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Examining the Relationship between Play and Executive Function in Toddlers with Down Syndrome

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Examining the Relationship between Play and Executive Function in Toddlers with Down Syndrome

A thesis submitted in partial satisfaction of the requirements for the degree Master of Arts in Education

by

Sydney Taylor Seese

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ABSTRACT OF THE THESIS

Examining the Relationship between Play and Executive Function in Toddlers with Down Syndrome

by

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Master of Arts in Education

University of California, Los Angeles, 2021

Professor Connie L Kasari, Chair

The present study explored the associations between executive function skills and play ability in toddlers with Down Syndrome (DS). Participants included 79 children with DS (mean age= 38 months; 53% female). Executive function ability was measured via parent report (BRIEF-P) and three child tasks (Memory Tower Task, EF Search Task, and the Persistence Puzzle Task). Play ability was measured via the Structured Play Assessment. Higher diversity of play acts predicted higher working memory ability and planning ability, while higher play level predicted better planning/persistence. Results suggest that play level and diversity of play can predict some aspects of EF (memory, planning, persistence), but not others (inhibition/shift from the Search Task) in this sample of toddlers with Down syndrome. Future research would benefit from larger samples that may address generalizability of study findings. Improving school readiness, as well as social and academic outcomes, in children with DS are critical research targets for this population during this developmental period. The results of this study may inform and support the development of interventions to better target improving these proficiencies.

The thesis of Sydney Taylor Seese is approved.

Sandra H. Graham

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2021

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Introduction

The transition to kindergarten is an important developmental period of growth for executive function skills, early academic skills, and emotion regulation (DiPerna et al., 2007; Duncan, 2011; Schmitt et al., 2017). In the United States, few states have policies in place guiding the transition to kindergarten for typically developing children (Education Commission of the States, 2020) and there are currently no federal or state policies guiding the transition for children with disabilities. Toddlers with Down syndrome (DS) are at risk for poor school readiness (Blair, 2002; Marsh et al., 2017) that may be due in part to deficits in their executive function (EF) abilities (Blair, 2002; Garon et al., 2008; Marsh et al., 2017). Prior to entry into kindergarten, children with DS may appear proficient in some of the skills needed to be successful. These include play and sociability (Kasari & Freeman, 2001; Kasari & Hodapp, 1996; Landry et al, 1998). However, these early competencies may deteriorate due to the increasing demands of the classroom environment and challenges with various EF skills. More information is needed to clarify the potential influence of play on executive functioning abilities during this critical period of development.

The purpose of the proposed study will be to examine the relationship between play skills and executive function (EF) abilities in toddlers with Down syndrome. By examining the relationship of play skills and executive function abilities in atypical populations, we may better understand the implications of play as it relates to EF. This in turn may serve to inform researchers and clinicians about contexts in which to improve cognitive skills, and school readiness, in young children with DS.

Profile of Down Syndrome

Down syndrome (DS) is associated with distinctive profiles of cognitive and behavioral functioning across the lifespan (Daunhauer et al., 2014; Grieco et al., 2015). Approximately 6,000 babies are born every year with Down syndrome, and researchers have noted an increase in the national population-based estimates of the prevalence of DS (Mai et al., 2019). DS children form the largest recognized group with a genetically identified cause of learning and intellectual disabilities (ID) (Patterson & Lott, 2008; Toole & Chiat, 2006). In early childhood, brain development in children with DS may present as typical, yet emerging differences become apparent, including delays in myelination and decreases in brain structure that result in a unique neuroanatomical profile (Nadel, 2003). Cognitive and behavioral deviations from typically developing (TD) children become increasingly discrepant as the child ages (Contestabile et al., 2010; Grieco et al., 2015).

There is a large degree of variability in terms of cognitive ability and behavior among children with DS and evidence for a distinct profile for DS has been explored across studies (Chapman, 2000; Fidler, 2005; Fidler, 2006; Rosser, 2018). Most children with DS are reported to have mild to moderate ranges of intellectual functioning, deficits in learning, and language and speech difficulties (Fowler, 1999). Under the broad umbrella of each of these domains of functioning, there are several areas in which children with DS have strengths and weaknesses.

In terms of cognitive abilities, children with DS have been reported to have strengths in spatial learning and object discrimination tasks (Grieco et al., 2015; Kogan et al., 2009). Some research suggests that children with DS play similarly to TD children. For example, past studies of children with DS report similar frequencies of play behaviors (i.e., pushing a truck, feeding a doll) during play sessions in comparison to TD children, suggesting that play abilities are a strength (Mundy, 1988; Sigman & Ruskin,1999). Difficulties in some aspects of executive function ability, including working memory and planning, have been documented in both laboratory-based performance measures of school-aged children (Baddely & Jarrold, 2007), and through parent and teacher report (Daunhauer et al., 2014). Children with DS have been documented to have perplexing learning styles, characterized by higher levels of off-task behavior during challenging tasks (Kasari & Freeman, 2001). Notably, children with DS have been observed to exhibit an array of behaviors in response to difficult tasks, including charming behaviors (such as clapping or smiling) to gain the attention of the examiner (Pitcairn & Wishart, 1994). It has also been noted that children with DS may avoid participating all together in hard tasks rather than just failing tasks (Wishart, 1993).

