Understanding Imitation:
The Role of Motor and Perceptual Skills

by

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A THESIS

Presented to the Department of Psychology and Human Physiology
and the Robert D. Clark Honors College
in partial fulfillment of the requirements for the degree of
Bachelor of Science

June 2014

An Abstract of the Thesis of

Erika Chesnutt for the degree of Bachelor of Science
in the Department of Human Physiology and Psychology to be taken June 2014

Title: Understanding Imitation: The Role of Motor and Perceptual Skills

Approved: ______________________

Dare Baldwin

Successful imitation is essential to early learning in childhood. Imitation seems to depend upon a host of skills; how the full complement of relevant skills jointly support children's imitation success is not yet fully understood. We investigate relationships between imitation and various skills in a small group of typically developing children, in order to gain a better understanding of the package of skills contributing to children's imitation ability. We focused in particular on children's motor skills, employing several behavioral measures and a parent-report motor questionnaire to assess them. As predicted, children's level of motor skill, visual-motor integration ability, self-regulation and social understanding, and memory for action appeared to predict imitation success, even while controlling for age. We also found that certain measures of our parent report motor questionnaire accurately measured motor skill and predicted imitation success. These findings support the idea that imitation ability is complex and reflects a number of skills, including motor skills. In addition, the results provide initial support for the utility of the parent-report motor questionnaire.

ACKNOWLEDGEMENTS

I would like to express my gratitude to Dare Baldwin and Jenny Mendoza for their support, guidance and expertise throughout the thesis process, as well as the countless hours they spent editing, discussing and supporting the project. Additionally, I would like to express great appreciation to Natalie Brezack for her constant encouragement, support, guidance and friendship throughout this process. I would also like to thank my wonderfully supportive family, boyfriend Keith Morrreira, and friends at the Trinity House and at large for their encouragement and prayers. I also express special thanks to my patient parents, Karin and Jim Chesnutt, with whom I spent many hours discussing my thesis. Further, I would like to thank Samantha Hopkins for advising me throughout my years in the honors college. Particular appreciation is also due to members of the Baldwin lab, both graduate students and undergraduate research assistants who made this research possible.

Table of Contents

I. INTRODUCTION

Have you ever watched a young child copying movements and expressions in a game of peek-a-boo? While this scene may be quite adorable, this skill of mimicking another's action is fundamental to development. Imitation is a learning strategy through which young children acquire and master new behaviors (Meltzoff & Moore, 1983). Imitation plays a key role in the development of cognitive and social communication behaviors such as language, play and joint attention (Rogers & Pennington, 1991). Successful imitation seems to depend on a collection of underlying skills, including attending to and successfully encoding another's activity sequence, mapping that representation into a plan for one's own action, and then successfully producing the target motor actions. The whole compliment of skills necessary for imitation success is not yet understood.

Imitation is a complex skill, as the skill that requires proficiency in a host of related developmental areas. Theory suggests that social, attentional, and motor abilities, all play a role in successful imitation (McDuffie et al., 2006). In addition, executive function, theory of mind, action processing, fine motor, gross motor, visual-motor integration and memory skills may also fold into imitation. Executive function (EF) refers to the ability to access and utilize voluntary attention skills and cognitive resources to problem solve and achieve a goal. EF includes the use of working memory, planning and flexibility (Carlson & Moses, 2001). In order to imitate a motor sequence, one must recruit executive function skills to plan and achieve an imitative goal. Theory of Mind (ToM) refers to understanding others' mental states (Wellman & Liu, 2004), allowing us to make inferences about other's goals, intentions and desires. In terms of imitation, ToM allows us to mentalize about an agent's intentions, while EF helps us to plan and carry out the action sequences ourselves. However, further research is needed to evaluate the extent to which each of these developmental skills plays a role in successful imitation.

The present study built on the work by Brezack and colleagues (2013), using the same measures of motionese preference and action segmentation, while incorporating measures of children's motor skills to enable exploration of possible connections among children's motor skill, action processing and imitation. These were included because of the extensive research that demonstrates an autism-specific deficit in motor imitation (Rogers & Pennington, 1991) and the need for further research into the problems of imitation and action in autism (Smith & Bryson, 1994). Due to the lack of conclusive evidence in the research field concerning the cause of these imitation deficits, we thought that adding in additional motor, perceptual and imitation tasks would help us better understand the underlying causes of differences in imitation.

Measuring motor skills in such a young population is a difficult task as distractibility can create noise in measurements. According to Piek et al. (2012), out of the numerous motor ability assessments for preschool children, there is no standard test proven to measure motor ability more effectively than the rest. This means that currently, for preschool aged children, we do not have one standard test that is widely used, but instead many different tests that vary in the exact motor skills assessed and scores produced. To account for this variability in measuring motor skill, we included multiple standardized measures of motor skill along with a parent report motor questionnaire. We included a parent report measure because we hypothesized that this would be a sensitive measure that would help eliminate some of the variance that previous researchers have found when performing motor assessments in young children.

Imitation is an essential skill that seems to depend upon a host of skills. The whole complement of skills necessary for imitation success is not yet understood. We explored how various relevant skills jointly support children's imitation success. One strategy for understanding individual differences in motor imitation performance is to examine predictors of motor imitation in a population where imitation deficits are present, such as children with autism (McDuffie et al., 2006). Research shows that children with ASD performed worse on imitative tasks (Williams, Whiten & Singh, 2004) and showed a delayed development of imitation (Young, 2011). Imitation deficits have a profound effect on learning and development in children with autism (Meltzoff & Gopnik, 1994; Rogers & Pennington, 1991). For example previous research has found that imitation impairment discriminates children with autism from typically developing children and those with other developmental disorders as early as age 2 (Rogers et al., 2003). Further exploration of connection between imitation and skill deficits commonly associated with this population may yield better understanding about the components vital for successful imitation.

Research has suggested many possible explanations for the imitation problems seen in children with ASD, including deficits in motor ability (Green et al., 2002; Vanvuchelen, Roeyers & Weerdt, 2007; McDuffie et al., 2007; Rogers, Stackhouse & Werner, 2003), motor planning (DeMyer et al., 1972), perceptual-motor integration (Vanvuchelen, 2007), social and attentional abilities (McDuffie et al., 2007) and social responsiveness (Rogers, Stackhouse & Werner, 2003). These causes can be broadened into three categories: motor deficits, perceptual (processing) deficits and in perceptual-motor integration deficits.

Evidence suggests that autistic children have an impaired ability to understand the perceptual world due to their inability to attend selectively to salient parts (Smith & Bryson, 1994). In this way, attentional deficits underlie perceptual abilities. Additionally, understanding social interactions is key to attention as well as perception because through social interactions we are directed towards important parts of an action. Social deficits that accompany autism contribute to perceptual problems; because children with autism avoid social interactions, they often miss out on a great deal of the information conveyed by other people during development (Klin et al., 2002). Children with autism typically show low-level EF and ToM skills (Zealot et al., 2002), which could also be contributing to their inability to direct attention, as without the proper social understanding and self-regulation, a child may not be able to identify the salient parts of the action. Additionally, children with autism display significant deficits in imitation that are associated with impairments in social communication skills (Ingersoll, 2008). This evidence suggests that perceptual ability, including the underlying role of attention and social skills, affect imitation ability.

Autistic children have been found to display a wide variety of problems with motor skills (DeMyer, 1976). Studies have found that on average 50-73% of children with ASD have significant motor delays (Provost, Lopez & Heimerl, 2007). Additionally, fine and gross motor skill level has been correlated with imitation performance (Rogers et al., 2003). This research indicates that motor skill development impacts imitation ability. Furthermore, DeMyer et al. (1972) stated that child’s inability to imitate reflects a disturbance of the capacity to carry out certain skilled voluntary movements. The question is whether this is related to the movements themselves, or to the process of producing the movements. Some argue that problems in imitation are caused by the inability of the brain to organize movement (DeMyer et al., 1972; DeMyer, 1975), suggesting a problem with perceptual-motor integration.

Perceptual-motor integration is the process of turning a perceived action into a motor plan for action. A vast amount of research has been done that demonstrates that children with autism fail to properly link perception and action (Ozonoff, South, & Miller, 2000). Problems in integration arise when the child is unable to map perception to movement. Allport (1987) emphasizes the importance of this perceptual mapping to control actions and suggests that in autism, this "map" is not organized as it is in normal development. This research is evidence that imitation may be affected by improper perceptual-motor integration.

Brezack, Baldwin and Mendoza (2013), examined individual and developmental differences that exist in children's action processing and their preferences for motionese stimuli. Motionese is a phenomenon in which adults modify their gestures and motions when performing an action sequence by using repetivitive, simple, exaggerated motions (Brand, Baldwin & Ashburn, 2002; Myhr, Baldwin & Brand, 2004) in order to promote learning in children. Motionese is an analogous phenomenon to motherese, a language domain equivalent, because both highlight essential parts of action sequences and linguistic utterances (Sage & Baldwin, 2012), respectively. Past research has shown that neurotypical children prefer motionese compared to adult-directed action (Sage &

Baldwin, 2012). This study aimed to further explore motionese and its connection to other developmental skills.

