THESIS

PARENTING BEHAVIOR AND EXECUTIVE FUNCTION IN CHILDREN WITH DOWN SYNDROME

Submitted by

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ABSTRACT

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Parenting behaviors have an important influence on child development, and recent work has demonstrated the specific effects of parenting on the development of executive function (EF) abilities. Although these associations have been examined in typically developing children, the relationship between parent-child interaction and EF abilities has yet to be examined in dyads where the child has a diagnosis of Down syndrome (DS). The current study examined the differences in parenting behaviors between DS dyads and dyads with TD children matched on non-verbal mental age. DS dyads (n= 44) and TD dyads (n=29) participated in the Parent-Child Challenge Task to assess behaviors of both the parent and child during a challenging problem-solving task. Parent directive and teaching behaviors were coded, along with child compliance and noncompliance. Child participants completed the pony/gator task, a laboratory measure of inhibition and working memory. Parents also completed the Behavior Rating Inventory of Executive Function-Preschool (BRIEF-P), a proxy-report measure of EF.

Results showed a difference in parenting behavior between DS dyads and TD dyads. Frequencies of parenting behaviors in DS were also related to both the pony/gator laboratory measure and the Inhibitory Self-Control index raw scores on the BRIEF-P. The findings indicate a unique pattern of association between parent behaviors and EF in DS. The implications for parent training and intervention are discussed.

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INTRODUCTION

Executive function (EF) refers to the working memory, inhibition, and cognitive flexibility required for individuals to attend to and complete goal directed behaviors (Garon & Smith, 2008; Müller & Kerns, 2015). The importance of EF has been highlighted by research showing positive correlations between EF and academic skills, social skills, and daily functioning across the lifespan (Best, Miller, & Naglieri, 2011; Riggs, Jahromi, Razza, Dillworth-Bart, & Mueller, 2006; Cahn-Weiner, Boyle, & Malloy, 2002). The development of EF has been attributed to the development of the prefrontal cortex, and individual differences are likely influenced by both biological factors (Friedman et al., 2008) and environmental factors (Hughes & Ensor, 2009). The current study focuses on one specific environmental consideration, the role of parent-child interaction in the development of EF, in dyads with both typically developing children and dyads where the child has a diagnosis of Down syndrome (DS). This contrast is of particular interest because EF is an area of challenge for individuals with DS (Daunhauer, & Fidler, 2011).

Associations between specific parenting behaviors and child EF performance have been reported previously in typically developing children (Bernier, Carlson, & Whipple, 2010; Landry, Smith, Swank, & Miller-Loncar, 2000; Hammond, Müller, Carpendale, Bibok, & Liebermann-Finestone, 2012), but it is unclear whether similar associations are observed in children with neurodevelopmental disorders. The current study examined two specific parenting behaviors, directive behaviors and teaching behaviors, in the context of a laboratory-based parent-child interaction in order to further understand how specific parenting behaviors are associated with EF (using both laboratory-based and ecological measures). Refining what we know about how environmental factors are associated with higher EF performance in different populations has the potential to influence future interventions for children with and without disabilities by providing evidence for integrating relationship-focused training into existing EF interventions.

REVIEW OF THE LITERATURE

Executive Function

Interest in the development of EF skills has grown dramatically over the past 40 years. In the 1980s, six articles were published on EF, while 8,018 were published on EF between 2001 and 2010 (Müller & Kerns, 2015). Studying EF from a developmental perspective is important because of the considerable changes in these cognitive abilities throughout the lifespan. This section will provide a brief overview of the current knowledge base regarding EF and the implications of these findings for childhood outcomes.

Executive function theories. EF emerges in infancy and continues to develop throughout childhood and adolescence (Best & Miller, 2010; Müller & Kerns, 2015). There are various theories regarding the development of EF, all incorporating a universal understanding that EF improvement is related to, but not interchangeable with the development of the prefrontal cortex (Zelazo, Carlson, & Kesek, 2008; Anderson, 1998). One approach hypothesizes that gains made in EF abilities are attributed to gains in working memory (Lehto, 1996). Another theory emphasizes the inhibition aspect as the driving force of EF (Barkley, 1997). A third approach, the cognitive complexity and control theory-revised (CCC-r), credits increases in EF to increased understanding of rule complexities and rule systems required for cognitive tasks (Zelazo et al., 2003). These theories have been at the forefront of EF studies, as evidence mounts both for and against various approaches. Despite the numerous conceptualizations of EF, it is clear that there are a number of components contributing to improvements in EF throughout development and more research is needed to better understand the function of each subcomponent within a greater EF context.

General intelligence and executive function. In addition to developmental approaches, research has focused on the associations between general intelligence and EF because of an individual's dependence on EF components to complete cognitive tasks (Crinella & Yu, 2000). Past research studies have found that there are strong links between intelligence and some aspects of EF, working memory in particular; however, there is less evidence to support the association between intelligence and inhibition or flexibility components (Friedman et al., 2006). Although there is often a strong association between intelligence and EF, there are instances when the connection does not stand, providing further evidence that other variables contribute to EF skills. For example, children with ADHD, as well as individuals with underdevelopment or injury to the frontal lobe, experience EF dysfunction, but do not necessarily have lower IQs (Crinella & Yu, 2000; Mahone et al., 2002). This connection has not been explicitly explored in DS, however, studies controlling for mental age indicate that there may be variation in the growth trajectories of IQ and EF for this population (Daunhauer et al., 2014; Costanzo et al., 2013). Taken together, past research has contributed greatly to the construct of EF, however, there are gaps in our knowledge regarding the contribution of environmental factors to EF development and further research is needed to understand the varying growth trajectories of IQ and EF.

Executive function development. With the rapid increase in research focused on EF, the field has been building a growing knowledge base regarding the typical trajectory of EF development. These known milestones indicate the age that subdomains of EF skills are mastered throughout development (Best, Miller, & Jones, 2009; Welsh, Pennington, & Groisser, 1991). It is important to note that measurement-dependent variability exists in EF research. However, there is general consensus regarding age ranges in which skills develop and are mastered in typically developing children (Garon & Smith, 2008; Denckla, 1994; Anderson, 1998). For typically developing children, working memory emerges in the first year of life and continues to increase in a linear fashion from ages 4 to 15 (Müller & Kerns, 2015). Inhibition skills develop between ages 3 and 4, reaching a peak between ages 5 to 7 (Müller & Kerns, 2015). Another component of EF, cognitive flexibility, emerges at one year, and continues to develop until it is mastered by most at the age of 7 (Garon & Smith, 2008; Müller & Kerns, 2015). Being aware of the typical sequence of mastery of skills is important for interpretation of development of EF and is critical for further work in atypical populations. There is a growing knowledge base regarding EF performance in various populations, including individuals with disabilities, across the lifespan in order to determine age appropriate achievement levels in atypically developing children (Griffith, Pennington, Wehner, & Rogers, 1999; Welsh et al., 1991; Brocki & Bohlin, 2004). However, more research is needed to synthesize the results from atypical populations, including DS, to create a thorough timeline of EF development for individuals with specific developmental disabilities.

Executive function performance and childhood outcomes. In addition to describing developmental trajectories, another important focus of EF research has been the effects of EF on later developmental outcomes and achievements (Hughes, 2011). Strong EF performance is linked to strong academic skills and high academic achievement scores (Müller & Kerns, 2015). Specifically, associations between initial EF skills and later mathematics and oral comprehension skills have been found in longitudinal studies when comparing pre-kindergarteners and kindergarteners (Fuhs, Nesbitt, Farran, & Dong, 2014). Longitudinal studies have also demonstrated correlations between EF and math and reading achievement in large samples of children ages 4 to 17 (Best et al., 2011; Bull, Espy, & Wiebe, 2008). The links between EF and later achievement outcomes highlight why researchers and practitioners consider EF to be an important target to be studied and has the potential to inform future interventions.

Down Syndrome

Examining EF in typical children is fundamental for further understanding of the construct; however, it is crucial to develop an understanding of EF for individuals with disabilities as well. What is currently known about EF in DS is limited, especially in young children. A greater understanding of EF in DS will not only broaden what we know about this specific developmental disability, but also will inform early intervention programs targeted for child with DS. This section will review our current knowledge base regarding development in DS and how EF develops differently in this population.

