EXECUTIVE FUNCTION AND PEDIATRIC OVERWEIGHT:

A PROBLEM-SOLVING FRAMEWORK

A Dissertation

by

AUDREA YOUNGMAN JOHNSON

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

August 2012

Major Subject: School Psychology

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A Problem-Solving Framework

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Approved by:

Co-Chairs of Committee,	Jeffrey Liew
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ABSTRACT

Executive Function and Pediatric Overweight:

A Problem-Solving Framework.

(August 2012)

Audrea Youngman Johnson, B.A., Samford University

Co-Chairs of Advisory Committee: Dr. Jeffrey Liew
Dr. Jan N. Hughes

Pediatric overweight has become a topic of interest primarily due to the severity of potential physical and socioemotional consequences and escalating rates of weight status in children. Legislative initiatives have called for the creation of intervention and prevention programs; however, the efficacy and effectiveness of most of these programs have either not been established or are limited. The limited effect programs have on pediatric obesity may be due to a lack of understanding of the complexity of risk and protective factors associated with weight status. Pediatric overweight occurs when social, familial, psychological, and biological factors interact to disrupt the balance of energy intake and energy expenditure. In order to impact weight status, it is important to understand specific factors that are associated with overweight and obesity. Research has started to examine social, familial, and psychological factors that can be addressed in prevention and intervention programs.

The present study examines potential relations between aspects of executive function and pediatric weight status as well as obesity-prone eating behaviors. Executive

function is operationally defined as a problem-solving construct with four steps that work together to solve a problem: recognizing the problem, planning a course of action, executing the action, and evaluating the success of the action. Participants (78 children and their caregivers) between the ages of four and seven had their heights and weights measured, completed language-appropriate receptive language assessments, and were engaged in four tasks that theoretically correspond to the four aspects of problem-solving. Caregivers of the participating children completed demographic, economic hardship, child eating behaviors, and child daily executive functioning measures.

No significant findings were indicated between problem-solving phases of executive function and current weight status. Using multiple linear regression analyses, findings indicated that children who have high general appetites for food demonstrated deficits in the problem recognition and plan execution phases of executive function on caregiver-report measures even when accounting for racial/ethnic membership and socioeconomic hardship. In addition, children who cope with their emotions through eating (i.e., Emotional Overeating) rather than through other means also exhibit deficits in problem recognition, problem analysis, and plan execution on caregiver-report measures even when accounting for racial/ethnic membership and socioeconomic hardship. The findings presented in this study are discussed in light of the current literature and their implications for the future direction of intervention and prevention programs for pediatric overweight and obesity.

DEDICATION

For my husband Kyle:

Whose steadfast love and unending support

Have enabled me to complete this momentous journey

Therefore, since we are surrounded by such a great cloud of witnesses,

let us throw off everything that hinders and the sin that so easily entangles,

and let us run with perseverance the race marked out for us

(Hebrews 12:1)

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limits. Your influence extends beyond this product and I hope to be able to have the same impact on students as you have had on me. Thank you for everything.

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INTRODUCTION AND LITERATURE REVIEW

Pediatric obesity and overweight has become a topic of interest to researchers primarily due to the severity of potential physical and socioemotional consequences and escalating rates of weight status in children (e.g. Baron, Byrne, & Branscombe, 2006; Davison & Birch, 2001; Gavin, 2006; Gardner & Tockerman, 1994; Harper, 2006; USDHHS, 2004). Recent legislative initiatives (USDA, 2004) have called for the implementation of programs to reduce weight status in overweight and obese children; however, the efficacy and effectiveness of most of these programs have either not been established or are limited (Budd & Volpe, 2006). The limited success that prevention and intervention programs have had on reducing the problem of pediatric obesity may be partly due to the complexity of how multiple risk and protective factors are jointly associated with weight status. The maintenance of weight status occurs when the energy intake of food matches the energy expenditure through physical activity (Goran, 2001). Overweight and obesity occur when social, familial, and individual (e.g., psychological and biological) factors interact to disrupt this balance of energy intake and energy expenditure (Morgan et al., 2002). In order for prevention and intervention programs to effectively impact weight status, it is important to understand and identify specific factors that are directly and indirectly associated with overweight and obesity. An increasing body of research has examined the contributions of social, familial, and psychological factors on childhood overweight and obesity, and how such factors can be targeted in prevention and intervention programs. In particular, limited but growing

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This dissertation follows the style of *School Psychology Review*.

evidence suggest that executive function may be an individual-level factor that relates to pediatric weight status (e.g. Agranat-Meged et al., 2005; Cserjési, Luminet, Poncelet, & Lénárd, 2009; Gunstad et al., 2007, 2008).

Pediatric Overweight and Obesity

Definition. Children who are classified as obese by the American Academy of Pediatrics have a Body Mass Index (BMI) at or above the 95th percentile for their age and gender in comparison to a normative sample, and are classified as overweight if they have a BMI between the 85th and 95th percentile (Krebs, Baker, & Greer, 2003). When age and gender are taken into account, BMI scores of children have been found to provide accurate estimates of body composition (Deurenberg, Westrate, & Seidell, 1991). BMI is also correlated with obesity-related conditions in children including type II diabetes, higher levels of cholesterol, and increased blood pressure (Fortmeier-Saucier, Savrin, Heinzer, & Hudak, 2008; Gundogdu, 2008) A main limitation to the use of BMI to measure adiposity in children is that it does not distinguish between fat mass and lean mass (Kopelman, 2000). However, the relatively high positive correlations between BMI and other measures of adiposity, weight status in adulthood, and consistent assessment of obesity across the life span makes BMI an appropriate, relatively accurate, and non-invasive measure of fatness in children and adolescents (Dietz & Bellizzi, 1999). Furthermore, since 1994, the International Obesity Task Force determined that the use of BMI score calculation (weight (kg) / [height (m)]^2) was an appropriate measure to assess adiposity in children (as cited in Dietz & Bellizzi, 1999) due to its efficient calculation and its reliability with other measures of body fat.

Epidemiology. Pediatric, or child-onset, overweight has been conceptualized as a national epidemic by the World Health Organization (1998) that has not only physical, but also mental, social, and health consequences (Barlow & Dietz, 1998). Since the 1980s, overweight in children and adolescents has been on the rise (Morgan, Tanofsky-Kraff, Wilfley, & Yanovski, 2002). The Neumors Foundation estimates that 10% of children aged 2 to 5 years are overweight (Gavin, 2006), and that this prevalence among preschoolers has nearly tripled in the past 30 years (Ogden et al., 2006). One of the most significant increases in the prevalence of children at risk for overweight occurs between preschool (age two to five) and grade school (age six to eleven) years (Ogden et al., 2006).

Although increasing rates of overweight are found across all racial-ethnic, age, and sex groups in the United States (Troiano & Flegal, 1998), children from ethnic minority and low income backgrounds are more likely to experience overweight as well as weight related comorbidities, such as hypertension, hypercholesterolemia, and type II diabetes (Ogden et al., 2006) in comparison to healthy weight children. The National Health and Nutrition Examination Survey demonstrated that Black and Hispanic children experience higher than average rates of overweight when compared to non-Hispanic White children at most ages (Kumanyika, 2008). Additionally, Hispanic children are twice as likely to be overweight when compared to non-Hispanic White and Black children at the same socioeconomic status (Kimbro, Brooks-Gunn, & McLanahan, 2007), and although the prevalence rates for pediatric overweight increase with lower

categories of socioeconomic status, racial and ethnic differences are still observed within each category (Kumanyika, 2008).

Although the consequences for childhood obesity are typically more severe than childhood overweight, overweight children often experience similar outcomes as clinically obese children. Both classifications of children are at greater risk for hypertension, hypercholesterolemia, type II diabetes, coronary artery, liver, and gall bladder disease (Gavin, 2006; USDHHS, 2004). In addition to potential physical health problems, overweight children typically experience lower self-esteem and greater amounts of depression (Gavin, 2006). In 2001, researchers found that overweight girls as young as 5 years of age appear to have a poorer self-concept than girls of average weight (Davison & Birch). Consistent with findings of poor self-concept for overweight girls, overweight children are often stigmatized in the United States. In many modern societies, positive personality characteristics are associated with being thin whereas negative personality characteristics are associated with being overweight (Baron et al., 2006). In fact, research has shown that round body shapes are typically associated with being sad and sloppy (Gardner & Tockerman, 1994). Because overweight children are often stereotyped or targets of discrimination and harassment (Harper, 2006), they are also at-risk for concurrent or later social or emotional problems. These problems will likely continue to impact children as approximately 70% of obese youth will remain obese as adults (Reilly, 2007). Given similar negative consequences experienced by obese and overweight children, the term overweight will be used to refer to both obesity and overweight for the purpose of this dissertation.

Due to the negative impact that early childhood overweight has on children's concurrent and future physical and mental health, pediatric overweight has become a public health concern. The Society of Behavioral Medicine has called researchers to integrate individual-level factors of overweight with broader contexts such as familial and cultural contexts, because the understanding of the determinants of childhood overweight is crucial to providing opportunities to prevent or intervene in the onset of overweight (Estabrooks, Fisher, & Hayman, 2008). The United States Congress has introduced legislative initiatives such as the Child Nutrition and WIC Reauthorization Act of 2004 to improve the quality of physical activity and food provided to children in the school environment (Estabrooks, Fisher, & Hayman, 2008; USDA, 2004), and the Robert Wood Johnson Foundation has called for research aimed to reverse the pediatric overweight epidemic by 2015 (2009). Importantly, in order to effectively reduce pediatric overweight, research is needed to understand the mechanisms which cause, or at least maintain overweight, in order to inform and design efficacious and effective prevention and intervention programs.

Etiology. Overweight is not the product of a single factor. Morgan and others (2002) explain that the etiology of overweight is multifactorial and involves the complex relationship of social, familial, personal, and biological factors. Typically these factors contribute to the maintenance of energy balance so that the number of calories a child consumes matches the number of calories burned (Reilly, 2007; Israel, 1990); however, one way that weight gain could develop is when genetic predispositions interact with environmental factors so that energy intake of food mismatches energy expenditure

through physical activity (Goran, 2001). Estabrooks, Fisher, and Hayman (2008) state that the social ecology of a child can impact the development and maintenance of weight status, including the child's family, community, and school-life contexts as well as local, state, and federal political environments. Therefore, although there may be a strong genetic component to overweight, environmental and psychological influences establish behavioral norms for dietary choices and activity levels. Over the past two decades, research suggests that children's intake of foods high in fat, saturated fat, sodium have increased proportional to the rate of overweight (St-Onge, Keller, & Hemsfield, 2003). Thus, it is important to identify extra- and intra-individual factors that promote excess caloric intake.

Role of Economic Hardship on Weight Status. Economic hardship is an extra-individual factor that can have substantial negative effects on the physical functioning of a child. Children who live below the poverty line can suffer worse outcomes in regards to their physical health (See Brooks-Gunn & Duncan, 1997 for a review). The role of economic hardship on weight status may also account for some of the racial and ethnic disparities that exist between in these areas. In regards to pediatric overweight, Sankofa and Johnson-Taylor (2007) explain that African American and Hispanic cultural groups on average have lower levels of SES, and have lower food affordability and lower food availability than White Americans. Food affordability or the ability to buy nutritious food is strongly affected by the price structure of food. In American markets, least expensive foods are often higher in calories, and individuals with limited or unstable income depend on the purchase of these high-calorie foods (Kumanyika, 2008). Thus,

children from low SES families may be at an increased risk for growing up with high-calorie diets and eventual early onset of pediatric overweight than children from higher SES families.

