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Examining the Relationship Between Imitation, Motor Movement, and Language Skill in Young Children with Developmental Disabilities

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EXAMINING THE RELATIONSHIP BETWEEN IMITATION, MOTOR MOVEMENT,
AND LANGUAGE SKILL IN YOUNG CHILDREN WITH DEVELOPMENTAL
DISABILITIES

by

ANI S. WHITMORE

Under the Direction of MaryAnn Ronski, Ph.D.

ABSTRACT

This study examined the relationship between imitation, motor movement, and language skill in 70 children with developmental disabilities. Four primary research questions were addressed: 1) What are the imitation, motor movement, and language profiles of young children with developmental disabilities?; 2) What is the relationship between imitation skill, motor movement, and language skill?; 3) What is the relationship between imitation, motor movement, and language skill, when accounting for reported spoken imitation skills?; and 4) Does motor movement skill moderate the relationship between imitation and language skill? Standardized direct assessments, parent report, and observational kinematic motion capturing was used to measure the participants' skill repertoire. In addition to replicating past research supporting the imitation-language relationship, the results of this study provided new evidence that motor movement is a significant moderator of this relationship. Furthermore, it was shown that the moderating effect of motor movement differs by developmental diagnosis, specifically for children with Autism Spectrum Disorder (ASD) and Down syndrome (DS).

INDEX WORDS: Developmental disabilities, Language, Motor Impairment, Imitation

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ANI S. WHITMORE

A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of

Philosophy

In the College of Arts and Sciences

Georgia State University

2015

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Ani S. Whitmore
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DEDICATION

I dedicate this dissertation to my grandparents; Evelyn L. Scott, Charles L. Scott, & Ouida Patricia Jordan Whitfield. Without them, I would not be here.

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I would like to first acknowledge my Lord, Jesus Christ, for providing me with the blessing of strength to complete this project.

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TABLE OF CONTENTS

ACKNOWLEDGEMENTS		v
LIST OF TABLES		ix
LIST OF FIGURES		x
1 INTRODUCTION		1
2 LITERATURE REVIEW		4
2.1 Early Language Development		4
<i>2.1.1 Typical Language Development</i>		<i>4</i>
<i>2.1.2 Language Development in Children with Developmental Disabilities</i>		<i>5</i>
2.2 Imitation Predicting Language Skills		7
2.3 Measurement of Early Language Skills		10
<i>2.3.1 Natural Language Samples</i>		<i>10</i>
<i>2.3.2 Direct Testing</i>		<i>11</i>
<i>2.3.3 Parent/Teacher Report</i>		<i>13</i>
2.4 Summary of Language Development and Assessment		14
2.5 Early Motor Development		14
<i>2.5.1 Typical Motor Development</i>		<i>14</i>
<i>2.5.2 Motor Development in Children with Developmental Disabilities</i>		<i>17</i>
<i>2.5.3 Mechanisms That Influence Motor Movement Impairment</i>		<i>21</i>
<i>2.5.4 Movement Skill Impairment and Imitation</i>		<i>21</i>
2.6 Measuring Early Movement Skills		23
<i>2.6.1 Direct Testing</i>		<i>24</i>

2.6.2	<i>Kinematic Motion Analysis</i>	24
2.6.3	<i>Summary of Motor Development and Assessment</i>	25
2.7	Summary of Literature review	25
2.8	Primary Research Questions and Hypotheses	26
3	METHODS	27
3.1	Study Design	27
3.2	Participants.....	27
3.3	Measures: Administration and Scoring	31
3.3.1	<i>Direct Testing and Parent Report: Imitation</i>	31
3.3.2	<i>Parent Report: Fine Motor Movement</i>	34
3.3.3	<i>Observation: Upper-Body Reaching Kinematics</i>	34
3.3.4	<i>Parent Report: Receptive and Expressive Language</i>	35
3.3.5	<i>Parent-Report: Vocabulary</i>	36
3.4	Missing Data	37
3.5	Data Analysis.....	38
4	RESULTS	39
4.1	Imitation, Motor Movement, and Language Skill Profiles	39
4.2	Examining the Imitation-Motor Movement-Language Relationship	42
4.2.1	<i>Entire Sample</i>	42
4.2.2	<i>Children with ASD</i>	42
4.2.3	<i>Children with DS</i>	43
4.3	Examining the Imitation-Motor Movement-Language Relationship: The Impact of Spoken Imitation Skill.....	43

4.3.1	<i>Participants without Reported Spoken Imitation</i>	44
4.3.2	<i>Participants with Reported Spoken Imitation</i>	44
4.4	The Moderating Effect of Motor Movement Skill on the Imitation-Language Relationship	45
4.4.1	<i>Entire Sample</i>	47
4.4.2	<i>Participants with ASD</i>	49
4.4.3	<i>Participants with DS</i>	50
5	DISCUSSION	51
5.1	Study Limitations	55
5.2	Future Directions	56
5.3	Conclusion	57
	REFERENCES	59
	APPENDICES	73
	APPENDIX A	73

LIST OF TABLES

Table 1. <i>Study participant demographic characteristics</i>	29
Table 2. <i>Description of SICR-R imitation items used and outcome measured</i>	33
Table 3. <i>Mean Imitation, Motor, and Language Skill Raw Scores</i>	40
Table 4. <i>Mean Proportion of Maximum Imitation, Motor, and Language Scores Obtained</i>	41
Table 5. <i>Independent Samples T-Tests</i>	41
Table 6. <i>Motor Composite Score Moderation Model 1 Predicting Language Skill</i>	47
Table 7. <i>Reaching Velocity Moderation Model 2 Predicting Language Skill</i>	48
Table 8. <i>VABS Motor Skill Moderation Model 3 Predicting Language Skill</i>	49
Table 9. <i>ASD: Reaching Velocity Moderation Model 2 Predicting Language Skill</i>	50
Table 10. <i>DS: VABS Motor Skill Moderation Model 3 Predicting Language Skill</i>	51

LIST OF FIGURES

Figure 1. <i>Relationship between the Proportion of Language and Imitation Scores by Reported Spoken Imitation Skill</i>	44
Figure 2. <i>Moderation Regression Model 1</i>	46
Figure 3. <i>Moderation Regression Model 2</i>	46
Figure 4. <i>Moderation Regression Model 3</i>	46

1 INTRODUCTION

Young children with developmental disabilities often attain developmental milestones at a slower rate and experience various levels of impairment that may affect the level of functioning for specific skills. Both delays and impairments may be observable either early in a child's life and/or throughout maturation. Similar to typical development, there is variance in the abilities and level of impairment observed across children with developmental disabilities. That variance may be a reflection of a number of influences, such as the presence of additional delays and/or impairments in one or more areas of development, such as the language, motor, and social domains (Batshaw, Roizen, & Lotrecchiano, 2013).

Within the language domain, a child's first word is the one of the most anticipated milestones early in development. Some children with developmental disabilities may have problems reaching this milestone when it is commonly expected. For example, children with Down syndrome (DS) experience a delay in language acquisition that is beyond what is expected for both their chronological age and nonverbal, cognitive ability (Adamson, Bakeman, Deckner, & Ronski, 2010; Chan & Iacono, 2001; Kumin, 1996; Mundy, Sigman, Kasari, & Yirmiya, 1988; Tager-Flusberg et al., 1990). They also experience deficits in expressive vocabulary, syntax, and morphology (Batshaw et al., 2013; Chapman, 1997; Kumin, 1996; Tager-Flusberg et al., 1990).

Delays or impairments throughout the motor domain are also well documented, as a child's first steps are another highly anticipated developmental milestone. Similar to language, the acquisition of foundational and complex motor skills may be difficult for children with developmental disabilities. These difficulties can be observed in the earliest years of life and persist throughout life. Fidler, Hepburn, Mankin, & Rogers (2005) examined the praxis skills of 19 typically developing infants, 16 toddlers with developmental disabilities of unknown or

mixed etiologies, and 16 toddlers with DS. Praxis is defined as the planning, execution, and appropriate sequencing of motor movements (Ayres, 1985). The child participants were compared on their performance on the motor subscales of the *Vineland Adaptive Behavior Scales* (VABS; Sparrow, Balla, & Cicchetti, 1984), a praxis battery developed by the researchers, and an experimental reaching task. Both atypically developing groups were observed with lower motor skills, when compared to typically developing infants. Furthermore, the praxis skills for both groups were significantly related to both overall motor skills and overall performance on the VABS Daily living subscale, which measures skills concerning personal hygiene, completing household tasks, and navigating the community

Although both language and motor development have been evaluated separately throughout the study of atypical child development, the relationship between the language and motor domains has been supported in the literature (Gernsbacher, Sauer, Geye, Schweigert, & Hill Goldsmith, 2008; Kumin, 2006). Rechetnikov & Maitra (2005) completed a meta-analysis that examined reports of motor impairments in children between 2-21 years of age with speech and language impairments. The analysis included 16 studies that measured motor error (number of test performance errors or impairment score), motor score (score received on the test), and motor time (time taken to complete a test). Children with speech and language impairments were categorized as having more severe motor impairments and lower test scores, as well as needing more time to complete the assessments, when compared to their typically developing peers.

Despite the strong relationship between both language and motor domains, the relationship did not remain significant when additional skills, such as social reciprocity, were included in the model (Rogers, Hepburn, Stackhouse, & Wehner, 2003). One possible explanation is that motor movement skill is related to specific aspects of imitation. During early imitative acts, a child has

the opportunity to practice and experience foundational oral motor and fine motor movement skills that support later language skill. Therefore, an individual's current degree of motor movement impairment may impact established relationships, such as imitation and language skill, differently than originally suggested. Little research has examined how motor impairment affects the effect imitation skill. To the author's knowledge, there has not been any research that has examined how motor movement skill and observed degree of motor movement impairment impacts the imitation-language relationship in young children with developmental disabilities. Knowledge of how early motor movement skill influences this relationship may be used to inform early intervention efforts (Kuhl et al., 2013). Furthermore, the use of multiple types of measurement tools to examine this relationship would provide a more complete picture of a child's skill repertoire in a variety of contexts and from diverse sources of information (Association, 2012; Brenner, 2003; Burton & Miller, 1998; Dockrell, 2001).

The purpose of this study was to examine the relationship between imitation, motor movement, and language skill in young children with various developmental disabilities. The following literature review will discuss the development of language, motor movement, and imitation skills in young typically and atypically developing children. Next, critical points will be summarized, and a model of the relationship between the language, motor movement, and imitation skills will be suggested. Finally, this study's research questions and hypotheses will be presented.

2 LITERATURE REVIEW

2.1 Early Language Development

2.1.1 *Typical Language Development*

Typical language development follows a relatively linear path despite the heterogeneity observed due to individual differences in early language and communication experiences. Within the first year, infants express a variety of non-spoken communicative behaviors, such as matching eye-gaze with their caregiver and utilizing vocal turn taking. Infants use behaviors such as reaching, pointing, and shaking their heads to communicate the same intentions that will be expressed later using spoken language (Tager-Flusberg, Paul, & Lord, 2005). Communicative gestures are paired with vocalizations in which the child is trying to produce the sounds of the language spoken by others in their environment. Children can comprehend a few words of their native language around 10 months of age and will produce their first word around 12 months of age (MacWhinney, 2005; Tager-Flusberg et al., 2005). After their first word, children slowly add more words to their vocabulary, using both cues from their communication partners and the language contexts in which the words are used. Their phonological and syntactical skills also are emerging, with the majority of vocalizations taking a consonant-vowel (CV) or consonant-vowel-consonant (CVC) form, and single words utterances. Once their expressive vocabulary has reached 50 words between 15 and 18 months of age, the “word explosion” begins, with rapid word learning occurring daily. Between 18 and 24 months of age, children begin combining words, make consistent comments and requests, and have an expressive vocabulary of 100-200 words. By 36 months of age, children have an expressive vocabulary of 900 words. They also use strategies to understand the meanings of new words, use grammatical morphemes, and begin to ask questions. From 4 years of age and into the school-age years, children have receptive and

expressive vocabularies that include thousands of words. They use word combinations and complex sentences more frequently, and language is used in a variety of ways, such as for negotiation and reasoning (Hoff, 2009; MacWhinney, 2005; Tager-Flusberg et al., 2005). Knowledge of typical language development and observable milestones has been used to inform research examining the language development of children with various developmental disabilities.

2.1.2 Language Development in Children with Developmental Disabilities

The heterogeneity observed with the acquisition of language milestones of typically developing children is also observed for children with developmental disabilities. Some children experience little delay in the acquisition of language skills, whereas other children experience significant delays in their overall acquisition of language milestones (Tager-Flusberg et al., 2005). Research has shown that young children with Autism Spectrum Disorder (ASD) have both a receptive and expressive language impairment, with receptive skills delayed more than expressive language skills (Barbaro & Dissanayake, 2012; Ellis Weismer, Lord, & Esler, 2010a; Hudry et al., 2010; Mitchell et al., 2006a; Tager-Flusberg et al., 2005). In contrast, other children may only experience an impairment of specific skills. Mundy et al. (1988) examined the communication skills of 18-48 month old children with DS ($n=30$) and mental-age-matched typically developing children ($n=30$). The results showed a significant delay in nonverbal requesting, as compared to the typically developing children. The specific difficulty in nonverbal requesting for children with DS was also related to the observed deficit in expressive language skill.

Weismer et al. (2011) found that toddlers with ASD ($n=40$) had the same level of vocabulary, as measured on the *MacArthur-Bates Communication Development Inventories*

(CDI; Fenson et al., 2007), as late talking, typically developing children ($n=40$) who were (on average) five months younger. Roberts et al. (2007) examined the receptive and expressive vocabulary of boys with Fragile X syndrome (FX) with ($n=49$; mean CA= 8 years) and without ($n=33$; mean CA= 8 years) characteristics of ASD, boys with DS ($n=39$; mean CA= 8 years), and typically developing boys ($n=41$; mean CA= 4 years) longitudinally for four years. Boys with DS had a lower receptive vocabulary than the typically developing boys and boys with FX; however, their receptive vocabulary did not differ from boys with FX with the ASD characteristics.

Additionally, the boys with DS had a smaller expressive language vocabulary than the typically developing boys, but again it did not differ from the boys with FX with the ASD characteristics

Hudry et al. (2010) examined and described the language profiles of 152 children with ASD between 24 and 59 months of age who were part of a larger language study in the United Kingdom. The participants came from a variety of both ethnic and economic backgrounds. The language measures included the *Vineland Adaptive Behavior Scales-2nd Edition* (VABS-2; Sparrow, Cicchetti, & Balla, 2005), the *Preschool Language Scales-3rd Edition* (PLS-3; Zimmerman, Steiner, & Pond, 1992), and the *CDI* (Fenson et al., 2007). The *Mullen Scales of Early Learning* (MSEL; Mullen, 1995) was administered to measure their nonverbal cognitive level and the *Autism Diagnostic Interview-Revised* (ADI-R; Rutter, Le Couteur, & Lord, 2003) was used to measure ASD symptom severity. As a group, both receptive and expressive skills were impaired, with receptive skills being lower than expressive language skills. Even within their lexicon, one-third of the entire sample fell outside of the 95th percentile score for the CDI's normative sample. Many of the participants experienced floor effects on the language measures. Examination of individual raw data revealed that some children had a typical language profile, with receptive language exceeding expressive language skill; however, these children had higher

scores on the MSEL, had a lower ADI-R symptom severity score, and were chronologically older. Despite the observance of a profile of typically developing children, they still had delayed receptive and expressive language skills. Overall, language acquisition delays and skill impairment has been widely documented and frequently observed across developmental diagnoses. Therefore the next logical step throughout the field was to identify and understand the preceding skills that predicted both typical and atypical language skill.

