LONGITUDINAL ASSOCIATIONS AMONG TODDLER TEMPERAMENT, THE
RELATIVE REINFORCING VALUE OF FOOD, AND WEIGHT STATUS DURING
MIDDLE CHILDHOOD

A Thesis in
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by
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ABSTRACT

Research suggests that early-emerging exuberant temperament is associated with increased risk of childhood obesity. Few studies have explored potential mechanisms through which temperament may affect weight outcomes. The present study examined longitudinal associations among toddler exuberant temperament, assessed at 18 months using LPA-derived temperament groups, observed approach behaviors, and parent-reported surgency, and the relative reinforcing value of food and weight status during middle childhood (6-8 years) in a sample of 46 children. Using Baron and Kenny’s (1986) framework, the study tested the relative reinforcing value of food as a mediator of the association between all three measures of toddler temperament and BMI z-score. Parental feeding strategies, instrumental feeding and restriction of food, were assessed as moderators of the association between toddler temperament and the relative reinforcing value of food. Parent-reported toddler surgency was associated with both increased levels of the relative reinforcing value of food, and with higher BMI z-scores, but the relative reinforcing value of food was not a significant mediator. Neither parental use of instrumental feeding nor restriction for health moderated the association between toddler surgency and the relative reinforcing value of food, but restriction for health was positively associated with increased levels of the relative reinforcing value of food. Overall, the results confirm that infant exuberant temperament is associated with increases in food reinforcement and in child weight status during middle childhood.
TABLE OF CONTENTS

LIST OF FIGURES ........................................................................................................................................ vi

LIST OF TABLES ........................................................................................................................................ vii

ACKNOWLEDGEMENTS ................................................................................................................................ viii

Chapter 1  Introduction .............................................................................................................................. 1

Infant and Child Temperament ................................................................................................................. 4
Temperament, Weight, and Eating Behaviors in Children ...................................................................... 12
Food Reinforcement, Temperament, and Obesity Risk ........................................................................... 19
Parenting and Feeding ............................................................................................................................... 26
Temperament and Parental Feeding Practices ......................................................................................... 29
The Current Study ..................................................................................................................................... 31

Chapter 2  Methods .................................................................................................................................... 35

Participants .................................................................................................................................................. 35
Procedures .................................................................................................................................................. 36
  18-month procedures ............................................................................................................................... 36
  6-8 year follow-up procedures ................................................................................................................ 37
Measures .................................................................................................................................................... 37
  18-month measures ................................................................................................................................ 37
    Approach behaviors ............................................................................................................................... 37
    Temperament groups ............................................................................................................................ 39
    Early childhood behavior questionnaire (ECBQ) ............................................................................... 40
  6-8 year follow-up measures .................................................................................................................. 41
    Relative reinforcing value of food task ................................................................................................. 41
    Parental instrumental feeding ............................................................................................................. 43
    Anthropomorphic measurements and BMI ......................................................................................... 44
    Potential covariates ............................................................................................................................. 45
Data Analayis Plan ...................................................................................................................................... 45

Chapter 3  Results ....................................................................................................................................... 52

Descriptive Statistics and Preliminary Analyses ....................................................................................... 52
Mediation Model Testing ............................................................................................................................ 56
  Model 1: Temperament groups ............................................................................................................... 58
  Model 2: Approach behaviors ............................................................................................................... 59
  Model 3: ECBQ surgency ....................................................................................................................... 59
Moderating Effect of Parental Instrumental Feeding .............................................................................. 61
Exploratory Moderating Effects of Parental Restriction ....................................................................... 61

Chapter 4  Discussion .................................................................................................................................. 63
References
LIST OF FIGURES

Figure 1-1: Conceptual moderated mediation model for the current study. .................33

Figure 2-1: Graph of means for latent profile analysis indicators by temperament group. .................................................................41

Figure 2-2: Diagram of paths in the hypothesized mediation models. ......................49

Figure 2-3: Diagram of paths in the hypothesized moderation model for parental instrumental feeding.................................................................50

Figure 2-4: Diagram of paths in the exploratory moderation models for parental restriction of food. .................................................................51

Figure 3-1: Mediation path diagram for model 3 with unstandardized coefficients....60
LIST OF TABLES

Table 3-1: Descriptive statistics for study variables. ..................................................54

Table 3-2: Summary of correlations among temperament, food reinforcement, parental feeding strategies, child BMI z-score and covariates. .........................55

Table 3-3: Summary of regression analyses testing for RRV_{food} as a mediator. .......58
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Chapter 1

Introduction

Childhood obesity is a serious public health concern in the United States. The Center for Disease Control defines obesity in children as having excess body weight for a particular height, as compared to sex- and age-specific reference values, and is most commonly assessed using the body mass index (BMI) (Ogden & Flegal, 2010). National Health and Nutrition Examination Survey (NHANES) data show significant increases in childhood obesity rates from 1988-1994 to 2003-2004 (Ogden, Carroll, Lawman, Fryar, Kruszon-Moran, Kit & Flegal, 2016; Skinner & Skelton, 2014). Current research demonstrates that prevalence rates have since settled for school-aged children (6 to 11) and adolescents (12 to 19), although significant decreases occurred for preschool-aged children (2 to 5) (Ogden et al., 2016). Despite this, obesity remains a common health risk among United States children and adolescents (Ogden, Carroll, Fryar, & Flegal, 2015). The National Center for Health Statistics (NCHS) reports that 17% of U.S. children and adolescents are considered obese (Ogden et al., 2015). Obesity prevalence rates from 2011 to 2014 are markedly high among school-aged children (17.5%) and adolescents (20.5%) and relatively lower among preschool-aged children (8.9%).

Obesity during childhood remains a public health issue because of its potentially deleterious short-term and long-term effects. Research suggests that children with overweight and obese BMIs are more likely to have risk factors for cardiovascular disease than their lower BMI peers, including high blood pressure, raised LDL
cholesterol and decreased HDL cholesterol, and increased triglycerides (Freedman, Dietz, Srinivasan, & Verenson, 1999; Freedman, Mei, Srinivasan, Berenson, & Dietz, 2007; Must & Strauss, 1999). Children with obesity are at increased risk of insulin resistance and thereby prone to the development of prediabetes and eventual type 2 diabetes (Ebbeling, Pawlak, & Ludwig, 2002; Hannon, Rao, & Arslanian, 2005). Further, longitudinal demonstrates that childhood obesity is associated with increased risk of asthma symptoms (Chinn & Rona, 2001; Figeroa-Munoz, 2001). Overweight and obese children are also at greater risk of being classified as obese in adulthood, during which intervention becomes more difficult (Freedman, Mei, Srinivasan, Berenson, & Dietz, 2007; Reilly, Methven, McDowell, Hacking, Alexander, Stewart, & Kelnar, 2003; Whitaker, Wright, Pepe, Seidel, & Dietz, 1997). Additional long-term associations include increased risk of morbidity and premature mortality in adulthood (Falkstedt, Hemmingson, Rasmassen, & Lundberg, 2007; Ford, Nonnemaker, & Wirth, 2008; Narayan, Boyle, Thompson, Gregg, & Williamson, 2007; Reilly & Kelly, 2011; Van Dam, Willett, Manson, & Hu, 2006).

Given the prevalence of childhood obesity and its associations with short-term and long-term health risks, it is necessary to develop effective and sustainable prevention programs targeting the onset of the disease. Obesity can be simply understood as the consequence of an energy imbalance, in which the individual’s energy intake is greater than his or her energy expenditure. However, energy intake and expenditure can be influenced by a variety of factors. Thus, it is likely that obesity is multicausal in its etiology, involving not only individual biological processes, but also behavioral, psychological, and environmental processes that influence both sides of the energy.
balance equation (Gill, 2014; Vandenbroeck, Goossens, & Clemens, 2007). There are likely a variety of pathways to obesity among people, with a variety of predispositions and environmental exposures affecting individual outcomes. It is imperative to identify the various predictors and underlying mechanisms of childhood obesity in order to best inform prevention efforts. The earlier the identification, the better, as children’s eating behaviors and weight trajectories become more or less stable by school age (Ashcroft, Semmler, Carnell, van Jaarsveld, & Wardle, 2008; Jackson & Cunningham, 2017; Wheaton, Millar, Allender, & Nichols, 2015).

Researchers from a variety of disciplines, including nutrition and ingestive behavior and public health, work to define these early pathways to obesity. The field of developmental science has more recently turned its attention to the topic, helping to expand the scope of obesity research through its inclusion of behavioral and psychological developmental processes in obesity-risk models, and its consideration of transactional or bi-directional processes occurring between spheres of influence. Bronfenbrenner’s bioecological theory of development is a popular framework by which to operationalize the study of childhood obesity, because it incorporates both individual biology and nested direct and indirect environmental domains of influence into its conceptualization of change over time (Bronfenbrenner & Ceci, 1994; Fiese & Bose, 2016; Harrison et al., 2011). The present study extends the current developmental literature on the etiology of child eating behaviors and subsequent obesity risk using a bio-ecological framework, with particular focus on influence of intrinsic infant characteristics, or temperament, and subsequent parental feeding practices, specifically
the use of food as reward, on the child’s food motivational systems and weight status during early middle childhood.

Infant and Child Temperament

The construct of temperament may be a useful predictor of childhood obesity, as it encapsulates early-emerging emotional and behavioral differences in children that may influence the subsequent development of eating patterns and related parental feeding strategies. A recent roundtable of leading temperament researchers produced the following definition: “temperament consists of early emerging traits across four domains, namely activity, affectivity, attention, and self-regulation” (Shiner, Buss, McClowry, Putnam, Saudino, & Zentner, 2012). Simply put, temperament reflects individual differences in reactivity and regulation observed early in development (Rothbart & Derryberry, 1981).

The construct of temperament has received considerable attention from developmental scientists since Chess and Thomas’ (1977) seminal work on the New York Longitudinal Study (NYLS). The temperament literature is generally guided by several fundamental principles. First, temperamental traits are considered to be relatively consistent (Goldsmith et al., 1987). This principle aims to both eliminate the potential inclusion of short-term, or “ephemeral,” behaviors and to frame traits as occurring across contexts (Goldsmith et al., 1987). Second, temperamental traits are expected to develop over time, with change occurring due to interactions between biology and environment (Shiner et al., 2012). According to such a principle, traits may be differentially stable for
individuals given their circumstances. Temperament traits may also appear or change in magnitude and expression at specific periods during development as a part of natural maturational processes, such as the increase of behavioral inhibition following the development of fear of novelty at 6 months of age (Putnam & Stifter, 2002; Schaffer, 1966). The third principle of temperament concerns the bidirectional and transactional processes occurring between children and parents that shape development (Sameroff, 2009; Stifter & Dollar, 2016). Parental influence on child development does not occur in isolation, but is instead partly determined by the unique characteristics of the child. Child temperament contributes to the child’s own developmental trajectory. Together, the three principles provide a means of conceptually integrating the various but unique models of temperament prevalent in the field.

The dominant approach to temperament conceptualizes it as dimensional in theory and in operationalization (Stifter & Dollar, 2016). Thomas and Chess (1977) were the first modern researchers to derive temperamental dimensions from structured interview protocols, including activity level, rhythmicity, approach/withdrawal, adaptability, sensory threshold, intensity of reaction, quality of mood, distractibility, and attention span and persistence. The nine dimensions comprised the style of a child’s behavior, rather than its content or motivational source (Thomas & Chess, 1977). Dimensions applied across contexts, reflecting overarching tendencies in the child’s behavior. Thomas and Chess’ dimensional model served as the foundation for all subsequent dimensional models, including Buss and Plomin’s (1975) genetic criterial approach and Goldsmith and Campos’ (1982) emotionality-based conceptualization of temperament.
The pivotal work of Thomas and Chess also informed Rothbart and colleagues’ (1981) theory of temperament. Though dimensional in approach, Rothbart extended the model to incorporate a neurobiological orientation, such that individual differences in behavior could be better understood. As the Rothbart model drives much of the theoretical underpinnings of the current study, particular attention will be paid to its tenets and nuances. Rothbart and Derryberry (1981) developed a theory of temperament focused on genetically inherent differences in reactivity and self-regulation, wherein reactivity is defined as one’s biological arousal capacity, and self-regulation is defined as the process by which reactivity is modulated (Rothbart & Derryberry, 1981). According to the Rothbart model, all temperamental dimensions may be contained within these two broader behavioral processes (Rothbart & Derryberry, 1981).