Food affordability is not the only socioeconomic factor that increases the racial disparity in pediatric overweight. Unlike food affordability, which affects all individuals at a certain socioeconomic status regardless of their race, food availability or access to certain foods varies based on SES as well as race (Kumanyika, 2008). Research has suggested that high minority communities and low-income communities have significantly higher rates of fast food restaurants and lower rates of supermarkets or other sources of healthy foods than low minority and high-income communities (Powell, Chaloupka, & Bao, 2007; Sankofa & Johnson-Taylor, 2007). This finding suggests that food choices available to low income, high minority communities are less nutritious, and evidence suggests that greater availability to supermarkets is associated with lower BMI (Powell et al., 2007). One way that socioeconomic factors play in the observed racial disparities in pediatric overweight is through differential opportunities in food affordability and food availability. Thus, families' economic hardship should be accounted for when attempting to examine the unique impact that intra-individual factors may have on weight status.

Executive Function

Definition. Executive function is an intra-individual factor that has been implicated in several childhood onset disorders (see Pennington & Ozonoff, 1996, for a review). Yet, there is no clear consensus among researchers as to the definition of

executive function (Varney & Stewart, 2004). There is agreement amongst researchers that executive functioning refers to prefrontal cognitive abilities needed to engage in purposeful, flexible behavior that accounts for future environmental challenges, negative habitual responses, and temptations (Norman & Shallice, 2000; Welsh, Friedman, & Spieker, 2006; Hughes, Graham, & Grayson, 2004). Executive function is often characterized in research as a diverse set of processes including cognitive control, the ability to sustain or flexibly redirect attention, the inhibition of inappropriate behavioral responses, the initiation and execution of strategies, and the ability to switch among strategies (Robbins, 1998; Zelazo, Frye, Carter & Reznick, 1997). Welsh and others (2006) explain that the conceptualization of executive functioning was based on symptoms of brain damage to the frontal cortex, and thereby leaves a gap in the understanding of the construct.

Several theories have become prominent and helpful in conceptualizing the construct of executive functioning. Barkley (1997) theorized that the basis of executive functioning is behavioral inhibition. The construct can be conceptualized in two related processes: the ability to inhibit or delay a dominant response and the ability to ignore interference from competing events that may elicit a more dominate and immediately reinforcing response. Individuals with low levels of behavioral inhibition are unable to inhibit prepotent or immediately reinforcing behaviors. They also have a preservation of ongoing responses and suffer from poor interference control, and therefore, have a lack of foresight and planning without careful reflection or deliberation of the ramifications of the behavior (Braet, Claus, Verbeken, & Van Vlierberghe, 2007). Similarly other

researchers (e.g., Baddeley, 1986; Deckla & Reiss, 1997) viewed executive function as a higher order cognitive module that involves inhibition, working memory, and organizational strategies needed to respond to conflicting stimuli.

Although these researchers sought to unify deficits in executive functioning by examining singular constructs such as behavioral disinhibition, there has been concern that the conceptualization of executive functioning makes it difficult to explain or characterize where impairment may be occurring. Unified definitions about the primary effects of executive functioning may not be accounting for the full range of impairments an individual can experience, how aspects of executive functioning may interact with one another, why performance on executive functioning tasks can be variable, or how executive function is accomplished (Parkin, 1998; Perecman, 1987; Stuss & Benson, 1986; Stuss, Eskes, & Foster, 1994; Varney & Stewart, 2004; Zelazo & Müller, 2002).

In contrast, Zelazo and others (1997) sought to characterize executive function as a function or a diverse macroconstruct that integrates functionally distinct aspects of executive function while being based on the temporal phases of problem solving. Researchers focused on Luria's (1980) emphasis that the human brain is made up of interactive functional systems that involve integration of subsystems, and explained that it is counterproductive to examine aspects of executive functioning in isolation rather than to consider them in the larger system in which they function. When an individual is faced with a novel problem or environmental stressor, four steps work together to solve the problem: recognizing the problem, planning a course of action, executing the action, and evaluating the success of the action. Zelazo and others (1997) explain that

examining executive function from this framework allows researchers to locate where lapses in executive function occur and to focuses on the over-arching problem solving purpose of executive functioning.

In the problem recognition stage, an individual reconstructs a problem in a way that is conducive to solving it. In order to successfully represent the problem, selective attention, or the ability to attend to some aspects of a problem while ignoring unnecessary or distractible aspects, is needed. This requires an ability not only to initiate activity, but also to flexibly shift and transition between aspects of the problem. Zelazo and colleagues (1997) utilize the literature to argue that the problem recognition phase of executive function develops as children age. In particular, they suggest that preschool children (under age 4) appear to be inflexible in their representation of situations and have difficulty ignoring distractible aspects and, therefore, have difficulty with successful problem-solving. The skills needed for problem recognition are emerging as children enter Kindergarten.

The second phase of problem solving is planning or creating a way to solve a problem that is posed by the environmental situation. Zelazo and others (1997) state that at this stage, an individual needs to be able to search for solutions in a well defined space, sequence proposed actions in time, and select a plan from alternative plans. Similar to problem recognition, the ability to plan develops throughout the lifespan. Although planning likely develops well into school age, significant gains in ability and inclination to plan are noted between three and five years of age (Zelazo et al., 1997).

In the third phase of problem solving, an individual executes the plan created from the second phase. In order to execute a plan, the individual has to intend to perform the plan or keep the plan in mind long enough by using working memory to guide thoughts and actions, organize the materials needed for the plan, and carry out the behavior within the constrictions of parameters set by the environment. Plan execution is also impacted by human development. Research indicates that children are able to follow arbitrary rules by the age of three; however, they are more likely to perseverate if they are asked to transition from one set of rules to another incompatible set of rules (Zelazo et al., 1997). This suggests that the ability to execute a plan continues to develop into school age.

Once a problem has been recognized, and a plan has been formulated and executed, a final phase of evaluation occurs where an individual evaluates the action and determines if the desired solution has been obtained. In this phase, an individual needs to be able to monitor performance in order to detect if an error occurred during the process, where the error occurred, and provide a correction to the error. The ability to evaluate a plan appears to develop as young as age three. Similar to other aspects of problem-solving, plan evaluation is a developmental ability. Zelazo and colleagues (1997) note that children begin to refine this skill around four years of age by accounting for the appropriateness of environmental constraints before utilizing a previously successful plan.

The problem-solving framework allows for the examination of the function of executive function, or the examination of the purpose of the construct (Zelazo, Müller,

Frye, & Marcovitch, 2003). It also makes it possible to consider aspects of executive functioning as working together instead of in isolation with one another; therefore, specific patterns of executive functioning deficits can be examined (Zelazo et al., 1997), because the various subfunctions of the approach can all be seen as contributing to an outcome (Zelazo et al., 2003). It is important to note that the functional problem-solving framework cannot explain or define executive function, but its strength as a theory is its ability to formulate specific hypothesis about the role of aspects of executive function including attention, monitoring, and memory (Zelazo et al., 2003).

Etiology. Similar to pediatric overweight, there is a genetic basis for the development of individuals' executive function (Krueger et al., 2002; Young, Stallings, Corley, Krauter, & Hewitt, 2000). Lenroot and others (2009) used magnetic resonance imaging (MRI) to examine the heritability of cerebral cortical thickness in a large child and adolescent sample of 600 monozygotic twins, dizygotic twins, twin siblings, and single participants. Findings from the study suggested that regions of the brain and brain functioning often associated with complex cognitive processes such as language, tool use, and executive function have genetic influences, and such influences increase with age through age-dependent gene expression, or underlying genetic predispositions that manifest when presented in certain environments. Therefore, executive function may be moderated by extra-individual factors (Welsh et al., 2006).

Role of Economic Hardship on Executive Function. Economic hardship is an extra-individual factor that may have similar negative effects on children's development of executive function as it may have on pediatric weight status. Hughes and Ensor

(2005) examined 129 two-year-old children from predominantly disadvantaged families, and found that on measures of working memory, rule learning and rule switching, and inhibitory control, children coming from socially disadvantaged families demonstrated poorer executive function performance. Parents' ability to pay bills each month, have monetary surplus left, and ability to meet the basic needs of their family, including shelter, food, household items, transportation, and medical care can affect levels of executive function independently, and should be considered as indicators of families' economic hardship when examining factors associated with executive function.

Association between Executive Function and Pediatric Overweight

Researchers have sought to explain the association between executive function and pediatric overweight through theoretical frameworks and research on eating prevention programs. Two theoretical explanations of eating have been proposed implicating cognitive control as one mechanism for regulation over food intake. The Boundary Model (Stunkard & Steller, 1984) of eating has been utilized in adults to explain how food intake can be regulated for weight maintenance. The biological nature of eating works to keep consumption of food in a certain range. The aversive nature of hunger keeps food intake above a minimum level while the aversive nature of satiety keeps it below a minimum. Between hunger and satiety, is a zone of biological indifference where food intake gets regulated by social, psychological, and environmental factors; however, individuals who have lost or haven't developed sensitivity to their bodily hunger and satiety responses have to regulate their dieting through executive control. As long as such individuals continue to provide executive

control, or skills implicated in the general definition of executive function over their eating, they will be able to maintain or achieve a desirable weight (Stroebe, 2008). The Boundary Model suggests that if individuals do not have the ability to rely on bodily cues to regulate their food intake, then they must rely on aspects of executive function.

Although the boundary model has not been fully examined in children, research supports a similar finding that lower levels of executive control are related to heavier weight status. Birch, Johnson, Andersen, Peters, and Schulte (1991) argue that all children are born with the biological capacity to self-regulate their dietary food intake, but this innate ability or predisposition may be affected by developmental and psychosocial factors (Berkowitz & Stunkard, 2002) causing some children to consume larger than needed portions when presented with them (Fisher, Rolls, & Birch, 2003). For example, Barkeling, Ikman, and Rossner (1992) studied 11-year-old children and discovered that the eating behaviors of obese children differed from non-obese children. Specifically, obese children not only ate more rapidly than non-obese children, but also never decelerated their eating rate throughout the course of a meal in comparison to non-obese children. The lack of deceleration suggests that obese children have lost or have compromised levels in the ability to self-regulate their dietary intake or respond to their satiety cues, or that this ability was never fully developed (Berkowitz & Stunkard, 2002; Barkeling et al., 1992). The decrease in satiety responsiveness exhibited by children with overweight may be related to poor cognitive or behavioral control over eating often referred to as eating restraint (Stroebe, 2008; Westenhoefer, Pudel, & Maus, 1990).

