Published in final edited form as:
Appetite. 2015 June ; 89: 1–9. doi:10.1016/j.appet.2015.01.009.

Executive functioning, emotion regulation, eating self-regulation, and weight status in low-income preschool children: How do they relate?

Sheryl O. Hughes, PhD[1], **Thomas G. Power, PhD**[2], **Teresia M. O'Connor, MD, MPH**[1], and **Jennifer Orlet Fisher, PhD**[3]

[1]USDA/ARS Children's Nutrition Research Center, Baylor College of Medicine, Houston TX

[2]Washington State University, Pullman WA

[3]Temple University, Philadelphia, PA

Abstract

The purpose of the present study was to examine relationships between child eating self-regulation, child non-eating self-regulation, and child BMIz in a low-income sample of Hispanic families with preschoolers. The eating in the absence of hunger task as well as parent-report of child satiety responsiveness and food responsiveness were used to assess child eating self-regulation. Two laboratory tasks assessing executive functioning, a parent questionnaire assessing child effortful control (a temperament dimension related to executive functioning), and the delay of gratification and gift delay tasks assessing child emotion regulation were used to assess child non-eating self-regulation. Bivariate correlations were run among all variables in the study. Hierarchical linear regression analyses assessed: 1) child eating self-regulation associations with the demographic, executive functioning, effortful control, and emotion regulation measures; and 2) child BMI z-scores associations with executive functioning, effortful control, emotion regulation measures, and eating self-regulation measures. Within child eating self-regulation, only the two parent-report measures were related. Low to moderate positive correlations were found between measures of executive functioning, effortful control, and emotion regulation. Only three relationships were found between child eating self-regulation and other forms of child self-regulation: eating in the absence of hunger was positively associated with delay of gratification, and poor regulation on the gift delay task was associated positively with maternal reports of food responsiveness and negatively with parent-reports of satiety responsiveness. Regression analyses showed that child eating self-regulation was associated with child BMIz but other forms of child self-regulation were not. Implications for understanding the role of self-regulation in the development of child obesity are discussed.

Address correspondence to: Sheryl O. Hughes, Children's Nutrition Research Center, Baylor College of Medicine, 1100 Bates, Houston, TX, 77030-2600, shughes@bcm.edu, 713-798-7017.
tompower@wsu.edu, teresiao@bcm.edu, jofisher@temple.edu

Keywords

Hispanic preschoolers; child eating self-regulation; child weight status; executive functioning; emotional regulation; delay of gratification

Introduction

Most researchers agree that a major factor contributing to high levels of childhood obesity is the environment to which children are exposed on a daily basis (Lake & Townshend, 2006; Wansink, 2004). In the United States, young people grow up in environments where palatable, inexpensive, high-calorie, low nutrient-dense foods are almost always readily available; where soft drinks and energy drinks are often the drink of choice; and where a large portion of daily calories come from heavily marketed, high-calorie, low-nutrient convenience foods (either in the home or at restaurants) often served in large portions. Because some children manage to maintain a healthy weight in the current "obesogenic" environment, a number of childhood obesity researchers have turned their attention to the role of children's self-regulation in the development of childhood obesity (Frankel et al., 2012; French, Epstein, Jeffery, Blundell, & Wardle, 2012; Laing, Matheson, Kaye, & Boutelle, 2014). The assumption of these researchers is that individual differences in child self-regulation may be one factor that contributes to some children's tendency not to consume too many calories, despite significant environmental pressures to do so.

Various types of self-regulation have been negatively related to child adiposity, obesity, and/or weight status. Eating self-regulation refers to the ability (inborn and socialized) to eat and not eat in response to internal cues of hunger and fullness (Baumeister & Vohs, 2004). There are two types of eating self-regulation—satiation and satiety. As described by Bellisle and colleagues (2012), "Satiation occurs during an eating episode and brings it to an end. Satiety starts after the end of eating and prevents further eating before the return of hunger" (p. 1149S). Satiation, which is negatively associated with child weight status (Faith et al., 2012; Johnson & Birch, 1994; Kral et al., 2012), is usually measured by examining intake at a meal when various aspects of that meal have been manipulated. A commonly used approach with children is to examine the effects of a preload on subsequent intake at a meal (e.g., Johnson & Birch, 1994). Satiety, the other type of eating self-regulation, is usually measured in children by assessing eating in the absence of hunger (Fisher & Birch, 1999). Because eating in the absence of hunger reflects low levels of satiety, it is positively associated with child weight status (Butte et al., 2007; Fisher & Birch, 1999, 2002; Francis & Birch, 2005; Hill et al., 2008; Moens & Braet, 2007; Shoemaker et al., 2010).

Wardle and colleagues (2001) developed a parent-report questionnaire, the Children's Eating Behavior Questionnaire (CEBQ), which assesses constructs related to satiation and satiety. Two of their scales, Food Responsiveness (referring to how responsive the child is to food and eating) and Satiety Responsiveness (referring to child responsiveness to feelings of fullness), were used in the present study. Both subscales are significantly associated with weight status in young children, with food responsiveness showing a positive relationship and satiety responsiveness a negative one (Carnell & Wardle, 2008; Sleddens, Kremers, &

Thijs, 2008; Viana, Sinde, & Saxton, 2008; Webber, Hill, Saxton, Van Jaarsveld, & Wardle, 2009).

Besides eating self-regulation, executive functioning has been associated with childhood obesity as well (see Laing et al., 2014 for a recent review). Executive functioning reflects a number of cognitive functions that are processed by the prefrontal cortex and required for such activities as carrying out plans, obeying social rules, and adapting to changing environmental circumstances (Grafman & Litvan, 1999). Core executive functions for preschool children are inhibitory control, cognitive flexibility, and working memory (Diamond, Barnett, Thomas, & Munro, 2007). Studies examining the different components of executive functioning show that differences in child weight status are usually only significant for response inhibition and cognitive flexibility, with few or inconsistent differences in intelligence, reasoning, working memory, and verbal fluency (Cserjesi, Molnar, Luminet, & Lenard, 2007; Laing et al., 2014; Verdejo-Garcia et al., 2010). Across studies, overweight and/or obese children tend to show lower levels of response inhibition and cognitive flexibility than healthy weight children.

Emotion regulation is also related to child weight status. Longitudinal studies show that delay of gratification—the ability to resist temptation for an immediate reward and wait for a later reward (Botano & Boland, 1983; Bruce et al., 2012)--is protective for the development of childhood obesity. Two separate analyses of data from the NICHD Study of Early Child Care and Youth Development found that delay of gratification in the preschool years was associated with lower child body mass index (BMI) at ages 11 (Seeyave et al., 2009) and 12 (Francis and Susman, 2009). In a separate study, Schlam, Wilson, Shoda, Mischel,and Ayduk (2013) found that children who exhibited greater delay of gratification in a laboratory at age four had lower BMIs thirty years later. Two additional studies showed that delay of gratification assessed in middle childhood negatively predicted BMI at age 13 (Duckworth, Tsukayama, & Geier, 2010; Evans, Fuller-Rowell, & Doan, 2012). Finally, Graziano and colleagues (2010, 2013), found that self-regulation assessed at age two (a combined measure of emotional regulation, delay of gratification, and sustained attention) negatively predicted child BMI at ages five and ten.

