2018

Stressed Out and Fed Up: The Effect of Stress on Maternal Feeding Behaviors and the Moderating Role of Executive Functioning

Isabel Mendiola

Claremont McKenna College

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submitted to
Dr. Stacey N. Doan

by
Isabel Mendiola

for
Senior Thesis in Psychology
2017-2018
April 23, 2018

Acknowledgements

First and foremost, I would like to thank my mom, dad, and sister for their unbridled love and support. Thank you for never letting me forget who I am while encouraging me to explore all aspects of who I might become. You all have shown me the world, and instilled in me a sense of responsibility to make it a better place through my academic and professional endeavors. This thesis is as much a product of your hard work as it is mine.

Second, I would like to thank Professor Stacey Doan for being one of my greatest sources of guidance throughout my time at CMC. Thank you for the time and energy you dedicated to me throughout these past three years. You have helped me grow as an intellectual thinker, as a researcher, and as a person. I hope to one day be as inspirational of a mentor to somebody as you have been to me. It is difficult for me to express my gratitude for the support you have provided me, but I hope this thesis can serve as a culmination of our work together, which we are both proud to have our names on.

To my fellow AMH-CARE Labsters, Professor Pat Smiley, and Professor Jessie Borelli, thank you for your encouragement, feedback, and friendship. This thesis would not have been possible without your hard work. Shruthi—I am honored to have had your guidance, input, and assistance in the coding of this thesis.

Lastly, thank you to my friends, my fellow senior thesis writers, and my fellow Poppa dwellers. When I reflect upon this thesis-writing-process, I am overwhelmed with gratitude for the times you all encouraged me during my low-points and celebrated with me during my successes.

Abstract

Stress is associated with a range of unhealthy eating habits. However, no previous studies have used experimental design to take an intergenerational perspective in the examination of how stress may influence parental feeding behavior, nor have they examined potential protective factors. The current study tests the effects of stress on maternal feeding behaviors and explores the potential protective role of maternal executive functioning (EF). We manipulated maternal stress with the Trier Social Stress Task (TSST) in a community sample mothers (*N* = 61, *M*age = 33.45 years). We measured maternal EF with a series of computerized tasks. Maternal feeding behavior was observationally coded using standardized procedures. Results indicate a main effect of stress on controlling feeding styles. Furthermore, this effect of stress on controlling feeding behaviors is ameliorated among mothers with higher levels of EF. Results suggest potential factors to be considered in the treatment and prevention of diet-related illnesses.

Keywords: maternal stress, maternal feeding behaviors, executive functioning

Table of Contents

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Introduction

Diet-related health conditions are some of the most common, and costly, preventable health conditions in the United States today (Ogden, Carroll, Fryar, & Flegal, 2015; Mokdad, Marks, Stroup, & Gerberding, 2004). As of 2014, 36.5% of adults and 17% of children in the United States were obese (Ogden et. al, 2015). In fact, the combination of poor diet and physical inactivity is the second leading cause of preventable death behind tobacco use, having caused 16.6% of deaths in the United States in 2000 (Mokdad et al., 2004). However, the economic implications of obesity go far beyond those directly affected. For example, in 2008, the estimated annual cost of obesity-related medical costs was $147 billion (Finkelstein, Trogdon, Cohen, & Dietz, 2009).

Despite high personal and economic costs, the rate of obesity is still on the rise (Alati et. al, 2016; Gordon-Larsen, The, & Adair, 2011; Ogden et. al, 2016). When examining the increase of obesity within and across generations, research has found that both daughters and sons are more likely than their parents to become obese (Alati et. al, 2016). Furthermore, obesity in childhood tracks into later life. Longitudinal research suggests that of the people who were obese in adolescence, ninety percent were obese twelve years later (Gordon-Larsen et. al, 2011).

While multiple factors are associated with childhood obesity, including soda consumption (Lytle, Seifert, Greenstein, & McGovern, 2000) and large portion sizes ofnutrient-low foods (Nielson, Siega-Riz, & Popkin, 2002; Young & Nestle, 2002), parental feeding practices have also been identified as a key factor. Authoritarian parental feeding practices are positively associated with child adiposity (Baughcum et. al, 2001). Specifically, parental pressure to eat is positively related to child weight (Powers, Chamberlin, Van Schaick, Sherman, & Whitaker, 2006). While research on the effect of restrictive feeding practices on child weight is inconclusive, studies suggest that restrictive feeding styles may also result in obesogenic eating behaviors in children (Birch, Fisher, & Davison, 2003).

However, few studies have examined causal factors that may lead to controlling or maladpative feeding practices. In the current study, we focus on stress. Maternal stress is associated with decreased maternal sensitivity and responsivness (Mills-Koonce, Appleyard, Barnett, Deng, Putallaz, & Cox, 2011). While few studies have investigated the role of stress on maternal feeding practices, most conclude that maternal stress is correlated with insensitive feeding styles as exhibited by overly controlling behaviors (El-Behadli, Sharp, Hughes, Obasi & Nicklas, 2015; Hurley, Maureen, Black, Papas, & Caufield, 2008). At the same time, the effects of stress on behavioral functioning have been found to be mitigated by executive functioning (Williams, Suchy, & Rau, 2009). Adults with higher executive functioning (EF) may be less biophysically reactive to stress (Hendrawan, Yamakawa, Kimura, Murakami, & Ohira, 2012). Furthermore, EF has been found to buffer the relationship between stress and externalizing behaviors, thus suggesting that EF could potentially moderate the role of stress on maternal feeding behaviors (Sprague, Verona, Kalkhoff, & Kilmer, 2011).