The goal conflict theory was proposed as an extension of the boundary model of food intake in adults. Stroebe (2008) speculated that the adults who already have a genetic tendency for weight gain experience difficulty in regulating their food intake, which may have less to do with their ability to recognize bodily cues than their ability to handle a conflict between the goal of eating palatable food and the incompatible goal of maintaining weight. For adults, the conflict between weight maintenance and food intake may be a problem that requires making a choice between short-lived immediate rewards of unhealthy foods (such as taste and associated emotional pleasure) and long-term physical, emotional, and social negative outcomes if the foods are eaten at a rate that disrupts the maintenance of energy balance (Davis, Levitan, Muglia, Bewell, & Kennedy, 2004). In order for adults to cognitively control eating and maintain weight status, aspects of executive functioning are implicated; these include impulse control, self-monitoring, goal-directed behavior, decision making, organization, planning, deliberate intention, and self-control (Lezak, Howieson, & Loring, 2004; Riggs, Sakuma, & Pentz, 2007). According to the boundary model and the goal-conflict theory of eating, individuals who have difficulty cognitively regulating their food intake lack the skills of executive function when faced with a novel problem or an environmental stressor. However, additional research is needed to examine whether and how theoretical explanations apply to early childhood eating and weight status.

Aspects of executive functioning have also been targeted in several successful weight loss programs. In a study on middle childhood and adolescence, Cohen, Gelfand, Dodd, Jensen, and Turner (1980) demonstrated that children between the ages of 10 and

17 were more capable of maintaining weight loss if they were able to utilize skills associated with executive functioning such as self-praise for weight control, self-monitoring of food intake and weight change, restricting food intake and increasing energy output to counteract weight gains, and restraining eating in tempting situations. Similarly, the stop light diet that teaches executive function strategies such as using a symbolic traffic-light diet (red = forbidden food, green = allowed food, yellow = can be eaten but seldom) to teach cognitive control towards food found that children who utilize such techniques show a significant improvement on weight management 10 years after treatment (Epstein, Valoski, Wing, & McCurley, 1990). Finally, a school-based prevention study piloted a program focused to impact children's impulse control, decision making, and social competence in order to create changes in students' food intake and physical activity. The findings indicated that the prevention program demonstrated significant positive increases in students' food choices and television viewing behaviors (Riggs et al., 2007). Although the association between aspects of executive function and successful treatment and prevention programs suggests that executive function plays a role in the onset and maintenance of pediatric weight status, research with a theoretical framework of executive function is needed to understand the complexity of the relationship.

According to the goal-conflict theory, food intake for individuals prone to overweight is a conflict between energy balance of calories consumed to calories used and enjoyment of palatable food (Stroebe, 2008). From this perspective, whenever an individual is faced with a novel problem or an environmental stressor such as palatable

food, decision for food intake requires cognitive problem solving involving the implementation of executive function. To date, there have not been empirical studies on the executive function and overweight in early childhood using a problem-solving framework. Furthermore, the relationship between problem-solving and overweight may be complex, because the evidence to support that problem-solving occurs in at least four stages.

According to the problem solving framework, in order for an individual to represent a problem accurately, attentional control is needed (Zelazo et al., 1997). Agranat-Meged and others (2005) investigated 26 Israeli children between the ages of 8 and 17 years referred to a pediatric clinic because of severe overweight. Fifteen of the 26 (57.7%) children had a diagnosis of Attention Deficit-Hyperactivity Disorder (ADHD) of the combined type or of the predominantly inattentive subtype. The inattentive diagnostic criteria cited by the Diagnostic and Statistical Manual of Mental Disorders-Fourth edition, Text Revision includes failing to pay attention to details, difficulty sustaining attention in tasks, and difficulty selectively attending to one stimuli (American Psychiatric Association, 2000). The percentage of participants in this study diagnosed with ADHD is significantly higher than similar children in the general population, and this suggests that there may be a relationship between attention and weight status. Cserjési and others (2009) furthered the findings of Agranat-Meged and others (2005) by utilizing objective measures of attention. Researchers examined the performance of a European sample of 12 clinically overweight boys and 12 control boys on an attention endurance task and on an attention shifting task. Boys who were

overweight performed poorly on both tasks in comparison to their same age peers. This finding suggest that childhood overweight is associated with cognitive deficits in attentional shifting between stimuli and sustaining attention; however, both studies need to be interpreted with caution: the limited number of participants, the homogeneity of the sample, and the fact that all overweight participants are seeking clinical treatment and qualify as being clinically obese may make it difficult to determine how findings generalize to a more heterogeneous community sample living in the United States.

Gunstad and colleagues (2007) examined the relation between executive function and weight status in a non-clinically overweight sample of 408 adults who were classified as normal weight, overweight, and obese. Executive function was assessed using a digit span forwards task, a computerized choice reaction time task, a trail making test that measures switching of attention, and a span of visual memory. Results indicate that individuals with higher BMI performed worse on all tasks. Although the negative correlations between performance on attention tasks and BMI were modest, the strongest correlation amongst those were for attention switching or shifting ($r(408)=.20$, $p< .01$) While, these findings provide support for a deficit in the problem recognition stage of executive function, information is not provided about the race/ethnicity of the sample and the socioeconomic status of participants was homogenous. It is not clear whether results may differ depending on participants' socioeconomic status and race/ethnicity account. Research is still needed to understand the relationship between deficits in the problem recognition stage and weight status beyond the role of race/ethnicity and socioeconomic status. In 2008, Gunstad and others sought to generalize the relationship

between switching attention and weight status to a community sample of children and adolescents between the ages of 6 and 19 years. Researchers administered tasks to 478 children that measured working memory, switching of attention, memory, language, and motor skills. Interestingly, weight status and performance on tasks were unrelated. Similarly to Gunstad and others (2007), information was not provided about the racial/ethnic makeup or the socioeconomic status of the sample. Although it appears from the findings of these two studies that selective attention may impact weight status in children and not in adults, research is still needed to understand this relationship in a culturally and economically heterogeneous sample because of disparities that exist in the epidemiology of overweight. Levitan and others (2004) provide further support that attentional deficits in childhood are associated with mild to moderate overweight in adulthood, but research is still needed to fully understand the severity of deficits that may occur in the problem recognition stage of executive functioning in diverse overweight and obese children.

Planning is the second phase of problem solving when individuals need to be able to search for solutions in a well defined space, sequence proposed actions in time, and select a plan from alternative plans (Zelazo et al., 1997).The relation between ability for planning and weight status has not been extensively studied in children, but limited research has examined such a linkage in adults. Boeka and Lokken (2008) examined 68 participants between 20 to 57 years of age who are suffering from clinical overweight (BMI$\geq$40). Participants' perceptual and organizational skills were measured using a complex figure test. Participants also received the trailmaking test to measure processing

speed and cognitive flexibility and the Wisconsin card sorting test to assess problem-solving ability and the ability to shift set. When compared to a normative sample at the same age and income level, extremely overweight individuals demonstrated impairments on planning and mental flexibility aspects of executive functioning. A strength of this research is that researchers also found that weight status served as an independent contributor to planning beyond medical comorbities. Although researchers accounted for income level, 76% of the sample was categorized as non-Hispanic White Americans. With such a homogeneous sample, potential influences of race/ethnicity and socioeconomic status on planning and weight status cannot be tested. Research has also examined decision making abilities in a community sample of overweight Canadian women (Davis et al., 2004). Forty-one women participated in a computer gambling task that measure planning and decision making, and results indicated that individuals who are overweight and obese tend to demonstrate impairments on planning in decision making tasks. Although, these studies suggest that overweight individuals likely experience deficits in executive functioning at the planning second phase of the problem-solving process, racial and ethnic membership or economic hardship were not taken into consideration in analyses. Research has also not accounted for the impact of planning in a community weight sample of children.

The third phase of the problem solving process involves execution of the plan. In this stage, an individual has to intend to perform the plan or keep the plan in mind long enough to guide thoughts and actions (Zelazo et al., 1997). In other words, individuals execute the plan that was initially intended to be utilized. Braet and others (2007)

examined overweight and average weight European children between the ages of 10 and 18 years old on a matching familiar figures task that requires children to correctly and efficiently match a stimuli figure to the same figure out of a set of very similar figures. Findings from the study suggest that overweight children are more likely to respond both faster and more inaccurately on the task than average weight children; overweight children appear to have more difficulty inhibiting their responses, and inhibition is needed to guide thoughts and actions in the plan execution phase of problem solving. It is unclear whether responding to events impulsively may predispose children to weight gain, being overweight in itself may impact behavioral impulsivity, or a reciprocal relationship between impulsivity and overweight exists; however, findings from this study must be interpreted and generalized with some caution as the sample consists of European children and without consideration of socioeconomic status. Other studies have found similar results (Cserjési et al., 2009; Hölcke, Marcus, Gillberg, & Fernell, 2008; Holtkamp et al., 2004), but they have all utilized homogenous European samples. The only study found that utilized a culturally and economically diverse sample suggested that children who exhibit higher than normative levels of impulsivity at 4 years old are more likely to be overweight at 11 years old (Seeyave et al., 2009). Although further research is needed, Hubel, Jass, Marcus, and Laessle (2006) found preliminary evidence that overweight children may have difficulties executing a plan as it had initially been intended. Researchers found that boys with ADHD (predominately hyperactive-impulsive type) were just as likely as other ADHD-subgroups to experience higher than expected levels of overweight. To date, research in this area is relatively

limited and further examination of the role of planning on weight status is needed in a culturally and economically diverse pediatric sample in order to generalize significant findings.

The final stage of the problem solving process is evaluation where an individual evaluates their action and determines if a solution is obtained (Zelazo et al., 1997). To date, no published study has examined the evaluation stage of problem solving and weight , perhaps because previous research traditionally has not approached the issue of executive functioning and pediatric overweight from a problem solving framework (e.g., Boeka & Lokken, 2008; Cserjési et al., 2009; Hölcke et al., 2008; Holtkamp et al., 2004); however, based on the temporal nature of the problem solving phases of executive function, if children demonstrate difficulties at an earlier phase, it would be logical to expect that difficulties would arise at later phases (Zelazo et al., 1997). Research does seem to suggest that children with overweight exhibit difficulties with executive function at various phases of the problem solving process. In particular, significant difficulties are likely to occur at the planning and plan execution phases. In regards to the problem recognition stage, there may not be a significant relationship between children's weight status and selective attention, but there is likely an association between selective attention and children's engagement in food related behaviors associated with later weight problems; however, there are gaps in the literature. Previous studies often conceptualize executive function as a unidimensional construct, without taking into account the various subfunctions of executive function that contribute to the outcome. Further, previous studies rarely consider aspects of executive functioning and

their joint contributions or joint effects on the outcome. Secondly, research does not consistently account for the roles racial/ethnic membership and socioeconomic status have in the relationship between executive function and weight status. The inclusion of a culturally and economically diverse sample is needed in order to not only generalize findings, but also to account statistically for the effect both racial/ethnic membership and socioeconomic status have with weight status and executive function, respectively (e.g. Brooks-Gunn & Duncan, 1997; Kimbro et al., 2007; Kumanyika, 2008; Sankofa & Johnson-Taylor, 2007).

Finally, research has been limited to examining only the relationship between executive function and weight status. Research is needed to look at how executive function not only relates to current weight status, but how it also relates to eating behaviors that put children at risk for overweight later in life. Overall, a better understanding is needed to examine how problem solving executive functioning may be related to weight status in a community sample of racially and ethnically diverse children at varying levels of socioeconomic status.