The satiety cascade (Blundell, 1991) helps describe the processes that trigger initial ingestion, terminate intake (satiation), and prevent subsequent intake after termination (satiety). The regulation of eating is a function of both homeostatic and hedonic factors (Harrold, Dovey, Blundell, & Halford, 2012). Homeostatic control helps ensure that sufficient calories are consumed to meet the body's energy needs, and once these needs have been met, ensures that negative feedback signals help bring the period of eating to an end. Hedonic factors, in contrast, are mediated by reward. The consumption of highly palatable foods, for example, can work against homeostatic control and lead to overconsumption. Poor self-regulation of eating, therefore, can be a function of homeostatic or hedonic factors and can be a function of factors at any point in the satiety cascade. Researchers offer several explanations for the relationships between executive functioning, emotion regulation, and childhood obesity. Most argue that, as a group, obese children may be susceptible to overeating due to inhibitory control deficits, cognitive inflexibility, and/or overly active food-related reward systems. As described by Delgado-Rico, Rio-Valle, Gonzalez-Jimenez, Campoy, and Verdejo-Garcia (2012), "excessive eating and obesity are increasingly viewed as a brain-related dysfunction, whereby reward-driven urges for pleasurable foods 'hijack' context-driven frontal-executive control" (p. 1604). These interpretations are consistent with both Schachter's (1971) externality theory (i.e., that obese individuals are more responsive to environmental cues to eat) and Singh's (1973) inhibition deficit theory (i.e., that obese individuals have difficulties inhibiting responses to palatable food stimuli). Verdejo-Garcia and colleagues (2010), however, warn that the correlational nature of such data "cannot resolve if the association of BMI and executive function is due to the deleterious effects of increased weight on prefrontal blood flow and executive competence, or to the possibility that children with poor executive skills are more likely to become obese" (pp. 1576-1577).

Despite the rather large number of studies in this area, very few have examined the relationships *between* the various forms of child self-regulation across the eating and non-eating domains. If, indeed, the interpretations that are offered for the relationship between child self-regulation and obesity are correct, one would expect moderate to strong positive intercorrelations between measures of self-regulation within and across these two domains. Previous research shows that for the non-eating domain, within-domain correlations are usually small to moderate with correlations between measures of executive functioning generally ranging between $r = 0.20$ and $r = 0.35$ (Bull & Scerif, 2001; Lehto, Juujarvi, Kooistra, & Pulkkinen, 2003; Wiebe, Espy, & Charak, 2008). Executive functioning and effortful control show similar correlations with measures of emotion regulation (see Spinrad, Eisenberg, & Gaertner, 2007 for a review). Within the eating domain, mothers' responses on the satiety responsiveness and food responsiveness subscales of the Children's Eating Behavior Questionnaire (CEBQ) are negatively correlated with one another (e.g., Frankel et al., 2014; Sleddens et al., 2008; Wardle et al., 2001). Fewer have examined inter-correlations of child eating self-regulation as measured by observed tasks and parent-reports of this construct. Carnell and Wardle (2007) examined the relationship between mothers' responses on the CEBQ and two laboratory assessments: caloric compensation trials (Johnson & Birch, 1994) and eating in the absence of hunger (Fisher & Birch, 1999) in a sample of 4- to 5-year-old children. The results showed no significant correlation between eating in the absence of hunger and child eating self-regulation as measured in the compensation trials. When they examined the relationship between mothers' responses on the CEBQ (food responsiveness and satiety responsiveness) and the laboratory measures of child eating self-regulation, only one relationship out of six was significant. Children whose mothers rated them high in satiety responsiveness were less likely to eat in the absence of hunger and exhibited greater compensation of caloric intake during a standard meal ($p < 0.07$).

Finally, very few studies have examined the relationships between measures of self-regulation across domains. In a study of adolescents, Maayan, Hoogendoorn, Sweat, and Convit (2011) found that self-reported disinhibition in eating (i.e., the tendency to eat in response to emotional factors and sensory cues) was negatively associated with performance on an executive function task. In a smaller study of 3- to 6-year-olds ($n = 37$), Pieper and Laugero (2013) found no significant relationships between eating in the absence of hunger and performance on several executive functioning tasks, including a delay of gratification task, and a questionnaire measure of effortful control—a child temperament measure related to executive functioning assessing child self-regulation across situations (Putnam & Rothbart, 2006).

Given the increased interest in the role of self-regulation in the development of children's obesity, the purpose of the current study was to examine relationships between various aspects of child self-regulation in the eating and non-eating domains and to examine their relationships with child weight status. To our knowledge, with only one exception (Pieper & Laugero, 2013), no study to date has examined the relationship between various measures of self-regulation within and between these two domains. Due to their small sample size, the Pieper and Laugero (2013) study was likely underpowered to identify such relationships. Because we were interested in studying these relationships in a sample at high risk for the development of childhood obesity (Anderson & Whitaker, 2009), the current study involved a sample of low-income, Hispanic families with preschool children. We predicted that measures of child self-regulation within the eating and non-eating domains would show moderate correlations with the other measures in the same domain, and that self-regulation in the non-eating domain (i.e., executive functioning, effortful control, and emotion regulation) would be positively be associated with children's eating self-regulation. Finally, we predicted that any relationships between child self-regulation in the non-eating domain and child BMI would be mediated by child eating self-regulation.

Methods

Participants

A total of 187 Hispanic parent-child dyads participated in this study. Parents were recruited through Head Start centers in a large urban city in southeastern United States. Multiple methods were used to recruit parents including presentations at monthly parent meetings, flyers placed in Head Start registration packets, and flyers sent home with the children. The parent primarily responsible for feeding the Head Start child when the child was not at school was targeted along with their Head Start preschooler. Consent forms were offered in English and Spanish, explained to parents in their language of choice, and signed prior to participating in the study. Seventy-seven percent of the parents consented in Spanish. All parents recruited for this study were mothers except for two grandmothers (herein referred to as mothers). Mothers received $90 for participating in the two day study ($25 for day one; $65 for day two). The study was reviewed and approved by the Institutional Review Board at Baylor College of Medicine. Parents were aware and provided consent that all observations were audio/videotaped for later review and coding. Characteristics of the sample are presented in Table 1.

Procedures

The recruited mother and her child came into the study laboratory on two separate days. On day one, mothers and their child participated in tasks not relevant to the questions considered here. On day two, the child participated in the delay of gratification task, the two executive functioning tasks, a standard meal, the eating in the absence of hunger task, and the gift delay task. Questionnaires were completed by the mother on day two while the child was involved in the tasks. Height and weight measures were taken on the child. All observational tasks were conducted in either English or Spanish, depending on the child's preference and audio/videotaped using unobtrusive cameras placed in the testing rooms. Seventy-seven percent of the tasks were conducted in Spanish. During all tasks, staff members viewed the child through cameras; staff members were located in a room adjacent to the testing room. The observational tasks are described below; more detailed descriptions can be obtained from the first author.

Measures

In this study, two domains of child self-regulation were measured—eating self-regulation and non-eating self-regulation. Both domains were measured through multiple methods. Child eating self-regulation was measured through the following assessments: eating in the absence of hunger (observed) and satiety responsiveness and food responsiveness (both mother-report). Child non-eating self-regulation was measured through the following assessments: executive functioning including the tapping task and the Flexible Item Selection Task (both observed), effortful control—a temperament dimension related to executive functioning (mother-report), and the delay of gratification[1] and gift delay tasks assessing emotion regulation (both observed) Details are presented in Table 2.