2.2 Imitation Predicting Language Skills

Imitation is an important social learning behavior and children gradually become more skilled at an early age at using imitation. Various measures of imitation skill have been found to be a significant predictor of current and future language skill in typically developing children. Typically developing children use imitation not only just to copy the observed behaviors and movements, but also to understand the intentions behind them. They only imitate behaviors and movements that they understand to have an obvious end goal and purpose (Carpenter, Tomasello, & Striano, 2005; Tomasello & Barton, 1994). Within the context of language, Tomasello and colleagues have shown that at a very early age, children learn early language skills via imitation when they are attempting to understand the purpose for usage by the adults in their surroundings (Tomasello & Barton, 1994). Furthermore, Carpenter et al. (2005) suggested that having the ability to understand the intentions behind a behavior or action when imitating is essential to understanding and producing linguistic symbols.

When reviewing the research literature concerning imitation ability in children with developmental disabilities, numerous studies have focused solely on children with ASD due to their marked impairment in social communicative behaviors, such as imitation (Carpenter et al., 2005; Luyster, Kadlec, Carter, & Tager-Flusberg, 2008; Mostofsky et al., 2006a; Tager-Flusberg

et al., 2005; J. H. Williams, Whiten, Suddendorf, & Perrett, 2001). Williams, Whiten, and Singh (2004) conducted a systematic literature review and meta-analysis to address the following issues: 1) Whether there is an overall existence of an imitative deficit and the significance of the overall effect size?; 2) Whether or not the imitative deficit is specific to ASD?; 3) What is the underlying neural mechanism of the imitative deficit?; and 4) What type of imitation skills are more susceptible to being affected? Studies included in the review were confined to participants with Autism or Asperger's syndrome, and only the imitation of hand and body actions. A total of 21 studies involving 281 children were reviewed. Eight of the 21 studies included had participants with a mean chronological age less than 5 years. The results revealed that 14 of the 21 studies found large group differences for an imitation deficit for children with ASD as compared to a control ($p=.00002$). Having an ASD diagnosis and motor skill impairment accounted for some of the imitative impairment, leaving the authors to suggest a possible correlation between imitation and the severity of ASD symptomology. Lastly, imitation of non-meaningful gestures resulted in the largest group differences, as compared to imitating actions upon objects.

Research has also shown that imitation skill may predict language ability in children with ASD. Ingersoll and Schreibman (2006) used a multiple-baseline naturalistic intervention that taught imitation skills to five young children with ASD between 29-45 months of age. This imitation intervention significantly increased their spontaneous spoken language use. Furthermore, Stone and Yoder (2001) examined whether play level, motor imitation, joint attention, socioeconomic status, and hours of speech/language therapy at two years of age predicted an aggregate measure of language skill at four years of age for 35 children with ASD ($n=24$) or Pervasive Developmental Disorder (PDD; $n=11$). The authors created an expressive

language aggregate that included both parent report and direct observation because both are valid measures of different aspects of language. They also wanted the expressive language measure to reflect the children's language use of language across various contexts. Controlling for language ability at age two, only imitation ability and hours of speech/language therapy predicted the aggregate score of language skills, as measured by the CDI, PLS-3, and the *Sequenced Inventory of Communication Development* (SICD; Hedrick, Prather, & Tobin, 1984).

Despite the field's focus mostly on imitative ability in children with ASD, some research has also shown the imitation skill profiles of children with other developmental disabilities, and the predictive value of imitation on language skill. Nonetheless, the most frequent comparison group involves children with DS (Lainé, Rauzy, Tardif, & Gepner, 2011; Libby, Powell, Messer, & Jordan, 1997; Tager-Flusberg & Calkins, 2009; Tager-Flusberg et al., 2005). Libby et al. (1997) examined the imitation of pretend acts of children with DS ($n=10$; mean CA= 4.5 years), ASD ($n=10$; mean CA=10.5 years), and typically developing children ($n=10$; mean CA= 2 years). Effective pretend play has been shown to be a significant developmental milestone for overall language development (Bergen, 2002). The children were presented with both single pretend acts, and multischeme acts that depicted a developmentally familiar script (e.g., feeding, bathing, etc.). Although the children with DS were described as having similar imitation skills to typically developing children, their percentage of correct scores on the imitation tasks were lower than their typically developing peers. Thurm et al. (2007) found that the ability to imitate tongue-clicking, a single measure on the SICD, at two years of age significantly predicted expressive language skill at five years of age for both young children with a developmental delay and no ASD symptoms ($n=21$) and young children referred for exhibiting ASD symptoms ($n=110$).

The literature reviewed represents the overall consensus that imitation skills are observed to be more impaired for children with ASD, in contrast to children with other developmental disabilities. However, this consensus may only reveal one aspect of what is actually occurring. Although children with developmental disabilities other than ASD may not be observed with the same level of impaired imitation skill, they may exhibit impairments in the imitation and later production of other actions.

2.3 Measurement of Early Language Skills.

Research concerning the language skills of typically developing children, and children with developmental disabilities has highlighted both the recommended practices and frequent issues encountered when measuring early language skills. The use of multiple evaluation tools to obtain information concerning the range of language skills of an individual child today is considered the gold standard. Researchers often use more than one of the following broad approaches for language assessment: standardized norm-referenced direct-testing, natural language sample analysis, and teacher/parent report (Dockrell, 2001; Paul, 2005).

2.3.1 Natural Language Samples

Language samples can provide researchers a wealth of information concerning the language skills of a child with either typical or atypical language development. Language samples are obtained by recording spontaneous language use during interactions with others or can be elicited using verbal prompts to gain specific information. Although both methods have their advantages, elicited language samples have been criticized in the past because of the constraints placed on the speaker and the questionable reflection of the speaker's true language skills. Having at least 50 utterances per language sample should also provide enough information concerning a child's language skill. Computer programs used to analyze natural language

samples, such as *Systematic Analysis of Language Transcripts* (SALT; Miller & Chapman, 1985), provide multiple outcome measures to describe their language skills (i.e. mean length of utterance, mean morphemes and words, and type-token ratio). Despite the labor-intensity of a single language sample, it is a highly-regarded method of language measure that can complement teacher/parent report and/or standardized direct testing (Dockrell, 2001).

Recent technological advances have increased the amount of language data and contexts explored, while decreasing the overall labor-intensive process of collection and analysis. One promising technological advance in natural language sampling is an automated vocal analysis system called the Language Environment Analysis (LENA). The system is comprised of both a digital language processor and language software analysis. A small digital recorder is placed inside the child's clothing to record information concerning the child's language input from others in the environment, overall vocal activity of the child, and conversational turns between the child and others in the environment. The reliability of the LENA system language samples were shown to be highly representative of language transcripts created by humans. Furthermore, there continued to be a high correlation between LENA and human-transcribed samples for various language measures and vocalization classification patterns observed. There are incidences where extreme environmental noise and overlapping speech may create false classifications of child or adult vocal activity, but the level inaccuracies are not higher than human-based transcription errors (Warren et al., 2010; Xu, Yapanel, & Gray, 2009).

2.3.2 Direct Testing

Direct testing is another method of measuring the language skills of both typically developing children and children with developmental disabilities. Commonly, standardized direct assessments are used in order to see how a child's skills compare to the conceptualized

“typical” child. The “typical” comparison child is representative of the average range of skills observed in the norm or standardization group when the test was being developed. Those skills also represent the norm group’s performance under specific testing procedures (Brenner, 2003). The purposes of these tests are to identify potential areas for concern with a need for further examination and/or designate the specific skills a child has. The tests’ purposes should be in line with the level of language skill they intend to measure, for example word meanings versus sentence completion (Batshaw et al., 2013; Stetson, Stetson, & Sattler, 2001). The language domains that can be examined range from general receptive and expressive language skills to specific aspects of language, such as vocabulary and syntax, and morphology (Stetson et al., 2001). The use of a general or global language test as opposed to a test of a specific language domain depends on the goal of the researcher.

A frequent criticism of general language measures is that they are less reliable for younger children; however, the counter-argument is that the decreased reliability is an accurate reflection of the individual differences and variability in early language development (Dockrell, 2001). Test selection depends on characteristics such as the constructs measured, administration protocols, and psychometric properties. Furthermore, there are often concerns of whether or not the standardization sample is appropriate (e.g. characteristics that match the population of interest). Not all standardized assessments included a variety of norm groups, such as children with a variety of disabilities, and not only physical or intellectual disabilities. Using assessments with a disregard for the presence of a disability, or other distinct cultural or linguistic features, will certainly have an effect on test performance and obtaining a true picture of a child’s skill repertoire (Brenner, 2003). Particularly for children with developmental disabilities, who have heterogeneous language and communication skill profiles, the tests chosen have to measure a

variety of domains in order to pinpoint the source of the difficulty. Tests developed for use with younger children with developmental disabilities, such as the *VABS* (Sparrow et al., 1984), have been shown to provide an accurate description of their skill repertoire.

2.3.3 Parent/Teacher Report

The use of parent or teacher report via interviews, checklists, and questionnaires is also a common method of gathering information regarding the language skills of both typically developing children and children with developmental disabilities. Parents are often the target respondents because of their ability to provide information regarding their child's language skills in a variety of contexts. Although parent/teacher reports have been subjected to criticisms of selective reporting bias, they can provide both valid and reliable information when the information referenced is from the present time period, the language skills in question are emergent skills, and the language skills identified by the parents are presented to them and not identified via recall. Additionally, parent/teacher report has been shown to have high concurrent validity with behavioral measures of vocabulary and syntax. One of the most widely used parent report measures used for both young typically developing children and children with developmental disabilities is the *CDI* (Fenson et al., 2007). The *CDI* is designed for use by parents of children between 8-30 months of age, but can be used for older children with a language delay or impairment and functioning developmentally within the age range of the measure. When the assessment is used for children outside of the age-range upon which it was standardized, standard scores cannot be obtained; thus, raw scores are the only available option. Overall, parent/teacher report language measures have been shown to provide reliable and valid information regarding a child's language skills when used in conjunction with other measurement methods (Dockrell, 2001).

2.4 Summary of Language Development and Assessment

In summary, early language development is a continuous, dynamic process that is reflective of the growth and experiences of the child interacting with their surrounding environment. Despite individual differences common throughout human development, the acquisition of a language is a linear process with essential milestones that must be met during the first five years of life (MacWhinney, 2005). For children with developmental disabilities, there is often an impairment of language skills, affecting the ability of the child to function. The skills affected are heterogeneous and range across levels of impairment. Additionally, imitative skill has been shown to be a significant predictor of both current and future language skill (Hudry et al., 2010; Lord, Shulman, & DiLavore, 2004; Tager-Flusberg et al., 1990, 2005). The methods used to measure language skills vary in the purpose and appropriateness of the tool; however, using a combination of natural language samples, parent/teacher report, and standardized direct testing is considered the gold standard in order to get a complete picture of a child's language skill repertoire or source of impairment (Dockrell, 2001). Another developmental domain that undergoes major changes during the first five years of life and has been shown to influence language and imitative skills is the motor movement.

2.5 Early Motor Development

2.5.1 Typical Motor Development

The motor domain is another developmental area that experiences continuous growth and increase in skill level during early childhood. The terms motor and movement are often used interchangeably when referencing the same skill set, but they are two different concepts. The term movement implies the directly observable, goal-directed acts of moving a body part, whereas the term motor implies general abilities that are not directly observable (e.g., internal

neuromuscular or motor processes) that underlie movement skills (Burton & Miller, 1998). Empirical research throughout the behavioral literature often conceptualizes and measures only observable skills within the motor domain; thus, this study will use the term motor movement skills to refer to the directly observable acts completed under the motor domain. Furthermore, the skills referenced in the following discussion will belong to one of three categories: gross, fine/manual, or oral motor movements. First, the development of gross and fine/manual motor movement skills will be discussed. Oral motor movement skills will be reviewed second.

2.5.1.1 Gross and Fine/Manual Movement Skills

Once children are born, their bodies experience constant growth. There is more than one rule-of-thumb concerning typical motor development: 1) Motor development occurs in a cephalocaudal (head to toe) and proximodistal (torso to the hands/feet) direction; 2) The control of movements is general (i.e. gross motor) and later becomes more refined (i.e. fine motor); 3) Children start with their all of their limbs flexed at the joints, but overtime gain more control over extending their limbs; and 4) The achievement of motor control and stability leads to increased mobility, and eventually performing a skilled act in a developmental position (Adolph & Berger, 2005; Heller, Alberto, Forney, & Schwartzman, 1996). During the first seven months, children begin to master control over their head, limbs, and postural balance. The acquisition of these gross motor movements allows infants to begin reaching for objects for manipulation, sitting and reaching simultaneously, and transitioning into a kneeling position. The biggest accomplishment associated with each one of these skills is managing the postural sway that occurs at all times and the strength to resist the earth's gravitational pull on the body. All of the aforementioned gross motor movement skills are foundational, on which more complex skills are built. These complex skills include crawling by seven months of age, walking on flat surfaces by

12 months of age, and walking up stairs without support by 30 months of age (Adolph & Berger, 2005).

Fine/manual motor movement skills arise from the child's ability to reach for objects. The primary obstacle to successfully reaching is stabilizing the body from disturbances created when moving the upper-body limbs. This obstacle must be overcome in the supine (i.e. lying back down with face upward), prone (i.e. laying stomach down with face downward), and sitting positions. From reaching, the child begins to master object exploration and manipulation. Object exploration and manipulation skills are necessary for the child to learn more about different object properties and act upon his or her own environment. The movement skills often employed include grasping and fingering with a single digit. The use of hand-held tools to complete tasks occurs when a child realizes the gap between his or her own skill repertoire and the task at hand (Adolph & Berger, 2005). Throughout toddlerhood, children become more advance with their fine/manual motor movement skills and are able to complete tasks such as stacking blocks, threading beads onto a string, and placing pegs in holes.

2.5.1.2 Oral Motor Movement Skills

The available literature concerning the development of typical oral movement skills is sparse. The majority of research has focused on infant feeding and swallowing. Delaney and Arvedson, (2008) provided a comprehensive review of oral motor development, as it pertained to feeding and swallowing within the first year of life. Both skills provide practice and require mastery of oral motor movements that are necessary for survival. Sensory input, methods of feeding, anatomic changes, and other gross and fine motor developments that are observed as the child grows are all continuously relevant to oral motor development. Furthermore, gradual experience coordinating the jaw, lips and tongue are necessary for children to transition from early, to

transitional, then advanced feeders. The progression to producing more accurate oral motor movements has also been shown to be linked to both speech and early language skills in very young children. Studies with typically developing toddlers have provided evidence that much of the increase in oral movement skills is related to the increased linguistic demands occurring around age two. Research has suggested links between oral movement skills, babbling (K. J. Alcock & Krawczyk, 2010), and speech fluency (Gernsbacher et al., 2008). Furthermore, both lip and jaw movements change in relation to a child's acquisition and production of new sounds and vocabulary (Nip, Green, & Marx, 2011) and are correlated with language skills measured on standardized assessments. Nonetheless, there is still a debate as to the specific age at which typically developing children have oral movement skills that are adult-like (Alcock, 2006).