Regarding the social and communication domains, children with DS are reported to have high sociability, great interest in social interactions, and competency in making friends (Fidler et al., 2008; Kasari et al., 2003; Ruskin et al., 1994). A plethora of studies have noted strong nonverbal communication abilities (such as gesture use) and receptive language skills in children and older individuals with DS (Chapman, 1999; Fidler et al., 2005; Sigman & Ruskin, 1999). Researchers have also reported competence in imitation abilities of young children with DS. These abilities have been documented during facial imitation tasks, during which an examiner may open their mouth or stick out their tongue, with the expectation that children will respond by imitating the examiner (Heiman & Ulstadius,1999). During object search tasks, in which objects are hidden by an examiner while a child observes, children with DS are often proficient in imitating the examiner’s actions and are able to successfully find objects (Fidler, 2005; Wright et al., 2006). Children with DS have relative strengths in their engagement ability and turn taking (Abbeduto et al., 2007; Sigman & Ruskin, 1999). In one study examining joint attention skills (i.e., coordinating eye contact, pointing to objects to direct adult's attention) during a semi-structured play task, children with DS showed equivalent amounts of joint attention behaviors in comparison to TD peers (Mundy, 1988; Sigman & Ruskin,1999). Greater challenges are apparent in terms of expressive language ability and understanding of grammar and syntax across the lifespan of individuals with DS (Chapman, 2006; Chapman et al., 2002).

The Role of Play

In typically developing children, play skills emerge within the first two years of life (Kasari, 2008; Ungerer & Sigman, 1981). Most research has supported the notion that there may be universal patterns of play development for both typically and atypically developing children (Mundy et al., 1987) and that play includes a hierarchy of skills that build upon each other (Kasari, 2013). Play behaviors often are defined in terms of their level (Freeman & Kasari, 2013; Kasari et al., 2006; Kasari & Chang, 2014), such that earlier level play behaviors may include acts such as object mouthing or taking toys apart, while more advanced levels of play involve symbolic play, such as using objects as a substitution for other objects or playing pretend. Although varying definitions of play exist, Vygotsky (1978) defines play as consisting of three core components: 1) creating imaginary situations, 2) taking on and acting out roles and 3) following a set of rules determined by specific roles (Bodrova & Leong, 2007). Play ability has been consistently documented to be related to other cognitive skills, such as language and emotional development (Beeghly & Cicchetti, 1987; Sigman & Ruskin, 1998; Venuti et al., 2008). Historically, theories of child development highlight the importance of play in developing cognitive skills (Piaget, 1952; Vygotsky, 1978). However, the direction of the relationship between play and cognitive skills is unclear in the most recent literature.

Lillard and colleagues (2012) have argued that pretend play may just go along with important developments (such as social skills, intelligence, language) but does not cause or influence their development. Instead, pretend play is considered an epiphenomenon. Other researchers have reported conflicting findings. One recent study by Faja and colleagues (2016) demonstrated that in children with autism spectrum disorder (ASD), early EF ability at age three predicted symbolic play skills at age six. However, some of these findings need to be interpreted with caution due to significant methodological limitations. Definitions, measures, and interpretations of play acts are widely varying (Kasari et al., 2013) and many studies may confuse correlational findings with causality (Lillard et al., 2012). Although the play abilities of typically developing children are fairly well documented in the literature, less is known about the play skills of children with DS.

Play Skills in DS

Past research examining the play abilities of children with DS is relatively sparse, with some conflicting findings due to varying measures and definitions of play. Play in children with Down syndrome has been documented to have both similarities and differences in comparison to TD children. Children with DS are reported to progress through similar sequences and schemes of play, but at a slower pace than their typically developing peers (Motti et al., 1983; Toole & Chiat, 2006; Venuti et al., 2009). Overall, many researchers suggest that children with DS have strong play skills commensurate with their cognitive development. In studies examining the spontaneous play behaviors of children with DS and TD children, results suggest that both groups spend similar amounts of time in varying play levels. Children with DS perform equal, if not more, play behaviors and turn-taking during independent and joint play sessions (Landry et al., 1998; Mundy,1988; Sigman & Ruskin,1999).

In terms of specific play weaknesses for children with DS, some research has shown that children with DS may be less motivated to explore objects and have displayed shorter sequences of goal-directed behavior than typically developing peers (Ruskin et al., 1994; Venuti et al., 2009). During play, children with DS may be more motivated to seek out social interactions rather than play with the toys themselves (Landry et al., 1998). However, more rigorous research studying the play skills of children with DS is needed. For all children, regardless of influence on cognitive skill development, play is often considered an important context in which children can explore, change, and manipulate their environment.