The dimensional structure of temperament devised by Rothbart and colleagues encompasses a variety of lower-order traits, as well as three higher-order factors, in which specific dimensions are nested (Posner & Rothbart, 2007; Rothbart & Bates, 2006). The first factor, surgency-extraversion, is comprised of high amounts of high-intensity pleasure, activity level, impulsivity and approach behaviors (Rothbart, Ahadi, Hershey, & Fisher, 2001; Stifter & Dollar, 2016). Negative affectivity, the second factor, characterizes children high in anger, frustration, fear, sadness, and a decreased ability to be soothed following distress (Rothbart et al., 2001; Stifter & Dollar, 2016). The third factor, effortful control, reflects children’s ability to regulate emotions and behaviors, and is comprised of high levels of inhibitory control, attention focusing, smiling and laughing, perceptual sensitivity, and low intensity pleasure (Rothbart et al., 2001; Stifter & Dollar, 2016). Rothbart and colleagues obtained their temperamental dimensions and
factors from a series of questionnaires corresponding to developmental period, including the Infant Behavior Questionnaire-Revised (IBQ-R) (Gartstein & Rothbart, 2003) designed for infants between 3 and 12 months of age, the Early Childhood Behavior Questionnaire (ECBQ) (Putnam, Gartstein & Rothbart, 2006), intended to assess toddlers aged 18 to 36 months, and the Children’s Behavior Questionnaire (CBQ), for children aged 3 to 7 years (Rotbart et al., 2001). Rothbart and colleagues integrated the developmental process of temperament into their measures, providing room for both relative trait stability and change over time. Although Rothbart assessed temperament through parent questionnaires across all applicable ages, the questions asked and the dimensions measured varied according to the corresponding neurobiological development of the child. For instance, the IBQ-R measures duration of orienting, an early-emerging form of attention, whereas the CBQ considers attentional focusing, a more sophisticated iteration of attention processes (Gartstein & Rothbart, 2003; Rothbart et al., 2001). The three higher-order factors of surgency/extraversion, negative affectivity, and effortful control were first derived from the CBQ, however, additional analyses replicated the factor structures using the IBQ-R (Gartstein & Rothbart, 2003) and the ECBQ (Putnam, Garstein, & Rothbart, 2006). Even measured across time, the underlying temperamental dimensions tend to cohere to particular overarching tendencies.

The underlying neurobiological development affecting children’s temperamental trajectories is integral to the Rothbart model, given that temperament is characterized both by relatively stability within-person and variability between-person. Derryberry and Rothbart (1997) outlined two neural systems that serve as the biological foundation of temperamental growth: the motivational system and the attentional system. The
motivational system, contained within the limbic circuits, influences the development of approach in addition to several other temperament traits, including fear and aggression (Derryberry & Rothbart, 1997). Approach behaviors originate in the basolateral amygdala in response to perceived rewards. Following the reward input, dopaminergic neurons are activated in the ventral tegmental area and sent to the nucleus accumbens to facilitate action (Derryberry & Rothbart, 1997). The attentional system is comprised of several brain circuits, each of which control different processes. The first, the reticular activating system, maintains overall alertness, while the second circuit, the posterior attentional system, entails the orientation of attention from one location to another (Posner & Raichle, 1994). The anterior attentional system is the executive system responsible for the regulation of other attentional circuits, providing the neurobiological basis for effortful control (Posner & Raichle, 1994; Posner & Rothbart, 1992). Attentional systems accordingly underlie the regulatory dimensions of temperament, whereas the motivational system serves as the origin of reactive dimensions, accounting both for temperamental stability over time and individual differences between people (Derryberry & Rothbart, 1997).

Rothbart and colleagues’ (1981) model is largely considered the gold standard, given its neurobiological origins, its stability across developmental periods, and its use of parent-report to yield temperamental dimensions and factors. However, parent-reported data is confounded by response-bias, and is accordingly an imperfect tool for accurately assessing infant and child behavior (Bates, Freeland, & Lounsbury, 1979; Stokes, Wecksell, & Zaccario, 2011). More recently, researchers have adopted increasingly sophisticated statistical analyses, including cluster analysis and latent profile analysis, to
derive temperament typologies from observational data (Putnam & Stifter, 2005; Moding & Stifter, 2017). The categorical approach to temperament differs from the dimensional approach not just in method of measurement (observation versus parent report) but also in its analysis. Temperament types adopt a person-oriented approach, in which the person is viewed holistically (Bergman & Magnusson, 1997). Thus, individual differences emerge through patterns of behavior. Under the person-oriented approach, individuals are clustered together based on their similar patterns, and should resemble others in their group more than members of different groups (Bergman & Magnusson, 1997). On the other hand, the traditional dimensional construction of temperament employs a variable-oriented approach that analyzes individual differences between dimensional variables, instead of individual differences among persons or groups.

Though the categorical, person-oriented, approach has recently been brought to the foreground, temperament types are routed in the history of the field, with Thomas, Chess and Birch (1968) designating children as “difficult,” “slow-to-warm,” and “easy” based upon factor analyses. More recent research yields results derived from data-driven analytical techniques. Kagan (1994) identified children as behaviorally inhibited or uninhibited based upon their respectively high or low fear response to unfamiliarity. This approach relies upon the determination of extreme groups through laboratory, or those that fall within the top 10% or the bottom 10% of the behavior of interest (Kagan, 1994). Although helpful in identifying children who may be especially prone to the development of internalizing or externalizing disorders, the extreme group technique cannot categorize all children in a given sample, and thereby omitting potential types from discovery.
One means of creating exhaustive temperament typologies is the implementation of multivariate analyses, such as cluster analysis or latent profile analysis. Both cluster analysis and latent profile analysis attempt to uncover hidden groups in quantitative data through different statistical approaches (Oberski, 2016). Putnam and Stifter (2005) used cluster analysis for a range of coded approach/withdrawal behaviors and emotionality elicited from toddlers in a series of laboratory assessments. The analysis identified three types: 1) exuberant, or children observed as high in approach and positive affect, 2) inhibited, or those exhibiting low approach and high negative affect, and 3) low reactive, or children moderately high in approach and low in positive and negative affect (Putnam & Stifter, 2005). A later latent profile analysis of preschoolers’ behavior during a risk-room procedure, in which children were asked to engage with various novel objects with an unfamiliar experimenter, yielded similar classifications to Putnam and Stifter (2005): exuberant, inhibited, and average (Dollar, Stifter, & Buss, 2017). This replication lends credence to the validity of temperament typologies, as does the similarity between research analyses and the work of Kagan (1994).

Considerable similarities and differences exist between the temperament types of Putnam and Stifter (2005) and the temperamental factors of Rothbart’s model (Posner & Rothbart, 2007; Rothbart & Bates, 2006). In general, the exuberant type resembles high surgency as measured by Rothbart and colleagues, while the inhibited type functions similarly to high negative affectivity and low surgency (Stifter & Dollar, 2016). The similarities between type and factor falter when interpreting emotional valence as related to the motivational systems of approach and avoidance (Carver & Harmon-Jones, 2009). Approach and avoidance systems represent the fundamentals of behavioral organization,
with approach characterizing behavior involved in approaching desired rewards or goals, and avoidance characterizing behavior involved in avoiding threat (Carver & Harmon-Jones, 2009). They are also fundamental to both the typological and the factorial approaches to temperament. In particular, exuberant type and surgency factor are both largely defined by the tendency to exhibit approach behaviors. It would logically follow, then, that approach tendencies would not be associated with the inhibited type or negative affectivity factor (Putnam & Stifter, 2005). Though this holds for the inhibited type, the negative affectivity factor is comprised of a host of affects, including fear and anger, often conceptualized as part of the avoidance motivational system due to their negative emotional valence (Rothbart et al., 2001; Carver & Harmon-Jones, 2009). Fear is inherently an avoidant affect that surfaces in response to perceived threats (Frijda, 1986, p. 197). Anger is more complicated. Though typically negative in valence, anger has been conceptualized both as an avoidant affect (Watson, Clark, & Tellegen, 1988) and as an approach–oriented affect (Carver & Harmon-Jones, 2009). As an approach affect, anger is theorized as an affective response to being prohibited from moving toward a desired goal, either material (a toy moved out of reach) or more abstract (rejection from a popular social group) (Berkowitz, 1993; Rothbart, Derryberry, & Posner, 1994). Empirically, high vagal tone, a biological indicator of approach tendencies, has been positively associated with anger reactivity during an arm restraint procedure during infancy (Stifter & Fox, 1990). In addition, laboratory-observed rates of high approach behaviors in toddlers have been associated with concurrent elevated levels of maternal-reported externalizing problems (Putnam & Stifter, 2005). Children with inhibited temperament types are demonstrably lower in approach behaviors than their exuberant peers,
suggesting that they may be less likely to experience anger than they are avoidant affects, like fear (Putnam & Stifter, 2005). Within Rothbart’s factor approach, anger dimensions, like distress to limitations and irritability, load onto negative affectivity (Rothbart et al., 2001; Gartstein & Rothbart, 2003). Thus, although the dimensions themselves reflect approach-oriented behaviors, the factor structure does not lend itself to that interpretation. Accordingly, the influence of approach becomes diluted once temperament is assessed at the factor-level. The categorical and dimensional approaches yield similar but not identical temperamental phenomena, and vary most profoundly in orientation (variable vs. person) and measurement.

Temperament, Weight, and Eating Behaviors in Children

Regardless of analytical approach, temperament is useful for parsing apart individual differences in child behavior that may contribute to the development of obesity. Traditionally, the field of nutrition has emphasized metabolic influences on differences in ingestive behaviors, with particular focus paid to homeostatic functioning and dysregulation (Blundell & Halford, 1994; Crowley, 2008). However, more recent work has included neuropsychological processes, including emotion, attention, reward, and cognitive control (Farr, Li, & Mantzoros, 2016). Temperament theory describes individual differences for most of these processes and is measurable from infancy through early adolescence and thereby lends itself readily to the study of the ontogeny of childhood obesity risk. Further, because temperament is identifiable at an early age, drawing connections between it and obesity may improve early prevention efforts that
traditionally target parental nutrition education exclusively. At present the literature examines temperament in relation to childhood obesity in two ways: through direct association between temperament and weight status or weight gain, or through associations between temperament and obesogenic eating behaviors that may contribute to weight status or weight gain.

Direct associations between temperament and weight are reported most prominently by studies focused on infant development. A recent systematic review has concluded that negative affectivity during infancy demonstrates robust association with higher weight status in the first year of life (Anzman-Frasca, Stifter, & Birch, 2012). Difficult infant temperament, characterized by negative affectivity, has also been associated with rapid infant weight gain (Carey, 1985). Darlington and Wright (2006) found a similar positive association between rapid infant weight gain from birth through 8 weeks of age and distress to limitations at 8 weeks of age, suggesting that anger reactivity may play a particular role in the connection between negative affectivity and obesity risk. This possibility was given further credit when Darlington and Wright (2006) observed that fear reactivity, also a component of negative affectivity, was found to be associated with slower weight gain across the same developmental period. These studies do not empirically identify the mechanistic links behind the found associations between temperament and obesity. Anzman-Frasca et al. (2012) speculated the associations reflected a parental tendency to soothe fussy infants with food, leading to early weight gain. Such a pattern of feeding in response to child characteristics suggests that temperament may contribute to the development of obesity risk through its influence on
parental behaviors and through subsequent learned eating patterns exhibited during childhood.

Research examining associations during later development periods, such as preschool and early middle childhood, addresses the question of temperamental reactivity’s contribution to the development of subsequent obesogenic eating patterns. Individual differences in eating patterns become especially important to study during this time, as children become more autonomous in making food choices, particularly in regards to food consumption and food responsiveness. Much of the literature examining later developmental periods indeed finds that temperament is linked to these patterns of eating behaviors. However, cross-sectional research during the preschool and early middle childhood years suggests that surgency, not negative affectivity, is the temperamental factor most likely to be implicated. Preschool children low in inhibitory control and high in approach have been found to be more likely to increase caloric intake of restricted foods than their peers (Rollins, Loken, Savage, & Birch, 2014b). In low-income preschoolers, surgent temperament has been associated with overeating in response to cues from the environment, increased levels of food responsiveness and food enjoyment, and decreased levels of satiety responsiveness (Leung et al., 2014). In contrast, though preschoolers higher in negative affectivity were more likely to tantrum when denied foods, they also were more responsive to satiety cues (Leung et al., 2014). When Leung and colleagues (2015) conducted additional path analyses including weight in the model, the results suggested an association between surgent temperament and increased obesity risk, although this association was fully mediated by increased food responsiveness and enjoyment. Such results suggest that surgent temperament, driven by
approach tendencies, contributes to the way in which children respond to and ingest foods that are palatable or otherwise rewarding. Clinical research examining temperamental differences between children with and without obesity supports this notion, suggesting that obese children may have elevated levels of impulsivity and sensitivity to reward (Braet, Claus, Verbeken, & Van Vlierberghe, 2007; Nederkoorn et al., 2006) and may be more likely to exhibit food approach behaviors (Haycraft, Farrow, Meyer, Powell, & Blissett, 2011).