Current Study

Using a problem-solving framework to define the various aspects of executive function, the purpose of the proposed study is to investigate relations between the aspects of executive function and child eating and weight status. By differentiating between the aspects of executive function, the present study aims to identify the specific phases in problem-solving that may be associated with increased eating and larger

weight status in a racially and ethnically diverse sample with varying levels of economic hardship.

The major variables examined this study are executive function, child weight status, eating behaviors, and economic hardship. This study addressed two main research questions. The first is whether weight status is associated with different phases of executive function in a socioeconomically and culturally diverse sample. Based on limited existing research, it is hypothesized that children with higher weight status will perform worse on measures representing the problem analysis, plan execution, or plan evaluation phases of executive function, even after accounting for race/ethnicity and socioeconomic hardship.

The second research question focuses on whether phases of the problem solving framework of executive function are associated with obesity-prone eating behaviors. Similar to the first research question, it is hypothesized that children who demonstrate obesity-prone eating behaviors will perform worse on measures representing the problem analysis, plan execution, and plan evaluation phases of executive function, even after accounting for race/ethnicity and socioeconomic hardship.

Implications. The current study expands upon the research by utilizing a construct theoretical definition of executive function. This allows the study to measure multiple aspects of executive function while acknowledging the complexities of the cognitive process. In addition, the study utilizes a unique sample of children and their caregivers in order to begin to generalize the associations between weight status and executive function for children of various racial/ethnic membership and socioeconomic.

The generalizability of these findings might impact future directions for the effectiveness of intervention and prevention programs for obesity. Finally, this study furthers the literature by taking a prospective approach and examining the associations between obesity-prone eating behaviors and executive function. The findings from this study provide a better understanding of the complexity of obesity risk factors and can help identify specific behaviors to target in prevention and intervention programs.

METHODS

Participants

Participants were 78 children between the ages of 4 and 7 (46 girls and 32 boys; *M* age=6.18 years, *SD*=.78) and one primary caretaker. All participants were recruited from eleven public schools in three different school districts, one summer day camp program, one after school private daycare, and one church daycare in Southwestern communities of the United States. Caregivers reported that 47% of children were Caucasian or Non-Hispanic White, 41% were Hispanic American, and 12% were African American or Non-Hispanic Black. Further, 48 of these children were exposed to only English in their home and school environments, while 38 were exposed to both English and Spanish.

Procedure

This study was approved by the Institutional Review Board before recruitment efforts and data collection began. Caregivers of children between the ages of 4 and 7 years received packets containing a recruitment letter, an informed consent form, and informed permission form from their affiliated school or community center. The recruitment information provided to parents described the purpose of the study as examining how children plan, pay attention, wait for things they want, and care for their physical health. Forms were provided to all parents in the schools and community centers who had children between the ages of 4 and 7 with administrators in each school or community center physically administering the form. Interested caregivers returned

signed forms and were then contacted by researchers in order to determine eligibility. Of the forms provided, 122 families returned forms interested in participation. Twenty children were exposed to languages other than English and Spanish, had an identified disability, or were taking some form of appetite-impacting medication and were therefore not included in this study in order to limit potential confounds. Of the remaining 102 participants and their caregivers, 78 (76.47%) completed a five minute phone interview to collect demographic information and arrange a testing session. These children and their caregivers completed testing sessions in a neutral location, such as a community or college library meeting room or in a quiet room in the family's home if transportation was difficult. The testing session typically lasted from 1 to 2 hours. Twenty-four families never responded to multiple phone calls and emails to determine eligibility and arrange a testing session.

During the testing session, the caregiver completed a series of questionnaires, while the child worked on activities in a one-on-one setting with a researcher. Caregivers completed the Behavior Inventory of Executive Function (BRIEF; Gioia et al., 2000), the Child Eating Behaviour Questionnaire (CEBQ; Wardle et al., 2001), and a questionnaire of economic hardship. These forms were completed by caregivers in their dominant or preferred language: Spanish or English.

Child participants, with the assistance of the researcher, had measurements of height and weight taken followed by standardized measures of receptive language using the Peabody Picture Vocabulary Test, Fourth Edition (PPVT-4; Dunn & Dunn, 2007). Children who were reported to be exposed to Spanish in addition to English in either the

home or school environment were also administered the standardized Test de Vocabulario en Imagenes Peabody (TVIP; Dunn et al., 1986) as the Spanish measure of receptive language. These children worked with trained researchers who were able to speak both Spanish and English languages. The remainder of the testing session for only these children was then conducted in the language that matched the higher obtained receptive language score, and the higher receptive language score was used for further analysis. Once receptive language was measured, five performance-based tasks were administered with the child. The order that the tasks were presented was randomly assigned to each child with five potential orders. Of the five tasks presented, only the four tasks that follow the problem-solving were analyzed in this study. These measures are: the Selective Attention task (Humphrey, 1982), the Tower of London (TOL; Shallice, 1982), the Children's Stroop task (Gerstadt, Hong & Diamond, 1994), and the Less is More task (Carlson, Davis & Leach, 2005). At the end of the session, the participating families received two small toys and $20 cash. In addition, families were entered into a drawing for a $150 Wal-Mart gift card.

Instruments

Demographics. A demographic questionnaire was administered with a caregiver of the participating child. This questionnaire contained 15 items. These items addressed background information about the child, including languages spoken at home and/or at school, the racial and ethnic identity of the child as well as the caregiver, and prescription medication children may be taking regularly.

Current Weight Status. Body mass index (BMI) was calculated using height and weight measurements of the participating child. Height was measured to using a fixed wall measuring board while weight was measured utilizing a digital scale, while children are fully clothed, but not wearing their shoes. Height was measured in inches rounding to the nearest half inch and weight was measured in pounds rounding to the nearest half pound. The Centers for Disease Control and Prevention (CDCP, 2008) endorsed formula of dividing weight in pounds by height in inches squared and multiplying by a conversion factor of 703 was used to assess BMI. Pietrobelli and colleagues (1998) demonstrated validity of BMI as a measure of fatness independent of age for both males and females by finding strong associations between BMI and total body fat and percentage of body weight as fat. Once each child's BMI was calculated, CDCP growth charts were used to determine BMI percentiles based on each child's gender and age.

Eating Behaviors. The caregiver-report Child Eating Behaviour Questionnaire (CEBQ; Wardle et al., 2001) was used to examine susceptibility to later obesity by measuring variations in eating behavior often associated with weight gain. Although this questionnaire measures seven factors, three factors were utilized in this study: Food Responsiveness, Enjoyment of Food, and Emotional Overeating. Food Responsiveness and Enjoyment of Food both address children's general appetite for food or desire to eat, while Emotional Overeating looks at increases in appetite based on emotional state. Higher scores on this measure are indicative of greater susceptibility to later obesity. These three factors were utilized because of their internal reliability and association with behavioral aspects of eating (Carnell & Wardle, 2007).

Internal reliability reported for the three scales of the CEBQ is high: the Food Responsiveness scale has an alpha of .80, the Enjoyment of Food scale has an alpha of .91, and the Emotional Overeating scale has an alpha of .74. Confirmatory factor analysis and correlational patterns among the subtests for each domain provide support for the construct validity of scores on this measure. Additionally, two of the three scales have been examined with four behavioral aspects of eating behavior including eating without hunger, caloric compensation, eating rate, and energy intake at a meal in 4-5 year old children. Behavioral measures explained 33% of the variance of Food Responsiveness and 40% of the variance of Enjoyment of Food (Carnell & Wardle, 2007). This finding provides external validity for the CEBQ. The CEBQ does not have a Spanish translation, so the measure was translated into Spanish by a native Spanish speaker originally from Mexico and reverse translated back into English by a native Spanish speaker also from Mexico. For the Food Responsiveness scale, the Cronbach's alphas were .83 and .86 for English and Spanish speaking caregivers, respectively. The Enjoyment of Food scale had alphas of .83 and .54 for English and Spanish speaking caregivers, respectively and the Emotional Overeating scale had alphas of .84 and .78, respectively. An additional scale of the CEBQ had been intended for use in this study. The Satiety Responsiveness scale examines the degree to which an individual ceases eating or chooses not to initiate eating based on their perceived fullness, and has been linked to greater risk for obesity later in life (Carnell and Wardle, 2007); however the internal consistency for Spanish speaking caregivers was .37 while English speaking

caregivers had an alpha of .88. Due to the unreliable nature for Spanish speaking families, the Satiety Responsiveness scale was not examined in this study.

Receptive Oral Language. The Peabody Picture Vocabulary Test, Fourth Edition (PPVT-4; Dunn & Dunn, 2007) was used to measure receptive oral language in English. The PPVT-4 is administered following standardized instructions where the trained researcher says one word while the child points to one of four pictures that best corresponds to the word (Dunn & Dunn, 2007). The internal consistency of the PPVT-4 ranges from .93 to .98, while the test-retest correlations range from .92 to .96. It correlates high with other language measures and has established content validity. The Test de Vocabulario en Imagenes Peabody (TVIP; Dunn et al., 1986) was used to measure of Spanish receptive oral language. Similar to the PPVT, The TVIP is administered following standardized instructions where the trained bilingual researcher says one word (in Spanish) while the child points to one of four pictures that best corresponds to the word (Dunn et al., 1986). The TVIP has an internal consistency ranging from .80 to .95. It has sufficient content validity and concurrent validity. It should be noted that the TVIP used a normative sample of monolingual Spanish-speaking children from either Mexico or Puerto Rico. Although this measure did not include bilingual participants in the normative sample, it was used as the measure of Spanish receptive language because no tests that have been standardized on bilingual populations were available at the time of data collection.

Economic Hardship. The construct of economic hardship was first developed by Conger and Elder (1994) to describe how the effects of economic pressure impact family

life. Parents who experience high levels of economic pressure due to economic hardships like those included as indicators can impact food affordability and food availability for families, can lead to high levels of negative emotions, and in turn be associated with poor psychological and physiological outcomes for children (Conger, Ge, Elder, Lorenz & Simons, 1994; Dennis, Parke, Coltrane, Blacher & Borthwick-Duffy, 2003; Elder, Conger, Foster & Ardelt, 1992; Mistry, Vandewater, Huston & McLoyd, 2002; Powell et al., 2007; Robila & Krishnakumar, 2006; Sankofa & Johnson-Taylor, 2007).

Consistent with research by Parke and colleagues (2004) that assessed families' economic hardship, caregiver provided information on the family's ability to pay bills each month, indexed by any monetary surplus by the end of the month and the caregiver's ability to meet the basic needs of the family. The family's ability to pay their monthly bills was measured on a 5-point Likert scale, with 1 indicating no difficulty paying bills, and 5 indicating much difficulty. The second item was measured on a 4-point Likert scale, with a rating of 1 indicating that the family has plenty of money left over, and a rating of 4 indicating that there was not enough money left at the end of the month (Parke et al., 2004). Parke and colleagues (2004) reported correlations of these two items ranging from .66-.67 in Hispanic parents and from .80-.81 in Non-Hispanic White parents. The third indicator of economic pressure involved the ability of caregivers to meet the basic needs of their family, including shelter, food, clothing, household items, transportation, and medical care. This item was measured on a 4-point Likert scare with a rating of 1 indicating that caregivers had no difficulties meeting the basic needs of their family and a rating of 4 indicating much difficulty. Parke and

colleagues (2004) report Cronbach's alphas of .92-.94 for Non-Hispanic White parents and .86-.90 for Hispanic parents. For the purpose of this study, this item was slightly modified: the term "transportation" was substituted for "car" and the term "recreational activities" was omitted. Table 1 presents the correlations between the three measures of economic hardship for English and Spanish speaking caregivers.

