child's eating behaviors across eight domains. One of the most prominent and widely investigated is a

4-item food responsiveness scale (CEBQ-FR). Although touted to evaluate food responsiveness, the CEBQ-FR items refer more to overeating behaviors than cue responsiveness (*i.e.,* “My child is always asking for food,” “If allowed to, my child would eat too much,” “Given the choice, my child would eat most of the time,” and “Even if my child is full up s/he finds room to eat his/her favorite food”). The Power of Food Scale is a 15-item self-report measure of hedonic eating and is designed to assess anticipation of cognitive expectations of the reward value of food prior to consumption (Lowe et al., 2009). A child specific adaptation (C-PFS) was later developed which utilizes more developmentally appropriate language (Laurent, 2015a) including questions such as “If I see or smell a food I like, I get a very strong desire to have some,” “When I know a delicious food is available, I keep thinking about having some,” and “It seems like I have food on my mind a lot.” The Food Craving Questionnaire-Trait (FCQ-T) is a 39-item self-report measure which assesses a related construct, cravings. (Cepeda-Benito et al., 2000). Food cravings are broadly characterized as wanting to eat a specific food or food type that is difficult to resist (Meule, 2020). This measure includes questions such as “Eating what I crave makes me feel better,” “If I get what I am craving I cannot stop myself from eating it,” and “It is hard for me to resist eating yummy foods that are right in front of me.” These questionnaires are more feasible to administer than behavioral paradigms, yet research on their validity in measuring their hypothesized latent constructs has yet to empirically support such claims.

While the EAH task, psychophysiological responses to food, CEBQ-FR, C-PFS, and FCQ-T are all posited to assess some aspect of FCR, to our knowledge, no studies have tested the convergence of all of these assessments. The present study

investigated the concordance among these five FCR assessments, including behavioral tasks and questionnaires, to better understand how they relate to each other in children with overweight/obesity. Of note, some assessments capture antecedents of food cue-based eating (psychophysiological responses, C-PFS, FCQ-T) and others assess resulting overeating behaviors (EAH and CEBQ-FR). This is of particular importance given that children are still early in their development when overeating behaviors are malleable and cognitive functions, particularly related to self-awareness, are not as advanced to be able to accurately answer self-assessment questions. Despite these potential differences, given that all are posited as measures of FCR, we hypothesized that all measures should be at least moderately associated.

Methods

Participants

Children ages 8-12 with overweight or obesity (OW/OB) and their parents (or caregivers) were recruited as part of the Intervention on the Regulation of Cues (iROC) study (NCT01708785). The original study recruited 140 parent-child dyads, with 111 completing all baseline measures (Boutelle et al., 2015). The latter, complete sample was used for the present investigation. To be eligible, children needed to be free from psychiatric, medical, or behavioral conditions that would interfere with treatment, be able to read at the third-grade level, and during their baseline assessment needed to consume at least 5% of their daily caloric needs during the EAH behavioral ad-libitum eating task. Parents could be of any weight, needed to be free from psychiatric, medical, or behavioral conditions that would interfere with treatment, and needed to be available one weekday afternoon or evening for treatment with their child. Parents

signed written consent and children signed written assent to participate, and the Institutional Review Boards of both the University of California, San Diego and Rady Children's Hospital approved the study.

Measures

Eating in the Absence of Hunger Paradigm (EAH; child measure). The Eating in the Absence of Hunger (EAH) paradigm is a pseudo taste-test designed to assess children's consumption after they report being sated. Children ate a meal that included pizza, carrots, and water until they were comfortably full, as assessed by rating at least a 3 on a 1-5 Likert scale of hunger. 10 minutes after the pizza dinner, children were presented with 8 pre-weighed highly palatable snack foods (gummy bears, chocolate chip cookies, Oreo® cookies, M & M's®, Skittles®, Doritos®, popcorn, and Cheetos®) and a variety of games and toys. The assessor left the room for 10 minutes, and the foods consumed were weighed and the amount of calories eaten were calculated. The primary outcome of the EAH task is total calories consumed. Reliability and validity data for EAH are infrequently reported given logistic barriers to conducting test- retest reliability, but the present paradigm is consistent with previous studies in youth (Adise et al., 2021; Miller et al., 2019).

Psychophysiological Food Exposure Paradigm (child measure). Electrocardiogram recordings (ECG) were measured during a food exposure paradigm that consisted of three 6-minute phases (baseline, food exposure, recovery; (Nederkoorn et al., 2000)) using a BIOPAC MP150. Participants identified their highly craved foods prior to the task. Two Ag±AgCl electrodes were placed, one on the left side of the subject and the other under the right collarbone. During the baseline phase,

children were told to sit quietly and limit movement. During the food exposure phase, children were presented with their identified highly craved food and were given standardized prompts to notice the desirable look and smell of the food at 30 second intervals. During the recovery phase the food was removed, and children were told to remain quiet and still. R-waves were detected off-line using a template matching procedure and inter-beat intervals were calculated. For the present study, the cephalic phase response assessed was heart rate variability (HRV). ECG recordings from each of these phases were used to derive HRV, with the root mean square of successive differences (RMSSD), posited as a measure of parasympathetic activation (Stein et al., 1994), being the parameter used as the outcome of this measure. Parasympathetic activity indices were used as they are more sensitive to acute changes and dysregulated states that can be assessed over the course of as little as a few minutes, in contrast to other indices driven by sympathetic changes (Bertsch et al., 2012; Koenig et al., 2014). Differences between RMSSD during the food exposure interval and baseline interval are then calculated to quantify changes in parasympathetic activity. Change in RMSSD is used as a proxy for cue responsive eating, with *decreases* being indicative of *increased* cue responsiveness. Similar to EAH, reliability and validity data for this paradigm are infrequently reported given logistic barriers to conducting test-retest reliability.

Child Eating Behavior Questionnaire (CEBQ; parent report of child). The Child Eating Behavior Questionnaire (CEBQ) is a 35-item parent report measure of children's eating behaviors across eight conceptual domains (*i.e.*, food responsiveness, enjoyment of food, desire to drink, emotional overeating, satiety responsiveness, food

fussiness, slowness of eating, and emotional undereating), utilizing a 1-5 Likert scale that assesses frequency of behaviors, not agreement with certain traits (Wardle et al., 2001). Parents are asked to read each statement and indicate which response is "most appropriate to your child's eating behaviour." The CEBQ has demonstrated good reliability and validity in school age children (Carnell & Wardle, 2007; Domoff et al., 2015). Only the food responsiveness subscale was used in the present study, and this subscale demonstrated good reliability (α = 0.85; ω_h = 0.85).

Child Power of Food Scale Questionnaire (c-PFS; child measure). The child Power of Food Scale (c-PFS) is a 15-item self- report measure assessing hedonic eating across 3 differing levels of proximity to food, including food available, food present, and food tasted (Lowe et al., 2009; Laurent, 2015). The measure developers' conceptualized the PFS as measuring appetitive responsiveness" at differing levels of food proximity, which is in line with cue responsive eating. A total score is calculated by averaging across all 15 items. The c-PFS has demonstrated strong reliability and validity in diverse pediatric samples (Laurent, 2015; Mitchell et al., 2016) and strong reliability was found in the present sample (α = 0.93; ω_h = 0.93).

Food Craving Questionnaire- Trait (FCQ-T; child measure). The Food Cravings Questionnaire-Trait (FCQ-T) is 39-item measure that assesses typical situations that lead to food cravings and hedonic eating (Cepeda-Benito et al., 2000). The FCQ-T contains the following 8 subscales: intentions/plans to consume food, anticipation of positive reinforcement from eating, anticipation of relief from negative states around eating, lack of control over eating, thoughts/preoccupation with food, craving as a physiological state, emotions around food cravings or eating,

environmental cues that may trigger food cravings, and guilt from cravings. Recent work investigating hedonic eating in youth has operationalized hedonic eating as an "extreme" form of cue responsive eating (Mason et al., 2020), and a recent meta-analysis included "cravings" as part of food cue reactivity (Boswell & Kober, 2016). Additionally, a child version of the FCQ-T had not been validated at the time of this study, so the measure was adapted by removing two items that were deemed less developmentally appropriate for children by the study team, resulting in a 37-item abridged version. The two items removed were: 'when I'm stressed out, I crave food' and 'I crave foods when I'm upset'. A total score is calculated by averaging across all 37 items and suggests the breadth of contexts in which food cues elicit craving responses. Reliability was found to be very strong (α = 0.96; ω_h = 0.96) in the present sample.

Statistical Analysis

Initial spearman correlations were used to investigate the observed associations between all five cue responsive eating assessments (*e.g.,* EAH, RMSSD, CEBQ, c-PFS and FCQ-T). Regression models were run for assessments with at least moderate associations, controlling for age and gender, to account for the influence of demographic characteristics on assessments.

Post-hoc exploratory hierarchical bifactor modeling was used to elucidate potential clusters of assessments. Hierarchical bifactor models simultaneously account for variance in assessment scores attributable to the overall latent construct (*i.e.* cue responsive eating) and the variance accounted for by the subdomain. Explained common variance (ECV) is the metric that represents the former, with higher values indicating more variance is attributable to the overall latent construct.

Results

The final sample of 111 children had a mean age of 10.6 years and were 70% female, 23% Latino, and 62% of families reported making over $100,000 a year. Correlation results are displayed in Table 1.1. Correlations were mixed, with only 4 of 10 potential associations reaching statistical significance.

Table 1.1: Spearman Correlations Between Cue Responsive Eating Measures

	1	2	3	4	5
1. EAH	--	--	--	--	--
2. RMSSD	.02	--	--	--	--
3. CEBQ-FR	.19*	.03	--	--	--
4. cPFS	-.13	-.32*	-.02	--	--
5. FCQ-T	-.01	-.34*	-.02	0.87***	--
Mean	424.5	-4.61	4.03	2.47	2.60
SD	193.0	18.84	0.76	0.95	0.93

**p<.05 **p<.01 ***p<.001*

Regression results are displayed in Table 1.2. The addition of demographic covariates accounted for some unexplained variance. Of note, the association between age and EAH was found to be statistically significant (β=0.23, p<.001). No other associations between assessments and covariates were found to be statistically significant.

Table 1.2: Regression Results between Cue Responsive Eating Measures and Correlated Behavioral Measures

Measure	**cPFS**			**FCQ-T**		
	β	SE	*p*	β	SE	*p*
RMSSD	-0.25	0.10	0.015*	-.26	0.10	0.008**

Measure	**CEBQ-FR**		
	β	SE	*p*
EAH	0.24	0.09	0.008**

**p<.05 **p<.01 ***p<.001*

Exploratory post-hoc analyses revealed a hierarchical model with 2 subdomains best fit the data, but while fit indices suggest this model fit better than models with 3- and 4-subdomains, the 2-factor model still had suboptimal fit (RMSEA=0.59). In this model the c-PFS, FCQ-T, and RMSSD clustered together, with the last loading negatively. The EAH and CEBQ-FR clustered somewhat, with the CEBQ explaining much of the variance in this exploratory factor.

Discussion

The present study sought to investigate the convergence of numerous FCR measures in children with OW/OB, however, it yielded mixed results. Overall, there was little to moderate convergence between most assessments, with many relationships among measures not reaching statistical significance. This contrasts with findings in adult samples where strong correlations have consistently been demonstrated among measures of overeating behaviors in individuals of varying weight statuses (Vainik et al., 2015; Price et al., 2015; Mason et al., 2017).

In this study, we found significant associations between the C-PFS, FCQ-T and RMSSD. The C-PFS and the FCQ-T are thought to measure the cognitive and physiological cravings in response to food cues respectively, while RMSSD measures the parasympathetic physiological reactivity. Not surprisingly, the two questionnaires were significantly associated in our data. These three concepts (i.e., cognitions, cravings, and physiological responsivity) could be thought of as antecedents to food-cue based eating. There is some support for this relationship in the adult literature. As part of the initial validation of the PFS, total PFS scores were demonstrated to predict chocolate cravings (Lowe et al., 2009). Moreover, an fMRI study found that PFS scores

moderated the relationship between food cravings and neural changes in the basal ganglia and sensorimotor regions that are implicated in addiction processes (Rejeski et al., 2012). Additionally, a pilot study demonstrated that heart rate variability (HRV) biofeedback sessions successfully reduced food cravings (Meule et al., 2012). Lastly, given the C-PFS and FCQ-T were child-report measures, it follows that subjective awareness of food cognitions and cravings would align with objectively assessed internal psychophysiological reactivity more so than parent-report measures. Thus, the C-PFS, FCQ-T, and psychophysiological changes may represent changes that occur prior to food cue-based eating and are representative of various facets of FCR among children with OW/OB.

While the measures above represent antecedents to food cue-based eating, both the CEBQ-FR subscale and the EAH paradigm seemed to measure actual overeating. Neither of these measures was associated with the three above, suggesting they could be measuring a different aspect of FCR, if not an entirely distinct construct. The statistically significant relationship between CEBQ-FR and EAH is not surprising, as the initial validation of the CEBQ included an adapted EAH paradigm for concurrent validity (Carnell & Wardle, 2007). Moreover, EAH has consistency been operationalized as an assessment of responsiveness to external, palatable food cues (Fogel et al., 2018; Hill et al., 2008). Furthermore, research suggests a heightened behavioral responsiveness to food cues to be both a risk and maintaining factor for the development of overeating behaviors and obesity (Carnell & Wardle, 2008; Masterson et al., 2019; Paquet et al., 2017). Lastly, both the CEBQ-FR and EAH assess observable behaviors, which could partially explain why these assessments converged. Taken together, these measures

are of great importance and future research should seek to clarify whether these behaviors are a behavioral aspect of FCR or are representative of more general overeating.

Despite there being some conceptual rationale for the differing aspects of FCR measures, the lack of consistent associations between assessments in these two potential clusters is notable. These clusters highlight the need for future work to better operationalize what is meant by FCR and how it leads to overeating and obesity. For example, recent work investigating hedonic eating in youth has operationalized hedonic eating as an “extreme” form of FCR (Mason et al., 2020), while a recent meta-analysis included “cravings” as a common example of FCR (Boswell & Kober, 2016). Whether these measures are assessing FCR, antecedents to FCR, or are so “extreme” that they represent a related but entirely distinct construct remains to be empirically evaluated. Furthermore, the External Food Cue Responsiveness scale was recently developed for use among preschool aged children which utilizes items that parallel the C-PFS, including specific types of food cues that prompt overeating as opposed to the more general overeating items of the CEBQ-FR (Masterson et al., 2019). Future work should explore the mechanisms driving overeating behaviors and determine at what point related constructs can be appropriately differentiated.

The present study has several strengths. First, this is the first study to evaluate the convergence of FCR assessments utilizing a multimodal assessment battery. Second, the sample was somewhat ethnically diverse (23% Latino), and despite including only children with OW/OB, all assessments demonstrated heterogeneity in

responses. Third, the investigation of assessment convergence is of critical importance to the replication of findings and accurate operationalization of assessments. Nevertheless, as in all studies, there are a number of limitations that need to be noted. First, while investigating children at the higher end of the weight spectrum is of great importance, having children with a variety of weight statuses could bolster the generalizability of the current findings to youth of all weight statuses. Furthermore, while FCR is found in children of all body sizes, it does tend to be more prevalent in children with OW/OB (Belfort-DeAguiar & Seo, 2018; Bohon, 2017). Thus, the decreased variance of FCR in children with OW/OB may have influenced the present results. Additionally, the present sample was comprised of treatment-seeking children with OW/OB who may have limited insight into their own motivations and cognitions around food, as well the potential for social desirability to influence reporting on parent- and self-reported measures (Miller et al., 2014; McKee et al., 2016). Thus, these findings cannot generalize to non-treatment seeking children with OW/OB, children of lower weight statuses, or older children. Furthermore, it is possible that varying methodologies (e.g., child self-report, parent self-report, physiological assessment and EAH) contributed to the unexplained variance in the present analyses. Subjective reports of eating behaviors notoriously differ from results of objective assessments (Dhurandhar et al., 2015), and child and parents likely have differing insights into the frequency or severity of observable behaviors. Lastly, post-hoc analyses were underpowered, so future studies should ensure adequately powered, diverse samples are used to further investigate the varying aspects of FCR.

FCR is an important construct to assess, particularly as it relates to overeating behaviors and weight status (Boswell & Kober, 2016; Boutelle et al., 2020). Of equal importance is confidence that assessments purported to assess this construct are indeed doing so. The present study provides some evidence that FCR may be differentially assessed via varying assessment measures and approaches. Moreover, as presently defined, FCR is characterized by anticipatory changes elicited by food and food cues while overeating is the resulting behavior. Moving forward, the C-PFS and FCQ-T appear to be the most valid questionnaires in assessing the anticipatory cognitive, affective, and psychophysiological changes that occur when exposed to food cues. A clear operationalization of FCR is critical in advancing our understanding of this important eating phenomenon. Future research should investigate the associative strength between FCR measures in individuals across the spectrums of age and weights, include assessments of appetite hormones such as ghrelin and leptin which are known to influence FCR and related neural processes (Wever et al., 2021), and assess the predictive validity of these measures to inform measure selection in intervention trials.

Chapter 1, in full, is a reprint of the material as it appears in Appetite, 2023, Manzano, Michael; Strong, David; Rhee, Kyung; Liang, June; Boutelle, Kerri. The dissertation author was the primary investigator and author of this paper.

CHAPTER 2: Evaluation of Uncontrolled Eating in Adolescents with Overweight or Obesity Utilizing Ecological Momentary Assessment

Abstract

Objectives: Despite adolescence being a critical period in the development of emotional awareness and disordered eating, little work has been done to characterize the momentary predictors of uncontrolled eating behaviors in this population. While negative affect and psychosocial stress are known to influence these behaviors in adults, less research has demonstrated these temporal relationships in youth. The present study sought to clarify the relationship between uncontrolled eating behaviors (food cue responsive eating, overeating, loss of control eating), negative affect, and various sources of stress in a sample of adolescents with overweight/obesity.

Methods: Treatment seeking adolescents (*N*=157, 57.2% female), aged 13-16 (mean=14.9±1.2) with overweight/obesity (OW/OB; mean BMIz=2.1±0.4) reported on eating episodes, negative affect, and sources of stress across a 10-day ecological momentary assessment period. Vector autoregressive modelling was used to evaluate the relationships between negative affect, stress, and uncontrolled eating.

Results: Within individuals, family stress and nervousness predicted endorsement of not being able to stop eating once started. Additionally, being afraid tended to fluctuate with overeating. Across individuals, those with high relationship stress tended to endorse feeling as though they can't stop eating once they started, and those with higher overall stress tended to have more overeating.

Discussion: Various sources of stress tended to be more consistently associated with LOC eating than negative affect, while negative affect tended to occur more concurrently with overeating. Further exploration of how specific types of emotion and stress influence specific uncontrolled eating behaviors in adolescents with OW/OB may

allow for more personalized interventions targeting emotion regulation and stress management.

Introduction

The term “uncontrolled eating” has been coined as a construct which includes varying overeating domains which represent differing levels of *severity* of a singular construct (Vainik et al., 2015, 2019). Uncontrolled eating encompasses overeating behaviors which range from clinically impairing loss of control (LOC) eating to normative consumption outside of nutritional needs. Adolescence is a critical period for examining overeating behaviors and weight status, given both are known to track into adulthood (Kumar & Kelly, 2017). However, few studies have evaluated the range of uncontrolled eating behaviors during adolescence, with most studies focusing only on LOC, and even fewer identifying predictors of these behaviors.