Importance of Executive Function

Executive function (EF) refers to a set of brain-based skills that are adaptive and goal-directed. EF is composed of three core abilities: working memory, inhibition and shifting (Miyake & Friedman, 2012). These skills can help children problem solve, remember the day's schedule or rules to a game, and handle unexpected events. Researchers have suggested a hierarchical model of EF, such that the development of EF abilities involves the coordination of component skills into higher order systems (Garon et al., 2008). Garon and colleagues (2008) posited that early core components are present during early toddlerhood while integration of components continues to develop later during the preschool period (3-5 years of age). Attention is considered a fundamental aspect of early EF development, which encompasses the ability to shift attention, sustain attention, and control what information to process (Garon et al., 2008). Children as young as 12 months exhibit some EF skills, including the use of attention control strategies in order to self-regulate. In one study, these early skills were present during a separation paradigm, in which young toddlers employed distraction strategies while they waited for their mothers (Sethi et al., 2000). The preschool period has been consistently cited as an integral period of dramatic growth for EF skills (Anderson & Reidy, 2012; Center on the Developing Child, 2012; Grammer et al., 2018; Hughes et al., 1998) and implicated as a critical transition stage of development from simple to more complex EF abilities (Garon et al., 2018).

Measures of EF are often divided into “hot” and “cool” tasks. Conventional “cool” tasks assess cognitive control functions. In contrast, “hot” EF tasks include decision-making and may emphasize social, emotional, or motivational saliency (Kenworthy et al., 2020; Zelazo & Cunningham, 2007). EF skills are important for many life outcomes, including school readiness (Blair, 2002) academic achievement (Will et al., 2017), social understanding and peer relations (Hughes, 2011), and positive behaviors (Center on the Developing Child, 2012). EF deficits have been associated with psychopathology (Kusche et al., 1993), impairments in adaptive behavior and learning (Pugliese et al., 2014), and poor outcomes in adulthood (Diamond, 2013; Kenworthy et al., 2008).

EF in DS

For children with DS, executive functioning has been less researched in comparison to typically developing children or other clinical groups (Fidler et al., 2005). Relatively little is known about EF ability specifically in young children (e.g., toddlers) with DS, and findings are varied when examining specific domains of EF ability across age groups. However, in general, the consensus appears to be that children and youth with DS show weaknesses across EF abilities (Lanfranchi et al., 2010; Lee et al., 2011; Pritchard et al., 2015).

Researchers have evidence for some neuroanatomical differences among infants with DS which may account for some of the differences observed in EF abilities. Specifically, the frontal lobes (a known area of the brain associated with EF) are reported to be reduced in size (Nadel, 2003).

Some researchers suggest that cognitive and memory deficits may not yet be evident in early preschoolers (Roberts & Richmond, 2015) and these deficits likely emerge and progress as the child ages. Deficits in working memory have been reported frequently and repeatedly in both laboratory tasks and caregiver reports of EF (Baddeley & Jarrold, 2007; Daunhauer et al., 2014; Lee et al., 2011).

In regard to planning and goal-directed behaviors, several researchers have cited specific difficulties in these aspects of EF ability in children with DS (Fidler et al., 2005; Fidler, 2006). Daunhauer and colleagues (2014) found that parent and teacher ratings of EF ability in children with DS, often reported deficits in the working memory domain and planning/organization domain compared to mental age-matched typically developing children. In a lab-based task of planning and inhibition, two to three-year olds with DS consistently used less optimal strategies for obtaining an object in comparison to mental age-matched controls (Baddeley & Jarrold, 2007).

Other studies have reported deficits in flexibility and tasks of attention (Grieco et al., 2015; Pritchard et al., 2015). Taken together, impairments across EF domains are apparent in young children with DS. Understanding, and perhaps intervening, on these challenges are particularly important for young children with DS as these skills are often related to important social and academic outcomes, including school readiness.

The Influence of Language on Play and EF

Children with DS may have strengths in their play abilities and weaknesses in aspects of EF, and both of these constructs may be associated with language. Neither play, nor EF, is seemingly dependent upon language ability (Bishop et al., 2014; Gooch et al., 2016). Rather, language may be associated with play and EF abilities, such that language may allow others to better understand a child's play or EF ability. Parallel developments in play and language abilities have been recognized in early childhood, ranging from 8-24 months (McCune, 1995). Regarding expressive language abilities specifically, Kasari and colleagues reported that in a sample of children with ASD, higher-level play acts at age 4-5 predicted expressive vocabulary abilities 5 years later (Kasari et al., 2012). In regard to EF and language, research has supported the notion that EF and language abilities may travel together (Gooch et al., 2015). The current study will utilize multiples measures of EF, including tasks that do not require expressive language, to better assess EF in children with DS. Overall, language is an important domain to consider when drawing conclusions about the relationship between play and EF abilities.

The Current Study

The current study's primary aim is to explore the relationship between play behaviors and executive function in a sample of toddlers with Down syndrome using a cross sectional study design and through a secondary data analysis.

Research Question:

RQ1) In a sample of toddlers with Down syndrome, are play behaviors and language development associated with executive function ability?

Hypothesis 1: Higher diversity of play acts will be related to better memory ability.

Hypothesis 2: Higher level play behaviors will be related to better ability to persist.

Hypothesis 3: Higher level play behaviors (more novel play acts and higher play complexity) and higher language ability will be associated with higher levels of executive function ability.