Cross-sectional research provides a necessary foundation for the field’s understanding of the role of temperament in the development of obesity risk, but it cannot capture change over time, over the developmental process by which temperamental traits might influence said risk. Although much of the current field has focused on cross-sectional research, several studies have used a longitudinal approach to examine the influence of early temperamental dispositions on subsequent weight and eating outcomes. High soothability during infancy has been associated with lean body composition during early childhood (Wells et al., 1997), whereas high distress to limitations measured at 3 months of age, has predicted increased levels of fat and weight-for-length in 12-month-old African American infants (Slining, Goldman, Borja, & Bentley, 2009). In regards to obesogenic eating, Vollrath and colleagues (2012) found that temperament types higher in negative emotionality at 1.5 years of age predicted the likelihood of daily unhealthy food and drink consumption at ages 3 and 7. Similarly, several infant temperamental traits, including soothability and negative reactions to food in girls and reduced attentional capacity in boys, have shown to predict standardized weight gain and risk of obesity at age 6 (Faith & Hittner, 2010). Coded observations of negative reactivity, as
determined during a structured toy removal task at 1 year of age, have been associated with greater weight gain at 3 years of age when accompanied by reduced rates of maternal self-efficacy (Anzman-Frasca, Stifter, Paul, & Birch, 2013). These studies are promising, but it should be noted that the literature is mixed, with other longitudinal studies finding no significant associations between infant temperament and childhood obesity (Pryor et al., 2011; Wright, Cox, & Couteur, 2011). Further, it is noteworthy that longitudinal projects again find effects for negative affectivity and related temperamental traits, not surgency. It is clear that more work needs to be done in order to understand the long-term importance of infant temperament on childhood obesity, and to ascertain which temperament traits place a child at greater risk of obesity.

Current associations between temperament and subsequent obesity risk appear to tell two different stories – depending upon the study’s methods and chosen timeframe, either highly negative or highly surgent temperamental factors relate to the development of obesogenic behavior and heightened weight status. Children high in negativity are easily distressed, fussy, and typically rated as inhibited, whereas children high in surgency are quick to exhibit approach behaviors, impulsive, and sensation seeking (Derryberry & Rothbart, 1997; Stifter & Dollar, 2016). With such different profiles, it may seem contradictory that both negativity and surgency would lead to an increased risk in obesity. However, there are methodological and theoretical explanations for why such a contradiction appears to exist in the literature.

Research has commonly relied upon associations between weight outcomes and higher-order temperamental factors obtained from parent-reported data. Factors like negative affectivity and surgency summarize a range of behavioral tendencies that help to
explain the relationship between temperament and obesity risk, but they do so at the expense of understanding the specific behaviors that drive such an association. Namely, an infant high in negative affectivity may be determined to be more likely to be at a higher weight status than infants low in negative affectivity (Anzman-Frasca et al., 2012) but this is not necessarily driven by all of negative affectivity’s components, including fear, sadness, and anger. In fact, research that examines temperamental dimensions has consistently found that it is distress to limitations, or anger reactivity in response to physical confinement or blockage from a desired action or object (Gartstein & Rothbart, 2003), that is associated with greater weight gain and adiposity (Anzman-Frasca et al., 2013; Darlington & Wright, 2006; Slining et al., 2009). These findings have been demonstrated using both Rothbart’s IBQ-R (Darlington & Wright, 2006; Slining et al., 2009) and observational measures of infant reactivity in response to a toy removal (Anzman-Frasca et al., 2013). It is possible, then, that mothers who rate their infants as high in negative affectivity might be particularly responsive to their infant’s distress to limitations in feeding contexts, contributing to their infant’s eating behavior development and pattern of weight gain in an attempt to soothe their distress.

Conceptualizing distress to limitations as the crux of the association found between negative affectivity and obesity risk also helps to bridge the gap between the discrepant findings implicating both negative affectivity and surgency. As previously established, there is robust behavioral and neurocognitive evidence to suggest that anger is rooted in approach tendencies (Carver & Harmon-Jones, 2009; Putnam & Stifter, 2005; Stifter & Fox, 1990). Furthermore, factor analysis demonstrates that anger and frustration load onto both negative affectivity and surgency in the CBQ (Rothbart et al., 2001). It is
possible that the approach tendencies driving associations for surgency may also be driving associations for negative affectivity, indicating that the seemingly contradictory findings present in the field may describe similar developmental processes. Namely, it is possible that these children are likely to display behaviors that provoke similar reactions from their caregiving environments, making caregivers more likely to turn to quick and effective means of modifying behavior. Given that temperaments characterized by approach, or action toward desired objects, has been associated with both greater weight gain and obesogenic eating behaviors in separate analyses, it is possible that food becomes a useful reward-system for quelling anger reactivity and impulsivity. Repeated exposure to such feeding strategies may undermine the child’s own ability to regulate energy intake. This dysregulated energy intake may then manifest into particular obesogenic eating behaviors over time, increasing the likelihood of obesity. However, there is scant evidence of such a mechanistic pathway, in which children’s obesogenic eating mediates the relationship between approach-oriented temperament and increased weight status or weight gain. To date, Leung and colleagues (2015) have published the most compelling pathway analyses, suggesting that food responsiveness and enjoyment mediate the association between surgent temperament increased risk of obesity. However, this study is limited in its use of parent-reported data for both independent variables, and therefore other mechanistic links may exist that have yet to be measured.

The available literature relies largely upon parent-reported measures of temperament, including Rothbart’s questionnaires and various others. Given the prevalence of parent-reported measures, any temperamental dimensions determined are likely limited by the parent’s perception of their child’s characteristics. This introduces
issues of response bias, creating an altogether different temperamental profile for a child
than may be observed by an independent observer. Prior research has demonstrated that
parent-reported temperament and observer-rated temperament do not always neatly
correlate, lending credence to the notion that parent-reported data may not fully articulate
the manner in which temperament is related to obesity risk (Anzman-Frasca et al., 2013).

It is vital that meditational models also incorporate observational measures of
temperament and eating behaviors in order to reduce the influence of response bias. The
current study addresses this gap in the literature by examining the potential mechanistic
associations between approach-oriented temperament, to be subsequently labeled as
exuberant temperament in order to reflect the observer-rated, typological method to be
utilized, and observed obesogenic eating behavior as they related to obesity risk in
children.

**Food Reinforcement, Temperament, and Obesity Risk**

Exuberant temperament describes a tendency toward motivational processes that
lead an individual to pursue desired goals (Carver & Harmon-Jones, 2009). These
motivational processes apply across contexts, but may be particularly relevant to the
eating context, influencing the frequency, quantity, and quality of food items consumed.
The relative reinforcing value of food (RRV$_{food}$) is one means of establishing differences
in food motivation when given the option to work for food or a non-food alternative
(Epstein, Leddy, Temple, & Faith, 2007). The relative reinforcing value of food is routed
in behavioral choice theory, a framework for understanding the choices individuals make when choosing between two or more alternatives (Epstein et al., 2007). According to this theory, a reinforcer is a stimulus that causes the preceding behavior to increase in occurrence. Any given reinforcer carries a reinforcing value, or the extent to which the stimulus will encourage the re-occurrence of the preceding behavior (Bickel, Marsch, & Carroll, 2000). Food is generally considered a powerful reinforcer, but individuals may exhibit different levels of motivated behavior to acquire it for consumption. Thus, the reinforcing value of food may be greater for some individuals than for others.

The $RRV_{food}$ paradigm parses out differences in motivational processes by asking individuals to choose to work toward a food or non-food reinforcer by pressing a computer mouse (Epstein et al., 2007). After a set number of mouse clicks, a reinforcer is acquired, after which progressive rate schedules alter the amount of work required to obtain the next reinforcer. Reaching later progressive rate schedules require more work from the individual, suggesting that the individual is more highly reinforced by the item being worked toward. From this paradigm, several key differences in motivational processes can be observed. First, one can observe a preference for food reinforcers or non-food reinforcers based upon which incentive is worked toward more. Second, one can determine the strength of the reinforcement, drawn from the number of progressive rate schedules reached for each stimulus. Both pieces of information elucidate patterns of behavior suggestive of maladaptive motivational processes that contribute to increased food consumption and obesity.

The relative reinforcing value of food versus a non-food incentive has been previously assessed in adult and child populations. Cross-sectional research finds positive
associations between high levels of food reinforcement and obese weight status, as well as increased energy intake for both adults and children (Epstein, Carr, Lin, Fletcher, & Roemmich, 2012; Giesen, Havermans, Douven, Tekelenburg, & Jansen, 2010; Temple, Lgierski, Giacomelli, Salvy, & Epstein, 2008). When examined longitudinally, the reinforcing value of food has predicted weight gain over one year in children aged 7-10 years (Hill, Saxton, Webber, Blundell, & Wardle, 2009) and nonobese adults (Carr, Lin, Fletcher, & Epstein, 2014). For both populations, it is theoretically stipulated that high rates of food reinforcement are related to increased ad libidum food consumption, resulting in energy imbalance and eventual weight gain (Epstein et al., 2012). This behavioral mechanism has been found in a cross-sectional sample of adults, for whom energy intake fully mediated the association between food reinforcement and BMI (Epstein et al., 2012). Although no comparable study exists for children, one can glean that a similar mechanism may be in effect from studies demonstrating associations between food reinforcement and increased ad libidum energy intake (Rollins, Loken, Savage, & Birch, 2014; Temple et al., 2008). Accordingly, there is sufficient evidence within the RRVfood literature to suggest that differences in food reinforcement are related to differential risk of obesity and that this effect can be seen in children.

Associations between food reinforcement and obesity are additionally supported by research examining differences in brain structures related to eating, hunger, and reward sensitivity. Functional magnetic resonance imaging results suggest that adolescents with obesity show greater activation in brain regions related to the sensory aspect of food (gustatory cortex) and the hedonic aspect of food (somatosensory region) than leaner peers when anticipating the consumption of food (Stice, Spoor, Bohon,
Velduizen, & Small, 2008). Stice and colleagues (2008) also demonstrated a significant decrease in caudate nucleus activation upon consumption of a highly palatable food. Heightened reactivity to the anticipation of food, but reduced reward activation during consumption may suggest a dopamine receptor deficit, hypothetically contributing to maladaptive overeating behaviors and obesity (Stice et al., 2008). Similar findings have been found in children aged 10-17, such that children with obesity demonstrate hyper-responsiveness to food pictures in the motivation, reward, and cognitive control centers of the brain (Bruce et al., 2010). Although this research is predominately cross-sectional, and therefore limits the interpretation of causality and directionality, it suggests that different reward-related responses to food contribute to obesogenic behaviors and risk of obesity.

The current literature focuses on the predictive value of food reinforcement and reward sensitivity, such that increases in one’s motivation to acquire food influence one’s likelihood of becoming obese or overweight. Less is known about what predicts one’s food reinforcement levels, although there is sufficient theoretical and emerging empirical evidence to suggest that temperament may be a salient early predictor. Approach behaviors emerge early in infancy, acting as the observed manifestation of the aptly named Behavioral Approach System (BAS) in the brain (Gray, 1981; Gray, 1987). The BAS utilizes the activation of the dopaminergic system to respond to positive, rewarding stimuli in the environment (Gray, 1981; Gray, 1987). Approach behaviors are employed when reward pathways in the brain signal the individual to obtain the rewarding stimuli. Exuberant or surgent children are approach-oriented, more impulsive and reward sensitive (Polak-Toste & Gunnar, 2006). It theoretically follows, then, that highly
exuberant or surgent children may be more likely to find food reinforcing, and therefore experience more motivation to pursue and consume that food.

Only one study to date has examined the connection between temperament and relative food reinforcement, with researchers reporting associations between the dimensions of negativity and regulation and the reinforcing value of food, such that infants rated as lower in rate of recovery from distress and cuddliness were likely to be more reinforced by food than other infants in the sample (Kong et al., 2016). This study is limited by its design, however, as it consisted of a cross-sectional analysis of 9 to 18 month old infants. This is problematic given the intensity of change that occurs throughout this period – it is likely the breadth of age groups included in the analyses confounds the potential results, as approach and inhibition behaviors develop and change from 6 to 12 months (Putnam & Stifter, 2005). As a result, infants of different ages may be assessed as temperamentally similar on a questionnaire but behave very differently in a laboratory task meant to capture food reinforcement. As a cross-sectional study, it cannot provide insight into temperament’s function as a predictor of later food reinforcement, nor does it include infant weight trajectories in its analyses. It is clear from this study that more work is needed to understand how temperament may be associated with food reinforcement and how food reinforcement may help to explain associations between exuberant temperament and weight status.

