PREDICTING COLLEGE STUDENTS' FOOD INTAKE WITH MEASURES OF EXECUTIVE FUNCTIONING

by

Christine C. Elliott

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Thesis Committee:

Dr. Seth J. Marshall

Dr. James Rust

Dr. Elroy Sullivan

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ABSTRACT

The purpose of this study was to investigate how, and to what extent, dimensions of executive functioning (EF) predict college students' food intake based on US Department of Agriculture's proportion food groups, namely, fruits, vegetables, grains, dairy, protein, and fats/sweets. Ninety-eight participants were administered a self-report EF measure, the Behavior Rating Inventory of Executive Function-Adult Version (BRIEF-A; Guy, Isquith, & Gioia, 2005), which assesses EF behavior regulation and metacognitive skills. In addition, two clinical measures of EF were administered, the Tempe Sorting Task (Marshall, Wodrich, & Gorin, 2009), a measure of EF inhibition, and Digit Span, which is a working memory subtest of the *Wechsler Adult Intelligence Scale–Fourth Edition* (WAIS-IV; Wechsler, 2008). To obtain a measure of food intake, participants were also administered the Personal Wellness Profile (PWP; Wellsource Inc., 1998). Results indicated that self-ratings of EF behavior regulation and metacognitive skills successfully predicted food intake scores. EF metacognitive skills appeared to be a better predictor of food intake when compared to EF behavior regulation. In comparison to the predictive ability of the EF rating scale, the clinical measures were not associated with food intake. There was an absence of significant added value of EF clinical measures when rating scale scores already existed.

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CHAPTER I

Introduction

The purpose of the current study is to examine the relationship between executive functioning (EF) and food intake. The two main EF constructs in this study are inhibition and working memory. The construct of food intake is based on the U.S. Department of Agriculture proportion guidelines for five food groups, namely, fruit, vegetable, grains, protein, and dairy. In the first section of the literature review, EF is operationally defined. Then, brain regions associated with EF inhibition and working memory, and EF measurement are reviewed. In the second section of the literature review, food intake is introduced. Correspondingly, the five groups are defined and current nutritional research is reviewed. Lastly, the purpose of this study and hypotheses are presented.

Definition of Executive Function

The first major construct of this study is executive functioning (EF). EF is a concept that refers to a set of higher order cognitive processes that work together to organize complex goal-directed behavior (Welsh, 1994). Denckla (1996), one of the first to use the term clinically, defined EF as control processes that "involve inhibition and delay of responding" for the goal of "organization and integration of cognitive and output processes over time" (p.265-266). Moran and Gardner (2007) describe EF as the integration of three parameters, namely (1) hill, (2) skill, and (3) will. First, "hill," is a metaphor for the ability to set clear goals for future operations. Second, "skill" refers to what an individual can do or can learn to do. Third, "will," is defined as the initiative and perseverance needed to accomplish set goals. Essentially, these three EF parameters must operate together for successful task conceptualization, execution, and completion. (Friedman et al., 2008; Shao, Roelofs, & Meyer, 2012; Welsh, Nix, Blair, Bierman, & Nelson, 2010).

While there are a variety of conceptualizations of EF, most researchers recognize three core components of EF. These include (1) interference control, (2) effortful and flexible organization, and (3) strategic planning or the readiness to act (Denckla, 1994; Miyake et al., 2000; Zheng et al., 2012). First, interference control is the ability to disregard irrelevant information while performing goal-oriented tasks (Burgess, Gray Conway, & Braver, 2011). For example, an individual having a conversation may need to selectively focus their attention on a voice while filtering out extraneous noise such as other people talking nearby. Second, effortful and flexible organization is the ability to organize through ongoing updating by using trial-and-error. For example, an individual may need to flexibly and continually rearrange a schedule to make time to attend a doctor's appointment. Third, strategic planning or the readiness to act is the ability to prepare for the future by formulating appropriate responses. For example, a teenager in band class will mentally prepare to play a piece of music in anticipation of being called on by his teacher to perform in front of the class. Overall, these three components of EF, interference control, effortful and flexible organization, and strategic planning or the readiness to act, work together to facilitate goal-oriented problem solving across time (Denckla, 1996).

Executive Function and the Frontal Cortex

EF is associated with the brain's frontal lobes, specifically the prefrontal cortex located within the forehead region of the skull. Historically, case studies of damage to the frontal cortex have been the primary method for understanding this brain region. For example, in 1868, Phineas Gage, a railroad foreman was injured on the job when an explosion propelled a three foot tamping iron into his left check, through his frontal area, and out through the top of his skull. After the accident, friends and family noticed that Gage's personality changed. Before the accident, he was known as a man who was "very energetic and persistent in executing all his plans of operation." After the damage to the frontal lobes, medical documentation reported that Gage became "fitful, irreverent, indulging at times in the grossest profanity, manifesting but little deference for his fellows, impatient of restraint or advice when it conflicts with his desires, at time pertinaciously obstinate, yet capricious and vacillating, devising many plans of future operation, which are no sooner arranged than they are abandoned in turn for others appearing more feasible" (Harlow, 1868 p. 339-340). This hallmark case study and many others since suggest that the prefrontal cortex is associated with a variety of higher order cognitive skills such as the ability to sustain attention, plan, reason, and orientate behavior flexibly toward goal attainment. Collectively, cognitive control associated with the frontal lobes is synonymous with the construct of EF.

The prefrontal cortex is recognized as the last area of the brain to mature. Current research suggests that development of the frontal lobes continues until approximately age 30 (Spencer-Smith & Anderson, 2009). During the early decades of life, the frontal lobes appear to undergo considerable reorganization in a stepwise developmental process. Many studies have documented this gradual maturation. For example, Durston et al. (2006) administered fMRIs to fourteen children at age 9 and again at age 11. Comparison of the brain scans from time 1 to time 2 indicated considerable brain activity changes in many areas including the prefrontal cortex. Other studies have documented that before puberty there is dramatic increase in synaptic formation. After puberty, there appears to be substantial reorganization as synaptic connections are eliminated (Blakemore & Choudhury, 2011; Rakic, Bourgeois, & Goldman-Rakic, 1994). Together, these studies and others suggest that EF development corresponds with the changes in the prefrontal cortex. This stepwise development extends through childhood and adolescence into early adulthood.

In general, the frontal lobes are viewed as the structure that characteristically separates humans from other species. In terms of evolution, human existence has been termed the "age of the frontal lobe" (Stuss & Benson, 1986). Many higher order thinking skills, such as drawing inference, problem solving, exercising restraint, and shifting attention correspond with this brain region (Denckla, 1994; Elliott, 2003; Miyake et al., 2000; Posner & Rothhart, 1998; Zheng et al., 2012).

EF Inhibition

The first main EF dimension of this study is inhibition. This is recognized as the ability to control impulses and stop the behavior (Gioia, Isquith, Guy, & Kenworthy, 2000). Miyake et al. (2000) describe this as the deliberate suppression of a prepotent response. For example, an individual with a habitual response of throwing objects when frustrated may learn that the behavior is inappropriate and successfully inhibit the dominant behavior when frustrated (Quay, 1997). Fundamentally, inhibition creates a delay between impulse and action. This allows an individual to restrain motivated behaviors before and/or after the behaviors are initiated (Barkley, 1997; MacLeod, 2007; Miyake et al., 2000; Pennington & Ozonoff, 1996). Difficulty with inhibiting behavior is related to a host of negative outcomes such as inattention and the lack of self-control. For example, Kooijmans, Scheres, & Oosterlaan (2000) investigated the relationship between inhibition and psychopathology in 42 nonclinical elementary children, ages 6 to 12. Participants were administered a stop signal task that required them to inhibit a prepotent response. In addition, participants were administered a measure of psychopathology that indicated children externalizing and internalizing behaviors. Results indicated that response inhibition was positively related to externalizing behavior. This suggests that children with inhibitory control deficits may show higher levels of externalizing behavior. Similarly, Bohlin, Eniger, Brocki, & Thorell (2012) administered clinical and behavioral EF measures and a play-based measures of attachment to 65 children who were five years of age. Many of the children in the sample had a history of significant externalizing behaviors. Results indicated that poor inhibition was associated with negative outcomes such as disorganized attachment styles, ADHD symptoms, Autism spectrum disorder symptoms, and callous-unemotional traits. Generally, these studies highlight the importance of inhibitory control and illustrate that, when impaired, inhibition is associated with many negative outcomes.