In this study a battery of task was used to investigate children's processing skill, memory skill, imitation skill and developmental level. This study used two tasks to investigate child's action processing skills: a video preference test and an action-processing task. In the video preference task, children simultaneously viewed two videos, one depicting normal action using motionese and another showing a non-action analog. Children's looking time to each was measured, thus recording their level of preference for viewing motionese. To measure children's action processing, Brezack and colleagues employed the dwell-time methodology (Hard, Recchia, and Tversky, 2011), in children advanced through a frame-by-frame slide show of a motionese action sequence at their own pace. The time spent looking at each frame- the 'dwell time' - was recorded as a measure of children's action segmentation. Children were asked memory questions about the dwell time slideshow. Additionally children were presented with a live action demonstration of a toy using motionese, and then asked to imitate the demonstration and answer memory questions about the demonstration. These actions were fine motor actions, the first a demonstration of a play dough toy and the second of peg task. The imitation performance and memory questions provided information about the child's ability to remember motionese action sequences. It was predicted that children who were more typically developed (i.e., higher scores on ToM and EF tasks) would show a stronger preference for motionese compared to the non-action analog as well as greater segmentation ability (i.e., longer dwell times to breakpoint slides vs. with-in unit slides). Furthermore, it was predicted that higher

ToM, EF, motionese preference and segmentation ability would predict higher scores for both imitation and memory questions. The parents also filled out questionnaires, reporting on their children's EF, ToM, language ability, and autism symptomotoloy. These forms were predicted to correlate with the data from the child during the study.

In this study, children were placed on a continuum based on their display of autism symptomology. This continuum stretched from the autism spectrum to neurotypical children. Children were placed on this spectrum according to their Executive Functioning (EF) and Theory of Mind (ToM) performance. These two measures were used because children with ASD are known to be impaired in both EF and ToM (Zelazo et al., 2002). Children with ASD tend to perform worse on these tasks because they require social engagement and understanding, as well as inhibition skills, so this composite score is termed social understanding and self-regulation. This study used this spectrum model so that from this data, inferences can be made about action processing in an ASD population.

This study found that increased Executive Function and Theory of Mind predicted increased motionese preference, suggesting the role of social understanding and self-regulation in this action preference. Additionally, motionese preference was a significant predictor of action segmentation skills, suggesting that these action preference and processing skills go hand in hand. Furthermore, a positive correlation was observed between motionese preference and imitation, as well as between memory questions and imitation, suggesting that visual perception also plays a role in imitation. However, these findings do not completely elucidate the mechanisms behind individual differences in imitation abilities; more research is necessary to tease apart the role that developmental skills, particularly visual perception skills, motor skill and visual-motor integration work together to predict imitation success.

This research along with the research on children with autism suggests that perceptual skills, motor skills and the integration of these domains all play a key role in imitation ability. Our study aims to assess whether children's motor and perceptual skills predict their success at imitation. We administered field-standard tests of motor skills, visual perception and visual- motor integration along with a battery of novel behavioral tasks measuring a variety of skills including but not limited to self-regulation, social understanding, action processing and imitation. Parents also provided information concerning these various skills, as a source of additional information regarding the children's development in these particular skills.

The main research question of the current study is whether perception of action (perceptual skills) and ability to produce action (motor skills) jointly predict imitation success. Importantly, the extent to which the imitation problems reflect a conceptual deficit or an underlying impairment in the programming of integrated movements has not been addressed (Smith & Bryson, 1994). More specifically we aim to determine whether children's motor proficiency level positively predicts their imitation success, among a group of typically developing children. Furthermore we seek to investigate the extent to which visual-motor integration, social understanding, and memory for action might positively predict imitation success? We hypothesize that motor skill will positively predict imitation ability. We also predict that visual-motor integration, self-regulation and social understanding, memory for action and visual perception will all positively predict imitation success. Additionally, we are exploring the sensitivity of a parent motor questionnaire in picking up on motor skill and development. If this parent questionnaire measures motor skill effectively, it could be a key contribution to the field, as with young children much variance is found in direct motor measures due to their great distractibility. We predict that this parent motor questionnaire will significantly predict motor development and in turn imitation. With this knowledge, we will be better able to understand imitation and equipped to explore tools for assisting with imitation deficits.

II. METHODS

Participants

Thirteen neurotypical children ages 2.5 to 3.5 years old (8 females, M_{age}= 35 months, SD_{age}= 3.7 months) were included in the study. Children were recruited from the Eugene, Oregon area through phone calls. The Institutional Review Board at the University of Oregon approved this research as a part of the Acquiring Minds Lab child protocol.

Set up

There are four different room set-ups, which change throughout the experiment. During the study, the parent sits in the corner of the room, while the child moves around according to the room set up (See Appendix C) specified for each task in the protocol (See Appendix B). The child's actions and responses are recorded by the experimenter or research assistant and were also recorded from two different camera angles. A research assistant is located behind a curtain and manages the camera angle to make sure the actions are recorded properly in each room set up.

Procedure

The experimental session typically took about an hour and a half per child. First, the parent and child come into the lab and are briefed on the study and the parent signs the consent forms. Then, for 40-50 minutes one experimenter tests the child on tasks one through seven. Next, after a short break, a second experimenter tests the child on tasks nine and ten, which last approximately 20-30 minutes. The tasks were administered as follows. See Appendix C for complete protocol with descriptions & scripts.

Video Preference Task

In this task children are presented with two videos on a computer, which are presented simultaneously, side by side. One video is a motionese video and the other is a non-action analog video. The motionese used in the video is essentially motherese (Kuhl, 2005) transferred from the language domain to the action domain. Motionese includes exaggerated action and expression and slow motions, analogous to the exaggerated speech and expression and elongated speech in motherese. The non-action analog was created by pixelating the motionese stimuli and rotating it 180 degrees. There are four videos of the actor interacting with toys, "Lego Man", "Sorting", "Train" and "Balloon". During this task, looking times to the motionese video and the non-action analog video are recorded, in order to assess children's preference for viewing one video type over the other.

Theory of Mind Tasks: Diverse desires, Diverse beliefs, False contents & Knowledge access

Children completed four classic theory-of-mind tasks, which aim at measuring children's development in their understanding of diverse desires, diverse beliefs, false contents and knowledge access.

The diverse-desires task probes the child's ability to understand that others have different beliefs and desires. In this task, the child is presented with two snacks and asked which they would prefer. Then, the child is told that another person ("Sammy") would like the other snack. Then, the child is asked to choose a snack for Sammy. Children are scored based on whether they choose the correct snack for Sammy.

The diverse-belief task probes whether the child understands that others may have different beliefs. In this task, the child is presented with two images a garage and tree. The child is asked to identify where they think the cat is hiding. Then, children are told that another person ("Linda") thinks her cat is hiding in the opposite place. The child is asked where Linda will look for her cat. A correct score is given if the child answers the opposite location than where the child had thought.

The false beliefs task is a task in which unexpected objects are hidden inside a box. First, the child is presented with a crayon box and is asked what is inside, then the box is opened and ribbons are revealed. Then the child is asked what another person, Sammy, thinks is inside the box, if Sammy hasn't seen inside the box. If the child responds with crayons because Sammy hasn't seen inside, then the child will answer correctly.

The knowledge access task measures a child's ability to understand that others may not know the same information because they do not have the same access to that information as the child. In this task the child is shown a box with a spring inside. Then the box is closed and the child is asked what Sammy will think is inside the box if Sammy has not seen inside the box. They receive a correct score if they answer that Sammy will not know because he hasn't seen inside.

Dwell-time Tasks and Memory Questions

The dwell-time tasks probed how well subjects processed and segmented motionese. Using the dwell-time methodology (Hard, Recchia & Tversky, 2011), the.

Child advanced through set sets of still-frame images, derived from two motionese videos: one of an actor playing with a puppet toy ("Puppet" slideshow) and another an actor playing with a novel pyramid toy ("Pyramid" slideshow). For each slideshow, the time between clicks is recorded as well as the child's looking time. Four memory questions follow each video, which asking children to recall information about the toy, actions performed and the order of the action sequence.

Executive Function Tasks: Card Sort, Dog Task, and Gift Delay

The executive function tasks are designed to probe aspects of executive functioning: Task Switching, Working Memory and Inhibition. The first task, the card sort, probes task switching. Task switching measures the child's ability to modify task according to instructions and inhibit previous task and instructions. This task was modeled off of the classic card-sorting task (Diamond, Carlson & Beck, 2005). For this task, children are presented with cards, which are either green or orange and have either the shape of a house or a bird on them. First, the child is asked to sort the 12 cards into a tray based on shape. Then after, the child is asked to sort the 12 cards into a tray based on color. The child's score is based on the number of cards correctly sorted.