Though temperament has rarely been explicitly associated with food reinforcement, research has explored associations between related child characteristics and food reinforcement, and between temperament, food reinforcement and other obesogenic outcomes. One study demonstrated predictive associations between parent-
reported overall reward sensitivity and food reinforcement in preschool aged children (Rollins, Loken, Savage, & Birch 2014a). Another study by the same group reported that lower inhibitory control, higher approach, and higher food reinforcement were all associated with increased food intake following laboratory-induced restriction, again measured in preschool-aged children (Rollins, Loken, Savage, & Birch, 2014b). Taken together, the studies conducted by Rollins and colleagues suggest some level of interplay between elements of exuberant temperament, like reward sensitivity, and food reinforcement, though neither study explicitly examined the association between temperament and food reinforcement. These works are suggestive of the potential for associations between approach behaviors and food reinforcement in childhood, however, more work is required to empirically test this assumption, particularly over a longitudinal period in order to provide insight into directionality, and with direct measurement of both temperamental types and food reinforcement.

Recent longitudinal evidence suggests that approach-withdrawal developmental processes appear to influence infant responses to novel food, providing further evidence of the link between temperament and patterns of potential obesogenic eating behaviors (Moding & Stifter, 2017). The study first established that developmental changes in inhibited approach, in which infants learn to inhibit approach responses depending upon the novelty of an object during the second half of the first year of life, can be observed in infant responses to both novel toys and novel food. The researchers subsequently determined that positive responses to novel food at 12 months of age predicted both observed approach behaviors and an increased likelihood of membership in the exuberant temperament type. From this foundational work, one can ascertain that exuberant
temperament is developmentally associated with the desire to consume foods, even when the food is unfamiliar. Thus, it seems likely that a similar association could be found between exuberant temperament and the desire to acquire and consume familiar and highly palatable foods.

Research examining the origins of adult obesity offers additional insight into possible connections between exuberant temperament, food reinforcement, and weight status. Obesity outcomes themselves are associated with higher rates of personality traits of extroversion and impulsivity, both of which relate to the characteristics of the exuberant child (Sutin, Ferrucci, Zonderman, & Terracciano, 2011). Further, dietary disinhibition, or the tendency to overeat when presented with highly palatable foods, moderates the effect of \( R_{\text{RRV}_\text{food}} \) on weight status and energy intake in adults, such that higher levels of food reinforcement values predict increases in weight and in food consumed when coupled with higher rates of dietary disinhibition (Epstein et al., 2012).

Dietary disinhibition is associated with impulsive personality traits in adults, indicating that adult personality influences the manner in which adults experience and express food reinforcement. The adult literature also demonstrates that sensitivity to reward predicts overeating, thereby influencing BMI through increases in energy intake overtime (Davis et al., 2007). Temperament is believed to be the basis for personality (Rothbart & Ahadi, 1994; Rothbart & Bates, 2006). Although subject to change, temperament is relatively stable across time (Rothbart, Derryberry, & Hershey, 2000) and it is likely that temperamental tendencies observed early during childhood will be similar to personality traits observed during adulthood (McCrae et al., 2000). The presence of associations between exuberant-like personality traits during adulthood, though minimal, is suggestive
of potential associations during childhood.

Prior research in childhood and adulthood indicate a possible link between dimensions of temperament and food reinforcement during infancy as well as associations between aspects of exuberant temperament, food reinforcement, and related obesogenic behavior during preschool. However, additional research is required to fully elucidate these associations. It is unknown whether temperament measured during infancy might remain predictive of food reinforcement rates during early middle childhood once children become enrolled in the school system and gain additional autonomy over their eating behaviors. It is also imperative to understand the potential of food reinforcement to act as a mechanism through which general emotional and behavioral growth may affect weight development. It is unlikely that temperament by itself leads to differences in weight outcomes. Rather, it is probable that temperament helps to shape the development of eating behaviors, and the more mechanistic links that can be drawn between temperament, obesogenic behaviors and weight, the more researchers can develop sound prevention tools utilizing temperament as a screener.

**Parenting and Feeding**

One must also consider the impact of parenting when considering the development of eating behaviors and obesity during childhood. Eating is inherently filtered through parental feeding styles and practices during early childhood. Thus, it is essential to examine parenting practices and behaviors when examining children’s weight trajectories. Parenting practices reveal exactly how parents govern their child’s eating
through feeding strategies. Ventura and Birch (2008) argue that parenting feeding practices play a mediating role on child weight, and must be considered in order to ascertain effects. One might also assume that any effects of parenting style on child weight are reflective of the influence of a combination of parenting practices.

Among the parenting practices associated with child weight status, perhaps the most commonly studied is the restriction of access to food (Fisher & Birch, 1999; Fisher & Birch, 2000; Fisher & Birch, 2002; Gubbels et al., 2009). Parents who restrict food are typically concerned about foods high in fat and sugar, although the means by which they restrict can be varied. Parents may reserve foods for special situations, keep foods out of the home, store foods in hard-to-access areas, or limit portions and helpings (Rhee, 2008). Several experimental studies have found that restricting access to palatable foods increases intake when the food becomes available, leads to eating in the absence of hunger, and is associated with an increased risk of overweight status (Fisher & Birch, 1999; Fisher & Birch, 2000; Fisher & Birch, 2002). It should be noted, however, that some research suggests that restriction does not affect weight outcomes but rather leads to increases in consumption of healthy foods and decreases in consumption of unhealthy foods (Gubbels et al., 2009). Consequently, there is some contention within the literature regarding the impact of parent restriction on children’s weight status.

Parenting practices affect child weight often when they involve the promotion of food. Research suggests that parental encouragements to eat can change the rate of consumption, as well as the types of foods that are eaten, which is in turn associated with child weight gain (Drucker, Hammer, Agras, & Bryson, 1999; Klesges et al., 1983). One parenting practice that has received recent attention is the use of food to soothe. There is
a substantial body of literature to support emotional eating as being predictive of weight gain and obesity in adults (Dallman, 2010; Evers, Stok, de Ridder, 2010). The use of food to soothe is hypothesized to act as a precursor to emotional eating by promoting food as a means of emotion regulation. Research suggests that the use of food to soothe distress is associated with heavier weight status in infants and toddlers (Stifter, Anzman-Frasca, Birch, Voegtline, 2011). Parental use of food to soothe also has effects on preschool-aged children, as one study found that children whose parents used this strategy consumed more sweets in the absence of hunger (Blissett, Haycraft, & Farrow, 2010). Additionally, parental use of food to soothe is associated with emotional eating in children aged 8 to 12, supporting the hypothesis that using food to soothe causes children to develop maladaptive emotion regulation strategies (Braden et al., 2014). Altogether, the research suggests that parental use of food to soothe influences both obesogenic behavior and weight status in children for a wide range of ages.

Another parenting practice less explored by the literature is the use of food as a reward, or instrumental feeding (Krölner & Warschburger, 2009; Vereecken, Keukeler, & Maes, 2004). It is assumed that instrumental feeding will encourage children to eat when prompted by emotions or circumstances that go beyond hunger cues, thus causing excessive energy intake, however, the empirical evidence is mixed on the exact nature of the relationship between weight and instrumental feeding. Research has demonstrated that parental use of instrumental feeding increases the amount of unhealthy food consumed by children (Krölner & Warschburger, 2009; Vereecken et al., 2004). Studies have also found that the use of instrumental feeding promotes a preference for sweet foods while it decreases the intrinsic value of healthy foods (Birch et al., 1982; Newman
& Taylor, 1992). To date, few studies have examined child weight as an outcome variable, with those that do reporting mixed findings. Rodgers et al. (2013) report positive predictive associations between maternal endorsement of instrumental feeding and child BMI z-scores one year later. In contrast, other studies have found little-to-no evidence of associations between instrumental feeding and child weight using cross-sectional data (Carnell & Wardle, 2007; Faith, Scanlon, Birch, Francis, & Sherry, 2004). Given the present literature, much is left unknown about instrumental feeding, including how it affects weight outcomes over longer periods of development, and how it might influence maladaptive eating behaviors. To date, no study has examined instrumental feeding in the context of food reinforcement, although it is possible that continued use of instrumental feeding might affect the extent to which a child is positively reinforced by food, given the involvement of reward processes in both constructs. It is at least theoretically viable that parental feeding might affect a child’s pattern of reward responding, although empirical work is necessary to establish such a connection.

Temperament and Parental Feeding Practices

It is likely that parental feeding practices are influenced by child characteristics, just as much as parents influence weight outcomes for children. Bi-directional processes have only received moderate attention in the childhood obesity literature, especially in regards to the role of temperament. Including temperament in models of pathways leading from parenting to child weight outcomes is important, because it brings in characteristics of the child that may influence parenting processes of interest. In other
words, it invites a more complex and comprehensive explanation for the manner in which parenting affects childhood obesity.

Few studies have actually extended the parenting practice and parenting style literature to include temperament. Stifter et al. (2011) found that infants and toddlers whose parents used food to soothe were more likely to be assessed as high in negativity and, in turn, to be heavier. When examining the concurrent influence of temperament and maternal sensitivity, Wu et al. (2011) found that children with difficult temperament and insensitive mothers were most likely to become overweight or obese during middle childhood. Similarly, Zeller, Boles, and Reiter Purtill (2008) reported an interaction between temperament and maternal warmth, such that the combination of difficult child temperament and low maternal warmth were highly predictive of childhood obesity. Both studies suggest that goodness-of-fit between parenting style and temperament influences children’s weight outcomes.

There is currently a need for more literature examining interactions between temperament, parenting feeding practice, child eating behavior and child weight status. This is particularly true for less examined feeding constructs, including instrumental feeding. As previously demonstrated, children with exuberant temperament types are particularly sensitive to reward and high in approach (Polak-Toste & Gunnar, 2006). Parents may be evoked to use instrumental feeding for these children in order to maintain positive behaviors and correct for unwanted behaviors because this feeding practice may effectively tap into natural inclinations toward approach and reward. For instance, an exuberant child may be more likely to experience and express frustration when prevented from reaching a goal, perhaps when prevented from taking home an extra toy from the
store. Displays of frustration and anger are largely considered inappropriate in public settings, and should an exuberant child react calmly to this goal blockage, his or her parent may choose to reward the child’s preferred response with a palatable treat. When used in excess with children of this temperamental type, instrumental feeding may contribute to the development of maladaptive eating behaviors and subsequent weight gain in children. There is some evidence to suggest that parents and children respond to the relative reinforcing value of food similarly (Epstein et al., 2008), suggesting that parents do play a role in shaping food reinforcement, but the exact nature of how parental practices may help shape child food reinforcement, or how temperament might influence the type of practices used has not been explored. Parental use of instrumental feeding may moderate the relationship between temperament and maladaptive eating behaviors like food reinforcement that then may predict increases in weight in children. Altogether, this would demonstrate a clearer pathway connecting exuberant temperament to childhood obesity.

The Current Study

The purpose of the current study was to elucidate pathways to childhood obesity that consider the effect of one’s temperament early in life on the relative reinforcing value of highly palatable foods like candy and weight status, while also addressing the nuanced transactional relationship between early child characteristics and parenting practices. Such a study would provide a more detailed, ecologically sound, depiction of a pathway to obesity that can readily be identified through behavioral traits. In order to
ascertain the associations required to fulfill this purpose, a longitudinal approach was implemented. The study examined a cohort of parent and child dyads and focused on temperament and obesity at two time points: once when the children were 18 months of age, and again when the children were 6 to 8 years of age. During the first time point, temperament was assessed through a multitude of means, including through typologies derived from structured lab protocols, measurements underlying approach and withdrawal responses to novel stimuli, and through parent report. During the second time point, parental feeding strategies, most notably instrumental feeding, and child relative reinforcing value of food (RRV\text{food}) levels, and child BMI z-scores were assessed.