Eating Self-regulation (observed and parent-report)

Eating in the Absence of Hunger Task (observed)—This task was developed by Fisher and Birch (1999) to measure child eating beyond satiation. Higher scores have been associated with higher child weight status, with studies typically reporting medium effect sizes (e.g., r's around .30) (see French et al., 2012 for a review). Prior to the task, the child was provided with a complete meal accounting for 40% of the daily food requirements for a four to five year old. A subjective measure of hunger was used to determine fullness after the meal. Sweet and savory snacks (i.e., potato chips, Skittles, pretzels, sherbet, ice-cream, Hershey bars and chocolate chip cookies) were then offered to the child along with age appropriate toys. The child was left by him/herself in the testing room with the food and toys for ten minutes. Scores on this task reflected the total number of kilocalories eaten in the absence of hunger for each child. Final scores across the children were highly positively skewed; therefore, data were recoded into three values: 1 = less than 20 kilocalories ($n = 37$); 2 = 20 to 125 kilocalories ($n = 74$); 3 = greater than 125 kilocalories ($n = 75$). High values reflected lower levels of child eating self-regulation. The first group was defined as children who ate no food or ate a very minimal amount (the distribution had a natural break at 20 kilocalories); the second and third groups were defined by a median split of the remaining children.

[1]Because the delay of gratification tasks involved food, it could be considered a measure of food-related self-regulation. However, we chose to include it as a measure of non-eating self-regulation, because unlike the other measures of eating self-regulation, it was not a direct measure of satiety or satiation (i.e., it was food-related, but not eating-related). Instead, it measured the child's ability to wait for a larger portion of desirable food rather than take a smaller portion that was immediately available. As pointed out by Francis and Susman (2009), because "no steps (were) taken to standardize children's hunger level before the delay of gratification procedure…the extent to which hunger played a role in children's decision to choose an immediate reward is unclear" (p. 301). This measure is typically described as a measure of emotion regulation or "hot" executive functioning because it is thought to be associated with brain activity in areas related to the processing of emotion (e.g., Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009; Hongwanishkul, Happaney, Lee, & Zelazo, 2005).

Children's Eating Behavior Questionnaire (CEBQ; parent-report)—Two subscales of the CEBQ were used to measure child eating self-regulation (Wardle et al., 2001). Satiety responsiveness referred to child responsiveness to feelings of fullness (e.g., "My child gets full up easily," "My child leaves food on his/her plate at the end of a meal," "My child gets full before his/her meal is finished") and the child's appetite (e.g., "My child has a big appetite"). Food responsiveness referred to how responsive the child was to food and eating (e.g., "My child's always asking for food," "If given a chance, my child would always have food in his/her mouth," "Given the choice, my child would eat most of the time") (Wardle et al., 2001).

Lower levels of satiety responsiveness and higher levels of food responsiveness have been associated with child weight, with r's typically between 0.20 and 0.25 (Carnell & Wardle, 2008; Sleddens et al., 2008; Viana et al., 2008; Webber et al., 2009). Responses were scored on a 1 to 5 scale (never to always). The factor structure, test-retest reliability, and internal consistency were established in a sample of predominately white families in the United Kingdom (Wardle et al., 2001). These subscales have been used successfully in a low-income sample of African-American and Hispanic mothers of preschoolers (Frankel et al., 2014). Coefficient alphas were adequate in the current sample (0.68 for satiety responsiveness; 0.79 for food responsiveness). Higher scores on satiety responsiveness reflected higher child eating self-regulation; higher scores on food responsiveness reflected lower child eating self-regulation.

Non-eating Self-regulation (observed and parent-report)

Tapping task (observed)—The tapping task measured one type of executive functioning in children— response inhibition. The task was created by Luria (1966) and modified by Diamond and Taylor (1996) to measure a child's ability to hold two pieces of information in their mind and exercise inhibitory control over behavior at the same time. Lower scores on response inhibition have been associated with higher child weight status, with studies typically reporting medium effect sizes (e.g., r's around .25) (Batterink, Yokum, & Stice, 2010; Nederkoorn, Coelho, Guerrieri, Houben, & Jansen, 2012; Pauli-Pott, Albayrak, Hebebrand, & Pott, 2010; Verdejo-Garcia et al., 2010). Material included a wooden block and dowel small enough for a preschooler to handle. The child was told "when I tap once, you tap twice" and then "when I tap twice, you tap once". The task was terminated if the child was unable to perform the tasks during demonstration trials. The total number of correct trials (out of 16) was determined by two independent coders based on audio/videotaped recordings; inter-coder reliability was assessed (Kappa = 0.98). Scores reflected the percentage of correct responses divided by the total number of trial opportunities (not including pretrial tests). Higher scores reflected higher levels of response inhibition (i.e., higher child self-regulation). Children for whom the task was terminated were assigned a score of zero ($n = 67$). When the analyses were run not including these children, results did not differ.

Flexible Item Selection Task (FIST; observed)—The FIST measured a different type of child executive functioning—cognitive flexibility (Jacques & Zelazo, 2001). Lower scores on cognitive flexibility have been associated with higher child weight status, with studies typically reporting medium effect sizes (e.g., r's around 0.30) (Cserjesi et al., 2007; Delgado-Rico et al., 2012; Verbeken, Braet, Claus, Nederkoorn, & Oosterlaan, 2009; Verdejo-Garcia et al., 2010). In this task, children selected items according to one dimension and were asked to immediately switch and select items according to a different dimension (Jacques & Zeazo, 2001). Twenty-five cards were used each depicting a set of items derived from the combination of three dimensions (color, shape, and size). Pretrial testing involved the child picking two favorite pictures, and then two pictures that were alike in "one way" and two that were alike in "another way." The number of correct trials (out of 15) were determined by two independent coders based on audio/videotaped recordings; inter-coder reliability was assessed (Kappa = 0.98). Scores reflected the percentage of correct responses divided by the total number of trial opportunities (not including pretrial tests). Higher scores reflected higher levels of cognitive flexibility (i.e., higher child self-regulation). The Flexible Item Selection Task correlates positively with the tapping task supporting convergent validity of these two measures (Blair & Peters Razza, 2007).

Delay of Gratification Task (observed)—The delay of gratification task was developed by Mischel and Ebbesen (1970) to measure a child's ability to resist temptation for an immediate, smaller reward and wait for a later, larger reward. Higher scores have been associated with lower child weight status, with studies typically reporting small effect sizes (e.g., r's around .20) (Evans et al., 2012; Francis & Susman, 2009; Schlam et al., 2013; Seeyave et al., 2009). Prior to the task, preference for one of three foods was determined (M&Ms, animal crackers, or pretzels). A large and small pile of the preferred food was placed on the table in the testing room. The child was instructed that if he/she could wait until the staff member returned (total of seven minutes), he/she could have the larger of the two piles; if the child could not wait, he/she must ring a bell and receive the smaller pile of food. Scores reflected the amount of time the child waited before ringing the bell or eating the food. Distribution of scores was bimodal (reflecting a very short wait time versus waiting the entire time); therefore, data were recoded into three wait values: 1 = less than a minute (n = 85); 2 = between one and seven minutes (n = 28); and 3 = waited the entire time (n = 67). High scores represented higher levels of self-regulation. One minute was chosen as the cutoff because this corresponded to a natural break in the distribution and reflected children who did not wait very long.