The second task, the dog task, assesses working memory, which refers to the memory capability. This task is based on the truck task designed by Hughes & Ensor (2005). The task is designed so that the child must remember the faces of different dogs in order to receive a sticker. The child is presented with two images of dogs and asked which dog they think will give them a sticker. If they chose correctly they receive a sticker. The child's score is based off the number of stickers received.

The third task is the gift delay task, which measures the child's inhibition skills. This task is a modified version of the "bow task" used by Carlson, Mandell &Williams (2004). In this task a present is placed in front of the child, but the child is instructed to not touch it or peek inside until the researcher returns with the bow. The researcher goes behind the curtain for three minutes and then returns with the bow. The research assistant records the number of times the child touches the bag or peeks and the time at which the child opens the present if opened prematurely.

Live Action Imitation Tasks and Memory Questions

The imitation task is used as a behavioral measure of action processing. For this, the researcher performed two sets of actions in front of the participant using motionese and then the child was asked to imitate the actions. The child was given 90 seconds to performs the imitation. The first action was using a play-dough toy to make butterflies out of the play-dough. The second action was making a star out of pegs and string. The experimenter followed a script and wore the same shirt and hairstyle each time to eliminate variables. Children were scored based on accuracy of imitation, including order. This methodology was based on research by Sage & Baldwin (2012). Four memory questions followed each Live Action & imitation, which asked questions about the toy, the order of action and the actions performed.

Working Memory Task

The spin the pots task measures working memory, specifically visual search working memory. This task is modeled off of Hughes (1998) spin the pots task. For this task, the researcher used a circular platform with eight distinct boxes on top. The researcher then opens all the boxes in front of the child and places stickers in six of the boxes. Then, all the boxes are closed and a black cloth is placed over all the boxes and the platform is spun 180 degrees. Then the cloth is taken off and the child is able to open one box to try to find a sticker. After, the cloth is placed over the boxes again and the platform is spun 180 degrees. Again the cloth is taken off and the child is given the opportunity to open one box to find a sticker. This is repeated until all the stickers are found or 16 trials are reached. A research assistant records the number of stickers found and the number of trials. Children who find the stickers in fewer trials receive higher scores.

Receptive Vocabulary Test

The receptive vocabulary test is a standardized test developed by Martin & Brownell (2011) to assess a child's receptive vocabulary skills. In this test, the researcher speaks a word and a child is presented with 4 pictures. The child has to point to the picture that most accurately shows the word. Scores are based on the standardized scoring system, which provides age norms.

Snack Break (5 minutes)

The child is given a choice of goldfish or raisins, with parental permission, and time to go to the bathroom or get a drink of water.

Beery-Buktenica Developmental Test of Visual-Motor Integration, Short Form (Beery VMI) with visual perception and motor supplements

The Beery VMI evaluates a child's imitation ability and integration of perception and motor skills (Beery & Buktenica, 1967). The short form is designed for two to eighteen-year olds. The procedure for this test is to have the child copy fifteen geometric forms with a thin tipped marker, arranged in developmental sequence, less to more complex. This assesses the extent to which individuals can integrate their visual and motor abilities. Then, the supplements are used to further identify trouble areas in the visual-motor integration. The VMI Supplemental Developmental Test of Visual Perception (VP) is used to parse out perceptual skills. In this test, the child is asked to identify the match for as many as 27 stimuli as possible in a three-minute time period. The VMI Supplemental Developmental Test of Motor Coordination (MC) assesses motor coordination. In this test, the child is asked to trace up to 27 stimulus forms with a thin tipped marker without going outside double-lined paths in a five-minute time period. Scores are based on the standardized scoring system developed with the test (Beery, Buktenica & Beery, 1997). Children receive an overall VMI score, a motor score and a visual perception score and a percentile for each according to their age. We also rank ordered the motor score to be able to better compare it to the rank ordering of the BOT-2.

Bruininks-Oseretsky Test of Motor Proficiency, Short Form (BOT-2)

This is a common battery of motor skills used to assess overall motor skills (Bruininks, 1978). The test is broken into eight subsections and each subsection has its own test(s) to evaluate this motor skill subset. The subtests sections include fine motor precision, fine motor integration, manual dexterity, bilateral coordination, balance, running speed & agility, upper-limb coordination, and strength. A battery of tests is used to evaluate each subsection (See Table 1). Originally, the tests were scored based on the manual created by Bruininks & Bruininks (2005) and resulted in one overall motor score. However, after further consideration we decided to re-score each task of the BOT-2 because our children were slightly younger than the age range for this test and using these measures, the variance displayed between children was not properly indexed. We collaborated to determine an appropriate re-scoring method. The rescoring method is as follows:

Subsections	Tasks	Revised Scoring
Fine Motor Precision	Filling in a star	Rank ordered based on our scoring rubric (Appendix 1) and then grouped according to the average rank. From these rankings, we put them into three groups. Top third: highest group, received a score of three, middle third: second group, received a score of two, bottom third: third group, received a score of 1.
Fine Motor Precision	Drawing a line through a path	Rank ordered based on our scoring rubric (Appendix 1) and then grouped according to the average rank. From these rankings, we put them into three groups. Top third: highest group, received a score of three, middle third: second group, received a score of two, bottom third: third group, received a score of 1.
Fine Motor Integration	Copying overlapping circles	Did not re-score these as a floor effect was seen (the task was redundant, measuring the same skill as the Beery VMI)
Fine Motor Integration	Copying a diamond	Did not re-score these as a floor effect was seen (the task was redundant, measuring the same skill as the Beery VMI)
Manual Dexterity	Stringing Blocks	Rate for stringing a single bead (reverse scored)
Bilateral Coordination	Touching nose with index fingers-eyes closed	1= can't do it, separate scoring for doing it with eyes closed, 2= touch their nose with two hands, 3= only does one, 4= does one hand perfectly and tries for the second, 5= does both hands correctly
Bilateral Coordination	Pivoting thumbs and index fingers *Modified: making two L's with fingers	We modified this task to simply making L's because we were observing a floor effect (no children were able to perform this task). Scale: 1=Can't make an L, 2= Can make an L

Balance	Walking forward heel-to-toe	1 = Not able to walk on the line, 2= Walking on the line big steps, 3= Walking on the line small steps. Also, if the child starts off the line, walking parallel to the line was counted as sufficient.
Running Speed & Agility	One-legged side hop	1= Can't hop, 2= Hopping on two feet, 3= Standing on one foot (balancing), 4= Launching off one foot & landing on two feet, 5= Launching off one foot & landing on one foot (Add 1 point if they do it over the line)
Upper Limb Coordination	Catching a tossed ball: one hand	1= Make some motion to prepare to catch ball, 2= Attempts to catch (grasps), 3= Adjust position of arm to catch ball, 4= Catch with hands & body (2 hands), 5= Catch with hands (2 hands)
Upper Limb Coordination	Dribbling a ball: alternating hands	1=drop the ball, 2= drop ball and hit it (at the same time), 3= drop ball and hit it with one hand, 4= drop ball and hit it twice, 5= drop ball and hit it alternating hands
Strength	Push-ups	1= Gets in position with hands, feet & knees 2= Gets in position with hands, feet & moves body up & down, 3= extends body to full push-up position 4= moves up & down in correct position but wrong form (but-up/ but-down or back bowed), 5=Does Push-up Correctly, 6= Does more than 5 push-ups correctly

Table 1. Table of Motor Task for BOT2- and Revised Scoring. Subsections of BOT-2 and corresponding tasks to evaluate each sections are include, as well as the revised scoring system for each task.

Parent Forms

During the study, the parents sit in the room and fill out forms (See Table 2) regarding different aspects of their child's development.

Name of Form	Aspects of Development Assessed	Sources
CDI-III: MacArthur-Bates Communicative Development Inventory	Word use, sentences, grammar	Fenson et al., 2006
CSUS Long Form:	Theory of mind, social	Putnam & Rothbart, 2006

Children's Social Understanding Scale	understanding	
CBQ Short Form Version 1: Children's Behavior Questionnaire	Temperament	Rothbart et al., 2001
EQ-SQ: Empathizing & Systemizing Quotient	Recognize ASD symptoms in the general population	Auyeung et al., 2009
Motor Questionnaire	Obtain additional information regarding the children's motor development	Baldwin Lab, 2013 (See Appendix 4 for full form*)*

Table 2. Table of Parent Forms. This includes title, purpose of form or aspect of developed assessed and the reference for the development of the form.

Data Processing

Z scores

For each of our tasks, we standardized the data by creating z scores for each individual score. A z score determines how many standard deviations an individual score is above or below the mean. With all the data standardized, we are able to better compare across tasks and also able to add scores across differing scoring systems to develop composites. To calculate composite scores, we averaged scores to account for the fact that some children did not complete all the tasks.