The purpose of the current study was to test the components of a conceptual moderated mediation model, see Figure 1-1, wherein RRV\text{food} levels mediates the association between infant exuberant temperament and child weight status among children with parents likely to use instrumental feeding. Prior research suggests that exuberant/surgent temperament is associated with increased risk of weight gain (Leung et al., 2015) though more work is needed to determine whether such associations will hold when analyzed longitudinally. Thus, it was first hypothesized that infants classified as exuberant will be more likely to have higher weight statuses than their non-exuberant peers.
There is also evidence to suggest that exuberant/surgent temperament is associated with obesogenic eating behavior development (Leung et al, 2014; Rollins et al., 2014a) and that obesogenic eating behaviors may mediate associations between exuberant/surgent temperament and weight gain (Leung et al., 2015). RRV_{food} is one such marker of obesogenic eating, as it has been positively associated with obese weight status and excessive energy intake in children (Epstein, Carr, Lin, Fletcher, & Roemmich, 2012; Hill, Saxton, Webber, Blundell, & Wardle, 2009) Levels of food reinforcement have been associated with reward pathways in the brain (Stice et al., 2008) and may be associated with exuberant temperament, as children classified as exuberant are more likely to be reward sensitive (Polak-Toste & Gunnar, 2006). Accordingly, it was hypothesized that

Figure 1-1: Conceptual moderated mediation model for the current study. Time point 1 occurred when the child was 18 months of age. Time point 2 occurred when the child was between the ages of 6-8.
RRV_{food} will fully mediate the positive association between infant exuberant temperament and child weight status.

As infants and children develop early eating behaviors within a caregiving environment, it is also likely that parental or caregiver feeding practice will influence the mediational model. There is evidence to suggest that parental instrumental feeding may contribute to the development of obesogenic eating behaviors, such as the increased preference for and consumption of unhealthy foods (Birch et al., 1982; Kröller & Warschburger, 2009; Newman & Taylor, 1992; Vereecken et al., 2004). The use of instrumental feeding and exuberant temperament type are also theoretically linked, as both constructs relate to reward and motivational processes (Kröller & Warschburger, 2009; Polak-Toste & Gunnar, 2006; Vereecken et al., 2004). It was therefore hypothesized that parental use of instrumental feeding will moderate the association between exuberant temperament and RRV_{food}, such that exuberant infants with parents more likely to endorse the use of instrumental feeding, will be more likely to exhibit higher levels of RRV_{food}.

Other parental feeding behaviors have been implicated as potential risk factors for childhood obesity – chief among them being parental restriction of food. These effects have been robustly reported in the extant literature, with parental restriction being associated with increases in the consumption of unhealthy food items and with weight outcomes (Clark. Goyder, Bissell, Blank & Peters, 2007; Fisher & Birch, 1999; Faith et al., 2004; Joyce & Zimmer-Gembeck, 2009). Accordingly, additional exploratory analyses were planned in order to determine whether restriction of food might also moderate the association between infant temperament and children’s RRV_{food}. 
Chapter 2

Methods

Participants

A total of 46 participants took part in the current study. Participants were drawn from a larger longitudinal project examining the associations among temperament, parental feeding, and childhood obesity. Parent-child dyads were recruited when the infants were 4 or 6 months of age, depending on the point in the project in which they were recruited, and followed through 18 months of age. Two follow-up projects occurred, once when the children were preschool-aged, and again when the children were 6-8 years of age, although the present study draws only from the 6-8 year follow up. Participants for this study were drawn from a largely homogenous sample. Participants were primarily Caucasian (95.0%, 3.1% Asian, 1.9% of other ethnicity). The vast majority of parent participants were mothers (91%). Parents averaged 37.89 years of age at the time of the 6-8 year follow-up (SD = 4.69 years) and parents reported an average of 15.59 years of education (SD = 2.70 years). The majority of parents were married (80.9%).

Participants were recruited from central Pennsylvania. Criteria for inclusion in the original study were mothers’ full-term pregnancy and ability to read and speak English. For the current project, participants were contacted through a letter informing them of their eligibility for an additional study within the larger project. Participants were
excluded from the current study if they did not first complete the visit at 18 months of age, and/or did not partake in the preschool follow-up visits.

**Procedures**

**18-month procedures**

When the children were 18 months of age, they participated in a laboratory visit with their mothers that entailed several tasks designed to assess toddlers’ temperament. The present study focuses on one of these tasks, the Risk Room, in which children are introduced to and encouraged to explore a room containing 4 novel activities, including a small set of stairs next to a mattress, a gorilla mask, a tunnel, and a balance beam (Buss & Goldsmith, 2000; Goldsmith, Reilly, Lemery, Longley, & Prescott, 1994). For the first three minutes of the task, the mother and child were left alone in the room, during which time the mother was asked to sit in a chair located in a corner of the room, and the child was informed that he or she could play with the toys. After the three minutes expired, an experimenter entered and asked the child to engage with the objects up to three times per object. During this time, the mother was asked to remain silent in order to minimize interaction between the child and mother. Approach and withdrawal responses and overall temperament groups were derived from this task. During this time, mothers also completed questionnaires to assess parental perceptions of toddler temperament.
6-8 year follow-up procedures

The follow-up laboratory visit lasted between 1-1.5 hours, during a chosen time most convenient for the families. After informed consent, demographic information was obtained. Parent-child dyads then entered the laboratory together in order to help acclimate the child to the lab space. Parents were asked to sit to the side while children completed hunger assessments in order to assess whether a snack was required prior to the start of the \( RRV_{food} \) (Fisher & Birch, 2000). Children who reported feeling hungry were given the option to snack on a package of Goldfish crackers prior to the \( RRV_{food} \) task, in order to prevent subsequent task behavior from being confounded by feelings of hunger, while children who reported feeling full or half-full moved onto the next task. Upon completion of the hunger assessment, and snack if indicated as being hungry, children completed the \( RRV_{food} \) task. While the \( RRV_{food} \) task was being administered, parents completed questionnaires related to feeding practices and parental eating habits. Pennsylvania State University Review Board approved all study procedures.

Measures

18 month measures

Approach behaviors

Approach behaviors were rated during the experimenter-present episode of the Risk Room task at the 18-month visit. Based upon prior research, (Fox et al., 2001;
Putnam & Stifter, 2005) approach behaviors included the following specific behaviors: activity level, level of engagement with risk room objects, spontaneous vocalizations, proximity to mother, latency to play with first object, and duration of time playing with novel objects. Activity level of engagement, and spontaneous vocalizations were coded using 5-second intervals generated by a coding computer program, (Better Coding Approach, Danville, PA). Activity level was coded on a 4-point scale, ranging from 0 (completely still) to 4 (vigorous/exuberant activity) and engagement was coded on a 5-point scale, ranging from 0 (no engagement) to 5 (high-activity engagement). Averages were calculated for both activity level and for engagement. For spontaneous vocalizations, the total number of vocalizations was counted across the episode. Drift reliability was calculated from 20% of coded videos for each scheme, with acceptable scores being achieved for activity level (ICC = 0.97), engagement (ICC = 0.99), and spontaneous vocalizations (Cohen’s $k = 0.70$). The remaining behaviors, proximity to mother, latency to play, and duration of time playing with novel objects, were coded continuously across the episode. Proximity to mother was coded on a 5-point scale from 1 (clinging to mother) to 5 (more than 2 arms lengths from mother), after which scores were averaged for each child. Latency to play was calculated as the length of time, in seconds, starting from the time the toddler first entered the risk room and ending at the point that the toddler starts playing with an object. The duration of time spent engaging with risk room objects was calculated as the total time, in seconds, that the child spent engaged with the objects in the room, from the moment the child entered the room to the time the task ended. For latency and duration scores, proportion scores were created in order to account for potential uncodable footage. Similar to the previous behaviors, drift
reliability was calculated using 20% of the coded videos and was deemed acceptable for proximity (ICC = 0.99), latency to play (ICC = 0.92), and duration of time spent playing (ICC = 0.99). All coded behaviors were then standardized and averaged in order to produce a composite variable. Higher composite scores indicate greater levels of observed approach behavior during the risk room.

**Temperament groups**

Using the previously described coded observations of toddler approach behaviors, as well as coded observations of positive and negative affect during the risk room task, groups of toddlers exhibiting similar ranges of behavior were identified in a previous study (Moding & Stifter). Positive and negative affect was coded based on 5-second interval assessments of facial and vocal expressions during the experimenter-present episode of the risk room task. Both schemes were coded on a 4-point scale, with a 0 indicating no affect, and a 4 indicating high positive or high negative affect respectively. The temperament groups were analyzed for a previous study of the same cohort using latent profile analysis (LPA). The LPA indicated a four class solution is the best fit, with profiles reflecting toddlers who were exuberant, average approach, extremely inhibited, and inhibited (Moding & Stifter, 2017). As described by Moding and Stifter, exuberant toddlers exhibited high levels of positive affect, behavioral approach, and high levels of activity; average approach toddlers displayed behavior close to the sample mean across behaviors, and extremely inhibited and inhibited children presented varying degrees of negative affect, as well as close proximity to their mothers and longer latencies to play
with risk room objects. Mean behaviors of each coded observation included in the latent profile analysis is described in Figure 2-1. Moding and Stifter combined the extremely inhibited and inhibited infants into one group based on their conceptual similarities and the precedent set by prior research (Dollar et al., 2017; Putnam & Stifter, 2005). The present study utilized those same groups as detailed by Moding & Stifter, 2017.

![Graph of means for latent profile analysis indicators by temperament group.](Image)


*Early childhood behavior questionnaire (ECBQ)*

Parent ratings of toddler temperament were obtained using the ECBQ (201) items when their child was between around 18 months. The ECBQ asks parents to report on
their toddler’s behavior over the past 7 months across a variety of frequently occurring contexts. A 7-point Likert style format was used, ranging from 1 (never) to 7 (always).

As previously mentioned, the ECBQ is based on Rothbart’s conceptualization of temperament, and thus is characterized by eighteen subscales and three superfactors: Negativity, Surgency, and Effortful Control. Because the study hypotheses identify exuberance as the temperament type of interest and exuberance and surgency are conceptually overlapping, the present study only considers the surgency superfactor for analysis. The surgency factor captures activity level, impulsivity, high intensity positive affect, sociability, and positive anticipation. The surgency superfactor showed good internal consistency in the present study ($\alpha = .72$).

6-8 year follow-up measures

*Relative reinforcing value of food task*

Child participants completed the RRV<sub>food</sub> task through the utilization of a computer program developed by Epstein and colleagues (Epstein et al., 2004). The computer program has been administered to adults, and children preschool and elementary school aged (Epstein et al., 2004; Rollins et al., 2010; Rollins et al., 2014). After the hunger assessment, the participants were presented with two computer monitors, approximately 4 feet apart, in order to eliminate the possibility that the child may attempt to engage with both monitors at one time. Two opaque containers will be
placed in between the computer monitors, situated on a table such that the child may easily view the items contained inside during the task administration.

An experimenter instructed children to click a computer mouse until three shapes appearing on the screen matched one another, meaning that all three shapes and all colors would be the same shape and the same color. In order to introduce more difficulty into the game, children were informed that they must make 5 consecutive matches in order to receive a point toward a prize, as indicated by a raffle ticket. Following the basic instruction, the opaque containers were opened and children were presented their prize options: candy, the food reinforcer, and toys, the alternative reinforcer. Children were offered a variety of candy and toy choices in order to accommodate the possibility that one option per category may not reflect the preferences of child participants and therefore may not be a motivating stimulus. Further, this is some evidence that liking ratings obtained in the lab most similarly match “real-world” situations when a variety of food options are offered (de Graaf et al., 2005). In order for the toy reward to most closely mirror the candy reward, a variety of toy options were also given. Candy options included Skittles, Starburst, Hershey’s bars, Milky Way bars, Airheads, Laffy Taffy, Dum Dum lollipops, and Reese’s cups. Toy options included small slinky toys, notepads, friendship bracelet kits, bouncy balls, animal figurines, yo-yos, and finger skateboards. Children were then informed that children must work on the left computer monitor to earn points toward candy, and on the right computer monitor to earn points toward toys. The computer used to provide an RRV tutorial was counterbalanced such that even IDs were given instructions at the candy computer, and odd IDs were given instructions at the toy
computer, in order to attend to the likelihood that the computer of instruction would influence which computer they used to begin participating in the task.

During the task participants were allowed to work for the prize of their choice and may go back and forth between the two stations at will. Caboodles containing the prizes were open and on display in-between the two computers. The computer program operated on progressive ratios, with the schedule of reinforcement beginning at a ratio of 4, such that 4 mouse clicks yield a match. After 5 matches comprised of 4 clicks each, the child would earn his or her first point toward a prize. Subsequent point-earning matches would feature doubled ratios (ranging from 8 clicks per match to 16,384 clicks per match). Both computer stations featured the same scheduled ratios, however the programs are not synced so that children could progress through many ratios for one computer and very few for the other depending upon preference. Participants played until they chose to discontinue the task, or until they reach the maximum task duration of 30 minutes, at which point the task was terminated. To examine RRV_{food}, a proportion score was created, in which the number of candy prizes earned was divided by the total number of prizes earned for both candy and toys.