The purpose of this study is to examine the effect of stress on maternal feeding behaviors, specifically those that may lead to the development of obesogenic eating behaviors in children later in life. We also examine the moderating role of executive functioning in the relationship of stress and feeding behaviors.

Development of Eating Behaviors

Parents play an integral role in the development of eating behaviors in early childhood (Birch & Fisher, 1998; Birch et al., 2003; Chong, et al., 2017). Eating behaviors in early childhood are predictive of eating behaviors throughout adulthood (Birch & Fisher, 1998; Birch et. al, 2003). Parental feeding behaviors are thought to influence the development of children's eating habits and food preferences as early as when children transition from milk to solid food (Birch & Fisher, 1998; Cowart, 1981). In the subsequent years following this transition to solid food, children learn "nutritional rules" in social contexts (Birch, McPhee, Sullivan, & Johnson, 1989). Thus, children learn what and when to eat not just solely through sensations of taste and hunger, but also through their observing and understanding of social norms.

For example, knowledge of *when* to eat may not be innate; it instead may be a learned behavior that is developed early in childhood (Birch & Fisher, 1996; Birch, Zimmerman, & Hind, 1980). When children learn to eat during "normal" meal times, they may in turn begin to disassociate sensations of hunger, or the lack of hunger, with the decision to eat or refrain from eating (Birch et. al, 1980). In western populations, children also learn that sweet foods are typically consumed in celebratory contexts, such as birthday parties, therefore associating high-sugar foods with positive events and emotions (Birch et. al, 1980).

While social norms are influential, parents are likely to be the most important socialization agents in the development of children's learned eating behaviors (Birch, 1980). For most children, parents determine what and when the child eats and serve as models for eating behavior and food preference, as well as teachers of social norms regarding food intake (Birch, 1980; Rozin & Schiller, 1980). Therefore, in order to understand the development of child eating behaviors, it is necessary to understand parental *feeding* behaviors.

Survey studies have shown that most parents are aware, to some extent, that what and how they feed their children impacts their child's health (Baughcum, Burklow, Deeks, Powers, & Whitaker, 1998). This knowledge, although well intentioned, can result in controlling parental feeding behaviors (Casey & Rozin, 1989). Overly controlling feeding styles, which usually manifest as restrictive and pressuring feeding practices, can have negative effects on a child's development of healthy eating behaviors (Birch & Fisher, 1998; Birch et. al, 2003). In fact, when parents restrict their child from eating a certain food, the child's preference for that food increases (Birch et. al, 1980). Restricting feeding behaviors can lead to children's unhealthy eating practices, as parents often restrict foods that are high in fat and sugar, thus increasing their child's desire for those foods. Furthermore, when parents use controlling feeding practices that encourage a child to eat a certain food, their child's *dislike* for that food may increase (Birch, Birch, Marlin, & Kramer, 1982). Research suggests that parents with good intentions often pressure their children to eat "healthy" foods such as fruits and vegetables, inadvertently making these healthy foods less preferential for children than they would otherwise be.

Not only do controlling feeding behaviors potentially affect children's food preferences, but these behaviors could also have profound negative implications on a child's ability to self-regulate based on internal hunger cues. In one naturalistic, observational study, researchers found that at mealtimes, children aged 12-30 months asserted little autonomy in making decisions about what and how much to eat throughout the meal (Klesges et al., 1983). The majority of children ate after a parental prompt or encouragement to do so, signaling a prioritization of external cues to eat over internal cues of hunger or satiation. Through an analysis of aggregate parental eating prompts and child weight, parental prompting to eat was significantly correlated with child weight, suggesting that parental prompts discourage children from following internal indications of hunger or satiation.

Furthermore, this diminished internal sensitivity in children may negatively affect their abilities to regulate their portion control (Birch, McPhee, Shoba, Steinberg, & Krehbiel, 1987). Birch and colleagues (1987) conducted a study in which they served two groups of children two courses. In the first condition, the first course was less energy-dense, and in the second group the first course was more caloric. The second course was the same for both groups. The researchers found that in an environment without parental control, children would adjust for higher levels of energy-density in their first course by eating less in their second course. This finding suggests that the children were adjusting their food intake according to their internal hunger cues. However, in a second condition in which parents rewarded children for cleaning their plate and focused on external cues to eat such as the amount of food they had eaten, the children did not adjust their food intake for the differing levels of energy-density of their first course when eating their second course. These findings further suggest that when parents focus on external cues to encourage, or discourage, their children to eat, children do not follow their internal hunger cues (Birch et. al, 1987).

Building upon these findings, a longitudinal study found that maternal restrictive feeding practices predicted child's eating in the absence of hunger (Birch et. al, 2003). Specifically, five year old girls whose mothers exhibited restrictive feeding behaviors were more likely to have a higher BMIs at ages seven and nine. This relationship between restrictive maternal feeding styles and higher child BMI was mediated by increased incidence of eating in the absence of hunger (Birch et. al, 2003). Thus, controlling feeding behaviors could have lasting negative impacts on children's ability to follow internal hunger cues.

Stress, Eating Behaviors & Parenting

One important contextual factor that may influence maternal feeding behaviors is stress. Stress is associated with changes in eating behaviors (Stone & Brownell, 1994; Yau & Potenza, 2013; Tryon, Carter, Decant, & Laugero, 2013; Rutters, Nieuwenhuizen, Lemmens, Born, & Westerp-Plantenga, 2012). Moreover, a host of correlational studies also demonstrate that stress affects parenting behaviors (El-Behadli et. al, 2015). Based on this body of work, it is likely that stress can lead to increased levels of controlling parenting practices.