Gift Delay Task (observed)—The gift delay task was used as a measure of child self-regulation of positive affect (i.e., excitement and anticipation). Carlson and Wang (2007) developed this task, adapting it from Kochanska, Murray, & Harlan (2000). Scores have been associated with other measures of child inhibitory control and emotional regulation (with r's around 0.35) (Carlson and Wang, 2007). In this task, the child was told that he/she would receive a gift but it needed to be wrapped by a staff member. The child was seated facing away from the table where the wrapping was conducted and told not to peek during the wrapping. The staff member noisily wrapped the gift for two minutes in a standardized manner (e.g., rifling through the bag for the gift; stuffing the bag with tissue paper). The number of peeks was determined by two independent coders based on audio/videotaped recordings; inter-coder reliability was assessed (Kappa = 0.79). Scores reflected the number of times the child peeked during the two minute session. Scores had a high positive skew;

therefore, data were recoded into three values: 1 = zero peeks (n = 92); 2 = one to three peeks (n = 48); and 3 = greater than three peeks (n = 46). The second and third groups were assigned based on a median split of the children who peeked. High scores reflected poor inhibitory control (i.e., low child self-regulation).

Children's Behavior Questionnaire (CBQ; parent-report)—Effortful control—a child temperament measure assessing inhibitory control across situations—was assessed by the Children's Behavior Questionnaire (Putnam & Rothbart, 2006). Child temperament was defined as constitutionally based individual differences in reactivity and self-regulation, influenced over time by heredity and experience (Rothbart & Derryberry, 1981). Evidence of internal consistency, convergent validity, and invariance across age groups and cultures (including low-income samples) has been demonstrated (Rothbart, Ahadi, Hershey, & Fisher, 2001; Putnam & Rothbart, 2006). Parents were asked to consider their child's reaction in the past six months to a set of situations (e.g., 'prefers quiet activities to active games'; 'when drawing or coloring in a book, shows strong concentration'). Extraversion, Negative Affectivity, and Effortful Control are assessed in the very short form (Putnam & Rothbart, 2006). To reduce participant burden, we assessed only Effortful Control. Scores were derived by calculating the mean of 12 items scored on a 7-point response scale ('extremely untrue' to 'extremely true'). Coefficient alpha with one item removed (i.e., 'approaches places he/she has been told are dangerous slowly and cautiously') was adequate in this sample (0.74). Higher scores reflected greater effortful control (i.e., high non-eating related child self-regulation).

Child Body Mass Index

Anthropometrics—Child height and weight measurements were taken by trained staff following procedures described by Lohman, Roche, and Martorell (1988). Children were dressed in light clothing and asked to remove their shoes. Height and weight were measured in duplicate to assure accuracy; the two scores were averaged. Scores were converted to age- and gender- specific BMI z-scores using the revised 2000 growth charts from the Centers for Disease Control and Prevention (Kuczmarski, Ogden, & Guo, 2002).

Statistical Analyses

All statistics were run using the Statistical Package for the Social Sciences (SPSS, Version 20.0, Chicago, IL). Statistical significance was set at p-value <0.05. Descriptives were run on all variables and examined to determine distributions. Because of non-normal distributions in the eating in the absence of hunger, the delay of gratification, and the gift delay tasks, these variables were recoded into three levels as described above. Because the tapping task and the FIST were significantly correlated (r = 0.37), they were standardized and summed to reflect a total executive functioning score for each child.[2]

Bivariate correlations were run on variables in the study. Four sets of hierarchical linear regression analyses were run: the first three predicted child eating self-regulation from

[2]When we ran the analyses with these two measures of executive functioning separately, the results were unchanged. Therefore, to keep the number of variables to a minimum, we used this combined score in all analyses.

demographic variables and non-eating related self-regulation measures; the fourth predicted child BMI z-scores from child non-eating and eating related self-regulation. Dependent variables in the first three sets of linear regressions included: a) eating in the absence of hunger; b) satiety responsiveness; and c) food responsiveness. Independent variables included child sex and child age in months as control variables (Block 1) and delay of gratification, effortful control, executive functioning, and gift delay as non-eating related self-regulation measures (Block 2). The significance of interactions with child sex were examined as well. The dependent variable in the fourth regression was child BMI z-score. Independent variables included child sex and age as control variables (Block 1), delay of gratification, effortful control, executive functioning, and gift delay as non-eating related self-regulation measures (Block 2), and eating in the absence of hunger, satiety responsiveness, and food responsiveness as child eating self-regulation measures (Block 3). Once again, interactions with child sex were examined. Because none of the interactions were significant, these analyses are not presented below. Finally, because non-eating related child self-regulation was not related to child BMI z-scores, it was not possible to examine the degree to which child eating self-regulation mediated the relationships between non-eating related self-regulation and child BMI z-scores.

Results

Bivariate Correlations

Only the three child eating self-regulation variables (i.e., eating in the absence of hunger, satiety responsiveness, and food responsiveness) were significantly correlated with child BMI z-scores, all in the expected direction (Table 3). None of the non-eating self-regulation variables were correlated with child BMI z-scores. As expected, satiety responsiveness was negatively correlated with food responsiveness. Also as expected, two positive correlations between the non-eating self-regulation variables were significant: a) executive functioning with effortful control and b) executive functioning with delay of gratification. Three significant correlations were found between eating and non-eating self-regulation: a) satiety responsiveness with peeking in the gift delay task; b) food responsiveness with peeking in the gift delay task; and c) eating in the absence of hunger with delay of gratification. Correlations with the gift delay task were in the expected direction; the positive correlation between eating in the absence of hunger and delay of gratification was the opposite of what was expected (i.e., eating self-regulation was negatively associated with non-eating self-regulation).

Associations of child eating self-regulation with non-eating child self-regulation

Eating in the absence of hunger—A hierarchical linear regression with eating in the absence of hunger as the dependent variable and non-eating self-regulation as independent variables in Block 2 (executive functioning, effortful control, delay of gratification, and peeking in the gift delay), while accounting for demographic variables in Block 1 (child sex and age in months), showed that the non-eating self-regulation predictors did not increase prediction of eating in the absence of hunger beyond child age and sex (Table 5). Boys ate more in the absence of hunger than girls, and older children ate more in the absence of hunger than younger children.

Satiety responsiveness—A hierarchical linear regression with satiety responsiveness as the dependent variable and the same predictors as above showed that the addition of non-eating self-regulation variables led to a significant increase in the prediction of satiety responsiveness beyond the demographic variables (Table 6). This was due to the gift delay task (standardized beta −0.215, $p < 0.01$). The negative beta showed that high levels of child eating self-regulation (satiety responsiveness) were associated with high levels of emotion regulation (less peeking during the gift task).

Food Responsiveness—The hierarchical linear regression with food responsiveness as the dependent variable yielded a significant effect of child sex in Block 1 (boys showed more food responsiveness) but the R^2 change was not significant when adding non-eating self-regulation predictors. However, the second equation was significant and the beta for the gift delay task was significant (standardized beta 0.155, $p < 0.05$). The positive beta showed that low levels of child eating self-regulation (food responsiveness) were associated with low levels of emotion regulation (more peeking during the gift task). Details are presented in Table 7.

Associations of child eating self-regulation and non-eating self-regulation with child BMI z-scores

A hierarchical linear regression was run with child BMI z-score as the dependent variable. Child sex and age were entered in Block 1, the non-eating self-regulation variables (executive functioning, effortful control, delay of gratification, and gift delay) were entered in Block 2, and child eating self-regulation variables (eating in the absence of hunger, satiety responsiveness, and food responsiveness) in Block 3. Details are presented in Table 8. As seen in the table, the non-eating self-regulation variables as a block did not account for any of the variance in child BMI z-scores. When child eating self-regulation variables were entered in Block 3, they significantly increased the variance accounted for in the model. Betas for two child eating self-regulation variables were significant: eating in the absence of hunger (standardized beta 0.238, $p < 0.01$) and satiety responsiveness (standardized beta −0.202, $p < 0.01$). Because the non-eating self-regulation variables did not explain any variance in child BMI z-scores, mediational analyses could not be conducted. Means and standard deviations for all independent and dependent variables are presented in Table 4.