2.5.2 Motor Development in Children with Developmental Disabilities

Children with developmental disabilities often exhibit some level of motor delay and/or impairment. Motor delays are defined as lag in the acquisition of a particular skill (Batshaw et al., 2013). Whereas motor impairment can be defined as an observed problem with the acquisition of motor skills or atypical patterns that prohibit the execution of specific movements (Mahoney, Robinson, & Fewell, 2001). The interest in motor development and impairment of children with developmental disabilities has increased over the past two decades. A potential reason for the late emergence of research interest is due to researchers assuming the motor skills of children with specific disorders (e.g. Down syndrome and cerebral palsy) were more impaired than children with other disorders (e.g. Autism Spectrum Disorder), or considered at-risk (premature births); thus, past research has only focused on a particular group of disorders.

2.5.2.1 Fine/Manual Motor Movements

The motor impairment observed in children with cerebral palsy has been studied in depth because it is a developmental disorder distinguished by impaired posture and movements. Cerebral palsy is categorized using subtypes to describe the disorder by the limbs affected and the degree of movement impairment (Batshaw, 2002). The fine motor skills required for everyday hand functioning are also often impaired. Many children are unable to engage in self-care tasks or manipulate objects in their hand. Rochat (1989) demonstrated that the hand is a necessary tool to complete simple and complex tasks that permits a child to interact and learn from the environment. The degree of manual impairment may have a significant impact in the level of participation in daily activities and a child's overall quality of life (Eliasson & Burtner, 2008). Kieviet, Piek, Aarnoudse-Moens, and Oosterlaan, (2009) conducted a meta-analysis that examined the motor development from birth to adolescence in children who were either born pre-term or had a very low birth weight. Both groups are known to be a risk for being diagnosed with a developmental disability as they age (Batshaw et al., 2013). Eighty-one percent of the children from the 41 studies included in the meta-analysis were between 0-4 years of age. The motor domains examined included balance, manual dexterity, and gross and fine motor skills. Overall, the impairments measured early in life were shown to persist throughout early to late childhood. Even when they appeared to meet the milestones similar to their typically developing peers, children who were premature or had a low birth weight still exhibited impairments in motor functioning as the demands increased throughout development.

Fournier, Hass, Naik, Lodha, and Cauraugh (2010) conducted a systematic literature review and meta-analysis of motor coordination in children, adolescents, and adults with ASD, as compared to a typically developing control group. There were seven outcome variables of

interest: movement time, movement accuracy, adaptation rate, gait velocity, center of pressure excursion, balance stability, and standardized motor control scores (e.g., PDMS). Forty-one studies with a total of 51 comparisons were included in the meta-analysis. Only 4 studies included children between 3 and five years of age. The results showed a large overall effect size, indicating significant motor coordination deficits in individuals with ASD as compared to typically developing children. A series of subgroup meta-analyses were conducted for three moderator variables: comparison studies with different groupings of ASD diagnoses (i.e. Autistic disorder, globally diagnosed with an Autism Spectrum Disorder per the DSM-IV-TR, and Asperger's syndrome), upper versus lower extremity deficits, and participant age (i.e. infant, toddler, child, young adult, and older). The first subgroup meta-analysis revealed that regardless of diagnostic label (autism, ASD, or Asperger's syndrome) they had significantly impaired motor coordination skills as compared to typically developing individuals. The second subgroup meta-analysis again revealed significant deficits in the upper, lower, and combined extremities for individuals with ASD, as compared to typically developing individuals. The final subgroup meta-analysis revealed that regardless of age, individuals with ASD had significant motor control deficits as compared to typically developing individuals.

Matson, Mahan, Fodstad, Hess, and Neal (2010) evaluated the movement skills of 397 toddlers 17-36 months of age with autistic disorder ($n=117$), Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS; $n=112$), and children with atypical development that who did not qualify for ASD ($n=168$). The results showed that more children with autistic disorder had gross and fine movement skill impairment than children with PDD-NOS and atypical development. Additionally, when compared to children with atypical development, the children with autistic disorder showed the largest impairment in fine movement skills.

Fidler et al. (2005) examined the general motor movement and praxis skills of children with DS ($n=16$; mean CA=3 years), as compared to chronological age- and mental age-matched children with developmental disabilities ($n=16$; mean CA=2.5 years), and typically children ($n=19$; mean CA= 1.5 years). A battery of tests were administered, including the MSEL (Mullen, 1995), the VABS (Sparrow et al., 1984), and a praxis test developed by one of the authors. The results showed that children with DS received lower scores on the general gross and fine motor subscales, as compared to the children with developmental disabilities. However, they did perform similarly to the younger, typically developing children. Additionally, the children with DS performed worse than the children with developmental disabilities on the praxis battery and reaching tasks. The results also showed a relationship between the praxis battery and the gross motor subscale on the VABS for children with DS, suggesting praxis difficulties beyond their motor movement impairment.

2.5.2.2 Oral Movement Skills

Similar to fine movement skills, the oral movement skills of children with developmental disabilities are often delayed or significantly impaired. Simple oral movements such as tongue protrusion and lip puckering have been shown to be related to speech fluency (Alcock, 2006; Gernsbacher et al., 2008). Adams (1998) examined the oral movement skills of typically developing children ($n=4$) and children with ASD ($n=4$) between 6-11 years of age using the *Kaufman Speech Praxis Test for Children* (KPST; Kaufman, 1995). Though the sample size was small, there was a significant difference between both groups on the Oral Movement scale of the KPST, with the children with ASD encountering the most difficulty. Specifically, the children with ASD had difficulty lifting their tongue and alternating between a lip spread and pucker.

They also were observed using oral groping (i.e. when the mouth searches for a position needed to produce a specific sound) and not being able to isolate single oral movements within a series.

An impairment of oral motor movements also has been reported for children with DS (Alcock, 2006; Barnes, Roberts, Mirrett, Sideris, & Misenheimer, 2006). Barnes et al. (2006) examined the oral structure and oral-motor movement skills of children with FX ($n=59$; CA= 4.7 years), children with DS ($n=34$; CA= 4.4 years), and typically developing children ($n=34$; CA=4.9 years). Both children with FX and DS performed worse than typically developing children on the oral structure and oral function tasks (i.e. isolated and repetitive movements without sound), and the speech function tasks (i.e. phoneme/syllable/word production and coordinated speech movements).

2.5.3 Mechanisms That Influence Motor Movement Impairment

Dynamic systems theory (DST) is a non-computational view of the mind, behavior, and development that moves away from the modular or localized arguments of knowledge and performance. It suggests that new forms of behavior are the result of the continuous, dynamic interactions between multiple cooperative components within a system (e.g., an individual child) and the surrounding environment (Thelen, 1995a; Thelen & Ulrich, 1991). The use of DST as a theoretical foundation supports the investigation of other developmental domains that may include additional mechanisms that influence the development and expression of a behavior. For example, impaired oral movements within the motor domain may influence the imitation of certain language skills and/or overall language production.

2.5.4 Movement Skill Impairment and Imitation

Currently, there is a debate throughout the literature concerning whether or not the observed symbolic imitation impairments in children with ASD is a sign of a larger issue, such as

dyspraxia. Dyspraxia is the inability to coordinate and perform skilled movements that cannot be accounted for completely by basic motor movement or sensory impairments. Children with a neurodevelopmental disorder, such as ASD, are often observed with basic movement and/or sensory impairments. However, it is unlikely that dyspraxia is the primary mechanism for the imitative deficit in young children. The development of praxis reviewed by Dewey (1995) showed that younger children have difficulty performing complex gestures because their praxis skills are not completely developed. They are also still learning how to complete the complex movement skills they observed others doing. The majority of studies concerning limb dyspraxia and imitation often employ older, school-aged children with ASD (Dziuk et al., 2007; Mostofsky et al., 2006b; Vanvuchelen, Roeyers, & De Weerd, 2007a, 2007b). The studies that have examined this relationship in younger children have resulted in either inconclusive evidence or a failure to accept the null hypothesis (Rogers et al., 2003; Zachor, Ilanit, & Itzhak, 2010). For other children with developmental delays, there is the assumption that their imitation skills are fully intact, leading to a lack of current research to confirm such a claim. However, it may be that social communicative skills that are not heavily affected in this population may compensate for their known motor impairments. Thus making it easier for them to produce more abstract or symbolic imitative acts, but still showing difficulty in producing specific motor movements.

The alternative hypothesis regarding the underlying mechanism of the imitation deficit in ASD (i.e. dyspraxia) and other children with developmental disabilities (i.e. no imitation deficit present) is that it is the result of the influence of motor movement impairment interacting with lack of experience. Vanvuchelen et al. (2007a) asserted, "Previous experience with real world action itself possibly also contributes to better imitation performance (p. 236)." Therefore, for younger children with developmental disabilities, including ASD, their observed movement skill

impairments may affect the ability to practice and experience the production of goal-directed actions. Movement skill impairment may be one of the mechanisms contributing to the imitation deficit until they are able to complete complex gestures when they get older. As for children with ASD specifically, their inability to attend to social learning opportunities also may influence their experience in imitating others (Shriberg, Paul, Black, & van Santen, 2011).

2.6 Measuring Early Movement Skills

Like language, the measurement of motor movement skills is best done through multiple measures that incorporate different measurement contexts. Including the overall purpose and appropriateness of the assessment, the selection of the tests utilized depends on the movement task and the unit of measurement of the movement. Movement task refers to the movement intention of the individual and is broken into five categories: locomotion, locomotion on an object, propulsion, reception, and object manipulation. The unit of measurement used to measure a particular movement can be one of two types: movement product or movement process. Movement product as a unit of measurement is a movement performance outcome that is expressed in terms of distance, time, mass, energy or frequency. Movement process as a unit of measurement is a movement pattern used to produce a particular movement and the underlying mechanisms. Lastly, the level of complexity of movement skill (i.e. overall motor abilities, early movement milestones, fundamental movement skills, and specialized and functional movement skills) can be used to determine the most appropriate tests to use. Based upon those specifiers, the common measurement tools used include checklists, interviews, parent/teacher report, observations, standardized direct testing, and kinematic motion analysis (Burton & Miller, 1998).

2.6.1 Direct Testing

Standardized direct testing of movement skills is often done via norm-referenced or criterion-referenced tests. Norm-referenced movement skill tests are often based on the original developmental milestones created by Arnold Gesell and focus only on a child's mean movement performance. In contrast, criterion-referenced movement skill tests focus on a specific (target) movement skill, the movement skill conditions, and the movement performance criterion determined by an activity curriculum. An example of these tests includes the PDMS-2. The use of movement checklists, interviews, parent/teacher report and observations (structured or unstructured) follow the same conventions and have similar issues of bias as language checklists, interviews, parent/teacher report and observations. An example of such is the *Manual Ability Classification System* (MACS; Eliasson et al., 2006), an observational tool for describing the manual movement skills of children with cerebral palsy (Burton & Miller, 1998).

2.6.2 Kinematic Motion Analysis

Another commonly used measurement tool for movement skills is kinematic motion analysis. Technological advances in both computer processing and digital cameras have made it possible to quantify the performance via movement product of motor movements in real-time. Kinematics describes movement without reference to the force used to produce the movement (Zatsiorsky, 1998) and can be examined via two- and/or three-dimensional planes. The use of one dimensional plane versus another depends on the focus of the analyses. Two-dimensional motion analysis provides a simple description of bodily movement and is relatively inexpensive. The required equipment includes at least one digital camera, body markers, and analysis software. Two-dimensional kinematic variables such as velocity, average acceleration, and distance can be determined to describe a particular movement. This method of measurement has been used with

young typically developing and atypically developing children completing gross, fine/manual, and oral movements (Chen & Yang, 2007a; Forti et al., 2011; Nip et al., 2011).

2.6.3 *Summary of Motor Development and Assessment*

Similar to language development, the early development of motor movements skills are a highly anticipated moment in early child development. From holding their head up without support, to manually exploring objects, and producing oral motor sequences, motor skills emerge in a gradual and hierarchical sequence (i.e. from foundational or complex sequences). The presence of a developmental disability may make the emergence of these skills more difficult and can impair everyday functioning. The difficulties encountered are heterogeneous within disability, can change depending on the environmental demands, and can impact other abilities, such as language and imitation. There are a variety of methods to measure and classify the level of motor skills observed. These methods range from parent report or checklists, direct assessment, and kinematic motion analysis.

2.7 Summary of Literature review

The current research literature concerning the imitation, language and movement skills of young children with developmental disabilities has been the focus of many studies. The impairment of early and later complex language skills has been observed continuously using a variety of measures (Kumin, 1996; Mitchell et al., 2006b; Mundy et al., 1988; J. A. Roberts, Rice, & Tager-Flusberg, 2004; Tager-Flusberg et al., 2005; Thurm et al., 2007; Weismer et al., 2011). Imitative skills have been observed to be impaired and a significant predictor of future language skills (Carpenter et al., 2005; Ellis Weismer, Lord, & Esler, 2010b; Ingersoll & Schreibman, 2006; Mitchell et al., 2006b; Rogers et al., 2003; W L Stone, Ousley, & Littleford, 1997; W. L. Stone & Yoder, 2001). Studies have suggested evaluating dyspraxia as a possible

mechanism for the imitation impairment, but the results are varied and overall not conclusive (Rogers et al., 2003). Because the acquisition of all of the complex movement sequences often impaired in dyspraxia do not emerge until six to seven years of age (Dewey, 1995; Steinman, Mostofsky, & Denckla, 2010), it may not be the mechanism for an imitation impairment in younger children. One hypothesis is that the impaired early motor movement skills and lack of experiencing producing them impacts overall imitation skill or and the types of imitative acts expressed, and ultimately early language skills. To date, no behavioral study has evaluated the relationship between imitation and language as moderated by movement skill in children with developmental disabilities.

2.8 Primary Research Questions and Hypotheses

The purpose of this study was to examine the relationship between motor movement, imitation skill, and language skills in young children with developmental disabilities. Specifically, this study will address four main questions: 1) What are the imitation, motor movement, and language skill profiles of young children with developmental disabilities? It was hypothesized that the imitation, motor movement, and language skills of young children with developmental disabilities would be significantly delayed with respect to their chronological age milestone expectations. It was also hypothesized that the children with ASD would have the more delayed imitation skills, as compared to children with other developmental disabilities and children with DS.; 2) What is the relationship between imitation skill, motor movement, and language skill? It was hypothesized that motor movement skill would be significantly related to overall imitation and language skills.; 3) What is the relationship between imitation, motor movement, and language skill, when accounting for reported spoken imitation skills? It was hypothesized that the relationship between imitation skill, motor movement impairment, and

language skill children with lower spoken imitation skill, as compared to higher spoken imitation skill would be significant, but exhibiting different strengths in the observed relationships.; and 4) Does motor movement skill moderate the relationship between imitation and language skill? It was hypothesized that motor movement skill would significantly moderate the relationship between imitation and language skill. It is also hypothesized that the expected the increase in predictive strength of imitation skill will be higher for young children with ASD, as compared to young children with DS.