**Parental instrumental feeding**

In order to assess the influence of environmental factors on RRV_{food}, mothers were asked to complete questionnaires specific to feeding style and food accessibility. Parental feeding practices were determined using scales from the Comprehensive Feeding Practices Questionnaire (CFPQ) including restriction of child’s food intake for health
reasons, restriction of child’s food intake for weight reasons, pressure to eat, food as reward, and emotion regulation (Musher-Eizenman & Holub, 2007). For the present study, the food as reward subscale, derived from three items, was used to depict parental instrumental feeding. Other subscales, specifically those related to restriction, were also considered for exploratory purposes but were not included in the primary hypotheses. Questionnaire responses utilized a five-point Likert scale, with options ranging from 1 (never) to 5 (always). The CFPQ has been validated and tested as reliable for parents with young children (Musher-Eizenman & Holub, 2007). In the present study, the food as reward subscale had acceptable internal consistency ($\alpha = .70$), as did restriction for weight reasons ($\alpha = .78$) and restriction for health reasons ($\alpha = .89$).

**Anthropomorphic measurements and BMI**

Child height and weight measurements were collected at the 6-8 year follow-up. Height was determined based upon the average measurements obtained using a SECA portable stadiometer, and weight was collected based upon averaged measurements obtained using a Tanita scale. Child BMI was calculated using the following formula: weight (kg) / [height(m)]^2, after which sex- and age-specific BMI scores were standardized according the Centers for Disease Control (CDC) growth charts (Kuczmarski et al., 2002). BMI percentiles were also determined according to the CDC growth charts. Using these percentiles, child participants were categorized into four weight status groups: underweight (less than the 5th percentile), normal weight (5th percentile to less than the 85th percentile), overweight (85th to less than the 95th percentile), and obese (95th percentile or greater).
Potential covariates

In order to account for potential confounding influences, the following potential covariates were examined: parental education, maternal BMI, child gender, and child age at the time of the 6-8 year visit. Demographic information was obtained during a brief interview at the beginning of the 6-8 year follow-up visit. Parental education was reported in years and child age was reported in months. Maternal height and weight was measured during the 6-8 year follow-up unless fathers participated, in which case maternal anthropomorphic measurements were taken from the closest lab visit when the children were 5.5 years of age. There were 4 cases in which these measurements were substituted out of 46 participants. BMI scores were calculated using the same formula as used for child BMI.

Data Analysis Plan

All data analysis was completed using R studio (R Core Team, 2015). Descriptive statistics were assessed for all variables, including potential covariates (including child’s age, gender, parental education, and maternal BMI). Variables were tested for normality, with all variables meeting criteria expect the following: parent-reported use of instrumental feeding, parent-reported restriction for health, parent-reported restriction for weight and maternal BMI. All non-normally distributed variables were log transformed. Pearson correlations were also calculated for all hypothesis variables, both independent and dependent, and potential covariates in order to determine which covariates to include in subsequent analyses. Additional independent samples T-tests and one-way ANOVAs
were conducted to test for mean differences in categorical variables, including gender and temperament group.

In order to test the study hypotheses, three mediation models were conducted, each utilizing a different measure of temperament as the independent variable. The first model utilized person-oriented LPA-derived temperament groups. The second model tested the variable-oriented continuous measure of approach behaviors observed during the Risk Room procedure, and the third model tested parent-reported measures of temperament derived from Rothbart’s ECBQ.

Baron and Kenny’s (1986) three-step approach was adopted to test for mediation in all three models. Following this approach, mediation is determined by conducting three regression analyses, each of which assess particular pathways in the mediation model (see Figure 2-2). First, child BMI, the dependent variable, was regressed on infant temperament, the independent variable in order to establish the statistical significance of Path c. Second, RRV_{food} as the mediating variable was regressed on infant temperament, in order to determine the significance of Path a. For the third step, the dependent variable, child BMI z-score, was regressed on both on infant temperament and child RRV_{food}. This final step functioned to determine two necessary criteria: first that RRV_{food} was associated with child weight even when controlling infant temperament (path b), and second that the effect of infant temperament on child weight be reduced in magnitude (path c’). Full mediation is determined when the significant association between infant temperament and child BMI z-score in path c is reduced to zero in path c’. Partial mediation was determined when the association between infant temperament and child
BMI z-score remained significant in path c’ but reduced below the coefficient reported in path c. The three steps are represented with the following equations:

**Step 1 (path c):** Child BMI = $\beta_0 + \beta_1$(Infant Temperament) + e

**Step 2 (path a):** Child RRV$_{food}$ = $\beta_0 + \beta_2$(Infant Temperament) + e

**Step 3 (paths b and c’):** Child BMI = $\beta_0 + \beta_4$(Infant Temperament) + $\beta_3$(RRV$_{food}$) + e

---

**Figure 2-2:** Diagram of paths in the hypothesized mediation models. Time point 1 occurred when the child was 18 months of age. Time point 2 occurred when the child was between the ages of 6-8.

Due to issues of sample size, the moderating effect of parental instrumental feeding on infant temperament’s hypothesized association with child RRV$_{food}$ was
assessed in separate analyses using multiple regression analyses, instead of an integrated moderated mediation model. Figure 2-3 shows the moderation model used to analyze the associations among infant temperament, parental instrumental feeding, and child $RRV_{food}$. As with the mediation models, three separate analyses were conducted in order to take into account the several methods of analysis for infant temperament, including the person-oriented temperament types, variable-oriented approach behaviors, and parent-reported temperamental factors. Follow-up simple slope analyses were planned for any significant interactions. Each of the three multiple regression analyses testing for the interaction between infant temperament and parental use of instrumental feeding can be summarized with the following equation:

$$RRV_{food} = \beta_0 + \beta_1(Infant\ Temperament) \times \beta_2(Parental\ Instrumental\ Feeding) + e$$
Lastly, several exploratory regression analyses were planned in order to examine the potential moderating effect of additional feeding practices, namely parental restriction of food, on the association between infant temperament and child RRV\textsubscript{food}. Figure 2-4 depicts the model used to assess the moderating effects of parental restriction. The CFPQ subscales of restriction for health and restriction for weight were also included in two separate regression analyses, summarized with the following equations:

\[
RRV_{food} = \beta_0 + \beta_1(\text{Infant Temperament}) \times \beta_2(\text{Parental Restriction for Health}) + e
\]

\[
RRV_{food} = \beta_0 + \beta_1(\text{Infant Temperament}) \times \beta_2(\text{Parental Restriction for Weight}) + e
\]

Figure 2-3: Diagram of paths in the hypothesized moderation model for parental instrumental feeding. Time point 1 occurred when the child was 18 months of age. Time point 2 occurred when the child was between the ages of 6-8.
Figure 2-4: Diagram of paths in the exploratory moderation models for parental restriction of food. Time point 1 occurred when the child was 18 months of age. Time point 2 occurred when the child was between the ages of 6-8.

Given the small sample size, a post-hoc power analysis was conducted using the software package G*Power to determine statistical power to detect effects (Faul, Erdfelder, Buchner, & Lang, 2009). The program required the following specifications: sample size, number of independent variables, the alpha, and the effect size (small: $f^2 = 0.02$, medium: $f^2 = 0.15$, and large: $f^2 = 0.35$). Because models run were tested with either 3 or 4 independent variables (the study variables and two covariates), several power analyses were conducted for each effect size with either 3 or 4 independent variables specified. The alpha level used for each power analysis was $p < .05$. The post hoc analysis for 3 independent variables revealed that the statistical power for this study was 0.10 for a small effect, 0.53 for a medium effect, and 0.91 for a large effect. The post hoc analysis for 4 independent variables revealed that the statistical power for this study was 0.09 for a
small effect, 0.48 for a medium effect, and 0.87 for a large effect. Accordingly, there is adequate power to detect large effects but not to detect small and medium effects for the linear regressions involving either 3 independent variables or 4 independent variables.
Chapter 3

Results

Descriptive Statistics and Preliminary Analyses

Table 3-1 presents descriptive statistics of all study variables. Interestingly, on average children worked for a slightly lower proportion of food than toys, though the value suggests that the average child split their time nearly evenly between the candy and toy workstations \((M = 0.46)\). Table 3-2 displays correlations among variables. \(RRV_{food}\), estimated as the proportion of candy prizes earned out of total prizes earned, was correlated with approach withdrawal scores during the Risk Room at the trend level \((r = 0.29, p > 0.05)\), and was significantly correlated with parent-reported surgency \((r = .45, p < 0.01)\). However, \(RRV_{food}\) was not associated with child BMI z-score and meditational analyses were approached with caution. The number of candy prizes earned were also uncorrelated with the number of toy prizes earned. A follow-up paired sample t-test was performed to test differences between the means and found no difference between the mean number of prizes earned for candy \((M = 3.59, SD = 1.98)\) and toys \((M = 3.98, SD = 1.42)\); \(t(45) = -.133, p > 0.05\). It should also be noted that the number of candy prizes earned was uncorrelated with temperament measures but the number of toy prizes earned was negatively correlated with parent-reported surgency \((r = -.47, p <0.01)\).
Table 3-1: Descriptive statistics for study variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>M or %</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Covariates</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parental Education (in years)</td>
<td>14.9</td>
<td>1.9</td>
<td>12.0</td>
<td>17.0</td>
</tr>
<tr>
<td>Maternal BMI</td>
<td>27.2</td>
<td>5.3</td>
<td>20.0</td>
<td>44.9</td>
</tr>
<tr>
<td>Child Age (in months)</td>
<td>86.8</td>
<td>6.98</td>
<td>72.00</td>
<td>98.0</td>
</tr>
<tr>
<td>Child Gender:</td>
<td>Male</td>
<td>49%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Infant Temperament</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperament Types:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exuberant&lt;sup&gt;a&lt;/sup&gt;</td>
<td>30.43% (n = 14)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inhibited&lt;sup&gt;a&lt;/sup&gt;</td>
<td>30.43% (n = 14)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Approach&lt;sup&gt;a&lt;/sup&gt;</td>
<td>39.14% (n = 18)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approach Behavior&lt;sup&gt;b&lt;/sup&gt; (z-score)</td>
<td>0.06</td>
<td>0.52</td>
<td>-1.07</td>
<td>1.12</td>
</tr>
<tr>
<td>ECBQ Surgency&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.91</td>
<td>0.62</td>
<td>2.80</td>
<td>6.42</td>
</tr>
<tr>
<td>3. RRV&lt;sub&gt;food&lt;/sub&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Prizes Earned</td>
<td>7.57</td>
<td>2.30</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Toy Prizes Earned</td>
<td>3.98</td>
<td>1.42</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Candy Prizes Earned</td>
<td>3.59</td>
<td>1.61</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Portion Candy Prizes Earned</td>
<td>46%</td>
<td>0.17</td>
<td>0</td>
<td>1.00</td>
</tr>
<tr>
<td>4. Parental Feeding (CFPQ)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instrumental Feeding</td>
<td>2.27</td>
<td>0.90</td>
<td>1.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Restriction for Health</td>
<td>2.95</td>
<td>1.07</td>
<td>1.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Restriction for Weight</td>
<td>1.57 (n = 45)</td>
<td>0.49</td>
<td>1.00</td>
<td>3.00</td>
</tr>
<tr>
<td>5. Child Weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>16.37</td>
<td>2.06</td>
<td>14</td>
<td>23</td>
</tr>
<tr>
<td>BMI (z-score)</td>
<td>0.23</td>
<td>0.92</td>
<td>-1.98</td>
<td>2.24</td>
</tr>
<tr>
<td>Weight Status:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Underweight</td>
<td>2% (n = 1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal Weight</td>
<td>84% (n = 37)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overweight</td>
<td>9% (n = 4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obese</td>
<td>9% (n = 4)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. n = 46 for all variables unless specified. BMI = body mass index; ECBQ = Early Childhood Behavior Questionnaire; RRV<sub>food</sub> = Relative Reinforcing Value of Food; CFPQ = Comprehensive Feeding Practices Questionnaire. Parental Feeding on a Likert scale from 1-5. Proportion of candy prizes assessed from total prizes (toy and candy) earned. <sup>a</sup> Behavioral observation; person-oriented. <sup>b</sup> Behavioral observation; variable-oriented. <sup>c</sup> Parent report.
A preliminary one-way ANOVA was conducted to test for mean differences among the temperament groups. The main effect of temperament group on RRV_{food} was not significant, $F(2,45) = 1.55$, $p > 0.05$, nor was the main effect of temperament group on child BMI z-score (Exuberant $M = -0.13$, $SD = 0.74$; Inhibited $M = 0.31$, $SD = 0.76$; Average Approach $M = 0.44$, $SD = 1.09$), $F(2,45) = 1.67$, $p > 0.05$. A chi-square test was
performed to examine the association between temperament group and weight status. To do so, normal weight individuals were grouped together and overweight and obese individuals were grouped together in order to increase the sample size. One child classified as underweight was not included in this analysis. Exuberant toddlers were predominantly normal weight, with only 1 out of 14 children classified as overweight or obese during middle childhood. Inhibited children were also rarely classified as overweight or obese, with only 2 out of 14 considered overweight or obese. 5 out of 18 average approach children were considered overweight or obese during middle childhood. However, the association was not significant, $X^2(4, N=46) = 3.71, p > 0.05$.