Composites

The key skills assessed in this study include motor skill, visual perception, social understanding and self-regulation, visual-motor integration, and memory for action skills. Individual tasks were utilized to index visual-motor integration (Beery VMI) and memory for action (memory questions). However, many of these skills incorporate a variety of subskills and were measured using multiple assessments, therefore we constructed composites across tasks to form an index of these skills. Three composite scores were constructed across tasks to form separate indices of motor skills, visual perception and social understanding and self-regulation skills (See Table 3 below).

Composites	Tasks included in each composite
Motor Composite	- BOT-2 scores: star rank, path rank, stringing bead, touching nose, walking heel-to-toe on a line, hoping from side-to-side, catching a tennis ball, dribbling a tennis ball and push-ups - Beery Motor Coordination Rank - Proficiency Composite from the parent motor questionnaire: able to perform, frequency and independence
Visual Perception Composite	- Beery Visual Perception Score - Video Preference Score
Social Understanding and self-regulation composite	- Executive Function Composite: card sort, gift delay and spin the pots tasks - Theory of Mind Score - Children’s Social Understanding Scale parent form Score

Table 3. Table of Composites. Includes the tasks that go into the calculation of composites for the motor skill, visual perception and social understanding and self-regulation skills.

III. RESULTS

Our main research question was: Does motor proficiency positively predict imitation success in typically developing children? And also, to what extent do visual-motor integration, social understanding, and memory for action also positively predict imitation success? We found that children's performance on the imitation, most motor tasks, and self-regulation and social understanding tasks was strongly related to their age (See Table 4), meaning that children's skills in these areas were increasing with age, as we would predict. This was encouraging because it indicated that many of our tasks were appropriately measuring children's advancement in these skills across development, supporting the validity of the data within this small sample of typically developing children. Conversely, memory, Beery VMI and visual perception performance was not strongly correlated with age (See Table 4). This could possibly mean that these tasks were not picking up on developmental differences across age but rather across individuals. However, since many of these variables were correlating well with age, we needed to control for age when examining relations between various skills and imitation so that correlations would not just reflect the relationship to age of both variables. To control for age, we ran a partial correlation on our data, partialing out age. A set of partial correlations revealed moderate-to-strong (i.e., $r > .40$) correlations between many of our variables and imitation, even when accounting for age-related variance (See Table 5). All of the following reported correlations have age partialed out. Additionally, given that our composites were made across numerous variables, we investigated relationships between individual variables and imitation to discern whether certain variables within a composite had greater contributions to these correlations than others.

	Imitation	Social Understanding & Self Regulation Composite	Visual Perception Composite	Motor Composite	Beery VMI	Memory Questions
Age (months)	r= .45	r = .70	r =.14	r = .67	r = .22	r = .13
P value	.12	.01	.65	.02	.48	.66

Table 4. Correlation matrix of Age with Imitation, social understanding & self-regulation composite &visual perception composite, motor composite, Beery VMI score and memory score.

	Social Understanding & Self Regulation Composite	Visual Perception Composite	Motor Composite	Beery VMI	Memory Questions
Imitation (Partialing out age)	r = .66	r =.27	r = .83	r = .64	r = .42
P value	.22	.66	.08	.25	.48

Table 5. Correlation matrix of Imitation with social understanding & self-regulation composite &visual perception composite, motor composite, Beery VMI score and memory score, partialing out age.

Motor Composite Data

Of all the dependent variables, the motor composite score was most strongly correlated with imitation, partialing out age, as clear from Table 5. This supports our hypothesis that motor skills positively predict imitation success (See Figure 1).

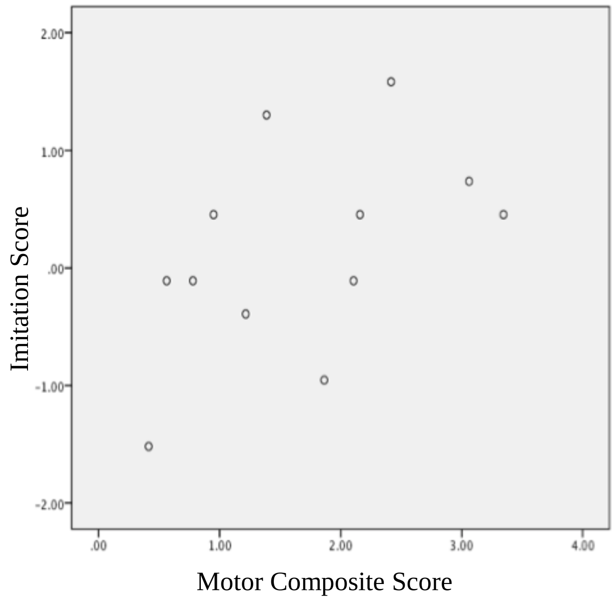

Figure 1. Motor composite z scores correlate strongly with imitation z scores. Increased motor composite scores predict increased imitation performance.

Interestingly, within the motor composite, the fine motor composite correlated positively with imitation (r= .80, p= .11, See Figure 2), whereas the gross motor composite correlated negatively with imitation (r= -.70, p= .19, See Figure 3).

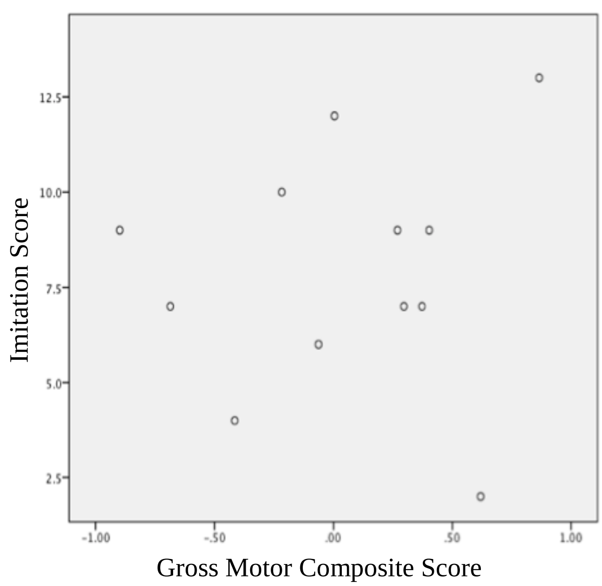

Figure 2. Fine motor composite z scores correlate strongly with imitation z scores. Increased fine motor predicts increased imitation success.

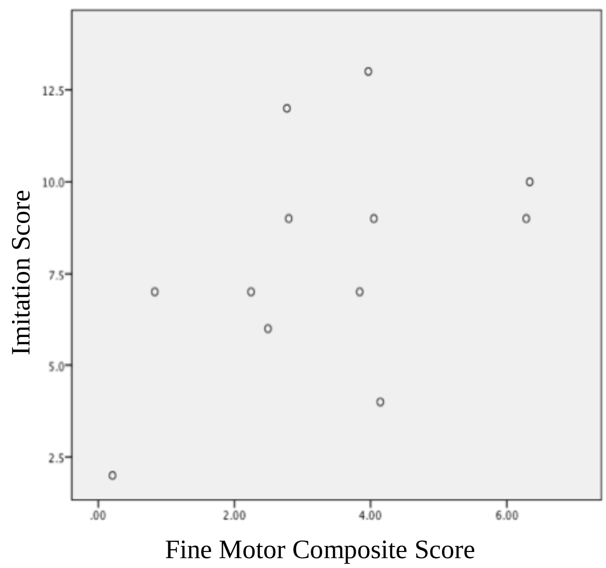

Figure 3. Gross motor composite z scores do not correlate with imitation z scores.

Additionally, two of the tasks within the motor composite showed a positive correlation with imitation: BOT-2 (r= .52, p= .27), Beery Motor Coordination Rank (r= .61, p= .28), while the third, the parent motor questionnaire proficiency score, showed a negative correlation (r= -.65, p= .24). We expected all the motor measures to positively correlate with imitation; thus the negative relation between parent report and imitation skill was surprising and not as yet clearly explicable.

The parent motor questionnaire was a questionnaire we developed, so it may not have measured motor skill as accurately as the standardized tests of the field. The parent motor proficiency score was composed of ratings of ability to perform, independence in performance and frequency of engaging in motor activity across thirty-six motor skills. One of the scores that made up the proficiency score, the percent able to perform score, displayed a positive correlation with imitation ($r = .47$, $p = .43$), showing that this section of our form was in line with the other motor measures. However, the independence score ($r = -.07$, p= 85.) and frequency score ($r = -.56$, $p = .07$) correlated negatively with imitation. This is likely because there was a great deal of variability in answers to frequency and independence questions and suggests that an able to perform measure is more precise at assessing motor ability on a motor skills parent report measures.

Visual Perception Data

The visual perception composite displayed a weak correlation with imitation ($r = .29$, $p = .48$, See Figure 4 below), partialing out age. This does not match our predictions, as we expected visual perception to be key in imitation. This could indicate that visual perception does not play as significant a role in imitation as expected or that our measures are not accurately indexing visual perception ability. This visual perception composite score includes the Beery visual perception score and the video preference score. When examined individually, we found that neither of these tasks correlated strongly with imitation: Beery visual perception ($r = .27$, $p = .66$), video preference ($r = .32$, $p = .60$). Typically we would include dwell time data into this score but we excluded the dwell time data that was collected due to the small sample size and its high variability. In such a small sample size, this variability can cause peculiar correlations and skew the data.