Interestingly, stress has been associated with both eating too much and eating too little, depending on individual differences (Stone & Brownell, 1994). However, most literature focuses on the effect of stress on overeating. Both chronic and acute stress have also been associated with obesogenic eating behaviors (Yau & Potenza, 2013). Stress affects one's hormones through the activation of the hypothalamic-pituitary-adrenal (HPA) axis (Yau & Potenza, 2013; Epel, Lapidus, McEwen, & Brownell, 2001). The hormones produced through the activation of the HPA axis may increase reward sensitivity, insulin sensitivity, metabolic functions, and other appetite-related processes, thus increasing one's desire for and satisfaction from fat- and glucose-dense foods (Yau & Potenza, 2013).

Dysregulated cortisol levels, which is associated with high reactivity to stress, predisposes individuals to partake in increased calorie consumption (Tryon et. al, 2013; Epel et. al, 2001). For example, when observed at a snack buffet, individuals with high chronic stress exhibited both blunted cortisol levels and increased food intake as compared to people with low stress (Tryon et. al, 2013). These findings suggest that chronic stress may affect hormones that decrease individuals' inhibition and decision making abilities regarding food choices. Furthermore, women with higher hormonal reactivity to stress consume more calorie-dense foods than women who exhibit less hormonal reactivity to the same stressful stimulus (Epel et. al, 2001). These findings suggest that individuals predisposed to higher stress reactivity, may be more vulnerable to differences in eating behaviors when exposed to a stressful situation.

Stress reactivity could also have implications on the relationship between parental stress and lower levels of parenting sensitivity (Evans, Boxhill, & Pinkava, 2008; Finegood, Blair, Granger, Hibel, & Mills-Koonce, 2016; Pelchat, Bisson, Bois, & Saucier, 2003). Maternal stress mediates the relationship between poverty and low maternal responsiveness (Evans et. al, 2008). Mothers who experience higher perceived stress are less likely to exhibit instrumental responsiveness (i.e. helping with homework) and emotional responsiveness (i.e. talking about negative emotions) with their children (Evans et. al, 2008). In a sample of families in poverty, mothers' dysregulation of the HPA axis and heightened cortisol levels, which signals high stress reactivity, explained low levels of maternal sensitivity (Finegood et. al, 2016). Thus, when mothers have lowered levels of stress-regulative abilities, stress has greater negative effects on their parenting sensitivity.

Despite the linkages between stress, eating behaviors, and parenting sensitivity, few studies have systematically examined the relationship between stress and maternal feeding behaviors. To the best of our knowledge no study has examined this relationship in an experimental context. However, correlational research has found that stress does affect how mothers feed their children (El-Behadli et. al, 2015; Hurley et. al, 2008). For example, one questionnaire study found that mothers with non-clinical symptoms of stress-related mental health difficulties, such as non-clinical anxiety and depression, were more likely to exhibit controlling feeding practices (Haycraft & Blissett, 2012). Furthermore, in a study conducted by interviewing 702 mothers of infants, those with higher levels stress self-reported more forceful and uninvolved feeding styles (Hurley et. al, 2008). These findings, although all correlational, suggest that under stressful conditions, mothers are less responsive to the dietary needs of their children.

The Role of Executive Functioning

Stress does not have the same effect on everyone. In particular, individual variability in executive function (EF) appears to influence an individual's susceptibility to stress. Executive functioning is an umbrella term for goal oriented behavior, including the setting and pursuit of goals, sustaining attention, ignoring interference, multitasking, and self-regulation (Chan, Shum, Toulopoulou, & Chen, 2008). Executive functioning has been associated with self-regulation and self-control (Hofmann, Schmeichel, & Baddely, 2012). Thus, individuals with high executive functioning also have greater emotion regulation. EF is also associated with the ability to resist exhibiting behaviors in response automatic attitudes in response to both sexual and food-related temptation (Hofmann, Gschwender, Friese, Wiers, & Smitt, 2008).

Previous literature suggests that stress reactivity is moderated by EF (Critchley, 2005). Functioning of the anterior cingulate cortex, which plays a key role in EF, is predictive of perceived stress to a controlled stimulus. This finding suggests that EF may predict the extent to which one feels distressed in response to a stressful event and thus one's reaction to the presented stressor (Critchley, 2005).

Executive functioning plays a role in both psychological and physiological signs of stress reactivity. For example, lower levels of EF are associated with higher blood pressure reactivity (Waldestein & Katzel, 2005). Further supporting the findings that individuals with lower EF exhibit greater stress reactivity, another study found that individuals with lower EF exhibited both higher scores on state anxiety scales and higher stress reactivity scores on physiological measurements such as cortisol, ECG, and skin conductance levels after being exposed to a stressful stimulus (Hendrawan et. al, 2012). This literature suggests that EF has an inverse relationship with stress reactivity both psychologically and physiologically.

The stress-regulating role of EF is important in the regulation of eating behaviors (Maayan, Hoogendoorn, Sweat, & Convit, 2012; Fagundo et. al, 2012; Kelly, Bulik, & Mazzeo, 2013). For example, similar EF deficits are found in individuals who exhibit extreme eating conditions including both anorexia nervosa and obesity (Fagundo et. al, 2012; Maayan et. al, 2012). Furthermore, EF is negatively correlated with behavioral impulsivity that leads to binge eating (Kelly et. al, 2013). The increased stress-reactivity that is associated with lower EF also plays a role in engagement of obesogenic eating in high stress conditions (Rutters et. al, 2012).