3 METHODS

3.1 Study Design

The study design for this project is a secondary data analysis. The data used for this study was collected by Romski and colleagues (Romski, et al., 2010); Romski et al. 2015) during two, longitudinal early augmented language interventions for toddlers with developmental delays. The data utilized for this project is only a small portion of the information collected during the twelve-month follow-up (12MFU) of each intervention study. Lastly, Romski et al. (2010; 2015) randomly assigned each child participant to one of three interventions in the first study, and one of two interventions in the second study. Because the different intervention groups were not essential to the hypotheses for this study, they will not be discussed any further or utilized in the analyses.

3.2 Participants

One hundred-thirteen child participants with developmental delays from both augmented language intervention studies conducted by Romski and colleagues were included in the initial sample pool for this study. The inclusion criteria for both studies involved the following: 1)

Between 24 to 36 months age range; 2) Had a risk for speech and language impairment, which was operationally defined as not having begun to talk (i.e. spoke no more than 10 intelligible words and received a score of less than 12 months of age on the Expressive Language scale of the MSEL; 3) Exhibited at least a primitive attempt to communicate; 4) Had the ability to touch symbols on the speech generating device (SGD) using upper body gross motor skills; 5) Did not have a diagnosis of delayed speech or language impairment, deafness/hearing impairment, or autism alone; and 6) only spoke English at home. The participants were recruited from local sources, such as speech-language pathologists, developmental pediatricians, pediatric neurologists, and child advocacy groups across the metropolitan Atlanta area.

As mentioned previously, data collected only from the 12MFU was utilized. Participation in the 12MFU was voluntary. Because participation was voluntary, there was not completed data for all 113 children in the sample pool. Having completed data at the 12MFU for the measures of interest for this particular study was the only additional inclusion criteria. Thus, 70 participants with a mean chronological age of 48.91 months ($SD= 5.00$) were included in the current study. Table 1 provides the additional demographic information for the included participants.

Table 1. Study participant demographic characteristics

	Frequency	Percentage
Original Study Participation		
Intervention Study 1	41	58.60%
Intervention Study 2	29	41.40%
Gender		
Female	20	28.60%
Male	50	71.40%
Ethnicity		
Hispanic	2	2.90%
Non-Hispanic	68	97.10%
Race		
African-American	16	22.90%
Asian-American	6	8.60%
Caucasian-American	46	65.70%
Multi-Racial	2	2.90%
Medical Etiology		
Cerebral Palsy	12	17.10%
Down Syndrome	17	24.30%
Pre-term Birth	10	14.30%
Other	9	12.90%
None/Unknown	22	31.40%

Note. N=70

For a small subset of the children participating in either intervention study ($n=14$, 21.43%), parents provided either official documentation or anecdotal notification noting that their child had received an ASD diagnosis at some point between the end of the intervention and the follow-up sessions using the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR; American Psychiatric Association, 2000). Out of the 14 children, five had formal documentation (i.e. report generated from an outside clinic using observation, clinical judgment & standardized assessment) noting an ASD diagnosis. Having a diagnosis of ASD was an exclusionary criterion when determining initial participation for all children in either intervention study. A retrospective diagnosis confirmation was conducted for this study to determine which

children exhibited behaviors that fall under the DSM-IV-TR category of ASD. The methodology used was adapted from (Ronski et al., 2009).

Two independent raters watched a videotaped 30-minute structured, naturalistic interaction between the child participant and their parent at the 12MFU home observation. The first rater was a licensed speech-language pathologist (SLP). The second rater was a fourth-year clinical psychology doctoral student. The child-parent interaction was divided into three 10-minute sessions of play, book, and snack, respectively. The DSM-IV-TR diagnostic criteria for Autistic Disorder/Autism and Pervasive Developmental Disorder were turned into a checklist adapted from a similar checklist used in a study by Ronski et al. (2009; See Appendix A for the checklist used). The core features of ASD were divided into three domains: Social, Communication, and Behavioral. Both raters watched the 14 child-parent interactions individually and selected the observed behaviors. Six of the child participants were from the (Ronski et al., 2009) study and eight of the child participants were from the second augmented language intervention study. Additionally, 12 of the participants were male and two were female. Under the Social domain of the checklist, an item evaluated whether or not there was a “failure to develop peer relationships appropriate to developmental level.” Because this specific item could not be measured using the content in the videotaped interactions, items measuring “friendship seeking behaviors” within the Socialization subscale of the VABS or VABS-2 (Sparrow et al., 1984, 2005) were used. For those particular items, if a child received a zero (0) score on the majority (i.e. 50%+) of the items, they were considered to meet criteria for that item on the diagnostic checklist.

Rater agreement was calculated using the percentage of times both raters agreed upon the final diagnosis of the following: ASD, PDD, or Non-ASD. Overall, there was 79% agreement

(11 out of 14) between the raters. For two of the participants in which the raters did not agree upon, the disagreement occurred when deciding on the specific spectrum disorder within ASD (e.g. PPD versus ASD). For the third participant, the disagreement occurred when assigning a non-ASD or ASD diagnosis. However, the external clinical assessment documentation for that participant, which occurred close to the 12MFU time point, assigned an ASD diagnosis. Therefore, that the ASD diagnosis was used. The percentage of agreement was also evaluated between the raters final diagnosis assigned and the diagnosis provided for the nine participants who also had diagnosis documentation. There was an agreement of 83.30% between the raters and outside documentation.

3.3 Measures: Administration and Scoring

A total of four measures were utilized to evaluate the language, imitation, and motor movement skills of the participants. An overall description, administration details, and scoring requirements are provided in the sections below.

3.3.1 Direct Testing and Parent Report: Imitation

The imitation skills of the participants were evaluated using the *Sequenced Inventory of Communication Development, Revised* (SICD-R; Hedrick et al., 1984). The SCID-R is a standardized assessment that primarily utilizes direct testing to evaluate the receptive and expressive language skills of children. The SICD-R also utilizes parent report for some of the items as the primary form of measurement or if the child refused to participate in administered task. Receptive and expressive language skills are divided into two separate subscales, with 34 and 67 items, respectively. It is appropriate for use with children functioning between 4-48 months of age and takes approximately 30-75 minutes to administer.

Within the Expressive Language subscale, there are 16 items that measures verbal, oral motor movement, and fine motor movement imitative acts. Table 2 provides a detailed summary of the individual assessment items used and outcome measured. A score of zero (0) was given if the child did not perform the task. Conversely, a score of one (1) was given if the child did perform the task. A composite raw score, which included the summation of all of the items, was calculated. The maximum score that could be received was 16.

Table 2. Description of SICR-R imitation items used and outcome measured

Imitation Category	Item Number	Item Description
Spoken	11	“Does (Child’s name) ever imitate sounds that you make?”
	25a	Examiner says “Say _____,” and encourages Child to imitated each of the following sounds: /ai/
	25b	Examiner says “Say _____,” and encourages Child to imitated each of the following sounds: /m^/
	25c	Examiner says “Say _____,” and encourages Child to imitated each of the following sounds: /n^/
	25d	Examiner says “Say _____,” and encourages Child to imitated each of the following sounds: /g^/
	25e	Examiner says “Say _____,” and encourages Child to imitated each of the following sounds: /p^/
	26a	Examiner says “Say _____,” and encourages Child to imitate each of the following sounds: Ma-ma
	26b	Examiner says “Say _____,” and encourages Child to imitate each of the following sounds: Pa-pa
	Manual Motor	14a
14b		Stacking blocks
14c		Returns ball by rolling or pushing
14d		Clapping hands
14e		Playing “peek-a-boo”
Oral Motor	15a	Examiner encourages Child to imitate the specified sounds: Tongue click
	15b	Examiner encourages Child to imitate the specified sounds: Cough
	15c	Examiner encourages Child to imitate the specified sounds: Motor sound

Note. Table adapted from items published on the SICD-R (Hedrick et al., 1984).

3.3.2 Parent Report: Fine Motor Movement

The Fine Motor subscale on the VABS (Sparrow et al., 1984) or VABS-2 (Sparrow et al., 2005) Survey Interview Forms were used to measure the fine motor skills. The VABS was administered in the first intervention study and the VABS-2 was administered in the second intervention study. The entire assessment utilizes parent report and can be used for children from birth to 18 years of age. The Fine Motor subscale contains 16 and 36 items on the VABS and VABS-2, respectively. The subscale evaluates object manipulation using both hands and fingers. Both raw and age-equivalent scores are calculated for the subscale; however, only the raw scores were used for this study. The maximum raw scores that could've been obtained were 32 and 72 for the VABS and VABS-2, respectively.

3.3.3 Observation: Upper-Body Reaching Kinematics

The upper-body reaching kinematic variable, tangential velocity, was calculated to measure the average reaching speed observed during a single interaction with an object during the 12MFU home observation. Reaching velocity was used for this study because research has provided evidence that it is indicative of individual motor planning skill in both infants and adults (Claxton, Keen, & McCarty, 2003). The participants' reaching movements were tracked using the software Kinovea (Charmant, 2013). Kinovea has been used in previous studies examining various aspects of human motion (Abbas & Abdulhassan, 2013; Aggarwal & Cai, 1999; Guzman-Valdivia, Ortega, Oliver-Salazar, & Carrera-Escobedo, 2013). During the 12MFU home observation, the child participant and parent engaged in a 30-minute structured, naturalistic interaction. The 30-minute session was divided into three, 10-minute routines, play, book, and snack, respectively. The recording was done using a handheld camcorder by the study's managing SLP, interventionist, or graduate research assistant. The digitized video of the

12MFU was imported into Kinovea. The movement tracker was placed on the most visible portion of the child's hand, between the middle of the top of the hand and bottom of the wrist. Once a completed reach was successfully tracked, two-dimensional x- and y-coordinates captured every 33 milliseconds (*ms*), for the entire reach, were exported into Excel. Tangential velocity was calculated using the following equations:

$$\text{X-Velocity: } (\text{Time } 3_{\text{Xcoordinate}} - \text{Time } 1_{\text{Xcoordinate}}) / 2 \times 33\text{ms}$$

$$\text{Y-Velocity: } (\text{Time } 3_{\text{Ycoordinate}} - \text{Time } 1_{\text{Ycoordinate}}) / 2 \times 33\text{ms}$$

$$\text{Tangential Velocity at Time X: } \sqrt{(X\text{-Velocity})^2 + (Y\text{-Velocity})^2}$$

$$\text{Avg. Tangential Velocity: } \sum (\text{Time}^{n-1} \text{Tangential Velocity}) / \# \text{ of Frames}$$

3.3.4 Parent Report: Receptive and Expressive Language

As mentioned previously, either the VABS (Sparrow et al., 1984) or VABS-2 (Sparrow et al., 2005) Survey Interview Forms were administered to the child participants' parents. The assessment includes both Receptive Language and Expressive Language subscales within the Communication domain. The Receptive Language subscale measures how well the child comprehends language. The Expressive Language subscale measures language production. Although standard scores and age equivalents can be calculated, only raw scores were used in this study. Separate raw scores were calculated for both subscales. The maximum Receptive Language raw scores that could've been obtained were 26 and 40 for the VABS and VABS-2, respectively. The maximum Expressive Language raw scores that could've been obtained were 62 and 108 for the VABS and VABS-2, respectively.

3.3.5 *Parent-Report: Vocabulary*

The *MacArthur-Bates Communicative Development Inventories* (CDI; Fenson et al., 2007) was used to measure early receptive and expressive vocabulary. The CDI is a parent-report measure and is often used with children with language delays. It is designed for use with children between 8 to 30 months of age; however, it can also be used with preschool-aged children older than 30 months with language delays. The CDI is divided into two forms: CDI: Words and Gestures (W&G) and Words and Sentences (W&S). The W&G form was administered first and focused on vocabulary production and comprehension, and communicative and symbolic gesture usage. Part I of the W&G form is comprised of four sections: First Signs of Understanding, Phrases, Starting to Talk, and Vocabulary Checklist. Only the Starting to Talk and Vocabulary Checklist were used from Part I. The Starting to Talk section used two items to measure the frequency the child imitates words or phrases, and the frequency the child labels objects. The Vocabulary Checklist contained 396 items to measure both comprehension and production vocabularies across 19 semantic categories (nouns, sound effects and animal sounds, games and routines, verbs, words about time, adjectives, pronouns, question words, prepositions and locations, and quantifiers and adverbs). Scoring for the Starting to Talk section involved summing the “yes,” “no,” or “sometimes” responses provided. Scoring for the Vocabulary Checklist was completed by summing the total number of reported words understood (receptive vocabulary only) or understood and spoken (receptive and expressive vocabulary). Only the receptive and expressive vocabulary count was used. The maximum raw score that could’ve been obtained was 396.

Part II of the W&G form evaluated the child’s usage of communicative and symbolic gestures. It is comprised of five sections: First Communicative Gestures, Games and Routines,

Actions with Objects, Pretending to be a Parent, and Imitating Other Adult Actions. Only the Imitating other Adult Actions section was used. Scoring for the Imitating Other Adult Actions section involves summing the number of “yes” responses across the 15 items, for a maximum score of 15. If during the administration of the W&G form, if the participant’s vocabulary exceeded the level measured, the CDI W&S form was administered. The W&S form focused only on vocabulary production and early grammar skills. Part I of the W&S form is comprised of two sections: Vocabulary Checklist and How Children Use Words. Only the Vocabulary Checklist was used. Similar to the W&G form, the Vocabulary Checklist contained 680 items and measured vocabulary production across 22 semantic categories. Scoring for the Vocabulary Checklist is completed by summing the total number of reported words spoken (production).

3.4 Missing Data

Patterns of missing data were examined for this study’s sample. There were 11 cases of missing data and it was all on the CDI W&G and W&S forms. Missing data were identified for 7 participants who were the only children to have been administered the CDI W&S form, which did not include two items necessary to measure imitation skill completely. It was important address this missing data because of the potential for creating bias by excluding these participants. Because this subgroup of participants were observed with skills high enough to be administered the CDI W&S form to assess more complex language skills, excluding them would misrepresent the spectrum of ability of the population of young children with developmental disabilities. The four remaining participants were observed to have randomly missing data from a single item on the CDI W&G form due to the parent either skipping or omitting the item. A common method for addressing systematic and randomly missing data is multiple imputation (MI). MI involves a simulation in which the missing data is replaced by $m > 1$ simulated versions.

The result is pooled estimates and confidence intervals that are used to replace the missing values. The suggested number of imputations is between 3-10, depending on the percentage of missing data to complete data in the sample (Graham, Olchowski, & Gilreath, 2007; Rubin, 1987). Because the percentage of missing data was moderate, the data was imputed 5(*m*) times for this study, the default. Once the MI was complete, the estimated data assigned to each participant was averaged and included in the final dataset for analysis.