Table 1

Correlations between Economic Hardship Items by Caregiver Language

Economic Hardship	English (*n*=56)			Spanish (*n*=22)		
	Item 1	Item 2	Item 3	Item 1	Item 2	Item 3
Item 1	-			-		
Item 2	0.67**	-		0.65**	-	
Item 3	0.82**	0.64**	-	0.84**	0.55**	-

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

For the current study, the three scores for the three constructs were added together to create a quantitative measure of Economic Hardship. The Cronbach's alphas were .87 and .86 for English speaking and Spanish speaking caregivers, respectively.

Problem Recognition. Zelazo and others (1997) describe the problem recognition phase of executive function as a period where an individual begins to represent or understand a problem in a way that is conducive to solving the problem. In order to be able to do this correctly, an individual first must be able to initiate activity, focus on important aspects while ignoring or filtering unimportant aspects, and to flexibly shift

and transition between aspects of the problem. In the current study, two caregiver-reported measures of day-to-day functioning and one performance-based measure were used to measure aspects of problem recognition. The Behavior Rating Inventory of Executive Function (BRIEF; Gioia et al., 2000) is an 86 item observational measure of aspects of executive functioning. The BRIEF is available in both English and Spanish and has provided evidence of internal consistency for each average score scale, ranging from .80 to .98 (Gioia et al., 2000). For this study, the Cronbach's alpha across scales on the BRIEF was .90 for English speaking and .94 Spanish speaking caregivers. Test-retest correlations across the clinical scales ranged from .76 to .85 with an average time interval of two weeks. The BRIEF demonstrates construct validity through significant correlations with the ADHD-Rating Scale-IV, the ASEBA Child Behavior Checklist, the Behavior Assessment System for Children, and the Conners' Rating Scale. For the purposes of this study, lower scores on the BRIEF scales are indicative of lower rated performance in the measured area. The two scales from the BRIEF used to measure aspects of problem recognition are the Initiate scale (measures an individual's ability to initiate activity) and the Shift scale (measures cognitive and behavioral flexibility).

For the performance-based measure of this composite, Zelazo and colleagues (1997) cite Humphrey (1982)'s Selective Attention task as an example of an objective task that measures selective attention and the ability to flexible use models to guide the search and examination of a problem. In this task, children were individually presented with 8 8x10 stimuli cards with yellow, green, and red triangles, circles, squares and stars and asked to match the two little colored shapes on the stimulus card. Every child was

presented with three stimuli cards for each of the four different conditions. The conditions differed in forms of distracters presented to the child during the attention task. Distracters included a mirror or extra shapes on the stimuli card that differ in dimension or number. Cronbach's alphas for this performance-based task were .72 and .75 for English and Spanish speaking children, respectively. Table 2 presents the correlations between Z-scores of the caregiver-report Initiate scale, caregiver-report Shift scale, and performance-based Selective Attention task.

Table 2

Z-Score Correlations between Measures of Problem Recognition

Problem Recognition	Participants and Caregiver (*n*=78)		
	Initiate	Shift	Selective Attention
Initiate	-		
Shift	.571**	-	
Selective Attention	.123	.082	-

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

Because the performance-based scale did not significantly correlate with the parent-report measures, problem recognition was measured separately by the performance-based task and the parent-report measures. Due to the correlation between the caregiver-report Initiate scale and the caregiver-report Shift scale ($r(76)= .571$, $p< .01$), a caregiver-report problem recognition composite was formed by using the mean of the Z-scores of the two scales. The lack of shared variance between the performance-based task and the caregiver-report measures may indicate that caregiver measures capture a

different aspect of a child's functioning than performance-based tasks. It has been theorized that performance-based tasks tap components of executive function over a short term and may not be able to capture more complex every day priority-based decision making that are present in real world situations (Goldberg & Podell, 2000; Shallice & Burgess, 1991).

Problem Analysis. Zelazo and colleagues (1997) describe the planning stage of executive function as consisting of the ability to plan and organize in well-defined problems, to route plan, to logical search, to plan to remember, and to utilize social planning. The current study used the caregiver-report Plan and Organize scale of the BRIEF (Gioia et al., 2000) and the Tower task of the NEPSY (Korkman, Kirk & Kemp, 1998). The Plan and Organize scale measures an individual's ability to problem-solve by organizing and planning cognitions (Gioia et al., 2000).

The Tower task has been conceptualized as an example of planning in a well-defined space for well-defined problems (Shallice, 1982). The task was administered according to the published instructions in the NEPSY manual (Korkman et al., 1998). In the Tower task, children were shown three colored balls that can move from one peg to another. They were then told the rules, which involved moving only one ball at a time, that the balls must remain on the pegs when not being moved, and that each move is finished when they remove their hand from the ball. The stimulus book contains the target positions for 20 trials. There was a time and move limit per trial. The test was discontinued after 4 consecutive failures to meet these limits. The score used in the current study was the total trials passed. The NEPSY Core Domain scores demonstrate

sufficient internal consistency (.69-.91) and stability coefficients (.67-.76) (Miller, 2001). Content validity was established through a review of the items by an expert panel. The construct validity was established through correlational patterns among the subtests for each domain. Convergent and divergent validity was established through correlational studies with measures of general cognitive ability, achievement, and neuropsychological functions. The current study demonstrated alphas on the Tower task of .79 and .85 for English and Spanish speaking children, respectively. Similar to measures of problem recognition, the Plan and Organize scale and the Tower task did not significantly correlate ($r(76)= .162$, $p= .156$). The Plan and Organize scale was used to measure the caregiver-report aspect of problem analysis, while the Tower task was used to measure the performance-based aspect of problem analysis.

Plan Execution. Zelazo and others (1997) describe plan execution as the ability to keep a plan in mind or intend to utilize a plan and the ability to translate a plan into action. In order to do this, an individual needs to utilize working memory, organize the materials needed for the plan, and then translate the plan into action. For this aspect, two caregiver-report BRIEF scales and one performance-based task were used. The Working Memory scale measures the ability to sustain information in working memory, while the Organization of Materials scale measures the ability to organize materials and the environment in a way that is conducive to putting a plan into action (Gioia et al., 2000).

The Children's Stroop task (Gerstadt et al., 1994) is a performance based task that was used to measure plan execution. The Children's Stroop task (Gerstadt et al., 1994), a simplified version of the Stroop color-word task (Stroop, 1935), has been

characterized as a measure that translates plans into action (Zelazo et al., 1997). In this task, a deck of cards were utilized. Half of the cards had a white face with a picture of a sun, and half had a black face with pictures of the moon and stars. When the child was presented with the sun card, he or she was to say "night." When the child was presented with the moon card, he or she was to say "day." There were a total of 16 cards presented in this task, with the total number correct being used as the score. The Children's Stroop task had a Cronbach's alpha of .86 for English speaking children and an alpha of .98 for Spanish speaking children. Table 3 presents the correlations between Z-scores of the three components chosen to measure aspects of plan execution.

Table 3

Z-Score Correlations between Measures of Plan Execution

Plan Execution	Participants and Caregiver (*n*=78)		
	Working Memory	Org. of Materials	Children's Stroop
Working Memory	-		
Org. of Materials	.576**	-	
Children's Stroop	.136	.067	-

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

Similar to previously presented problem-solving aspects of executive function, the performance-based Children's Stroop task did not significantly correlate with either of the caregiver-report measures; therefore, the Children's Stroop task was used as the performance-based measure of plan execution. The Working Memory scale and the

Organization of Materials scale were highly correlated ($r(76)= .576$, $p< .01$), and the mean of each Z-score was used to create a caregiver-report composite of plan execution.

Plan Evaluation. The final phase of the theoretical model of executive function is evaluation (Zelazo et al., 1997). In this phase, the ability to detect when a goal has not been accomplished and to formulate or carry out a new plan is needed. In order to be successful in this phase, an individual must be able to monitor the success of each plan and learn in situations with uncertain or unknown outcomes (Zelazo et al., 1997). The current study used the caregiver-report Monitor scale of the BRIEF (Gioia et al., 2000) and the performance-based Less is More task (Carlson et al., 2005). The Monitor scale measures an individual's ability to monitor the success of a plan in the problem-solving process.

Less is More (Carlson et al., 2005) is a performance-based task that utilized unknown outcomes to measure children's learning and was utilized to represent the evaluation phase of executive function. This task was a reverse-reward contingency task, because the children received a larger amount of a reward when they pointed to the smaller amount of that same reward. In this task, the examiner first gave the child a choice between two treats (e.g. jelly beans or stickers), which were then used as the reward for the rest of the task. The examiner then presented a pile of five treats and a pile of two treats, asking the child which pile was preferred. After the child selected the larger pile, the experimenter introduced a puppet, who was described as naughty because he wanted all the treats for himself. The experimenter then explained that every time the child selects a pile of treats, the treats would go into the puppet's cup, and the other pile

would go into the child's cup. After one practice and a check for rule understanding, the child received 16 test trials. Each trial involved sets of two and five treats, with the positions counterbalanced (left vs. right).The score on this task was based on the number of times the child followed the rule to receive the larger number of treats. The Less is More task had Cronbach's alphas of .91 and .76 for English and Spanish speaking children, respectively. As expected, the Monitor scale and the Less is More task were not significantly correlated ($r(76)= 1.30$, $p= .255$); therefore, the Monitor scale was the caregiver-report measure of plan evaluation, while the Less is More task was used as the performance-based measure of plan evaluation.

Data Analyses

Skewness and kurtosis were examined for each variable. Findings suggested that most measures had skewness statistics less than 2 standard deviations and kurtosis of 7 deviations from the mean scores as suggested by the work of West, Finch, and Curran (1995); however, the performance-based measures of the Children's Stroop task and the Less is More task were extremely negatively skewed and overly kurtotic. To correct for this, a restricted range technique was implemented for both tasks. All scores for these tasks were corrected to fall within one standard deviation of the mean. Outlier scores for these measures were changed to the respective value of one standard deviation above or below the mean. This technique reduced the skewness and kurtosis for both tasks, with only the Children's Stroop task remaining extremely negative skewed and overly kurtotic. A second step was then taken to correct for this. The entire sample's Children's Stroop task scores were reversed in order to change the negative skew to positive and a

multiplicative inverse or reciprocal transformation was applied. With the transformation, all of the study's skewness and kurtosis values were within acceptable values.

There was data missing at random from the set due to caregiver errors in completing measures as well as from researcher errors in not providing the appropriate language measures for caregivers. These errors resulted in missing data points that ranged from 1 to 8 depending on the variable. Missing data points were found to be unrelated to any participant characteristic. Using Norm, 10 different data sets were imputed and the average of these data sets was used for the remaining analyses.

The current study then employed descriptive and correlational analyses as well as t-tests, chi-square tests, and multiple linear regression. Demographic differences in weight status, eating behavior, and executive function performance was examined using t-tests and chi-square statistics in order to determine appropriate covariates to be utilized in later analyses. Correlational analyses were used to examine the relationships of the measures and determine the appropriateness of using multiple linear regression in order to account for shared variance on the relationship that may be associated with covariates. Multiple linear regression analyses were only conducted when aspects of executive function significantly correlated to the dependent weight variables: BMI percentile, Food Responsiveness eating behavior, Enjoyment of Food eating behavior, and Emotional Overeating behavior.