An additional T-test was conducted to determine mean differences in $RRV_{food}$ based on weight status. No difference in the mean $RRV_{food}$ score was detected between normal weight children ($M = 0.45, SD = 0.16$) and overweight/obese children ($M = 0.53, SD = 0.21$), $t(43) = -1.24, p > 0.05$.

Relevant covariates, including maternal BMI, maternal education, child’s gender and child’s age at time of the follow-up study visit were largely found to be uncorrelated with study variables with a few exceptions. Maternal education was positively associated with child BMI z-score ($r = .29, p < 0.05$) and with parental use of instrumental feeding ($r = .296, p < 0.05$). A preliminary t-test found gender differences, such that male participants ($M = 0.49, SD = 0.12$) were more reinforced by candy during the RRV paradigm than female participants ($M = 0.43, SD = 0.21$), $t(44) = 1.19, p < 0.05$. Given these findings, maternal education and child gender were included as covariates in each of the mediation and moderation models.
Mediation Model Testing

Table 3-3 describes the results of the series of multiple regression analyses mandated by Baron and Kenny’s (1986) three-step approach to mediation testing. Results for each tested step of all three hypothesized models are included. Model 1 tested a mediation model, in which the association between exuberant temperament, a temperament group derived previously by latent profile analysis, and child BMI z-score, was hypothesized to be mediated by RRV$_{food}$ levels, such that increases in RRV$_{food}$ explained the association between belonging in the exuberant temperament group during infancy and increased child weight. Model 2 tested a similar mediation model, this time testing RRV$_{food}$ as a potential mediator between approach responses and child BMI z-score, such that higher RRV$_{food}$ levels would explain the association between higher levels of approach during infancy and child weight. Model 3 tests this mediation again using parent-reported temperamental surgency as the independent variable. Similar to both prior models, higher levels of RRV$_{food}$ were hypothesized to mediate the association between parental endorsement of toddler surgency and child weight. Testing all three mediation models therefore examines the influence of temperament through a mixture of observational and parent-reported methods featuring person-oriented and variable-oriented approaches to the measurement of temperament.
Table 3-3:  Summary of regression analyses testing for RRV<sub>food</sub> as a mediator

<table>
<thead>
<tr>
<th>Meditation Step</th>
<th>Path</th>
<th>B Estimate</th>
<th>Standard Error</th>
<th>R²</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exuberant Temperament</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. BMI</td>
<td>c</td>
<td></td>
<td></td>
<td>0.19</td>
<td>2.41 (4, 41)†</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Average Approach</td>
<td>0.66*</td>
<td>0.31</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inhibited</td>
<td>0.45</td>
<td>0.34</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maternal Education</td>
<td>0.16*</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Child Gender</td>
<td>0.15</td>
<td>0.26</td>
<td></td>
</tr>
<tr>
<td>2. Food Reinforcement</td>
<td>a</td>
<td></td>
<td></td>
<td>0.08</td>
<td>0.92 (4, 41)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Average Approach</td>
<td>0.02</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inhibited</td>
<td>-0.07</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maternal Education</td>
<td>0.00</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Child Gender</td>
<td>-0.04</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>3. Not tested</td>
<td>b, c'</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Approach Behavior</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. BMI</td>
<td>c</td>
<td></td>
<td></td>
<td>0.11</td>
<td>1.72 (3, 42)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Approach Behavior</td>
<td>0.17</td>
<td>0.29</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maternal Education</td>
<td>0.14</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Child Gender</td>
<td>0.29</td>
<td>0.28</td>
<td></td>
</tr>
<tr>
<td>2. Food Reinforcement</td>
<td>a</td>
<td></td>
<td></td>
<td>0.09</td>
<td>1.44 (3, 42)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Approach behavior</td>
<td>0.09†</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maternal Education</td>
<td>-0.00</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Child Gender</td>
<td>-0.03</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>3. Not tested</td>
<td>b, c'</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ECBQ Surgency</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Predicting BMI from surgery</td>
<td>c</td>
<td></td>
<td></td>
<td>0.20</td>
<td>3.52 (3, 42)*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Surgency</td>
<td>0.45*</td>
<td>0.19</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maternal Education</td>
<td>0.13†</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Child Gender</td>
<td>0.30</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>2. Predicting food reinforcement from surgery</td>
<td>a</td>
<td></td>
<td></td>
<td>0.22</td>
<td>3.89 (3, 42)*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Surgency</td>
<td>0.12**</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maternal Education</td>
<td>-0.00</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Child Gender</td>
<td>-0.04</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>3. Predicting BMI from food reinforcement and surgery</td>
<td>b, c'</td>
<td></td>
<td></td>
<td>0.22</td>
<td>2.89 (4, 41)*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Surgency</td>
<td>0.35</td>
<td>0.22</td>
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<tr>
<td></td>
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<td>Food Reinforcement</td>
<td>0.82</td>
<td>0.82</td>
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<tr>
<td></td>
<td></td>
<td>Maternal Education</td>
<td>0.13†</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Child Gender</td>
<td>0.34</td>
<td>0.26</td>
<td></td>
</tr>
</tbody>
</table>

*Note. * p < .05 ** p < .01, *** p < .001, † p ranges from .05-.09.
Model 1: Temperament groups

The first model aimed to assess RRV\textsubscript{food} as a mediator of the potential association between the exuberant temperament group and child BMI z-score. Temperament group data was first dummy-coded to allow for interpretable results of categorical variables in a regression framework. Because exuberant temperament was hypothesized as the temperament group of interest, it was coded as the reference variable. Average approach temperament and inhibited temperament groups were included in the regression model and provided information about exuberant temperament through the estimated coefficients.

As the first of the three steps outlined earlier for assessing mediation, the direct effect between temperament group, the predictor variable, and child BMI z score, the outcome variable, was tested (path c). The overall model trended toward significance but did not pass the 0.05 threshold, $R^2 = 0.19$, $F(4,41) = 2.41$, $p = 0.06$. The dummy coded average approach group emerged as a significant predictor ($B = 0.66$, $SE = 0.31$, $p < 0.05$), suggesting that children classified within the average approach group were more likely to have higher BMI z scores than children classified as exuberant, contrary to expectations. Step 2 required that the first indirect effect, between temperament groups and RRV\textsubscript{food}, be tested (path a). This step did not produce significant results, indicating that mediation detection was not likely. Subsequent steps were not considered any further.
Model 2: Approach behavior

The second model aimed to assess $RRV_{food}$ as a mediator of the potential association between approach behavior and child BMI z-score. For Step 1, the direct effect between the predictor, approach behavior, and the outcome variable, child BMI z-score, was tested (path c), and was found to be non-significant. Due to this null result, the requirement for mediation in Step 1 was not met. Step 2 yielded further non-significant results between approach behavior and $RRV_{food}$, although it should be noted that approach behavior somewhat trended toward significance ($B = 0.09, SE = 0.05, p = 0.09$) (path a). Given the lack of both direct effect and indirect effects, it was concluded that the mediation model does not fit the data when using approach/withdrawal indices of temperament and the remaining steps were not considered any further.

Model 3: ECBQ surgency

The third model aimed to assess $RRV_{food}$ as a mediator of the potential association between parent-reported temperamental surgency and child BMI z-score. Figure 3-1 shows the unstandardized coefficients for each path in the third mediation analysis. For Step 1, the direct effect of temperament on child BMI z-score was tested (path c). Parent-rated surgency at 18 months was associated with child BMI z-score at the 6-8 year follow-up ($B = 0.45, SE = 0.20, p < 0.05$), indicating that path c was significant and requirement for mediation in Step 1 was met. Step 2 required that temperament be related to $RRV_{food}$ levels at the 6-8 year follow-up (path a). Upon running the multiple regression, it was found that the association was significant ($B = 0.12, SE = 0.03, p <$
0.05) and that the condition for Step 2 was met. Step 3 entailed associating RRV_{food} with child BMI z-score while controlling for parent-rated surgency (path b and path c').

Though the overall model was significant ($R^2=.22$, $F(4,41)=2.89, p < 0.05$), the association between RRV_{food} and child weight was not significant, and neither was the association between infant temperament and child weight. Notably, however, maternal education emerged as related to child weight at the trend level ($B = 0.13, SE = 0.06, p = 0.05$). Based upon the null findings in the third step, it was determined that a mediation model did not fit the data when utilizing parent-reported measures of temperament.

![Figure 3-1: Mediation path diagram for model 3 with unstandardized coefficients. * $p < .05$ ** $p < .01$](image-url)
Moderating Effect of Parental Instrumental Feeding

The moderating effect of parental endorsement of instrumental feeding was tested for all three measures of infant temperament using three multiple linear regressions. All three moderation models proved non-significant.

Exploratory Moderating Effects of Parental Restriction

Exploratory analyses were conducted in order to determine the potentially moderating effect of parental restriction of food. Because parental restriction of food for weight reasons was not significantly associated with temperament or $RRV_{food}$, it was not assessed. Further, parental use of restriction for health reasons was positively associated with child age, as seen in Table 3-2, and so child age was included as an additional covariate. When $RRV_{food}$ was predicted from the interaction between temperament group and parental restriction for health, no significant results were found. When approach withdrawal indices of temperament and parental restriction of health were tested for an interaction, parental restriction of food for health did emerge as a significant predictor of $RRV_{food}$ levels ($B = 0.05, SE = 0.02, P < 0.05$) though the overall model was not significant. When the interaction term was removed from analyses, the full model proved marginally significant ($R^2 = .23, F(4,41)=2.39, p = 0.05$), with parental restriction for health remaining as a significant predictor of $RRV_{food}$ ($B = 0.06, SE = 0.02, p < 0.05$) when controlling for child age and gender and maternal education. The last model predicted $RRV_{food}$ from the interaction between parent-reported surgency and parental restriction of health but was not significant. Like the model utilizing approach withdrawal as the
temperament measure, removing the interaction term from the model improved the overall fit ($R^2=.36$, $F(4,41)=5.17$, $p < 0.01$), with both surgency ($B = 0.11$, $SE = 0.03$, $p < 0.01$) and parental use of restriction for health ($B = 0.06$, $SE = 0.02$, $p < 0.01$) remaining as significant predictors of $RRV_{food}$ when controlling for child age and gender and maternal education.
Chapter 4

Discussion

The intended goals of the present study were twofold. First, the study aimed to assess the influence of toddler temperament on the development of $RRV_{food}$, or the potentially obesogenic motivation to work for food in the presence of non-food alternatives, and subsequent weight status. To do so, toddler temperament was assessed three ways at 18 months of age, and $RRV_{food}$ and weight status were measured during a 6-8 year follow-up. Toddler temperament data was derived three ways: 1) using a latent class analysis in which 3 groups were identified (exuberant, inhibited, and average-approach), 2) using a measure of the underlying approach and withdrawal behaviors exhibited during a threat-inducing paradigm, and 3) using factors obtained from a parent-reported temperament questionnaire. Three mediation models were tested in an effort to elucidate potential pathways linking each of the three described measurements of toddler temperament to childhood weight status through the hypothesized mediator, $RRV_{food}$. The study also aimed to explore the potentially moderating role of parental feeding strategies on the association between toddler temperament and $RRV_{food}$, utilizing parent-report to illuminate whether or not the use of instrumental feeding and restriction of food might have differentially affected $RRV_{food}$ levels of children with exuberant/surgent temperament.

Due to the lack of association between $RRV_{food}$ and child weight status, neither full nor partial mediation was found for any of the three tested mediation models. Because of the small sample size, interpretation of the reported null effects should be
treated with caution. Prior research has identified the third step of the Baron and Kenny (1986) method of analysis as being particularly low in power (Kenny & Judd, 2014). Additionally, multicollinearity is an unavoidable phenomenon in mediation analysis, further complicating the detection of effects (Baron & Kenny, 1986). The sample size available for the present analysis was likely not large enough to account for the issues of power and multicollinearity. It is possible that a larger sample size may have overcome these issues, allowing for the detection of mediation. Lastly, it is possible that an additional and unmeasured variable may have confounded the data (Judd & Kenny, 1981).