Uncontrolled eating is anchored by two major subtypes of overeating behaviors, LOC and food cue responsive eating (FCR) (Vainik et al., 2015, 2019). LOC is characterized by an individual feeling as though they are unable to regulate how much or what they consume (Tanofsky-Kraff et al., 2011). LOC warrants particular focus as it represents the most severe form of uncontrolled eating and is a defining feature of binge-spectrum eating disorders (American Psychiatric Association, 2022). FCR represents the least severe form of uncontrolled eating and is characterized by eating due to the physiological and psychological arousal that result from exposure to food related cues (Kanoski & Boutelle, 2022). Understanding predictors of LOC and FCR

may help elucidate how to best intervene on these behaviors, which are implicated in the development of both obesity and disordered eating.

Negative emotions have long been thought to be a significant vulnerability factor for and antecedent to LOC eating (Harrison et al., 2010; Svaldi et al., 2012). This has been in part due to the affective regulation model of binge eating, which posited that binge eating is used to regulate negative emotions (Hawkins & Clement, 1984). However, this model has consistently demonstrated mixed findings, suggesting a more nuanced framework is needed (Haedt-Matt & Keel, 2011). A recently proposed developmental framework highlights how negative affectivity (*e.g.*, negative emotions and stress) serves as an antecedent to LOC eating in youth (Tanofsky-Kraff et al., 2020). While there is a strong theoretical grounding for this framework, emerging evidence for this developmental model suggests the relationship between negative affectivity and LOC in youth is multifaceted (Bejarano et al., 2023).

Cross-sectionally, youth who engaged in LOC eating endorsed experiencing more negative affect and social stress (Byrne et al., 2019; Shomaker, Tanofsky-Kraff, Elliott, et al., 2010). At a biological level, chronic activation of the stress response is known to influence glucose metabolism and appetitive hormones, in addition to promote insulin resistance (Adam & Epel, 2007). Despite these clear physiological mechanisms, more acute stressors have demonstrated only partial effects on overeating (Naish et al., 2019). Moreover, while these cross-sectional investigations provide important empirical support for the interplay between negative emotions, stress, and uncontrolled eating behaviors, more work investigating the temporal nature of these relationships in youth is greatly needed.

Despite LOC having received much attention, relationships between negative affect, stress, and FCR remain elusive. Cross-sectionally, greater social stress and anxiety were associated with increased caloric intake during a laboratory test meal (Shank et al., 2017). Additionally, the relationship between affect and eating is stronger among adolescents with higher versus lower FCR (Schneider-Worthington et al., 2022). Beyond looking at relationships between negative affect, stress and FCR *or* LOC, FCR is implicated in the development of concurrent obesity and binge spectrum eating disorders characterized by LOC (Meule et al., 2018). Thus, concurrently exploring negative emotions and stress in relation to FCR and LOC eating may help clarify the importance, or not, of each.

The vast majority of the research to date has utilized questionnaires to assess these relationships. Ecological Momentary Assessment (EMA) is an assessment approach that utilizes repeated data collection in an individual's natural environment, and can evaluate temporality and reduces retrospective biases associated with questionnaires and interviews (Shiffman et al., 2008; Stone & Shiffman, 1994). EMA studies among adults have consistently found negative affect as a predictor of LOC eating (Berg et al., 2015; Goldschmidt et al., 2012; Smith et al., 2018; Berg et al., 2014; Goldschmidt et al., 2014). However, the few naturalistic studies conducted in adolescents have failed to demonstrate the relationship between negative affect and LOC eating (Goldschmidt et al., 2018; Hilbert et al., 2009; Ranzenhofer et al., 2014). Additionally, the inclusion of older adolescents (*i.e.,* older than 14 years of age) and males has been limited in these studies, which hinders the ability to generalize findings to the broader adolescent population. Moreover, these studies have also not included

FCR behaviors, as EMA has only more recently been posited as important assessment technique for this behavior (Rigby, 2021).

Given the lack of naturalistic studies exploring the relationships between the range of uncontrolled eating behaviors, negative affect, and stress in adolescents, the aims of the present study were twofold. First, the prevalence of two major subtypes of uncontrolled eating, LOC and FCR eating, was assessed in adolescents with OW/OB utilizing a 10-day ecological momentary assessment protocol. Additionally, the temporal relationships between uncontrolled eating subtypes, negative affect, and stress were also examined. It was predicted that all forms of uncontrolled eating behaviors would be common among treatment-seeking adolescents, with LOC eating occurring less frequently than FCR eating. It was also hypothesized that several forms of negative affect and stress would be predictive of both LOC and FCR eating.

Methods

Participants

Data were drawn from baseline assessments as part of a randomized controlled clinical trial (NCT03674944) evaluating the efficacy of a traditional family-based behavioral treatment (FBT) for adolescents with OW/OB compared with an adapted FBT program targeting emotion regulation and emotional eating. Adolescents ages 13-16 years with OW/OB and a primary caregiver were recruited from the San Diego, CA and Minneapolis, MN metropolitan areas. Participants were recruited using several methods, including physician referral, listservs, ResearchMatch, letters mailed to families identified as potentially eligible through electronic medical records, local advertisements, online advertisements, and school flyers. Interested families completed

phone and online screeners to further assess eligibility. If adolescent-caregiver dyads met initial screening criteria and remained interested following a study orientation, caregivers provided informed consent and adolescents provided assent before completing baseline assessments. Assessments included in this study consisted of anthropometric measurements and a 10-day EMA protocol. Recruitment occurred between September 2019 and October 2021. Due to the COVID-19 pandemic restrictions, all but the first cohort of adolescents (N=26) completed assessments entirely remotely.

Adolescent-caregiver dyads were enrolled if they met the following inclusion criteria: a) 13-16-year-old adolescent whose BMI is ≥ 85th and < 99.9th percentile; b) able to read English at a minimum of a 6th grade level; c) adolescent willing to complete phone surveys (*i.e.,* ecological momentary assessment; EMA) using their personal smartphone or a study provided device. Exclusion criteria were as follows: a) current enrollment in a weight management program; b) adolescent on a medication prescribed for weight loss, c) medical or psychiatric condition that may interfere with treatment participation; d) regular compensatory behaviors for weight loss (e.g., purging) during the past 6 months; e) currently pregnant or lactating; f) alteration in medication that may impact weight during the previous 3 months.

EMA prompts were delivered over a 10-day window during which adolescents were randomly signaled 4 times per day during the week, outside of school hours, and 6 times per day during the weekend, similar to other studies (Goldschmidt et al., 2018; Hilbert et al., 2009; Ranzenhofer et al., 2014). If adolescents did not have their own smart phone, they were provided a study tablet to complete EMA (n=4). Adolescents

were trained by research staff regarding how to provide responses, in addition to being given a test day prior to the 10-day window to troubleshoot technical issues. At each signal, adolescents were asked to report their current affect, inter-and intra-personal stressors, and qualities of any recent eating episode (*i.e.,* within the last 90 minutes). Adolescents were contacted by phone by a member of the study team after the first day of EMA recording, and as needed thereafter, to improve compliance and address any questions or concerns regarding assessment procedures. Adolescents were compensated for completing the EMA protocol ($100), with supplementary compensation ($50) provided if they completed at least 70% of recordings. 166 adolescents completed baseline assessments, with 9 adolescents having technical issues that prevented compliance with EMA protocols, resulting in usable data from 157 adolescents at baseline. The Institutional Review Boards of the University of California, San Diego, Rady Children's Hospital San Diego, and the University of Minnesota approved the study.

Measures

Ecological Momentary Assessment (EMA) Protocol. Adolescents completed EMA responses across 10 days. At semi-random times (four times/day on weekdays and six times/day on weekends), the adolescents were signaled to complete measures of uncontrolled eating, negative affect, and stress (see below for more details). Exact signal windows were specific to each adolescent given varying school schedules, but adolescent's EMA signal windows generally occurred every 2 hours between 10:00am to 10:00pm on the weekends, and between 7:00–9:00am, 4:00–6:00pm, 6:00–8:00pm

and 8:00–10:00pm on weekdays so as not to interfere with participants' school schedules.

EMA measures

Negative affect. Negative affect was measured using the Positive and Negative Affect Schedule-Short Form (PANAS-SF) (Watson et al., 1988; Thompson, 2007), which has been used in previous EMA studies among adolescents (Bourke et al., 2021; Brannon et al., 2016; Cushing et al., 2017). Ten negative affect items were used for the present study (*Prompt:* "I am feeling…" *Items:* "Distressed, Upset, Guilty, Scared, Hostile, Irritable, Ashamed, Nervous, Jittery, Afraid"). Response options were on a 5-point Likert type scale, with 1 = *not at all* to 5 = *extremely*. Of note, five of the negative affect items (Distressed, Scared, Hostile, Irritable, Jittery) did not demonstrate statistically significant associations for within-subject analyses, and were excluded from being presented in all network analyses for ease of visual interpretation.

Uncontrolled Eating. Adolescents were queried whether they had eaten or not in the last 90 minutes, and if they had done so, the uncontrolled eating items were delivered. Uncontrolled eating items queried about FCR, LOC, and overeating. Two FCR items from the Child Eating Behavior Questionnaire (Wardle et al., 2001) were adapted to be momentary, including: (1) "Right now, if there was more food in front of me, I would still eat it" and (2) "Right now, if my favorite food was in front of me, I would find room to eat it." Five LOC items consistent with past EMA studies (Goldschmidt et al., 2018; Ranzenhofer et al., 2014; Engel et al., 2009) were utilized, including: "While you were eating, rate the extent that you… (1) felt out of control, (2), felt like you couldn't resist eating, (3) couldn't stop eating once you started, (4) felt driven or

compelled to eat, (5) paid attention to your eating". A general overeating item was asked to allow for endorsement of overeating independent of identifying a reason for the behavior, "While you were eating, rate the extent that you overate." Response options for all 8 uncontrolled eating items were on a 5-point Likert type scale, with 1 = *don't agree at all* to 5 = *strongly agree*. Each uncontrolled eating behavior was analyzed individually.

Stress. Adolescents were asked to rate their general stress level ("What is your overall stress level") in addition to specific sources of stress ("In the past hour, to what extent were each of the following sources of stress? (1) School/Academics, (2) Home/Family, (3) Friends, (4) Extracurriculars, (5) Romantic Relationships"), adapted from previous studies (Tan et al., 2012). Response options were on a 3-point Likert type scale, with 1 = *none*, 2 = *somewhat*, 3 = *very*. Each source of stress was analyzed individually.

Statistical Analysis

The frequency of FCR, LOC, and overeating was described in two ways. First, aggregate scores were calculated averaging across all days for each of these behaviors in a continuous manner. Additionally, dichotomous variables were computed for FCR, LOC and overeating, with ratings of 2 or higher (out of 5) being considered as having the behavior "present," while ratings of 1 ("don't agree at all") were considered "absent." Dichotomous frequencies of FCR, LOC, and overeating were computed by creating a proportion of behaviors "present" out of all reported eating episodes by an individual over the 10-day EMA window. Of note, the dichotomous variables were calculated only

for descriptive purposes and the continuous values were used for all subsequent analyses.

Vector autoregressive (VAR) modeling (Emerencia et al., 2016) was utilized to elucidate the associations between the various uncontrolled eating behaviors, negative affect, and stress. VAR simultaneously modeled uncontrolled eating, negative affect, and stress, with temporally preceding values (*i.e.,* the previous EMA response) being used to predict current values for *each* outcome. The temporal and contemporaneous networks characterized the unique within-person interactions between all nodes at consecutive and concurrent timepoints, respectively. The between-subjects network depicts relationships between nodes based on the person-wise averages of each variable. Only pathways that were statistically significant at the $p<.05$ level were shown, with at least one of two observed p-values in the in the contemporaneous and between-subject networks needing to be significant for the association to be displayed. The width of lines was inversely related to the *p* values of the association (*i.e.,* wider, more pronounced lines have lower *p* values). Analyses were conducted in R (version 4.3.2), utilizing the *mlVar* package (Epskamp et al., 2018). Data were imputed using the *imputeFin* package (Liu & Palomar, 2021). This approach was utilized in lieu of the common practice of listwise deletion as emerging literature that suggests listwise deletion is particularly flawed when handling missing data in multivariate time series datasets and can lead to biased observed estimates (Bashir & Wei, 2018).

Results

The final sample of 157 children had a mean age of 14.9 years and were 57.2% female and 30.7% Latino. The median annual family income was $95,000 - $99,999.

Detailed demographic information is displayed in Table 2.1. Overall, adolescents compliance (*i.e.,* the percentage of signal-contingent ratings that were completed for each prompt) was 86.6%, consistent with past EMA work investigating eating behaviors (Goldschmidt et al., 2018; Schaefer et al., 2020).

Table 2.1: Adolescent Demographics (% or Mean (SD))

	Adolescent
Age (years); Mean (SD)	14.9 (1.2)
Sex (female)	57.2%
Ethnicity	
Latino/a	30.7%
Race	
Asian	4.2%
Black	6.0%
White	61.4%
Indigenous/Alaska Native	4.8%
Multiple	12.7%
Not reported	10.9%
Anthropometrics); Mean (SD)	
zBMI	2.1 (0.4)
Household Income; Median	$95,000 - $99,999

Uncontrolled Eating Behavior Frequency

Descriptive statistics of continuous variables are displayed in Table 2.2, while frequencies of dichotomous variables are displayed in Table 2.3.

Table 2.2: Means and standard deviations of FCR, overeating, and LOC items

Item	Mean	SD	Median
While you were eating, rate the extent that you…			
-felt out of control	1.2	0.7	1
-could not stop eating once you started	1.3	0.7	1
-felt overwhelmed	1.3	0.7	1
-paid attention to what you were eating	2.4	1.3	3
-could not resist eating the food that was in front of me	1.4	0.9	1
-overate	1.4	0.8	1
Right now, if there was more food in front of me, I would eat it.	2.4	1.3	2
Right now, if my favorite food was in front of me, I would eat it.	2.8	1.4	3

Note: all items demonstrated the full range of responses (*i.e.,* range of 1-5)

Table 2.3: Categorical frequencies of FCR, overeating, and LOC items

Item	Percent
While you were eating, rate the extent that you…	
-felt out of control	15.0%
-could not stop eating once you started	18.8%
-felt overwhelmed	16.2%
-paid attention to what you were eating*	34.7%
-could not resist eating the food that was in front of me	25.2%
-overate	23.0%
Right now, if there was more food in front of me, I would eat it.	67.7%
Right now, if my favorite food was in front of me, I would eat it.	75.4%

*reverse coded

When analyzed continuously, while all LOC items demonstrated the full range of responses, item intensity was low and “paid attention to what you were eating” was higher than the rest. When analyzed categorically, as has historically been the case when approaching LOC, item endorsement was more variable, ranging from 15% to 35%. Of note, feeling “out of control” was the least endorsed item and “Right now, if there was more food in front of me, I would eat it” was the highest. FCR items were positively endorsed in the majority of responses.

Networks Among Uncontrolled Eating Subtypes, Negative Affect, and Stress

Temporal Effects. Some statistically significant findings will be reported in detail below; however, no predictors of uncontrolled eating demonstrated effects above $r > 0.10$. Several sources of stress, being guilty or nervous, as well as paying attention while eating demonstrated strong positive auto-regression (*i.e.,* they tended to persist over time), particularly relationship stress which demonstrated the most temporal stability. Family stress ($r = 0.06$, $SE = 0.02$, $p = 0.009$) and nervousness ($r = 0.06$, $SE = 0.03$, $p = 0.01$) had a forward influence on one feeling they could not stop eating once they started, suggesting that when family stress or nervousness increased, feelings of not being able to stop eating also increased at the following timepoint. Nervousness

also predicted both FCR items (more food, r = 0.07, SE = 0.03, p = 0.01; favorite food, r = 0.05, SE = 0.02, p = 0.03). Academic (r = 0.05, SE = 0.02, p = 0.03) and extracurricular stress (r = 0.06, SE = 0.03, p = 0.03) had a forward influence on feeling overwhelmed while eating. Being ashamed predicted overeating (r = 0.07, SE = 0.02, p = 0.002) and feeling as though one cannot resist the food in front of them (r = 0.05, SE = 0.03, p = 0.04). Neither FCR item demonstrated any statistically significant forward influences on LOC items. Figure 2.1 visually depicts all statistically significant temporal associations. See Appendix for further details.

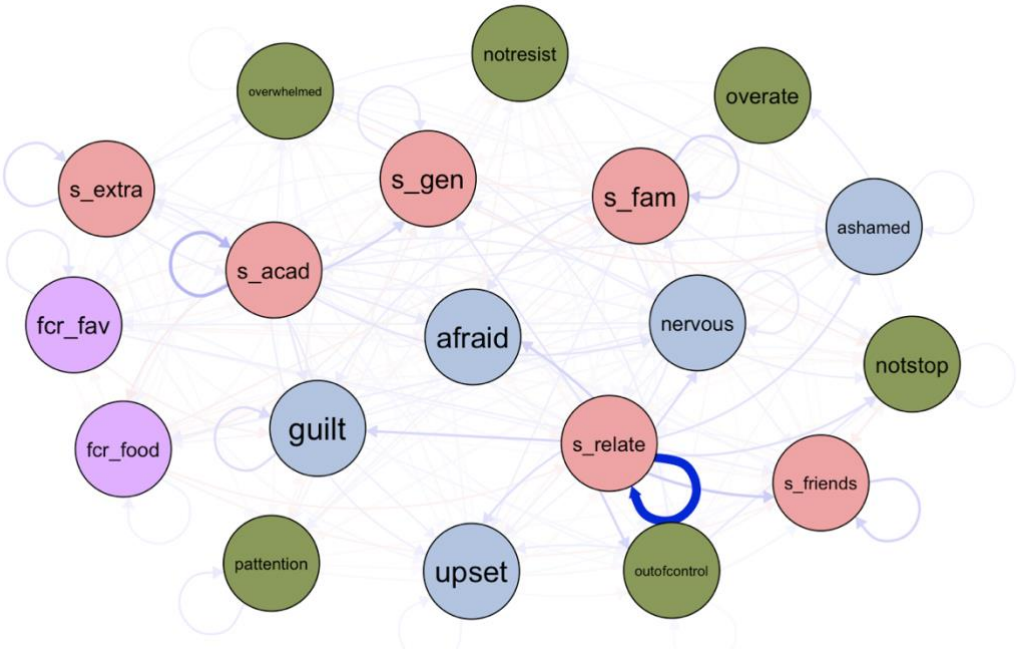

Figure 2.1: Temporal Network

Contemporaneous Effects. Being afraid (r = .06, $p_{1\rightarrow 2}$< 0.001, $p_{2\rightarrow 1}$= 0.004) tended to fluctuate with overeating. Stress and negative affect did not demonstrate any further statistically significant concurrent fluctuations with uncontrolled eating behaviors (no p's<.05 for both coefficients). The LOC items fluctuated together (r's: .10-.31), as did

the two FCR items with each other (r =.80, $p_{1\rightarrow 2}$< 0.001, $p_{2\rightarrow 1}$< 0.001). Negative emotions and stress also tended to vary together (*r's*: .07-.37). Figure 2.2 visually depicts all statistically significant contemporaneous associations. See Appendix for further details.