EF Working Memory

The second main EF dimension of this study is working memory. This is recognized as the ability to hold information in the mind for the purpose of completing tasks (Gioia et al., 2000). Similarly, Baddeley (1986) described it as visual and verbal subsystems that mentally catches and holds information “on line,” so that it can be manipulated and transferred to long-term storage (Goldman-Rakic, 1994). For example, if an individual is given a six-step set of instructions, the information must be stored in working memory. While stored, the information must be periodically updated and revised as the individual completes each step of the instructions. Essentially, working memory allows for the flexible manipulation of information needed to problem solve (Redick, Calvo, Gay, & Engle, 2011).

Research suggests that working memory difficulties are associated with a number of negative learning characteristics. For example, Menghini, Finzi, Carlesimo and Vicari (2011) investigated working memory deficits in children that were diagnosed with dyslexia aged 8 to 13 (n = 100). Two groups of children, namely 54 children with dyslexia and 46 typical readers were administered a variety of tests that included verbal and visual working memory tasks (e.g., verbal and visual-spatial tasks). Results indicated that children with dyslexia, when compared to typical readers, exhibited significantly increased impairments in verbal and visual working memory tasks. This suggests that working memory difficulties are associated with reading problems. Historically, phonological deficits have received most of the attention in reading research. These findings suggest that working memory is also a key component. Recently, Alderson, Hudec, Patros, & Kasper (2013) studied working memory deficits in adults with attention-deficit/hyperactivity disorder (ADHD) aged 18 to 24 (n = 37). Two groups of adults, namely 21 adults with ADHD and 16 adults without ADHD were administered a variety of EF measures including phonological and visuospatial working memory tasks. Results indicated that adults with ADHD, when compared to adults without ADHD, exhibited significant working memory deficits. Essentially, impaired working memory is associated with negative outcomes including difficulty with learning, reading, and studying.

Inhibition and Working Memory Correspondence

Theoretically, inhibition and working memory should be viewed as closely related. Barkley (1997) explained that individuals who effectively refrain from irrelevant responses should be successful with processing and storing important information in working memory. Similarly, Al-Aidroos, Ferber, Emrich, & Pratt (2012) suggested that working memory allows for the processing of new information by inhibiting old material from being reselected for attention. Recent research has supported this correspondence. McNab, Leurox, Strand, Thorell, Bergman, & Klingberg (2008) administered clinical EF tasks and fMRIs to 11 university students. Results indicated common activation in the prefrontal cortex linking inhibition and working memory. The authors highlighted the association between the two constructs but pointed out that the results do not suggest that they are the same cognitive function. In fact, research supports the notion that they are indeed distinct. For example, Lambek & Shevlin (2011) administered EF inhibition and working memory measures to 239 seven to sixteen year-old children. Using a multi-group confirmatory factor analysis, results yielded three factors, namely, verbal working memory, visual working memory, and inhibition. Results suggested that inhibitory control and both types of working memory skills constitute different, although correlated, EFs. Though related to some degree, inhibition and working memory appear to be independent of each other. For the purpose of this study, each trait will be individually investigated.

Food Intake

The second major construct of this study is food intake. According to Riggs, Chou, Spruijt-Metz, & Pentz (2010), food intake is the dietary consumption by mouth of particular food items, such as fruit, vegetables, and snacks. Similarly, Togo, Osler, Sorensen, & Heitmann (2001) defined food intake as the amount and frequency that food is consumed in the regular diet. Despite definitional differences, most researchers agree that dietary consumption is the key aspect of this construct.

Researchers also agree that food intake is a key component of nutrition. However, it is noted that nutrition is a much broader construct compared to food intake. It encompasses many domains such as biological, biochemical, and behavioral aspects. For example, Beaumon and colleagues (2005) explains that nutrition is broadly “the study of food systems, foods and drinks, and their nutrients and other constituents; and of their interactions within and between all relevant biological, social and environmental systems.” In other words, nutrition is the “the study of food and drink in all its aspects” (Mottram & Graham, 1956). In comparison, food intake is merely one dimension of nutrition. It is a more specific construct that refers to the amount and frequency of food orally consumed.

Researchers recognize that food intake is a key component of general health. Recent studies have highlighted that many individuals struggle with this dimension of nutrition. For example, Kimmons, Gillespie, Seymour, Serdula, & Blanck (2009) reported that fewer than one in 10 Americans meet the USDA’s dietary food recommendations for fruit or vegetables food intake. Moreover, research also indicates that individuals with poor food intake report higher rates of a variety of health conditions such as depression, heart disease, diabetes, high blood pressure and food allergies (Casagrande et al., 2011; He, Nowson, Lucas, & MacGregor. 2007; Savica, Bellinghieri, & Kopple, 2010; Vozoris & Tarasuk, 2003). Griep, Verschuren, Kromhout, Ocke, &

Geleijnse (2011) investigated the food intake of 20,069 Dutch participants (8,988 men and 11,081 women, ages 20 to 65 years) between 1993 and 1997. Participants were administered food intake self-report questionnaires. Participants reported the type of food, based on 178 items, and the frequency (e.g., times per day, week, and month) of the food that they consumed. Baseline measurements of a variety of other variables were also taken such as body weight, height, physical activity, smoking status, blood pressure, and blood samples. Results indicated that healthy food intake, such as high raw fruit and vegetable consumption, was inversely related with poor health outcomes such the incidents of strokes. The results of this study match other studies that suggest that healthy food intake is associated with mental and physical health factors even when controlling variables such as income, gender, and ethnicity (Casagrande et al., 2011; Davison & Kaplan, 2012; Grisaru, Kaufman, Mirsky, & Witztum, 2011; Nunes et al., 2010; Sorsdahl et al., 2011).

In response to the noted importance of food intake, organizations such as the U.S. Department of Agriculture (USDA) and the U.S. Department of Health and Human Services (DHHS) have developed recommendations for healthy food intake. This has resulted in the USDA food guide, *MyPlate* that was released in 2011. The main goal for the initiative is promote a well-balanced diet and good health (USDA, 2013). This initiative replaced the well-known food pyramid that was released in 1992 and included food groups and portion sizes groups for fruit, vegetable, grains, protein, and dairy and classifies oils/fats. MyPlate is an updated model that identifies and recommends daily meal proportions for five food groups which are pictorially illustrated to increase user-friendliness.

For the purposes of this study, food intake will be based on the USDA's proportion guidelines for five food groups, namely, fruit, vegetable, grains, protein, and dairy. The additional category of fats/sweets will also be included to better understand students' food intake. Below, each of these groups is defined and corresponding research is presented.

The first food group is fruit. According to the 2013 USDA guidelines, foods this group includes fruit that is fresh, canned, frozen, or dried. This group also includes 100% fruit juices such as apples, oranges, raisins, and strawberries. In general, one cup of fruit is the equivalent to one small apple. Research pertaining to fruit intake suggests a correspondence with body mass index (BMI). Dehghan, Akhtar-Danesh, & Merchant (2011) surveyed 5,512 Canadians individuals between the ages of 18 and 64 years. Results indicated a significant association between total fruit and vegetable intake and BMI. Specifically, overweight individuals reported significantly lower fruit and vegetable intake compared to the normal weight group. The researchers also noted that individuals who reported that they had never smoked consumed more fruit and vegetables than individuals that smoked occasionally or daily. Generally, these findings suggest that fruit intake is associated with healthy behaviors.

According to the 2013 USDA, the vegetable food group includes vegetables that are raw, cooked, fresh, frozen, canned, or dried. This group includes 100% vegetable juice, such as spinach, corn, beans, and peas. In general, one cup of vegetable is equivalent to one large baked sweet potato or one large ear of corn. Vegetable intake research has linked this food group to a variety of healthy factors. Griep, Verschuren, Kromhout, Ocke, & Geleijnse (2011) reported that vegetable consumption was inversely associated with ischemic strokes that suggested that vegetable intake may act as a stroke protector. Furthermore, Dehghan, Akhtar-Danesh, & Merchant (2011) analyzed the relationship between vegetable consumption and healthy lifestyles. Participants (*n* = 15,512), ages 18 to 64, were administered a food frequency questionnaire (i.e., 20 items) assessing different types of food intake. Results indicated a negative correlation between vegetable intake and obesity. These studies together suggest that vegetable consumption is also an important component of a well-rounded diet.