RESULTS

Preliminary Analyses

Demographic Characteristics. In the current study, 64 percent (n=50) of participants had a BMI within the 5th and 84th percentile for their age and gender and were therefore classified as healthy weight. Thirty-five percent (n=27) of participants were measured to have a BMI greater than or equal to the 85th percentile for their age and gender. These participants were classified as overweight. One participant had a BMI below the 5th percentile and was classified as underweight. Healthy weight and overweight participants were compared across multiple variables including age, race/ethnicity, gender, economic hardship, and receptive oral language. Healthy weight and overweight participants did not significantly differ in terms of age (t(75) = .548, p =.545). Healthy weight and overweight participants did not differ in regards to race and ethnicity (χ^2(4) = 4.127, p =.389) or gender (χ^2(2) = 1.46, p =.482). Healthy weight and overweight participants did not significantly differ in terms of economic hardship (t(75) = .156, p =.877) or receptive oral language (t(46) = -.588, p = .560). Group means are included in Table 4.

Table 4

Participant Characteristics

	Total Sample (n =78)		Healthy Weight (n=27)		Overweight (n=27)		Underweight (n=1)	
Categorical Variables	*N*	%	*N*	%	*N*	%	*N*	%
Males	32	41%	20	40%	11	41%	1	100%
Females	46	59%	30	60%	16	59%	-	-
Non-Hispanic Black	9	12%	5	10%	4	15%	-	-
Non-Hispanic White	37	47%	27	54%	9	33%	1	100%
Hispanic	32	41%	18	36%	14	52%	-	-
Continuous Variables	Mean	*S.D.*	Mean	*S.D.*	Mean	*S.D.*	Mean	*S.D.*
Age	6.18	0.76	6.15	0.76	6.26	0.79	5.42	-
Economic Hardship	7.11	3.00	7.11	2.87	7.22	3.29	4	-
Receptive Oral Language	105.88	15.34	106.28	14.04	104.04	16.94	136	-

Because of the limited number of underweight participants and the qualitative difference in economic hardship and receptive oral language with the underweight participant, this participant was excluded from all further analyses.

Analyses were conducted to examine whether there were differences on study variables across majority (Non-Hispanic White) participants and minority (Hispanic and Non-Hispanic Black) participants. Specifically, group comparisons were conducted on age, dominant receptive language, Economic Hardship, measures of performance-based executive function (Selective Attention task, Tower task, Children's Stroop task, and Less is More task), measures of caregiver-report executive function (Shift, Initiate, Plan and Organize, Working Memory, Organization of Materials, and Monitor), BMI percentile, and measures of obesity-prone eating behaviors (Enjoyment of Food, Food

Responsiveness, and Emotional Overeating). No differences were found across majority and minority participants on age ($t(71) = .873$, $p = .385$). In contrast, there were group differences on Economic Hardship ($t(75) = 5.642$, $p < .01$) and dominant receptive language ($t(76) = -6.125$, $p < .01$) with Hispanic and Non-Hispanic Black participants reporting higher levels of economic hardship and lower levels of receptive oral language than Non-Hispanic White participants.

In regards to measures of executive function, no group differences were found on caregiver-report measures of problem analysis: Initiate ($t(76) = .332$, $p = .741$) and Shift ($t(76) = -.399$, $p = .691$); however, group differences were found on the Selective Attention task ($t(76) = -2.434$, $p < .05$) with Non-Hispanic White participants performing better on average than Hispanic and Non-Hispanic Black participants. For measures of problem analysis, no group differences were found on the caregiver-report of Plan and Organize ($t(76) = -1.61$, $p = .112$) or performance on the Tower task ($t(76) = -.449$, $p = .655$). Similarly, for measures of plan execution, no group differences were found on the caregiver-report of Working Memory ($t(76) = .702$, $p = .485$), the caregiver-report of Organization of Materials ($t(76) = 1.873$, $p = .065$), or the performance on the Children's Stroop task ($t(67) = 1.639$, $p = .106$). Finally, for measures of the plan execution phase of executive function, no group differences were found on the caregiver-report measure of Monitor ($t(76) = .466$, $p = .933$); however, group differences were found on the Less is More task ($t(75) = -3.515$, $p < .01$), with Hispanic and Non-Hispanic Black participants performing significantly lower on average when compared to Non-Hispanic White participants.

For measures of weight status and obesity-prone eating behaviors, no differences were found across Hispanic and Non-Hispanic Black, and Non-Hispanic White participants on BMI percentile ($t(76) = 1.517$, $p = .133$), caregiver-report of Enjoyment of Food ($t(75) = -.612$, $p = .542$), caregiver-report of Food Responsiveness ($t(76) = -1.303$, $p = .196$), or caregiver-report of Emotional Overeating $t(76) = .367$, $p = .715$).

Correlations. Two-tailed correlations among age, economic stress, receptive oral language, problem recognition, problem analysis, plan execution, plan evaluation, BMI percentage, food responsiveness, enjoyment of food, and Emotional Overeating were conducted. Table 5 presents the correlations between the covariates not including racial/ethnic membership (Economic Hardship and receptive oral language), BMI percentile, and the performance-based measures of the four aspects of executive function.

Table 5

Correlations between Current Weight Status and Performance-Based Measures

	1	2	3	4	5	6	7
1. Economic Hardship	-						
2. Receptive Oral Language	-.28*	-					
3. Performance Problem Recog.	-.22*	.34**	-				
4. Performance Problem Analysis	-.28*	.23*	.35**	-			
5. Performance Plan Execution	-.07	.34**	.3**	.30**	-		
6. Performance Plan Evaluation	-.23*	.29*	.24*	.27*	.23*	-	
7. BMI Percentile	-.04	-.03	-.06	-.05	-.11	.05	-

**Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Of the demographic variables, economic hardship was significantly correlated with receptive oral language ($r(75) = -.28$, $p < .05$), suggesting that children from families with more economic hardship tended to perform worse on measures of receptive oral language. Additionally, economic hardship was negatively correlated with the performance-based measure of problem recognition ($r(75) = -.22$, $p < .05$), the performance-based measure of problem analysis ($r(75) = -.28$, $p < .05$), and plan evaluation ($r(75) = -.23$, $p < .05$); However, Economic Hardship was not significantly correlated with BMI percentile ($r(75) = -.04$, $p = .71$). Receptive oral language was also with all four performance-based measure of the problem-solving process, but did not correlate with BMI percentile ($r(75) = -.04$, $p = .74$). All four of the performance-based measures of executive function were highly correlated with each other; however, none of the measures were correlated with BMI percentile. Table 6 presents the correlations between the covariates, BMI percentile, and the caregiver-report measures of the four aspects of executive function.

Table 6

Correlations between Current Weight Status and Caregiver-Report Measures

	1	2	3	4	5	6	7
1. Economic Hardship	-						
2. Receptive Oral Language	-.28*	-					
3. Caregiver Problem Recog.	-.11	-.08	-				
4. Caregiver Problem Analysis	-.32**	-.04	.67**	-			
5. Caregiver Plan Execution	-.12	-.12	.67**	.76**	-		
6. Caregiver Plan Evaluation	-.21	-.12	.73*	.83*	.76*	-	
7. BMI Percentile	-.04	-.03	.004	-.01	-.13	-.04	-

**Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Of the demographic variables, economic hardship was only significantly correlated with the caregiver-reported problem analysis measure ($r(75) = -.32$, $p < .01$). Receptive oral language was not significantly related to any of the caregiver-reported measures of executive function. Similarly to the performance-based measures, all four of the caregiver-report measures of executive function were highly correlated with each other; however, none of the measures were significantly correlated with BMI percentile. Table 7 presents the correlations between the covariates, the obesity-prone eating behaviors, and the performance-based measures of the four aspects of executive function.

Table 7

Correlations between Obesity-Prone Eating Behaviors and Performance-Based Measures

	1	2	3	4	5	6	7	8	9
1. Economic Hardship	-								
2. Receptive Oral Language	-.28*	-							
3. Performance Problem Recog.	-.22*	.34**	-						
4. Performance Problem Analysis	-.28*	.23*	.35**	-					
5. Performance Plan Execution	-.07	.34**	.3**	.30**	-				
6. Performance Plan Evaluation	-.23*	.29*	.24*	.27*	.23*	-			
7. Enjoyment of Food	.11	-.08	.05	-.05	-.06	-.08	-		
8. Food Responsiveness	-.11	.04	.02	-.002	-.14	-.09	.53**	-	
9. Emotional Overeating	.13	-.06	.06	-.09	-.04	-.15	.30**	.70**	-

**Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Of the obesity-prone eating behaviors, Enjoyment of Food is positively correlated with Food Responsiveness ($r(75) = .53$, $p < .01$) and Emotional Overeating ($r(75) = .30$, $p < .01$), while Food Responsiveness is correlated with Emotional Overeating ($r(75) = .70$, $p < .01$). None of the three obesity-prone eating behaviors are correlated with Economic Hardship or with receptive oral language. The eating behaviors are also not significantly correlated with any of the performance-based measures of executive function. Table 8 presents the correlations between the covariates, the obesity-prone eating behaviors, and the caregiver-report measures of the four aspects of executive function.

Table 8

Correlations between Obesity-Prone Eating Behaviors and Caregiver-Report Measures

	1	2	3	4	5	6	7	8	9
1. Economic Hardship	-								
2. Receptive Oral Language	-.28*	-							
3. Caregiver Problem Recog.	-.11	-.08	-						
4. Caregiver Problem Analysis	-.32**	-.04	.67**	-					
5. Caregiver Plan Execution	-.12	-.12	.67**	.76**	-				
6. Caregiver Plan Evaluation	-.21	-.12	.73*	.83*	.76*	-			
7. Enjoyment of Food	.11	-.08	.12	.22	.07	.18	-		
8. Food Responsiveness	-.11	.04	-.28*	-.13	-.31**	-.15	.53**	-	
9. Emotional Overeating	.13	-.06	-.35**	-.30**	-.31**	-.23*	.30**	.70**	-

**Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

The Enjoyment of Food eating behavior does not correlate with any of the caregiver-reports of executive function. Food Responsiveness negatively correlates with the caregiver-report of problem recognition ($r(75) = -.28$, $p < .05$) and with the caregiver-report of plan execution ($r(75) = -.31$, $p < .05$). These findings suggest that as children demonstrate poor performance on daily problem recognition tasks as well as poor performance on daily plan execution tasks, they also tend to be highly responsive to food. Emotional Overeating is significantly negatively correlated to all four caregiver-report measures of executive function. These findings suggest that children who tend to eat more food based on their emotional state also tend to demonstrate lower levels of

daily problem recognition, problem analysis, plan execution, and plan evaluation tasks in comparison to children whose eating behaviors are not tied to their emotional states.

Multiple Regression Analyses

Hypothesis 1. Because BMI percentile was not correlated with any of the performance-based measures of executive function or with any of the caregiver-report measures, further analyses to account for relations between BMI and major study variables, above and beyond contributions from racial/ethnic membership or for economic hardship were neither necessary nor conducted.