3.5 Data Analysis

As mentioned previously, raw scores were obtained for all of the variables of interest in this study. Because each variable was measured on a different scale, the data were transformed so that composite scores could be created. Two types of transformations were used: 1) proportions and 2) standardized z-scores. The imitation skill (SICD-R and CDI items), language skill (VABS Receptive Language, VABS Expressive Language and CDI Vocabulary checklist), and VABS motor skill scores were all converted into proportions. Proportions created for each imitation and language skill measured were combined to create an imitation and language skill composite score, respectively. Standardized z-scores were also created for both the participants' average reaching velocity, and the VABS motor skill score. The z-scores were created because the proportion of the participants' average reaching velocity could not be calculated without creating a bias cutoff score for the proportion transformation. Furthermore, the VABS motor skill z-score was calculated and combined with the reaching velocity z-score, creating a motor skill composite score.

A series of descriptive, correlation, and regression analyses were used in the planned data analysis. The bootstrapping technique was also utilized throughout the following analyses to account for data that is either skewed, non-normal distribution, or resulting from small samples

(Haukoos & Lewis, 2005; Sideridis & Simos, 2010). Bootstrapping creates k samples of n size and draws them randomly for replacement for the collected data. The bootstrapped samples create confidence intervals (CI) that explain the likelihood that the true population parameters fall within the bootstrapped CIs. Specifically, bias corrected accelerated (BC_a) confidence intervals were used. In contrast to percentile confidence intervals, the BC_a confidence interval adjust for skewness in the bootstrap sampling distribution and non-constant variance that may be observed in the dataset (Haukoos & Lewis, 2005).

4 RESULTS

4.1 Imitation, Motor Movement, and Language Skill Profiles

The purpose of the first research question was to examine the imitation, motor movement, and language profiles of young children with developmental disabilities. To address this question, descriptive statistics, score distribution for all of the variables, and a series of t -tests were conducted for the entire sample. The analyses were also conducted for the subsample of participants with a confirmed ASD diagnosis and DS diagnosis. The profiles for the subsample of participants with ASD and DS were completed to evaluate if their performance on the assessments, especially the imitation measures, were significantly different from the remainder of the participants with other developmental disabilities. Table 3 provides the raw scores for imitation skill, motor movement, and language skill for the entire sample, and the two subsamples of participants diagnosed with either ASD or DS.

Table 3. Mean Imitation, Motor, and Language Skill Raw Scores

	Entire Sample (N=70)	ASD Only (n=14)	DS Only (n=17)
	M (SD)	M (SD)	M (SD)
SICD-R Spoken Imitation	6.63 (3.95)	6.21 (4.08)	7.64 (2.91)
SICD-R Fine Motor Imitation	4.49 (1.45)	4.64 (1.34)	5.00 (< .01)
SICD-R Oral Motor Imitation	2.36 (1.17)	2.07 (1.20)	2.94 (.24)
CDI Motor Imitation	11.04 (4.25)	9.64 (3.54)	13.18 (1.85)
VABS/VABS-2 Fine Motor Movement	21.77 (11.27)	24.79 (14.14)	19.71 (4.86)
VABS/VABS-2 Receptive Language	22.27 (4.27)	22.00 (4.88)	23.00 (2.85)
VABS/VABS-2 Expressive Language	29.91 (18.95)	31.79 (21.17)	28.47 (10.93)
CDI Vocabulary	221.96 (199.32)	149.64 (139.46)	220.88 (161.97)
Upper-body Reaching Velocity (in milliseconds)	.10 (.11)	.07 (.05)	.08 (.09)

Note. M= mean; SD= standard deviation; N= sample size; n= sub-sample.

The score distributions for all of the measures were examined using both histograms, and skewness and kurtosis statistics. The analysis showed that the participants' scores for all of the measures were significantly skewed (i.e. asymmetrical), thus not conforming to the normal distribution. Furthermore, both motor skill measures were determined to be more leptokurtic (i.e. peaked) than the normal distribution. Due these results, the following analyses were chosen to account for data following a non-normal distribution.

The mean proportions of the participants' scores for each measure were examined in comparison to the maximum scores that could be received for each assessment (see Table 4). The minimum and maximum scores and corresponding standard deviations were also reported. The descriptive analysis showed that the participants' did not obtain a maximum raw score above 50% for the VABS Fine Motor score, VABS Expressive Language score, and CDI Vocabulary count.

Table 4. Mean Proportion of Maximum Imitation, Motor, and Language Scores Obtained

	<i>Min.</i>	<i>Max.</i>	<i>M</i>	<i>SD</i>
SICD-R Imitation	.00	1.00	.75	.33
VABS Expressive Language	.09	.86	.37	.20
VABS Receptive Language	.25	.92	.72	.16
VABS Fine Motor	.06	.84	.47	.17
CDI Vocabulary Count	.00	1.00	.46	.37
CDI Imitation	.00	1.00	.73	.28

Note. N=70. Min=minimum; Max=maximum; M=mean; SD= standard deviation.

A series of independent samples *t*-tests using the BC_a bootstrapping technique were also conducted to determine if the mean imitation, motor movement, and language skill scores were different for the child participants with ASD and DS, as compared to the remaining participants in the study sample. There were no significant mean score differences for all of the variables between children with ASD and the remaining study sample. Significant mean differences were observed between the participants with DS and the study sample for the CDI, SICD-R motor, and SICD-R oral motor imitation scores. Significant differences were also observed between the participants with DS and ASD for the CDI and SICD-R oral motor imitation scores (see Table 5).

Table 5. Independent Samples T-Tests

	<u>DS vs. Entire Sample</u>			
	<i>t</i>	Bias	SE	95% BC _a CI
CDI Imitation	-3.64**	.02	.77	[-4.53, -1.18]
SICD-R Motor Imitation	-3.02*	.01	.23	[-1.18, -.28]
SICD-R Oral Motor Imitation	-4.13**	.01	.19	[-1.16, -.40]
	<u>DS vs. ASD</u>			
SICD-R Motor Imitation	-3.57**	.01	.97	[-5.53, -1.62]
SICD-R Oral Motor Imitation	-2.65*	-.01	.33	[-1.54, -.25]

Note. *t*= t-test statistic. SE= standard error; BC_a CI= bias corrected accelerated confidence interval.

p*<.05. *p*<.01.

4.2 Examining the Imitation-Motor Movement-Language Relationship

The purpose of the second research question was to examine the type, strength & direction of the relationship between imitation, motor movement, and language skill. To answer this question, a series of Pearson correlation analyses using the BC_a bootstrapping technique were conducted. The number of samples drawn (k) was 1000 for the study sample size (n) of 70 child participants.

4.2.1 Entire Sample

The first analysis was conducted for the entire study sample and showed both positive moderate and strong, significant correlations between the imitation, motor movement, and language skills, indicating as one skill increased, so did the other skill. Imitation and VABS motor skills had a moderate relationship, $r(67) = .49, p < .01, 95\% \text{ BC}_a \text{ CI} [.27, .66]$. Additionally, imitation and language skills had a strong relationship, $r(67) = .80, p < .01, 95\% \text{ BC}_a \text{ CI} [.72, .87]$. Lastly, language and VABS motor skills had a moderate relationship, $r(67) = .47, p < .01, 95\% \text{ BC}_a \text{ CI} [.28, .64]$. A significant relationship was not observed between the participants' reaching velocity and imitation, language, or motor scores.

4.2.2 Children with ASD

The second analysis conducted showed positive moderate and strong, significant correlations between the imitation, motor movement, and language skills, meaning as one skill increased, so did the other skill. Imitation and VABS motor skills had a moderate relationship, $r(12) = .54, p < .05, 95\% \text{ BC}_a \text{ CI} [-.28, .91]$. Additionally, imitation and language skills had a strong relationship, $r(12) = .90, p < .01, 95\% \text{ BC}_a \text{ CI} [.75, .96]$. A significant relationship was not observed between the participants' average reaching velocity and imitation, language, or VABS motor scores.

4.2.3 *Children with DS*

The third analysis was conducted for the participants with DS. Again, the results showed both positive moderate and strong significant correlations between the imitation, motor movement, and language skills. Both imitation and language skills showed a moderate relationship, $r(15) = .55, p < .05, 95\% \text{ BC}_a \text{ CI} [.21, .80]$, and strong relationship, $r(15) = .55, p < .05, 95\% \text{ BC}_a \text{ CI} [.21, .80]$ with reaching velocity, respectively. Thus, indicating as imitation or language skill increased, participants had a short reaching velocity (i.e. quicker reach). Additionally, imitation and language skills had a strong relationship, $r(15) = .66, p < .01, 95\% \text{ BC}_a \text{ CI} [.23, .88]$, meaning as imitation skill increased, so did language skills. Lastly, language and VABS motor skills had a moderate, positive relationship, $r(15) = .55, p < .05, 95\% \text{ BC}_a \text{ CI} [-.04, .88]$, meaning as language skill increased, so did motor skills.

4.3 **Examining the Imitation-Motor Movement-Language Relationship: The Impact of Spoken Imitation Skill**

The purpose of the third research question was to describe the relationship between imitation, motor movement, and language skill, when examined by reported spoken imitation skills. To address this question, participants were divided into two groups by parent report on MCDI item C1, which asked if the child has ever imitated the parent using spoken language. The groups consisted of 1) children whose parent reported that they “never” imitated their spoken language and 2) Children whose parent reported that they “sometimes” or “often” imitated their spoken language. A Pearson correlation coefficient using the bias corrected bootstrapping technique was conducted. One thousand samples were drawn for both sub-groups analyses. Figure 1 provides a scatterplot depicting the relationship between language and imitation scores by sub-group.

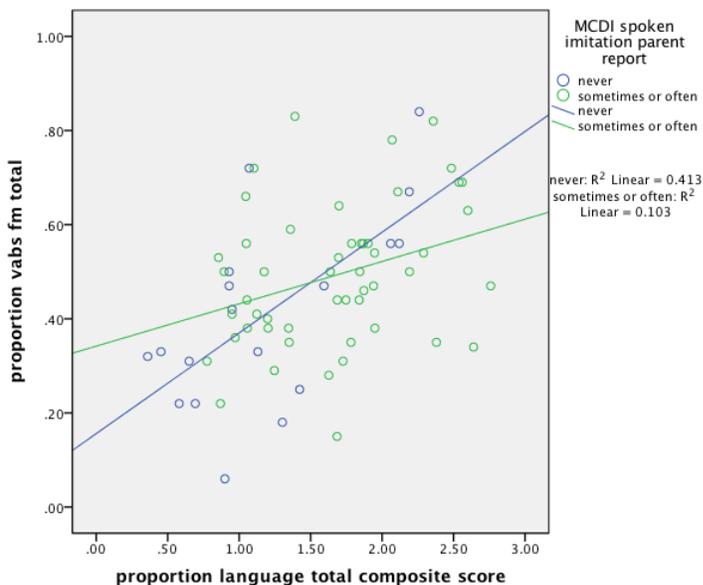


Figure 1. Relationship between the Proportion of Language and Imitation Scores by Reported Spoken Imitation Skill

4.3.1 Participants without Reported Spoken Imitation

For the participants whose parent reported they “never” imitated their spoken language, the analysis showed strong, significant correlations between the imitation, motor, and language skills. Imitation and language skills had a strong, positive relationship, $r(16) = .87, p < .01, 95\% \text{BC}_a \text{CI} [.72, .95]$, meaning as imitation skill increased, so did language skills. Additionally, a strong, positive relationship was observed between VABS motor skills and imitation, $r(16) = .72, p < .01, 95\% \text{BC}_a \text{CI} [.44, .89]$. A significant relationship was not observed between reaching velocity imitation and language, imitation, or VABS motor skills for this sub-group.

4.3.2 Participants with Reported Spoken Imitation

For the participants whose parent reported they “sometimes” or “often” imitated their spoken language, the analysis showed small and strong, significant correlations between the imitation, motor, and language skills. Language and VABS motor skills had a small, positive

relationship, $r(49) = .32, p < .05$, 95% BC_a CI [.06, .57], indicating as language skill increased, so did motor skills. Similarly, imitation and language skills had a strong, positive relationship, $r(49) = .76, p < .01$, 95% BC_a CI [.61, .86], meaning as imitation skill increased, so did language skills. Again, a significant relationship was not observed between reaching velocity imitation and language, imitation, or VABS motor skills for this sub-group.

4.4 The Moderating Effect of Motor Movement Skill on the Imitation-Language Relationship

The purpose of the fourth and final research question was to determine whether or not motor movement moderated the relationship between imitation and language skill. To answer this question, a series of moderation regression analyses were conducted using the PROCESS SPSS macro syntax developed by Andrew Hayes (Hayes, 2013a, 2013b). The first model (Model 1) examined used the composite motor movement score as the moderating variable (see Figure 2). The second model (Model 2) examined used reaching velocity only as the moderating variable (see Figure 3). Lastly, the third model (Model 3) examined used the VABS motor movement score only as the moderating variable (see Figure 4). The analyses were conducted for the entire sample, participants with ASD only, and participants with DS only.

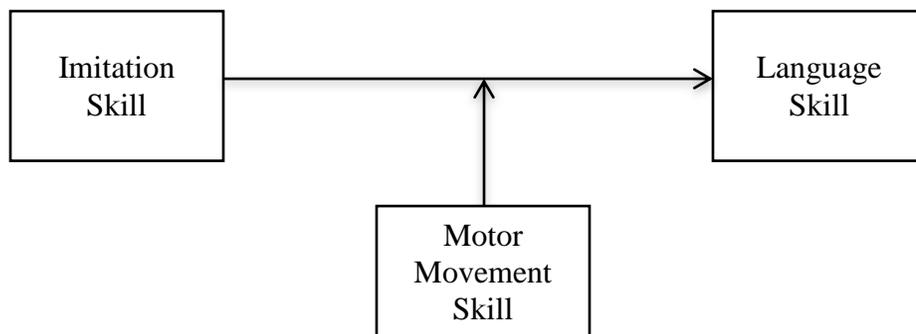


Figure 2. *Moderation Regression Model 1*

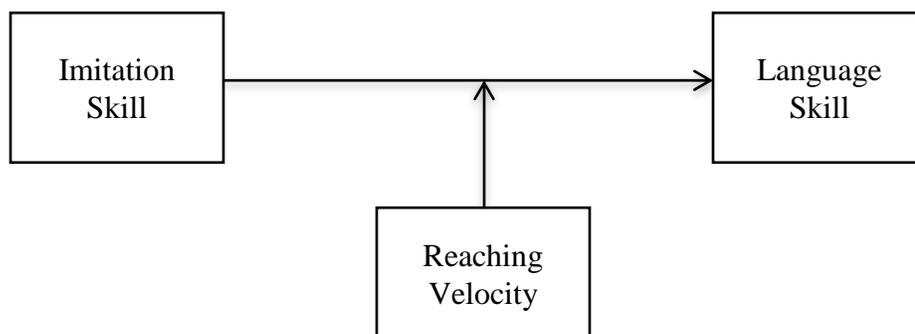


Figure 3. *Moderation Regression Model 2*

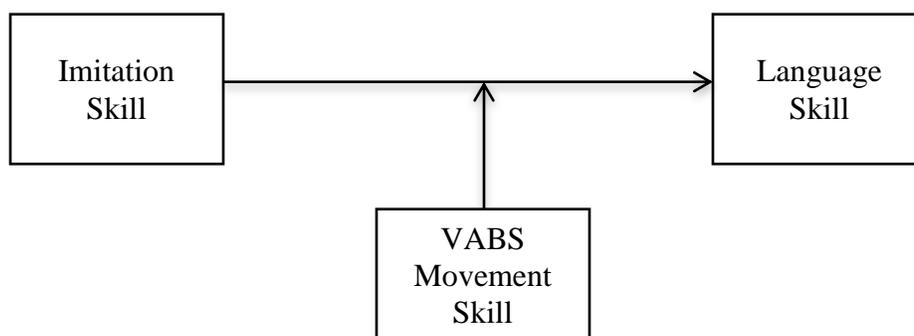


Figure 4. *Moderation Regression Model 3*

4.4.1 Entire Sample

The first moderation model examined the effect of imitation skill on language skill, as moderated by participants' composite motor movement skill. The overall model itself was statistically significant, $F(3, 65) = 45.62, p < .01, R^2 = .68$. The participants' composite motor movement score was a significant moderator of the effect of imitation skill on language skill, $F(1, 65) = 7.62, p < .01, \Delta R^2 = .04$ (see Table 6). Thus, motor movement skill accounted for 4% of the effect of imitation on language skill. Furthermore, for every unit increase in motor skill, there was a .17 unit increase in the effect of imitation on language. The interaction between motor skills and imitation skills was probed for transitional significance. Probing an interaction is used to determine if and where changes in the distribution of the composite motor score has a differential effect on imitation predicting language skill. PROCESS automatically produces the Pick-a-Point Approach for probing. This common technique evaluates the conditional effect of the independent variable on the dependent variable at different values of the moderator (Hayes, 2013a). In this study, the conditional effect of imitation on language skill was examined at different percentile ranks (e.g. 10th, 25th, 50th, 75th, and 90th percentiles) of motor movement skill. The analysis showed that the significant effect of the imitation on language skill did not change throughout the composite motor score distribution.