Furthermore, executive functioning is associated with maternal sensitivity (Gonzalez, Jenkins, Steiner, & Fleming, 2012). EF serves as a mediator in the relationships between maternal negative early life experiences and later maternal sensitivity (Gonzalez et. al, 2012). Thus, mothers with higher EF may exhibit greater maternal sensitivity despite exposure to high stress conditions.

The Purpose of the Current Study

In the current study, we investigated the effects of stress on maternal feeding behaviors and the protective role of maternal executive functioning in an experimental design. Given the previous literature, we hypothesized that there would be a positive relationship between maternal stress, as manipulated in the laboratory, and observed maternal controlling feeding behaviors. Secondly, we hypothesized that baseline maternal executive functioning would serve as a buffer to mitigate the effects of stress on controlling feeding behaviors.

Methods

Participants

Research participants include 61 dyads of mothers and children (34 girls, 27 boys) from the local community in Claremont, California. The age range of the mothers was 22-46 years (*M*=33.45, *SD*=4.86). The age range of the children is 34-56 months (*M*=43.41, *SD*=5.37). The majority of mothers identified as white (59.77%), followed by mixed-race (16.1%), then Asian or Asian American (4.8%), black or African American (3.2%), and lastly American Indian/Native (1.6%). However, 14.3% of mothers did not specify their race. Of these 61 mothers, 40.3% identified themselves as Hispanic/Latina. Furthermore, the majority of mothers had earned at least bachelor's or associate's degree (40.3%), with 22.6% of mothers having earned a graduate degree. The second largest group of mothers (22.6%) had attended some college, and 6.5% had only a high school education. However, 6.5% of mothers did not specify their education levels. Non-English speaking dyads were excluded from this study.

Recruitment

In order to carry out this design, participants were recruited through flyers, social media, and word-of-mouth. We displayed flyers, which advertised that we needed mothers with children ages three to five years old to participate in this study, in public places such as bookstores, coffee shops, and local preschools. We also posted similar advertisements on social media, and used word-of-mouth to spread knowledge of our study. Mothers were offered monetary compensation ($30 for an in lab visit and $20 for completion of surveys for a total of $50), and children were offered a "compensatory toy." Each dyad was informed that this study examined their parent/child relationship, but there was no mention of maternal feeding styles or stress. Consent was given by the mother by signing a consent form. Mothers also gave consent for their children.

Procedure

The current study is part of a larger study on stress and health. Only procedures relevant to the current study are described here. Upon arrival to the lab, mothers reported on basic demographics. While mothers were completing the demographics form, we measured the child's height and weight. In order to control for the hunger levels of the child in this experiment, children were also offered a snack at the beginning of the study.

Mothers were then randomly assigned to either an experimental condition or control condition of the Trier Social Stress Test (TSST) in order to either induce high or low levels of stress (Kirschbaum, Pirke, & Hellhammer, 1993). The TSST includes a public speaking tasks and an arithmetic task, both of which must be performed in front of three “panelists,” who were in reality research assistants in the laboratory. Further details on the control and experimental conditions are described below.

Mothers and children had the opportunity to eat snacks during the preparation phase of the TSST, which is when the task begins to ellicit stress responses (Kirschbaum et. al, 1993). An RA provided a tray of snacks which included a mixture of “healthy” foods, including pretzels, carrots, and raisins, and “unhealthy” foods such as potato chips, gummy bears and M&Ms. These snacks were presented on the same tray in the same quantities for each dyad. Note, that mothers were told that their child could have as much or as little of the provided snacks as they wanted.

We used computerized tasks (CBS Trials) to measure maternal executive functioning. The CBS Trials is comprised of twelve tasks which were presented in the same order for each participant. The CBS Trials are described in-depth below. Upon completion, the mother is given her compensation, and the child is given a compensatory toy. Throughout the dyad’s visit in the laboratory, they were reminded that they were able to cease participation at any time while still receiving the compensation. Human subjects approval was provided by the Institution’s IRB.

Materials

Demographics. Participants (mothers) recorded their level of education, age, their child's age, their race and ethnicity, and their family income on a standardized demographics form.

Executive functioning. Cambridge Brain Sciences Trials (CBS Trials) measures maternal executive functioning on three different domains: reasoning, memory, and verbal skills (Levine, 2013). This measure consists of twelve computerized tasks, each of which measures an aspect of one of these domains of EF. These twelve tasks have been developed from well-established paradigms designed to test different aspects of cognitive functioning. The participants received both a raw score and a "single score," which is a computation of the participants' raw scores using Z-scores, thus allowing researchers to compare scores across tests and participants. Participants' scores on each of these tasks were summed to compute a final Executive Functioning Score.

The CBS Trials have been used in a variety of studies, which have shown its reliability and validity. One study found a significant bivariate correlation between the mean standardized scores on these computerized tasks and the Cattell Culture Fair Intelligence test ($r=0.65$, $p<0.001$) (Hampshire, Highfield, Parkin & Owen, 2012). These findings held true across the three domains of reasoning, verbal skills, and short term memory.

Stress manipulation. The Trier Social Stress Test (TSST) is a manipulation of acute social stress. The TSST consists of two behavioral tasks that are designed to induce social stress (Kirschbaum et. al, 1993). The first behavioral task is a public speaking task. In the high stress condition, participants are told that they must prepare a five-minute-long speech defending herself against an accusation that she had shoplifted while shopping with her child. She must perform this speech in front of three unsympathetic panelists (research assistants). Furthermore, the participant is told that her speech will be rated on both content and presentation. If she pauses during the five minutes, she is prompted to continue speaking by questions from one of the panelists.