DS is a neurogenetic disorder and is the most common cause of intellectual disability (Parker et al., 2010). Most cases of DS are characterized by the presence of a third chromosome 21, or trisomy 21. There are also rarer cases of translocation and mosaicism that result in a DS diagnosis. Individuals with DS are predisposed to a pattern of relative strengths in aspects of visual processing, receptive language, and nonverbal social functioning (Fidler, 2005), and relative weaknesses in motor skills, expressive language, and EF (Fidler, 2005; Daunhauer, & Fidler, 2011; Cebula, Moore & Wishart, 2010). These phenotypic outcomes are considered probabilistic, and general characteristics of individuals with DS may vary from person to person (Daunhauer, & Fidler, 2011). As such, not all children with DS will demonstrate strengths and weaknesses described associated with the DS behavioral phenotype, but they are more likely to show these outcomes relative to those without this specific diagnosis.

Executive Function in Down Syndrome

There is growing evidence that there are differences in EF development and performance for individuals with DS across the lifespan (Costanzo et al., 2013; Daunhauer, & Fidler, 2011). These differences are evident when making comparisons to mental age matched typically developing children (Daunhauer et al., 2014; Baddeley & Jarrold, 2007). Across different studies, various EF components, including working memory, response inhibition and cognitive flexibility, have been shown to be areas of relative weaknesses for individuals with DS (Daunhauer et al., 2014; Kogan et al., 2009; Daunhauer, & Fidler, 2011; Costanzo et al., 2013).

Working memory is well established as an area of difficulty for individuals with DS across the lifespan (see Baddeley & Jarrold, 2007 for a review). Working memory is the cognitive process responsible for maintaining and manipulating information in order to complete goal-directed behaviors. Poor verbal short-term memory in DS has been suggested as to one reason for this deficit in working memory (Baddeley & Jarrold, 2007). Specifically, forty-seven individuals with DS, between ages 5 to 20, were found to remember significantly fewer digits and information from a story as assessed by digit span and narrative recall when compared to mental age matched controls (Kay-Raining Bird & Chapman, 1994). School aged children (age 5-11) also exhibit working memory challenges on everyday EF skills, measured by the Behavior Rating Inventory of Executive Function-Preschool (BRIEF-P) as reported by both parents and teachers (Daunhauer et al., 2014; Lee et al., 2011). Adolescents with DS have also exhibited poor working memory performance in both a verbal and visuo-spatial dual task (Lanfranchi, Jerman, Dal Pont, Alberti, & Vianello, 2010). These various studies provide substantial evidence of the observed deficit in working memory for individuals with DS.

Inhibition, another component of EF, has shown inconsistency in research findings, with some evidence classifying it as a relative strength for individuals with DS and other evidence categorizing it as a weakness. Inhibition involves the act of restraint or hindering an instinct when it is required by the task. Inhibitory processes can include response inhibition and interference control (Müller & Kerns, 2015). Specifically, inhibition has been classified as a relative strength for children with DS when compared to other developmental disabilities, such as fragile X Syndrome (FXS;Cornish, Scerif, & Karmiloff-Smith, 2007). Cornish et al., (2007) assessed 100 children, twenty-five with DS with a mean age of 11.17, using the Test of Everyday Attention for Children and the Wilding Attention Test for Children. Individuals with DS performed significantly better on the inhibition task when compared to individuals with FXS (Cornish et al., 2007). Conversely, research has been completed on individuals with DS in comparison to typically developing (TD) controls and found a deficit in three types of inhibition; prepotent response inhibition, resistance to proactive interference and response to distracter inhibition (Borella, Carretti, & Lanfranchi, 2013). Other studies using the BRIEF-P, a parent and teacher report survey used to assess daily EF performance in preschool children, found that although parents report inhibition as an area of weakness for their child with DS, teachers do not identify this component as an area of weakness (Daunhauer et al., 2014). Given this conflicting evidence, further research is warranted regarding the nature of inhibitory control in individuals with DS.

Finally, cognitive flexibility has been reported as an area of weakness for individuals with DS. Cognitive flexibility involves the ability to shift between tasks or responses when following a set of rules and relies on both working memory and inhibition (Müller & Kerns, 2015). Research suggests that verbal mental age, which is lower for children with DS when compared to typical children, is a strong contributor to individuals' with DS cognitive flexibility development (Campbell et al., 2013). Other studies, comparing DS and typically developing individuals found impairments in verbal set-shifting for the DS group (Carney, Brown, & Henry, 2013). Deficits in cognitive flexibility provide further evidence for weaknesses in EF for individuals with DS.

Despite the few instances of subdomains of EF being reported as relative strengths; when compared to typical development, individuals with DS have substantial weaknesses in EF components. These weaknesses in EF persist through adulthood, highlighting the importance for early intervention in order to improve the trajectories of individuals' EF skills (Rowe, Lavender, & Turk, 2006). One way to improve intervention in this area is to increase our understanding of the variability and similarities of EF profiles in DS (Carney et al., 2013). If we are able to describe the EF deficits in DS with more precision and detail, the targets for interventions will become clear. Additional research is also needed to further explore the possibility of enhancing these EF skills. Although training on targeted subcomponents has been attempted, there have been mixed results, and limited longevity of training effects (Pulina, Carretti, Lanfranchi, & Mammarella, 2015; Bennett, Holmes, & Buckley, 2013). Exploring environmental variables such as parent-child interaction is an important next step toward a better understanding of EF deficits in DS, and will help determine whether a relationship-based intervention could be potentially beneficial to EF for DS as well as TD populations.

Parent-Child Interaction

Although many different environmental and biological factors have been studied in relation to EF, the present investigation focuses specifically on parent-child interactions and how dyadic patterns relate to the child's EF skills. Before examining interactions in DS, it is essential to first understand interactions in TD populations in order to draw conclusions based on similarities and differences in atypical populations. There is a growing body of research examining parent-child interactions and how these interactions relate to a child's behavior and development (Spencer, Perone & Buss, 2011; Olson, & Lunkenheimer, 2009; Gauvain & Perez, 2008; Ginsburg, 2007). Parent-child patterns of interactions begin in infancy and are described as circular in nature, with the child's behavior affecting the parent's behavior and vice versa (Spencer et al., 2011; Trevarthen, & Aitken, 2001). Initial work primarily explored parent influences on child behavior (Zegiob & Forehand, 1975; Baumrind, 1967). The field has since made a shift to include a greater focus on child cues and the active role of the child in the interaction (Loulis & Kuczynsky, 1997; Harrist, Pettit, Dodge, & Bates, 1994). These parent-child interactions produce a reciprocal relationship, with both the parent and child's behavior influencing each other in a bidirectional system (Bell, 1979). Specific parenting behaviors that significantly contribute to this reciprocal relationship have been identified in past research and include directive and teaching behaviors.

Directive Behaviors. One set of behaviors observed in parent-child interactions is directive behaviors from the parent. These behaviors include demands or requests for a certain behavior change in the child. This type of parental control is often viewed as intrusive for preschool aged children, however, directive behaviors can also be understood as providing guidance to a child rather than taking over the situation (Grolnick & Pomerantz, 2009). Although directives can provide guidance, negative effects from the overuse of directives have also been reported. There is evidence that directive behaviors could hinder cognitive development by lowering the need for a child to problem solve during a task (Bibok, Carpendale, & Müller, 2009). By giving the child an explicit direction, the task becomes less complex and requires little cognitive contribution from the child (Bibok et al., 2009). However, this negative effect may be attributed to directive behaviors that are simply too strong. TD children have been shown to have increased dysregulation and outerdirectedness when directives are overused (Lunkenheimer, Kemp, & Albrecht, 2013). The effects of directive behaviors could also depend on a child's age (Landry et al., 2000). When children are young, they rely on these direct requests as their own goal-directed behaviors and behavioral regulation develop. Landry et al., (2000) observed 364 parent child dyads and examined the use of directiveness in these interactions. During toddlerhood, parent directive behaviors showed a positive influence on cognitive and social skills, including goal-directed and initiating skills. However, the opposite is true for directive behaviors for children age three and a half to four and a half. High levels of directive behaviors from parents at age three and a half predicted lower levels of independence at age four and a half (Landry et al., 2000). Therefore, the use of directive behaviors may be appropriate at young ages, but has negative effects on the child if they are used later in development.