The grains food group is defined by the USDA as any food made from wheat, rice, oats, cornmeal, barley, or grain product. Examples of foods in the group might include oatmeal, cereal, tortillas, or grits among many others. The USDA recommends that at least half of all grains eaten should be whole grains. In general, one ounce equivalent of grains is equivalent to one slice of bread or one half cup of cooked rice. Studies show a diet high in whole grain foods is correlated with a lower risk of developing cardiovascular disease (CVD) (Larsson, Mannisto, Virtanen, Kontto, Albanes, & Virtamo, 2009; Mellen, Walsh, & Herrington, 2007). For example, Kim, Stote, Behall, Spears, Vinyard, & Conway (2009) studied the relationship between whole grain intake and diabetes in obese women (*n* = 17) with the mean age of 51 years. Many of the participants in the sample were at-risk for insulin resistance. Participants were administered a series of wheat and/or barley meals. In addition, blood samples were taken periodically to obtained glucose and insulin readings. Results indicated that whole grain consumption was associated with beneficial effects related to glucose and insulin response. Similarily, Esmaillzadeh, Mirmiran, & Azizi (2005) investigated the relationship between whole-grain consumption and metabolic syndrome. Participants (*n*

= 827) with metabolic risk factors, ages 18 to 74, were administered a food frequency questionnaire. Participants reported the type (e.g., bread, cereal, or pasta) and frequency (i.e., daily, weekly, or monthly) of food grain consumption. In addition, participants' body mass index was measured and blood samples and blood pressure were obtained. Results indicated that whole grain intake was inversely related to metabolic risk factors such as high cholesterol. Together these findings suggest that grain intake is also a dimension of a healthy diet that is associated with a variety of preventative health factors.

The protein food group is defined as any food from meat, poultry, seafood, beans, peas, eggs, nuts, and seeds. However, according to the USDA, beans and peas can be included in either the vegetable or protein food group. Examples of foods in this group might include hamburger, almonds, and cod fish. In general, one ounce is equivalent to one small steak or one egg. Protein intake research has linked this food group to a variety of healthy factors. Specifically, animal protein intake appears to be significantly correlated with bone health (Beasley et al., 2010; Heaney, & Layman, 2008). A variety of studies suggest that this applies strongly to postmenopausal women (Bonjour, 2005; Darling, Millward, Torgerson, Hewitt, & Lanham-New, 2009; Wengreen et al, 2004). For example, Misra et al. (2011) studied the relationship between protein intake and hip fracture in 946 men and women with the average age of 75. Participants were administered food frequency questionnaires and protein intake was assessed. Results indicated that higher consumption of protein intake was significantly associated with reduced risk of hip fracture. Essentially, protein consumption is associated many health outcomes including bone health.

The dairy food group includes fluid milk products and foods made from milk that retain their calcium content. Examples of foods in this group include yogurt, puddings, soymilk, and cheese. The USDA does not include cream cheese or butter in this food group as it provides little to no calcium. In general, one cup of dairy is equivalent to one-third cup of shredded cheese or two cups of cottage cheese. Research suggests that dairy food intake may counteracting many chronic ailments such as bone loss, heart disease, obesity, and hypertension (Leite & Sampaio, 2010; Rice, Quann, & Miller, 2013; Tenta, Moschonis, Koutsilieris, & Manios, 2011). For example, Leite & Sampaio (2010) analyzed the relationship between dairy food intake and metabolic syndrome in 100 individuals with HIV/AIDS, ages 22 to 65. Participants were administered a series of food and lifestyle questionnaires. Results indicated that lower dairy intake was related to metabolic syndrome and hypertension. Other studies have documented that dairy intake may provide increased protection against colon cancer (Holt, 2008; Huncharek, Muscat, & Kupelnick, 2009). These and other studies suggest that dairy is a key food group associated with health protection.

In addition to the five-food groups, the USDA recognizes fats and sweets as foods that should be generally limited as they often provide empty calories or little nutritional value. This recommendation has been based on research that suggests the intake of fats and sweets is associated with a number of poor health outcomes such as cardiovascular disease and obesity. For example, Sokup, Mioduszewska, Bak, & Kotzbach (2010) investigated the relationship between diabetes and consumption of snacks, namely sweets and fruit among 83 diabetic women, ages 20 to 46. Participants were administered a 56 item questionnaire to assess eating habits prior to their diagnosis of diabetes. Results indicated that frequent consumption of sweets was significantly related to diabetes. Similarly, Maffeis et al. (2012) compared the saturated fat intake in 114 children, ages 6 to 16, with diabetes to 448 children without diabetes. Each child was administered food intake interviews and assessed for cardiovascular risk factors such as obesity. Results indicated that children with diabetes, when compared to healthy children, exhibited increased levels of fat intake. These findings corroborate others studies that highlight the link between in intake of fats/sweets and poor health outcomes.

Knowledge of the reviewed food groups and appropriate food intake appears to improve dietary habits (Cooper et al., 2012; Eicher-Miller, Fulgoni, & Keast, 2012). For example, Kolodinsky, Harvey-Berino, Berlin, Johnson, & Reynolds (2007) investigated the food intake of 200 college students using an internet-based survey. Results indicated students' understanding of the USDA's dietary guidelines corresponded with healthy food intake. Moreover, nutrition labeling that serving sizes and information about the five food groups appeared to increased students' healthy food intake.

EF and Nutrition

The relationship between EF and nutrition has recently emerged as an area of empirical investigation. Conceptually, this is to be expected as nutrition incorporates many cognitive and behavioral aspects such as motivation and self control (Chung et al., 2012; Davison & Kaplan, 2012; Hall, 2012). This has been highlighted in a variety of studies. For example, Hall (2012) investigated the relationship between EF and fat intake. Participants (*n* = 208) between the ages of 18 and 89 were administered an intelligence test and two computer EF measures of inhibition. Also, on two occasions, participants completed the National Cancer Institute's Fat Screener to assess the frequency of fatty and nonfatty food consumption. Results indicated a significant association between EF inhibitory control and fatty food consumption even after controlling for age, gender, income, BMI and intelligence quotient (IQ). The authors explained that individuals with stronger EF skills appear to be better able to avoid or limit their fatty foods intake compared to individuals with poor EF skills. Similarly, Riggs et al. (2010) researched the relationship between executive function, food intake, and physical activity. Fourth grade students (n = 184) were administered the Behavioral Rating Inventory of Executive Function, Self-Report (Guy, Isquith, & Gioia, 2005) and the adjusted Nurse's Health Study survey (Willett et al., 1985). Participants were also administered an adapted version of the Physical Activity Questionnaire for Older Children (Crocker, Bailey, Faulkner, Kowalski, & McGrath, 1997) to assess physical activity. Results indicated a significant negative correlation between EF and snack food intake. EF was also significantly correlated with fruit and vegetable intake, and physical activity in non-structured activities. These findings suggest that EF is associated with food intake.

In addition, Salmon, Fennis, De Ridder, Adriaanse, & De Vet (2013) researched the relationship between self-control and food choice. Participants (n = 177) were administered a self-report questionnaire that measured their current hunger level. Participants were also administered two tasks, namely a self-control task and a food-choice task. Results indicated that poor self-control was significantly associated with poor food-choice. These studies suggest an association between EF and dietary eating behaviors. Individuals with high EF skills consistently demonstrate a higher degree of fatty food avoidance, while individuals with low EF skills demonstrate a lower degree of self-control. Additionally, individuals with poor EF seem to have greater difficulty with making healthful food choice in an unstructured environment. Despite the current literature on EF and nutrition, more research is needed to clarify the nature and extent of relationship between various EF components and nutrition variables such as food intake (Riggs et al., 2010; Rollins, Dearing, & Epstein, 2010).

Purpose of Current Study

The primary purpose of this study is to examine the extent to which EF inhibition and working memory predict food intake. Below, each rationale and hypothesis is provided.

Hypothesis One

It is hypothesized that self-ratings of EF (Inhibition and Working Memory) taken together will be related to students' total Food Intake Quality scores.