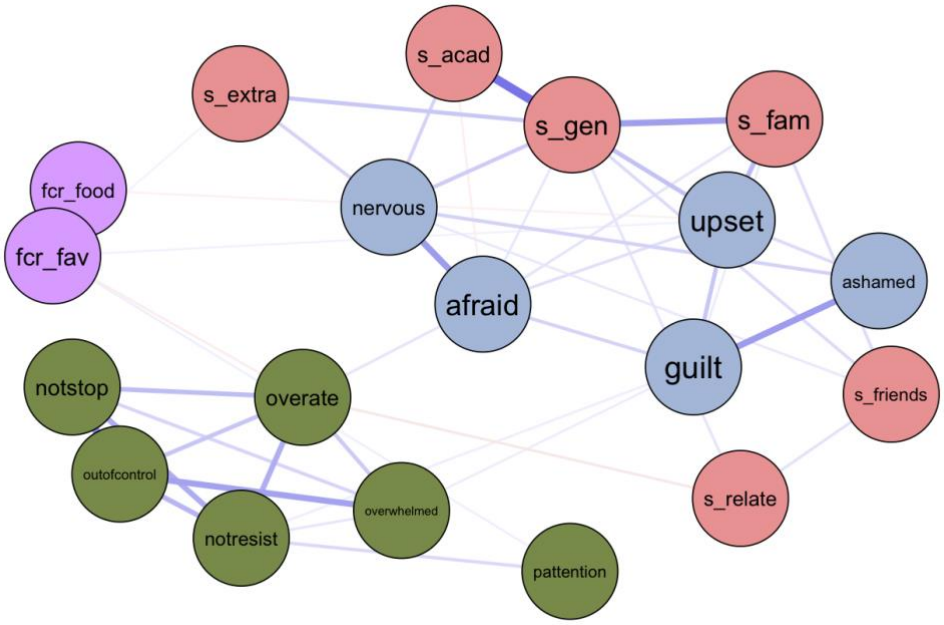

Figure 2.2: Contemporaneous Network

Between-Subject Effects. Across adolescents, many variables covaried (see Figure 3 for all associations). Adolescents with high relationship stress tended to have greater endorsement of feeling as though they can't stop eating once they start (r = 0.25, $p_{1\rightarrow 2}$ = 0.003, $p_{2\rightarrow 1}$= 0.003). Adolescents who reported high levels of upset (r = 0.24, $p_{1\rightarrow 2}$ = 0.006, $p_{2\rightarrow 1}$= 0.005) had higher endorsement of feeling overwhelmed while eating. Adolescents with high overall stress tended to have more reporting of FCR eating (r = .30, $p_{1\rightarrow 2}$ < 0.001, $p_{2\rightarrow 1}$< 0.001) and overeating (r = .20, $p_{1\rightarrow 2}$ = 0.002,

$p_{2\rightarrow 1}$= 0.05). Figure 2.3 visually depicts all statistically significant between-subject associations. See Appendix for further details.

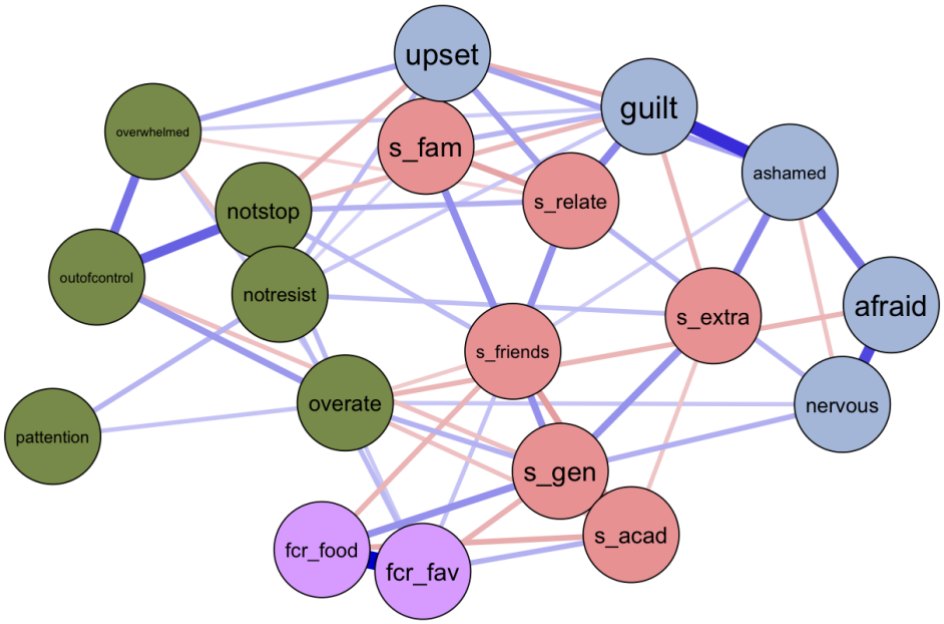

Figure 2.3: Between-Subject Network

Discussion

The present study sought to investigate the frequency of uncontrolled eating endorsement among adolescents during a 10-day EMA protocol, in addition to characterizing the predictive and concurrent associations of negative affect and sources of stress with uncontrolled eating behaviors. Prevalence rates of LOC were consistent with previously observed rates in adolescents (He et al., 2017; Schlüter et al., 2016). FCR items were readily endorsed by adolescents, with frequencies that exceeded those of LOC items. Day-to-day experiences of nervousness and feeling ashamed were each predictive of subsequent uncontrolled eating behaviors, but none of the other eight negative affect items were predictive of eating behaviors. These data add to a growing

body of literature that, particularly among adolescents, momentary negative affect does not consistently predict FCR or LOC eating (Goldschmidt et al., 2018; Ranzenhofer et al., 2014).

We found that uncontrolled eating frequencies were consistent with previously observed prevalence rates in youth with OW/OB, with greater LOC observed than the general population (Schlüter et al., 2016). Furthermore, FCR item endorsement was high, consistent with the view that FCR may represent a less severe form of uncontrolled eating that is more normative, particularly among adolescents living in larger bodies (Vainik et al., 2015). However, FCR did not demonstrate forward influences on LOC, suggesting that these two types of overeating may be more independent than predicted and raising questions about the predictive nature of less severe forms of uncontrolled eating preceding more severe forms (Vainik et al., 2019). Future work is needed to empirically evaluate a model of uncontrolled eating in youth, in addition to the elucidating the temporal development of these related eating behaviors.

While the adult literature has consistently found that negative affect precedes LOC eating, evidence over the last decade in youth has not corroborated such findings (T. Mason et al., 2020). Furthermore, no one form of negative affect or stress was consistently predictive of more than one form of LOC eating. Interestingly, nervousness and family stress were the only two constructs to positively predictive subsequent endorsement of feeling that one cannot stop eating once they have started. A previous EMA study in adolescents demonstrated that worry was predictive of binge eating thoughts, not behaviors (Shingleton et al., 2013). This adds to an emerging body of literature demonstrating stress and anxiety are particularly salient predictors of eating

behaviors in adolescents (Caso et al., 2020; Hsu & Raposa, 2021; Lim et al., 2021). Furthermore, challenges with academic adjustment and stress experienced by adolescents following the COVID-19 pandemic (Branje & Morris, 2021) suggests the role of school related stress on uncontrolled eating behaviors warrants further investigation.

The ability of EMA to model within subject fluctuations, both temporally and concurrently, as well as between subject effects allows for a nuanced understanding of the complex interactions between uncontrolled eating, negative affect, and stress. Surprisingly, FCR items did not demonstrate relationships with many other domains. This may be in part due to FCR being a more stable appetitive trait, as opposed to LOC which is known to fluctuate (Boutelle et al., 2020; Fogel et al., 2018). Stress items were found to have the most associations with other domains, both temporally and concurrently, such that several sources of stress were associated with increased FCR eating, LOC eating, and negative affectivity across subjects. This highlights the importance assessing stress when exploring uncontrolled eating behaviors, particularly amongst adolescents. Additionally, it is important to be clear when emotions and stress are interchangeable versus distinct, as was clarified in the developmental framework for binge eating which was clear to describe negative affectivity as being inclusive of stressful experiences and not unique to discrete emotions (Tanofsky-Kraff et al., 2020). This can inform future intervention development, which may need to more explicitly target stress management *and* emotional regulation, given these domains have historically been considered overlapping yet distinct in nature (Myruski et al., 2020; Yunus & Chaudhary, 2023).

The present study has many strengths. The sample was relatively large, ethnically diverse, and included male adolescents. The last point is of particular importance given the field's historical exclusion of males in research, and emerging research continuing to demonstrate the unique presentation of disordered eating amongst males (Nagata et al., 2020). Additionally, the use of EMA allowed for exploration of temporal associations of both FCR and LOC among adolescents. Furthermore, the novel statistical modelling approach of vector autoregression allows for greater accounting of within-person similarities in response endorsement and explicit partitioning of this variance which is not possible with many conventional modelling techniques. There are also limitations that need to be considered. First, responses were limited to outside of school hours to ensure that study participation did not interfere with school engagement. However, this eliminated significant portions of adolescents' weekdays during which data on these relationships could be evaluated and are possibly different. Moreover, all participants were treatment seeking with overweight or obesity which may limit the generalizability of the present findings the general adolescent population.

In summary, the present study provides further evidence that FCR and LOC present differently in adolescents than in adults. While frequencies of these behaviors were consistent with previously observed prevalence rates, negative affect and stress were not consistent predictors of LOC or FCR eating. Moreover, demonstrated statistically significant associations, particularly in the temporal network, were small in magnitude. Emerging work over the past decade is accumulating empirical evidence that predictors of uncontrolled eating manifest different in adolescents; however, few

evidence-based overeating or weight management interventions have been developed specifically for this population (Marzilli et al., 2018). Exploration of contextual and external factors, such as food proximity and accessibility, being around others, and other social factors, warrant further investigation in relation to uncontrolled eating behaviors of all severities, particularly across adolescents of all gender identities and marginalized backgrounds.

Chapter 2, in full, is currently being prepared for submission for publication of the material. Manzano, Michael; Strong, David; Peterson, Carol; Rhee, Kyung; Eichen, Dawn; Engel, Scott; Boutelle, Kerri. The dissertation author was the primary investigator and author of this paper.

CHAPTER 3: An Evaluation of Uncontrolled Eating in Youth: Characterizing the Continuous Nature of Overeating Behaviors

Abstract

Objectives: Overeating encompasses a range of behaviors which have been linked to the increased prevalence of pediatric obesity. While a variety of overeating assessments are conceptualized as assessing distinct constructs because they use differing terminology, these claims have not been empirically tested. The model of uncontrolled eating proposes a framework by which a variety of related overeating behaviors can be subsumed under an overarching spectrum of "uncontrolled eating," with subconstructs ranging from normative overeating to loss of control (LOC) eating but has not been validated in youth.

Methods: Data were drawn from baseline assessments completed as part of 3 randomized controlled clinical trials evaluating the efficacy of adaptations to traditional family-based behavioral treatment for youth with OW/OB. Two trials included children ages 7-12 with OW/OB (*N*=310) and one trial included adolescents ages 13-16 with OW/OB (*N*=148). A 4-step analytic approach was utilized, including correlational analysis, exploratory graphical analysis, bifactor modeling, and item response theory.

Results: Preliminary validation of a model of uncontrolled eating in youth with OW/OB (*N*=458) was demonstrated, with bifactor models in school age youth (mean age=10.0, 53.2% female; $\chi^2 = 6476.2$, df = 2481, $p < .001$, RMSEA = .072) and adolescents (mean age=14.9, 56.8% female; $\chi^2 = 4827.7$, df = 2770, $p < .001$, RMSEA = .068) demonstrating good model fit.

Discussion: To our knowledge, this is the first study to empirically validate a model of uncontrolled eating in youth with OW/OB. This pediatric uncontrolled eating

model may provide valuable insights into the range of overeating behaviors implicated in the development of obesity and disordered eating.

Introduction

Eating behaviors develop early in the lifespan, with differences in eating patterns emerging as early as infancy (Birch & Fisher, 1998; Oliveira et al., 2015; Story et al., 2002; Kral & Rauh, 2010). Caloric consumption beyond nutritional needs, overeating, remains the principle eating behavior implicated in the development of obesity (Romieu et al., 2017; Hill et al., 2008) and excessive weight gain (van Strien et al., 2012; Drapeau et al., 2003; Piaggi, 2019). Moreover, research comparing children with overweight or obesity (OW/OB) to those of a healthy weight has demonstrated the former have greater difficulties regulating their energy intake (Johnson & Birch, 1994; Kininmonth et al., 2021), which is likely further exacerbated by the current obesogenic environment. Thus, understanding eating behaviors in youth with OW/OB is critical to identify maladaptive behaviors early in development when behaviors are potentially more malleable (Magarey et al., 2016; Scaglioni et al., 2011).

A major issue with the study of overeating has been lack of clearly defined terminology and assessments. At present, a myriad of terms for specific forms of overeating have been proposed, including *external eating, food cue responsiveness, reward-based eating, hedonic eating, emotional eating, loss of control eating, binge eating, food cravings, disinhibited eating, emotional eating,* and *food addiction* just to name a few. Furthermore, recent investigations of eating behaviors in youth specifically continue to struggle with using consistent terminology, with “maladaptive eating,” “disinhibited eating,” and “eating behaviors in obesity” all being used to broadly

characterize the span of overeating behaviors (Calcaterra et al., 2020; Hampton-Anderson & Craighead, 2021; Alberga et al., 2022; Swanson et al., 2022). While a host of assessments have been developed to assess these purportedly distinct forms of overeating, these instruments were primarily developed for use in adults and the validity of whether these overeating constructs are indeed distinct remains to be empirically tested. In adults, overeating measures assessing the above mentioned constructs are typically correlated at or above r>.50 (Vainik et al., 2015; Price et al., 2015; A. E. Mason et al., 2017). Even though r>.50 is a standard threshold for evaluating the convergent validity of measures, many measures that meet or exceed this threshold are cited as unique (Vainik et al, 2019).

An emerging model suggests these overeating domains may represent differing levels of *severity* of an overarching construct labelled *uncontrolled eating* (Vainik et al., 2015, 2019). In this framework, uncontrolled eating represents a range of overeating behaviors that exist on a continuum, starting with impulsive or cue-based eating which is marked by normative overeating that is largely a result of responding to food cues. The next levels of severity encompass hedonic and emotional eating, which are characterized by more frequent overeating for reasons outside of true physiological need, including pleasure and emotions, respectively. The most severe end of the spectrum includes loss of control and binge eating, which are characterized by driven or uncontrollable eating episodes and are hallmark behaviors of individuals with binge spectrum eating disorders (American Psychiatric Association, 2022). Thus, this model of uncontrolled eating was designed to capture the range of normative overeating to binge eating, and all overeating behaviors in between. Given past fluidity in

operationalizations of these terms, conceptualizations for the present study will be further detailed.

Cue responsive eating can be said to represent the least severe form of uncontrolled eating, characterized by eating due to physiological and psychological changes that occur in response to food cues (Kanoski & Boutelle, 2022). Next, hedonic eating was said to capture the second form of uncontrolled eating, characterized by a desire to eat due to the pleasure obtained from the palatability of foods irrespective of satiety. Hedonic eating is similar to cue responsive eating in that consumption is driven by external factors; however, hedonic eating is distinct from the previous level of severity, due to the conditioning observed in cue responsive eating being largely outside of individuals' consciousness, while hedonic eating is said to influence individuals' thoughts and feelings to a greater extent and are thus more cognitively intrusive. Emotional eating is the next form of uncontrolled eating. This is distinct from both hedonic eating and loss of control eating, as while all can be associated with some experiences of negative affectivity, it is the primary driver of overeating in emotional eating. Next, loss of control (LOC) eating is characterized by any experience of not being under conscious control of one's eating or having eating be experienced as compulsive or driven in nature. Lastly, binge eating represents the most severe form of uncontrolled eating in which LOC is present while an objectively large amount of food is consumed. Of note, while the distinction between LOC eating and binge eating is commonplace in adults, there are longstanding debates as to whether the amount of food consumed during LOC eating is a salient factor in youth (Pratt et al., 1998; Marcus & Kalarchian, 2003; Shomaker, Tanofsky-Kraff, Elliott, et al., 2010; Bohon, 2019). As

such, LOC eating will be said to include binge eating in the present investigation, given LOC is a defining feature of both.

Altogether, the uncontrolled eating model puts forth a framework with a continuous spectrum of behaviors ranging from cue responsive eating to binge eating, which have clear operational definitions and the relationships between subconstructs is clearly defined. To date, Vainik's model of uncontrolled eating has not been evaluated in pediatric samples (Vainik et al., 2015, 2019). Given these behaviors are known to develop early in the life course and the more severe behaviors are characteristic behaviors of certain eating disorders, validating a model of uncontrolled eating in youth is crucial. Not only could validation of this model serve as an important step forward in clarifying how overeating behaviors are related and distinct in children, it could provide potential targets to intervene upon before severe forms of uncontrolled eating worsen.

The present study investigated the verisimilitude of a model of uncontrolled eating in two pediatric samples with OW/OB, one consisting of school-age children and the other consisting of adolescents. Two samples were utilized to ensure models encompass a wide age spectrum. Data were drawn from three treatment studies, including two with youth ages 7-12 (N=310) and another including adolescents ages 13-16 (N=148). It was hypothesized that a model of uncontrolled eating would be validated across the age spectrum, with all questionnaires reflecting differing levels of uncontrolled eating severity in the proposed order of severity (*i.e.,* cue responsive eating, hedonic eating, emotional eating, LOC eating).

Methods

Participants

Data were drawn from baseline data in 3 randomized controlled clinical trials evaluating the efficacy of adaptations to traditional family-based behavioral treatment for youth with OW/OB. Two trials included children ages 7-12 with OW/OB and one trial included adolescents ages 13-16 with OW/OB. The three clinical trials assessed 158 school age child- caregiver dyads (NCT03096132), 152 school age child-caregiver dyads (NCT02976636), and 148 adolescent-caregiver dyads, respectively (NCT03674944).

Inclusion and exclusion criteria were similar across studies, with the exception of age. Caregiver-youth dyads were enrolled with the following criteria: a) youth with BMI ≥ 85^{th} and < 99.9^{th} percentile; b) caregiver and youth willing to commit to attending all treatment and assessment sessions and be randomized to either treatment arm; c) caregiver and youth willing to complete anthropometric measurements and surveys (adolescents needed to be willing to complete an ecological momentary assessment (EMA) protocol using their personal smartphone or a study provided device assessments); d) youth, caregiver, and first degree relatives are free from psychiatric illness than may affect participation; e) youth is free from any medical conditions that impact weight or may affect participation in physical activity or treatment; f) youth is not taking medications that may impact their weight (unless medication dosage is stable and not for the purpose of impacting weight and appetite); and g) caregiver or youth not current enrolled in another weight management program. Additionally, adolescents were screened for eating disorders using clinical interviews, and those that engaged in

compensatory behaviors or severe restriction in the past 6 months were not included and were given referrals for more appropriate treatments.

Children ages 7-12 with OW/OB and a primary caregiver were recruited from the San Diego metropolitan area, and adolescents ages 13-16 and a primary caregiver were recruited from both the San Diego, CA and Minneapolis, MN metropolitan areas. Participants were recruited in several ways including physician referral, listservs, ResearchMatch, letters mailed to families identified as potentially eligible through electronic medical records, local advertisements, online advertisements, and school flyers. Caregivers with interest in the study completed an online screen to determine initial eligibility, which was followed up by a phone screen and a study orientation to further assess eligibility. If interested after completing the orientation, caregivers provided informed consent and youth provided assent to enroll in the study.