How the child responds to directives has been correlated with various behaviors in children as well. Parent directive behaviors followed by compliance predict a greater level of self-regulation in typical children as reported by both parents and teachers (Lunkenheimer et al., 2013). Child behavioral regulation is essential for child functioning, therefore looking closer at how parent-child interactions shape this regulation is important for future understanding of the role of directive behaviors in parenting.

Teaching Behaviors. As children develop, their behavioral regulation abilities increase, which allows them to rely less on support from parent directives and transition to support from parent teaching behaviors (Landry et al., 2000). Teaching behaviors include explanation or instruction about how to do a task. Although less is known about teaching behaviors when compared to directives, studies show an association between teaching behaviors and child self-regulation (Lunkenheimer et al., 2013; Eisenberg et al., 2010). One example of a teaching behavior, scaffolding, has been examined in more detail than teaching behaviors in general throughout the literature. Scaffolding is often used to guide a child toward the correct solution and can consist of giving hints or asking guided questions. Direct effects are present between scaffolding, one specific teaching behavior, at age 3 and EF at age 4 (Hammond et al., 2012). Further analysis indicates that scaffolding at age 2 influences child verbal ability, which then influences EF at age 4 (Hammond et al., 2012). This research indicates that there are both direct and indirect associations between scaffolding and EF depending on the age of the child. Additional studies have found similar patterns in older children with scaffolding at age 3 influencing child language and nonverbal problem solving skills at age 4, which then influences EF performance at age 6 (Landry, Miller-Loncar, Smith, & Swank, 2002). Supporting goal-directed behaviors through scaffolding increases performance on EF tasks at age 4 more than other factors in the child's social environment, such as mother-child talk when controlling for verbal ability and previous EF performance (Hughes, Ensor, Wilson, & Graham, 2009). The timing of teaching behaviors throughout a structured activity is also associated with the child's cognitive flexibility performance, providing further evidence that the development of EF is affected by much more than the child's cognitive and verbal abilities (Bibok et al., 2009). Fully understanding how scaffolding influences EF performance will be essential for future research in the area of parent-child interaction.

It is crucial to understand both directive and teaching behaviors in typical populations and the impact each have on parent-child dyads. However, dyadic interaction between parent and child becomes even more complex when the child has communication or intellectual impairments (Cress, Grabast, & Jerke, 2013). Children with specific neurogenetic disorders exhibit unique patterns of behaviors depending on the specific nature of the disability, which in turn affects parent strategies used throughout interactions (Hodapp, 1997; Ly & Hodapp, 2005). Further investigation is needed to determine how these specific reciprocal interactions shape the parent-child dyads for individuals with developmental disabilities.

Parent-Child Interaction in Developmental Disabilities

Parent-child interactions in children with disabilities have an additional layer of complexity when compared to TD dyads and vary in challenges across different diagnoses (Childress, 2010; Eisenhower, Baker, & Blacher, 2005; Doussard-Roosevelt, Joe, Bazhenova, & Porges, 2003). Behavior problems exhibited by children with disabilities may be challenging for parents, putting stress on the parent-child dyad, which impacts the parent and in turn impacts developmental outcomes of the child (Spiker, Boyce & Boyce, 2002; Hodapp, 1997; Schaffer & Crook, 1979). Parent-child interactions have also been linked to the effectiveness of early intervention in children with disabilities (Mahoney, Boyce, Fewell, Spiker, & Wheeden, 1998). Children with mothers who are able to adjust their responsiveness, directiveness, achievement orientation, and affect throughout an intervention have more successful child outcomes, suggesting a great benefit to relationship-focused intervention models (Mahoney et al, 1998). There are even interventions designed specifically to enhance the quality of parent-child interaction and joint attention in families of children with developmental disabilities, indicating the importance placed on this relationship for positive child outcomes (Harrold, Lutzker, Campbell, & Touchette, 1992; Girolametto, Verbey, & Tannock, 1994).

Parent-Child Interaction in Down Syndrome

The importance of parent-child interactions has also been highlighted in families of children with DS, with a particular emphasis on directive behaviors and how they influence the reciprocal interactions in this population (Crawley & Spiker, 1983; Gilmore, Cuskelly, Jobling, & Hayes, 2009). Past research on parent-child interaction in DS has consisted of observational studies of children participating in free play with their parent (Cielinski, Vaughn, Seifer, & Contreras, 1995; Crawley & Spiker, 1983). These studies focused on parent behaviors and child characteristics separately and made correlations accordingly (Crawley & Spiker, 1983). Specifically, associations were found between maternal directiveness and sensitivity and child Mental Development Index (MDI) in mother-child interactions with two-year old children with DS (Crawley & Spiker, 1983). Of greater importance were the observations of the mother's behavior, including the finding that while mothers were more directive, they also exhibited substantial sensitivity to their child with DS (Crawley & Spiker, 1983). Identifying parent attributes relevant for positive child outcomes was a critical first step in this area of research and continues to be explored.

Directive behaviors in Down syndrome. A common theme in the parent-child interaction in DS literature is the pronounced over use of directive behaviors from the parent, referred to as overdirectiveness (Crawley & Spiker, 1983; Roach, Barratt, Miller, & Leavitt, 1998; Cielinksi, Vaughn, Seifer, & Contreras, 1995; Mahoney, Fors, & Wood, 1990; Tannock, 1988). Unlike in typical populations, this overdirectiveness has been found to promote success for the child during a difficult task within the parent-child interaction (Landry, Garner, Pirie, and Swank 1994; Gilmore et al., 2009). Although the parent uses more direct requests, which has a negative effect on TD parent-child dyads, the increase in directives is considered developmentally appropriate for children with DS (Roach et al., 1998). Despite using more directives, research on mother-child dyads indicates that directives elicit no unique changes in the child's play or vocalizations and directive use may be connected to the language abilities of the child with DS (Roach et al., 1998; Sterling & Warren, 2014). Therefore, although the parent may be using a greater frequency of directives, a child with DS may benefit developmentally from this parental accommodation. The high level of directives used in parent-child interactions in DS warrants additional study and comparison to TD populations with updated approaches, including new coding systems for parent-child dyads, and will be addressed in the current research. Furthermore, detailed comparisons will be made with teaching behaviors to determine how these two parenting behaviors function in interactions with children with DS.

Teaching behaviors in Down syndrome. Although information on teaching behaviors in DS is limited, a review of the literature in families of children with a developmental disability indicates that children with disabilities, like TD children, benefit from scaffolding incorporated into parent-child interactions (Childress, 2010). Mothers of children with DS have been found to use more guiding or scaffolding behaviors when compared to mental age and chronological age matched TD children (Roach et al., 1998). Associations were found between the amount of guidance and support from the mother and the amount of play and vocalizations from the child with DS (Roach et al., 1998). Confirming these results and looking further into the impact of teaching behaviors on child outcomes during goal directed tasks is addressed in the current study.

Child behaviors in Down syndrome. Recently, researchers have begun to examine the contingent interactions between the parent and their child with DS, reporting how various parent behaviors come either before or after child compliance or disengagement within an interaction

(Gauvain & Perez, 2008; Cress et al., 2013). Slonims and McConachie (2006) examined videotaped early interactions in twenty-three children with DS and twenty-three TD children and their mothers. At 8 weeks old, infants with DS were found to be less communicative and less lively than TD children (Slonims & McConachie, 2006). Differences persisted in mothers' behaviors when the child was 20 weeks old and the quality of the interaction was attributed to the behavior of the infant (Slonims & McConachie, 2006). Additional studies show that parents of children with DS were not considered overdirective compared to a TD group (Gilmore et al., 2009). However, children exhibited less persistence when their parent used more directive parenting compared to more supportive techniques (Gilmore et al., 2009). Throughout the examination of parent-child interactions in DS, it is important to keep in mind the relative strengths and weaknesses in these individuals. Many children with DS show early competencies in the area of social relatedness (Fidler, 2005). These social competencies may lead one to believe that parent-child interactions would not be as challenging as with other disabilities. However, children with DS have less interest in objects, making the completion of goal directed tasks more challenging (Legerstee & Weintraub, 1997; Adamson, Deckner, & Bakeman, 2010). Challenging situations can also intensify the use of social interaction and distract from completion of a task in children with DS (Fidler, 2005). Having a complete understanding about the behavioral challenges and DS phenotype will be critical to increase our understanding of how the parent-child dyads function in this population.