The first hypothesis examines how and to what extent students' self-ratings of EF inhibition and EF working memory taken together will be related to students' total food intake quality scores. It is anticipated that Food Intake Quality scores reflect mental skills that depend on EF abilities. Conceptually, it is feasible that increased inhibitory control and working memory corresponds with maintaining healthy food intake. For example, individuals with better EF inhibition may better refrain from high levels of fats and sweets. Individuals with better EF working memory will better plan their day-to-day dietary activities as reflected in their quality scores.

Hypothesis Two

It is hypothesized that clinical measures of EF (inhibition and working memory) taken together will be related to students' total food intake quality scores.

The second hypothesis examines how and to what extent clinical measures of the EF constructs (impulsivity and working memory) taken together predict students' quality of food intake based on USDA recommendations. This hypothesis is similar to the first, though it investigates the utility of clinical measures in predicting food intake.

Hypothesis Three

It is hypothesized that students' self-ratings of EF Inhibition and EF Working Memory combined with clinical measures of the EF Inhibition and EF Working Memory will predict students' quality of food intake based on USDA recommendations.

The third hypothesis examines how and to what extent students' self-ratings of EF inhibition and EF working memory, combined with clinical measures of the EF inhibition and EF working, predict student's total food intake. It is anticipated that clinical EF measurement and behavior rating scales each measure food intake differently and each will make independent contributions.

CHAPTER II

Methods

Ninety-eight undergraduate students were recruited at a public university in the midsouth United States. Inclusion criteria were: a) psychology research pool participants, and b) currently attending the university. Exclusion criteria were a) vision or hearing problems and b) under the age of 18. Before contacting potential participants and conducting the experiment, approval was secured through the Middle Tennessee State University (MTSU) Human Subjects Committee (Institutional Review Board [IRB]). Participants were provided a written description of the study and asked to sign a letter of informed consent indicating their permission to participate in the study (see Appendix A). Before the data were collected, each student was informed that he/she had the option to decline participation in the study and was free to stop at any time (See Appendix B).

Participants

The sample was composed of students from the following ages: 26.5% (n = 26) were 18 years old, 25.5% (n = 25) were 19 years old, 24.5% (n = 24) were 20 years old, 9.2% (n = 9) were 21 years old, and 15.3% (n = 15) were 22 years old or older. In the sample, 51 % (n = 50) were male. Based on the students' report of their ethnicity 61% (n = 60) were White or Caucasian, 24.5% (n =24) were Black or African American, 2.0% (n =2) were Asian, 3.1% (n = 3) were Hispanic or Latino, 5.1% (n = 5) were "other," and 4.1% (n = 4) were unknown.

Measures

Clinical Measures of Executive Function

The Tempe Sorting Task

The Tempe Sorting Task (TST) is an EF measure developed by Marshall et al. (2009) that is based on Denckla's (1994) Core Characteristics of EF Measures. The TST assesses a individual's ability to inhibit previously learned responses while performing a sorting task under a timed condition. For the purposes of this study, the TST was adapted for computer administration. Individuals were shown how to place 32 manipulable symbols of four types, namely, black-square, black-circle, white-square, or white-circle, displayed at the bottom of the computer screen to the corresponding graphical symbol illustrated above the empty boxes. The individual's task was to sort the manipulable symbols, by dragging the mouse as fast as possible, into the appropriate box according to the prescribed symbol stimuli image.

The TST is administered in one Baseline Trial and three EF trials under timed conditions. During the Baseline Trial, students are required to sort all of the manipulable images into boxes regardless of symbolic stimuli. The chief purpose of this trial is to obtain a motor skill baseline in seconds. This time is subsequently subtracted from future trials in efforts to obtain a processing speed time that excludes motor skill. During EF Trial One (Congruent Shape, Congruent Color Trial), students are required to place manipulable images into empty boxes with corresponding symbol stimuli (square manipulable symbols in square boxes, circle manipulable symbols in circle boxes, black manipulable symbols in black boxes, and white manipulable symbols in white boxes). During EF Trial Two (Congruent Shape, Incongruent Color Trail), students are required to place square manipulable images in square boxes and circle manipulable images in circle boxes, but to select the manipulable with color opposite the graphical symbol stimulus (black manipulable image in white box and white manipulable image in black box). During EF Trial Three (Incongruent Shape, Congruent Color Trial), students are required to place black manipulable images in black boxes and white manipulable images in white boxes, but to place square manipulables into circle boxes and circle manipulables into square boxes.

Two scores are calculated for each of the EF Trials: Completion Times and Error Points. Completion Times are based on the amount of time, in seconds, required for a child to complete each trial. Error Points are based on a system that assigns points for progressively greater problems in sorting execution. Poor performance on the TST could be defined as extended Completion Times and high Error Points. Poor performance would presumably provide evidence for lack of impulse control and inhibition.

Digit Span

Digit Span (DS) is a subtest of the *Wechsler Adult Intelligence Scale–Fourth Edition* (WAIS-IV; Wechsler, 2008). The DS assesses working memory abilities, specifically the ability to encode, mentally manipulate information, and to flexibly sequence numbers. For this study, only the DS backward was utilized. This measure served as the clinical measure of EF working memory. During DS backward, participants are presented a sequence of numbers verbally and are instructed to repeat the sequence back to the examiner in reverse order. This task requires a child to hold information in working memory. In addition, DS backwards requires children to mentally re-sequence or manipulate information. Poor performance during the subtest, as defined as short digit span recall and incorrect sequencing of numbers provides evidence of working memory problems, cognitive inflexibility, and lack of mental alertness. DS qualifies for a fixed indicator of effort (Young, Sawyer, Roper, & Baughman, 2012). It is noted that for the purposes of this study, raw scores of DS backward were used. Administration of the subtest will follow WAIS-IV guidelines.

Reliability and validity of the DS were established with a national norming sample of 2,200 adults between the ages of 16 to 90 was selected from the 2005 U.S. Census data. The national sample was stratified by sex, education level, ethnicity, and region. WAIS-IV validity studies were equated with WISC-IV age group 16:0-16:11. Test-retest stability for the subtest for all ages of children was .83. DS internal consistency was above .89 in all age groups. Split-half reliability for DS was .93.

Behavior Measure of Executive Function

Behavior Rating Inventory of Executive Function

The Behavior Rating Inventory of Executive Function-Adult Version (BRIEF-A) was developed by Psychological Assessment Resources, Inc. as a self-report rating scale to assess an individual’s ability to self-regulate his or her emotions and behavior (Gioia et al., 2000). This clinically validated behavior questionnaire is comprised of 75 questions that measures multiple EF areas (see Appendix C), namely inhibit, shift, emotional control, self-monitor, initiate, working memory, plan/organize, task monitor, and organization of materials (Gioia et al., 2000).

Rating scale responses are based on a three point Likert scale ranging from N (if the behavior is Never a problem), S (Sometimes a problem) to O (Often a problem). Participants circle the answer that best describes their behavior over the past month.

Examples of the inhibit items are: “I tap my fingers or bounce my legs” and “I have trouble sitting still.” Examples of the shift questions include: “I have trouble changing from one activity or task to another” and “After having a problem, I don’t get over it easily.” Examples of the emotional control items are: “I have angry outbursts” and “I overreact emotionally.” Examples of the self-monitor questions are: “I don’t notice when I cause others to feel bad or get mad until it is too late” or “I talk at the wrong time.” Examples of the initiate items are: “I need to be reminded to begin a task even when I am willing” and “I have trouble getting ready for the day.” Examples of the working memory questions are: “I have trouble concentrating on tasks (such as chores, reading, or work) or “I have trouble with jobs or tasks that have more than one step.” Examples of the plan/organize items are: “I have trouble prioritizing activities” and “I start tasks (such as cooking, projects) without the right materials.” Examples of the task monitor questions are: “I don’t check my work for mistakes” and “I misjudge how difficult or easy tasks will be.” Examples of the organization of materials are: “People say that I am disorganized” or I lose things (such as keys, money, wallet, homework, etc.).”