Method

Participants

Participants for the proposed study participated in a larger randomized control trial across two sites (University of California, Los Angeles (UCLA) and Vanderbilt University) which examined the effects of a social communication intervention for young children with DS (Merck grant 2409-017298; UL1 TR000445 from NCATS/NIH). Participants were primarily recruited through early intervention programs, schools and local DS associations across Nashville and Los Angeles. A University Institutional Review Board at each site gave approval for the study. Caregivers provided written consent for their participation and their children's participation. Children were included in the larger study if they met the study's eligibility criteria: 1) had a formal diagnosis of DS from medical records, 2) minimum mental age (MA) of 18 months as indicated by the Mullen Scales of Early Learning (MSEL), 3) expressive vocabulary of at least 2 words (spoken or signed). Children were excluded from the study if they had any major medical conditions other than DS.

Of the 80 children originally enrolled in the study, (N=79) will be included in the secondary data analysis. Children were between the ages of 35 to 54 months (mean=38.99), 53% were female, and 22% of the children spoke a language other than English at home. The racial breakdown of the sample is 70% White, 4% Asian, 3% Black/African American, 12% multiple races, 1% other, and 10% did not respond. The ethnic breakdown of the sample is 45% identified as Hispanic/Latino, while 55% did not identify as Hispanic/Latino. All baseline demographic information across the sample is included below in table 1.

Measures

Cognitive and Language Ability

The child's cognitive and language abilities were measured using the Mullen Scales of Early Learning (Mullen, 1995) and the Preschool Language Scales-5 (Zimmerman, 2011).

Mullen Scales of Early Learning (MSEL; Mullen,1995). The MSEL is a standardized assessment designed for young children between the ages of birth to 68 months. This assessment measures the child's cognitive, language and motor abilities via child response to activities administered by the examiner. The MSEL measures five skill domains: gross motor, visual reception, fine motor, receptive language and expressive language. An overall measure of cognitive ability uses four of the scales (fine motor, visual reception, receptive and expressive language scales) to yield the Early Learning Composite. The assessment provides standardized scores, as well as age equivalent scores to more fully capture the range of individual differences (Riley et al., 2019). The MSEL has been shown to have strong psychometric properties and is regarded as reliable and valid (Mullen, 1995). The MSEL was conducted by qualified assessors in accordance with assessment protocol. For the proposed study, age equivalency scores will be utilized.

Preschool Language Scales-5 (PLS-5; Zimmerman et al., 2011). The PLS-5 is a standardized assessment that measures both expressive and receptive language abilities for children ranging in age from two weeks to 83 months. The PLS-5 is often used with children with language impairments/difficulties given that children can use gestural or verbal responses to the assessment questions. Age equivalency scores will be used for data analysis.

Play Ability

Structured Play Assessment (SPA; Ungerer & Sigman, 1984). The child's play ability was measured using the SPA. In this 20-minute play assessment, the interventionist (assessor) sequentially presents five sets of toys that are designed to elicit specific play levels and types. The child is given ample time to freely play with each toy set but is not given instructions or prompts by the assessor on how to play. Video recordings of this assessment were obtained and later coded for three variables: frequency of play acts, diversity of play acts, and play level. For the current study, the diversity of play acts and play level variables will be used for analysis. The diversity of play acts refers to the number of different play acts within a level of play. Play level represents the highest and most frequent level at which the child played with mastery and ranges from indiscriminant acts (such as mouthing objects) to multi-scheme symbolic play acts (such as sociodramatic play). The SPA is coded by blind assessors and the overall reliability across coders was high (90%). This assessment has been widely used for a range of young children with disabilities and language difficulties (Freeman & Kasari, 2013; Harrop et al., 2014; Kasari et al., 2006).

Executive Function Ability

The child's executive function ability was assessed using a parent report measure (BRIEF-P) and three task assessments: The Puzzle Task, The Tower Task, and the EF Search Task.

Behavior Rating Inventory of Executive Function (BRIEF-P; Gioia et al., 2003). The BRIEF-P is a 63-item questionnaire that assesses executive function behaviors in the home and school environments. The BRIEF-P is composed of a Global Executive Composite (GEC) as well as five non-overlapping clinical scales, including: Inhibit, Emotional Control, Shift, Working Memory and Plan/Organize. The BRIEF-P requires the caregiver of the child to specify the frequency of EF behaviors; higher scores indicate greater EF difficulties. This questionnaire has high internal consistency as demonstrated in past studies (Gioia et al., 2003; Schwoerer et al., 2013).

Puzzle Task (Jahromi et al., 2008). The Puzzle Task is an adapted task from Jahromi and colleagues that assesses several components of EF including planning and persistence. In this task, the child is given three different puzzles. The first two puzzles have missing or incorrect pieces, while the third puzzle is complete (solvable). The task is coded for the presence of coping and emotional strategies, such as cognitive/verbal or physical self-soothing, avoidance or distraction. The number of puzzle pieces placed correctly during each puzzle presentation will be used for data analysis. The overall intra-rater reliability across the coders was very high (95%). Higher scores indicate better planning and persistence.