Only baseline assessments were used for this analysis. Recruitment for the school age studies occurred between April 2017 and May 2021, and recruitment for adolescent study occurred between September 2019 and October 2021. Of note, initial assessments were in person, however, starting March 2020, treatment and assessments were moved to remote in accordance with UC San Diego Health and University of Minnesota policies. The following represent the numbers of dyads that completed assessments *virtually:* school-age study 1 (N=62), school-age study 2 (N=34), and adolescent study (N=135). Individuals were only included in the present study if they had complete baseline data. The Institutional Review Boards of the University of California, San Diego and the University of Minnesota (adolescent study only) approved the parent studies from which data were drawn.

Measures

Across Children and Adolescent Samples

Child Eating Behavior Questionnaire (CEBQ; caregiver report of child & child and adolescent self-report). Eating behaviors related to food approach and avoidance were assessed via the 35-item CEBQ (Wardle et al., 2001; Carnell & Wardle, 2007). Responses were completed both by caregivers about their child and youth about themselves and resulted in 8 subscales; however, only the emotional overeating, enjoyment of food (child only), food responsiveness, hunger (adolescent only), satiety responsiveness, and slowness in eating subscales (child only) were used for the present study. Response options were on a 5-point Likert type scale that assessed frequency of behaviors. Subscale scores were generated by averaging the items loading onto each subscale. Of note, given self-report has emerged as common practice with adolescents (Loh et al., 2013; Warkentin et al., 2022), to maintain consistency across samples, school age children were asked to self-report their eating behaviors. Furthermore, given all other eating measures across samples had youth self-report irrespective of age, to limit measurement variance attributable to respondent (e.g., parent- versus youth-report), youth self-report data were utilized across samples.

Emotional Eating Scale (EES; child and adolescent self-report). Eating in response to various emotions was assessed via the 25-item EES (Tanofsky-Kraff et al., 2007; Bryant et al., 2014). Response options were on a 5-point Likert type scale that assessed their desire to eat. A total score and three subscale scores result, which include eating due to anxiety/anger/frustration, depression, and feeling unsettled.

Scores were generated by averaging the items loading onto each subscale, and a total score was created by averaging across all 25 items.

Child Power Food Scale (c-PFS; child and adolescent self-report). Appetite for consuming highly palatable foods at varying levels of food proximity was assessed via the 15-item c-PFS (Laurent, 2015; Mitchell et al., 2016). Response options were on a 5-point Likert type scale that assessed agreement with each item. A total score and three subscale scores result, including food available, food present, and food tasted. Scores were generated by averaging the items loading onto each subscale, and a total score was created by averaging all 15 items.

School Age Children Only

Eating in the Absence of Hunger Questionnaire (EAHQ; child self-report) Beginning or continuing to eat due to various internal (*e.g.,* emotions) and contextual factors was assessed via the 14-item EAHQ (Madowitz et al., 2014; Tanofsky-Kraff et al., 2008). Response options were on a 5-point Likert type scale that assessed frequency of behaviors. A total score and three subscale scores result, which include negative affect eating, external eating, and bored eating. Subscale scores were generated by averaging the items loading onto each subscale, and a total score was created by averaging all 14 items.

Youth Eating Disorder Examination Questionnaire (YEDE-Q; child self-report). LOC eating and disordered eating concerns in school age children were assessed via the YEDE-Q (Fairburn & Beglin, 1994; Goldschmidt et al., 2007) and only LOC and eating concerns subscale items were used for the present study. Of note, “really big amount of food” and “feeling out of control” were both defined for children

prior completing the assessment and examples of each type of eating episode were given, consistent with previous studies utilizing the YEDE-Q (Goldschmidt et al., 2007; Kass et al., 2017). Response options for most items were on a 7-point Likert-type scale, with higher scores indicating greater pathology. LOC items were free response, asking for the number of times that type of episode occurred over the past 28 days. Three LOC eating items were included, as was an item assessing fear of LOC. The eating concerns subscale was scored by averaging across five items.

Adolescents Only

Reward Based Eating Drive Scale (RED; adolescent self-report). Eating due to the reinforcement and pleasure obtained from engaging in eating irrespective of appetite was assessed via the 13-item RED (Epel et al., 2014; Mascioli & Davis, 2018; A. E. Mason et al., 2015). Response options were on a 5-point Likert type scale that assessed agreement with each item. A total score was calculated by taking the average of all 13 items.

Naturalistic Loss of Control Eating (EMA-LOC; adolescent report). LOC eating in adolescents was assessed via a 10-day ecological momentary assessment (EMA) protocol during which adolescents were prompted 4 times on weekdays and 6 times on weekend days regarding the extent to which they experienced phenomena consistent with LOC. Research staff trained adolescents with regard to how to provide responses, in addition to adolescents being given a test day prior to the 10-day window to troubleshoot technical issues. At each semi-random signal, adolescents were asked to report on of any eating episode within the last 90 minutes. Five LOC items were asked, including, “While you were eating, rate the extent that you… (1) felt out of

control, (2), felt like you couldn't resist eating, (3) couldn't stop eating once you started, (4) felt driven or compelled to eat, (5) paid attention to your eating," consistent with other EMA studies in adolescents (Goldschmidt et al., 2018). The last item was reverse coded in all analyses. Adolescent's extent to which they overate was also assessed. Response options were on a 5-point Likert type scale that assessed agreement with each item.

Statistical Analysis

A four-step analytic approach was used, seeking to parallel the analytic plan described in Vainik et al. (2015). First, associations between total and subscale scores from all measures were calculated utilizing spearman correlations. Second, exploratory graphical analysis (EGA) was utilized to explore the presence of a higher order factor and visually group potential subfactors (Golino & Epskamp, 2017). The emergence of a bifactor structure over a lower order factor structure was determined by exploring the total entropy fit index (TEFI). Third, bifactor modeling was used to assess the commonalities and uniqueness of each item from all questionnaires. More specifically, a bifactor model with a general uncontrolled eating factor and subfactors of cue responsive eating, hedonic eating, emotional eating, and loss of control eating was investigated. Bifactor model fit was determined using explained common variance (ECV), omega reliability coefficients, and clinical utility in combination (Rodriguez et al., 2016). Two reliability coefficients were reported, omega-total and omega-hierarchical. The omega-total represents the combined reliability of all the factors of the model, without differentiating between the sources of variance (*i.e,* specific or general factors). In contrast, the omega- hierarchical coefficient estimates the reliability of the general

factor, controlling the variance from the specific factors. Lastly, item response theory (IRT) sought to further assess the extent to which various subscales represent different levels of uncontrolled eating severity. Item information curves were grouped by uncontrolled eating subtype to form a Test Information Function (TIF) which represents the aggregated IICs for all items in that subdomain (Boone & Staver, 2020). R version 4.3.2 was utilized for all analyses, including the "EGAnet," "mice", "mirt", and "psych" packages (Buuren & Groothuis-Oudshoorn, 2011; Chalmers, 2012; Golino & Christensen, 2024; Revelle, 2024).

Results

Demographic Characteristics

Table 3.1: Child and Caregiver Demographics (% (N) or Mean (SD))

	Child (n=310)	**Caregiver (n=310)**
Age (years); Mean (SD)	10.0 (1.5)	41.6 (7.9)
Sex Assigned at Birth (female)	53.2% (165)	91.0% (282)
Ethnicity		
Latino/a	50.6% (157)	50% (155)
Race		
Asian	5.5% (17)	7.4% (23)
Black	8.1% (25)	4.8% (15)
Indigenous/Alaska Native	5.8% (18)	4.8% (15)
White	46.1% (143)	54.8% (170)
Multiple	10.3% (32)	2.3% (7)
Declined/Not reported	24.2% (75*)	25.8% (80)
Anthropometrics); Mean (SD)		
BMI	28.0 (5.1)	31.8 (7.6)
zBMI	2.1 (0.4)	-----
% of 95th percentile	119.8 (20.1)	-----
Household Income**		
<$50,000/year	-----	34.5% (107)
$50,000-$99,999/year	-----	27.4% (85)
>$100,000/year	-----	37.7% (117)

*73/75 specifically declined to report
**1 declined to report

Table 3.2: Adolescent Demographics (% or Mean (SD))

	Adolescent (N=148)
Age (years); Mean (SD)	14.9 (1.2)
Sex Assigned at Birth (female)	56.8% (84)
Gender	
Female	50.7% (75)
Male	43.2% (64)
Trans-Masculine	0.7% (1)
Non-Binary	2.7%(4)
Questioning	1.4% (2)
Not sure	1.4% (2)
Ethnicity	
Latino/a	29.7% (44)
Race*	
Asian	12.8% (19)
Black	10.1% (15)
White	70.0% (103)
Indigenous/Alaska Native	9.5% (14)
Pacific Islander/Native Hawaiian	1.4% (2)
Not reported	7.4% (11)
Anthropometrics); Mean (SD)	
BMI	32.8 (6.0)
zBMI	2.1 (0.4)
% of 95th percentile	119.9 (21.5)
Household Income; Median	$95,000 - $99,999

*Numbers do not add up to 100% as individuals were not restricted to selecting one racial category

For the school age sample, caregivers reported socio-demographic data for both themself and their child. Children were a mean age of 10.0 years and 53.2% identified their sex as female. The sample was ethnically and racially diverse with approximately half of both children and parents identifying as Latino (see Table 3.1). For the adolescent sample, adolescents reported socio-demographic data for themselves. Adolescents were a mean age of 14.9 years and 56.8% identified their sex as female. The sample was also ethnically and racially diverse with approximately a third of adolescents identifying as Latino (see Table 3.2).

Associations Among Measures

In the school age sample (see Table 3.3 for full details), items from the CEBQ demonstrated statistically significantly associations among one another, with satiety responsiveness and slowness is eating being inversely associated with enjoyment of food, emotional overeating, and food cue responsiveness. Additionally, items from the C-PFS, EAHQ, RED and to a lesser extent overall eating concerns from the YEDE-Q demonstrated statistically significantly associations among one another. In the adolescent sample (see Table 3.4 for full details), subscales across all measures demonstrated more consistent statistically significant associations, with the exceptions of the satiety responsiveness subscale which was less reliability associated from subscales from other measures.

Table 3.3: Spearman Correlations Among School-Age Children Questionnaires

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. CEBQ_EF															
2. CEBQ_EOE	0.48***														
3. CEBQ_SR	-0.50***	-0.18**													
4. CEBQ_FR	0.80***	0.54***	-0.56***												
5. CEBQ_SE	-0.36***	-0.11*	0.50***	-0.36***											
6. PFS_Available	0.09	0.14*	-0.03	0.17**	-0.04										
7. PFS_Present	0.01	0.07	-0.02	0.07	-0.01	0.70***									
8. PFS_Tasted	0.03	0.01	-0.02	0.05	-0.02	0.71***	0.73***								
9. PFS_Total	0.04	0.07	-0.03	0.1	-0.03	0.87***	0.89***	0.92***							
10. EAHC_NA	0.12*	0.27***	-0.01	0.19***	-0.07	0.38***	0.30***	0.30***	0.37***						
11. EAHQ_Ext	0.01	0.15**	-0.02	0.08	-0.03	0.50***	0.53***	0.41***	0.53***	0.42***					
12. EAHQ_Bored	0.14*	0.16**	-0.03	0.14*	-0.01	0.41***	0.37***	0.36***	0.42***	0.48***	0.49***				
13. EAHQ_Total	0.12*	0.21***	-0.02	0.15**	-0.04	0.54***	0.49***	0.45***	0.55***	0.75***	0.80***	0.81***			
14. RED_Total	0.12*	0.18**	-0.07	0.19***	-0.06	0.65***	0.61***	0.61***	0.68***	0.37***	0.61***	0.38***	0.56***		
15. EDEQ_EC	0.05	0.21***	-0.07	0.15*	-0.01	0.44***	0.35***	0.34***	0.41***	0.29***	0.29***	0.27***	0.34***	0.43***	

*p<.05, **, p<.01, ***p<.001

KEY: EF-enjoyment of food, EOE- emotional overeating, SR- satiety responsiveness, FR- food responsiveness, SE- slowness in eating, NA- negative affect, Ext- external eating, Bored- bored/fatigue, EC- eating concerns

Table 3.4: Spearman Correlations Among Adolescent Questionnaires

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. CEBQ_EOE													
2. CEBQ_SR	0.02												
3. CEBQ_FR	0.36***	-0.12											
4. CEBQ_HUNGER	0.38***	-0.02	0.61***										
5. PFS_Available	0.33***	-0.17*	0.48***	0.32***									
6. PFS_Present	0.32***	-0.23**	0.56***	0.33***	0.76***								
7. PFS_Tasted	0.33***	-0.16*	0.57***	0.38***	0.71***	0.72***							
8. PFS_Total	0.36***	-0.20*	0.59***	0.38***	0.91***	0.91***	0.88***						
9. RED_Total	0.34***	-0.17*	0.66***	0.45***	0.73***	0.69***	0.58***	0.74***					
10. EES_UNS	0.35***	-0.12	0.35***	0.30***	0.38***	0.37***	0.31***	0.40***	0.39***				
11. EES_AAF	0.54***	-0.09	0.37***	0.39***	0.46***	0.43***	0.39***	0.47***	0.44***	0.87***			
12. EES_DEP	0.55***	-0.06	0.32***	0.29***	0.50***	0.44***	0.39***	0.49***	0.41***	0.77***	0.88***		
13. "out of control"	0.22**	-0.04	0.31***	0.19*	0.41***	0.39***	0.31***	0.41***	0.39***	0.11	0.22**	0.21**	

*p<.05, **, p<.01, ***p<.001

KEY: EOE- emotional over eating, SR- satiety responsiveness, FR- food responsiveness, UNS- unsettled, AAF- anger, anxiety, frustration, DEP- depression

Exploratory Factor Structure

Network graphical analysis in the school age sample (Figure 3.1) demonstrated a bifactor structure (TEFI = -44.609) better fit the data than a correlated lower order factor structure (TEFI = -116.525). Network graphical analysis in the adolescent sample (Figure 3.2) also demonstrated a bifactor structure (TEFI = -28.776) better fit the data than a correlated lower order factor structure (TEFI = -161.242). Both models suggested 3 sub-factors may be present.

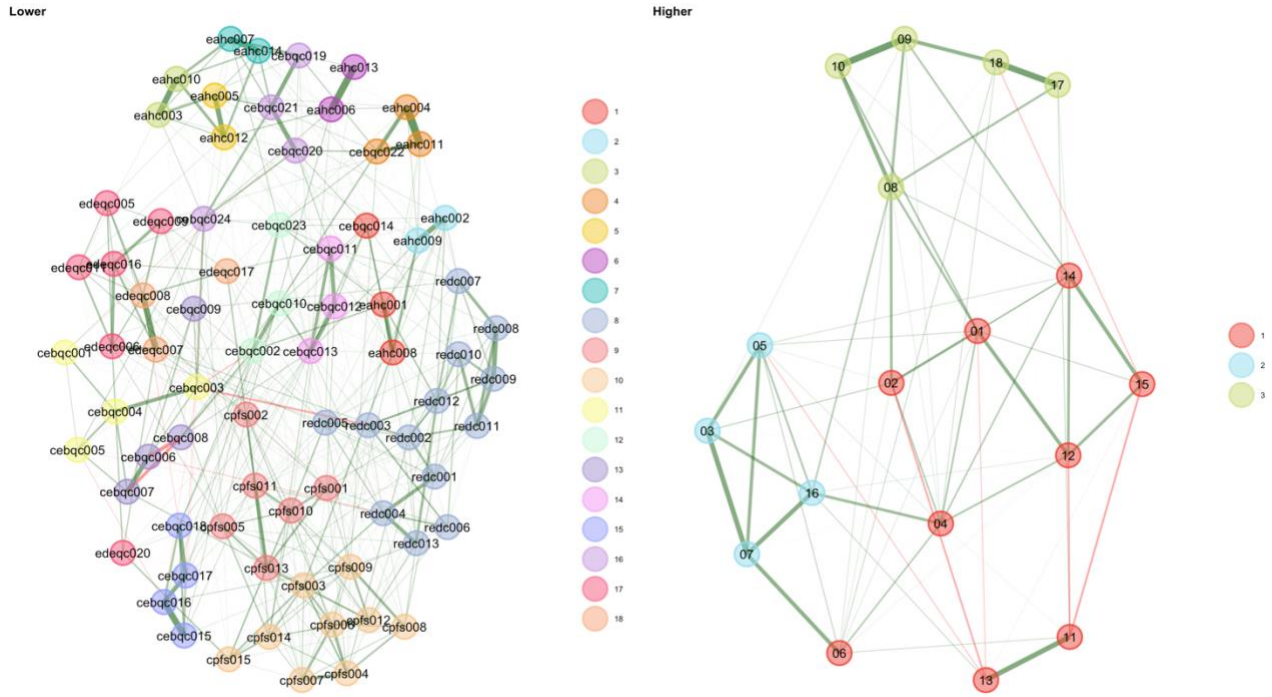

Figure 3.1: Exploratory Graphical Analysis in School Age Children

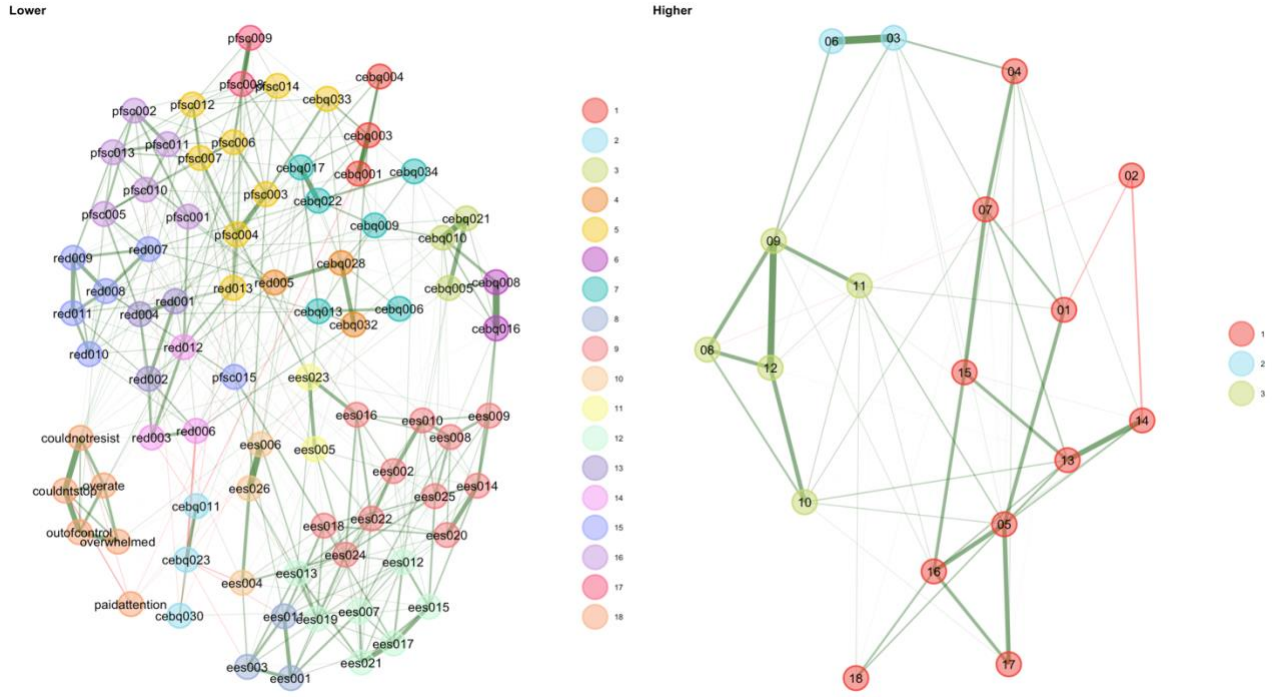

Figure 3.2: Exploratory Graphical Analysis in Adolescents

Hierarchical Factor Structure

In the school age sample, a higher order model with 1 higher order factor and 4 lower order factors demonstrated relatively good model fit (χ^2 = 6476.2, df = 2481, $p < .001$, RMSEA = .072, $\omega_{hierarchical}$= 0.64, ω_{total}= 0.96). The model demonstrated an ECV of 43.5 and all but 8 items loaded onto the general uncontrolled eating factor. Figure 3.3 shows all factor loadings. Notably, all 8 items that did not load onto the factor came from the CEBQ. Nine items demonstrated cross loadings on multiple factors. In the adolescent sample, a higher order model with 1 higher order factor and 5 lower order factors also demonstrated good model fit (χ^2 = 4827.7, df = 2770, $p < .001$, RMSEA = .068, $\omega_{hierarchical}$= 0.64, ω_{total}= 0.98). This model emerged over the originally hypothesized 4 factor model as the EES items and emotional overeating items from the CEBQ did not load into one factor. Thus, the factor structure was relaxed to model an additional factor that allowed for two unique clusters of emotion eating items. The resulting 5-factor model demonstrated an ECV of 38.6 and all but 6 items loaded onto the general uncontrolled eating factor. For ease of visual interpretation, the two emotion eating factors were visually combined given both represent items consistent with a common latent factor. Figure 3.4 shows all factor loadings. Notably, 5 items that did not load onto the general factor came from the CEBQ and the final item was the EMA item, “I paid attention while I ate.”