Reliability and validity of the BRIEF-A Self-Report Form were established with a normative sample of 1,050 individuals between the ages of 18 to 90 who had no history of diagnosis or treatment of psychiatric illness, learning disorder, neurological disorder, or serious medical illness. Three measures of reliability were evaluated by calculating alpha coefficients: (a) internal consistency, (b) test-retest stability, and (c) interrater agreement. The internal consistency alpha coefficients for the BRIEF-A Self-Report Form and its nine subscales are as follows: inhibit (.73), shift (.78), emotional control (.90), self-monitor (.78), initiate (.79), working memory (.80), plan/organize (.85), task monitor (.74), and organization of materials (.84). Test-retest data was gathered from a subsample of 50 individuals (22 males and 28 females) across a four week interval. Pearson product-moment correlation coefficients were as follows: inhibit (.91), shift (.89), emotional control (.90), self-monitor (.83), initiate (.85), working memory (.92), plan/organize (.82), task monitor (.84), and organization of materials (.93). Interrater agreement correlations between the BRIEF-A Self-Report Form and Informant Report form Ratings were gathered from a subsample of 180 individuals (50% males and 50% females ranging from 19 to 88 years). A Pearson product-moment correlation coefficients were as follows: inhibit (.62), shift (.44), emotional control (.68), self-monitor (.48), initiate (.59), working memory (.60), plan/organize (.55), task monitor (.46), and organization of materials (.59).

Lifestyle Measures

Physical Wellness Profile

The Personal Wellness Profile (PWP) was developed by Wellsource, Inc. as a self-report rating scale to assess an individual's lifestyle and health (Wellsource, 1998). This scientific, health-based questionnaire was written to identify health factors associated with exercise, nutrition, and health (Gioia et al., 2000). The assessment form has seventy-five questions pertaining to the following wellness areas: health history, physical activity, eating practices, alcohol, drugs, smoking, stress and coping, social health, safety, medical care, and health view (see Appendix D).

The PWP is widely used in the wellness health sector and is has been reviewed by the American Cancer Institute, American College of Sports Medicine, American Heart Association, U.S. Department of Health and Human Services, National Center of Health

Statistics. The measure assesses good health practices that are linked to increased life expectancy as well as behavioral risk factors that are linked to premature deaths and chronic disabilities. The good health practices assessment has subtests that measure lifestyle daily activities such as not smoking, eating a good breakfast daily, regular aerobic exercise, hours of sleep daily and avoidance of frequent snacking.

CHAPTER III

Results

For this study, three hypotheses were addressed. Below, each hypothesis is reviewed and the corresponding multiple regression results are presented (see Table 1 and Figure 1).

Table 1

Means, Standard Deviations, and Intercorrelations for Predictor and Outcome Variables (N=98)

Variable	*M*	*SD*	1.	2.	3.	4.	5.	6.
1. Food Intake	64.88	11.67	--					
2. BRIEF Overall	113.89	19.65	-.303**	--				
3. BRIEF Metacognition Index	65.30	12.33	-.295**	.934**	--			
4. BRIEF Behavioral Regulation Index	48.59	9.25	-.250*	.880**	.652**	--		
5. Digit Span	8.26	2.33	-.007	-.055	-.004	-.130	--	
6. Tempe Sorting Task	2.97	3.89	.022	-.245*	-.212*	-.237*	.063	--

*Note. * p <. 05. ** p < .01 and N=92 for Tempe Sorting Task*

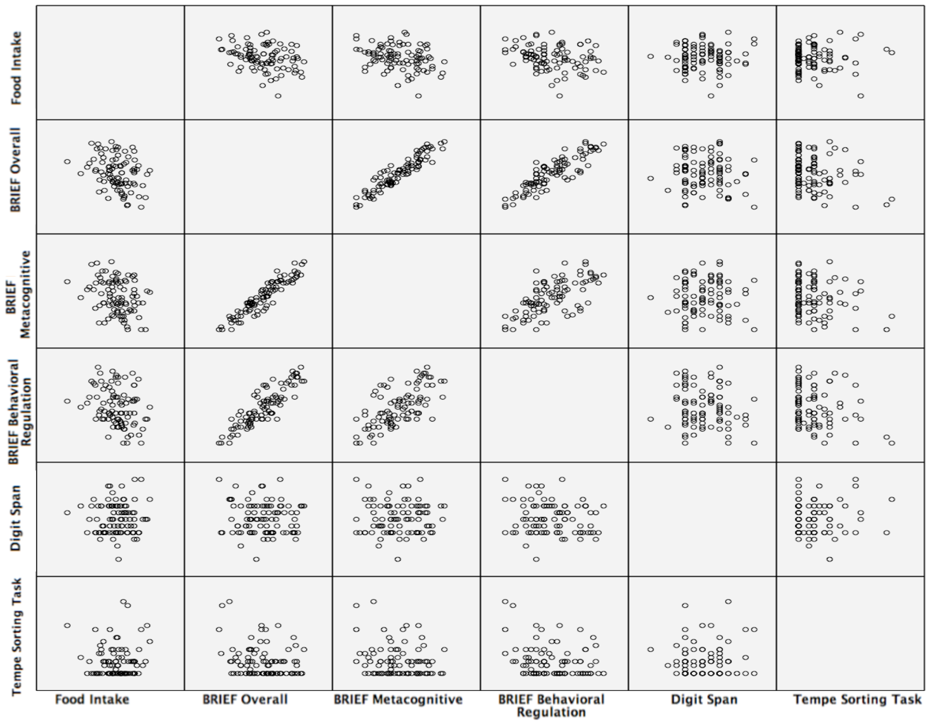

Figure 1

Scatterplot Matrix for Predictor and Outcome

EF Self-Ratings of Inhibition and Working Memory Predicting Food Intake Quality (Hypothesis One).

The first hypothesis concerned combining the EF self-report scores, namely, the Behavior Regulation Index (i.e., inhibition) score and Metacognition Index (i.e., working memory) score in order to predict Food Intake Quality Scores. To address the first hypothesis, one multiple regression was conducted. Findings confirmed that the linear combination of these unordered predictors was indeed significantly related to Food Intake Quality Scores, $R^2 = .093$, adjusted $R^2 = .074$, $F(2,95) = 4.854$, $p = .010$ (see Table 2). The self-ratings of EF scores together accounted for approximately 9% of the variance of

Food Intake Quality Scores in the sample. Regarding EF predictors' individual contributions, the Behavior Regulation Index was significantly correlated with Food Intake Quality Scores (*r* = -.250, *p* = .013) and the Metacognition Index was significantly correlated with food quality intake (*r* = -.295, *p* = .003). However, the Metacognition Index became insignificant after partialling out the effects of the Behavior Regulation Index (zero order *r* = -.295; partial *r* controlling for ratings of BRIEF Behavior Regulation Index = .179).

A second analysis was conducted to evaluate whether the Metacognition Index predicted Food Intake over and above the Behavior Regulation Index. The Metacognition Index accounted for an insignificant proportion of the variance of Food Intake after controlling for the effects of the Behavior Regulation Index self-rating, R^2 change = .030, F(1,95) = 3.143, *p* = .079.

Table 2

Regression Analysis Summaries for Hypotheses One (N = 98)

Variable	*B*	*SEB*	*B*	*T*	*p*	Zero-Order	Partial	Part
BRIEF Behavior Regulation Index self-rating	-.128	.163	-.101	-.787	.433	-.250	-.081	-.077
BRIEF Metacognition Index self-rating	-.216	.122	-.228	-1.773	.079	-.295	-.179	-.173

EF Clinical Measures of Inhibition and Working Memory Predicting Food Intake Quality (Hypothesis Two).

The second hypothesis concerned combining the EF clinical measure of inhibition (The Tempe Sorting Task) and working memory (Digit Span) in order to predict Food Intake Quality Scores. Findings from a multiple regression confirmed that the linear combination of these unordered predictors was not significant, R^2 = .002, adjusted R^2 = -.021, F (2,89) = .076, p = .927 (see Table 3). The clinical EF scores together accounted for less than one percent of the variance in Food Intake. Regarding EF predictors' individual contribution, the Tempe Sorting Task scores were not significantly correlated with Food Intake (zero order r = .022; partial r controlling for Digit Span scores = .020). Digit Span scores were also not significantly correlated with Food Intake (zero order r = .036; partial r controlling for the Tempe Sorting Task scores = .035). In general, it appears that neither clinical measure was associated with Food Intake Quality Scores.