Tower Task (Kochanska et al., 1996). The Tower Task is a measure that assesses the child's working memory. The task involves both the assessor and the child playing with a set of blocks across three trials. The goal of the task is for the child and assessor to jointly build a tower by taking turns placing blocks. Variables that will be included in analysis is the Global Code, which reflects the proportion of blocks placed by an individual compared to the total number of placed blocks (examiner and the child). The score also considers whether the child knocks the tower over before the assessment is completed. The mean score will be used across the two trials. Higher scores indicate better working memory.

Executive Function Search Task (Diamond, 2001). The EF Search Task (also known as an A-not-B task) is an assessment that evaluates the EF constructs of inhibition and the ability to shift. The task involves the child searching for a toy (or reinforcing object) inside a bin that has been hidden by an assessor. The assessor places the toy inside the same bin several times before switching where the object is placed. The task is coded for whether the child was able to find the object and the number of errors before successfully finding the object.

Procedures

At the initial baseline appointment, caregivers and participants completed a variety of baseline assessments (including standardized parent reports, observational measures, and measures administered via clinician) at the designated testing site. Assessments were conducted by experienced master's level special educators, research assistants, psychologists, or speech-language pathologists. All assessors and coders were blind to experimental conditions.

Data Analysis Plan

Data Management

The study data was managed and collected using REDCap (Harris et al., 2009) a secure, web-based software platform designed to support data collection for research studies. The REDCap electronic data capture tools were hosted at Vanderbilt University and UCLA. Statistical analysis will be conducted using IBM SPSS Statistics (Version 26).

Statistical Analysis and Expected Outcomes

First, demographic, and standardized measures for participants were described using summary statistics (means, medians, frequencies). Baseline differences across sites are evaluated via independent t-tests using demographic information, including age and other baseline outcome measures such as cognitive and language ability.

Next, correlations between play behaviors, language ability and EF ability will be examined. An alpha of .05 will be used as the significance level for the correlations. It is hypothesized that play behaviors and language will demonstrate a significant relationship to executive function ability. To further explore the nature of the association between play behaviors, language development and EF ability, multiple regression will be performed in order to examine the effect of play behaviors and language on EF performance (via the BRIEF-P and the three task assessments: Puzzle, Tower & EF Search Task). Tests for assumptions of regression will be performed. Anticipated control variables include IQ (using the MSEL & PLS-5) and age; other variables may be controlled if there are significant differences between sites. It is anticipated that some outcome variables may not be linear, therefore non-parametric models may be used to account for the non-continuous variables. It is hypothesized that high level play behaviors and higher language ability will predict higher levels of executive function ability. Moreover, it is hypothesized that higher diversity of play acts will be related to better memory ability (via the Tower Task) and better inhibition (via the EF Search Task). Higher play levels will be related to better ability to persist (via the Puzzle Task).

Results

The normality of the distribution of the dependent variables were examined. All distributions were found to be normal. Participant and family demographics are included in Table 1 and baseline summary statistics are in Table 2. Group differences were evaluated via independent t-tests using demographic information, including Mullen visual reception and fine motor scores, as well as expressive and receptive language abilities via the PLS-5. Results of an independent t-test evaluating the two sites (UCLA and Vanderbilt) revealed significant differences in terms of cognitive and language abilities. Participants at UCLA had significantly lower expressive language abilities (Mean=15.72, SD=5.675) in comparison to participants at Vanderbilt (Mean=19.66, SD=4.089) (t (65) =3.299, p= .002). Regarding cognitive abilities, significant differences were found between sites on both the Mullen visual reception (VR) scale and the fine motor (FM) scale. Participants at UCLA had significantly higher visual reception scores (Mean=24.20, SD=5.928) as well as fine motor scores (Mean=22.475, SD=4.739) in comparison to participants at Vanderbilt (VR: Mean=20.13, SD=2.232, (t(65)=-4.069, p=000); FM: Mean=20.02, SD=2.674) (t(65)=-2.847, p=.006).

Correlation Analyses

Bivariate correlations were examined to assess relations between the play and executive function variables.

Results indicate that play and EF were related. Pearson product correlations determined that diversity of play acts was significantly correlated to the Memory Tower Task score on Tower 1 ($r(59)=.257$, $p<.05$). No significant relations were found between diversity of play acts and the other primary variables on the Memory Tower Task (including Tower 2 scores and Tower Total Score) (See Table 3). Less children completed the second administration of the tower task (N=18) compared to the first administration (N=30). A chi-square test for a one sample test of proportions revealed that there was an equal likelihood of participants completing the task versus not completing the task $X2$ $(1, N = 40) = .400$, $p = .527$.

Additional supporting evidence for the relation between play and EF were found. Bivariate correlations were examined in reference to play variables and persistence/planning ability as assessed via the Puzzle Persistence Task. Pearson product correlations determined that diversity of play acts was significantly correlated to planning/persistence performance for the first trial of the Puzzle (Puzzle 1 score). No significant relations were determined between the play variables and the other Puzzle Persistence Task variables (See Table 5).

Regarding the association between diversity of play acts and flexibility/inhibition assessed via the Search Task, no significant correlations were determined (See Table 4).