After completing the public speaking task, the participant is then asked to complete an arithmetic task in which she must verbally subtract 13 from the number 1022 without using a pen and paper in front of the panelists (Kirschbaum et. al, 1993). If she says an incorrect number, she must start over. She must continue this task for five-minutes.

The control condition still consists of a speech task and an arithmetic task, in order to control for any effect the act of speaking or doing arithmetic may have on participants' emotions. However, the tasks in the control condition are designed to limit the level of social stress the participant will experience (Kirschbaum et. al, 1993). For the speaking task, participants are asked to prepare for a five-minute long speech about their favorite book, movie, or vacation, which they will perform in front of a camera rather than a group of panelists. After the speech task, they are asked to add 15, starting at zero, for five minutes. Rather than doing this arithmetic verbally, they are encouraged to use a pencil and paper. Because this speech and arithmetic may still illicit some stress, we call the control condition "low-stress" rather than "no-stress." There is no scoring involved in either condition of this task.

Multiple studies have validated the Trier Social Stress Task as a manipulation of acute stress in order to experimentally study the psychological and physiological effects of stress (Kirschbaum et al., 1993; Buske-Kirschbaum, Kern, Ebrecht, & Hellhammer, 2007; Lennartsson, Kushnir, Bergquist, & Jonsdottir, 2012). The TSST elicits a hypothalamic-pituitary-adrenal axis (HPA axis) response consistent with typical HPA axis responses under stress (Kirschbaum et al., 1993). Specifically, studies have shown increases in adrenocorticotropic hormone (ACTH), cortisol, and dehydroepiandrosterone (DHEA) while completing the TSST, which have all been previously shown to be secreted by the HPA axis in response to stress (Buske-Kirschbaum et. al, 2007; Lennartsson et. al, 2012).

In addition to physiological measures of stress, the TSST is related to participants' subjective, psychological reports of stress. Studies have found that the TSST increases levels of subjective stress and anxiety in participants (Jezova, Makatsori, Duncko, Moncek, & Jakubek, 2004). It has also been associated with increase in negative mood as measured by the Positive and Negative Affective Scale (Firk and Markus, 2009).

Negative affect. We used the Positive and Negative Affective Schedule (PANAS) as a manipulation check for the effectiveness of the TSST (Firk and Markus, 2009; Watson, Clark, & Tellegen, 1988; Thompson, 2007). PANAS is a 20-point scale that includes 10 negative emotions, such as “upset” and 10 positive emotions, such as “inspired” (see Appendix A). Participants rate how well these emotions explain their own feelings in that moment on a five-point Likert scale with 1 being “Not at all” and 5 being “Extremely”. For the purposes of this study, we only score participants' responses for negative emotions before and after the TSST. A sum total for all the negative emotions are computed to get a “negative affect” score before and after the TSST.

Researchers have found the PANAS to be valid and reliable (Watson et. al, 1988; Thompson, 2007). When correlated with the 60 Zevon and Tellegen Mood Descriptors, they had between 62.8% and 68.7% common variance (Watson et. al, 1988). The PANAS has also been correlated with the Hopkins Symptom Checklist, the Beck Depression Inventory, and the State-Trait Anxiety Inventory State Anxiety Scale (Watson et. al, 1988).

Observed maternal feeding behavior coding. We developed this coding scheme using the Child Feeding Questionnaire and Bill and Tom's Method of Assessing Nutrition (Birch, Fisher, Grimm-Thomas, Markey, Sawyer, & Johnson, 2000; Klesges et al., 1983). There are three subsections of maternal feeding behaviors in this coding scheme: monitoring, pressuring, and restricting (see Appendix B). An example of monitoring: questioning would be "What are you eating?" or "Did you get more carrots?" Labeling is coded for when the mother labels the type of food or how much food the child is eating.

The second subsection is pressuring. Examples of pressuring codes include when the mothers tell the child to eat something, without giving him/her the option. For example, "Eat a raisin, please" or "Have three more carrots" would be coded as pressuring: command. In addition, mothers' use of minimization, in which the mother minimizes or disregards the child's desires or feelings, such as "You're not full" in response to the child's lack of desire to eat in response to either a command or question is also coded under pressuring.

The third subsection is restricting, which is coded when the mother commands the child not to eat something, or to eat less, such as “No more M&Ms” or “Only two M&Ms.”

This coding scheme has an inter-rater reliability of 0.8. The inter-rater reliability was computed from the scores of 25% of the videos (n=15).

Results

The aim of our study was to investigate the effect of stress on maternal feeding behaviors, specifically on controlling feeding practices. Pressuring and restricting behaviors were highly correlated (r=.520, p=.000), so we combined the two to create a controlling feeding behaviors variable. We also investigated the effect of stress on the monitoring domain of observed maternal feeding behavior in order to be sure that stress was not simply leading to over or under involvement, rather than controlling feeding practices in particular.

Preliminary Analyses

To determine associations among variables, bivariate correlations were conducted for maternal education, child age in months, child BMI and feeding behaviors (see Table 1). We found that child age was the only one of these demographic variables that was significantly correlated with feeding practices. Specifically, it was significantly correlated with restrictive feeding practices (r=0.298, p=.021), but not pressuring or monitoring feeding practices. Therefore, we controlled for child age when conducting our subsequent analyses in order to discount any potential effect this variable may have on our findings.