Table 3

Regression Analysis Summaries for Hypotheses Two (N = 92)

Variable	*B*	*SEB*	*B*	*T*	*p*	Zero-Order	Partial	Part
Tempe Sorting Task	.059	.319	.020	.186	.853	.022	.020	.020
Digit Span	.176	.535	.035	.329	.743	.036	.035	.035

Behavior Regulation Index Self-Rating Measure, Metacognition Index Self-Rating Measure, Tempe Sorting Task Clinical Measure, and Digit Span Clinical Measure Predicting Total Food Intake Quality Scores (Hypothesis Three)

The third research hypothesis concerned combining all four predictors, the two EF self-ratings and the two EF clinical measures to predict Food Intake Quality Scores. This was accomplished with one multiple regression in which the Behavior Regulation Index, Metacognition Index ratings, the Tempe Sorting Task clinical measure, and Digit Span clinical measure scores were entered as ordered predictors.

Regarding Food Intake Quality Scores, the regression equation was significant, $R^2 = .105$, adjusted $R^2 = .063$, F (4,87) = 2.540, $p = .045$ (see Table 4). The two EF self-ratings and two clinical measures together accounted for approximately six percent of the variance of Food Intake Quality Scores. Regarding the predictors' individual contributions, the Behavior Regulation Index self-rating measure was significantly correlated with Food Intake Quality Scores ($r = -.269$, $p = .005$), without partialling out the effects of the self-ratings of the Metacognition Index measure and both clinical measures. However, the Behavior Regulation Index did not continue to contribute after partialling out these effects (zero order $r = -.269$, partial r controlling for the Metacognition Index self-rating and clinical measures = -.102, $p = .343$). Similarly, the Metacognition Index self-rating measure was significantly correlated with Food Intake Quality Scores ($r = -.303$, p = .002), without partialling out the effects but was not significantly correlated with Food Intake after partiallig out these effects (zero order $r =$ -.303; partial r controlling for the Behavior Regulation Index self-ratings and two clinical measures = -.181, *p* = .090). Concerning clinical measures, the Tempe Sorting Task was not significantly correlated with Food Intake Quality Scores (*r* = .022, *p* = .418). Likewise, Digit Span was not significantly correlated with Food Intake Quality Scores (*r* = .036, *p* = .366). In general, EF self-ratings were stronger than EF clinical measures in predicting Food Intake Quality Scores. Specifically, self-ratings of EF Metacognition Index was strongest in predicting Food Intake Quality Scores. EF clinical measures did not predict Food Intake Quality Scores.

Table 4

Regression Analysis Summaries for Hypotheses Three (N = 92)

Variable	*B*	*SEB*	*B*	*t*	*p*	Zero-Order	Partial	Part
Model 1								
BRIEF Behavioral Regulation	-.157	.166	-.125	-.943	.348	-.269	-.099	-.095
BRIEF Metacognitive	-.207	.124	-.222	-1.677	.097	-.303	-.175	-.169
Model 2								
BRIEF Behavioral Regulation Index	-.164	.172	-.130	-.953	.343	-.269	-.102	-.097
BRIEF Metacognitive Index	-.216	.126	-.231	-1.713	.090	-.303	-.181	-.174
Tempe Sorting Task	-.178	.315	-.059	-.565	.573	.022	-.060	-.057
Digit Span	.111	.519	.022	.214	.831	.036	.023	.022

CHAPTER IV

Discussion

The purpose of this study was threefold. The first objective was to determine how EF self-ratings of inhibition and working memory predict food intake scores. The second goal was to determine how clinical EF measures of inhibition and working memory predict food intake scores. The third purpose was to better understand how the combination of EF self-ratings and clinical tests predict food intake scores. Below, each hypothesis and corresponding results are discussed. Limitations of the present study and suggestions for future research are also presented.

Implications

Self-Ratings of Inhibition and Working Memory Predicting Food Intake Quality Scores

As hypothesized, self-ratings of EF predicted college students' food intake scores. Specifically, in this study, individuals' EF behavior regulation and metacognitive skills predicted food consumption based on the US Department of Agriculture proportion guidelines for six food groups, namely, fruit, vegetables, grains, fats/sweets, dairy, and protein. One potential explanation of this is that individuals with increased EF skills are better able to perform nutritional tasks such as creating an internal schema of a healthy diet, setting healthy eating goals, inhibiting the desire for unhealthy food, and implementing healthy food choices. Also feasible is a bidirectional association where healthy food intake also promotes better brain development and corresponding executive functioning skills.

Overall, findings from this study lend credence to previous research that link EF ability and food intake. For example, Riggs et al. (2010) found that fourth grade children's EF abilities were linked to healthy food intake variables such as consuming more fruits and vegetables and limiting unhealthy snack food. Findings are also consistent with Kanoski & Davidson's (2011) research that found that Western diets that incorporate a high degree of saturated fats and simple carbohydrates appear to be associated with hippocampal dysfunction, decreased memory inhibition, other EF related difficulties. Other studies have linked EF skills and food intake in clinical populations. Though the current study uses a non-clinical sample, clinical studies are helpful in better understanding the relationship. For example, Vaisman, Katzman, Carmiel-Haggai, Lusthaus, & Niv (2010) found that individuals diagnosed with cirrhosis (n = 21) exhibited significant improvement of EF attention two hours after eating a breakfast meal that consisted of 30 percent of the participant's daily calories and 21 grams of protein. Similarly, Chan, Sze, Han, & Mei-chun (2012) randomly assigned 24 children diagnosed with autism to a dietary modification condition or experimental group. Compared to the control group, children in the experimental condition demonstrated improved mental flexibility, inhibition, and planning ability following a one month nutrition plan that consisted of fresh grains, vegetables, fruits, beans, mushrooms, nuts, and roots. That is, the dietary modification group had a positive and large effect (0.94 to 1.20) on the three EF measures, and the planning measure had a medium effect size (0.73).

Findings from the present study also extend the literature on EF and nutrition. To date, there is limited research that investigates how and to what extent EF inhibition and working memory are linked to food intake. Regarding EF behavior regulation, the ability to inhibit motivated impulses indeed predicted the type and/or amount of food that individuals consumed. It is feasible that increased inhibitory control allows an individual to successfully resist unhealthy, though desirable, food choices such as fats and sugars, and opt for more healthy products. This finding supports previous research that links EF inhibition and nutritional outcomes. Hall (2012) reported that increased EF inhibition, as by clinical go-no go tests, was associated with lower frequency of fatty food consumption after controlling for age, gender, SES, BMI, and IQ. In addition, In addition, Nederkoorn, Houben, Hofmann, Roefs, & Jansen (2010) reported that individuals with low response inhibition gained more weight when demonstrating a strong preference for snack food as measured by an implicit preference test. Overall, inhibitory control appears to be linked to the type and amount of food that an individual consumes in their diet.

Regarding EF metacognitive skills such as working memory, findings from this study suggest that the ability to plan, organize, and hold information in mind also predicts healthy food consumption. Conceptually, it is feasible that increased metacognitive skills allow an individual to structure and initiate a healthy diet over periods of time. Generally, these findings support previous research that links working memory to healthy nutritional outcomes. For example, Kang (2005) reported that slower working memory declines were associated with increased vegetable intake in 13,388 aged women that were surveyed longitudinally. Also, Crichton, Murphy, Howe, Buckley, & Bryan’s (2012) reported that obese adults’ (n = 38) working memory skills improved following a six month diet that consisted of four daily servings of reduced fat milk, yogurt or custard.

Moreover, in this study, metacognitive skills better predicted healthier food intake in comparison to behavior regulation skills, This may imply that an individual’s ability to plan, organize, and initiate, is more connected to healthy food consumption. To a lesser degree, inhibition and the ability to shift attention predicts healthy food intake. This is an important finding in that previous nutritional research has focused more on inhibitory processes and self-control associated with healthy or poor food choices. This study suggest that the ability to plan, organize, and monitor is just as important and even more so.

Inhibition Clinical Measure and Working Memory Clinical Measure Predicting Food Intake Quality Scores

Contrary to the hypothesis, EF clinical measures did not predict food intake scores. Specifically, college students' scores on the Tempe Sorting Task, a measure of inhibitory control, and Digit Span, a measure of working memory, did not predict food intake. Regarding the Tempe Sorting Task scores, errors that reflect poor inhibitory control skills did not predict Food Intake Quality scores. However, there was support for an association between the Tempe Sorting Task and self-ratings of EF inhibition. This is expected as both measures reportedly tap similar EF construct, that is, inhibitory control and task-shifting. This correspondence supports the multitrait-multimethod approach that suggests that measures of the same construct should agree with each other. However, when the construct is measured by different methods, associations can be difficult to establish (Campbell & Fiske, 1959).