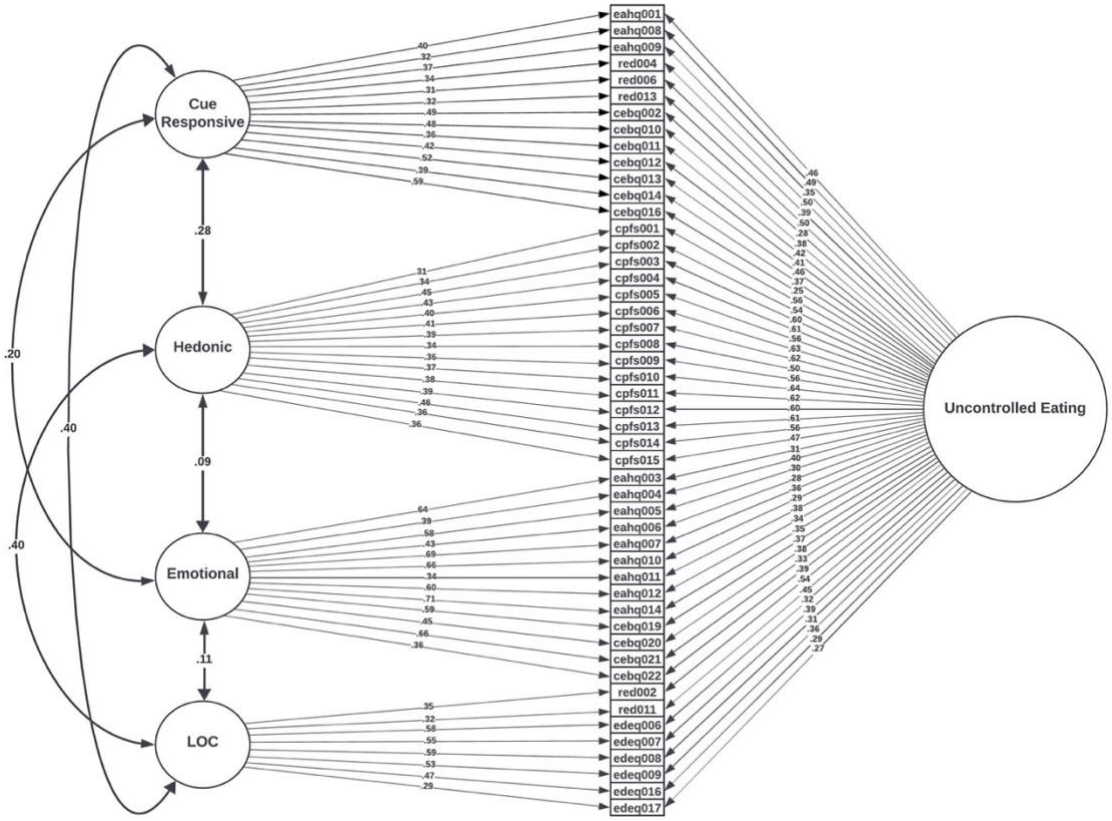

Figure 3.3: Bifactor Model of Uncontrolled Eating In School Age Children

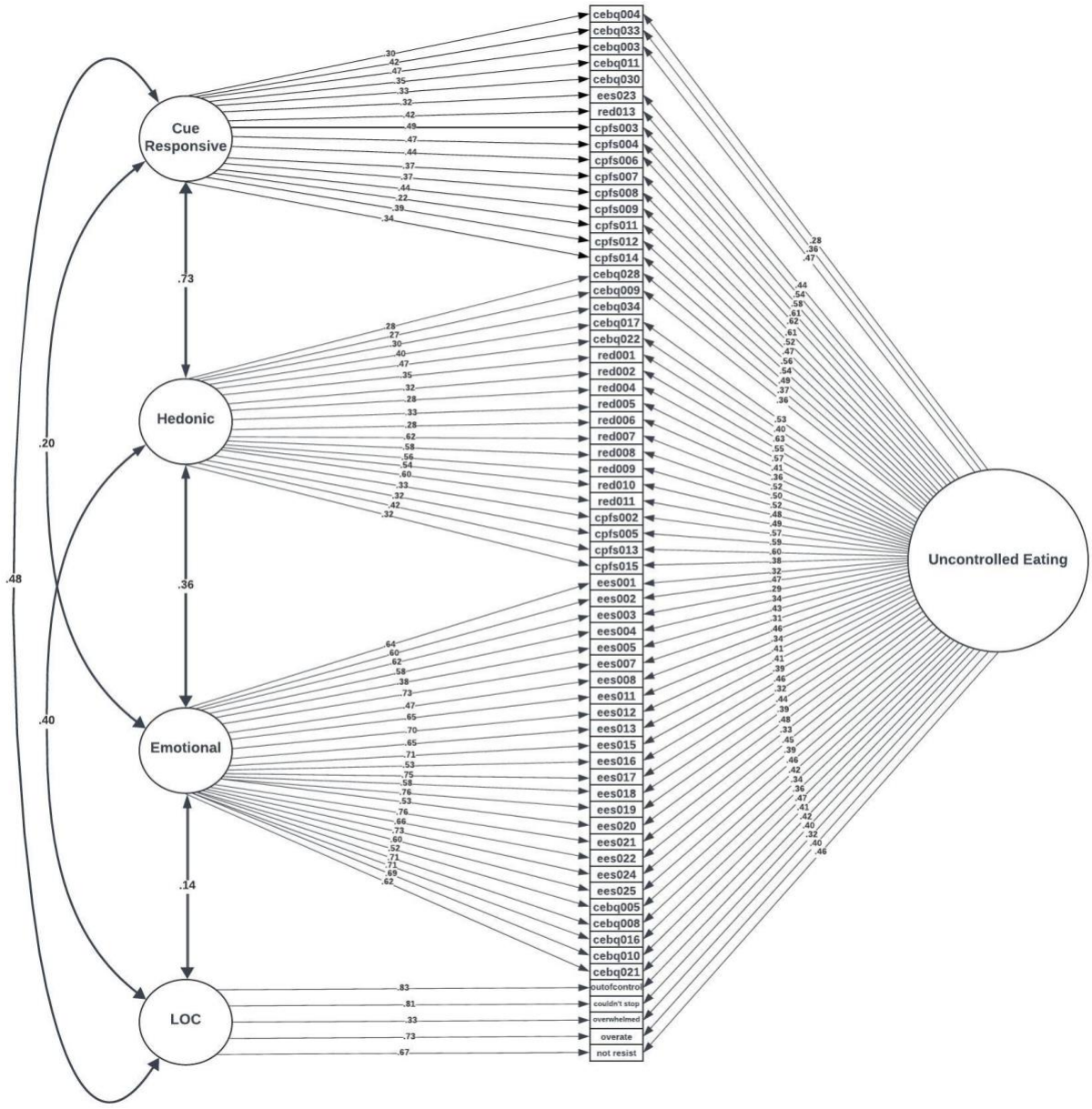

Figure 3.4: Bifactor Model of Uncontrolled Eating In Adolescents

Test Information Functions

Item information curves were examined and aggregated to investigate response variability across each proposed factor independently. These information curves revealed responses were reported across the behavioral continuum of each domain, suggesting that although all of the children had OW/OB, the behaviors of these youth

were still heterogeneous (Figures 3.5 and 3.6). The points on the peaks of the curves represent where on the latent construct of uncontrolled eating information from that factor's items is maximal.

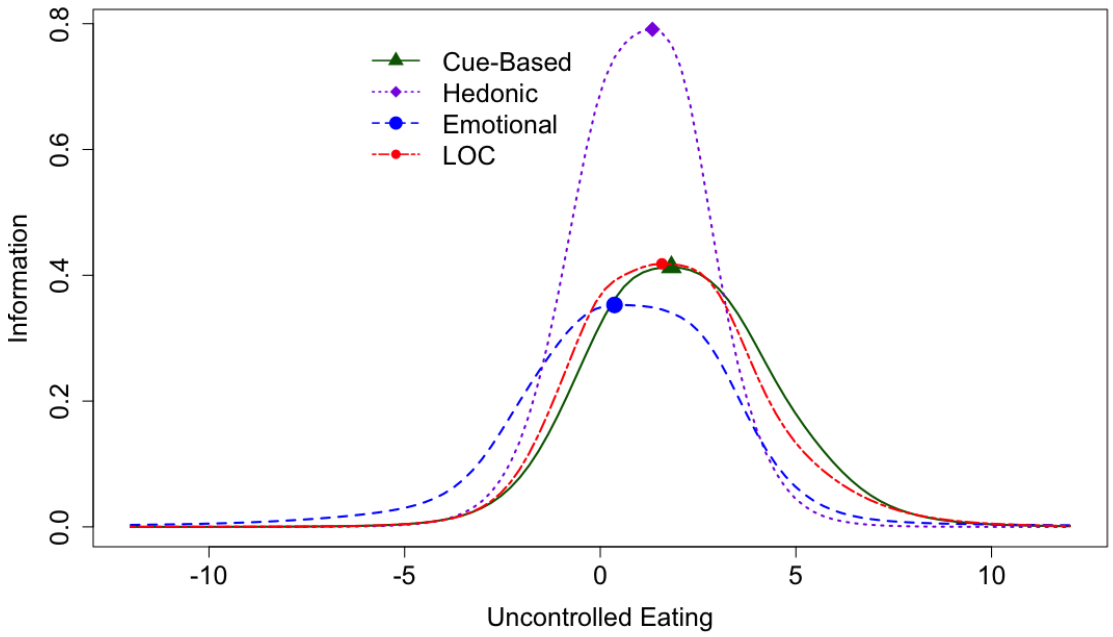

Figure 3.5: Test Information Functions in School-Age Children

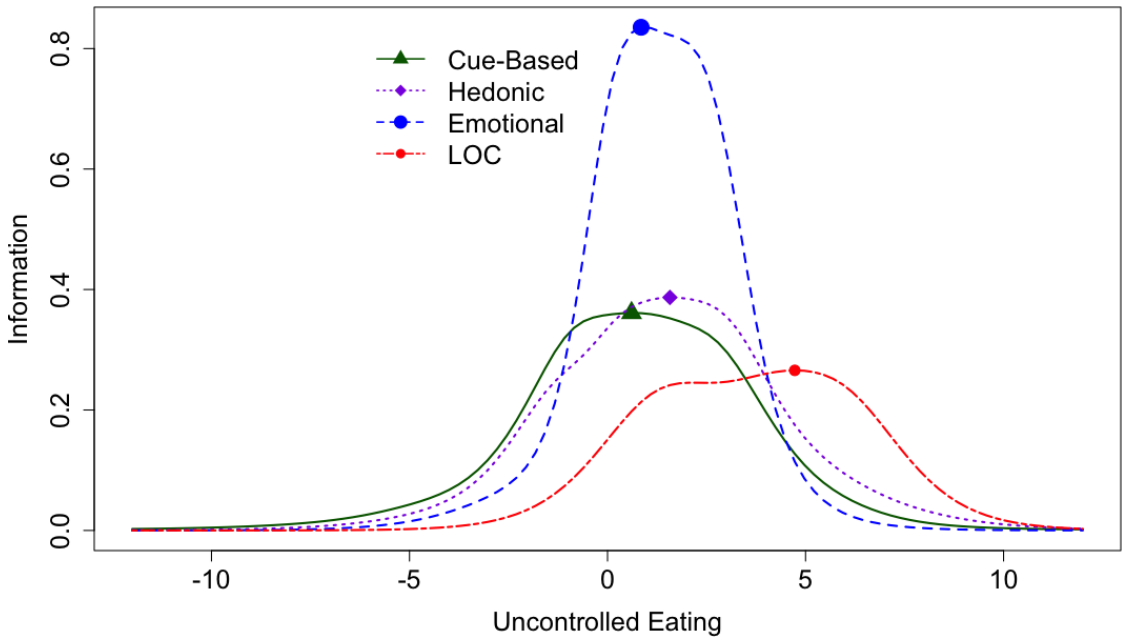

Figure 3.6: Test Information Functions in Adolescents

Discussion

This study aimed to evaluate the verisimilitude of a model of uncontrolled eating in youth with OW/OB. We demonstrated the interconnected nature of purportedly unique overeating domains, while also demonstrating the unique information provided independently by each questionnaire. Indeed, while the overarching uncontrolled eating factor explained a significant amount of shared variance among items, items also demonstrated unique variance explained by subconstructs. Taken together, the study provides preliminary empirical support for a common factor (*i.e.,* uncontrolled eating) in youth that organizes related eating behaviors in terms of severity while allowing for unique information from each subconstruct to still be assessed.

The step-wise analytic approach allowed for exploration of all aspects of the interrelated nature of items, including analyzing rank-ordered associations, specific variance partitioning, and more modern IRT-based information functions. The visual representation of potential factors underlying uncontrolled eating and preliminary support for a bifactor structure provided by exploratory graphical analysis, coupled with the accounting of common and unique variance in item responses provided by bifactor modeling, allowed for a comprehensive understanding of the structure of uncontrolled eating. The results of bifactor modeling supported the existence of a general uncontrolled eating factor, with subfactors representing cue responsive eating, hedonic eating, emotional eating, and loss of control eating. Item response theory (IRT) analysis further enriched our understanding by examining the discriminative power and severity of individual items within each subtype of uncontrolled eating. By delineating the specific characteristics of each item, IRT revealed how different measures contribute to the

assessment of uncontrolled eating severity. The ability to visually analyze the increasing peaks of information curves provides preliminary support for the spectral nature of the behaviors, which is not possible with bifactor modeling in insolation. Taken together, this allows for greater understanding beyond whether subscales are related but *how* they are related, which has been sorely missing from past work in overeating assessment.

Interestingly, the emergence of emotion eating as a particularly salient subfactor in the adolescent sample parallels Vainik's original uncontrolled eating investigation in adults, which found emotion eating items demonstrated the largest factor loadings onto the general factor (Vainik et al., 2015). This may be due to emotions being a common precipitant to and consequence of binge eating (Lim et al., 2021; Matheson et al., 2021). Additionally, it may be due to adolescents having a greater capacity to fully experience and to a lesser extent regulate their emotional experiences (Hazen et al., 2008; Rosenblum & Lewis, 2006). Furthermore, the emergence of LOC as a having a clear heightened severity in the adolescent sample parallels the emergence of clinical binge spectrum disorders emerging during this period of development (Bohon, 2019; Marzilli et al., 2018). Consequently, given engaging in LOC or binge eating has been associated with more difficulties managing weight, focusing on reducing maladaptive eating prior to directly targeting weight change may indicated in some individuals (Moustafa et al., 2021).

The continuous nature of uncontrolled eating domains was supported in the adolescent sample, but more mixed in the school age sample. The results in the adolescent sample replicate the findings found by Vainik and colleagues in their original investigation (Vainik et al., 2015). As was originally demonstrated, the hypothesized

ends of the spectrum were supported with the hedonic eating and emotional eating peaks being switched but very close to one another. Interestingly, in the school age sample the same order of peaks was similar to the adolescent sample, but cue-based eating peaked at a higher severity than expected. This may be in part due to children having less self-awareness (Rochat, 2003) and insight into their emotional experiences (Veirman et al., 2011) and are thus less able to parse apart their reasons for eating. Furthermore, the CEBQ was originally validated as a parent-report measure. Thus, further work in school age children is warranted to elucidate at what point the construct of uncontrolled eating begins to emerge, and clarify if child-report, parent-report, or some combination is best able to assess constructs of interest in younger children.

The present study has several strengths. First, this is the first study to examine this model in youth spanning a wide age range. These samples also included males, which were excluded from past investigations of uncontrolled eating (Vainik et al., 2015). Furthermore, the samples were both racially/ethnically and socioeconomically diverse. As with all studies, the present study is not without its limitations. First, the samples included all treatment-seeking youth with OW/OB which many limit the generalizability of the present findings to youth in the community, including those of varying body sizes. Additionally, while the assessment battery was extensive, other eating assessments such as the Dutch Eating Behavior Questions, Yale Food Addiction Scale, and Binge Eating Scale were not included. Additionally, we used self-report measures of CEBQ which were originally validated as parent-report in school-age youth. Lastly, the cross-sectional design precludes causal inferences regarding the relationships among variables.

Taken together, this investigation provides preliminary validation of a model of uncontrolled eating in youth. This represents an important step forward in clarifying the definitions of various overeating behaviors and related terminology used. This is particularly important given the assessment of overeating and LOC has struggled to demonstrate reliability and validity across populations, particularly those from marginalized backgrounds (Goldschmidt, 2017). Additionally, given iterative assessment such as EMA is emerging as more common in studying overeating, the importance of psychometrically sound measurement is essential given the limited number of items that are administered in naturalistic assessments (Mason et al., 2024; Song et al., 2023). Furthermore, a validated model of uncontrolled eating provides a framework to describe the relationships among overeating behaviors known to be related. Future work should seek to evaluate uncontrolled eating in youth of all body sizes, as LOC and binge eating are important to address regardless of weight status, especially given rates of binge eating in the population are only rising following the COVID-19 pandemic (Caldiroli et al., 2023). Further validation of uncontrolled eating as a continuous, overarching construct subsuming several well-known overeating domains would allow for greater shared language amongst researchers and clinicians alike.