Table 6. Motor Composite Score Moderation Model 1 Predicting Language Skill

Variable	B	<i>p</i>	95% CI
Constant	1.49	< .01**	[1.40, 1.58]
Composite Motor Score	-.03	.44	[-.09, .04]
Imitation Skill	.90	< .01**	[.73, 1.08]
Composite Motor x Imitation Skill Interaction	.17	< .01**	[.05, .28]

Note. N=70. CI= confidence interval.

** $p < .01$.

The second moderation model examined the effect of imitation skill on language skill, as moderated by participants' average reaching velocity. Although the overall model itself was statistically significant, $F(3, 65) = 40.30, p < .01, R^2 = .65$, participants' average reaching velocity did not significantly moderate the predictive effect of imitation skill on language skill, $F(1, 65) = 1.32, p = .26, \Delta R^2 = .01$ (see Table 7).

Table 7. Reaching Velocity Moderation Model 2 Predicting Language Skill

Variable	B	<i>p</i>	95% CI
Constant	.41	.02*	[.08, .74]
Reaching Velocity	-1.30	.38	[-4.25, 1.65]
Imitation Skill	.70	< .01**	[.50, .90]
Reaching Velocity x Imitation Skill Interaction	.97	.25	[-.72, 2.66]

Note. N=70. CI= confidence interval.

* $p < .05$. ** $p < .01$.

The third moderation model examined the effect of imitation skill on language skill, as moderated by motor movement skill measured on the VABS. The overall model was statistically significant, $F(3, 65) = 46.48, p < .01, R^2 = .68$. Furthermore, motor skill, as measured on the VABS, was a significant moderator of the predictive effect of imitation skill on language skill, $F(1, 65) = 7.23, p < .01, \Delta R^2 = .04$ (see Table 8). VABS motor scores accounted for 4% of the effect of imitation on language skill; thus, for every unit increase in VABS motor skill, there was a 1.07 unit increase in the effect of imitation on language. The interaction between VABS motor skills and imitation skills was probed to determine if and where changes in the distribution motor skill scores has an effect on imitation predicting language skill. Both Pick-a-Point Approach and the Johnson-Neyman Technique were produced to probe for conditional effects. In both analyses, the significant effect of imitation skill on language skill did not change throughout the VABS motor movement score distribution.

Table 8. VABS Motor Skill Moderation Model 3 Predicting Language Skill

Variable	B	<i>p</i>	95% CI
Constant	1.49	< .01**	[1.40, 1.58]
VABS Fine Motor Skill	.26	.35	[-.30, -.83]
Imitation Skill	.84	< .01**	[.67, 1.02]
VABS Fine Motor x Imitation Skill Interaction	1.07	< .01**	[.28, 1.87]

Note. N=70. CI= confidence interval.

** $p < .01$.

4.4.2 Participants with ASD

The first moderation regression model conducted examined the effect of imitation skill on language skill, as moderated by the composite motor skill score. The overall model itself was statistically significant, $F(3, 10) = 17.43, p < .01, R^2 = .84$, but the participants' composite motor scores was not a significant moderator of the effect of imitation skill on language skill, $B = -.23, SE = .23, t = -.96, p = .34$. The second moderation model examined the effect of imitation skill on language skill, as moderated by participants' average reaching velocity. The overall model was statistically significant, $F(3, 10) = 22.45, p < .01, R^2 = .87$. The results indicated that the average reaching velocity was a significant moderator of the effect of imitation skill on language skill, $F(1, 10) = 5.3, p < .05, \Delta R^2 = .07$ (see Table 9); thus, average reaching velocity contributed 7% to the effect of imitation on language skill. Furthermore, for every unit increase in reaching velocity, there was an 4.91 unit decrease in the effect of imitation on language. The interaction was also probed to for transitional significance; however, the significant effect of imitation skill on language skill did not change across an increase or decrease in reaching velocity.

Table 9. ASD: Reaching Velocity Moderation Model 2 Predicting Language Skill

Variable	B	<i>p</i>	95% CI
Constant	1.36	< .01**	[1.23, 1.48]
Reaching Velocity	.787	.48	[-1.76, 3.49]
Imitation Skill	.96	< .01**	[.70, 1.24]
Reaching Velocity x Imitation Skill Interaction	-4.91	< .05*	[-9.70, -.12]

Note. *n*=14. CI= confidence interval.

p*<.05. *p*<.01.

The third moderation regression model examined the effect of imitation skill on language skill, as moderated by VABS motor skill. The overall model was statistically significant, $F(3, 10) = 20.86$, $p < .01$, $R^2 = .86$. However, VABS motor skills was not a significant moderator of the predictive effect of imitation skill on language skill, $B = 1.83$, $SE = .89$, $t = 2.06$, $p = .07$. The interaction was still probed for transitional significance effects. Conditional effects of imitation skill on language skill were observed for the VABS motor movement score distribution. The Pick-a-Point Approach showed that participants with VABS fine motor skills at and above the 25th percentile had a significant effect of imitation skills predicting language skills. For participants with VABS fine motor skills below the 25th percentile, VABS motor skills did not have a significant moderating effect on imitation skills predicting language skills.

4.4.3 Participants with DS

The first moderation regression model examined the effect of imitation skill on language skill, as moderated by the composite motor skill score. The overall model itself was not statistically significant, $F(3, 11) = 2.88$, $p = .08$, $R^2 = .84$. The second moderation model examined the effect of imitation skill on language skill, as moderated by participants' average reaching velocity. Although the overall model itself was statistically significant, $F(3, 13) = 6.51$, $p < .01$, $R^2 = .60$, participants' average reaching velocity did not significantly moderate the predictive effect of imitation skill on language skill, $B = .65$, $SE = 11.25$, $t = .06$, $p = .96$.

The third moderation regression model examined the effect of imitation skill on language skill, as moderated by VABS motor skill. The overall model was statistically significant, $F(3, 13) = 15.26, p < .01, R^2 = .78$. VABS motor skills was indicated to be a significant moderator of the effect of imitation skill on language skill, $F(1, 13) = 7.66, p < .05, \Delta R^2 = .13$ (see Table 10). Thus, VABS motor scores accounted for 13% of the effect of imitation on language skill. Furthermore, for every unit increase in VABS motor skill, there was a 4.02 unit increase in the effect of imitation on language. The interaction between VABS motor skills and imitation skills was probed and transitional significance observed for the VABS motor movement score distribution. Again, the Pick-a-Point Approach showed that participants with VABS fine motor skills at and above the 25th percentile had a significant effect of imitation skills predicting language skills. For participants with VABS fine motor skills below the 25th percentile, VABS motor skills did not have a significant moderating effect on imitation skills predicting language skills.

Table 10. DS: VABS Motor Skill Moderation Model 3 Predicting Language Skill

Variable	B	<i>p</i>	95% CI
Constant	1.61	< .01**	[1.48, 1.74]
VABS Fine Motor Skill	1.73	< .01**	[.74, 2.72]
Imitation Skill	1.50	< .01**	[.87, 2.09]
VABS Fine Motor x Imitation Skill Interaction	4.02	< .05*	[.88, 7.17]

Note. $n=17$. CI= confidence interval.

* $p < .05$. ** $p < .01$.

5 DISSCUSSION

The results of this study suggest that the level of motor movement skill significantly impacts the effect of imitation on language skill in young children with developmental disabilities. The descriptive analysis of the participants' imitation, motor movement, and language skill profiles partially supported the first series of hypotheses. The hypothesis

proposing that the imitation, motor movement, and language skills of young children with developmental disabilities would be significantly delayed with respect to their chronological age milestone expectations was supported. There was a wide spectrum of skills within the sample; however, the distribution of skill level was not evenly distributed. Furthermore, the majority of the mean scores were located on the lower end of the skill continuum, suggesting a delay in skills. The imitation, motor movement, and language profiles observed for the participants have been reported numerous times throughout the research literature involving children with developmental disabilities (Barbaro & Dissanayake, 2012; Carpenter et al., 2005; Chapman, 1997; Ellis Weismer et al., 2010a; Lefevre, 1960; Provost, Lopez, & Heimerl, 2007; Visscher, Houwen, Scherder, Moolenaar, & Hartman, 2007; Wright, Lewis, & Collis, 2006).

The hypothesis proposing that children with ASD would have lower imitation skills, as compared to children with other developmental disabilities, and children with DS was also partially supported. It was surprising that the imitation skills of the participants with ASD were not significantly different from the entire sample, but only the children with DS, as that is an often cited key deficit for children with ASD that distinguishes from other developmental disorders (Batshaw et al., 2013). A potential explanation for these results is that children with ASD may not have had more difficulty completing the imitation tasks measured, but may have encountered more problems if administered more complex imitation tasks. Libby et al. (1997) found that children with ASD only had problems imitating multi-scheme imitation tasks, performing better than children with DS and typical development on simple imitation tasks. They suggested echolalia as a potential effect on their findings. The observed results for this study showing higher imitation skills for children with DS may indicate their ability to compensate by utilizing other well-developed social skills (Fidler, 2005; Pitcairn & Wishart, 1994).

The series of correlation analyses partially supported the hypothesis that motor movement skill would be significantly related to overall imitation and language skills. Imitation, language and VABS measured motor skills were significantly related for all groups. In contrast, reaching velocity was not significantly related to either imitation or language skill, except for the children with DS. It is believed that reaching velocity was not significantly related to all of the variables measures due to it being a measure of a single behavior. As the imitation, language, and VABS motor scores derived were inclusive of multiple skills. Nonetheless, these results support past research findings concerning the imitation-language relationship, and the suggested significant effect of motor skill on imitation and/or language skill for children with other developmental disabilities, ASD, and DS (K. J. Alcock & Krawczyk, 2010; Carpenter et al., 2005; Charman et al., 2000; Gernsbacher et al., 2008; Iverson & Braddock, 2010; Iverson, 2010; Tager-Flusberg & Calkins, 2009; Thurm et al., 2007; Viholainen et al., 2010; Wright et al., 2006). Although similar relationship strengths and directions were observed for the entire study sample, and the different sub-groups, different patterns amongst the skills measured were observed.

Lastly, the series of moderation regression models examined provided support for the hypotheses that motor movement significantly moderated the relationship between imitation and language for children with developmental disabilities. Because the conditional effect of the composite motor movement score was not significant despite the significant moderation effect, the two motor measures (reaching velocity & VABS fine motor score) were examined independently. Reaching velocity was a significant moderator only for the children with ASD. In contrast, motor movement skills as measured by the VABS were a significant moderator only for the children with DS, and when the entire sample was examined as a whole.

For the participants with ASD, the observance of reaching velocity as a significant moderator provided only a small contribution (4%) to the proposed model. Additionally, the overall fine motor movement measured by the VABS was not a significant moderator and probing of transitional significance revealed that children under the 25th percentile (2-3 participants) accounted for the change in significance. The small number of participants in the analyses may have contributed to the lack of significant findings. Another explanation may be that other skills may contribute to the effect of imitation on language skill for these children at this age, such as theory of mind, joint attention, and the severity of ASD symptomology. Studies by Adamson et al. (2010) and Rogers et al. (2003) have provided evidence for the substantial impact of both initiating joint attention and symbol-infused supported joint engagement on imitation, respectively. Past research has also suggested the significant impact of ASD symptom severity (even after controlling for mental age), and deficits in theory mind and other related social skills, such as social responsibility and understanding action intentions (Carpenter et al., 2005; Hamilton, Brindley, & Frith, 2007; Rogers et al., 2003). Thus, all of the aforementioned skills, in addition to motor movement, may each contribute to a complex system of imitative ability in these children, their ability to practice those skills, and its overall effect on language skill. A possible explanation of why the VABS motor movements score was not shown to be a significant moderator may be due to the source of information, parent report. Despite delayed motor movement skills observed in children with ASD, their social and language impairments are often considered a priority concern for parents. Thus, parents of children with ASD may not have been as attentive to the difficulties with motor movement skills considered on the VABS, as compared to parents of children with DS, who are more likely to participate in early motor interventions and therapies.

The moderation analyses also produced results that failed to support the hypotheses that the effect of the moderator would be higher for young children with ASD, as compared to young children with DS. For the children with DS, their VABS motor skill score accounted for 13% of the effect of imitation on language skill, which is more than three times the variance accounted for children with ASD. As mentioned previously, young children with DS are often described as being more social and using those skills to compensate for impairments in other domains, such as language. The children with DS were observed with delayed language and motor movement skills similar to the children with ASD. Also similar to the children with ASD, transitional significance of the moderator was observed for those with scores at and above the 25th percentile. A possible explanation for these results may be that because of their higher imitation skills (and potentially other social skills), the presence of increased motor movement skills had a stronger impact on the imitation-language impairment because it did not have to share the variance with other skills, as compared to children with ASD. Furthermore, the freeing of this variance may provide more opportunities to practice and master those common imitation skills.