Despite the outcomes of the mediation analyses, several key direct effects were observed that deserve attention. Surgent temperament, as assessed through parental report, was found to directly relate to $RRV_{food}$ levels during the 6-8 year follow up. Children whose parents were more likely to rate them as high in surgency at 18 months worked toward a greater proportion of food in the $RRV_{food}$ task at 6-8 years. This finding is consistent with the work of Leung et al. (2014), in which higher parent-reported rates of preschool surgent temperament were associated with an increased likelihood of overeating in response to environmental cues, deriving pleasure from the consumption of food, and eating in the absence of hunger. As both food responsiveness and eating in the absence of hunger have been positively associated with child weight status, Leung and colleagues’ (2014) study supports the notion that surgent temperament may play influence children’s propensity toward obesogenic eating behaviors. The present study extends this work by revealing that toddler surgent temperament is also longitudinally related to the development of $RRV_{food}$ during middle childhood. Furthermore, it is the
first study to date to associate any temperamental factor with $RRV_{food}$, and the first to relate surgency, specifically, to increases in levels of $RRV_{food}$, providing unique evidence that surgent temperament as early as 18 months may play a role in the development of children’s hedonic responses to food over time. It is therefore possible that surgent temperament may be a viable indicator for early prevention programs targeting obesogenic eating behaviors and obesity risk, although more work is necessary to confirm the results of this study. However, it is important to note that the $RRV_{food}$ measure used was comprised of the number of candy prizes earned divided by the total number of prizes earned, both candy and toys. When the total number of candy and toy prizes were separately included in the correlation analyses, the number of toy prizes was significantly negatively associated with parent-rated surgency but the number of candy prizes was not. Accordingly, it may be the case that children rated as high in surgency were not more reinforced by candy, and were instead less reinforced by toys than children rated as low in surgency, and that this effect underlies the significant association found between $RRV_{food}$ and parent-rated surgency.

Toddler temperament, when operationalized as person-oriented temperament groups and parent-reported factor, was uniquely associated with weight status during middle childhood. Contrary to expectation, toddlers categorized as having average approach temperament were more likely to have higher BMI $z$-scores during the 6-8 year follow up than were exuberant toddlers. This finding was surprising, and more research is needed to understand why average approach, and not exuberant temperament, might be related to weight status. The average approach temperament type characterized toddlers whose approach-withdrawal and affect scores were close to the sample mean with the
exception of proximity and activity level, in which they were slightly above the mean (Moding & Stifter, 2017). In contrast, the exuberant temperament type characterized toddlers high in positive affect, approach behavior, activity level, time spent playing, and engagement and low in latency to play (Moding & Stifter, 2017). It is possible that average approach toddlers behave differently than exuberant toddlers in a manner that contributes to a higher weight status during middle childhood. This may include activity level, one component of approach. Although both temperament types are characterized by activity levels above the mean, they differ in the magnitude of difference, with exuberant toddlers being about 0.56 standard deviations above the mean, and average approach toddlers being about 0.32 standard deviations above the mean (Moding & Stifter, 2017). The elevated levels of activity level may help to protect exuberant toddlers from future weight gain, while the activity level typical of average approach toddlers may not be as protective. However, such differences were not found in the present sample, with no differences found in normal weight and overweight/obese statuses among the three studied temperament group, suggesting that the differences in BMI z-score may capture differences within the normal weight range. Accordingly, future studies are needed to study how these differences may influence weight outcomes in different types of temperament.

It is both noteworthy and unexpected that parent-reported temperament was related to both $RRV_{food}$ and to child weight status, whereas both the observed measures of temperament were not. Parental reports and observer reports of temperament are often discordant with one another (Anzman-Frasca et al., 2013; Seifer, Sameroff, Barret, & Krafchuk, 1994). However, in this study parent-reported surgency was modestly
positively correlated with approach behaviors, and approach behaviors were also positively correlated with RRV\textsubscript{food} levels. The latter effect dissipated when maternal education and child gender were controlled for in the mediation analysis. As such, it is likely that parental-reported measures of temperament may capture a different aspect of children’s early individual differences in surgency than is revealed by observed measures of approach behavior. Whereas the approach behaviors and temperament types were derived from a single laboratory assessment of behavior, the parent-reported measure of surgency is more holistic in nature, as parents are required to complete the parent-reported measure of surgency while considering toddler behavior over two weeks across various contexts, including sleeping, feeding, bathing, and play (Putnam et al., 2006). Furthermore, the ECBQ’s surgency factor is comprised of several scales, including activity level, impulsivity and high intensity pleasure, sociability and positive anticipation. The temperament types are comprised of positive and negative affect and approach behaviors, including activity, and it is possible that the surgency factor’s significant association with RRV\textsubscript{food} and weight status, and the nonsignificant associations found for approach behaviors and the temperament types suggests that approach behaviors may not be driving effects, and instead another component of surgency may be implicated. Furthermore, it may be that temperament across contexts is more related to obesogenic eating outcomes and weight status than temperament assessed during an isolated time point. Temperamental tendencies across contexts may help to influence parental feeding behaviors, as is suggested by the finding that parental restriction of food for health reasons was positively related to increased RRV\textsubscript{food}. Additionally, it is possible that observed temperament may be confounded by other
environmental influences, given that observed approach behaviors were no longer significantly related to $\text{RRV}_{\text{food}}$ when maternal education was added to the model. Child weight status was also negatively associated with maternal education, suggesting that the examined eating behaviors and weight outcomes may be more affected by conditions socioeconomic status than could be measured in this sample.

Parent-reported surgent temperament was found to be positively associated with child BMI $z$-score at the 6-8 year follow up. This finding has been previously substantiated in the literature (Leung et al., 2015). Leung and colleagues measured temperament and BMI concurrently when children were preschool-aged. The present study extends the extant research by adopting a longitudinal approach, suggesting that surgent temperament may help to facilitate pathways to obesity. Though $\text{RRV}_{\text{food}}$ was not found to mediate the association between surgency and weight status in this study, and indeed was not found to be related to weight status, prior research indicates that children with greater surgent tendencies may have higher weight statuses because they are responsive to external cues to food and less responsive to satiety cues (Leung et al., 2014, Leung et al., 2015). In this way surgency may contribute to children’s susceptibility to the rewarding qualities of highly palatable foods (Leung et al., 2014, Rollins et al., 2014a). Surgent temperament and related approach behaviors may also affect parental feeding strategies over time, such that parents may find themselves using food to reward because it is likely an effective management tool for surgent children (Polak-Toste & Gunnar, 2006; Rollins et al., 2014b), or they may be more likely to completely restrict access to highly palatable foods because their children are both reward sensitive and
goal-oriented, and may be more prone to overconsumption when food is freely accessible (Carver & Harmon-Jones, 2009; Leung et al., 2014; Polak-Toste & Gunnar, 2006).

To this end, parental use of instrumental feeding was hypothesized to moderate the association between toddler temperament and RRV_{food}. Parental endorsement of instrumental feeding did not directly relate to RRV_{food} levels, nor did it moderate the existing positive association between parent-reported surgent temperament and RRV_{food} levels. While some studies have linked instrumental feeding to maladaptive eating behaviors (Kröller & Warschburger, 2009; Vereecken et al., 2004), others have found no such association (Carnell & Wardle, 2007; Faith et al., 2012; Wardle et al., 2002). While the present study lends further credence to instrumental feeding’s lack of influence on child outcomes, such a conclusion should be considered with caution given the sample size examined. Restriction of food, on the other hand, was revealed to be positively associated with RRV_{food} levels, albeit in an overall model trending toward significance. Although restriction of food did not moderate the association between toddler temperament and RRV_{food}, it did remain uniquely positively related even when controlling for toddler temperament, suggesting that parental patterns of restriction of food (in this case out of a concern for the child’s health) may contribute to how motivated children are to work for palatable food items. This effect is supported by the existing literature examining the negative health consequences of parental restriction of food (Faith et al., 2004; Fisher & Birch, 1999; Joyce & Zimmer-Gembeck, 2009; Rollins et al., 2014b). Whereas it was originally hypothesized that parents’ use of food to reward behavior may affect children’s subsequent motivational focus on foods, this finding suggests that parents who restrict access to food may further incentivize children to
acquire palatable food items when they are provided the opportunity. Previous work indicates that this effect may be stronger in children with low regulatory abilities and high appetitive tendencies (Rollins et al., 2014b). It is difficult to glean directionality of effects from the present findings and from prior research due to the use of cross-sectional data, that is, it is possible that parental use of restriction may increase the reinforcing nature of candy for children but it is also possible that children’s elevated levels of RRV_{food} may result in greater use of restriction of unhealthy foods in parents, perhaps because these children are more likely to consume such foods often and in larger quantities. The latter conclusions is supported by the questions that comprise the restriction for health subscale of the CFPQ, such as “If I did not guide or regulate my child’s eating, s/he would eat too much of his/her favorite foods” (Mushzer-Eizenman & Holub, 2007). Accordingly, more work is needed to understand how restriction of food may relate to RRV_{food} across time in order to determine the directionality of the relationship between parental restriction and children’s relative reinforcing value of food.

The current study had several strengths. This is the first study to examine longitudinal associations between toddler temperament and RRV_{food} and weight outcomes during middle childhood, identifying both a direct positive association between parent-reported toddler surgent temperament and middle childhood weight status and a direct positive association between parent-reported surgent temperament and middle childhood RRV_{food} levels. These findings are both novel contributions to the literature, demonstrating the predictive value of toddler temperament in regards to eating behavior development and weight trajectories. Additionally, the study examined toddler
temperament using multiple measures, allowing for a more complete examination of temperament’s potential associations with $RRV_{food}$ and weight status.

This study also had several limitations. The small sample size likely reduced our ability to detect many of the effects hypothesized in the present study. A priori power analyses indicate that a total of 77 participants would have been required to detect medium effects ($f^2 = 0.20$), whereas a total of 550 participants would have been required to detect small effects ($f^2 = 0.02$) (see Cohen, 1977). The present sample size was large enough to detect large effects. Given the effects that were detected as significant or marginally significant, it is possible that medium effect sizes may have been found had the sample size been increased by 31 participants. Accordingly, a Type II error is more likely to have occurred, limiting the interpretability of the findings. Although causal mediation models were employed, causal conclusions cannot be drawn from this data in part due to the null findings. More work is required to determine whether $RRV_{food}$ is a possible mechanism through which toddler temperament influences later weight status. The manner in which the relative reinforcing value of food was collected was also a limitation. Past research examining the relative reinforcing value of food has demonstrated that food is an inherently powerful reinforcer, though food is thought to be more reinforcing for individuals with obesity (Epstein et al., 2007), it is possible that the design of the $RRV_{food}$ task used for the present study was unable to discriminate differential reinforcement levels in children with higher BMI z-scores. Children were offered a wide array of candy and toy prizes intended to appear equally intense and appealing and it is possible that the prizes were so enticing that children were more or less equally reinforced by candy and toys regardless of weight status, as suggested by the lack of difference found between the means of candy and toy prizes.
earned. Furthermore, the selection of only candy prizes limited the interpretability of the RRV findings, such that the findings could not be generalized to other highly palatable food items, like fatty or salty foods. For future studies examining associations between RRV_{food} and weight status a smaller range of equivalent food and non-food alternatives may be needed in order to prevent such ceiling effects. The inclusion of the wide variety of food items, including baked goods and salty snacks may also extend the generalizability of RRV findings. The longitudinal nature of the study, though a novel feature, may be an additional limitation of the present study because the intervening years are unaccounted for, leaving any potentially illustrative developmental processes occurring during this period of time unidentifiable. Lastly, the sample was largely homogenous and therefore the study’s findings cannot be generalized beyond the white, largely middle-class population examined.

The current study explored longitudinal associations among toddler temperament, measured at 18 months of age, and RRV_{food} and weight status, measured at 6-8 years of age. Findings suggest that toddler temperament is uniquely positively associated with both weight status and levels of RRV_{food} during early middle childhood, indicating that early emerging surgent temperamental traits may influence the development of obesogenic eating behaviors and weight outcomes. Furthermore, parental endorsement of restriction of food was also concurrently associated with elevated levels of RRV_{food}, signifying that parents play an important role in shaping children’s eating behavior development. Future research is necessary to confirm these findings, and to examine their potential mechanisms using a more diverse sample.
References