Discussion

The purpose of this study was to examine relationships between various aspects of child eating and non-eating self-regulation in a low-income Hispanic sample of preschoolers and to examine the relationships between these types of self-regulation and child BMIz. We included both observational measures of eating and non-eating self-regulation in our study as well as parent-report measures of the two domains. We expected that measures within each domain would correlate with one another and that measures of child eating self-regulation would be positively associated with non-eating self-regulation. Unexpectedly, we found few relationships across and within the two domains of child self-regulation. Within the child eating self-regulation measures, only the two parent-report measures of satiety responsiveness and food responsiveness were related; this negative relationship has been found in previous studies (Frankel et al., 2014; Sleddens et al., 2008; Wardle et al., 2001). Unlike findings by Carnell and Wardle (2007), in our sample of Hispanic preschool children, we found no relationship between child eating in the absence of hunger and mother's reports of child satiety responsiveness. This is not that surprising given that this was the only significant correlation between observed and parent-report measures of child eating self-regulation in the Carnell and Wardle (2007) study. Because Carnell and Wardle (2007) also found that observed eating in the absence of hunger was not significantly associated with children's compensation of caloric intake, it may be that these measures of child eating self-regulation assess different aspects of child regulatory eating behaviors—i.e., food approach behaviors and inhibitory responses to food may be relatively independent aspects of child eating self-regulation. On the other hand, it may be that there is little convergence across the two methodologies—parents' perceptions of their child's eating behavior may be different from observed child behavior.

Within the non-eating self-regulation measures, the relationships we found between executive functioning, effortful control, and delay of gratification were typical of what has been found in previous studies—i.e., low to moderate positive correlations between measures (Bull & Scerif, 2001; Lehto et al, 2003; Spinrad et al., 2007; Wiebe et al., 2008). Of the three measures of non-eating self-regulation used in this study, only the gift delay task did not show associations with the other measures.

Only three out of twelve relationships across the two domains of child self-regulation were significant—child eating in the absence of hunger with child delay of gratification and parent-reports of satiety and food responsiveness with child peeking on the gift delay task. Although the relationships found across the two domains of child self-regulation were small, the associations between the two CEBQ measures of child eating slef-regulation and responses to the gift delay task (a measure of child self-regulation of positive emotion) are consistent with Delgado and colleagues (2012) argument that in obese individuals, an overly active reward system can 'hijack' frontal control thereby interfering with behavioral inhibition. This inability to self-regulate in a non-food situation involving a very positive environmental stimulus (the gift) might predict how these children respond to food rewards as well.

Child responses in the eating in the absence of hunger and delay of gratification tasks were related in the opposite direction than was expected. Children who were able to delay gratification were expected to eat less when they were full; however, the opposite association was observed. One possibility is that children who had a greater interest in snack foods were more motivated to wait longer in order to consume them. Although this is inconsistent with the reward explanation offered above (that an overly active reward system hijacks frontal control—Delgado et al., 2012), the delay of gratification task involved controlling negative, not positive emotions, so different cognitive skills may have come into play. The only other study that examined eating in the absence of hunger and delay of gratification in this age range (Pieper & Laugero, 2013) showed no association between the two; however, the sample of 37 was not sufficient to identify the small effect size found here. More studies are needed to replicate these findings and to better understand the relationship between these constructs in young children.

Finally, consistent with previous studies linking eating behaviors in children with child weight (see French et al., 2012 for a review), in our current study with low-income Hispanic children, child eating self-regulation was moderately associated with child BMI z-scores. Unexpectedly, different from previous studies linking non-eating self-regulation and child weight (e.g., Botano & Boland, 1983; Bruce et al., 2012; Graziano et al., 2012; Maayan et al., 2011; Schwartz et al., 2013), none of our measures of executive functioning or emotional regulation (executive functioning, effortful control, delay of gratification, or gift delay) were related to child BMIz. However, most previous studies linking executive functioning with child weight status tended to have samples of older children and adolescents[3]. Although some studies have predicted later child weight status from delay of gratification in the preschool years (e.g., Francis and Susman, 2009; Schlam et al., 2013; Seeyave et al., 2009), none of these studies reported a significant association between delay of gratification and weight status concurrently (Francis and Susman, 2009, examined this relationship at age five, but it was not significant). Pieper and Laugero (2013) looked at such relationships concurrently, but found no significant associations with child weight. Francis and Susman (2009), however, found that combining performance on the delay of gratification task at age five with performance on a different self-control task at age three (a waiting task not involving food) predicted BMI percentiles at age five. One possible explanation for our findings is that when children are younger, their parents make most of the food decisions for them, so non-eating self-regulation skills may not be as important in explaining childhood obesity. So despite the fact that almost half of the children in this sample were overweight or obese, their weight status may have been more a function of the home food and physical activity environment. However, as children grow older and have more autonomy, they are able to make their own food choices. This is when other child self-regulation factors may come into play impacting food choices, eating, and weight status.

Limitations of this study include the cross-sectional nature of the design, the lack of multiple ethnicities, and the fact that questionnaire data were reported by a single reporter—mothers. Due to these limitations, we were unable to examine how child eating and non-eating self-regulation changes over time or to examine the bi-directional nature of these constructs with child BMIz. Also, a combination of parent-report measures from multiple reporters across multiple ethnicities would strengthen these results.

Conclusions

Despite these limitations, this is the first study, to our knowledge, that examines, in a sufficiently large sample, both child eating and non-eating self-regulation as correlates of preschooler's BMIz. Strengths include the relatively large, homogeneous, high-risk sample, and the use of multiple, well-validated measures (both observational and parent-report) of various types of child self-regulation. The results suggest that child self-regulation in these various domains may develop rather independently, so future research needs to further

[3]The lack of significant associations does not appear to be due to a lack of power. Examination of the sample sizes in Laing et al's. (2014) review of the neurocognitive correlates of child and adolescent obesity show that 22 of the 25 studies revealing significant associations between cognitive or emotional self-regulation (executive functioning, delay of gratification, inhibition, and/or impulsivity) and child weight status had sample sizes smaller than the current study (most had sample sizes between 24 and 81 participants).

examine which specific competencies and skills they entail and how each may contribute to the development of childhood obesity. The results also suggest that interventions focusing on child eating self-regulation may be more successful in preventing childhood obesity than interventions focusing on non-eating self-regulation. Such a conclusion, however, must be tempered by the cross-sectional nature of this study. Because non-eating self-regulation is concurrently related to weight status in studies of older children (Laing et al., 2014), and because longitudinal studies show that non-eating self-regulation in infancy and the preschool years predicts the development of later obesity (Francis and Susman, 2009; Graziano et al., 2010, 2013; Schlam et al., 2013; Seeyave et al., 2009), it is likely that the early years are an important period in development of the non-eating self-regulation skills that may help prevent future obesity. By better understanding the complex relationships between child self-regulation across domains, eating behavior, and weight status, we can better know how to help families to create appropriate eating environments that may potentially reduce the rates of overweight and obesity in children.