5.1 Study Limitations

Since this was a secondary data analysis (SDA), the sample size was limited by measures that were available for all of the participants. Additionally, because the data originated from two previous studies, the videotaped home observations used to capture the kinematic reaching variable were recorded within a communication context. This context made it difficult to analyze more than a single reach for every participant, which was contrary to the initial protocol design for this study. It would not have been appropriate to use MI to estimate this data without other types of kinematic data to aid the software in the parameter estimations. Nonetheless, the kinematic data used in this study were captured using systematic and well-defined procedures

with the goal of producing valid data. This is first time this measure has been used in combination with behavioral assessments to develop an overall motor skill composite; however, it is clear that a specific protocol even for SDA is needed to fully utilize the value of the tool. Despite this limitation, the use of SDA was still appropriate and successfully applied to the primary research questions and helped to provide preliminary support for future research. Additionally, the statistical techniques (e.g. MI, data transformation, and bootstrapping) used to account for the limiting effects on data analysis provided relief for the common concerns of compounding of biases, extremely cautionary interpretations, and lack of generalizability (Graham et al., 2007; Hayes, 2013a; Rubin, 1987).

5.2 Future Directions

There are a number of avenues to extend this line of research. First, an experimental research design would move the examination and interpretation of the imitation-language-motor relationship from correlational to causal. The inclusion of children at different ages (e.g. 2, 3, 4, and 5 years of age) would provide both a longitudinal and developmental perspective to the examined relationship. The benefits of conducting longitudinal research would permit the examination of how the relationship changes in regards to the acquisition of more complex skills across time. Kinematic data should be measured more than once, use a variety of measurements (i.e. velocity, path analysis, sub-movements, etc.), and examine different motor movements, such as oral motor movement skills, to provide a more comprehensive account of this potentially valuable observational tool. This practice is often used in research that also uses kinematic motion analysis as the primary data collection tool (Chen & Yang, 2007b; Corbetta & Thelen, 1996; Forti et al., 2011; Kuhtz, Stolze, Boczek, & Illert, 1998; Nip et al., 2011).

The inclusion of a comparison group of children with cerebral palsy (CP) would also add to the comparative nature of this study. The primary deficit of CP is motor movement and functioning (Batshaw et al., 2013). Having a comparison group where imitation and language skill are not always impaired at similar levels, or that the observed impairment may be structurally different would further develop the proposed model across multiple developmental disorders. As suggested previously, it would be interesting to include measures of diagnosis severity, theory of mind, social skills, and joint attention in future modeling of this relationship. As those skills have been reported to impact the imitation-language relationship differentially across populations (Adamson, Bakeman, et al., 2010; Adamson, Ronski, Bakeman, & Sevcik, 2010; Carpenter et al., 2005; Hamilton et al., 2007; Rogers et al., 2003; Rogers & Pennington, 1991). The last suggestion for future research directions involved using both latent class and growth curve modeling techniques. Latent class analysis would aid in examining how individual assessment items and/or skills contribute to the overarching imitation, language, and motor domains and within a moderation model. Additionally, growth curve modeling and analysis could be applied with the inclusion of data collected at multiple ages and/or time points.

5.3 Conclusion

In conclusion, this study showed that the significant imitation-language relationship exists for young children with a variety of developmental disabilities. More importantly, this study contributed new evidence about how the nature of the imitation-language relationship is impacted differently based on diagnosis when motor movement skill is included into the relationship. Furthermore, this study highlights the importance of examining at what point does a particular skill cease or begin to be a significant contributor. This information is important because it may be able to improve the outcomes of early interventions focused on imitation that

also utilize a variety of motor movements. By identifying if a child has skills below the point at which it positively impacts the imitation-language relationship, more individualized interventions may be utilized decrease the added difficulty they are experiencing, in addition to the overall effectiveness of the intervention for that child.

REFERENCES

- Adams, L. (1998). Oral-motor and motor-speech characteristics of children with autism. *Focus on Autism and Other Developmental Disabilities, 13*(2), 108–112.
- Adamson, L. B., Bakeman, R., Deckner, D. F., & Romski, M. (2010). Joint engagement and the emergence of language in children with Autism and Down syndrome. *Journal of Autism and Developmental Disorders, 39*(1), 84–96. doi:10.1007/s10803-008-0601-7. Joint
- Adamson, L. B., Romski, M., Bakeman, R., & Sevcik, R. A. (2010). Augmented Language Intervention and the Emergence of Symbol-Infused Joint Engagement. *Journal of Speech, Language, and Hearing Research, 53*(6), 1769–1773. doi:10.1044/1092-4388(2010/09-0208). Augmented
- Adolph, K. E., & Berger, S. E. (2005). Physical and motor development. In M. Bornstein & M. Lamb (Eds.), *Developmental Science: An Advanced Textbook* (pp. 223–282). Mahwah, NJ: Erlbaum.
- Alcock, K. (2006). The development of oral motor control and language. *Down Syndrome Research & Practice, 11*(1), 1–8.
- Alcock, K. J., & Krawczyk, K. (2010). Individual differences in language development: relationship with motor skill at 21 months. *Developmental Science, 13*(5), 677–691. doi:10.1111/j.1467-7687.2009.00924.x
- American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders: DSM-IV-TR*. Washington, DC: Author.
- Association, A. P. (2012). Guidelines for assessment of and intervention with persons with disabilities. *American Psychologist, 67*(1), 43–62. doi:10.1037/a0025892

- Ayres, A. J. (1985). *Development of apraxia and adult onset apraxia*. Torrence, CA: Sensory Integration International.
- Barbaro, J., & Dissanayake, C. (2012). Developmental profiles of infants and toddlers with autism spectrum disorders identified prospectively in a community-based setting. *Journal of Autism and Developmental Disorders*, 42(9), 1939–48. doi:10.1007/s10803-012-1441-z
- Barnes, E. F., Roberts, J., Mirrett, P., Sideris, J., & Misenheimer, J. (2006). A comparison of oral structure and oral-motor function in young males with fragile X syndrome and Down syndrome. *Journal of Speech, Language, and Hearing Research : JSLHR*, 49(4), 903–17. doi:10.1044/1092-4388(2006/065)
- Batshaw, M. L., Roizen, N. J., & Lotrecchiano, G. R. (2013). *Children with disabilities* (7th ed.). Baltimore, MD.: Paul H. Brookes Publishing Co.
- Bergen, D. (2002). The role of pretend play in children’s cognitive development. *Early Childhood Research and Practice*, 4(1), 2–10.
- Brenner, S. M. (2003). *Assessment of Young Children with Special Needs: A Context-Based Approach*. Clifton Park, NY: Delmar Learning.
- Burton, A. W., & Miller, D. E. (1998). *Movement skill assessment*. Champaign, IL: Human Kinetics.
- Carpenter, M., Tomasello, M., & Striano, T. (2005). Role Reversal Imitation and Language in Typically Developing Infants and Children With Autism. *Infancy*, 8(3), 253–278. doi:10.1207/s15327078in0803_4
- Chan, J. B., & Iacono, T. (2001). Gesture and Word Production in Children with Down Syndrome. *Augmentative and Alternative Communication*, 17(June), 73–87.

- Chapman, R. S. (1997). Language development in children and adolescents with Down syndrome. *Mental Retardation and Developmental Disabilities Research Reviews*, 3, 307–312.
- Charman, T., Baron-Cohen, S., Swettenham, J., Baird, G., Cox, a, & Drew, a. (2000). Testing joint attention, imitation, and play as infancy precursors to language and theory of mind, *15*(2000). doi:10.1016/S0885-2014(01)00037-5
- Chen, Y., & Yang, T.-F. (2007a). Effect of task goals on the reaching patterns of children with cerebral palsy. *Journal of Motor Behavior*, 39(4), 317–324. doi:10.3200/JMBR.39.4.317-325
- Chen, Y., & Yang, T.-F. (2007b). Effect of task goals on the reaching patterns of children with cerebral palsy. *Journal of Motor Behavior*, 39(4), 317–24. doi:10.3200/JMBR.39.4.317-325
- Claxton, L. J., Keen, R., & McCarty, M. E. (2003). Evidence of Motor Planning in Infant Reaching Behavior. *Psychological Science*, 14(4), 354–356. doi:10.1111/1467-9280.24421
- Corbetta, D., & Thelen, E. (1996). The Developmental Origins of Bimanual Coordination : A Dynamic Perspective. *Journal of Experimental Psychology*, 22(2), 502–522.
- Delaney, A. L., & Arvedson, J. C. (2008). Development of swallowing and feeding: Prenatal through first year of life. *Developmental Disabilities Research Reviews*, 14(2), 105–117. doi:10.1002/ddrr.16
- Dewey, D. (1995). What is developmental dyspraxia? *Brain and Cognition*, 29, 254–274.
- Dockrell, J. E. (2001). Assessing language skills in preschool. *Measurement Issues: Assessing Language Skills*, 6(2), 74–86.
- Dziuk, M. a, Gidley Larson, J. C., Apostu, A., Mahone, E. M., Denckla, M. B., & Mostofsky, S. H. (2007). Dyspraxia in autism: association with motor, social, and communicative deficits.

Developmental Medicine and Child Neurology, 49(10), 734–739. doi:10.1111/j.1469-8749.2007.00734.x

Eliasson, A.-C., Krumlinde-Sundholm, L., Rosblad, B., Beckung, E., Arner, M., Ohrvall, A.-M., & Rosenbaum, P. (2006). The Manual Ability Classification System (MACS) for children with Cerebral Palsy: Scale Development and Evidence of validity and reliability.

Developmental Medicine & Child Neurology, 48, 549–554.

Ellis Weismer, S., Lord, C., & Esler, A. (2010a). Early language patterns of toddlers on the autism spectrum compared to toddlers with developmental delay. *Journal of Autism and Developmental Disorders*, 40(10), 1259–1273. doi:10.1007/s10803-010-0983-1

Ellis Weismer, S., Lord, C., & Esler, A. (2010b). Early language patterns of toddlers on the autism spectrum compared to toddlers with developmental delay. *Journal of Autism and Developmental Disorders*, 40(10), 1259–73. doi:10.1007/s10803-010-0983-1

Fenson, L., Marchman, V. A., Thal, D., Dale, P. S., Reznick, J. S., & Bates, E. (2007).

MacArthur-Bates communication development inventories: User's guide and technical manual (2nd ed.). Baltimore, MD: Paul H. Brookes Publishing Co.

Fidler, D. J. (2005). The Emerging Down Syndrome Behavioral Phenotype in Early Childhood Implications for Practice, 18(2), 86–103.

Fidler, D. J., Hepburn, S. L., Mankin, G., & Rogers, S. J. (2005). Praxis skills in young children with Down syndrome, other developmental disabilities, and typically developing children.

The American Journal of Occupational Therapy, 59(2), 129–138. Retrieved from

<http://www.ncbi.nlm.nih.gov/pubmed/15830612>

- Forti, S., Valli, A., Perego, P., Nobile, M., Crippa, A., & Molteni, M. (2011). Motor planning and control in autism. A kinematic analysis of preschool children. *Research in Autism Spectrum Disorders*, 5(2), 834–842. doi:10.1016/j.rasd.2010.09.013
- Fournier, K. A., Hass, C. J., Naik, S. K., Lodha, N., & Cauraugh, J. H. (2010). Motor coordination in autism spectrum disorders: a synthesis and meta-analysis. *Journal of Autism and Developmental Disorders*, 40(10), 1227–1240. doi:10.1007/s10803-010-0981-3
- Gernsbacher, M. A., Sauer, E. A., Geye, H. M., Schweigert, E. K., & Hill Goldsmith, H. (2008). Infant and toddler oral- and manual-motor skills predict later speech fluency in autism. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, 49(1), 43–50. doi:10.1111/j.1469-7610.2007.01820.x
- Graham, J. W., Olchowski, A. E., & Gilreath, T. D. (2007). How many imputations are really needed? Some practical clarifications of multiple imputation theory. *Prevention Science*, 8(3), 206–213. doi:10.1007/s11121-007-0070-9
- Hamilton, A. F. D. C., Brindley, R. M., & Frith, U. (2007). Imitation and action understanding in autistic spectrum disorders: how valid is the hypothesis of a deficit in the mirror neuron system? *Neuropsychologia*, 45(8), 1859–68. doi:10.1016/j.neuropsychologia.2006.11.022
- Haukoos, J. S., & Lewis, R. J. (2005). Advanced statistics: Bootstrapping confidence intervals for statistics with “difficult” distributions. *Academic Emergency Medicine*, 12(4), 360–365. doi:10.1197/j.aem.2004.11.018
- Hayes, A. F. (2013a). *Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach*. (T. Little, Ed.). New York, NY: The Guilford Press.
- Hayes, A. F. (2013b). PROCESS. Columbus, OH: The Ohio State University.

- Hedrick, D. L., Prather, E. M., & Tobin, A. R. (1984). *Sequenced Inventory of Communication Development*. Seattle: University of Washington Press.
- Heller, K. W., Alberto, P. A., Forney, P. E., & Schwartzman, M. N. (1996). Typical and atypical motor development. In *Understanding physical, sensory, and health impairments* (pp. 12–34). Pacific Grove, CA: Brooks/Cole Publishing Co.
- Hoff, E. (2009). *Language Development* (4th ed.). Belmont, CA: Wadsworth.
- Hudry, K., Leadbitter, K., Temple, K., Slonims, V., McConachie, H., Aldred, C., ... Charman, T. (2010). Preschoolers with autism show greater impairment in receptive compared with expressive language abilities. *International Journal of Language & Communication Disorders / Royal College of Speech & Language Therapists*, *45*(6), 681–90.
doi:10.3109/13682820903461493
- Ingersoll, B., & Schreibman, L. (2006). Teaching reciprocal imitation skills to young children with autism using a naturalistic behavioral approach: effects on language, pretend play, and joint attention. *Journal of Autism and Developmental Disorders*, *36*(4), 487–505.
doi:10.1007/s10803-006-0089-y
- Iverson, J. M. (2010). Developing language in a developing body: the relationship between motor development and language development. *Journal of Child Language*, *37*(2), 229–261. doi:10.1017/S0305000909990432
- Iverson, J. M., & Braddock, B. A. (2010). Gesture and Motor Skill in Relation to Language in Children with Language Impairment. *Journal of Speech, Language, and Hearing Research*, 1–45. doi:10.1044/1092-4388(2010/08-0197)The
- Kaufman, N. R. (1995). *The Kaufman Speech Praxis Test for Children*. Wayne State University Press.

- Kieviet, J. F., Piek, J. P., Aarnoudse-Moens, C. S., & Oosterlaan, J. (2009). Motor Development in Very Preterm and Very Low-Birth-Weight Children. *American Medical Association, 302*(20), 2235–2242.
- Kuhl, P. K., Coffey-Corina, S., Padden, D., Munson, J., Estes, A., & Dawson, G. (2013). Brain responses to words in 2-year-olds with autism predict developmental outcomes at age 6. *PloS One, 8*(5), 1–13. doi:10.1371/journal.pone.0064967
- Kuhtz, P., Stolze, H., Boczek, A., & Illert, M. (1998). Development of prehension movements in children : A kinematic study. *Experimental Brain Research, 424–432*.
- Kumin, L. (1996). Speech and language skills in children with Down syndrome. *Mental Retardation and Developmental Disabilities Research Reviews, 2*, 109–115.
- Kumin, L. (2006). Speech intelligibility and childhood verbal apraxia in children with Down syndrome. *Down's Syndrome, Research and Practice, 10*(1), 10–22. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/16869369>
- Lainé, F., Rauzy, S., Tardif, C., & Gepner, B. (2011). Slowing down the presentation of facial and body movements enhances imitation performance in children with severe autism. *Journal of Autism and Developmental Disorders, 41*(8), 983–96. doi:10.1007/s10803-010-1123-7
- Lefevre, M. C. (1960). Language Problems of the Child with Cerebral Palsy. *Monographs of the Society for Research in Child Development, 25*(3), 59–69.
- Libby, S., Powell, S., Messer, D., & Jordan, R. (1997). Imitation of pretend play acts by children with Autism and Down syndrome. *Journal of Autism and Developmental Disorders, 27*(4), 365–383.