Previous parent-child interaction studies with DS groups indicate that children with DS are more compliant and self-regulated than children with autism (Blacher, Baker, & Kaladjian, 2013). There has even been a term coined the "Down Syndrome Advantage", suggesting that families of children with DS, when compared to other disabilities, have great amounts of social support and lower levels of stress (Sanders & Morgan, 1997). However, studies show that this advantage in families of children with DS can be attributed to socioeconomic status of the family (Stoneman, 2007). It is also important to remember that this "advantage" is described when compared to other families of children with disabilities. Families of children with DS still experience greater stress related to their disabled child when compared to families of TD children (Sanders & Morgan, 1997). It will be important to further explore the role the child plays in the differences in interactions with parents of children with DS and relate these differences to EF performance in order to inform future interventions and inform services provided to families.

Parent-Child Interaction and Executive Function

In addition to the research describing interaction variations in typical and atypical populations, parenting practices have recently received research attention in studies of EF development and self-regulation in TD children (Landry et al., 2002; Bernier et al., 2010; Lunkenheimer et al., 2013). It is well established that caregivers and the environment in which one is raised are related to early brain development and this development is mediated by biological components (Nelson & Bloom, 1997; Schore, 1996). Specifically, the development of the frontal lobes, the brain area responsible for execution of EF, has been linked to interactions with primary caregivers (Glaser, 2000). Certain parent characteristics, such as parent education level and family income, are also positively associated with child EF skills and cognitive skills in general (Ardila, Rosselli, Matute, & Guajardo, 2005; Noble et al., 2015).

Additionally, specific aspects of parent-child interaction, such as maternal sensitivity, have been related to the emergence of EF (Bernier et al., 2010). In one study, 80 mothers of 12-18 month olds were assessed on maternal sensitivity, using a 90-item measure completed by the examiner to determine mother-child interaction quality. Maternal sensitivity in 18 month olds predicted follow up performance at 26 months on EF tasks designed for infants (Bernier et al., 2010). These tasks consisted of “spin the pots”, “delay of gratification”, “shape stroop”, and “baby stroop”. This study adds to the hypothesis that mother-child interactions play a role in predicting later EF in developing infants and may be useful in determining the specific parent qualities that contribute to later EF performance. Due to the value placed on these interactions, it is important to look closer at parent-child interactions to examine how these behaviors are associated with the child’s development across the lifespan. Despite the large amount of research on parenting style, it is necessary to examine specific parenting behaviors that have been previously important in past parent-child research, including directive behaviors and teaching behaviors (Eisenberg et al., 2010).

CURRENT STUDY

Research over the past forty years has led to a growing EF knowledge base, however, there is a need to increase our understanding of the interplay between environmental and child factors with regards to EF. It is evident that parent-child interactions vary based on characteristics of the child, including disability status and the behaviors of the parent. When a child has developmental challenges, parent-child dynamics may vary based on unique disability related variations in parent-child dyads (Ly & Hodapp, 2005). Though it is recognized that one component of development will not explain all of the variance in EF, further investigation of the contribution that parent-child interactions play in EF abilities is a crucial next step for the field. Furthermore, identifying how the relationship varies based on child diagnosis will be a stepping-stone to contribute to enhancing future interventions and therapies for children with DS.

METHODS

Participants

The participants were 44 children with Down syndrome (DS) and 29 typically developing (TD) children. TD children were matched based on nonverbal mental age to allow for comparisons to the DS group of children. An independent samples *t* test was completed in order to determine whether the DS and TD group of children differed on nonverbal mental age (NVMA). The results were not significant, t (69) = -.55, p =.58. A p value greater than .5 indicates the groups were appropriately matched, which allows comparisons between groups to be made beyond mental age differences (Mervis, & Klein-Tasman, 2004). Groups differed on chronological age (CA), t (54.3) = 18.71, p <.001. The mean CA in the DS group was 91.4 months, whereas the mean was 39.0 months in the TD group (see Table 1).

Table 1
Participant Characteristics by Group

Child Characteristics	DS (*N* = 44) *M*(*SD*)	TD (*N* = 29) *M*(*SD*)	t/χ^2	*p*-value
CA (in months)	91 (17.4)	39 (5.2)	18.71	<.001
NVMA (in months)	49 (10.1)	50 (6.8)	-.55	.58
Sex				
Male	28	17	.19	.81
Female	16	12	-	-
Race (%)				
White	84%	86%		
African American	2%	-		
American Indian/Alaskan Native	2%	-		
Asian	-	3%		
More than one race	9%	10%		
Ethnicity (% Non-Hispanic)	80%	93%		
Parent Characteristics				
Parent Gender (% female)	86%	93%	.81	.47
Mother's Age (in years)	42	36	3.79	<.001
Father's Age (in years)	43	38	3.00	.004

Procedures

Participants in the current study were originally recruited to participate in two larger studies of executive function at Colorado State University funded by the U.S. Department of Education: Institute for Educational Sciences. Participants were contacted through flyers distributed at early childhood centers and local resources for children with disabilities. Support groups and DS organizations also dispersed information to their networks for recruitment purposes. Due to the low incidence of DS, nonrandom sampling techniques were also used including snowball sampling. Participants attended 2-3 assessment appointments. Upon arrival, the experimenter described the purpose of the study, and what the participants should expect from their visit. Risks and benefits were outlined for each participant, indicating no foreseeable risks or benefits to their participation beyond what would be expected in participating in playful and educational activities. Research team members explained how identities and data were kept confidential by giving each participant an assigned ID and limiting the number of researchers with video access. Parents provided consent and assent was obtained from the child by asking the child if they wanted to play and complete activities with the examiner. Participants were compensated a total of $30 for their time and travel to the laboratory. The child was seated with the examiner during the laboratory visit. Unless they were needed for the Parent-Child Challenge Task, the parent sat nearby or watched from an observation room during assessment. Parents completed questionnaires while the child was being assessed as well.

Measures

Parent-Child Challenge Task. The Parent-Child Challenge Task (PCCT) characterizes parent-child interactions during a challenging problem-solving task. This task has been used in previous parent-child interaction studies (Lunkenheimer et al., 2013). For the purpose of this study, the examiner gave each parent-child dyad a castle puzzle with seven wooden pieces, and an instruction booklet illustrating three castle configurations to build, each one more challenging than the previous. Before leaving the parent and child to engage in the task for 5-minutes, the examiner instructed them to play as they would at home. This instruction is an adaptation of the original task, as the original procedure had a stressor embedded in it (complete the puzzles in the time period for a prize). A team of graduate students coded video recordings of the task using Noldus Observer XT 10.5 software. Inter-rater reliability was determined using percent agreement to ensure reliability across coders. Two raters reached an average of 74% agreement on 30% of the sample. Once reliability was established with 15% of the sample, coders continued to check reliability intermittently to increase the reliability sample and prevent drift. Seventy percent agreement is considered an acceptable threshold for this task and has been used in previous published work using a similar coding system (Lunkenheimer et al., 2013). All parent-child interactions lasted for the full 5 minutes, with the exception of two dyads from the DS group and one dyad from the TD group. Shorter interactions were included in analyses, as they each had reached 4 minutes.

Parent and child behaviors of interest were measured using a modified version of Lunkenheimer's Dyadic Interaction Coding System (DICS; Lunkenheimer, 2009). The DICS was adapted from the Relationship Process Code (Dishion et al., 2008; Jabson, Dishion, Gardner, & Burton, 2004) and the Michigan Longitudinal Study (Lunkenheimer, Olson, Hollenstein, Sameroff, & Winter, 2011). The parent behaviors of the modified version of the DICS for the current study included Teaching, Directives, Proactive Structure, Positive Reinforcement/Support, Correction, Intrusion, and Engagement. The total frequency of parenting behavior was calculated by summing the total number of parent behaviors throughout the interaction. The child behaviors included Compliance, Noncompliance, Persistence, and Nonpersistence. Affect coding of the original system was excluded because it was not essential to answer the research questions in the current study.