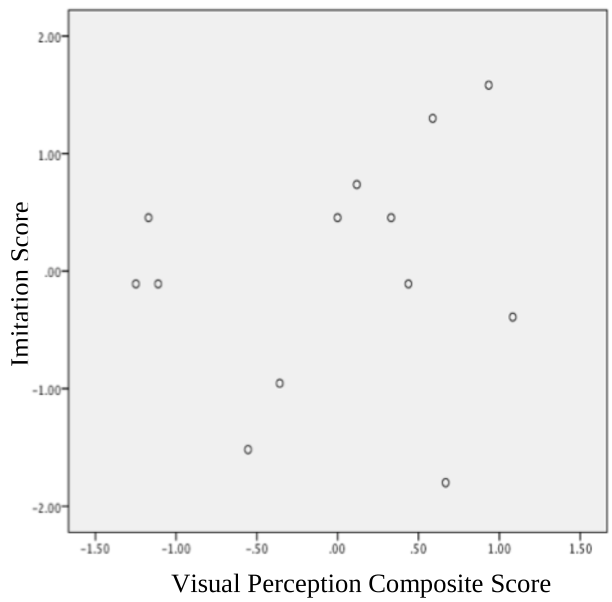

Figure 4. Visual Perception Composite z scores very weakly predict imitation z scores.

Visual- Motor Integration Data

Despite the lack of correlation with imitation and visual perception, the Beery VMI score, indexing visual-motor integration, showed a moderate-to-strong correlation with imitation (r= .64, p= .25, See Figure 5 below), as predicted, partialing out age. This suggests the significance of both visual perception and motor skills and the integration of these skills in imitation. Integration of visual perception and motor skills enables proper mapping of a perceived action into a motor execution. However, this is interesting because our previous finding surrounding visual perception suggest that visual perception does not play a large role in imitation.

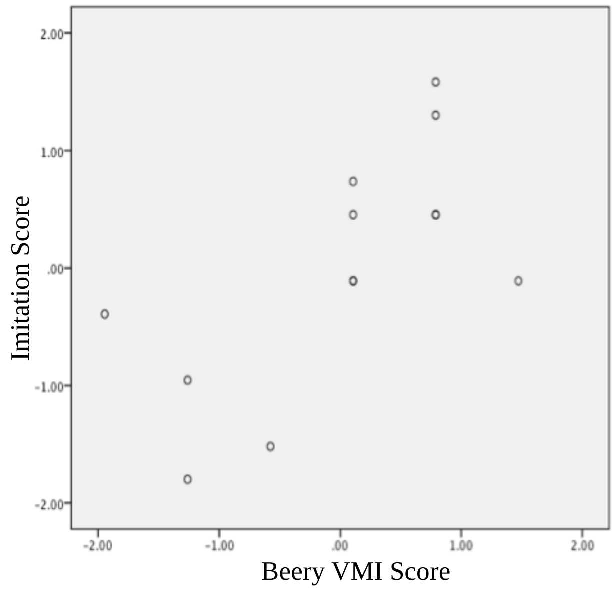

Figure 5. Beery VMI z scores positively predict imitation z scores. Increased Beery VMI predicts increased imitation performance.

Social Understanding and Self-Regulation Data

The social understanding and self-regulation composite also displayed a strong correlation with imitation (r= .66, p= .22, See Figure 6), partialing out age. However, after examining the social understanding and self-regulation composite, it was apparent that certain measures, including Executive Function (EF) and Children's Social Understanding Scale (CSUS), were driving this positive correlation, while other measures, such as Theory of Mind (ToM), were less involved in this relationship. Both the EF and CSUS scores correlated highly together (.83, p=. 08), partialing out age, and correlated moderate- to-strongly with imitation, [EF (.91, p= .03), CSUS (.62, p=. 27)]. This suggests that both EF and CSUS are important predictors of imitation. Executive function is a measure of self-regulation of attention and cognitive resources, so it makes sense that children who have lower EF scores would likely have worse imitation abilities because it would affect their ability to focus on salient parts of the action and remember them. Additionally, the correlation with CSUS, which moderately predicts imitation, is also intuitive because the CSUS measures children's social understanding. Without proper social understanding, a child would have difficulty understanding another's actions and picking up on key features, hindering their imitation ability. However, our Theory of Mind measure displayed only a weak correlation with imitation (r= .19, p= .76). This is counterintuitive because ToM skills, understanding others' mental states, would seem to assist with imitation and therefore correlate positively, as seen in studies with autism. This relationship could be indicative that our ToM tasks were not indexing ToM skills correctly or simply that the relationship between ToM and imitation are different in typically developing children relative to children with autism.

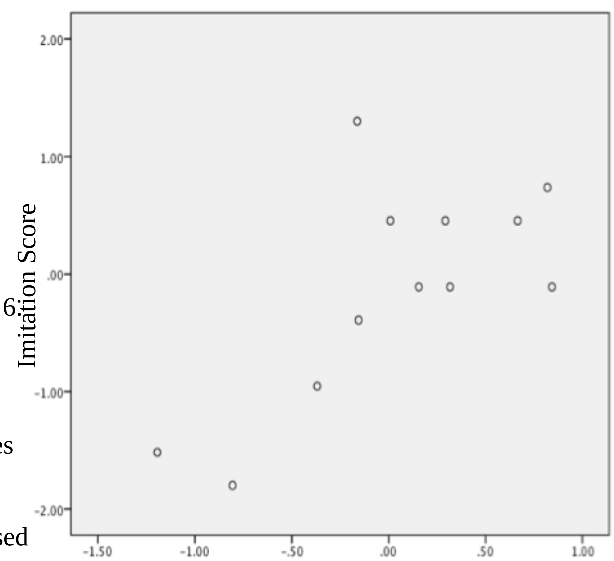

Figure 6: Social Understanding and Self-regulation composite z-scores positively predict imitation z-scores. Increased Social Understanding and Self-regulation composite predicts increased imitation performance.

Additionally, since the social understanding and self-regulation and motor composites were the greatest predictors of imitation, we decided to also explore their relationship to each other. We found that the motor composite correlated with the social understanding and self-regulation (r =.94, p=.02, See Figure 7), partialing out age. Interestingly, within the motor composite, gross motor is negatively correlated with social understanding and self-regulation (r = -.97, p= .01, See Figure 8), while fine motor is positively correlated with social understanding and self-regulation (r = .97, p= .01, See Figure 9), both partialing out age. This relationship parallels the relationship between the fine and gross motor composites and imitation, supporting the idea of a fine motor and gross motor trade-off or an extreme outlier.

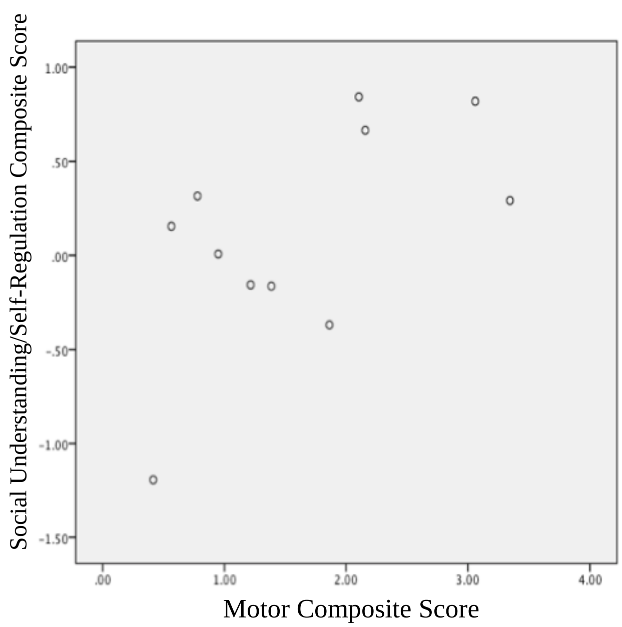

Figure 7. Social understanding and self-regulation composite z-scores show strong, positive correlations with the motor composite z-scores.

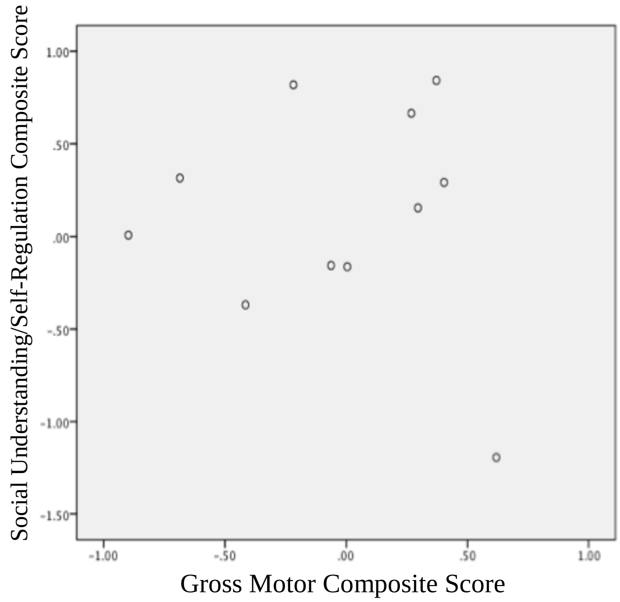

Figure 8. Social understanding and self-regulation composite z-scores correlate negatively with gross motor composite z-scores.