Pearson product correlations were estimated to determine the extent to which variables on the BRIEF-P are linearly related to the behavioral executive function tasks (The Memory Tower Task, Search and Puzzle Persistence Tasks). No significant correlations were found (See Table 6).

Next, the relation between language abilities and play was examined. It was determined that receptive language abilities mattered more so than expressive language abilities in relation to play skills. Receptive language was related to the diversity of play acts score ($r(78)=.381$, $p<.01$) and to play level ($r(78)=.448$, $p<.01$).

Language abilities were also important to EF. It was determined that receptive language scores were associated with most of the EF tasks, including the global executive composite (GEC) score from the BRIEF-P ($r(78)=-.289$, $p<.05$), the Memory Tower Task ($r(78)=.387$, $p<.01$)., and the Puzzle Persistence Task ($r(78)=.673$, $p<.01$).

The relation between play abilities and cognitive skills were examined. Significant correlations were found between play and fine motor abilities. Fine motor abilities were associated with the diversity of play acts ($r(78)=.467$, $p<.01$) and play level ($r(78)=.282$, $p<.05$).

Cognitive skills also related to EF. Fine motor skills mattered for most of the EF tasks, including the Memory Tower Task total score ($r(78)=.352$, $p<.01$) and the Puzzle Persistence Task total score ($r(78)=. 429$, $p<.05$). Visual reception abilities related to the Puzzle Persistence Task ($r(78)=.453$, $p<.01$).

Prediction of Executive Function Ability from Play, Language and Cognitive Variables

Regression analyses were conducted to examine if executive function ability could be predicted by play, language, and cognitive ability. Additionally, given the group differences as mentioned previously, study site was also entered into the models.

A subset of individuals completed the Memory Tower Task (N=61). Memory ability was predicted by the diversity of play acts, fine motor and receptive language ability and study site ($F(4, 56) = 8.028$, $p <.000$), with an R2 of .364 (See Table 7).

A regression analysis was conducted to assess whether inhibition/shift scores (via Search Task, Total Error Scores) could be predicted by play ability via the diversity of play acts variable, fine motor and receptive language ability and study site. Results indicated that there was no significant relation between these variables (See Table 8).

A subset of individuals (all from UCLA) completed the Puzzle Persistence Task ($N=34$). Planning/persistence Puzzle task scores (via Puzzle 1) was predicted by play level, receptive language, and cognitive abilities ($F(4, 29) = 5.160$, $p = .003$), with an $R2$ of .416 (See Table 9 for Coefficients). An additional analysis demonstrated that planning/persistence (via Puzzle 1 on the Puzzle task) could be predicted by diversity of play acts, receptive language abilities, and cognitive abilities ($F(4, 29) = 6.080$, $p < .001$), with an $R2$ of .456 (See Table 10 for Coefficients). These results both indicate that play abilities, along with language, predict performance on an EF task of planning/persistence.

Discussion

Play is an important activity and context in which children learn and develop new skills. For children with DS, play might be an area of relative competency in relation to other cognitive abilities, such as EF. The purpose of this study was to investigate the relationship between play skills and executive function skills in young children with DS. Previous studies suggest that play skills are related to other cognitive skills, including expressive language or emotional development (Fewell et al., 1997; Sigman & Ruskin, 1998; Venuti et al., 2008). Some research suggests that play might influence EF, or alternatively, develop alongside EF (Lillard et al., 2012). Other research has suggested that EF may predict later symbolic play skills (Faja et al., 2016). In this study, we examined whether play abilities were related to specific executive function abilities (such as memory, inhibition, planning) in young, limited language Down syndrome children. Results from this study indicate that play skills and EF abilities are related. More specifically, results suggest that higher play behaviors predict higher levels of executive function ability within the context of certain EF assessments (Memory Tower Task & Puzzle Persistence Task). Higher diversity of play acts predicted higher working memory and planning ability, while higher play level predicted better planning/persistence. Overall, these findings imply that play level and diversity of play predict some aspects of EF (memory, planning, persistence), but not others (inhibition/shift from the Search Task) in a sample of preschoolers with Down syndrome.

Additionally, this study's findings support past research that has indicated language as an important factor to consider within each of these constructs (play; Fewell et al., 1997 and EF; Gooch et al., 2015). The language and cognitive abilities of young children with Down syndrome are highly variable in the 2- to 5-year-old age range (Miller et al., 2015). Children with DS in the current study were selected for significant delay in language abilities (having fewer than 20 words, and no two-word combinations). Still, there is heterogeneity within their language and cognitive abilities, and both constructs are important in the development of play and EF abilities. Specifically, receptive language proved to be more important to play and EF than expressive abilities.

In terms of play skills, this study examined both play diversity (or flexibility in play skills) as well as play level. In contrast, a previous study of a small sample of children with DS (N=19, mean age=33 months) found that expressive language skills, in terms of mean length of utterance (MLU), was significantly associated with play level after controlling for chronological age (Fewell et al.,1997). The discrepancy in results may be due to the inclusion of children with more expressive language skills than in the current study. These findings are consistent with previous studies examining the association of play and language that suggest play develops alongside language abilities (McCune, 1995; Gooch et al., 2016).