Chapter 3, in full, is currently being prepared for submission for publication of the material. Manzano, Michael; Strong, David; Peterson, Carol; Rhee, Kyung; Eichen, Dawn; Engel, Scott; Boutelle, Kerri. The dissertation author was the primary investigator and author of this paper.

CHAPTER 4: Summary of Findings and Comprehensive Discussion

The present dissertation suggests uncontrolled eating is a salient construct for conceptualizing related overeating behaviors, demonstrating preliminary validation in youth with overweight/obesity (OW/OB). The behaviors that anchor this proposed spectrum of uncontrolled eating, cue responsive eating at the least severe end and loss of control (LOC) eating at the most severe end, were given particular focus given they represent the most normative and clinically impairing behaviors, respectively. Thus, greater understanding of how these behaviors should be defined and assessed is critical to understanding what is meant by uncontrolled eating and what mechanisms underly these behaviors. The discordance amongst cue responsive eating measures found in Study 1 is concerning and highlights the importance of clearly operationalizing specific constructs and careful consideration as to the terminology being used to characterizes assessment measures. Study 2 demonstrated that specific negative emotions, such as nervousness and fear, and specific stressors, such as family and relationship stress, predicted specific uncontrolled eating behaviors among adolescents. Moreover, cue responsive eating and LOC behaviors, particularly the former, were common among adolescents with OW/OB. However, the failure of negative emotions and stressors to consistently predict cue responsive eating and LOC eating highlights the idiosyncratic nature of these relationships, in addition to the importance of not presuming associations between constructs found in adults holds true in youth. The preliminary validation of a model of uncontrolled eating in youth with OW/OB aged 7-16 in Study 3 provides empirical support for an important framework which could serve to better integrate a body of overeating research which has been plagued by inconsistent

terminology and mapping of how these behaviors relate to one another. The implications from each of the studies will be further explored.

Assessment Considerations

Construct Operationalization

Studies 1 and 2 highlight the importance of clear and consistent operationalization of overeating terms. As an example, during the initial development of the eating the absence of hunger (EAH) paradigm, Fisher and Birch said that EAH was characterized by a "heightened responsiveness to environmental factors [that] may constitute a normative aspect of development during early childhood" and is driven by using "cues to initiate and terminate eating." Despite this clear focus on the external cue-driven nature of EAH, the later development of a questionnaire adaptation of EAH (EAH-C) included two subscales unrelated to environmental food cues (Tanofsky-Kraff et al., 2008). While the measure developers conceptualized negative emotions as being internal cues to eating, this was inconsistent with the original conceptualization of EAH as being directly related to environmental factors. This exemplifies a persistent issue in the field- even when the initial operationalization of concepts is clear, there are ever evolving operational definitions used among research groups. Moreover, a recent commentary on "restrained eating" highlights that while the term emerged in the literature as early as 1975 (Herman & Polivy, 1975), debate among experts in the field has persisted around this construct for decades (Lowe, 2022). While this may seem problematic, the author of the commentary suggests that scientific progress is best served by engaging in discussion and debate about differing perspectives on eating behaviors, not avoiding such conversations. Indeed, finding ways to engage in regular

and respectful debate surrounding the conceptualization of overeating behaviors is likely to advance the field.

Beyond evolving definitions of existing terms, understanding how terms are related, or not, is critical given the expansive list of overeating terms currently in use. The developers of the PFS emphasized that the pleasurable eating phenomenon they were aiming to capture could be prompted by exposure to food cues, but make clear they were trying to more specifically capture a subjective state of anticipated pleasure that may be independent of actual food intake (Lowe et al., 2009; Lowe & Butryn, 2007). This clearly delineates how cue-driven eating may be a component of hedonic eating, but they remain distinct concepts. Nonetheless, the lack of even small to moderate effects found between the CEBQ-FR and PFS, as demonstrated in Study 1, suggest that even when terminology is clear, empirical questions regarding potentially shared phenomenology require empirical evaluations. Conceptual hypotheses regarding how concepts may be related are important; however, data-driven exploration of construct validity and quantifying the relationships among constructs is essential.

Reliability and Validity of Measures in Youth with Overweight/Obesity

Regardless of which specific behavior is being assessed, these overeating behaviors need to be explored across the age and weight spectrums, with specific evaluation in youth with OW/OB being particularly critical (Braet et al., 2008, 2014). Indeed, a targeted examination of the potentially unique factors that may contribute to uncontrolled eating in this group is vital given one of the most robust predictors of obesity and its related physical and mental health sequelae in adulthood is obesity in childhood (Kumar & Kelly, 2017). Furthermore, focusing on youth with OW/OB provides

insights into the developmental trajectories of uncontrolled eating when these behaviors may be more malleable, as evidenced by the fact that weight management interventions in youth demonstrate more consistent efficacy as compared with adults (Chai et al., 2019; Dombrowski et al., 2014). Thus, early, and targeted interventions are greatly needed in youth, and can only occur in the context of accurate assessment.

Informant Validity

Eating assessments have not consistently utilized a particular informant, with youth and parent reports being commonplace (Braet et al., 2007). Moreover, consistent patterns of over- or under- reporting have not been demonstrated, with measures finding concordance (Lamb et al., 2007; Mariano et al., 2013), under-reporting by youth (Salbach-Andrae et al., 2008), and over-reporting by youth (Bartholdy et al., 2017). A rationale for investigating youth-report in particular is warranted, given disparaging comments about body image and weight are commonplace among parents and are likely to bias reporting of their child's behaviors and internal experience (Lydecker et al., 2018). While assessment in youth has its own challenges, systematic, internalized biases are less likely and thus youth-report may have a greater potential for construct validity if proper scaffolding and developmentally appropriate explanations are provided (Goldschmidt et al., 2007). Ideally, a synthesis of information from multiple informants should be utilized to best triangulate youth's eating behaviors. That was not undertaken by the current investigation given that the integration of data from multiple informants, particularly when the reports disagree, remains an emerging area of research and was beyond the scope of the current study (De Los Reyes et al., 2013, 2015; Makol et al., 2020). Future work should seek to validate approaches that may prove more objective

assessments, such as computerized diagnostic assessment (Moya et al., 2005), iterative assessment (Smith & Juarascio, 2019), virtual reality (Gutiérrez-Maldonado et al., 2016), and wearable technology (Skinner et al., 2020).

Ecological Momentary Assessment

EMA approaches address many of the challenges with traditional single-administration assessment by improving ecological validity, reducing retrospective recall biases, and allowing for temporal investigations through repeated assessment (Shiffman et al., 2008; Stone & Shiffman, 1994). However, as exemplified by Study 2, the importance of word choice remains an ongoing issue. The DSM-5-TR defines loss of control as, “a sense of lack of control over eating during the episode (*e.g.,* a feeling that one cannot stop eating or control what or how much one is eating).” (American Psychiatric Association, 2022). However, in Study 2, when phrased as experiencing “loss of control” versus “cannot stop eating,” different frequencies emerge, as do differing antecedents. One potential strategy to ensure shared language is being used between assessment developers and those completing assessments for youth is to provide developmentally appropriate definitions of terms and concepts before beginning assessments (Goldschmidt et al., 2007). Beyond helping address assessment issues, naturalistic methodologies also hold great promise for understanding momentary mechanisms and developing momentary interventions, which may be particularly salient in the context of eating behaviors (Smith & Juarascio, 2019). Whether exploring naturalistic assessment or intervention, antecedents to behaviors of interest are important to clarify as they relate to specific populations of interest, adolescents with OW/OB in the present investigation.

Antecedents to Uncontrolled Eating

Study 2 demonstrated that while specific experiences of negative affect or psychosocial stress have some statistically significant forward influences on uncontrolled eating behaviors, particularly LOC eating, the magnitude of these associations was small. One rationale for the small magnitude of observed effects may be that even more dynamic explorations of how these negative affect and stress interact with one another are needed. For example, constructs such as being afraid or nervous may be moderated by certain forms of stress which leads to a particularly high susceptibility to engaging in uncontrolled eating. Future work should seek to explore how interactions between negative affect and stress best capture the complex internal experiences that precede uncontrolled eating. Moreover, these domains may further interact with unassessed constructs such as reward responsivity and executive functioning, as purported by the developmental framework pediatric LOC (Tanofsky-Kraff et al., 2020). This could explain how even in the presence of triggers to uncontrolled eating, higher order constructs such as self-regulation and impulsivity may further moderate the effects of affect and stress on these behaviors (Tanofsky-Kraff et al., 2020). Empirical, naturalistic investigations exploring how negative affectivity, reward responsivity, and executive functioning interact to influence eating behaviors are greatly needed.

Models of Overeating Behaviors

To date, models of overeating and LOC eating have been developed in adults, and later adjusted to incorporate salient factors in youth. This is exemplified by the affective regulation (Hawkins & Clement, 1984), cognitive-behavioral (Fairburn et al.,

1993, 2003), dual-pathway (Stice et al., 1996), and interpersonal (Wilfley et al., 2000) models all being initially posited in adults populations and later evaluated in youth (Allen et al., 2012; Elliott et al., 2010; Van Malderen et al., 2021). The developmental framework of pediatric LOC represents an important step forward in considering important developmental factors from model conceptualization (Tanofsky-Kraff et al., 2020). However because its overall aim was to predict the development of Binge Eating Disorder (BED) and adult obesity (Tanofsky-Kraff et al., 2020), the issue of LOC being conceptualized dichotomously persists. This is problematic both statistically and clinically, as dichotomizing continuous constructs has long been recommended to be avoided in statistical modeling (Dawson & Weiss, 2012), and exploratory investigations of measuring LOC continuously have demonstrated increased clinical utility (Blomquist et al., 2014). The model of uncontrolled eating begins to explore the spectrum of overeating behaviors concurrently, which is missing from all past models of overeating (Vainik et al., 2015, 2019). To our knowledge, Study 3's preliminary validation of an uncontrolled eating model in youth is the first model of overeating behaviors that included a range of commonly described forms of overeating, conceptualized LOC as being a severe presentation on a spectrum of overeating behaviors and did so in youth with OW/OB of varying ages and sexes.

Future Implications

Research Implications

Exploring potential predictors of uncontrolled eating in youth creates opportunities for targeted intervention and prevention efforts. Beyond negative affect and stress, as were investigated in Study 2, additional factors may play significant roles

in the development and maintenance of uncontrolled eating behaviors, which have not been included in models of LOC eating to date. For example, poor sleep quality and quantity are associated with greater overeating, including LOC eating specifically (Burt et al., 2014; Kracht et al., 2019; Parker et al., 2022). Furthermore, affective lability, the degree to which an individual experiences significant mood fluctuations, has been associated with increased engagement in many maladaptive behaviors to provide relief from distress and has been implicated in the development of LOC eating (Anestis et al., 2009; Greenberg & Harvey, 1987). Additionally, environmental cues have long been known to influence overeating behaviors (Hetherington, 2007), with Pavlovian learning theory being suggested as a mechanism by which cravings and overeating behaviors can be learned (Van Den Akker et al., 2018). Understanding these predictors can inform the design of effective interventions tailored to individual needs, ultimately improving outcomes for youth affected by uncontrolled eating. Moreover, there are individual differences in how youth respond to specific cues to overeat (Kral et al., 2018). Future work should seek to identify behavioral phenotypes of overeating that may be at particular risk for developing obesity or disordered eating and clarify when these phenotypes emerge.

Clinical Implications

The importance of not over-medicalizing normative overeating behaviors remains an important consideration for clinicians and researchers alike (Finlayson, 2017). That said, given uncontrolled eating behaviors can be distressing to experience and are associated with the development of a variety and physical and psychological conditions over time (Goldschmidt et al., 2015; Ruhm, 2012; Sonneville et al., 2013), effective

treatments are warranted. However, limited BED and weight management options exist in adolescents (Davison et al., 2023). Indeed, while family based strategies and other modalities have been studied extensively in the context of anorexia nervosa (AN) (Lock, 2019), little work has been done in the context of BED and the few studies conducted to date often exclude males (Marzilli et al., 2018). This is striking given the prevalence of BED is estimated to be 2-3 times higher than AN (Ward et al., 2019). Emerging work is exploring how cognitive behavioral therapy and family based treatment can best be adapted to meet the unique needs of adolescents with LOC eating (Baker et al., 2024; Hilbert et al., 2020). Future randomized control trials that include youth, particularly adolescents, across the spectrums of gender and socioeconomic status are vitally needed to allow the early implementation of evidence-based treatments for severe uncontrolled eating behaviors. Beyond treatment development, to reduce blame towards youth, clinicians could discuss the multifaceted nature of uncontrolled eating with patients and caregivers in an effort to shift the family's focus to understanding antecedents to intervene upon prior to behaviors occurring.

Conclusions

Taken together, the concept of a singular uncontrolled eating construct that subsumes related but distinct overeating behaviors appears to be a valid framework for better understanding these behaviors in youth. While conceptual frameworks are important, empirical evidence in favor of a framework is essential before it can be adopted as valid. Study 1 highlights that the least severe form of uncontrolled eating, cue responsive eating, is difficult to assess and needs more reliable and valid measures in youth with OW/OB. The prevalence rates of uncontrolled eating behaviors in Study 2

demonstrate these behaviors are common amongst adolescent with OW/OB. While common, no forms of negative affect or stress consistently predicted cue responsive eating or LOC. Moreover, LOC eating and its predictors are complex, present differently than in adults, and vary depending how LOC is worded. Study 3 suggests that uncontrolled eating appears to be capturing a significant portion of shared variance among related overeating behaviors. Future work should seek to further validate uncontrolled eating in youth of all body sizes. Additionally, the temporal nature of the relationships between subtypes of uncontrolled eating needs to be further explored, in addition to the extent to which uncontrolled eating is a continuum versus a profile of related behaviors.

APPENDIX

Supplementary Table S.1: Detailed Temporal Effects

from	to	β	SE	p
stress_singleitem	stress_singleitem	0.10	0.03	0.003
stress_singleitem	stress_academic	0.04	0.03	0.198
stress_singleitem	stress_family	-0.05	0.02	0.049
stress_singleitem	stress_friends	-0.02	0.03	0.430
stress_singleitem	stress_extracurricular	0.02	0.03	0.378
stress_singleitem	stress_relationships	0.01	0.02	0.620
stress_singleitem	upset	0.01	0.03	0.886
stress_singleitem	ashamed	-0.07	0.03	0.025
stress_singleitem	nervous	0.01	0.03	0.634
stress_singleitem	afraid	-0.02	0.04	0.658
stress_singleitem	guilty	-0.05	0.03	0.061
stress_singleitem	outofcontrol	-0.04	0.02	0.138
stress_singleitem	couldntstop	-0.01	0.02	0.594
stress_singleitem	overwhelmed	-0.02	0.02	0.395
stress_singleitem	paidattention	-0.04	0.02	0.089
stress_singleitem	overate	0.04	0.02	0.149
stress_singleitem	couldnotresist	-0.02	0.02	0.408
stress_singleitem	foodinfrontofme	0.04	0.03	0.117
stress_singleitem	favfood	0.04	0.02	0.155
stress_academic	stress_singleitem	0.15	0.03	0.000
stress_academic	stress_academic	0.28	0.03	0.000
stress_academic	stress_family	0.05	0.03	0.042
stress_academic	stress_friends	-0.01	0.02	0.610
stress_academic	stress_extracurricular	0.04	0.02	0.083
stress_academic	stress_relationships	0.03	0.02	0.104

Supplementary Table S.1: Detailed Temporal Effects, continued

from	to	β	SE	p
stress_academic	upset	0.06	0.03	0.036
stress_academic	ashamed	0.06	0.03	0.011
stress_academic	nervous	0.10	0.02	0.000
stress_academic	afraid	0.08	0.03	0.007
stress_academic	guilty	0.09	0.02	0.000
stress_academic	outofcontrol	0.03	0.02	0.235
stress_academic	couldntstop	-0.01	0.02	0.571
stress_academic	overwhelmed	0.05	0.02	0.028
stress_academic	paidattention	0.00	0.02	0.828
stress_academic	overate	-0.01	0.02	0.719
stress_academic	couldnotresist	0.00	0.02	0.946
stress_academic	foodinfrontofme	-0.08	0.03	0.003
stress_academic	favfood	-0.05	0.02	0.051
stress_family	stress_singleitem	0.02	0.03	0.452
stress_family	stress_academic	-0.02	0.02	0.412
stress_family	stress_family	0.16	0.03	0.000
stress_family	stress_friends	0.00	0.03	0.957
stress_family	stress_extracurricular	-0.01	0.03	0.622
stress_family	stress_relationships	-0.02	0.01	0.184
stress_family	upset	0.06	0.03	0.047
stress_family	ashamed	0.04	0.03	0.166
stress_family	nervous	0.07	0.03	0.017
stress_family	afraid	0.09	0.04	0.019
stress_family	guilty	0.07	0.03	0.035
stress_family	outofcontrol	0.02	0.02	0.321
stress_family	couldntstop	0.06	0.02	0.009

Supplementary Table S.1: Detailed Temporal Effects, continued

from	to	β	SE	p
stress_family	overwhelmed	-0.01	0.02	0.743
stress_family	paidattention	0.04	0.02	0.038
stress_family	overate	0.02	0.03	0.359
stress_family	couldnotresist	0.03	0.02	0.128
stress_family	foodinfrontofme	-0.01	0.02	0.592
stress_family	favfood	0.01	0.02	0.586
stress_friends	stress_singleitem	0.02	0.02	0.359
stress_friends	stress_academic	0.00	0.02	0.903
stress_friends	stress_family	0.01	0.02	0.659
stress_friends	stress_friends	0.17	0.04	0.000
stress_friends	stress_extracurricular	0.03	0.02	0.276
stress_friends	stress_relationships	0.03	0.03	0.209
stress_friends	upset	-0.02	0.03	0.574
stress_friends	ashamed	-0.01	0.03	0.653
stress_friends	nervous	-0.01	0.02	0.673
stress_friends	afraid	0.04	0.03	0.284
stress_friends	guilty	0.01	0.03	0.883
stress_friends	outofcontrol	-0.02	0.02	0.435
stress_friends	couldntstop	0.02	0.02	0.490
stress_friends	overwhelmed	-0.03	0.02	0.245
stress_friends	paidattention	-0.01	0.02	0.501
stress_friends	overate	-0.01	0.02	0.516
stress_friends	couldnotresist	-0.02	0.02	0.385
stress_friends	foodinfrontofme	-0.03	0.02	0.232
stress_friends	favfood	-0.01	0.02	0.689
stress_extracurricular	stress_singleitem	0.02	0.03	0.424

Supplementary Table S.1: Detailed Temporal Effects, continued

from	to	β	SE	p
stress_extracurricular	stress_academic	0.07	0.02	0.002
stress_extracurricular	stress_family	0.02	0.02	0.514
stress_extracurricular	stress_friends	-0.02	0.03	0.458
stress_extracurricular	stress_extracurricular	0.14	0.04	0.000
stress_extracurricular	stress_relationships	0.00	0.02	0.798
stress_extracurricular	upset	0.03	0.02	0.182
stress_extracurricular	ashamed	0.01	0.03	0.835
stress_extracurricular	nervous	0.05	0.02	0.033
stress_extracurricular	afraid	0.03	0.02	0.182
stress_extracurricular	guilty	0.03	0.03	0.379
stress_extracurricular	outofcontrol	0.00	0.03	0.955
stress_extracurricular	couldntstop	0.00	0.03	0.926
stress_extracurricular	overwhelmed	0.06	0.03	0.033
stress_extracurricular	paidattention	0.02	0.02	0.306
stress_extracurricular	overate	0.01	0.02	0.506
stress_extracurricular	couldnotresist	0.02	0.03	0.465
stress_extracurricular	foodinfrontofme	-0.02	0.02	0.318
stress_extracurricular	favfood	-0.02	0.02	0.199
stress_relationships	stress_singleitem	0.09	0.04	0.008
stress_relationships	stress_academic	0.05	0.04	0.139
stress_relationships	stress_family	0.07	0.05	0.194
stress_relationships	stress_friends	0.19	0.05	0.000
stress_relationships	stress_extracurricular	0.05	0.03	0.061
stress_relationships	stress_relationships	1.00	0.06	0.000
stress_relationships	upset	0.12	0.07	0.114
stress_relationships	ashamed	0.11	0.11	0.299