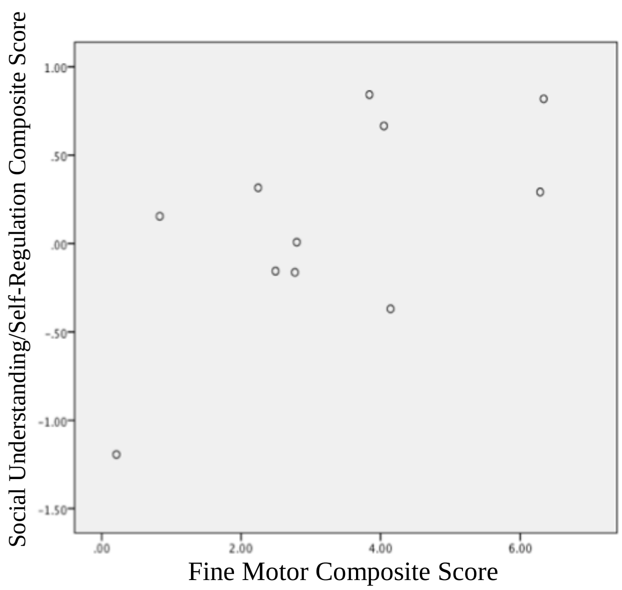

Figure 9. Social understanding and self-regulation composite z-scores show strong, positive correlations with fine motor composite z-scores.

Memory Data

The memory questions showed a moderate correlation with imitation (r= .42, p= .48, See Figure 10), partialing out age. This matches our predictions that memory questions would predict imitation success. Memory of an action makes it possible for the action to be reproduced, or in other words imitated.

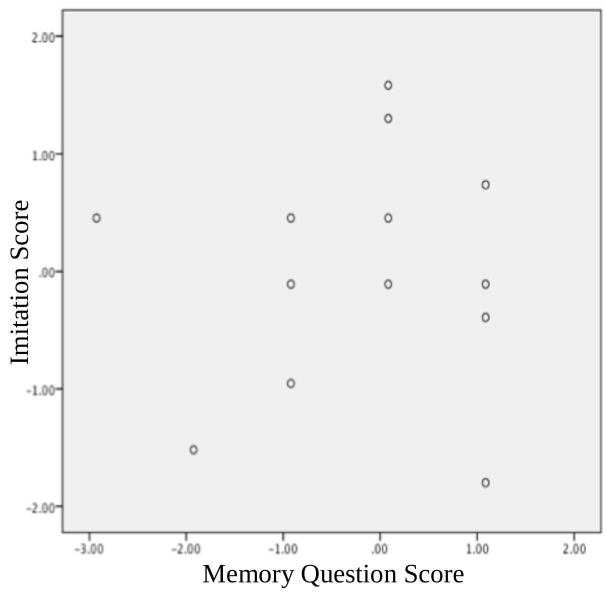

Figure 10. Memory questions scores positively predict imitation. Increased memory question scores predict increased imitation performance.

Parent Questionnaire Data

Our secondary research question was: Is a parent motor report questionnaire effective at assessing motor skill in comparison to existing behavioral measures? We found that in its current form, it is not effectively gauging children's motor skills. In line with the pattern we see in correlations between the parent motor form scores and imitation success, the parent motor form does not correlate with either the Beery Motor coordination or BOT-2 scores (See Table 6), partialing out age, and in fact with some aspects of the parent motor form it correlates negatively. To explore this we looked into the different aspects of the proficiency score: able to perform, independence in performance and frequency of engaging in motor activity.

	Proficiency Composite	Able to Perform	Frequency of Engaging	Independence
Beery Motor Coordination (partialing out age)	r= -.70	r= .37	r= -.81	r= -.65
P value	.20	.29	.01	.04
BOT-2 (partialing out age)	r= -.25	r=.31	r= -.47	r= -.19
P value	.49	.39	.17	.60

Table 6. Correlation matrix of the Beery Motor Coordination score and BOT-2 score with Parent Form proficiency composite, able to perform score, frequency of engaging score and independence score.

These data demonstrate that the parent motor form does not predict motor skill, as defined by the Beery motor coordination and BOT-2 tests. The only score that comes close to correlating weakly is the able to perform score. This suggests that this parent motor form is not valid measure of motor skill.

IV. DISCUSSION

General Conclusions

In this preliminary sample of typically developing children, motor skills were strongly predictive of imitation success, as hypothesized. This shows signs that motor function does contribute to imitation success. All the motor scores within the composite strongly and positively correlated with imitation except the parent motor form and the gross motor composite. One explanation for this interesting negative correlation between gross motor composite and imitation is that the imitation task we used in our study utilized primarily fine motor skills. With this in mind, this negative correlation makes more sense. Perhaps if we had used a gross motor imitation task we would see a positive correlation with the gross motor composite. As for the negative correlation between the parent motor questionnaire and imitation, this can be rationalized through the conclusion that this parent questionnaire is not an effective measure of motor skill. This idea is supported, as the questionnaire did not correlate well with either of the standardized motor tasks, the Beery motor coordination and the BOT-2. This evidence questions the validity of the parent motor questionnaire and encourages future exploration into a motor measure of this kind.

In addition to motor skills, several other skills seemed also to be positively related to imitation skill. Particularly, children who displayed high levels of visual-motor integration, social understanding and self-regulation, and memory for action also tended to show high levels of imitation success, even when controlling for age-related variance. Conversely, the visual perception composite and the measures within the composite did not predict imitation success, illustrating that either our visual perception measures were not accurate measures or that in a typically developing population visual perception does not play a significant role in imitation or even simply that our sample size was too small, skewing the correlation. These finding suggest that all these variables, excluding visual perception, fold in with motor skills to impact imitation, although the exact degree to which each variable contributes is still yet to be discovered.

Limitations & Future Directions

In the current study, there were numerous limitations that hinder our ability to interpret the data and draw strong conclusions about our findings. We propose several possible ways these limitations could be addressed through future research. One of the greatest limitations was our small sample size. Given this limitation, we cannot generalize our findings to all typically developing children; we can only conclude that within our data certain variables predict others. Moreover, with such a small sample size, any one individual child's data can greatly impact and potentially skew the correlations, leading us to be cautious about over-interpreting the relationships we see in this data. If this research were extended to a larger sample, relationships between variables would be more stable and inferences could be established regarding the degree of importance of both perceptual skills and motor ability in predicting imitation. In the future it would also be interesting to extend this research to an autistic population to see if the same patterns that emerged in the typically developing children would also appear.

Another limitation is that we were unable to determine whether certain motor tasks were picking up on motor skills or conceptual skills, as some of the motor tasks in the BOT-2 were quite complex to understand. One example of this is that some children have an understanding about how to do push-ups through an older sibling or sport and therefore are able to perform the skill effectively. However there were children that demonstrated high motor ability in a variety of other tasks, but clearly were unable to do push-ups because they were unfamiliar. In this way, this task could be picking up on perceptual issues, integration issues or motor issues because we are unable to determine whether these tasks were properly understood. This could mean that our tasks were too developmentally complex and that other tasks should be used to measure motor ability that are more age appropriate. Future research should be done to examine other means for assessing motor skills in young children as well as specifically parse out individual skills and find out the extent to which each affect imitation.

An additional limitation in the study design was the BOT-2, in its original form, did not effectively assess young children's motor skills. We addressed this by developing a re-scoring system (See Table 1). This rescoring system allowed us to capture more of the variance we were seeing in children's motor abilities, whereas with the original scoring system we were often seeing a floor effect where a majority of the children were simply receiving zeros. However, in the future we suggest also revising some of the tasks. First, we would exclude the 'copying overlapping circles' and 'copying a diamond' tasks, as all the children received zeros. This was likely because they were bored rather than unable because these same children received scores on the Beery VMI, which was essentially measuring the same skill. Second, we would cut the string from the ‘stringing the bead’ task shorter so that children would not take up time pulling down the bead. With the string longer, it created additional noise in the data because some children would pull all the beads down (even when instructed not to), taking up more time than peers who simply strung on the bead. Third, we would include specific instructions in the ‘touching nose with index fingers’ task for children to keep going and do as many as possible, as all the children maxed out at 2 touches. We were unsure if the children didn’t understand that they were supposed to do as many as possible or if this was simply the greatest number children of this age range could do. Additionally we would exclude the ‘Making two L’s’ task. This was a task that we had modified from the ‘pivoting fingers & thumbs” task that was clearly beyond this age range. However, this task did not seem to be indexing the same skill as the previous task. Also, for the ‘one-legged side hop’ task we would suggest revising it to starting on two legs and hopping side-to-side and then asking the child to balance on one foot and after asking the child to hop side-to-side on one foot, so that it would be more apparent which skills within a one-legged side hop the children did or did not possess. For the ‘catching a tossed ball’ task we would use a bigger ball, try a two hand catch before a one hand catch and even add in an assessment of whether the child could throw the ball back, both overhand and underhand. With this amendment, it would be easier to evaluate the child’s ability. Lastly, for the ‘dribbling the ball’ task we would use a bigger ball because with such a small ball, most children were not able to perform very well. With these changes, we predict that the BOT-2 would be more accurate for this age range. Future research could also explore other means for measuring motor skills in this young population to determine the best assessment of motor skills.