Parent behaviors.

Directive behaviors. This behavior is a clear and firm demand from the parent to change the child's behavior. The desired response from the child must be potentially observable within the session to indicate a directive behavior. Examples of directive behaviors include, "I want" statements, "do" and "don't" commands, "it's time to clean up", or "grab the blue block". Each statement was coded as a single event in order to determine the frequency of the behavior.

Teaching behaviors. In this behavior. a parent explains how to complete a task to the child. Additionally, it is worded to encourage or provide a hint as to how the child can complete the task himself/herself. Examples of teaching behaviors include, "where does the red one go?", "we might want to flip that the other way", or "what does the picture show?". Each statement was coded as a single event in order to determine the frequency of the behavior.

Additional parent behaviors. In addition to directive and teaching behaviors, there were seven other parent behaviors coded that were used to calculate the frequency of all parenting behaviors throughout the task. "Proactive Structure" is defined as a behavior suggesting a positive activity, imaginative prompt, reminder, or reasoning with the child (i.e. "this looks like the blocks we have at home"). "Positive Reinforcement/Support" was coded when praise or support for a child's behavior was observed (i.e. "keep building, you're doing a good job"). "Correction" was defined as a statement that indicates to the child they have not completed the task correctly ("that piece does not go there"). "Intrusion" was defined any instance the parent takes a block from a child or builds part of the castle for the child. Finally, "Engagement" was coded when the parent interacted with the child socially about puzzle-oriented or non-task related topics, or after ten seconds of no other specific parenting behavior occurred.

Child behaviors.

Compliance/noncompliance. Compliance is a clear response to the parent's bid for a behavior change. If after 10 seconds compliance is not observed, noncompliance is coded. Noncompliance is defined as a clear refusal to cooperate with the behavior change request. Examples of noncompliance include "no, I don't want to" or picking up the blue block after being asked to pick up the red one. Both compliance and noncompliance were coded using frequency, as each behavior was a single event.

Persistence/nonpersistence. Persistence is described as continuing work on the task without being given a directive. Persistence can include talking about the task with the parent or continuing to complete the task without engaging with the parent. Nonpersistence is defined as ignoring or refusing a request or not staying on task. If the child continues to comply or not comply three seconds after compliance or noncompliance has been observed, persistence or nonpersistence is coded accordingly. This code was recorded using a frequency approach.

Executive function task. To assess inhibition and working memory EF skills, a modified "Bear/Dragon" task was administered ("Pony/Gator"; Carlson, 2005). The examiner instructed child participants to inhibit motor responses (i.e. blow a kiss) from the "naughty" gator puppet and perform motor responses from the "nice" pony puppet. In order to complete the task participants needed to remember the game rules while completing or inhibiting the motor responses. Before the task began, participants completed each motor action to assure they were able to understand the instructions. The participants then completed practice trials and 10 test trials, randomly alternating between pony and gator trials. Children passed the trials if they completed the pony trials and inhibited the gator trials. Two coders independently coded 50% of the study sample with high reliability, Cohen's kappa = .89. Finally, the total number of correct trials was calculated for use in subsequent analyses.

Parent report of executive function. To assess everyday EF skills the Behavior Rating Inventory of Executive Function-Preschool (BRIEF-P) is used (Gioia, Espy, & Isquith, 2003). This version of the BRIEF was chosen in order to match the mental age of the participants. The BRIEF-P is a 63-item scale that requires the parent to specify the frequency of various behaviors using a 3-point Likert scale (Never, Sometimes, Often). From these responses, a total score, the Global Executive Composite, is calculated by summing each index. Three other indexes can also be calculated including Inhibitory Self-Control, Flexibility, and Emergent Metacognition. Each of these three indexes are combinations of the clinical scales on the questionnaire including Inhibit (i.e. "is impulsive"), Emotional Control (i.e. "becomes upset too easily"), Shift (i.e. "is upset by a change in plans or routine"), Working Memory (i.e. "has trouble finishing tasks", and Plan/Organize ("needs to be told to begin a task even when willing to do it") scales. High scores indicate more EF impairment.

Although self-reported measures of EF have small to moderate correlation with laboratory measures of EF performance (Toplak, West & Stanovich, 2013; Rabin et al., 2006), there is great value in the use of these parent and teacher report measures, as the scores reflect real world applications of EF performance without the structure of a laboratory setting. The BRIEF-P was normed on 460 children age 2.0 to 5.11 years old. The BRIEF-P has been previously evaluated for internal consistency (Cronback's alpha from .80-.97). Test-retest reliability was also assessed with a two-week interval and correlations between time points were adequate (.78-.90). Convergent and divergent validity were also evaluated based on correlations between BRIEF-P clinical scales and other scales aimed to measure similar behaviors (Gioia et al., 2003).

Control Measures

NVMA. The Leiter International Performance Scale-Revised (Leiter-R) is a nonverbal measurement of intelligence. Four subtests (Figure Ground, Form Completion, Sequential Order, and Repeated Patterns) of the Leiter-R were administered in order to obtain a Brief-IQ for each participant (Roid & Miller, 1997). The Brief IQ was used to determine the child's NVMA. This measure has been standardized with a national sample of 2,000 individuals age 2.0 to 20.11 years old and has established high test-retest reliability (.80s-.90s). The Leiter-R has also shown adequate concurrent validity with other IQ measures, including the WISC-III Full Scale and Performance IQs (.85) (Roid & Miller, 1997).

ANALYSIS PLAN

Hypothesis 1

It was hypothesized that parents of children with DS would exhibit a higher number of directive behaviors than parents of TD children during the modified PCCT. We expect this difference based on previous literature describing the overdirectiveness of parents of children with DS (Roach et al., 1998). To test this hypothesis, an independent samples *t* test was performed. This analysis lends itself to the two groups in the study, matched on mental age, with no overlap, and a dichotomous independent variable, child diagnosis (either DS or TD). The dependent variable was also interval ratio, as frequency of directive behaviors was measured.

Hypothesis 2

It was hypothesized that parents of children with DS would exhibit a similar number of teaching behaviors as parents of TD children during the modified PCCT. We expect there to be limited differences in teaching behaviors because, while parents of children with DS use more directives, there is no evidence that there are any differences in frequency of teaching behaviors based on the diagnosis of the child, and both groups benefit from the use of teaching behaviors (Roach et al., 1998; Hammond et al., 2012). To test this hypothesis, an independent samples *t* test was performed. This analysis lends itself to the two groups in the study, matched on mental age, with no overlap, and a dichotomous independent variable, child diagnosis (either DS or TD). The dependent variable was also interval ratio, as frequency of teaching behaviors was measured.

Power for hypothesis 1 and 2. Based on the analytic plan for hypothesis one and two and a sample size for this study of 44 DS and 29 TD children, post hoc power analyses conducted using Gpower 3 (Faul, Erdfelder, Lang, & Buchner, 2007) indicated limited power to detect small effects ($1-\beta = .13$) and moderate effects (.54), but adequate power to detect large (.91) effects.

Hypothesis 3

It was hypothesized that children with DS would respond differently to directive behaviors when compared to TD children. To test this hypothesis, transitional probabilities were calculated using Noldus Observer XT. Lag sequence analyses allowed us to determine what behaviors followed directive behaviors, as well as what child behaviors preceded them.

Hypothesis 4

It was hypothesized that both groups of children would respond similarly to teaching behaviors. To test this hypothesis, transitional probabilities were calculated using Noldus Observer XT. Lag sequence analyses allowed us to determine what behaviors followed teaching behaviors, as well as what child behaviors preceded them.