Regarding Digit Span scores, the clinical measure of working memory did not predict Food Intake Quality scores. This would suggest that the ability to hold information mentally online is not associated with health food intake. However, this particular finding must be viewed with caution. As mentioned in the first research hypothesis, EF metacognitive ratings that include working memory did indeed predict food intake. In this sense, construct under representation may be a limiting factor for this particular research question. The Digit Span measure cannot be assumed to be an ample measure of the domain of working memory. Multiple measures of working memory should be utilized, thus, representing the EF construct more fully.

Self-Ratings of Inhibition and Working Memory, Inhibition Clinical Measure, and Working Memory Clinical Measure Predicting Food Intake Quality Scores.

This hypothesis investigated the potential added value of EF clinical tests of inhibition and working memory when rating scales exist. The prediction of food intake was not enhanced by pairing EF clinical measures with EF self-ratings. In comparison to the predictive ability of the rating scale, the clinical measures were not associated with food intake. As noted previously, the Tempe Sorting Task did correspond with self-ratings of EF inhibition, though the association tended to be weak. This parallels previous research that indicates that clinical EF instruments alone are often limited in their predictive validity (Perugini, Harvey, Lovejoy, Sandstrom, & Webb, 2000; McGee, Clark, & Symons, 2000). Findings from this study support previous criticisms of clinical EF measures low correlations with extra-test behaviors.

Overall, EF self-ratings were more effective in predicting food intake than EF clinical measures. The predictive ability of self-ratings may be due to participants' familiarity with their own abilities and behavior over extended periods of time (Vazire & Mehl, 2008). Furthermore, EF clinical measures tend to be administered in laboratory settings farther removed from an individual's day-to-day environment.

Limitations and Future Research

There are several limitations of this study. First, EF is a complex and multi-dimensional construct (Spencer-Smith & Anderson, 2009). For example, Baron (2004) listed approximately twenty domains of EF that have been proposed in empirical research. There are feasibly other EF skills that are not directly addressed in this study. Moreover, clinical measures only reflect certain EF abilities and construct under representation is a common issue (Friedman & Miyake, 2004; Redick et al., 2011). The measures utilized for this study cannot be assumed to fully capture the many EF sub domains. Future studies might include a variety of EF measures that tap other dimensions such as mental flexibility, fluency, and concept formation. It would also be interesting to measure participants' EF skills with ratings from a close friend or relative. Vazire & Mehl (2008) suggest that predictive ability of self-ratings might be more meaningful by incorporating close informant ratings. A noteworthy second limitation of this study is the method of measuring food intake. This study utilized the USDA's food guidelines that are based on participant self-ratings of daily meal proportions for six food groups, including fats/sweets. Though this method has been used in a variety of studies, it does not take into account factors such as, physical activity, body mass index, socioeconomic status, or consumption of alcohol. Construct underrepresentation of food intake is also a potential shortcoming. Future studies might consider measuring food intake more rigorously by having participants report food and portion size information through daily interviews or asking participants to keep a daily food journal/record. In addition, future studies should also consider better controlling for body mass by measuring weight with an electronic balance, height with a stadiometer, and body fat with dual-energy X-ray absorptiometry (DEXA) for accuracy (Crichton et al., 2012; Rollins et al., 2010).

A third limitation concerns the sample. Results for this study were based on a sample of college students and may lack generalizability to a certain degree. In the future, it would be important to examine the relationship between EF and food intake in older adults and children. In addition, this study did not include a clinical sample of individuals. It might be useful for future studies to include a group of individuals that have been formally diagnosed with EF difficulties. Nutritional outcomes of this group could then be compared to a control group, fundamentally addressing EF skills and food intake more thoroughly. In addition, the majority of EF and nutrition research is correlational. More experimental studies are needed that establish cause and effect.

Summary

In conclusion, self-ratings of EF skills successfully predicted college students' food intake scores. Individuals' EF behavior regulation (e.g., inhibitory control) and EF metacognitive skills (e.g., working memory) significantly predicted food intake based on the US Department of Agriculture proportion guidelines for six food groups, namely, fruit, vegetable, grains, protein, dairy, and fats/sweets. Broadly, findings suggested that EF self-regulation and working-memory processes are closely linked to day-to-day nutritional behaviors. Both EF dimensions significantly predicted food intake. However, EF metacognitive skills appeared to be a better predictor when compared to EF behavior regulation. This may suggest that planning and organizing skills are more connected to healthy food consumption than behavioral regulation and inhibition skills. Findings also suggested that clinical EF measures of inhibition (the Tempe Sorting Task) and working memory (Digit Span) did not predict food intake. In this sense, there was an absence of significant added value of EF clinical measures when rating scale scores already existed.

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APPENDICES

Appendix A

IRB Approval Letter

9/11/2012

Names: Christy Elliott
Protocol Title: Executive Functioning and Physical Wellness
Protocol Number: 13-034
Elliottpc@bellsouth.net

Dear Investigator,

The MTSU Institutional Review Board, or a representative of the IRB, has reviewed the research proposal identified above. The MTSU IRB or its representative has determined that the study poses minimal risk to participants and qualifies for an expedited review under 45 CFR 46.110 and 21 CFR 56.110.

Approval is granted for one (1) year from the date of this letter for 200 participants.

According to MTSU Policy, a researcher is defined as anyone who works with data or has contact with participants. Anyone meeting this definition needs to be listed on the protocol and needs to provide a certificate of training to the Office of Compliance. **If you add researchers to an approved project, please forward an updated list of researchers and their certificates of training to the Office of Compliance (c/o Andrew Jones, Box 134) before they begin to work on the project.** Any change to the protocol must be submitted to the IRB before implementing this change.

Please note that any unanticipated harms to participants or adverse events must be reported to the Office of Compliance at (615) 494-8918.

This protocol will expire **9/11/2013**. You will need to submit an end-of-project report to the Office of Compliance upon completion of your research. Complete research means that you have finished collecting and analyzing data. **Should you not finish your research within the one (1) year period, you must submit a Progress Report and request a continuation prior to the expiration date.** Please allow time for review and requested revisions.

Also, all research materials must be retained by the PI or faculty advisor (if the PI is a student) for at least three (3) years after study completion. Should you have any questions or need additional information, please do not hesitate to contact me.

Sincerely,

William H. Leggett
MTSU Institutional Review Board

Appendix B

IRB Participant Consent Form

We are conducting a study about how the young adult's self-regulation relates to physical activity, nutrition, and sleep habits. We invite you to participate in this research. You were selected as a participant because of your voluntary enrollment in the MTSU Psychology Research Pool. Please read this form and ask any questions you may have before agreeing to be in the study.

This study is being conducted by: Christy Elliott and Dr. Seth Marshall from the Division of Psychology in School Psychology at Middle Tennessee State University.

Background Information:

The purpose of this study is to understand how young adult's physical well-being relates to executive functions, or self-regulation (plan, shift, inhibition).

Procedures:

If you agree to be in this study, we will ask you to complete three rating scales about yourself. These rating scales pertain to your physical well-being (physical activity, nutrition, sleep habits, and health related risks). The other rating scale pertains to your self-regulation skills (ability to plan, organize, initiate, goal-set). In addition, a researcher will schedule a computer lab visit with you to administer an interactive computer-based abstract reasoning program.

Risks and Benefits of Being in the Study:

The study has very minimal risks involved. However, to ensure that all participants are kept anonymous, researchers will code all information. Only researchers will have access to a master list containing names and conjoining information separate, sealed, and secured in our personal office at Middle Tennessee State University for approximately 5 years. Although there may be no direct benefit to you, the possible benefit of your participation is a greater understanding of how young adult's physical wellness relates to goal-setting and thinking.

Confidentiality:

The records of this study will be kept private. In any published report, we will not include information that will make it possible to identify you in any way. Research records will be kept in a locked file and secured database; we are the only individuals who will have access to the records.

Voluntary Nature of the Study:

Your participation in this study is entirely voluntary. Your decision whether or not to participate will not affect your current or future relations with the Middle Tennessee State University. If you decide to participate, you are free to withdraw at any time without penalty. Should you decide to withdraw data collected about you will not be used in any results.