First, we conducted a manipulation check to ensure that our induction of stress was indeed increasing stress in participants. Thus, we quality checked the TSST with the Positive and Negative Affective Schedule (Firk and Marcus, 2009), which the mothers completed before and directly after the stressor. We conducted a dependent-samples t-tests: one to compare pre-TSST negative affect in mothers in the low-stress condition and mothers in the high stress condition, and one to compare post-TSST negative affect in these two conditions. We found no significant difference in the pre-TSST scores of negative affect between the low-stress condition (M=6.100, SD=2.107) and the high-stress condition (M=6.677, SD=2.242); $t(59)=-1.036$, p=.304. Conversely, we did find a significant difference in post-TSST scores for negative affect between the low-stress condition (M=6.567, SD=2.417) and the high-stress condition (M=8.097, SD=3.390); $t(59)=-2.024$, p=.048. Therefore, we concluded that the TSST did indeed induce stress in participants in the high-stress condition but not the low-stress condition.

Furthermore, we conducted independent-samples t-tests to examine whether there were significant group differences in the experimental and control group among all variables. We analyzed maternal education, child BMI, child age, monitoring feeding behaviors, restricting feeding behaviors, and pressuring feeding behaviors among the two conditions. The only significant differences between the control and experimental conditions were on restricting feeding behaviors, $F(59)=6.328$, p=.015, and pressuring feeding behaviors, $F(59)=5.650$, p=.021, consistent with our hypotheses.

Did stress lead to controlling feeding practices?

We then ran an analysis of covariance (ANCOVA) in order to examine group differences in controlling feeding practices and monitoring between the mothers in the high-stress and low-stress conditions, controlling for child age. We found no significant effect of stress condition on monitoring behaviors, suggesting that stress did not lead to changes in general maternal involvement or uninvolvement. However, results showed a significant main effect of stress on controlling maternal feeding practices after controlling for child age, $F(1,57)=4.085$, $p=.048$, (see Table 2). The mean sum of controlling feeding behavior scores in the low stress condition was 2.911 ($SE=0.832$) while the mean scores controlling feeding behaviors for mothers in the high stress condition was 5.289 ($SE=0.832$) (see Table 3; Figure 1).

Does executive functioning moderate the relation between stress and feeding behaviors?

We then investigated the interaction between stress and maternal executive functioning on controlling maternal feeding behaviors. We modeled these effects as an interaction between stress and EF using the SPSS macro PROCESS (Hayes, 2013). In this analysis we controlled for child age because, as noted above, it was shown to be a correlate of controlling feeding practices.

The overall model was significant $F(4, 51)=3.115$, $p=.023$ predicting 19.64% of the variance in controlling maternal feeding behaviors. The main effect of condition remained significant $b=.827$ ($SE=.260$), $p=.003$, 95% CI [.3042, 1.349]. The interaction term significantly increased the variance explained by 0.14, $F(1,51)=8.495$, $p=.005$.

Conditional effects analyses were used to determine the effect of stress condition on controlling feeding styles at low (one standard deviation below the mean), average (mean), and high (one standard deviation above the mean) levels of executive functioning. The effect of stress was only significant at low levels of EF, $b=.299$ ($SE =$

.100), *p*<.005, 29.89% CI [.10, .500]. The effect of stress on controlling feeding behaviors did not hold at medium and high levels of EF (see Figure 2).

Discussion

The current study investigated the relationship between stress and controlling maternal feeding practices, and the protective role of executive functioning. Consistent with our hypotheses, we found a significant main effect of stress on maternal controlling feeding behaviors. Specifically, mothers in the high stress condition exhibited more controlling feeding behaviors, including restriction and pressuring, than mothers in the low stress condition. Moreover, we found that the relationship between stress and controlling feeding practices was moderated by executive functioning. When maternal executive functioning is low, mothers in the high stress condition exhibit significantly more controlling feeding behaviors, however, the relationship between stress and controlling feeding behaviors was absent when maternal executive functioning is high. These results have implications on how we understand both parental sensitivity and potential causes of unhealthy eating behaviors. More specifically, our results suggest that stress influences how mothers feed their children. While there is a large body of work linking stress to an individual's own eating habits, to the best of our knowledge our study is the first to demonstrate causal relations between stress and feeding behaviors. Our results are consistent with past correlational work showing that stress influences feeding practices (El-Behadli et. al, 2015).

Additionally, previous literature suggests that parental stress negatively affect parental sensitivity towards children (Mills-Koonce et. al, 2011). For example, parenting stress has been suggested to serve as a mediator in the relationship between certain stressful life events and lower maternal sensitivity (Pereira et. al, 2012). Importantly, the results of our study demonstrating that stress decreases maternal sensitivity as exhibited in feeding styles may be generalizable to parenting sensitivity in general.

Furthermore, these results are consistent with previous findings that high executive functioning can buffer against the effects of stress (Critchley, 2005; Waldestein & Katzel, 2015; Hendrawan et. al, 2012). The findings that EF could serve as a protective factor in the relationship between stress and feeding sensitivity could have implications for future intervention efforts. If parents have higher EF, they may exhibit less stress reactivity in their parenting behaviors more generally. Training executive functioning abilities in parents may in turn improve parenting practices under stress.

Additionally, these results could have implications on interventions of diet-related illnesses and encourage people to expand their framework on how to prevent obesity at an early age. Parents' restrictive and pressuring feeding styles are associated with the development of unhealthy eating behaviors in children, including eating in the absence of hunger (Birch et. al, 2013), and some studies suggest that restrictive and pressuring maternal feeding styles are associated with higher child BMI (Baughcum et. al, 2001; Chong et. al, 2017). The results of this study suggest that stress is a predictor of feeding behaviors that could lead to these unhealthy eating behaviors, but only when the mother has low levels of EF. Thus, when considering preventions and early interventions for obesity and diet-related illnesses for children, it is important to consider both maternal stress and EF in addition to maternal feeding behaviors.