Hypothesis 5

It was hypothesized that the frequency of directive behaviors and teaching behaviors would be associated with the executive function (EF) performance of the child in everyday life. Specifically, we expect that children with parents that use a greater frequency of directive behaviors would be associated with better child EF performance in the DS group and children with parents that use a greater proportion of teaching behaviors would be associated with better child EF performance in the TD group. We expect this difference because past literature indicates that directives used after age three hinder cognitive development in typical children, but promote positive outcomes in children with DS (Bibok et al., 2009; Crawley & Spiker, 1983; Gilmore et al., 2009). We expect TD children to have better EF performance when more teaching behaviors are used because this is developmentally appropriate for typical children and has been previously shown to be associated with self-regulation (Lunkenheimer et al., 2013). To test this hypothesis first, bivariate correlations were examined between parent directive and teaching behaviors and each measure of EF (pony/gator task and BRIEF-P domain of Inhibition). Next, separate hierarchical multiple regressions were performed for the DS and TD groups using NVMA in step 1 and directive behavior and teaching behavior in step 2 as the independent variables and an EF measure as the dependent variable. The first hierarchical regression used pony/gator performance as the dependent variable and the second used the BRIEF-P Inhibit raw score. This analysis was used because each predictor variable was interval ratio and the dependent variables were interval ratio as well. Additionally, simultaneous regressions were completed excluding NVMA from analyses in order to determine the role of NVMA in the results.

Power for hypothesis 5. Based on the analytic plan for hypothesis five and a sample size for participants with a completed pony/gator task and BRIEF-P questionnaire of 39 DS and 28 TD children, post hoc power analyses conducted using Gpower 3 (Faul et al., 2007) indicated limited power to detect small effects (1-β= .09) and moderate effects (.46), but adequate power to detect large effects (.85) for the DS group, and limited power to detect small effects (1-β= .08), moderate effects (.32), and large effects (.67) for the TD group.

RESULTS

Dyad Behaviors

Hypotheses 1 & 2: Parent Behaviors. To determine whether the frequency of parenting behaviors differed in the TD and DS parent-child dyads, independent samples *t* tests were completed. Overall, the parents of children with DS used more total parenting behaviors throughout the modified Parent-Child Challenge Task (PCCT), $t(71) = 3.18$ $p \leq .01$. Differences in the total parenting were attributed to increased frequency in specific types of behaviors. Specifically, parents in the DS group used significantly more directive behaviors than the TD dyads across the five-minute interaction period, $t(71) = 3.98$, $p \leq .001$. Frequency of teaching behaviors did not differ significantly across groups. Means and standard deviations for each parenting behavior are provided in Table 2.

Table 2
t-Tests for Parent Behaviors during the modified PCCT

	DS		TD				
	M	*SD*	*M*	*SD*	*t*	*df*	95% CI
Behaviors							
Total^{n}	59	18.2	45	17.2	3.18**	71	[5.07, 22.06]
Directive^{n}	18	9.5	11	6.3	3.98***	71	[3.69, 11.09]
Teaching^{n}	30	11.7	26	11.3	1.37	71	[-1.71, 9.27]

Note. * = $p \leq .05$, ** = $p \leq .01$, *** =. $p \leq .001$ ^{n}Total number during 5 minute interaction.

Child Behaviors. Independent samples *t* tests were completed to compare the frequency of child behaviors across groups. Children with DS exhibited significantly more compliant behavior than the TD children during the modified PCCT, $t(71) = 2.38$, $p \leq .05$. Noncompliance, persistence, and nonpersistence did not differ across group. Means and standard deviations for each child behavior are provided in Table 3.

Table 3
t-Tests for Child Behaviors during the modified PCCT

	DS		TD				
	M	*SD*	*M*	*SD*	*t*	*df*	95% CI
Behavior							
Compliance^{n}	29	10.8	23	11.2	2.38*	71	[1.01, 11.45]
Noncompliance^{n}	6	6.0	6	4.8	.13	71	[-2.48, 2.83]
Persistence^{n}	7	3.9	7	4.9	-.45	71	[-2.53, 1.59]
Nonpersistence^{n}	2	2.7	2	2.7	-.62	71	[-1.69, 0.88]

Note. * = $p \leq .05$, ** = $p \leq .01$, *** =. $p \leq .001$ ^{n}Total number during 5 minute interaction.

Hypotheses 3 & 4: Dyadic Contingencies. Lag sequence analyses were completed using Noldus Observer XT to determine contingency patterns of parent and child behaviors. Transitional probabilities were calculated using the previously described parent and child behaviors (i.e. likelihood that a teaching behavior preceded child compliance or the likelihood a directive behavior followed a teaching behavior). Among these transitional probabilities, there were patterns of parent behavior that followed child behavior. In the DS dyads, child compliance and child persistence were more likely to be followed by a parental directive than in the TD dyads, $t(71) = 2.77$, $p \leq .01$, $t(70.8) = 2.46$, $p \leq .05$. On average in the DS dyads, 19.9% of child compliance instances were followed by a directive behavior, whereas in the TD dyads child compliance was followed by a directive behavior only 12.9% of the time. Similarly, on average in the DS dyads, 15.0% of child persistence events were followed by a directive behavior, compared to only 5.8% in the TD dyads. Transitional probabilities also indicated patterns of parent behaviors that followed other parent behaviors. Parent correction behaviors were more likely to be followed by a parental directive in DS than in the TD dyads, $t(67.2) = 2.10$, $p \leq .05$. On average, in the DS dyads, 25.6% of parent corrections were followed by a directive behavior, whereas 10.3% of parent correction was followed by a directive behavior in the TD dyads.

Contingencies of all other transitional probabilities from coded behaviors did not differ significantly across groups.

Hypothesis 5: Executive Function

Parenting Correlations. First, bivariate correlations among parenting behaviors, BRIEF-P subscales, and the pony/gator laboratory task were examined. In the DS group, parent directive behavior was significantly negatively correlated with pony/gator laboratory task performance $r(39) = -.52$, $p < .01$. Thus, as the frequency of directive behavior increased, children had fewer correct answers on the pony/gator task. This relationship was not present in the TD comparison group. There was also no meaningful association between teaching behavior and pony/gator laboratory performance, $r(39) = .01$, $p = .93$.

In DS dyads, there were also significant correlations between parenting and the BRIEF-P Inhibit raw scores. Parent teaching behavior was significantly negatively correlated with the Inhibit raw score of the BRIEF-P, $r(37) = -.40$, $p < .05$. Thus, higher BRIEF-P scores, indicative of weaker inhibition skills, were associated with lower frequency of teaching behaviors. These correlations were not observed in TD dyads. See table 4 for complete correlation matrix.

Table 4

Bivariate Pearson Correlations for Directive Behaviors and EF

	DS (N=37)			
	1	*2*	*3*	*4*
1. Directive Behavior[n]				
2. BRIEF-P Working Memory	.23			
3. BRIEF-P Shift	.07	.53***		
4. BRIEF-P Inhibit	.06	.76***	.41*	
5. Pony/Gator Correct	-.52***	-.38*	-.18	-.34
	TD (N=26)			
1. Directive Behavior[n]				
2. BRIEF-P Working Memory	.22			
3. BRIEF-P Shift	.22	.75***		
4. BRIEF-P Inhibit	.31	.79***	.64***	
5. Pony/Gator Correct	-.28	-.19	.06	-.21

Bivariate Pearson Correlations for Teaching Behaviors and EF

	DS (N=37)			
	1	*2*	*3*	*4*
1. Teaching Behavior[n]				
2. BRIEF-P Working Memory	-.25			
3. BRIEF-P Shift	-.21	.53***		
4. BRIEF-P Inhibit	-.40*	.76***	.41*	
5. Pony/Gator Correct	.01	-.38*	-.18	-.34
	TD (N=26)			
1. Teaching Behavior[n]				
2. BRIEF-P Working Memory	.32			
3. BRIEF-P Shift	.06	.75***		
4. BRIEF-P Inhibit	.38	.79***	.64***	
5. Pony/Gator Correct	-.30	-.19	.06	-.21

Note. * = $p \leq .05$, ** = $p \leq .01$, *** =. $p \leq .001$ [n]Total number during 5 minute interaction

Parent Report of EF. Regression analyses using the Inhibit raw score were completed to further explore the association between parenting and inhibitory control as measured by the BRIEF-P. A hierarchical regression attempted to predict the Inhibit raw score, using NVMA in step 1 and directive and teaching behavior in step 2, however results indicated nonsignificant findings. In a separate simultaneous multiple regression, removing NVMA, the overall regression equation was significant in the DS group, $F(2, 34) = 3.62$, $p < .05$. Teaching emerged as the only significant predictor of the BRIEF-P Inhibit raw score, t=-2.66, p <.05, such that for every four instances of parent teaching behavior there was a one unit decrease in BRIEF-P Inhibit raw scores (see table 5). Thus, increases in teaching behavior were associated with less impaired inhibitory control. None of the previously described regression equations were significant in the TD group.