Supplementary Table S.1: Detailed Temporal Effects, continued

from	to	β	SE	p
stress_relationships	nervous	0.13	0.07	0.046
stress_relationships	afraid	0.17	0.09	0.058
stress_relationships	guilty	0.15	0.08	0.049
stress_relationships	outofcontrol	0.15	0.09	0.099
stress_relationships	couldntstop	0.12	0.07	0.071
stress_relationships	overwhelmed	0.03	0.06	0.667
stress_relationships	paidattention	-0.01	0.03	0.806
stress_relationships	overate	0.02	0.04	0.611
stress_relationships	couldnotresist	0.01	0.03	0.735
stress_relationships	foodinfrontofme	0.02	0.03	0.445
stress_relationships	favfood	0.01	0.02	0.681
upset	stress_singleitem	0.03	0.02	0.160
upset	stress_academic	0.02	0.02	0.332
upset	stress_family	0.01	0.03	0.842
upset	stress_friends	0.02	0.02	0.353
upset	stress_extracurricular	0.02	0.02	0.317
upset	stress_relationships	-0.02	0.02	0.140
upset	upset	0.04	0.03	0.164
upset	ashamed	0.04	0.03	0.184
upset	nervous	0.01	0.02	0.656
upset	afraid	-0.01	0.03	0.666
upset	guilty	0.01	0.03	0.876
upset	outofcontrol	-0.03	0.02	0.161
upset	couldntstop	-0.04	0.02	0.082
upset	overwhelmed	-0.03	0.02	0.116
upset	paidattention	0.01	0.02	0.767

Supplementary Table S.1: Detailed Temporal Effects, continued

from	to	β	SE	p
upset	overate	-0.03	0.02	0.155
upset	couldnotresist	-0.03	0.02	0.149
upset	foodinfrontofme	0.02	0.02	0.452
upset	favfood	0.00	0.02	0.899
ashamed	stress_singleitem	-0.03	0.02	0.178
ashamed	stress_academic	0.00	0.02	0.961
ashamed	stress_family	0.00	0.03	0.928
ashamed	stress_friends	0.00	0.03	0.967
ashamed	stress_extracurricular	-0.01	0.03	0.783
ashamed	stress_relationships	0.05	0.03	0.095
ashamed	upset	0.00	0.04	0.991
ashamed	ashamed	0.06	0.04	0.159
ashamed	nervous	-0.01	0.04	0.865
ashamed	afraid	0.01	0.04	0.861
ashamed	guilty	0.02	0.04	0.576
ashamed	outofcontrol	0.03	0.03	0.351
ashamed	couldntstop	0.03	0.03	0.234
ashamed	overwhelmed	0.01	0.03	0.715
ashamed	paidattention	-0.02	0.02	0.282
ashamed	overate	0.07	0.03	0.011
ashamed	couldnotresist	0.06	0.02	0.010
ashamed	foodinfrontofme	-0.02	0.02	0.385
ashamed	favfood	-0.01	0.02	0.478
nervous	stress_singleitem	0.07	0.02	0.000
nervous	stress_academic	0.06	0.02	0.004
nervous	stress_family	0.02	0.02	0.436

Supplementary Table S.1: Detailed Temporal Effects, continued

from	to	β	SE	p
nervous	stress_friends	0.05	0.03	0.069
nervous	stress_extracurricular	0.01	0.02	0.744
nervous	stress_relationships	0.02	0.02	0.267
nervous	upset	0.05	0.03	0.094
nervous	ashamed	0.04	0.02	0.058
nervous	nervous	0.09	0.03	0.007
nervous	afraid	0.00	0.03	0.954
nervous	guilty	-0.02	0.03	0.517
nervous	outofcontrol	0.04	0.03	0.149
nervous	couldntstop	0.06	0.03	0.013
nervous	overwhelmed	0.03	0.02	0.198
nervous	paidattention	0.01	0.02	0.725
nervous	overate	0.01	0.03	0.639
nervous	couldnotresist	0.04	0.02	0.067
nervous	foodinfrontofme	0.07	0.03	0.011
nervous	favfood	0.05	0.02	0.029
afraid	stress_singleitem	-0.01	0.03	0.849
afraid	stress_academic	-0.01	0.02	0.573
afraid	stress_family	-0.03	0.03	0.181
afraid	stress_friends	0.00	0.03	0.931
afraid	stress_extracurricular	-0.01	0.02	0.824
afraid	stress_relationships	-0.04	0.02	0.022
afraid	upset	0.00	0.03	0.888
afraid	ashamed	0.03	0.03	0.324
afraid	nervous	0.05	0.03	0.127
afraid	afraid	0.04	0.04	0.287

Supplementary Table S.1: Detailed Temporal Effects, continued

from	to	β	SE	p
afraid	guilty	0.02	0.04	0.612
afraid	outofcontrol	-0.01	0.02	0.584
afraid	couldntstop	-0.01	0.02	0.789
afraid	overwhelmed	-0.01	0.02	0.628
afraid	paidattention	-0.01	0.02	0.730
afraid	overate	-0.01	0.02	0.554
afraid	couldnotresist	0.00	0.02	0.986
afraid	foodinfrontofme	-0.02	0.02	0.325
afraid	favfood	-0.01	0.02	0.689
guilty	stress_singleitem	0.03	0.02	0.150
guilty	stress_academic	0.02	0.02	0.513
guilty	stress_family	0.03	0.03	0.282
guilty	stress_friends	-0.02	0.02	0.423
guilty	stress_extracurricular	0.07	0.03	0.004
guilty	stress_relationships	0.01	0.02	0.711
guilty	upset	0.05	0.03	0.132
guilty	ashamed	0.04	0.04	0.345
guilty	nervous	0.05	0.03	0.072
guilty	afraid	0.01	0.04	0.726
guilty	guilty	0.13	0.04	0.002
guilty	outofcontrol	0.03	0.03	0.214
guilty	couldntstop	-0.01	0.03	0.619
guilty	overwhelmed	0.01	0.03	0.641
guilty	paidattention	0.01	0.02	0.732
guilty	overate	0.03	0.03	0.402
guilty	couldnotresist	0.00	0.02	0.931

Supplementary Table S.1: Detailed Temporal Effects, continued

from	to	β	SE	p
guilty	foodinfrontofme	0.04	0.02	0.082
guilty	favfood	0.04	0.02	0.064
outofcontrol	stress_singleitem	0.01	0.02	0.629
outofcontrol	stress_academic	0.01	0.02	0.449
outofcontrol	stress_family	0.00	0.02	0.904
outofcontrol	stress_friends	0.04	0.02	0.125
outofcontrol	stress_extracurricular	-0.01	0.02	0.628
outofcontrol	stress_relationships	0.03	0.02	0.131
outofcontrol	upset	0.06	0.03	0.044
outofcontrol	ashamed	-0.01	0.03	0.838
outofcontrol	nervous	-0.02	0.02	0.392
outofcontrol	afraid	-0.03	0.02	0.152
outofcontrol	guilty	-0.01	0.03	0.766
outofcontrol	outofcontrol	0.03	0.03	0.318
outofcontrol	couldntstop	0.08	0.03	0.006
outofcontrol	overwhelmed	0.06	0.03	0.033
outofcontrol	paidattention	-0.01	0.02	0.546
outofcontrol	overate	0.00	0.03	0.889
outofcontrol	couldnotresist	0.00	0.02	0.957
outofcontrol	foodinfrontofme	-0.01	0.02	0.580
outofcontrol	favfood	0.00	0.02	0.880
couldntstop	stress_singleitem	-0.02	0.02	0.390
couldntstop	stress_academic	0.00	0.02	0.973
couldntstop	stress_family	-0.01	0.03	0.802
couldntstop	stress_friends	-0.06	0.02	0.017
couldntstop	stress_extracurricular	0.01	0.03	0.595

Supplementary Table S.1: Detailed Temporal Effects, continued

from	to	β	SE	p
couldntstop	stress_relationships	-0.02	0.02	0.290
couldntstop	upset	-0.02	0.03	0.434
couldntstop	ashamed	-0.01	0.03	0.641
couldntstop	nervous	-0.03	0.02	0.150
couldntstop	afraid	0.01	0.03	0.749
couldntstop	guilty	-0.01	0.03	0.809
couldntstop	outofcontrol	0.02	0.04	0.512
couldntstop	couldntstop	0.05	0.03	0.095
couldntstop	overwhelmed	-0.01	0.03	0.611
couldntstop	paidattention	0.03	0.02	0.155
couldntstop	overate	-0.01	0.03	0.674
couldntstop	couldnotresist	0.02	0.02	0.331
couldntstop	foodinfrontofme	-0.01	0.03	0.579
couldntstop	favfood	0.01	0.02	0.536
overwhelmed	stress_singleitem	0.01	0.02	0.749
overwhelmed	stress_academic	-0.01	0.02	0.626
overwhelmed	stress_family	0.00	0.02	0.934
overwhelmed	stress_friends	-0.02	0.02	0.315
overwhelmed	stress_extracurricular	0.00	0.03	0.882
overwhelmed	stress_relationships	0.00	0.02	0.853
overwhelmed	upset	0.01	0.03	0.826
overwhelmed	ashamed	0.03	0.02	0.186
overwhelmed	nervous	-0.02	0.02	0.346
overwhelmed	afraid	-0.01	0.03	0.728
overwhelmed	guilty	0.03	0.02	0.208
overwhelmed	outofcontrol	0.03	0.03	0.300

Supplementary Table S.1: Detailed Temporal Effects, continued

from	to	β	SE	p
overwhelmed	couldntstop	-0.06	0.03	0.023
overwhelmed	overwhelmed	0.03	0.02	0.202
overwhelmed	paidattention	0.02	0.02	0.291
overwhelmed	overate	0.01	0.02	0.647
overwhelmed	couldnotresist	0.02	0.02	0.500
overwhelmed	foodinfrontofme	-0.02	0.02	0.337
overwhelmed	favfood	-0.02	0.02	0.234
paidattention	stress_singleitem	0.01	0.02	0.726
paidattention	stress_academic	0.01	0.02	0.676
paidattention	stress_family	0.01	0.02	0.668
paidattention	stress_friends	-0.02	0.02	0.191
paidattention	stress_extracurricular	0.01	0.02	0.525
paidattention	stress_relationships	0.00	0.01	0.922
paidattention	upset	0.02	0.02	0.417
paidattention	ashamed	0.00	0.02	0.836
paidattention	nervous	0.02	0.02	0.242
paidattention	afraid	0.03	0.02	0.115
paidattention	guilty	-0.03	0.02	0.123
paidattention	outofcontrol	0.01	0.02	0.623
paidattention	couldntstop	0.02	0.02	0.149
paidattention	overwhelmed	-0.01	0.02	0.472
paidattention	paidattention	0.08	0.02	0.000
paidattention	overate	0.01	0.02	0.753
paidattention	couldnotresist	0.01	0.02	0.509
paidattention	foodinfrontofme	-0.01	0.02	0.734
paidattention	favfood	-0.01	0.02	0.720

Supplementary Table S.1: Detailed Temporal Effects, continued

from	to	β	SE	p
overate	stress_singleitem	0.02	0.02	0.193
overate	stress_academic	0.03	0.02	0.139
overate	stress_family	0.02	0.02	0.248
overate	stress_friends	-0.02	0.02	0.295
overate	stress_extracurricular	0.01	0.02	0.582
overate	stress_relationships	-0.01	0.01	0.333
overate	upset	0.00	0.02	0.859
overate	ashamed	-0.03	0.02	0.090
overate	nervous	-0.01	0.02	0.691
overate	afraid	0.02	0.02	0.265
overate	guilty	0.01	0.02	0.465
overate	outofcontrol	-0.03	0.02	0.114
overate	couldntstop	-0.02	0.02	0.462
overate	overwhelmed	-0.01	0.02	0.545
overate	paidattention	-0.03	0.02	0.073
overate	overate	0.00	0.02	0.975
overate	couldnotresist	-0.01	0.02	0.794
overate	foodinfrontofme	0.01	0.02	0.683
overate	favfood	-0.01	0.02	0.615
couldnotresist	stress_singleitem	0.01	0.02	0.490
couldnotresist	stress_academic	-0.01	0.02	0.600
couldnotresist	stress_family	-0.02	0.02	0.279
couldnotresist	stress_friends	0.03	0.02	0.240
couldnotresist	stress_extracurricular	0.00	0.02	0.975
couldnotresist	stress_relationships	0.03	0.02	0.197
couldnotresist	upset	0.02	0.02	0.364

Supplementary Table S.1: Detailed Temporal Effects, continued

from	to	β	SE	p
couldnotresist	ashamed	-0.01	0.02	0.764
couldnotresist	nervous	0.02	0.02	0.522
couldnotresist	afraid	-0.05	0.02	0.038
couldnotresist	guilty	0.00	0.02	0.951
couldnotresist	outofcontrol	-0.01	0.02	0.796
couldnotresist	couldntstop	-0.04	0.03	0.198
couldnotresist	overwhelmed	-0.01	0.02	0.574
couldnotresist	paidattention	0.03	0.02	0.125
couldnotresist	overate	0.00	0.03	0.924
couldnotresist	couldnotresist	0.00	0.03	0.905
couldnotresist	foodinfrontofme	0.03	0.02	0.190
couldnotresist	favfood	0.04	0.02	0.054
foodinfrontofme	stress_singleitem	-0.05	0.03	0.039
foodinfrontofme	stress_academic	-0.03	0.02	0.251
foodinfrontofme	stress_family	-0.05	0.03	0.048
foodinfrontofme	stress_friends	-0.05	0.03	0.083
foodinfrontofme	stress_extracurricular	-0.03	0.03	0.262
foodinfrontofme	stress_relationships	-0.05	0.02	0.008
foodinfrontofme	upset	0.01	0.03	0.673
foodinfrontofme	ashamed	0.00	0.02	0.936
foodinfrontofme	nervous	0.00	0.03	0.934
foodinfrontofme	afraid	-0.01	0.03	0.665
foodinfrontofme	guilty	0.01	0.03	0.712
foodinfrontofme	outofcontrol	0.00	0.03	0.873
foodinfrontofme	couldntstop	0.02	0.03	0.471
foodinfrontofme	overwhelmed	0.00	0.03	0.903

Supplementary Table S.1: Detailed Temporal Effects, continued

from	to	β	SE	p
foodinfrontofme	paidattention	-0.02	0.03	0.497
foodinfrontofme	overate	-0.01	0.03	0.697
foodinfrontofme	couldnotresist	0.03	0.03	0.208
foodinfrontofme	foodinfrontofme	0.05	0.03	0.108
foodinfrontofme	favfood	-0.03	0.03	0.275
favfood	stress_singleitem	0.03	0.03	0.233
favfood	stress_academic	0.02	0.03	0.446
favfood	stress_family	0.05	0.03	0.124
favfood	stress_friends	0.06	0.03	0.047
favfood	stress_extracurricular	0.02	0.03	0.442
favfood	stress_relationships	0.04	0.02	0.072
favfood	upset	-0.01	0.03	0.794
favfood	ashamed	0.00	0.03	0.939
favfood	nervous	-0.01	0.03	0.787
favfood	afraid	-0.03	0.03	0.301
favfood	guilty	-0.05	0.03	0.076
favfood	outofcontrol	0.00	0.03	0.885
favfood	couldntstop	-0.03	0.03	0.283
favfood	overwhelmed	-0.02	0.03	0.417
favfood	paidattention	0.02	0.03	0.587
favfood	overate	-0.01	0.03	0.837
favfood	couldnotresist	-0.04	0.03	0.193
favfood	foodinfrontofme	-0.01	0.04	0.863
favfood	favfood	0.09	0.03	0.008

Supplementary Table S.2: Detailed Contemporaneous Effects

Variable 1	Variable 2	partial correlation	p 1→2	p 1←2
stress_academic	stress_singleitem	0.37	0.000	0.000
stress_family	stress_singleitem	0.25	0.000	0.000
stress_family	stress_academic	0.02	0.302	0.666
stress_friends	stress_singleitem	0.09	0.003	0.001
stress_friends	stress_academic	-0.02	0.388	0.304
stress_friends	stress_family	0.08	0.035	0.013
stress_extracurricular	stress_singleitem	0.14	0.000	0.000
stress_extracurricular	stress_academic	0.05	0.104	0.108
stress_extracurricular	stress_family	-0.04	0.053	0.148
stress_extracurricular	stress_friends	0.06	0.240	0.055
stress_relationships	stress_singleitem	0.06	0.008	0.058
stress_relationships	stress_academic	0.02	0.271	0.477
stress_relationships	stress_family	0.05	0.166	0.056
stress_relationships	stress_friends	0.07	0.037	0.027
stress_relationships	stress_extracurricular	-0.03	0.601	0.184
upset	stress_singleitem	0.15	0.000	0.000
upset	stress_academic	-0.03	0.234	0.332
upset	stress_family	0.17	0.000	0.000
upset	stress_friends	0.04	0.116	0.185
upset	stress_extracurricular	0.01	0.998	0.272
upset	stress_relationships	0.02	0.254	0.350
ashamed	stress_singleitem	0.01	0.967	0.266
ashamed	stress_academic	0.03	0.065	0.297

Supplementary Table S.2: Detailed Contemporaneous Effects, continued

Variable 1	Variable 2	partial correlation	p 1→2	p 1←2
ashamed	stress_family	0.04	0.277	0.076
ashamed	stress_friends	0.00	0.585	0.731
ashamed	stress_extracurricular	0.01	0.742	0.444
ashamed	stress_relationships	0.06	0.162	0.348
ashamed	upset	0.09	0.007	0.008
nervous	stress_singleitem	0.13	0.000	0.000
nervous	stress_academic	0.11	0.000	0.000
nervous	stress_family	0.02	0.185	0.690
nervous	stress_friends	0.05	0.117	0.022
nervous	stress_extracurricular	0.11	0.000	0.000
nervous	stress_relationships	0.00	0.878	0.813
nervous	upset	0.03	0.122	0.732
nervous	ashamed	0.11	0.002	0.000
afraid	stress_singleitem	0.06	0.023	0.013
afraid	stress_academic	-0.04	0.087	0.017
afraid	stress_family	0.07	0.015	0.034
afraid	stress_friends	0.03	0.277	0.395
afraid	stress_extracurricular	-0.01	0.311	0.917
afraid	stress_relationships	0.02	0.208	0.754
afraid	upset	0.08	0.135	0.009
afraid	ashamed	0.04	0.217	0.428
afraid	nervous	0.25	0.000	0.000
guilty	stress_singleitem	-0.02	0.534	0.550