Some studies have suggested that EF improvement in adults is possible. For example, computer-based training programs that challenge targeted cognitive abilities, such as working memory, for example, led to EF improvement in young and older adults (Dahlin, Nyberg, Backman, & Neely, 2008). However, other studies suggest that EF improvements from computerized tasks may not be generalizable (Owen et al., 2010). Thus, more research needs to be done on the generalizability of EF training programs for neuro-typical adults. These training programs for EF improvement could have implications for interventions that aim to mitigate the relationship between the maternal stress and maternal feeding behaviors.

Results of our study also have implications for understanding parents' influence on child obesity. When studying the effect of parenting on children's eating behaviors, it is important to note both genetic factors, such as a predisposition to prefer certain tastes or nutrient composures, and behavioral factors, such as portion size and timing of meals (Birch & Fisher, 1998). While obesity may have genetic components, the findings of this study point to the importance of understanding behavioral components of parental influence on childhood obesity. Therefore, when designing prevention programs to decrease diet-related illnesses in at-risk populations, it is important to examine psychological and behavioral factors in *parents* that may be leading to feeding practices that are increasing, or buffering, children's risk for unhealthy eating practices later in life.

Diet has implications on an individual's health, and therefore affects the population of the United States as a whole. There has recently been a surge in initiatives to increase nutrition education and accessibility to nutritious foods for all populations, including Michelle Obama's main mission as first lady, the "Let's Move!" campaign to encourage children to engage in physical activity and eat more nutrient dense foods ("Eat Healthy," 2018). However, less research has investigated what may affect people's diet *choices*, even when healthy food is accessible, and therefore what factors may be inhibiting people from modifying their diet-related health behaviors for the better. It is important to acknowledge that choices in diet, and therefore parents' choices in their children's diets, is affected by a plethora of environmental, psychological, and biological factors (Birch, Savage, & Ventura, 2009).

Limitations and Future Directions

Although the presented findings are consistent with previous literature, it is important to interpret them within the context of the limitations of this study. First, we do not have baseline measures of maternal feeding practices, so we are comparing scores of individuals in a low-stress condition to other individuals in a high stress condition, rather than comparing how the same individuals act in a low-stress situation compared to a high-stress situation. We considered this limitation when designing the study, but concluded that if there was a baseline snack task, it may affect the hunger levels of the child and restrictive behaviors of the parent. Future studies could mitigate this limitation by conducting a baseline snack task on a different day than the experimental snack task. Furthermore, it is notable that this study was conducted in a laboratory setting which is a foreign environment with potentially foreign foods, and thus may not reflect naturalistic feeding patterns. Lastly, the majority of our participants were either white or Latino. The feeding practices exhibited may be related to different cultural values and norms, so the findings of this study may not be generalizable. Despite these limitations, this study is the first to demonstrate the causal relationship between maternal stress and controlling feeding behaviors in an experimental design and to investigate EF as a buffer in this relationship.

Furthermore, our findings that executive functioning serves as a moderator in this relationship between stress and controlling feeding behaviors could have important implications on future research and implementation of intervention and prevention programs for diet-related illnesses. Future studies could investigate if this relationship held true when studying father's feeding behaviors. Men and women may exhibit different levels of stress reactivity in response to the TSST (Kudielka, Buske-Kirschbaum, Hellhammer, & Kirschbaum, 2014). Furthermore, men may exhibit greater decrease in performance of EF tasks in response to the TSST than women (Wolf, Schommer, Hellhammer, McEwen, & Kirschbaum, 2001). Thus, if this study was replicated with father-child dyads, the relationship between stress and feeding behaviors, and the effect of EF on that relationship, may manifest differently.

It would also be important for future work to investigate the relationship between parental stress, feeding behaviors, and executive functioning, in a naturalistic setting. In doing so, we could gain greater insight into how this relationship manifests on a day-to-day basis with the dyad, in their own home, and with the foods of their choice. Additionally, it would be important to investigate if this relationship holds in the context of daily stressors, such as recent events that induce work-related stress, economic stress, or social stress.

Conclusion

The current study suggests a causal relationship between high-maternal stress and controlling feeding behaviors. This relationship only holds true for mothers with low levels of executive functioning, thus suggesting that EF serves as a moderator in the relationship between stress and controlling feeding behaviors. This study is the first study to investigate the relationship between maternal stress and controlling feeding behaviors in an experimental design, as well as to consider EF as a moderator for this relationship. The presented findings have implications on factors to consider when designing prevention and early intervention programs for childhood obesity and mitigate the risk for other diet-related illness.

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Appendix A

Positive and Negative Affective Scale (PANAS)

This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you feel this way right now, that is, at the present moment. Use the following scale to record your answers.