Table 5
Simultaneous Multiple Regression Analysis for Predicting BRIEF-P Inhibit Raw Scores in Children with Down Syndrome (N = 37)

	B	*SE B*	β	*sr*	ΔR^2
Predictor Variable					
Directive[n]	.11	.13	.14	.13	.18
Teaching[n]	-.24*	.09	-.42	-.41	

Note. * = $p \leq .05$, ** = $p \leq .01$, *** =. $p \leq .001$ [n]Total number during 5 minute interaction

Laboratory Task. To explore the associations in the DS group between parenting and the pony/gator task further, a hierarchical regression was performed to examine the effects of NVMA, directive behavior, and teaching behavior on pony/gator laboratory task performance. In Step 1, NVMA was entered into the regression equation. In Step 2, directive behavior frequency and teaching behavior frequency were added to the equation. The overall regression equation was significant for the DS group, $F(3, 35) = 6.22$, $p < .01$, and frequency of directive behaviors contributed significantly to the prediction of pony/gator performance. The total amount of variance accounted for by the three predictors was 34.8%, adjusted $R^2 = .29$. According to Cohen (1988), this represents a small to medium effect size.

In terms of the separate steps of the hierarchical regression, NVMA was a significant predictor of pony/gator performance, $F(1, 37) = 10.28$, $p < .01$. NVMA accounted for 21.7% of the variance in pony/gator performance. Directive and teaching parent behaviors also contributed significantly to the regression equation, change in $F(2, 35) = 3.50$, $p < .05$. The additional amount of variance accounted for by these two predictors was 13%. Directive behaviors were negatively associated with pony/gator performance and significantly predicted pony/gator performance, $B = -.09$, $t(35) = -2.25$, $p < .05$. Specifically, for every ten instances of parent directives there was a decrease of one correct response during the pony/gator task, keeping all other predictors in the equation constant. Teaching behaviors were not associated and did not significantly contribute to the prediction of pony/gator performance.

For the overall regression equation, as is indicated by the semipartial correlations (*sr'*s) and standardized regression coefficients (β's), directive behaviors were the most important predictor of pony/gator performance ($\beta = -.38$, $sr = -.31$). NVMA and teaching behaviors failed to be significant predictors of pony/gator performance, $t(35) = 1.82$, $p = .08$ and $t(35) = 1.45$, $p = .16$, respectively. NVMA, directive behaviors, and teaching behaviors were not significant predictors in the TD regression analyses. A summary of the findings is in Table 6.

Table 6
Hierarchical Multiple Regression Analysis for Predicting Pony/gator Performance in Children with Down Syndrome (N = 39)

	B	*SE B*	β	*sr*	ΔR^2
Predictor Variable					
Step One					
NVMA	.07	.04	.32	.25	.217
Step Two					
Directive^n	-.09*	.04	-.38	-.31	.130
Teaching^n	.04	.03	.21	.20	

Note. Total $R^2 = .348$, adjusted $R^2 = .292$
* = $p \leq .05$, ** = $p \leq .01$, *** =. $p \leq .001$ ^{n}Total number during 5 minute interaction.

A second simultaneous multiple regression was performed to determine if the association between directive behavior and pony/gator performance remained when removing NVMA. Results indicated that the overall regression equation was significant in the DS group, $F(2, 36) =$

7.21, $p < .05$. Directives remained the only significant predictor of pony/gator performance, t=-3.80, p =.001, such that for every seven instances of parent directive behavior there was a one unit decrease in correct responses in the pony/gator task. Thus, increases in directive behavior were associated with more impaired inhibitory control as measured by the pony/gator task (see Table 7). None of the previously described regression equations were significant in the TD group.

Table 7
Simultaneous Multiple Regression Analysis for Predicting Pony/gator Performance in Children with Down Syndrome (N = 39)

	B	*SE B*	β	*sr*	ΔR^2
Predictor Variable					
Directive[n]	-.14***	.04	-.55	-.54	.29
Teaching[n]	.03	.03	.14	.13	

Note. * = $p \leq .05$, ** = $p \leq .01$, *** =. $p \leq .001$ [n]Total number during 5 minute interaction.

DISCUSSION

Results from the current study expand upon previous findings regarding parenting and executive function (EF) in typically developing (TD) children by investigating these associations in parents of children with Down syndrome (DS; Bernier et al., 2010; Lunkenheimer et al., 2013). Most notably, associations were observed between parenting behavior and child EF in the DS group in the area of child inhibitory control and working memory. The frequency of parent directive behavior in the DS dyads was related to child performance on the EF laboratory measure, such that more directive behaviors were associated with fewer correct answers that involve the use of working memory and inhibition. Furthermore, the frequency of parent teaching behavior in the DS dyads was negatively correlated with inhibition scales on the parent reported EF measure, such that more teaching behaviors were associated with better child inhibitory control. Comparisons between DS and TD dyads also revealed differences in rates of specific parenting behaviors and dyadic contingencies, highlighting the variations in patterns of parenting when a child presents with a disability such as DS.

Parenting Behavior and Child Executive Function

The central finding from the current study was the statistically significant relationship between directive parenting behaviors during the modified Parent-Child Challenge Task (PCCT)and child performance on the EF laboratory task. In the DS group, the first step of the regression indicated that NVMA was a significant factor when predicting pony/gator (EF) performance. However, when controlling for NVMA, and adding both frequencies of directive and teaching behavior to the equation, directives were found to be the only significant predictor of child performance on the pony/gator tasks. Parents who used more directives had children with more impaired performance on the pony/gator task. In the DS group, teaching behavior and NVMA were not significant predictors when directives were included in the model. Results also remained significant after excluding NVMA from analyses. Therefore, although developmental status was associated with success in the pony/gator task, additional parental influences may play an important role in shaping EF performance. This significant contribution of parent directive behaviors to performance on the pony/gator laboratory task is in line with the hypothesis that parenting behavior may affect inhibition and working memory abilities in children with DS.

Though the parenting and child EF patterns reported in this study are novel, it is not possible to establish the directionality of these associations from the present cross-sectional study design. An alternative interpretation of the results is that parents used more directive behaviors because their child with DS had greater difficulty with working memory and inhibition, and they tailored their parenting style to meet the needs of their child. However, it is also possible that these associations represent the opposite direction of effects wherein child EF performance is affected by parenting style (Bernier et al., 2010). In the latter scenario children with DS who have parents who infrequently used directive behaviors are more likely to develop more advanced EF skills. Despite the limitations of the cross sectional data, the relationship between parenting and EF is noteworthy, as these connections were not observed in the TD dyads.

Although teaching behaviors were not found to have a significant contribution to the pony/gator laboratory task, in DS, there was a relationship observed between teaching behaviors during the modified PCCT and inhibitory control measured by the BRIEF-P. Specifically, there was a negative association between teaching behaviors and inhibition scores such that, as inhibition scores became less impaired, parents of children with DS used more teaching behaviors. Similar to the directive behavior and pony gator laboratory task results, the directionality of these associations cannot be interpreted with the current study. One conceivable interpretation of this association is that parents used fewer teaching behaviors because their child had more trouble with working memory and inhibition, and they adjusted the amount of teaching they used to meet the needs of their child. Alternatively, parenting behavior could also be interpreted as affecting child EF, and therefore, children who have parents who frequently used teaching behaviors would be more likely to develop more advanced EF skills.

One important consideration is that the BRIEF-P is the parent perception of EF skills in the child. Additionally, the same parent that filled out the parent report measure also completed the modified PCCT with the child. Thus, their perceptions of their child's inhibitory skills may have influenced their behaviors in the parent-child interaction. Although reporter bias is a limitation to the parent-reported measures, one strength of the pony/gator task is that it is an objective measure of the child's EF skills. The use of multiple assessments presents a stronger case that parent behaviors were related to EF, as their parent perceptions of child EF skills could not have been an interfering factor in the EF laboratory-based performances.