Supplementary Table S.2: Detailed Contemporaneous Effects, continued

Variable 1	Variable 2	partial correlation	p 1→2	p 1←2
guilty	stress_academic	0.00	0.790	0.590
guilty	stress_family	0.05	0.022	0.173
guilty	stress_friends	0.00	0.692	0.552
guilty	stress_extracurricular	0.01	0.614	0.967
guilty	stress_relationships	0.01	0.755	0.992
guilty	upset	0.14	0.000	0.000
guilty	ashamed	0.25	0.000	0.000
guilty	nervous	0.04	0.233	0.088
guilty	afraid	0.11	0.003	0.003
outofcontrol	stress_singleitem	0.02	0.085	0.372
outofcontrol	stress_academic	-0.01	0.264	0.597
outofcontrol	stress_family	0.01	0.914	0.570
outofcontrol	stress_friends	0.00	0.734	0.808
outofcontrol	stress_extracurricular	-0.01	0.389	0.876
outofcontrol	stress_relationships	-0.01	0.980	0.350
outofcontrol	upset	0.00	0.637	0.751
outofcontrol	ashamed	0.02	0.403	0.189
outofcontrol	nervous	0.00	0.945	0.871
outofcontrol	afraid	0.01	0.756	0.569
outofcontrol	guilty	0.03	0.052	0.498
couldntstop	stress_singleitem	-0.01	0.747	0.708
couldntstop	stress_academic	0.00	0.854	0.868
couldntstop	stress_family	-0.01	0.710	0.189

Supplementary Table S.2: Detailed Contemporaneous Effects, continued

Variable 1	Variable 2	partial correlation	p 1→2	p 1←2
couldntstop	stress_friends	0.01	0.326	0.558
couldntstop	stress_extracurricular	0.01	0.558	0.747
couldntstop	stress_relationships	0.02	0.382	0.228
couldntstop	upset	0.00	0.714	0.976
couldntstop	ashamed	0.02	0.606	0.224
couldntstop	nervous	0.00	0.788	0.902
couldntstop	afraid	-0.01	0.203	0.681
couldntstop	guilty	-0.02	0.104	0.359
couldntstop	outofcontrol	0.31	0.000	0.000
overwhelmed	stress_singleitem	0.03	0.073	0.134
overwhelmed	stress_academic	-0.01	0.287	0.704
overwhelmed	stress_family	0.03	0.166	0.085
overwhelmed	stress_friends	-0.01	0.800	0.459
overwhelmed	stress_extracurricular	0.03	0.264	0.080
overwhelmed	stress_relationships	0.04	0.115	0.428
overwhelmed	upset	-0.03	0.072	0.238
overwhelmed	ashamed	0.02	0.367	0.442
overwhelmed	nervous	-0.02	0.462	0.244
overwhelmed	afraid	-0.01	0.448	0.989
overwhelmed	guilty	0.04	0.065	0.019
overwhelmed	outofcontrol	0.24	0.000	0.000
overwhelmed	couldntstop	0.10	0.000	0.004
paidattention	stress_singleitem	-0.02	0.424	0.143

Supplementary Table S.2: Detailed Contemporaneous Effects, continued

Variable 1	Variable 2	partial correlation	p 1→2	p 1←2
paidattention	stress_academic	0.02	0.146	0.074
paidattention	stress_family	0.02	0.316	0.235
paidattention	stress_friends	0.00	0.863	0.999
paidattention	stress_extracurricular	0.02	0.129	0.216
paidattention	stress_relationships	0.01	0.758	0.741
paidattention	upset	0.00	0.952	0.603
paidattention	ashamed	0.01	0.531	0.967
paidattention	nervous	0.00	0.901	0.604
paidattention	afraid	-0.01	0.589	0.268
paidattention	guilty	0.01	0.712	0.639
paidattention	outofcontrol	0.01	0.600	0.862
paidattention	couldntstop	-0.02	0.353	0.443
paidattention	overwhelmed	0.03	0.579	0.132
overate	stress_singleitem	-0.02	0.229	0.293
overate	stress_academic	0.02	0.112	0.198
overate	stress_family	0.00	0.602	0.986
overate	stress_friends	0.01	0.349	0.962
overate	stress_extracurricular	-0.01	0.527	0.270
overate	stress_relationships	-0.06	0.006	0.147
overate	upset	0.01	0.848	0.450
overate	ashamed	-0.02	0.266	0.380
overate	nervous	-0.02	0.080	0.121
overate	afraid	0.06	0.001	0.000

Supplementary Table S.2: Detailed Contemporaneous Effects, continued

Variable 1	Variable 2	partial correlation	p 1→2	p 1←2
overate	guilty	-0.01	0.944	0.271
overate	outofcontrol	0.14	0.000	0.000
overate	couldntstop	0.16	0.000	0.000
overate	overwhelmed	0.13	0.000	0.000
overate	paidattention	-0.04	0.238	0.126
couldnotresist	stress_singleitem	0.00	0.896	0.698
couldnotresist	stress_academic	0.00	0.876	0.536
couldnotresist	stress_family	-0.01	0.728	0.854
couldnotresist	stress_friends	0.01	0.853	0.142
couldnotresist	stress_extracurricular	-0.02	0.128	0.237
couldnotresist	stress_relationships	0.02	0.598	0.385
couldnotresist	upset	-0.01	0.738	0.498
couldnotresist	ashamed	0.01	0.526	0.966
couldnotresist	nervous	-0.01	0.566	0.649
couldnotresist	afraid	0.00	0.993	0.977
couldnotresist	guilty	0.04	0.014	0.004
couldnotresist	outofcontrol	0.18	0.000	0.000
couldnotresist	couldntstop	0.21	0.000	0.000
couldnotresist	overwhelmed	0.06	0.020	0.052
couldnotresist	paidattention	0.09	0.000	0.002
couldnotresist	overate	0.21	0.000	0.000
foodinfrontofme	stress_singleitem	0.01	0.285	0.633
foodinfrontofme	stress_academic	0.01	0.641	0.895

Supplementary Table S.2: Detailed Contemporaneous Effects, continued

Variable 1	Variable 2	partial correlation	p 1→2	p 1←2
foodinfrontofme	stress_family	-0.01	0.545	0.856
foodinfrontofme	stress_friends	0.01	0.352	0.578
foodinfrontofme	stress_extracurricular	-0.02	0.058	0.494
foodinfrontofme	stress_relationships	0.01	0.305	0.728
foodinfrontofme	upset	-0.03	0.104	0.008
foodinfrontofme	ashamed	0.02	0.322	0.240
foodinfrontofme	nervous	-0.01	0.611	0.610
foodinfrontofme	afraid	0.00	0.686	0.650
foodinfrontofme	guilty	0.00	0.563	0.861
foodinfrontofme	outofcontrol	-0.02	0.132	0.262
foodinfrontofme	couldntstop	-0.02	0.162	0.230
foodinfrontofme	overwhelmed	0.01	0.862	0.604
foodinfrontofme	paidattention	-0.02	0.080	0.246
foodinfrontofme	overate	-0.01	0.759	0.526
foodinfrontofme	couldnotresist	0.02	0.307	0.320
favfood	stress_singleitem	0.00	0.494	0.888
favfood	stress_academic	0.01	0.713	0.673
favfood	stress_family	0.01	0.300	0.460
favfood	stress_friends	-0.01	0.311	0.510
favfood	stress_extracurricular	0.03	0.022	0.404
favfood	stress_relationships	-0.01	0.229	0.844
favfood	upset	0.03	0.020	0.037
favfood	ashamed	-0.01	0.391	0.594

Supplementary Table S.2: Detailed Contemporaneous Effects, continued

Variable 1	Variable 2	partial correlation	p 1→2	p 1←2
favfood	nervous	0.02	0.367	0.289
favfood	afraid	0.01	0.310	0.838
favfood	guilty	-0.01	0.347	0.916
favfood	outofcontrol	0.02	0.062	0.131
favfood	couldntstop	0.02	0.207	0.370
favfood	overwhelmed	0.00	0.958	0.663
favfood	paidattention	0.04	0.020	0.017
favfood	overate	-0.04	0.012	0.002
favfood	couldnotresist	0.01	0.589	0.211
favfood	foodinfrontofme	0.80	0.000	0.000

Supplementary Table S.3: Detailed Between-Subject Effects

Variable 1	Variable 2	partial correlation	p 1→2	p 1←2
stress_academic	stress_singleitem	0.78	0.000	0.000
stress_family	stress_singleitem	0.15	0.050	0.065
stress_family	stress_academic	0.04	0.462	0.861
stress_friends	stress_singleitem	0.30	0.000	0.000
stress_friends	stress_academic	-0.27	0.001	0.000
stress_friends	stress_family	0.31	0.000	0.000
stress_extracurricular	stress_singleitem	0.30	0.000	0.000
stress_extracurricular	stress_academic	-0.15	0.039	0.042
stress_extracurricular	stress_family	0.01	0.827	0.896
stress_extracurricular	stress_friends	-0.11	0.112	0.212
stress_relationships	stress_singleitem	-0.08	0.369	0.365
stress_relationships	stress_academic	0.12	0.114	0.163
stress_relationships	stress_family	-0.25	0.002	0.002
stress_relationships	stress_friends	0.30	0.000	0.000
stress_relationships	stress_extracurricular	0.02	0.831	0.709
upset	stress_singleitem	0.10	0.449	0.081
upset	stress_academic	-0.10	0.221	0.173
upset	stress_family	0.15	0.024	0.112
upset	stress_friends	0.10	0.384	0.108
upset	stress_extracurricular	-0.11	0.098	0.174
upset	stress_relationships	0.26	0.001	0.001

Supplementary Table S.3: Detailed Between-Subject Effects, continued

Variable 1	Variable 2	partial correlation	p 1→2	p 1←2
ashamed	stress_singleitem	-0.03	0.883	0.541
ashamed	stress_academic	0.13	0.082	0.090
ashamed	stress_family	-0.07	0.545	0.278
ashamed	stress_friends	0.13	0.265	0.024
ashamed	stress_extracurricular	0.33	0.000	0.000
ashamed	stress_relationships	-0.14	0.118	0.062
ashamed	upset	0.25	0.002	0.000
nervous	stress_singleitem	0.21	0.011	0.005
nervous	stress_academic	-0.04	0.666	0.574
nervous	stress_family	-0.08	0.208	0.399
nervous	stress_friends	0.10	0.180	0.233
nervous	stress_extracurricular	-0.04	0.496	0.692
nervous	stress_relationships	0.20	0.008	0.022
nervous	upset	0.08	0.346	0.309
nervous	ashamed	-0.16	0.025	0.050
afraid	stress_singleitem	0.01	0.740	0.557
afraid	stress_academic	-0.04	0.590	0.658
afraid	stress_family	0.10	0.289	0.169
afraid	stress_friends	-0.05	0.649	0.386
afraid	stress_extracurricular	-0.07	0.785	0.169
afraid	stress_relationships	-0.12	0.114	0.196

Supplementary Table S.3: Detailed Between-Subject Effects, continued

Variable 1	Variable 2	partial correlation	*p* 1→2	*p* 1←2
afraid	upset	0.05	0.470	0.572
afraid	ashamed	0.38	0.000	0.000
afraid	nervous	0.51	0.000	0.000
guilty	stress_singleitem	-0.07	0.368	0.414
guilty	stress_academic	-0.03	0.638	0.845
guilty	stress_family	0.20	0.010	0.011
guilty	stress_friends	0.10	0.270	0.143
guilty	stress_extracurricular	-0.19	0.013	0.012
guilty	stress_relationships	0.33	0.000	0.000
guilty	upset	-0.21	0.010	0.003
guilty	ashamed	0.60	0.000	0.000
guilty	nervous	-0.02	0.961	0.671
guilty	afraid	-0.02	0.669	0.970
outofcontrol	stress_singleitem	-0.17	0.013	0.062
outofcontrol	stress_academic	0.09	0.222	0.276
outofcontrol	stress_family	-0.11	0.085	0.259
outofcontrol	stress_friends	0.10	0.745	0.062
outofcontrol	stress_extracurricular	0.01	0.928	0.852
outofcontrol	stress_relationships	0.01	0.626	0.709
outofcontrol	upset	0.02	0.906	0.665
outofcontrol	ashamed	0.01	0.790	0.933

Supplementary Table S.3: Detailed Between-Subject Effects, continued

Variable 1	Variable 2	partial correlation	p 1→2	p 1←2
outofcontrol	nervous	-0.01	0.630	0.980
outofcontrol	afraid	-0.03	0.877	0.633
outofcontrol	guilty	-0.06	0.857	0.289
couldntstop	stress_singleitem	-0.02	0.788	0.935
couldntstop	stress_academic	-0.03	0.645	0.748
couldntstop	stress_family	-0.03	0.573	0.911
couldntstop	stress_friends	0.18	0.056	0.013
couldntstop	stress_extracurricular	-0.03	0.715	0.694
couldntstop	stress_relationships	0.21	0.083	0.005
couldntstop	upset	-0.21	0.015	0.007
couldntstop	ashamed	0.12	0.092	0.275
couldntstop	nervous	-0.04	0.298	0.992
couldntstop	afraid	0.03	0.594	0.819
couldntstop	guilty	-0.19	0.104	0.004
couldntstop	outofcontrol	0.44	0.000	0.000
overwhelmed	stress_singleitem	0.01	0.880	0.849
overwhelmed	stress_academic	0.03	0.588	0.886
overwhelmed	stress_family	0.02	0.658	0.933
overwhelmed	stress_friends	0.15	0.053	0.070
overwhelmed	stress_extracurricular	0.09	0.242	0.323
overwhelmed	stress_relationships	-0.12	0.044	0.305

Supplementary Table S.3: Detailed Between-Subject Effects, continued

Variable 1	Variable 2	partial correlation	p 1→2	p 1←2
overwhelmed	upset	0.24	0.001	0.005
overwhelmed	ashamed	-0.08	0.305	0.384
overwhelmed	nervous	0.06	0.534	0.354
overwhelmed	afraid	0.14	0.138	0.056
overwhelmed	guilty	0.14	0.034	0.227
overwhelmed	outofcontrol	0.39	0.000	0.000
overwhelmed	couldntstop	0.10	0.080	0.628
paidattention	stress_singleitem	-0.05	0.410	0.600
paidattention	stress_academic	0.07	0.318	0.392
paidattention	stress_family	-0.13	0.089	0.097
paidattention	stress_friends	0.09	0.238	0.239
paidattention	stress_extracurricular	0.01	0.866	0.599
paidattention	stress_relationships	-0.01	0.931	0.973
paidattention	upset	0.05	0.480	0.521
paidattention	ashamed	-0.08	0.360	0.192
paidattention	nervous	0.03	0.559	0.814
paidattention	afraid	0.09	0.188	0.332
paidattention	guilty	0.00	0.988	0.920
paidattention	outofcontrol	0.05	0.304	0.854
paidattention	couldntstop	-0.11	0.338	0.066
paidattention	overwhelmed	0.03	0.567	0.865

Supplementary Table S.3: Detailed Between-Subject Effects, continued

Variable 1	Variable 2	partial correlation	*p* 1→2	*p* 1←2
overate	stress_singleitem	0.20	0.002	0.050
overate	stress_academic	-0.17	0.059	0.012
overate	stress_family	0.10	0.298	0.133
overate	stress_friends	-0.14	0.021	0.158
overate	stress_extracurricular	-0.03	0.937	0.580
overate	stress_relationships	0.11	0.404	0.114
overate	upset	-0.06	0.525	0.306
overate	ashamed	0.00	0.988	0.945
overate	nervous	0.15	0.074	0.031
overate	afraid	-0.20	0.017	0.007
overate	guilty	-0.06	0.494	0.418
overate	outofcontrol	0.27	0.001	0.000
overate	couldntstop	0.18	0.143	0.003
overate	overwhelmed	0.15	0.139	0.038
overate	paidattention	0.16	0.104	0.011
couldnotresist	stress_singleitem	-0.04	0.902	0.468
couldnotresist	stress_academic	0.02	0.719	0.954
couldnotresist	stress_family	0.11	0.043	0.354
couldnotresist	stress_friends	-0.11	0.101	0.209
couldnotresist	stress_extracurricular	0.17	0.061	0.010
couldnotresist	stress_relationships	-0.09	0.193	0.341

Supplementary Table S.3: Detailed Between-Subject Effects, continued

Variable 1	Variable 2	partial correlation	*p* 1→2	*p* 1←2
couldnotresist	upset	0.18	0.008	0.039
couldnotresist	ashamed	-0.15	0.052	0.063
couldnotresist	nervous	0.10	0.204	0.228
couldnotresist	afraid	0.02	0.665	0.965
couldnotresist	guilty	0.15	0.040	0.095
couldnotresist	outofcontrol	0.05	0.498	0.650
couldnotresist	couldntstop	0.64	0.000	0.000
couldnotresist	overwhelmed	-0.15	0.118	0.032
couldnotresist	paidattention	0.20	0.005	0.010
couldnotresist	overate	-0.04	0.304	0.989
foodinfrontofme	stress_singleitem	0.30	0.000	0.000
foodinfrontofme	stress_academic	-0.22	0.006	0.003
foodinfrontofme	stress_family	0.04	0.813	0.523
foodinfrontofme	stress_friends	-0.20	0.002	0.022
foodinfrontofme	stress_extracurricular	-0.08	0.344	0.342
foodinfrontofme	stress_relationships	-0.06	0.590	0.416
foodinfrontofme	upset	0.01	0.610	0.595
foodinfrontofme	ashamed	-0.04	0.496	0.799
foodinfrontofme	nervous	-0.04	0.948	0.434
foodinfrontofme	afraid	0.03	0.934	0.499
foodinfrontofme	guilty	0.07	0.487	0.329

Supplementary Table S.3: Detailed Between-Subject Effects, continued

Variable 1	Variable 2	partial correlation	*p* 1→2	*p* 1←2
foodinfrontofme	outofcontrol	0.12	0.128	0.152
foodinfrontofme	couldntstop	0.10	0.189	0.301
foodinfrontofme	overwhelmed	-0.13	0.207	0.079
foodinfrontofme	paidattention	0.04	0.741	0.512
foodinfrontofme	overate	-0.14	0.073	0.081
foodinfrontofme	couldnotresist	-0.10	0.262	0.203
favfood	stress_singleitem	-0.21	0.004	0.014
favfood	stress_academic	0.21	0.006	0.006
favfood	stress_family	0.00	0.964	0.969
favfood	stress_friends	0.16	0.045	0.041
favfood	stress_extracurricular	0.00	0.947	0.969
favfood	stress_relationships	-0.01	0.791	0.652
favfood	upset	0.07	0.159	0.607
favfood	ashamed	0.06	0.547	0.434
favfood	nervous	-0.13	0.217	0.050
favfood	afraid	-0.04	0.580	0.717
favfood	guilty	0.00	0.984	0.997
favfood	outofcontrol	-0.14	0.055	0.093
favfood	couldntstop	-0.07	0.493	0.375
favfood	overwhelmed	0.09	0.125	0.482
favfood	paidattention	-0.08	0.394	0.263

Supplementary Table S.3: Detailed Between-Subject Effects, continued

Variable 1	Variable 2	partial correlation	*p* 1→2	*p* 1←2
favfood	overate	0.15	0.151	0.026
favfood	couldnotresist	0.19	0.032	0.013
favfood	foodinfrontofme	0.84	0.000	0.000

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