Regarding the role of cognitive abilities on EF performance, results indicate that fine motor abilities and play skills are related. For children with DS, these results are important to highlight given that past research suggests that children with DS often have motor impairments that may result in compromised performances in both mental tasks and functional activities (Volman et al., 2007). The results of this study may cause us to consider if the assessment results are reflective of the child's true play or EF ability, or if fine motor abilities contribute to, or may limit, performance on assessments. Given the current study's findings, future studies should take this relationship into consideration. Furthermore, assessments and measures designed for young children with DS may aim to control, limit, or consider the use of skills that require fine motor abilities. For example, in reference to the Memory Tower task, perhaps a better test or measure of working memory ability for young children with DS might be one that does not require stacking of blocks in the specific manner of the test (perhaps bigger blocks, or not stacking vertically). For the current study, fine motor ability was controlled for in the regression analyses to take these relations into account and play and EF were found to be related.

In our study, children with DS who had limited language abilities could complete most portions of the EF tasks yet may be limited in their performance due to their ability to persist in the face of challenging tasks or inefficiencies in their learning styles (Wishart, 1993). This was most evident when examining the completion rates of the Memory Tower Task, in which less children completed the second tower in comparison to the first administration. These findings might lead us to believe that, perhaps, another mechanism is influencing or shaping these patterns. As highlighted by previous research, children with DS often respond to difficult or challenging tasks with an assortment of behaviors, including charming or "party tricks" in which they attempt to socialize and engage, or gain the attention of, the examiner (Kasari & Freeman, 2001). Possibly, children with DS performed to the best of their abilities (utilizing all their skills) during the first initial trials of the task. After the first trial, performance may have been impacted (and thus the relation to play and EF was impacted) due to external influences, including social diversion or lack of motivation or persistence. Further investigation, perhaps considering the role of motivation or engagement with challenging tasks in children with DS, is needed to fully unpack and understand these results.

Limitations and Future Directions

Some limitations must be noted. First, the findings of the current study are based on a relatively small sample size, with varying subsamples with less participants, therefore, results are suggestive and not conclusive. Future studies would need to replicate this study with a larger sample size. Additionally, given the cross-sectional design of the current study, future research would benefit from investigating, and clarifying, the relation between play and EF abilities across time. The effects of play on development may occur over a long period of time, especially during the critical developmental period known as the "five-to-seven-year shift" (Skinner, 2018), therefore, future studies using longitudinal methods would greatly enhance our current knowledge.

One interesting finding of this study involved the lack of relation between the BRIEF-P and the EF behavioral tasks. Given that the BRIEF-P is a widely used clinical tool, and is well-validated for research (Gioia et al., 2003; Schwoerer et al., 2013), it is curious that there were no relations between this measure and the behavioral measures. Perhaps, it is due to the different reporting methods (parents and direct behavior measures). Multi-informant approaches are considered gold standard within the field of mental health, but some studies suggest that caregivers may be over or under reporting, specifically among children with mental health concerns. Future studies would benefit from investigating these informant discrepancies, possibly by including additional informants from other contexts (school) or enhancing the behavioral EF tasks. Regardless, a strength of this study is the inclusion of a variety of assessment methods. There were several behavioral tasks that assess an assortment of EF domains, as well as parent report via the BRIEF-P.

Results of this study suggest that there is a relationship between play and EF which offers a unique contribution to the field. Prior studies examining this relationship have primarily focused on different populations of children, including ASD (Lillard et al., 2012) and children with higher language ability. A major strength of this study was the intentionally narrow inclusion criteria of children with DS with limited language abilities. Most studies about early child development include only healthy, typically developing children. The focus on the relation between play and EF in young children with DS is important given that these children are often at risk for poor school readiness, perhaps due to challenges with their EF abilities. This study indicates that play might be an important context in which EF skills may be learned or enhanced. Play, and EF skills, are malleable with intervention. Therefore, interventions may want to focus or include these two constructs. These findings have strong implications for early intervention research that may aim to enhance the outcomes of atypically developing children related to development and early school success.

Appendices

Appendix 1. Child and Family Demographics.

Measure	Variable	Value	Mean (SD) or N (%)
Child Demographic	Child Age	(months)	38.99 (7.17)
	Gender	Male	37 (47%)
		Female	42 (53%)
	Child's Race	White	51 (70%)
		Multiple	9 (12%)
		Asian	3 (4%)
		Black/African American	2 (3%)
		Other	1 (1%)
		Did Not Respond	7 (10%)
	Child's Ethnicity	Hispanic/Latino	33 (45%)
		Not Hispanic/Latino	41 (55%)
Family Demographics	Mother's Age	(years)	38.13 (6.15)
	Primary Language Spoken at Home	English	60 (78%)
		Spanish	15 (19%)
		Other	2 (3%)
	Mother's Education	Less than 7th	4 (5%)
		Junior High	6 (8%)
		Some High School	3 (4%)
		Some College	11 (14%)
		Special Training	2 (3%)
		College	31 (40%)
		Graduate School	13 (17%)
	Income	<$10,000	3 (4%)
		$10,000-$19,999	7 (10%)
		$20,000-$29,999	7 (10%)
		$30,000-$39,999	8 (11%)
		$40,000-$49,999	6 (8%)
		$50,000-$59,999	5 (7%)
		$60,000-$79,999	6 (8%)
		$80,000-$100,000	7 (10%)
		>$100,000	23 (32%)

Appendix 2. Baseline Summary Statistics.