Furthermore, we realized a limitation in the amount of time the children were participating in the study. Our study took an hour and a half in total. For children this young, this was a long time for them to focus. By the end, it was apparent that they were fatigued and often not performing to the best of their ability. This was evident in differing performance from the same child on similar tasks and from comments from parents that their child seemed tired or typically was able to perform tasks that they were unable to perform in the study. We included a snack break to give children a mental break and reduce the effect of tiredness but even so this fatigue effect was clear. We would advise future research with this population to design shorter studies or schedule families for two sessions if a longer time is needed.

There were also apparent limitations in the parent motor questionnaire. We found that the parent form proficiency score correlated well with imitation and age, but the frequency score and independence score within this composite did not. This shows that these scores are not properly indexing motor skills and need to be removed or revised. Additionally, after reviewing the parent motor questionnaire, we realized that a few edits could be made to make the parent form more effective. When asking about the child's daily activity level we would include "in comparison to peers" as we presume parents may have answered this question with differing contexts in mind. Furthermore when asking about handedness we would only include a three point scale, as it would be helpful to know whether children are ambidextrous or not. Nevertheless, we do think that the parent motor questionnaire able to perform score was a good index of the child's motor skill, as it correlated well with imitation and age. We would encourage further exploration to validate its usefulness and to explore how to use or revise the other measures in the parent motor questionnaire to make it a more effective assessment of motor skills. An effective parent motor questionnaire would be a valuable tool especially for this young population, where fatigue and distractibility can skew behavioral motor scores.

Broader Implications

Despite limitations, our findings do have implications for future research. Our small group of typically developing children displayed a relationship between motor and imitation skill that parallels what has been documented in autism. Of interest in future research will be whether the relationships we observed between visual-motor integration, self-regulation and social understanding, and memory for action in this group of typically developing children also turns out to be predictive of imitation success in an autism sample. Such findings will help to clarify the extent to which imitation success, important for children's learning and development, derives from an ability to recruit and coordinate a host of crucial underlying skills. Understanding the skills that contribute to imitation can aid in determining best therapies for children with imitation deficits, supporting improved learning and development.

V. APPENDICES

Appendix A: BOT-2 Rescoring rubric for ranking Star and Path Task

RA initials: ____

Re-Scoring BOT-2 form for Ranking System

1. Front page: Color in the star!

Dimensions to keep track of:

- o How fully the star is colored in
- o Extent to which they colored outside the lines
- o The distance they diverged when going outside the lines
- o It might help to think about this in terms of areas (areas colored, left blank, colored outside, etc)

Your order:

Best ____ ____ ____ ____ ____ ____ ____ ____ ____ Worst

2. Back page: Stay inside the road!

Dimension to keep track of:

- o Start and end at the proper places
- o Amount of time in the road
- o General contour matches the road's contour
- o The extent to and frequency of diversions from the road

Your order:

Best ____ ____ ____ ____ ____ ____ ____ ____ ____ Worst

Appendix B: Protocol

KidMoQuest Protocol

Inform parent of the following consent issues:

1. You can stop the study at any time, no questions asked.
2. Please silence your cell phone.
3. If you child asks you or looks to you for help during the study, please be supportive without giving explicit instructions. For example, you should say, “Great job! Keep going!” rather than, “Look at that!” or “Do [something specific].”
4. You get to sit there (point to chair) and work on these forms. We appreciate you working through all the forms; we know there are a lot of them! They all have instructions, but if you have questions, we can go over them at the end of the study.
5. Explain structure of study: 40-50 min with NB, snack break, Beery- Buktenica Developmental Test of Visual-Motor Integration (VMI) with visual perception & motor coordination supplements: 15 min, Bruininks- Oseretsky Test of Motor Proficiency, Second Edition (BOT-2): 15 min

Parent forms:

1. CDI: Language Assessment
2. CSUS: Theory of Mind
3. CBQ: Temperament
4. EQ-SQ: ASD symptoms in the general population
5. Motor Questionnaire: designed by EC

During any of the following tasks, if the child is clearly not engaging and indicates he/she does not want to participate, here are some contingencies:

If child looks away from the task for about a minute and is not engaging at all, indicating that he/she wants to stop, say, *“Do you want to keep [playing the game/watching the videos/clicking the mouse]?”* If the child does not, say, *“That’s ok, let’s move on to our next game.”*

If the child comes behind the curtain, say, *“Hi there! Why don’t you come back and sit here and [watch the videos/click the mouse/play with this toy].”* Lead child back to chair.

If the child is not engaging and, when asked, indicates that he/she does not want to continue AT ALL, check with parent, then say, *“That’s ok, let’s be all done. Let me get you a prize since you played so well with all my games!”*

1. Video Preference Task

Room Setup A

Say, *"Look at the screen! Some movies are going to play up here. You get to sit here and watch them. I'll go behind the curtain while you watch."*

RA Role: Code left/right fuzzy button for looking time. When RA is coding, the videos will advance on their own. Four doubled videos play (Lego Man, Sorting, Balloon, Train).

Once videos are done, come out and say, *"Great job watching those! Now we're going to play some games over at the table here."*

2. Theory of Mind (ToM) Tasks

Room Setup B

Adjust camera angle so small table can be seen. Bring out all 4 ToM tasks. Child sits on side of table closest to parent but facing away from the parent. I sit in the other chair facing the child and the parent.

RA records answers to all questions on RA sheet. RA should adjust camera angle as needed to keep us in view. RA should also set up Order 2 on MatLab during this time.

ToM tasks assess diverse desires (ToM1), diverse beliefs (ToM2), false contents (ToM3), and knowledge access (ToM4).

Say, *"Ok, we're going to play some games now. Here's our first game:"*

ToM 1: *"This is Sammy. It's snack time, so Sammy wants a snack to eat. Here are two different snacks: cookies and carrots* [point to each as they are named]. *Which snack would you like?* [If child does not respond] *Would you like cookies or carrots* [point to each]*?"*

Whichever snack the child picks, insert the opposite choice for Sammy. *"Well, that's a good choice, but Sammy really likes [carrots]. He doesn't like [cookies]. What he likes best are [carrots]." "So, now it's time to eat. Sammy can only choose one snack, just one. Which snack will Sammy choose?* [If child does not respond] *Will Sammy choose cookies or carrots* [point to each as they are named]*?"* [If child still does not respond, encourage child to point, repeating *"cookies"* (point) *"or carrots"* (point) until the child points to one. May also say, *"Can you point to one for me?"* or, if the child points to more than one, *"He can only choose one snack, which one will he choose?*]

"Ok, let's play another game!"

ToM 2: *"This is Linda. Linda wants to find her cat. Her cat might be hiding in the garage or it might be hiding in the tree* [point to each as they are named]. *Where do you think the cat is?* [If the child does not respond] *Do you think it's in the garage or in the tree* [point to each]*?"*

Whichever location the child picks, insert the opposite choice for Linda. "*Well, that's a good idea, but Linda thinks her cat is in the [tree]. She doesn't think it's in the [garage]. Linda thinks her cat is in the [tree]." "So, now it's time for Linda to look for her cat. Where will Linda look for her cat?* [If child does not respond] *Will she look in the garage or in the tree?"* [If the child still does not respond, encourage the child to point, repeating *"in the garage"* (point) *"or in the tree"* (point) until the child points to one. May also say, *"Can you point to one for me?"* or, if the child points to more than one, *"She can only pick one place to look, where will she look?*]

"Ok, let's play another game!"

ToM 3: *"I have a crayon box here. What do you think is inside?*

If the child indicates that he/she doesn't know, say, *"You don't know? That's ok, take a guess!"* If the child still won't guess, say, *"You don't know? Ok, let's find out!"*

If the child says "crayons" or something else, say, *"You think there are [crayons] in there? Ok, let's open it and find out!"*

[Open box.] "*Wow, it really has ribbons inside!"* [Close the box.] *"Ok, do you remember what is in the crayon box?"*

If the child says "ribbons" say, *"Yeah, there are ribbons in there!"*

If the child indicates that he/she doesn't know, say, *"There are ribbons inside, remember?"* [Open the box again and show the ribbons.