To thank you for your participation in this research, you may choose to submit your email address to receive one of 5 randomly drawn gift certificates in compensation for your time. In addition, you may request to receive a summary of the results of this study by email. Email addresses will be held in a separate database, and survey responses will not be traceable to specific addresses.

Contacts and Questions

If you have questions, you may contact me via email: cce2n@mtmail.mtsu.edu or Dr. Seth Marshall at 615-898-2581 or semarsha@mtsu.edu. You may also contact the Middle Tennessee State University Institutional Review Board at (615) 494-8918 with any questions or concerns.

Statement of Consent:

I have read the above information. My questions have been answered to my satisfaction. I consent to participate in the study.

______________________________ _______________

Signature of Participant **Date**

______________________________ _______________

Signature of Researcher **Date**

Appendix C

BRIEF Self-Report

Name of Rated Individual____________________ Gender ☐ Male ☐ Female Age______
Your Name____________________ Today's Date___/___/___
Your relationship to him/her: ☐ Parent ☐ Spouse ☐ Sibling ☐ Friend ☐ Other__________
How well do you know him/her? ☐ Not well ☐ Moderately well ☐ Very well You have known him/her for ____ years.

During the past month, how often has each of the following behaviors been a *problem*?

N = Never S = Sometimes O = Often

1.	Has angry outbursts	N	S	O
2.	Makes careless errors when completing tasks	N	S	O
3.	Is disorganized	N	S	O
4.	Has trouble concentrating on tasks (such as chores, reading, or work)	N	S	O
5.	Taps fingers or bounces legs	N	S	O
6.	Needs to be reminded to begin a task even when willing	N	S	O
7.	Has a messy closet	N	S	O
8.	Has trouble changing from one activity or task to another	N	S	O
9.	Gets overwhelmed by large tasks	N	S	O
10.	Forgets his/her name	N	S	O
11.	Has trouble with jobs or tasks that have more than one step	N	S	O
12.	Overreacts emotionally	N	S	O
13.	Doesn't notice when he/she causes others to feel bad or get mad until it is too late	N	S	O
14.	Has trouble getting ready for the day	N	S	O
15.	Has trouble prioritizing activities	N	S	O
16.	Has trouble sitting still	N	S	O
17.	Forgets what he/she is doing in the middle of things	N	S	O
18.	Doesn't check work for mistakes	N	S	O
19.	Has emotional outbursts for little reason	N	S	O
20.	Lies around the house a lot	N	S	O
21.	Starts tasks (such as cooking, projects) without the right materials	N	S	O
22.	Has trouble accepting different ways to solve problems with work, friends, or tasks	N	S	O
23.	Talks at the wrong time	N	S	O
24.	Misjudges how difficult or easy tasks will be	N	S	O
25.	Has problems getting started on his/her own	N	S	O
26.	Has trouble staying on the same topic when talking	N	S	O
27.	Gets tired	N	S	O
28.	Reacts more emotionally to situations than his/her friends	N	S	O
29.	Has problems waiting his/her turn	N	S	O
30.	People say that he/she is disorganized	N	S	O
31.	Loses things (such as keys, money, wallet, homework, etc.)	N	S	O
32.	Has trouble thinking of a different way to solve a problem when stuck	N	S	O
33.	Overreacts to small problems	N	S	O
34.	Doesn't plan ahead for future activities	N	S	O
35.	Has a short attention span	N	S	O
36.	Makes inappropriate sexual comments	N	S	O
37.	When people seem upset with him/her, doesn't understand why	N	S	O
38.	Has trouble counting to three	N	S	O

During the past month, how often has each of the following behaviors been a *problem*?

N = Never S = Sometimes O = Often

39.	Has unrealistic goals	N	S	O
40.	Leaves the bathroom a mess	N	S	O
41.	Makes careless mistakes	N	S	O
42.	Gets emotionally upset easily	N	S	O
43.	Makes decisions that get him/her into trouble (legally, financially, socially)	N	S	O
44.	Is bothered by having to deal with changes	N	S	O
45.	Has difficulty getting excited about things	N	S	O
46.	Forgets instructions easily	N	S	O
47.	Has good ideas but cannot get them on paper	N	S	O
48.	Makes mistakes	N	S	O
49.	Has trouble getting started on tasks	N	S	O
50.	Says things without thinking	N	S	O
51.	His/her anger is intense but ends quickly	N	S	O
52.	Has trouble finishing tasks (such as chores, work)	N	S	O
53.	Starts things at the last minute (such as assignments, chores, tasks)	N	S	O
54.	Has difficulty finishing a task on his/her own	N	S	O
55.	People say that he/she is easily distracted	N	S	O
56.	Has trouble remembering things, even for a few minutes (such as directions, phone numbers)	N	S	O
57.	People say that he/she is too emotional	N	S	O
58.	Rushes through things	N	S	O
59.	Gets annoyed	N	S	O
60.	Leaves room or home a mess	N	S	O
61.	Gets disturbed by unexpected changes in daily routine	N	S	O
62.	Has trouble coming up with ideas for what to do with free time	N	S	O
63.	Doesn't plan ahead for tasks	N	S	O
64.	People say that he/she doesn't think before acting	N	S	O
65.	Has trouble finding things in room, closet, or desk	N	S	O
66.	Has problems organizing activities	N	S	O
67.	After having a problem, does not get over it easily	N	S	O
68.	Has trouble doing more than one thing at a time	N	S	O
69.	Mood changes frequently	N	S	O
70.	Doesn't think about consequences before doing something	N	S	O
71.	Has trouble organizing work	N	S	O
72.	Gets upset quickly or easily over little things	N	S	O
73.	Is impulsive	N	S	O
74.	Doesn't pick up after self	N	S	O
75.	Has problems completing his/her work	N	S	O

Appendix D

Personal Wellness Profile (Modified)

Food groups How many servings do you eat of the following food groups each day?

Servings per day ⓪ ② ④ ⑥ ⑧ ⑩ +	Serving size
1. ⓪ ② ④ ⑥ ⑧ ⑩ +	**GRAINS** 1 slice bread, 1 oz. dry cereal, ½ cup cooked cereal, rice, or pasta
Servings per day ① ② ③ ④ ⑤ +	**Serving size**
2. ① ② ③ ④ ⑤ +	**VEGETABLES** 1 cup raw, ½ cup cooked, ¾ cup juice, 1 med. potato
3. ① ② ③ ④ ⑤ +	**FRUIT** 1 med. Apple, orange, banana, ½ cup cooked, ¾ cup juice
4. ① ② ③ ④ ⑤ +	**DAIRY** 1 cup milk or yogurt, 1.5 oz. Natural cheese, or 2 oz. Processed cheese
5. ① ② ③ ④ ⑤ +	**PROTEIN FOODS** 2 to 3 oz. cooked lean meat, poultry, or fish, 1 large egg, 1 cup cooked beans, lentils, peas, 3 oz. tofu, 1 oz. nuts, one 3 oz. vegetarian burger
6. ① ② ③ ④ ⑤ +	**SWEETS & DESSERTS** 12 oz. soft drink, 1 sm. Candy bar, 2 Tbs. sugar or jam, 2 sm. cookies, ½ cup ice cream, 1 slice of pie or cake
7. ① ② ③ ④ ⑤ +	**FATS** 1 Tbs. butter, oil, or margarine, 2 Tbs. salad dressing or mayonnaise

Food Intake Scoring

Serving/Day	Score	Serving/Day	Score	Serving/Day	Score	Serving/Day	Score
Grain Group		Vegetables		Fruits		Fats and Sweets Group	
0	20	1	20	1	20	Sweets	
2	30	2	30	2	30	<2	100
4	40	3	40	3	40	3-4	40
6	70	4	70	4	70	5+	20
8	90	5+	100	5+	100	Fats	
10+	100					1	100
						2	65
						3	45
						4	35
Dairy and Protein Group						5+	20
Response	Score	Response	Score				
Dairy		Protein					
0	20	0	20				
1	45	1	40				
2+	100	2	70				
		3+	100				

Combine sweets and fats scores and divide by 2 for score

To calculate the Food Intake Quality score, add food group scores for all 6 sections and divide by 6.