Measure	Variable	Value	N=80 Mean (SD) or N (%)
Mullen	Visual Receptive	(raw score)	24.53 (3.85)
		(standard score)	23.09 (6.20)
		(age equivalence months)	22.16 (4.90)
	Fine Motor	(age equivalence months)	21.25 (4.01)
Language Scales	Expressive	(raw score)	22.85 (4.93)
		(standard score)	66.38 (10.40)
		(age equivalence months)	17.96 (5.18)
	Auditory	(raw score)	24.55 (5.84)
		(standard score)	64.05 (12.04)
		(age equivalence months)	21.12 (6.51)
SPA	Diversity of Play Acts	(raw score)	55.08 (24.85)
	Play Level	(raw score)	8.83 (2.29)
BRIEF	GEC	(raw score)	110.97 (20.32)
		(t score)	62.29 (12.59)
Tower Task	Total Score	(raw score)	18.72 (12.27)
	Tower 1 Score	(raw score)	4.75 (4.38)
	Tower 2 Score	(raw score)	4.27 (3.62)
Search Task	Total (No Error)	(raw score)	2.44 (1.38)
	Total (With Error)	(raw score)	1.58 (1.44)
	Total Delay	(raw score)	1.19 (1.24)
	Total Errors	(raw score)	2.43 (2.74)

Appendix 3. Bivariate Correlations Among Diversity of Play Acts and Memory Tower Task.

	Diversity of Play Acts
Tower 1	.257*
Tower 2	.273
Tower Total Score	.250

Note. *. Correlation is significant at the .05 level (2-tailed).

Appendix 4. Bivariate Correlations Among Diversity of Play Acts and Flexibility/Inhibition.

	Diversity of Play Acts
Search Task: Total Delay	.151
Search Task: Total Errors	-.008

Note. *. Correlation is significant at the .05 level (2-tailed).

Appendix 5. Bivariate Correlations Among Play Variables and Persistence/Planning.

	Diversity of Play Acts	Play Level
Puzzle 1	.484**	.150
Puzzle 2	-.013	.021
Puzzle 3	-.080	-.062
Puzzle Task Total Score	.295	-.003

Note. **. Correlation is significant at the .01 level (2-tailed).

Appendix 6. Bivariate Correlations Among Executive Function Variables.

	Tower Task (Working Memory)	Search Task: Total Delay (Flexibility/Inhibition)	Search Task: Total Errors (Flexibility/Inhibition)	Puzzle Task (Plan/Persistence)
BRIEF: GEC	-.191	.025	-.020	-.286
BRIEF: Working Memory	-.221	.116	-.035	-.233
BRIEF: Inhibition/Self Control	-.179	.115	-.010	-.290
BRIEF: Flexibility	-.059	.077	-.019	.032
BRIEF: Plan/Organize	-.023	-.059	-.063	-.235

Note. *. Correlation is significant at the .05 level (2-tailed).

Appendix 7. Coefficients for Regression Model Predicting Memory Ability from Diversity of Play Acts.

	Unstandardized B	Beta	t	Sig.
(Constant)	-10.983		-3.764	.000
Diversity of Play Acts	-.022	-.127	-.910	.367
Fine Motor	.707	.601	4.165	.000
Receptive Language	.007	.011	.088	.930
Study Site	1.422	.163	1.450	.153

Note. Dependent Variable: Tower 1 Scores

Appendix 8. Coefficients for Regression Model Predicting Inhibition/Shift Ability from Diversity of Play Acts.

	Unstandardized B	Beta	t	Sig.
(Constant)	4.228		2.371	.021
Diversity of Play Acts	-.001	-.009	-.063	.950
Fine Motor	.107	.164	1.052	.297
Receptive Language	-.079	-.182	-1.299	.198
Study Site	-1.543	-.283	-2.221	.030

Note. Dependent Variable: Search Task: Total Errors Score

Appendix 9. Coefficients for Regression Model Predicting Planning Ability from Play Level.

	Unstandardized B	Beta	t	Sig.
(Constant)	-2.515		-2.169	.038
Play Level	-.001	-.003	-.017	.987
Fine Motor	.035	.137	.774	.445
Receptive Language	.047	.341	1.593	.122
Visual Reception	.061	.330	1.873	.071

Note. Dependent Variable: Puzzle Task, Puzzle 1 Scores

Appendix 10. Coefficients for Regression Model Predicting Planning Ability from Diversity of Play Acts.

	Unstandardized B	Beta	t	Sig.
(Constant)	-2.026		-1.912	.066
Diversity of Play Acts	.011	.265	1.466	.153
Fine Motor	-.003	-.011	-.054	.957
Receptive Language	.044	.316	1.629	.114
Visual Reception	.054	.289	1.757	.090

Note. Dependent Variable: Puzzle Task, Puzzle 1 Scores

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