- Lord, C., Shulman, C., & DiLavore, P. (2004). Regression and word loss in autistic spectrum disorders. *Journal of Child Psychology and Psychiatry*, 45(5), 936–955.
doi:10.1111/j.1469-7610.2004.t01-1-00287.x
- Luyster, R. J., Kadlec, M. B., Carter, A., & Tager-Flusberg, H. (2008). Language assessment and development in toddlers with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, 38(8), 1426–38. doi:10.1007/s10803-007-0510-1
- MacWhinney, B. (2005). Language Development. In M. Bornstein & M. Lamb (Eds.), *Developmental Science: An Advanced Textbook* (5th ed., pp. 359–387). Mahwah, NJ: Erlbaum.
- Matson, J. L., Mahan, S., Fodstad, J. C., Hess, J. a., & Neal, D. (2010). Motor skill abilities in toddlers with autistic disorder, pervasive developmental disorder-not otherwise specified, and atypical development. *Research in Autism Spectrum Disorders*, 4(3), 444–449.
doi:10.1016/j.rasd.2009.10.018
- Miller, J., & Chapman, R. (1985). *Systematic analysis of language transcripts*. Madison: University of Wisconsin.
- Mitchell, S., Brian, J., Zwaigenbaum, L., Roberts, W., Szatmari, P., Smith, I., & Bryson, S. (2006a). Early language and communication development of infants later diagnosed with autism spectrum disorder. *Journal of Developmental and Behavioral Pediatrics : JDBP*, 27(2 Suppl), S69–78. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/16685188>
- Mitchell, S., Brian, J., Zwaigenbaum, L., Roberts, W., Szatmari, P., Smith, I., & Bryson, S. (2006b). Early language and communication development of infants later diagnosed with autism spectrum disorder. *Journal of Developmental and Behavioral Pediatrics*, 27(2), S69–S78. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/16685188>

- Mostofsky, S. H., Dubey, P., Jerath, V. K., Jansiewicz, E. M., Goldberg, M. C., & Denckla, M. B. (2006a). Developmental dyspraxia is not limited to imitation in children with autism spectrum disorders. *Journal of the International Neuropsychological Society*, *12*(3), 314–326. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/16903124>
- Mostofsky, S. H., Dubey, P., Jerath, V. K., Jansiewicz, E. M., Goldberg, M. C., & Denckla, M. B. (2006b). Developmental dyspraxia is not limited to imitation in children with autism spectrum disorders. *Journal of the International Neuropsychological Society : JINS*, *12*(3), 314–26. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/16903124>
- Mullen, E. M. (1995). *Mullen Scales of Early Learning*. San Antonio, TX: Pearson.
- Mundy, P., Sigman, M., Kasari, C., & Yirmiya, N. (1988). Nonverbal communication skills in Down syndrome children. *Child Development*, *59*(1), 235–249. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/2963734>
- Nip, I. S. B., Green, J. R., & Marx, D. B. (2011). The co-emergence of cognition, language, and speech motor control in early development: a longitudinal correlation study. *Journal of Communication Disorders*, *44*(2), 149–160. doi:10.1016/j.jcomdis.2010.08.002
- Paul, R. (2005). Assessing communication in Autism Spectrum Disorders. In F. R. Volkmar, R. Paul, A. Klin, & D. Cohen (Eds.), *Handbook of Autism and Pervasive Developmental Disorders, Volume 2: Assessment, Intervention, and Policy* (3rd ed., pp. 799–857). John Wiley & Sons, Inc.
- Pitcairn, T. K., & Wishart, J. G. (1994). Reactions of young children with Down's syndrome to an impossible task. *British Journal of Developmental Psychology*, *12*(4), 485–498.
- Provost, B., Lopez, B. R., & Heimerl, S. (2007). A comparison of motor delays in young children: autism spectrum disorder, developmental delay, and developmental concerns.

Journal of Autism and Developmental Disorders, 37(2), 321–328. doi:10.1007/s10803-006-0170-6

- Rechetnikov, R. P., & Maitra, K. (2005). Motor impairments in children associated with impairments of speech or language: a meta-analytic review of research literature. *The American Journal of Occupational Therapy : Official Publication of the American Occupational Therapy Association*, 63(3), 255–263.
- Roberts, J. A., Rice, M. L., & Tager-Flusberg, H. (2004). Tense marking in children with autism. *Applied Psycholinguistics*, 25(03), 429–448. doi:10.1017/S0142716404001201
- Roberts, J., Price, J., Barnes, E., Nelson, L., Burchinal, M., Hennon, E. a, ... Hooper, S. R. (2007). Receptive vocabulary, expressive vocabulary, and speech production of boys with fragile X syndrome in comparison to boys with down syndrome. *American Journal of Mental Retardation : AJMR*, 112(3), 177–193. doi:10.1352/0895-8017(2007)112[177:RVEVAS]2.0.CO;2
- Rogers, S. J., Hepburn, S. L., Stackhouse, T., & Wehner, E. (2003). Imitation performance in toddlers with autism and those with other developmental disorders. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, 44(5), 763–81.
- Rogers, S. J., & Pennington, B. F. (1991). A theoretical approach to the deficits in infantile autism. *Development and Psychopathology*, 3(2), 137–162.
- Romski, M. A., Sevcik, R. A., Smith, A., Barker, R. M., Folan, S., & Barton-Hulsey, A. (2009). The system for augmenting language: Implications for young children with autism spectrum disorders. In P. Mirenda & T. Iacono (Eds.), *Autism spectrum disorders and AAC* (pp. 219–217). Maryland: Paul H. Brooks.

- Romski, M., Sevcik, R. A., Adamson, L. B., Smith, A., & Barker, R. M. (2010). Randomized comparison of augmented and nonaugmented language interventions for toddlers with developmental delays and their parents. *Journal of Speech, Language, and Hearing Research, 53*(April), 350–365.
- Rubin, D. B. (1987). *Multiple imputation for nonresponse in surveys*. New York: Wiley & Sons.
- Rutter, M., Le Couteur, A., & Lord, C. (2003). *Autism Diagnostic Interview-Revised*. Los Angeles, CA: Western Psychological Services.
- Shriberg, L. D., Paul, R., Black, L. M., & van Santen, J. P. (2011). The hypothesis of apraxia of speech in children with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 41*(4), 405–426. doi:10.1007/s10803-010-1117-5.
- Sideridis, G. D., & Simos, P. (2010). What is the Actual Correlation Between Expressive and Receptive Measures of Vocabulary ? Approximating the Sampling Distribution of the Correlation Coefficient Using the Bootstrapping Method. *The International Journal of Educational and Psychological Assessment, 5*(August), 117–133.
- Sparrow, S. S., Balla, D. A., & Cicchetti, D. V. (1984). *Vineland Adaptive Behavior Scales*. Circle Pines, MN: American Guidance Service.
- Sparrow, S. S., Cicchetti, D. V., & Balla, D. A. (2005). *Vineland Adaptive Behavior Scales, Second Edition* (Second.). Bloomington, MN: Pearson Education, Inc.
- Steinman, K. J., Mostofsky, S. H., & Denckla, M. B. (2010). Toward a narrower, more pragmatic view of developmental dyspraxia. *Journal of Child Neurology, 25*(1), 71–81. doi:10.1177/0883073809342591.

- Stetson, R., Stetson, E. G., & Sattler, J. M. (2001). Assessment of receptive and expressive language. In J. M. Sattler (Ed.), *Assessment of Children: Cognitive Applications* (4th ed., pp. 610–634). Le Mesa, CA: Jerome M. Sattler, Publisher, Inc.
- Stone, W. L., Ousley, O. Y., & Littleford, C. D. (1997). Motor imitation in young children with autism: what's the object? *Journal of Abnormal Child Psychology*, *25*(6), 475–85.
- Stone, W. L., & Yoder, P. J. (2001). Predicting Spoken Language Level in Children with Autism Spectrum Disorders. *Autism*, *5*(4), 341–361. doi:10.1177/1362361301005004002
- Tager-Flusberg, H., & Calkins, S. (2009). Does imitation facilitate the acquisition of grammar? Evidence from a study of autistic, Down's syndrome and normal children. *Journal of Child Language*, *17*(03), 591. doi:10.1017/S0305000900010898
- Tager-Flusberg, H., Calkins, S., Nolin, T., Baumberger, T., Anderson, M., & Chadwick-Dias, A. (1990). A longitudinal study of language acquisition in autistic and Down syndrome children. *Journal of Autism and Developmental Disorders*, *20*, 1–21.
- Tager-Flusberg, H., Paul, R., & Lord, C. (2005). Language and Communication in Autism. In *Handbook of Autism and Pervasive Developmental Disorders* (pp. 335–364).
- Thelen, E. (1995). Motor Development. *American Psychologist*, *50*(2), 79–95.
- Thelen, E., Ulrich, B. D., & Wolff, P. H. (1991). Hidden skills: A dynamic systems analysis of treadmill stepping during the first year. *Monographs of the Society for Research in Child Development*, *56*(1), 1–103.
- Thurm, A., Lord, C., Lee, L.-C., & Newschaffer, C. (2007). Predictors of language acquisition in preschool children with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *37*(9), 1721–1734. doi:10.1007/s10803-006-0300-1

- Tomasello, M., & Barton, M. E. (1994). Learning Words in nonostensive contexts. *Developmental Psychology, 30*(5), 639–650. doi:<http://psycnet.apa.org/doi/10.1037/0012-1649.30.5.639>
- Vanvuchelen, M., Roeyers, H., & De Weerdt, W. (2007a). Nature of motor imitation problems in school-aged boys with autism: a motor or a cognitive problem? *Autism : The International Journal of Research and Practice, 11*(3), 225–240. doi:[10.1177/1362361307076846](https://doi.org/10.1177/1362361307076846)
- Vanvuchelen, M., Roeyers, H., & De Weerdt, W. (2007b). Nature of motor imitation problems in school-aged males with autism: how congruent are the error types? *Developmental Medicine and Child Neurology, 49*(1), 6–12. doi:[10.1111/j.1469-8749.2007.0047a.x](https://doi.org/10.1111/j.1469-8749.2007.0047a.x)
- Viholainen, H., Ahonen, T., Lyytinen, H., Cantell, M., Lyytinen, P., & Tolvanen, A. (2010). The association of motor and language development. In *Connecting paradigms of motor behavior to sport and physical education* (pp. 232–248).
- Visscher, C., Houwen, S., Scherder, E. J. a, Moolenaar, B., & Hartman, E. (2007). Motor profile of children with developmental speech and language disorders. *Pediatrics, 120*(1), e158–63. doi:[10.1542/peds.2006-2462](https://doi.org/10.1542/peds.2006-2462)
- Warren, S. F., Gilkerson, J., Richards, J. a., Oller, D. K., Xu, D., Yapanel, U., & Gray, S. (2010). What automated vocal analysis reveals about the vocal production and language learning environment of young children with autism. *Journal of Autism and Developmental Disorders, 40*(5), 555–569. doi:[10.1007/s10803-009-0902-5](https://doi.org/10.1007/s10803-009-0902-5)
- Weismer, S. E., Gernsbacher, M. A., Stronach, S., Karasinski, C., Eernisse, E. R., Venker, C. E., & Sindberg, H. (2011). Lexical and grammatical skills in toddlers on the autism spectrum compared to late talking toddlers, *41*(8), 1065–1075. doi:[10.1007/s10803-010-1134-4](https://doi.org/10.1007/s10803-010-1134-4).

- Williams, J. H. G., Whiten, A., & Singh, T. (2004). A systematic review of action imitation in autistic spectrum disorder. *Journal of Autism and Developmental Disorders*, 34(3), 285–99.
- Williams, J. H., Whiten, A., Suddendorf, T., & Perrett, D. I. (2001). Imitation, mirror neurons and autism. *Neuroscience and Biobehavioral Reviews*, 25(4), 287–95.
- Wright, I., Lewis, V., & Collis, G. M. (2006). Imitation and representational development in young children with Down syndrome. *British Journal of Developmental Psychology*, 24(2), 429–450. doi:10.1348/026151005X51257
- Xu, D., Yapanel, U., & Gray, S. (2009). *Reliability of the LENATM language environment analysis system in young children's natural home environment*. Boulder, CO: LENA Foundation. doi:xu
- Zachor, D. a., Ilanit, T., & Itzhak, E. Ben. (2010). Autism severity and motor abilities correlates of imitation situations in children with autism spectrum disorders. *Research in Autism Spectrum Disorders*, 4(3), 438–443. doi:10.1016/j.rasd.2009.10.016
- Zatsiorsky, V. M. (1998). *Kinematics of human motion*. Champaign, IL: Human Kinetics.
- Zimmerman, I. L., Steiner, V. G., & Pond, R. E. (1992). *Preschool Language Scale-3*. San Antonio, TX: The Psychological Corporation.

APPENDICES

APPENDIX A

Autism Dx Confirmation Form

Please check the following items based on your observations from the 12MFU home observation.

*To validate this checklist item, use VABS items #8, 22, 29, 33 & 37. If the child receives a zero (0) score on the majority ($50% < x$) of these items, then the criteria has been met to select this determinant.

For the VAB-2, use items #15 & 20. If the child receives a zero (0) score on the majority ($50% < x$) of these items, then the criteria has been met.

Participant # _____ Rater _____ Observation Time-point _____ Dx _____

Social

- Marked impairment in the use of multiple nonverbal behaviors such as eye-to-eye gaze, facial expression, body postures, and gestures to regulate social interaction
- Failure to develop peer relationships appropriate to developmental level*
- A lack of spontaneous seeking to share enjoyment, interests, or achievements with other people (e.g. by a lack of showing, bringing, or pointing out objects of interest to other people)
- Lack of social or emotional reciprocity

Communication

- Delay in, or total lack of, the development of spoken language (not accompanied by an attempt to compensate through alternative modes of communication such as gesture or mime)
- In individuals with adequate speech, marked impairment in the ability to initiate or sustain a conversation with others.
- Stereotyped and repetitive use of language or idiosyncratic language

- Lack of varied, spontaneous make-believe play or social imitative play appropriate to developmental level

Behavioral

- Encompassing preoccupation with one or more stereotyped and restricted patterns of interest that is abnormal either in intensity or focus
- Apparently inflexible adherence to specific, nonfunctional routines or rituals
- Stereotyped and repetitive motor mannerisms (e.g. hand or finger flapping or twisting, or complex whole-body movements)
- Persistent preoccupation with parts of objects

To meet DSM-IV criteria

ASD- 2 social; 2 communication; AND 1 behavioral

PDD- 1 social; AND 1 communication OR 1 behavioral