Hypothesis 2. Significant correlations existed between the obesity-prone eating behavior Food Responsiveness and aspects of caregiver-reported executive function as well as between Emotional Overeating and aspects of caregiver-reported executive function; therefore, multiple linear regressions were conducted to estimate the amount of variance accounted for by each phase of executive function on Food Responsiveness or on Emotional Overeating, above and beyond any contributions from Economic Hardship, racial/ethnic membership, and receptive oral language. Six separate multiple regressions were conducted to examine the hypothesis that lower levels of performance in phases of executive function is associated with stronger demonstration of obesity-prone eating behaviors after controlling for receptive oral language, Economic Hardship, and racial/ethnic membership (see Tables 9 to 14).The predictors were entered into the model in two steps using forced entry. The first step included receptive oral language, Economic Hardship, and two contrasts for racial and ethnic membership (contrast 1 was Hispanic vs. Non-Hispanic; contrast 2 was White vs. Non-White). The second model

followed the initial predictors with the problem-solving phase of executive function that correlated with the eating behavior. Because of the significant relationships between caregiver-reports of the phases of executive function, only one phase was entered into each regression analysis.

As previously demonstrated, responsiveness to food cues was negatively associated with caregiver reports of daily functioning on problem recognition tasks ($p<.01$). Children who were viewed by their caregivers as highly responsive to food cues are also tended to be viewed as having difficulty on daily problem recognition tasks, even after accounting for receptive oral language, economic hardship, and racial/ethnic membership. The variance in Food Responsiveness accounted for (R^2) by economic hardship, racial/ethnic membership, and receptive oral language equaled .04 and was not significantly different from zero ($F(4,77)=.81$, p=.52). In step 2, the caregiver-report of problem recognition was entered into the regression equation. The change in variance accounted for by caregiver-report of problem recognition was .08, which was approaching significance ($F(5,77)=1.93$, p=.10).The unstandardized regression coefficients (*B)* and the standard errors as well as the standardized regression coefficients (β) for both models are reported in Table 9. Only the caregiver-report of problem recognition was a significant predictor of food responsiveness.

Table 9

Summary of Multiple Regression Examining the Effects of

Caregiver-Report Problem Recognition on Food Responsiveness

Model		*B*	*SE B*	β	*T*	Sig.
1	Economic Hardship	-.03	.22	-.02	-.13	.90
	Race/Ethnicity Contrast 1	-2.19	1.92	-.23	-1.14	.26
	Race/Ethnicity Contrast 2	.20	1.92	.02	.11	.92
	Receptive Oral Language	-.03	.05	-.11	-.73	.47
	R-Square			.04		
2	Economic Hardship	-.11	.22	-.07	-.52	.60
	Race/Ethnicity Contrast 1	-1.07	1.91	-.11	-.56	.58
	Race/Ethnicity Contrast 2	.92	1.88	.10	.49	.63
	Receptive Oral Language	-.04	.05	-.12	-.86	.39
	Problem Recognition	-1.57	.63	-.29	-2.48	.02
	R-Square			.12		
	R-Square Change			.08		

Food Responsiveness was negatively associated with caregiver reports of daily functioning on plan execution tasks (p<.01). Children who were viewed by their caregivers as highly responsive to food cues tended to also be viewed by their caregivers as having difficulty on daily plan execution tasks, even after accounting for receptive oral language, Economic Hardship, and racial/ethnic membership. Similar to the previous regression analysis, the variance in Food Responsiveness accounted for (R^2) by Economic Hardship, racial/ethnic membership, and receptive oral language equaled .04 and was not significantly different from zero (F(4,77)=.81, p=.52). In step 2, the caregiver-report of plan execution was entered into the regression equation. The change in variance accounted for by caregiver-report of plan execution was equal to .08, which

was approaching significance in difference from zero ($F(5,77)=1.97$, p=.09). The unstandardized regression coefficients (*B)* and the standard errors as well as the standardized regression coefficients (β) for both models are reported in Table 10. Only the caregiver-report of plan execution was a significant predictor of low Food Responsiveness.

Table 10

Summary of Multiple Regression Examining the Effects of Caregiver-Report Plan Execution on Food Responsiveness

Model		*B*	*SE B*	B	*T*	Sig.
1	Economic Hardship	-.03	.22	-.02	-.13	.90
	Race/Ethnicity Contrast 1	-2.19	1.92	-.23	-1.14	.26
	Race/Ethnicity Contrast 2	.20	1.92	.02	.11	.92
	Receptive Oral Language	-.03	.05	-.11	-.73	.47
	R-Square			.04		
2	Economic Hardship	-.22	.23	-.14	-.98	.33
	Race/Ethnicity Contrast 1	.16	2.07	.02	.08	.94
	Race/Ethnicity Contrast 2	.71	1.87	.07	.38	.71
	Receptive Oral Language	-.02	.05	-.07	-.50	.62
	Plan Execution	-1.78	.70	-.33	-2.53	.01
	R-Square			.12		
	R-Square Change			.08		

Emotional Overeating was negatively associated with caregiver reports of daily functioning on problem recognition tasks ($p<.01$). Children who were viewed by their caregivers as likely to engage in emotional overeating also tended to be viewed by their caregivers as having difficulty on daily problem recognition tasks, even after accounting

for receptive oral language, Economic Hardship, and racial/ethnic membership. The variance in Emotional Overeating accounted for (R^2) by Economic Hardship, racial/ethnic membership, and receptive oral language equaled .02 and was not significantly different from zero ($F(4,77)=.28$, p=.89). In step 2, the caregiver-report of problem recognition was entered into the regression equation. The change in variance accounted for by caregiver-report of problem recognition was .12, which was approaching significance ($F(5,77)=2.31$, p=.05). Please see Table 11. Only the caregiver-report of problem recognition was a significant predictor of low Emotional Overeating.

Table 11

Summary of Multiple Regression Examining the Effects of Caregiver-Report Problem Recognition on Emotional Overeating

Model		*B*	*SE B*	B	*T*	Sig.
1	Economic Hardship	.16	.14	.15	1.09	.28
	Race/Ethnicity Contrast 1	-.44	1.24	-.07	-.35	.73
	Race/Ethnicity Contrast 2	.009	1.24	.001	.007	.99
	Receptive Oral Language	-.01	.03	-.06	-.42	.68
	R-Square			.02		
2	Economic Hardship	.09	.14	.09	.65	.52
	Race/Ethnicity Contrast 1	.44	1.21	.07	.36	.72
	Race/Ethnicity Contrast 2	.58	1.19	.09	.48	.63
	Receptive Oral Language	-.02	.03	-.08	-.57	.57
	Problem Recognition	-1.23	.40	-.35	-3.08	.003
	R-Square			.14		
	R-Square Change			.12		

Emotional Overeating was also negatively associated with caregiver reports of daily functioning on problem analysis tasks ($p<.01$). Children who were viewed by their caregivers as likely to engage in emotional overeating also tended to be viewed as having difficulty on daily problem analysis tasks, even after accounting for receptive oral language, Economic Hardship, and racial/ethnic membership. The variance in Emotional Overeating accounted for (R^2) by Economic Hardship, racial/ethnic membership, and receptive oral language equaled .02 and was not significantly different from zero ($F(4,77)=.39$, p=.81). In step 2, the caregiver-report of problem analysis was entered into the regression equation. The change in variance accounted for by caregiver-report of problem analysis was .08, which was approaching significance ($F(5,77)=1.52$, p=.19). Please see Table 12. Only the caregiver-report of problem analysis was a significant predictor of low Emotional Overeating.

Table 12

Summary of Multiple Regression Examining the Effects of

Caregiver-Report Problem Analysis on Emotional Overeating

Model		*B*	*SE B*	B	*t*	Sig.
1	Economic Hardship	.16	.14	.15	1.09	.28
	Race/Ethnicity Contrast 1	-.44	1.24	-.07	-.35	.73
	Race/Ethnicity Contrast 2	.009	1.24	.001	.007	.99
	Receptive Oral Language	-.01	.03	-.06	-.42	.68
	R-Square			.02		
2	Economic Hardship	.02	.15	.02	.14	.89
	Race/Ethnicity Contrast 1	.24	1.23	.04	.19	.85
	Race/Ethnicity Contrast 2	.25	1.21	.04	.20	.84
	Receptive Oral Language	-.01	.03	-.07	-.48	.63
	Problem Analysis	-.20	.08	-.301	-2.43	.02
	R-Square			.10		
	R-Square Change			.08		

Emotional Overeating was negatively associated with caregiver reports of daily functioning on plan execution tasks (p<.01). Children who viewed by their caregivers as likely to engage in emotional overeating also tended to be viewed as having difficulty on daily plan execution tasks, even after accounting for receptive oral language, Economic Hardship, and racial/ethnic membership. The variance in Emotional Overeating accounted for (R^2) by Economic Hardship, racial/ethnic membership, and receptive oral language equaled .02 and was not significantly different from zero (F(4,77)=.39, p=.81). In step 2, the caregiver-report of plan execution was entered into the regression equation. The change in variance accounted for by caregiver-report of plan execution was .10, which was approaching significance (F(5,77)=1.95, p=.10). Please see Table 13. Only

the caregiver-report of plan execution was a significant predictor of low Emotional Overeating.

Table 13

Summary of Multiple Regression Examining the Effects of Caregiver-Report Plan Execution on Emotional Overeating

Model		*B*	*SE B*	B	*t*	Sig.
1	Economic Hardship	.16	.14	.15	1.09	.28
	Race/Ethnicity Contrast 1	-.44	1.24	-.07	-.35	.73
	Race/Ethnicity Contrast 2	.009	1.24	.001	.007	.99
	Receptive Oral Language	-.01	.03	-.06	-.42	.68
	R-Square			.02		
2	Economic Hardship	.02	.15	.02	.11	.91
	Race/Ethnicity Contrast 1	1.24	1.33	.20	.94	.35
	Race/Ethnicity Contrast 2	.37	1.19	.06	.31	.76
	Receptive Oral Language	-.004	.03	-.02	-.15	.88
	Plan Execution	-1.27	.45	-.369	-2.83	.006
	R-Square			.12		
	R-Square Change			.10		

Emotional Overeating was negatively associated with caregiver reports of daily functioning on plan evaluation tasks ($p<.05$); however, when controlling for receptive oral language, Economic Hardship, and racial/ethnic membership, the relationship between Emotional Overeating and caregiver reports of plan evaluation is no longer significant. The variance in Emotional Overeating accounted for (R^2) by Economic Hardship, racial/ethnic membership, and receptive oral language equaled .02 and was not significantly different from zero ($F(4,77)=.39$, $p=.81$). In step 2, the caregiver-report

of plan evaluation was entered into the regression equation. The change in variance accounted for by caregiver-report of plan evaluation was .05, which was not significantly different from zero ($F(5,77)=1.03$, p=.40). Please see Table 14.