	Not at all	A little	Moderately	Quite a bit	Extremely
Upset	○	○	○	○	○
Hostile	○	○	○	○	○
Alert	○	○	○	○	○
Ashamed	○	○	○	○	○
Inspired	○	○	○	○	○
	Not at all	A little	Moderately	Quite a bit	Extremely
Nervous	○	○	○	○	○
Determined	○	○	○	○	○
Attentive	○	○	○	○	○
Afraid	○	○	○	○	○
Active	○	○	○	○	○

Appendix B

Observed Maternal Feeding Behaviors Coding Scheme

A. The most important component of the current study is to capture maternal feeding behaviors. Specifically, we are interested in how the mothers exhibit controlling feeding behaviors in three different domains: monitoring, pressuring, and restricting.
B. This coding scheme is developed from the Child Feeding Questionnaire and Bill and Tom's Method of Assessing Nutrition (BATMAN).
C. The coding table will include these three domains as three different sections. Each of the sections will include a variety of behaviors that fit these categories. When each behavior occurs, a tick mark will be written in the appropriate section. Each behavior will be counted at the beginning of each sentence.
    a. Monitoring:
        i. Serves child food
            1. Uses utensil or hand to put food on child's plate or in child's mouth.
        ii. Asks the child *what* they are eating
            1. Ex. "What are you eating?" "Did you eat a carrot?"
                a. Asking for information.
            2. Ex. "What else do you want?" "So what are you going to choose?"
            3. This can include gentle overseeing or encouraging conversation
        iii. Asks about *how much* they are eating
            1. Focuses on quantity
            2. Ex. "How many carrots did you get?" "Did you get more carrots?"
        iv. Label type of food: Labels *what* they are eating.
            1. Ex. "Yum M&M's!" "You chose a carrot!"
        v. Labels quantity of food: Labels *how much* they are eating.
            1. Ex. "Wow so many carrots!" "Looks like you have more M&M's than raisins." "You took 2 carrots"
    b. Pressuring/ explicitly asking child to eat
        i. Command
            1. Ex. "Eat this!" "Have another bite!"
            2. "Please try one" is still a command.
        ii. Autonomy granting: Questioning/asking
            1. The child has the option to say "no"

2. Ex. “Will you eat one more” “Would you like to try just one pretzel?”

iii. Explanation: *Why* they should eat.

1. “Please try a carrot, they are good for you.”

iv. Minimization: “Oh you’re not full.” In response to child’s lack of desire to eat, “Eat this pretzel.”

c. Restricting/regulation

i. Command: “Don’t eat now”

ii. Explanation: why they shouldn’t eat a certain food

1. Explanations are usually positive, if negative write it down

iii. Minimization: “Oh, you’re not hungry.”

iv. Autonomy granting: “Will you put this back?”

1. Restricting but in a nice way

D. There will be a third section for “other” behaviors, in which maternal feeding behaviors that are not accounted for in this coding form will be accounted for.

Table 1

Correlations

	1	**2**	**3**	**4**	**5**	**6**	**7**
1. Maternal Education	-						
2. Child's Age	.008	-					
3. Child BMI	.203	.300	-				
4. Pressuring Feeding Behaviors	.111	.116	.105	-			
5. Restricting Feeding Behaviors	.049	.298*	-.053	.520**	-		
6. Monitoring Feeding Behaviors	.100	-.065	.242	.472**	.141	-	
7. Stress Condition	.052	-.029	.183	.177	.241	.113	-

**p*<.05; **<.005

Table 2

Effect of Stress Condition on Controlling Feeding Practices Behaviors, Controlling for Child Age

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	150.474[a]	2	75.237	3.625	.033
Intercept	20.686	1	20.686	.997	.322
Child Age	68.808	1	68.808	3.316	.074
Stress Condition	84.770	1	84.770	4.085	.048
Error	1182.926	57	20.753		
Total	2342.000	60			
Corrected Total	1333.400	59			

Note. R Squared = .113 (Adjusted R Squared = .082)

Table 3

Estimated Means of Controlling Feeding Behaviors by Low-Stress and High-Stress Conditions

			95% Confidence Interval	
Stress Condition	Mean	Std. Error	Lower Bound	Upper Bound
Low-Stress	2.911[a]	.832	1.245	4.577
High-Stress	5.289[a]	.832	3.623	6.955

Note. Covariates appearing in the model are evaluated at the following values: Child's age in months = 42.4988.

Figure 1

Estimated Means of Controlling Feeding Behaviors with SE by Stress Conditions

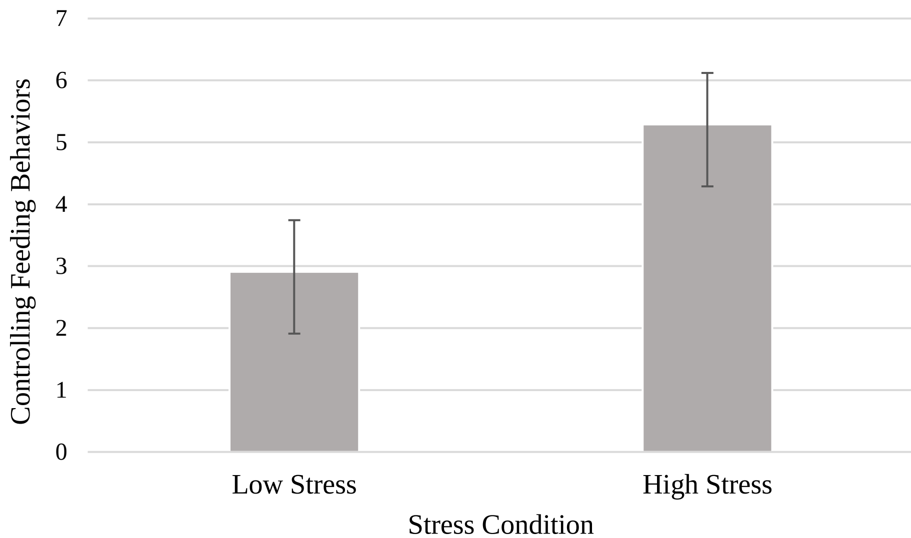

Figure 2

Moderation Model of Controlling Feeding Behaviors Depending on Stress Condition and Levels of EF