Acknowledgements

This research was supported by funds from the National Institute of Child Health and Human Development (Grant R01 HD062567). This work is also a publication of the US Department of Agriculture (USDA/ARS) Children's Nutrition Research Center, Department of Pediatrics, Baylor College of Medicine (Houston, TX) funded in part by the USDA/ARS (Cooperative Agreement 6250-51000). The contents of this publication do not necessarily reflect the views or policies of the USDA, nor does mention of trade names, commercial products, or organizations imply endorsement from the US government. We would like to acknowledge the following people who were instrumental in collecting and coding the data for this study: Nilda Micheli, Monica Lopez, Ashley Beck, Veronica Bonilla-Pacheco, Rachael Hill, Yadi Olivera, Kayla Weinmann, and Noemi Aguilar.

References

Anderson SE, Whitaker RC. Prevalence of obesity among US preschool children in different racial and ethnic groups. Archives of Pediatric and Adolescent Medicine. 2009; 163:344–348.

Batterink L, Yokum S, Stice E. Body mass correlates inversely with inhibitory control in response to food among adolescent girls: An fMRI study. Neuroimage. 2010; 52:1696–1703. [PubMed: 20510377]

Baumeister, R.; Vohs, K. Handbook of self-regulation: Research, theory and applications. 1st ed.. The Guilford Press; New York, NY: 2004.

Bellisle F, Drewnowski A, Anderson GA, Westerterp-Plantenga MA, Martins CK. Sweetness, satiation, and satiety. Journal of Nutrition. 2012; 142:1149S–1154S. [PubMed: 22573779]

Blair C, Peters Razza R. Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. Child Development. 2007; 78:647–663. [PubMed: 17381795]

Blundell JE. Pharmacological approaches to appetite suppression. Trends in Pharmacological Sciences. 1991; 12:147–157. [PubMed: 2063481]

Botano DP, Boland FJ. Delay of gratification in obese children. Addictive Behaviors. 1983; 8:71–74. [PubMed: 6880927]

Brock LL, Rimm-Kaufman SE, Nathanson L, Grimm KJ. The contributions of 'hot' and 'cool' executive function to children's academic achievement, learning-related behaviors, and engagement in kindergarten. Early Childhood Research Quarterly. 2009; 24:337–349.

Bruce AS, Black WR, Bruce JM, Daldalian M, Martin LE, Davis AM. Ability to delay gratification and BMI in preadolescence. Obesity. 2012; 19:1101–1102. [PubMed: 21151018]

Bull R, Scerif G. Executive functioning as a predictor of children's mathematics ability: Inhibition, switching, and working memory. Developmental Neuropsychology. 2001; 19:273–293. [PubMed: 11758669]

Butte NF, Cai G, Cole SA, Wilson TA, Fisher JO, Zakeri IF, Ellis KJ, Comuzzie AG. Metabolic and behavioral predictors of weight gain in Hispanic children: The Viva la Familia Study. American Journal of Clinical Nutrition. 2007; 85:1478–1485. [PubMed: 17556682]

Carlson SM, Wang TF. Inhibitory control and emotion regulation in preschool children. Cognitive Development. 2007; 22:489–510.

Carnell S, Wardle J. Measuring behavioural susceptibility to obesity: validation of the child eating behaviour questionnaire. Appetite. 2007; 48:104–113. [PubMed: 16962207]

Carnell S, Wardle J. Appetite and adiposity in children: Evidence for a behavioral susceptibility theory of obesity. American Journal of Clinical Nutrition. 2008; 88:22–29. [PubMed: 18614720]

Cserjesi R, Molnar D, Luminet O, Lenard L. Is there any relationship between obesity and mental flexibility in children? Appetite. 2007; 49:675–678. [PubMed: 17543417]

Delgado-Rico E, Río-Valle JS, Gonzalez-Jimenez E, Campoy C, Verdejo-Garcia A. BMI predicts emotion-driven impulsivity and cognitive inflexibility in adolescents with excess weight. Obesity. 2012; 20:1604–1610. [PubMed: 22421897]

Diamond A, Barnett WS, Thomas J, Munro S. Preschool program improves cognitive control. Science. 2007; 30:1387–1388. [PubMed: 18048670]

Diamond A, Taylor C. Development of an aspect of executive control: Development of the abilities to remember what I said and to 'do as I say, not as I do.'. Developmental Psychobiology. 1996; 29:315–334. [PubMed: 8732806]

Duckworth AL, Tsukayama E, Geier AB. Self-controlled children stay leaner in the transition to adolescence. Appetite. 2010; 54:304–308. [PubMed: 20004223]

Evans GW, Fuller-Rowell TE, Doan SN. Childhood cumulative risk and obesity: The mediating role of self-regulatory ability. Pediatrics. 2012; 129:e68. [PubMed: 22144695]

Faith MS, Pietrobelli A, Heo M, Johnson SL, Keller KL, Heymsfield SB, Allison DB. A twin study of self- regulatory eating in early childhood: Estimates of genetic and environmental influence, and measurement considerations. International Journal of Obesity. 2012; 36:931–937. [PubMed: 22249227]

Fisher JO, Birch LL. Restricting access to foods and children's eating. Appetite. 1999; 32:405–419. [PubMed: 10336797]

Fisher JO, Birch LL. Eating in the absence of hunger and overweight in girls from 5 to 7 y of age. American Journal of Clinical Nutrition. 2002; 76:226–231. [PubMed: 12081839]

Francis LA, Birch LL. Maternal weight status modulates the effects of restriction on daughters' eating and weight. International Journal of Obesity. 2005; 29:942–949. [PubMed: 15782227]

Francis LA, Susman EJ. Self-regulation and rapid weight gain in children from age 3 to 12 years. Archives of Pediatrics and Adolescent Medicine. 2009; 163:297–302. [PubMed: 19349557]

Frankel LA, Hughes SO, O'Connor TM, Power TG, Fisher JO, Hazen NL. Parental influences on children's self-regulation of energy intake: Insights from developmental literature on emotion regulation. Journal of Obesity. 2012 Article ID 327259, 12 pages.

Frankel LA, O'Connor TM, Chen T, Nicklas T, Power TG, Hughes SO. Parents' perceptions of preschool children's ability to regulate eating: Feeding style differences. Appetite. 2014; 76:166–174. [PubMed: 24533968]

French SA, Epstein LH, Jeffery RW, Blundell JE, Wardle J. Eating behavior dimensions: Associations with energy intake and body weight. A review. Appetite. 2012; 59:541–549. [PubMed: 22796186]

Grafman J, Litvan I. Importance of deficits in executive functions. The Lancet. 1999; 354:1921–1923.