The differences in which specific parenting behaviors were correlated with each type of EF measure in DS also warrants consideration. In the current study, directive behaviors were associated with the laboratory task and teaching behaviors were associated with the parent report measure. Thus, there is support for the idea that parent perception of child EF may alter parenting. For example, if a parent believes their child with DS has stronger inhibitory control skills, they will report this on the parent measure and also use more teaching during the parent-child interaction. Another interpretation is that the EF measurements were capturing differences in ecological EF versus laboratory EF which in turn are each associated with different parenting behaviors. The modest associations between parent report EF and laboratory EF reported in numerous previous studies limits the extent to which comparisons can be made between tasks for the current study (Toplak, et al., 2013; Rabin et al., 2006). It is notable, however, that these associations were not identified in the comparison group, suggesting overall differences in the relationship between parenting and EF in TD dyads. One interpretation of the lack of association is that parents of TD children may not have as many expectations around inhibitory control because of the children's lower chronological age in the comparison group. Parents of TD children may also be less likely to alter their parenting behaviors to adapt to their child because they are less attuned to the strengths and challenges faced by their child, and potentially needed less adjustment of their behaviors when helping their child complete everyday activities that require EF skills. Despite the limited correlation between laboratory tasks and parent report, both types of measures were associated with parenting behaviors in DS dyads, indicating the strength in the hypothesis of the association between parenting and EF in DS.

Regardless of the differences in association patterns with each EF measure, inhibitory control emerged as the component of EF with the strongest connection to parenting. This result could be attributed to the experience and practice children have with their parents in this area of EF. There are many instances within a parent-child dyad when a child must use inhibitory control and thus their parents may have an increased awareness of their child's inhibition abilities. An alternative explanation is that inhibition is more subject to environmental input and parenting behavior affects the inhibitory control component of EF more than other areas of EF in DS. Thus, the association between parenting and inhibitory control demonstrates a potential target for future parenting focused interventions in dyads with a 5-10 year old with DS.

Overall, despite limitations with questionnaires and the cross sectional study design, it is notable that the association between specific parenting behaviors and inhibitory control was observed in the DS group in this study, but not the NVMA matched TD group. One interpretation of these results is that there are core differences in the behavioral phenotype of children with DS, with EF in particular, that affect the association between parenting and EF that is not observed in TD dyads. Another plausible reason for this difference may be in the differences in the trajectory of EF development in DS, resulting in a greater emphasis on the parent-child relationship for development of certain EF skills over time in DS. Alternatively there could be systematic differences in how parents of children with DS interact with their child, affecting the associations found between EF and parenting in DS. The differences in frequencies of parenting behaviors and dyadic contingencies were analyzed in the current study in order to further explore the possibility of dissimilarities in parenting in DS compared to TD dyads.

Dyadic Behaviors

Overall, rates of total parenting and specific parenting behaviors during the modified PCCT varied when comparing DS and TD dyads. Total parenting behaviors were significantly greater in the DS dyads compared to the TD dyads. Additionally, parents of children with DS exhibited more directive behaviors, which aligns with the first hypothesis of the current study and previous work on parental overdirectiveness in the DS literature (Roach et al., 1998). The greater frequency of total parent behaviors and directives in DS dyads highlights the stylistic differences parents use when interacting with their child with DS. Greater use of directive behaviors in the DS group may have been elicited from the goal-directed nature of the modified PCCT. However, considering the comparison to the matched TD dyads, there is clear evidence of systematic differences in parenting styles of child with DS compared to the TD group despite the particular nature of the parent-child task.

Previous research on TD children shows that as behavioral regulation increases, children rely less on direct requests and more on teaching behaviors from the parent (Landry et al., 2000). Additionally, past studies indicate that children with disabilities also benefit from teaching behaviors (Childress, 2010). The frequency of teaching behavior did not differ between groups, as was hypothesized, indicating that the use of teaching behavior in DS dyads was similar to TD dyads. The lack if a difference between groups indicates that parents' use of teaching behaviors does not differ based on disability status of the child alone. The current study presents unique differences in patterns of parenting behaviors based on child factors, which is in line with the larger hypothesis that parent-child interactions vary when the child has developmental challenges (Ly & Hodapp, 2005).

Dyad Transitional Properties. Syndrome-specific variations were also examined using transitional probabilities in order to define differences between DS and TD dyads in patterns of behaviors throughout the modified PCCT. Analysis of transitional probabilities showed that children with DS did not respond differently to parent directive or teaching behaviors when compared to TD children. However, differences were observed when examining behaviors that preceded parent directives behaviors when comparing DS and TD groups. In the DS dyads, parents were more likely to use a directive after child compliance or child persistence. It is interesting to note that parents used directives in the DS dyads even after the child was complying, and not just in situations when the child was off task or noncompliant. Similarly, the use of directive behaviors after child persistence highlights how parents of children with DS continued to give clear instruction even when the child persisted with the modified PCCT. This may have been due to the persistent use of an unsuccessful task strategy from the child (i.e. the child was building the puzzle incorrectly) or a greater reliance on the parent to aid in completion of the puzzle within the DS group.

In addition to child behaviors, other parenting behaviors, specifically parent correction, also preceded directive behaviors. Directive behaviors used after parent correction indicate that after correcting the child, the parent gave clear instruction on how to fix the puzzle piece that was built incorrectly by the child. Thus, within DS, parents were more likely to give clear instructions when the child was completing the puzzle incorrectly, rather than using a parenting behavior such as teaching that would allow the child to figure out the correct way to build the puzzle with less direct help from the parent. These variations in transitional properties in DS and TD dyads emphasize the differences in interaction styles between groups, especially with respect to directive behavior.

Limitations and Future Directions

There are several limitations of this study that should be considered. One main limitation relates to the cross-sectional study design. Without longitudinal data, it is not possible to assess the directionality of the correlations that have been reported. Future work should include a longitudinal model for testing parent-child interactions to determine the extent to which EF predicts parenting behavior and how parenting behavior contributes to the development of EF in DS.

Another consideration of the current study is the lack of power to detect medium and small effects. Because parent behavior is an environmental difference, it is likely that the size of the effects would be at the small to medium level based on previous literature (Bernier, 2010). Future studies should attempt to use as large of a sample as possible to account for these power limitations. Another limitation is the generalizability of the sample collected in the current study. The majority of participants were members of white, middle class families, and patterns may not reflect the broader population of children with DS and their families.

Additionally, the DS and TD samples had significantly different chronological age, which allows the possibility that differences between groups could be affected by differences in the amount of educational and life experience in each group. To address differences in chronological age, a NVMA estimate was used to match the groups. NVMA was used because matching on verbal mental age would have underestimated the developmental status of the DS group due to relative challenges in expressive language for individuals with DS (Chapman, 1997). Moreover, due to the difference in measurement between the DS and TD group, verbal ability was not controlled for within the current analyses. Nevertheless, the task demands for completion of the modified PCCT and the EF measures were minimized with respects to expressive language. Therefore, despite potential differences in verbal ability and chronological age, these variables may not be critical for the results reported in the current study.

Finally, the study results are limited because there were only comparisons made between DS and TD dyads. Future work should include other disabilities to specify what syndrome or disability specific differences exist within these more refined examinations of parent-child interactions (Ly & Hodapp, 2005). Studying groups with varied genetic etiologies will contribute to the broader understanding regarding the contribution of environmental and child factors on EF development. Expanding the knowledge on dyadic interactions will contribute to advancements in the effectiveness of interventions for all individuals with disabilities.

Conclusions and Implications

The current study builds upon previous research on parent-child interactions in DS and provides new information regarding the relationship between parenting behaviors and child EF.

Findings from the current study provide unique additions to the area of EF in DS, as the relationship between parenting behavior and child EF has not been previously described. Given that specific parenting behaviors were significantly related to child inhibitory control and working memory, this study provides the initial foundation for future work aimed to determine the contribution of parenting to EF development in DS. Examining the relationship between parent-child dyads and EF in the context of children with DS is central to determining how parenting approaches can support EF development and should be examined with future longitudinal studies. Because of the substantial implications of EF on academic, social, and daily functioning skills and the challenges with EF that individuals with DS experience, there is a need to better understand the optimal parenting contributions to enrich EF development in DS. A clearer understanding of the social antecedents to EF development in DS and other neurogenetic disorders can inform future parent training and intervention strategies, which has the potential to positively impact the lives of individuals with disabilities and their families.

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