Table 14

Summary of Multiple Regression Examining the Effects of Caregiver-Report Plan Evaluation on Emotional Overeating

Model		*B*	*SE B*	B	*T*	Sig.
1	Economic Hardship	.16	.14	.15	1.09	.28
	Race/Ethnicity Contrast 1	-.44	1.24	-.07	-.35	.73
	Race/Ethnicity Contrast 2	.009	1.24	.001	.007	.99
	Receptive Oral Language	-.01	.03	-.06	-.42	.68
	R-Square			.02		
2	Economic Hardship	.08	.15	.08	.54	.59
	Race/Ethnicity Contrast 1	.12	1.26	.02	.10	.92
	Race/Ethnicity Contrast 2	.32	1.23	.05	.26	.80
	Receptive Oral Language	-.02	.03	-.09	-.60	.55
	Plan Evaluation	-.23	.12	-.23	-1.88	.06
	R-Square			.07		
	R-Square Change			.05		

CONCLUSION

Summary

The present study addressed two main research questions. The first examined whether weight status is associated with different phases of executive function in a socioeconomically and culturally diverse sample. Not only have theoretical associations between weight status and executive function frequently been postulated (e.g. Stunkard & Steller, 1984; Stroebe, 2008), but aspects of executive function have been successfully targeted in effective weight loss programs (e.g. Cohen et al., 1980; Epstein et al., 1990). Preliminary research has supported the association between weight status and executive function at various phases of the problem solving process (Agranat-Meged et al., 2005; Cserjési et al., 2009; Gunstad et al., 2007; Gunstad et al., 2008; Levitan et al., 2004; Boeka & Lokken, 2008; Davis et al., 2004; Braet et al., 2007; Hölcke et al., 2008; Holtkamp et al., 2004; Seeyave et al., 2009; Hubel et al., 2006); however, there are gaps in the literature.

In particular, previous studies often conceptualize executive function as a unidimensional construct and rarely consider aspects of executive functioning and their joint contributions or joint effects on the outcome. In addition, research does not consistently account for racial/ethnic membership and socioeconomic status in the relationship between executive function and weight status. Even with these gaps, the preliminary empirical evidence, theoretical associations, and successful intervention programs provide support for the hypothesis that that children with higher weight status

will perform worse on measures representing the problem analysis, plan execution, or plan evaluation phases of executive function, even after accounting for race/ethnicity and socioeconomic hardship.

The second research question inquired about whether phases of the problem solving framework of executive function are associated with obesity-prone eating behaviors. Previous research has been limited to examining only the relationship between executive function and weight status. Based on the significant relation between pediatric overweight and adult weight status (Reilly, 2007), research was needed to look at how executive function relates to eating behaviors that put children at risk for overweight later in life. It was hypothesized that that children who demonstrate obesity-prone eating behaviors would perform worse on measures representing the problem analysis, plan execution, and plan evaluation phases of executive function, even after accounting for race/ethnicity and socioeconomic hardship.

Current Weight Status. Study findings did not support this study's first hypothesis that aspects of executive function will predict weight status in children. In fact, neither performance-based measures nor caregiver-report measures of executive function were associated with current weight status. Although this finding is inconsistent with some previous research (Braet et al., 2007; Cserjési et al., 2009; Hölcke et al., 2008; Holtkamp et al., 2004; Hubel et al., 2006), present study findings of associations between executive function and obesity-prone eating behaviors are consistent with previous longitudinal studies. For instance, Seeyave and colleagues (2009) and Levitan and colleagues (2004) found non-significant cross-sectional associations between

executive function and weight status; however, both studies supported a longitudinal relationship between delays in executive function early in childhood with risk for overweight later in life.

It should be noted that the current study is cross-sectional and utilized a younger sample than previous research. Because of the associations indicated between executive function and obesity-prone eating behaviors, it is likely that relationships between phases of executive function and weight status may emerge later in childhood as children continue to grow and develop. Future research is needed to examine the association between executive function and weight status from a longitudinal perspective. This could provide information about the linear growth of weight status over time and allow for the examination of developmental periods that may be most optimal or critical for intervention. Additionally, a longitudinal study design may account for the continual growth in children's executive function abilities across early childhood or adolescence.

Obesity-Prone Eating Behaviors. In relation to the second research question, study results demonstrated support for associations between aspects of executive function and obesity-prone eating behaviors. In particular, caregiver reports of problem recognition and plan evaluation were associated with Food Responsiveness even when racial/ethnic membership and Economic Hardship were accounted for. Caregiver reports of problem recognition, problem, analysis, and plan execution were associated with Emotional Overeating also when racial/ethnic membership and Economic Hardship were examined. These findings suggest that children's general appetites for food may be linked to deficits in their ability to recognize a problem and accurately execute a plan. In

addition, children who cope with their emotions through eating (i.e., Emotional Overeating) rather than by other means also exhibit deficits in their ability to recognize a problem, create a feasible plan, and then execute the plan. Ultimately, the findings provide evidence that children who struggle with phases of the problem-solving process are more likely than other children to engage in eating behaviors that increase the risk of being overweight later in life.

These findings also highlight the need for pediatric overweight intervention and prevention programs that target concrete skills focused on enhancing the ability to recognize problems, to create appropriate plans, and to accurately implement those plans. The emphasis needed on developing these skills appears to be based on the unique obesity-prone eating behaviors children might be demonstrating. For example, children who are demonstrating a high general appetite for food may struggle with specific aspects of problem recognition (initiating activity and demonstrating behavioral and cognitive flexibility) as well as aspects of plan execution (sustaining information in working memory and organizing necessary materials). Programs may need to include consistent external support through parents, teachers, and friends in order to help initiate appropriate eating behaviors and encourage or reframe rigidity that may be noted around eating habits. In addition, a plan that can frequently be referred to during the execution phase may be needed. Epstein and colleagues (1990) symbolic traffic-light diet is a good example of a concrete plan that can be provided during the execution phase in multiple modalities (e.g. written out and posted near meal areas such as the cafeteria or kitchen, auditory reminders through words, rhyme, or song before meals and snacks, or tactile

reminders such as a model stoplight with food symbols that can be attached to each category). In order to assist with organization, programs may need to help families set up environments were appropriate food is available to follow the plan and assistance is given in using appropriate cooking tools. In comparison, study findings indicate that children who cope with their emotions through eating tend to struggle globally with aspects of the problem-solving process of executive function. For these children, prevention and intervention programs may need to focus on finding other gratifying methods of coping with negative emotions, before targeting specific deficits in executive function. This indicates that prevention and intervention programs need to be flexible so that they can be uniquely tailored to the needs demonstrated by at-risk children.

Being able to account for the specific executive function deficits children may encounter likely will increase the efficacy and effectiveness of prevention and intervention programs. It is also important to note that these deficits do not appear to be specific to food-related problems, suggesting that children demonstrating obesity-prone eating behaviors experience difficulties with various aspects of executive function for a variety of problems encountered. Programs need to generalize coping strategies to other problems children may encounter (e.g. doing a long-term school project; following home rules).

Limitations and Future Research

The present study is an attempt to extend the research examining executive function and weight status as well as exploring the association between executive function and obesity-prone eating behaviors. Although some have already been noted,

there are limitations of the present study that need to be considered. First, there was no significant association between any of the performance-based measures of executive function and any of the caregiver-report measures. Researchers have theorized that performance-based tasks and caregiver-report measures capture different aspects of a child's functioning with performance-based tasks tapping short-term components of executive function and caregiver-report capturing complex every day priority-based decision making that are present in real world situations (Goldberg & Podell, 2000; Shallice & Burgess, 1991); however, the lack of significant shared variance may reflect the complex nature of executive function consisting of multiple components and appropriate measurement of these various components. Further research with adequate sample size and statistical power is needed to examine measurement of executive function in diverse samples such as measurement invariance for questionnaire and performance-based measures across age, gender, and racial and ethnic membership.

Secondly, this study used one theory of executive function. As described earlier, there is no clear consensus in the literature on the definition of executive function (Varney & Stewart, 2004). Although the abilities measured in this study are similar to those noted in other theories, a different construct definition may better encompass the complexities of executive function abilities. Additionally, the temporal nature of the problem solving phases of executive function suggests that if children demonstrate difficulties at an earlier phase, it would be expected that difficulties would arise at later phases (Zelazo et al., 1997); however, the current study did not support the temporal nature because no association was noted between the problem analysis phase of

executive function and Food Responsiveness. Research on the relationship between executive function and pediatric overweight should continue to reflect and stay up to date with the empirical understanding of the construct of executive function.

Another limitation in this study is the use of caregiver-report of obesity-prone eating behaviors. Caregiver-reports may not capture the intensity or consistency of obesity-prone eating behaviors. Behavioral measures such as food diaries, children's eating response to standardized meals varying in caloric value, and average time of food intake during meals may more accurately reflect eating behavior and provide a stronger understanding of the relationship to executive function.

It should also be noted that not all scales of the Child Eating Behaviour Questionnaire were reliable for Spanish-speaking caregivers when the form was translated into Spanish. The Satiety Responsiveness scale which measures children's ability to self-regulate their dietary intake in response to their satiety cues was not able to be examined in this study. This scale has been associated with behavioral aspects of overeating in children (Carnell & Wardle, 2007), and warrants future research to understand the relationship between satiety responsiveness and executive function.

Along with concerns regarding measurement of obesity-prone eating behaviors, it should also be noted that the use of BMI percentiles as a measure of current weight status may have impacted findings in this study. Although BMI has been found to correlate with other measures of adiposity as well as with weight status in adulthood (Dietz & Bellizzi, 1999), it does not distinguish between lean mass and fat mass (Kopelman, 2000). In fact, research indicates that BMI has poor sensitivity when used to

screen for overweight status in children. Mast and colleagues (2002) compared BMI findings with anthropometric measurements of skinfold thickness and bioelectrical impedance analysis with children between the ages five and seven years. Findings indicated that while BMI was relatively accurate screener of obesity, it under-identified overweight status in approximately 30 percent of both males and females. In a review of the literature, Freedman and Sherry (2009) contend that BMI serves as a measure of excess weight rather than excess body fatness and may not be sensitive enough to accurately capture weight status of moderately overweight children. They suggest that weight circumference and skinfold thickness measures in addition to BMI may serve as a better representation of weight status in children. Researchers need to consider the affordances allowed and most appropriate for their research designs and for their research samples, and consider the advantages and drawbacks for the various ways of assessing BMI.

Although this study found significant associations between eating behaviors and executive function even when racial/ethnic membership and economic hardship were accounted for, research is still needed to examine the roles of any third variables that may mediate the relationship. For example, research suggests that parent feeding practices such as parental control, prompting, rewarding, and restrictiveness are all associated with the loss of dietary self-regulation and ultimately weight gain in children (Arredondo et al. 2006; Johnson & Birch, 1994; Klesges et al., 1986; Faith et al., 2004). Additionally, global parenting practices have been found to be associated with executive functioning. Practices such as parental responsiveness, maternal warmth, and parental

instruction have all been shown to relate to demonstrated self-regulatory behaviors in children (Bradley et al., 2001; Jennings et al., 2008; LeCuyer-Maus & Houck, 2002; Houck & LeCuyer-Maus, 2004).

Finally, because of the limited number of participants, this study was not able to compare differences in associations between overweight and obese children or between normal weight and underweight children. Future research is needed to examine the differences between pediatric populations. Finally, it is important to note that this was a sample of convenience in that only volunteers were included and the study was limited geographically to just the southwestern region of the United States. It should not be generalized without appropriate caution and future research should be conducted to examine these associations in other cultural samples.

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