Graziano PA, Bagner PM, Waxmonsky JG, Reid A, McNamara JP, Geffken GR. Co-occurring weight problems among children with attention deficit/hyperactivity disorder: The role of executive functioning. International Journal of Obesity. 2012; 36:567–572. [PubMed: 22158266]

Graziano PA, Calkins SD, Keane SP. Toddler self-regulation skills predict risk for pediatric obesity. International Journal of Obesity. 2010; 34:633–641. [PubMed: 20065961]

Graziano PA, Kelleher R, Calkins SD, Keane SP, Brien MO. Predicting weight outcomes in preadolescence: The role of toddlers' self-regulation skills and the temperament dimension of pleasure. International Journal of Obesity. 2013; 37:937–942. [PubMed: 23044856]

Harrold JA, Dovey TM, Blundell JE, Halford JCG. CNS regulation of appetite. Neuropharmacology. 2012; 63:3–17. [PubMed: 22313528]

Hill C, Llewellyn CH, Saxton J, Webber L, Semmler C, Carnell S, Van Jaarsveld CHM, Boniface D, Wardle J. Adiposity and ‘eating in the absence of hunger’ in children. International Journal of Obesity. 2008; 32:1499–1505. [PubMed: 18645573]

Hongwanishkul D, Happaney KR, Lee WSC, Zelazo PD. Assessment of hot and cool executive function in young children: Age-related changes and individual differences. Developmental Neuropsychology. 2005; 28:617–644. [PubMed: 16144430]

Jacques S, Zelazo PD. The flexible item selection task (FIST): A measure of executive function in preschoolers. Developmental Neuropsychology. 2001; 20:573–591. [PubMed: 12002094]

Johnson SL, Birch LL. Parents’ and children’s adiposity and eating style. Pediatrics. 1994; 9:653–661. [PubMed: 7936891]

Kochanska G, Murray KT, Harlan ET. Effortful control in early childhood: Continuity and change, antecedents, and implications for social development. Developmental Psychology. 2000; 36:220–232. [PubMed: 10749079]

Kral TVE, Allison DB, Birch LL, Stallings VA, Moore RH, Faith MS. Caloric compensation and eating in the absence of hunger in 5-to 12- y- old weight discordant siblings. American Journal of Clinical Nutrition. 2012; 96:574–583. [PubMed: 22854400]

Kuczmarski R, Ogden C, Guo S. CDC growth charts for the United States: Methods and development. Vital Health Statistics. 2002; 11:1–190. [PubMed: 12043359]

Laing J, Matheson BE, Kaye WH, Boutelle KN. Neurocognitive correlates of obesity and obesity-related behaviors in children and adolescents. International Journal of Obesity. 2014; 38:494–506. [PubMed: 23913029]

Lake A, Townshend T. Obesogenic environments: Exploring the built and food environments. The Journal of the Royal Society for the Promotion of Health. 2006; 126:262–267. [PubMed: 17152319]

Lehto JE, Juujarvi P, Kooistra L, Pulkkinen L. Dimensions of executive functioning: Evidence from children. British Journal of Developmental Psychology. 2003; 21:59–80.

Lohman, TG.; Roche, AF.; Martorel, M. Anthropometric standardization reference manual. Human Kinetics; Champaign, IL: 1988.

Luria, AR. Higher cortical functions in man. Basic Books; New York: 1966.

Maayan L, Hoogendoorn C, Sweat V, Convit A. Disinhibited eating in obese adolescents is associated with orbitofrontal volume reductions and executive dysfunction. Obesity. 2011; 19:1382–1387. [PubMed: 21350433]

Mischel W, Ebbesen EB. Attention in delay of gratification. Journal of Personality and Social Psychology. 1970; 16:329–337.

Moens E, Braet C. Predictors of disinhibited eating in children with and without overweight. Behaviour Research and Therapy. 2007; 45:1357–1368. [PubMed: 17101117]

Nederkoorn C, Coelho JS, Guerrieri R, Houben K, Jansen A. Specificity of the failure to inhibit responses in overweight children. Appetite. 2012; 59:409–413. [PubMed: 22664299]

Pauli-Pott U, Albayrak O, Hebebrand J, Pott W. Association between inhibitory control capacity and body weight in overweight and obese children and adolescents: Dependence on age and inhibitory control component. Child Neuropsychology. 2010; 16:592–603. [PubMed: 20552471]

Pieper JR, Laugero KD. Preschool children with lower executive function may be more vulnerable to emotional-based eating in the absence of hunger. Appetite. 2013; 62:103–109. [PubMed: 23211377]

Putnam SP, Rothbart MK. Development of short and very short forms of the Children’s Behavior Questionnaire. Journal of Personality Assessment. 2006; 81:103–113.

Rothbart MK, Ahadi SA, Hershey KL, Fisher P. Investigations of temperament at three to seven years: The Children’s Behavior Questionnaire. Child Development. 2001; 72:1394–1408. [PubMed: 11699677]

Rothbart, MK.; Derryberry, D. Development of individual differences in temperament. In: Lamb, ME.; Brown, AL., editors. Advances in developmental psychology. Vol. 1. Lawrence Erlbaum Associates, Inc.; Hillsdale, NJ: 1981. p. 37-86.

Schachter S. Some extraordinary facts about obese humans and rats. American Psychologist. 1971; 26:129–144. [PubMed: 5541215]

Schlam TR, Wilson NL, Shoda Y, Mischel W, Ayduk O. Preschoolers' delay of gratification predicts their body mass 30 years later. Journal of Pediatrics. 2013; 162:90–93. [PubMed: 22906511]

Schwartz DH, Leonard G, Perron M, Richer L, Syme C, Veillette S, Pausova Z, Paus T. Visceral fat is associated with lower executive functioning in adolescents. International Journal of Obesity. 2013; 37:1136–1343.

Seeyave DM, Coleman S, Appugliese D, Corwyn RF, Bradley RH, Davidson NS, Kaciroti N, Lumeng JC. Ability to delay gratification at age 4 years and risk of overweight at age 11 years. Archives of Pediatric and Adolescent Medicine. 2009; 163:303–308.

Shoemaker LB, Tanofsky-Kraff M, Zocca JM, Courville A, Kozlosky M, Columbo KM, Wolkoff LE, Brady SH, Crocker MK, Ali AH, Yanovski SZ, Janovski JA. Eating in the absence of hunger in adolescents: intake after a large-array meal compared with that after a standardized mea*l*. American Journal of Clinical Nutrition. 2010; 92:697–703. [PubMed: 20720255]

Singh D. Role of response habits and cognitive factors in determination of behavior of obese humans. Journal of Personality and Social Psychology. 1973; 27:220–238. [PubMed: 4723971]

Sleddens EFC, Kremers SPJ, Thijs C. The Children's Eating Behaviour Questionnaire: Factorial validity and association with Body Mass Index in Dutch children aged 6–7. International Journal of Behavioral Nutrition and Physical Activity. 2008; 5:49. [PubMed: 18937832]

Spinrad TL, Eisenberg N, Gaertner BM. Measures of effortful regulation for young children. Infant Mental Health Journa.l. 2007; 28:606–626.

Verbeken S, Braet C, Claus L, Nederkoorn C, Oosterlaan J. Childhood obesity and impulsivity: An investigation with performance-based measures. Behavior Change. 2009; 26:153–167.

Verdejo-Garcia A, Pérez-Exposito M, Schmidt-Río-Valle J, Fernandez-Serrano MJ, Cruz F, Perez-García M, Lopez-Belmonte G, Martín-Matillas M, Martin-Lagos JA, Marcos A, Campoy C. Selective alterations within executive functions in adolescents with excess weight. Obesity. 2010; 18:1572–1578. [PubMed: 20057376]

Viana V, Sinde S, Saxton JC. Children's eating behaviour questionnaire: Associations with BMI in Portuguese children. British Journal of Nutrition. 2008; 100:445–450. [PubMed: 18275626]

Wansink B. Environmental factors that increase the food intake and consumption volume of unknowing consumers. Annual Review of Nutrition. 2004; 24:455–479.

Wardle J, Guthrie CA, Sanderson S, Rapoport L. Development of the Children's Eating Behaviour Questionnaire. Journal of Child Psychology and Psychiatry. 2001; 42:963–970. [PubMed: 11693591]

Webber L, Hill C, Saxton J, Van Jaarsveld CHM, Wardle J. Eating behaviour and weight in children. International Journal of Obesity. 2009; 33:21–28. [PubMed: 19002146]

Wiebe SA, Espy KA, Charak D. Using confirmatory factor analysis to understand executive control in preschool children: I. Latent structure. Developmental Psychology. 2008; 44:575–587. [PubMed: 18331145]

Table 1

Characteristics of the Sample

	n = 187
Parent gender - female	100.0%
Child gender - female	47.6%
Child age, mean in months (SD)	57.4 (5.2)
Education of parent	
High school diploma or less	64.7%
Some college or more	35.3%
Employment status, currently employed	23.5%
Marital status	
Married	59.3%
Never Married	14.4%
Widowed, separated, divorced	26.3%
Parent Immigrant status	
Born in the U.S.	21.4%
Born in Mexico	60.4%
Born in Central America	16.6%
Born in another country	1.6%
Child BMI categories	
Normal (<85th percentile)	52.9%
Overweight (85th to <95th percentile)	20.9%
Obese (≥95th percentile)	26.2%

ADD mean and SD for child BMI

Table 2

Measures assessing child eating and non-eating self-regulation

	Eating self-regulation	**Non-eating self-regulation**
Observed	Eating in the Absence of Hunger (EAH) [1]	Tapping task (executive functioning)[3] Flexible Item Selection Task (FIST; executive functioning)[4] Delay of gratification (emotion regulation)[5] Gift delay task (emotion regulation)[6]
Parent-report	Satiety Responsiveness (CEBQ subscale)[2] Food Responsiveness (CEBQ subscale)[2]	Effortful control (CBQ subscale)[7]

[1]Fisher & Birch, 1999

[2]Wardle et al., 2001; CEBQ = Children’s Eating Behavior Questionnaire

[3]Luria, 1966; Diamond & Taylor, 1996

[4]Jacques & Selazo, 2001

[5]Mischel & Ebbesen, 1970

[6]Carlson & Wang, 2007

[7]Putnam & Rothbart, 2006; CBQ = Children’s Behavior Questionnaire

Author Manuscript

Author Manuscript

Author Manuscript

Table 3

Correlations among child eating self-regulation, non-eating related self-regulation, and child BMIz (n = 187).

	Child BMIZ	EAH	Satiety Respon-siveness	Food Respon-siveness	Executive Function Tasks	Effortful Control	Peeking in Gift Delay Task
EAH	.20**						
Satiety Respon-siveness	−.24**	.00					
Food Respon-siveness	.15*	.11	−.30**				
Executive Functioning Tasks	−.02	.12	.04	−.06			
Effortful Control	−.04	−.03	.08	−.11	.15*		
Peeking in Gift Delay Task	.01	.10	−.22**	.16*	.07	.01	
Delay of Gratification Task	−.05	.15*	.14	.05	.43**	.09	−.10

*Correlations significant at the 0.05 level (2-tailed)

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

Author Manuscript

Author Manuscript

Author Manuscript

Table 4

Means and Standard Deviations for Predictor and Outcome Variables

Variable	M (SD)
Eating in the Absence of Hunger	2.20 (0.75)
Satiety Responsiveness	2.84 (0.65)
Food Responsiveness	2.21 (0.85)
Executive Functioning Tasks	0.03 (1.62)
Effortful Control	5.89 (0.66)
Delay of Gratification Task	1.86 (0.91)
Gift Delay Task	0.75 (0.83)

Table 5

Regression analysis of demographic variables and non-eating related child self-regulation measures on child Eating in the Absence of Hunger (N = 184).

	Block 1 ***(demographic variables)***		**Block 2** ***(non-eating self-regulation measures)***	
Model Adjusted R^2	0.136		0.150	
F (Model)	F(2,181) = 14.23	***	F(6,177) = 5.21	***
F (R^2 Change)			F(4,177) = 0.74	
Independent Variables	Std Beta		Std Beta	
Child sex (1 = male; 2 = female)	**−0.141**	*	−0.132	
Child age in months	**0.348**	***	**0.336**	***
Executive Functioning Tasks			−0.031	
Effortful Control			0.006	
Delay of Gratification Task			0.080	
Peeking in Gift Delay Task			0.107	

Abbreviation: Standardized beta coefficient (Std Beta)

* Significant at $p<0.05$;

** Significant at $p<0.01$;

*** Significant at $p<0.001$

Table 6

Regression analysis of demographic variables and non-eating related child self-regulation measures on child Satiety Responsiveness (N = 183).

	Block 1 ***(demographic variables)***	**Block 2** ***(non-eating self-regulation measures)***	
Model Adjusted R^2	0.004	0.069	
F (Model)	F(2,180) = 0.40	F(6,176) = 2.17	*
F (R^2 Change)		F(4,176) = 3.05	*
Independent Variables	Std Beta	Std Beta	
Child sex (1 = male; 2 = female)	0.031	−0.017	
Child age in months	0.058	0.030	
Executive Functioning Tasks		−0.007	
Effortful Control		0.081	
Delay of Gratification Task		0.098	
Peeking in Gift Delay Task		**−0.215**	**

Abbreviation: Standardized beta coefficient (Std Beta)

+ $p < 0.10$;

* Significant at p<0.05;

** Significant at p<0.01;

*** Significant at p<0.001

Table 7

Regression analysis of demographic variables and non-eating related child self-resulation measures on child Food Responsiveness (N = 183).

	Block 1 ***(demographic variables)***		**Block 2** ***(non-eating self-regulation measures)***	
Model Adjusted R^2	0.059		0.095	
F (Model)	F(2,180) = 5.66	**	F(6,176) = 3.09	*
F(R^2 Change)			F(4,176) = 1.76	
Independent Variables	Std Beta		Std Beta	
Child sex (1 = male; 2 = female)	**−0.234**	**	**−0.209**	**
Child age in months	0.023		0.019	
Executive Functioning Tasks			−0.088	
Effortful Control			−0.071	
Delay of Gratification Task			0.127	
Peeking in Gift Delay Task			**0.155**	*

Abbreviation: Standardized beta coefficient (Std Beta)

* Significant at p<0.05;

** Significant at p<0.01;

*** Significant at p<0.001

Table 8

Regression analysis of non-eating related self-regulation and eating self-regulation measures on child BMIz (N = 183).

	Block 1 ***(demographic variables)***	**Block 2** ***(non-eating self-regulation measures)***	**Block 3** ***(eating self-regulation measures)***	
Model Adjusted R^2	0.009	0.016	0.125	
F (Model)	F(2,180) = 0.80	F(6,176) = 0.49	F(9,173) = 2.75	**
F (R^2 Change)		F(4,176) = 0.34	F(3,173) = 7.18	***
Independent Variables		Std Beta	Std Beta	
Child sex (1 = male, 2 = female)	−0.032	−0.015	0.030	
Child age in months	0.090	0.121	0.052	
Executive Functioning Tasks		−0.031	−0.018	
Effortful Control		−0.035	−0.011	
Delay of Gratification Task		−0.064	−0.071	
Peeking in Gift Delay Task		0.007	−0.078	
Eating in the Absence of Hunger			**0.233**	**
Satiety Responsiveness			**−0.223**	**
Food Responsiveness			0.091	

Abbreviation: Standardized beta coefficient (Std Beta)

*Significant at p<0.05;

**Significant at p<0.01;

***Significant at p<0.001