[Hold up Sammy] *"Here's Sammy again. Sammy hasn't seen inside this crayon box. Now, here comes Sammy!* [Indicate that Sammy is coming over by making him "walk" across the table towards the child.] *So, what does Sammy think is inside the box?"*

If child says "ribbons" or "crayons" (or something else), say, *"He thinks there are [crayons] inside!"*

If child doesn't answer, say, *"Does Sammy think there are crayons or ribbons inside the box?"* If child still won't answer, hold out my palms. Shake right hand for "crayons" and left hand for "ribbons" and encourage child to point to one or the other. Say, *"Does* *he think there are crayons* (shake right hand) *or ribbons* (shake left hand) *inside?"* If needed, *"Can you point for me?"*

Say, *"Did Sammy see inside the box?"*

Repeat child's answer, *"Yes, he saw inside the box"* or *"No, he didn't see inside the box."*

If child won't answer, try head shaking. Ask, *"Yes, he saw inside the box* (while nodding head)" or *"No, he didn't see inside the box* (while shaking head)." If needed, say, *"Can you choose one for me? Yes he saw* (nod) *or no he didn't see* (shake)."

If child still won't answer, try with holding palms out to child, shaking right palm for yes and left for no. Encourage child, *"Can you choose one for me? Yes he saw inside the box* (shake right hand) *or no he didn't see inside the box* (shake left hand)."

"Ok, let's play another game!"

ToM 4: *"I have a box here. What do you think is inside?"*

If child answers, repeat answer. *"You think there's [response] inside!"*

If child shrugs or says he/she doesn't know, say, *"You don't know what's inside?"*

"Let's find out! [open] *Wow, there's a spring inside!* [close]"

Ok, do you remember what is in the box?

If the child says "a spring" say, *"Yeah, there's a spring in there!"*

If the child indicates that he/she doesn't know, say, *"There's a spring inside, remember?"* [Open the box again and show the spring.]

[Hold up Linda] *Here's Linda again. Linda hasn't seen inside the box. Now here comes Linda.* [walk Linda towards child] *So, does Linda know what is inside the box?*

Child should answer yes/no. If child won't answer, encourage child to answer by nodding/shaking head while saying, *"Yes she knows* (nod) *or no she doesn't know* (shake)." If child still won't answer, hold out hands and encourage child to point to one. *"Yes she knows* (shake right hand) *or no she doesn't know* (shake left hand)." If needed, *"Can you point to one for me?"*

"Did Linda see inside the box?"

Child should answer yes/no. If child won't answer, encourage child to answer by nodding/shaking head while saying, *"Yes she saw* (nod) *or no she didn't see* (shake)." If child still won't answer, hold out hands and encourage child to point to one. *"Yes she saw* (shake right hand) *or no she didn't see* (shake left hand)." If needed, *"Can you point to one for me?"*

"Ok, great job! You played all my games!"

---

3. Dwell Time Tasks

Room Setup A

Kid sits at big table. Adjust camera angle. Set up KidMotion practice slides. Remind RA to recording looking time (normal fuzzy button—no left/right).

Dwell time assesses looking time to one practice and 2 longer slideshows of action.

Say, *"Ok, now we're going to play a game at the computer."* [Make sure practice slides are loaded and music is playing.] *"Do you see that picture up there? We are going to click this big button on the mouse* (point to the button) *to change the pictures."* Help with practice slides. Encourage by saying, *"Keep click click clicking that big button in the mouse to change the picture. See, there goes the airplane!"*

Say, *"Great job! You're going to see some pictures of me playing with a toy, and you get to click click click that big button on the mouse to see all the fun things I do with the toy! Now I'm going to go back behind the curtain. Watch carefully, ok?"*

Go behind curtain. Load KidMotion dwell time movie 1. If child doesn't start clicking, say, *"Ok, go ahead and click the mouse to change the pictures!"* Make sure RA is coding for looking time.

If child is not clicking for 30 seconds or more, or looks confused, say, *"Just keep click click clicking that big button on the mouse to change the pictures!"*

If child seems fatigued or bored, reluctant to keep clicking, say, *"Just a few more clicks and then you'll be all done!"*

When dwell 1 ends, come out and say, *"Great job looking at all those pictures! Now I'm going to ask you some questions about that toy you saw me play with."*

Load question set 1 pictures. Click through to show pictures associated with each question. Point to the right of the screen and then the left when naming each option. If the child doesn't choose verbally or by pointing to an option, say, *"Can you point to one for me?"* If they still do not respond, repeat the options and point to each one, and again as, *"Can you point to one for me?"* After the child responds, repeat their answer. For example, *"Yeah, I took it apart."*

Dwell 1: Pyramid

1. What did I do with the toy? Did I take it apart or play with it?
2. What fruit did I put on the toy? Did I use a lemon or grapes?
3. What did I do with the duck? Did I squeeze the large duck's beak or did I pull on the small duck?
4. Which part of the toy did I play with last? Was it the puzzle or the duck?

Say, *"Great job with those questions! Ok, now you're going to see some pictures of me playing with a different toy, and you get to click click click that big button on the mouse to see all the fun things I do with that toy. I'm going back behind the curtain again. Watch carefully, ok?"*

Go behind curtain. Load KidMotion dwell time movie 2. If child doesn't start clicking, say, *"Ok, go ahead and click the mouse to change the pictures!"* Looking time coding.

If child is not clicking for 30 seconds or more, or looks confused, say, *"Just keep click click clicking that big button on the mouse to change the pictures!"*

If child seems fatigued or bored, reluctant to keep clicking, say, *"Just a few more clicks and then you'll be all done!"*

When dwell 2 ends, come out and say, *"Great job looking at those pictures! Now I'm going to ask you some questions about that toy you saw me play with."*

Load question set 2 pictures.

Dwell 2: Puppet

1. What did I do with the pieces of the puppet? Did I take the puppet apart or did I put the puppet together?
2. What color were the eyes of the puppet? Were they white or blue?
3. What did I do with the puppet when I was done? Did I put it on my hand or did I flip it upside down?
4. Which piece did I put on right before I put the puppet on my hand? Was it the eyes or the arms?

4. EF Tasks

Room Setup B

Say, *"Great job with those questions! Now we're going to play some more games at the small table."*

Change camera angle. Go back to the small table. Go through two rounds of card sorting (measures task switching and inhibition), one round of dogs (working memory), and the gift delay task (inhibition). RA codes on RA sheet.

EF 1: Card Sort—Reverse Categorization

Set up card tray. Green house on right, orange bird on left. Set up 4 practice cards and 2 sets of 12 game cards (one set for shape task and one set for color task).

Say, *"This is a house* [point to display card] *and this is a bird* [point]. *Can you point to the house? And can you point to the bird?* [Make corrections as needed, saying *"This one's the house, right"* and *"This one's the bird, right?*] *Good job! We're going to play a shape game, ok? You're going to put these cards into the trays. You're going to put the houses in this side* (point) *and the birds in this side* (point). *Can you point and show me where the house cards go? Great! And can you point and show me where the bird cards go? Great!* [Make corrections as needed, saying *"The house cards go here, right?"* and *"The bird cards go here, right?"*] *Ok, let's practice."*

Sort 4 practice cards with corrections (orange house, green bird, green house, orange bird). Retry all 4 cards again if any mistakes are made. Hold up one by one, say *"Where does this one go?"* If correct, *"Great job! Where does this one go?"* If incorrect, say *"Oh, this one is a bird (house), so it goes here. Where does this one go?"* Once all the way through practice one, if mistakes were made, redo the practice. For each practice card, hold it up and ask where it goes, then hand the card to the kid so they can place it in the tray.

After practice is done, say *"Great job! Let's play."* Do card set one (labeled in purple). Hand to kid one by one. Don't say anything during this part. If child looks at me at all, make a friendly encouraging face, but don't help or look at one side of the tray or the other. If kid doesn't place card in a tray, say, *"Where does this one go?"*

Say, *"Ok, great job with that game! Now we're going to play a different game. This game is a color game! This card is green* [point] *and this card is orange* [point]. *Can you point to the green card? And can you point to the orange card?* [Make corrections as needed.] *Good job! For this game, all the green cards go here and all the orange cards go here. Can you point and show me where the green cards go? Great! And can you point and show me where the orange cards go? Great!* [Make corrections as needed.] *Ok, let's practice."*

Sort 4 practice cards with corrections (orange house, green bird, green house, orange bird). Retry all 4 cards again if any mistakes are made. Hold up one by one, say *"Where does this one go?"* If correct, *"Great job! Where does this one go?"* If incorrect, say *"Oh, this one is green (orange), so it goes here. Where does this one go?"* Once all the way through practice one, if mistakes were made, redo the practice. If child makes two errors in a row, remind the child of the game, saying, *"We're playing a color game, remember?"*

After practice is done, say *"Great job! Let's play."* Use card set 2 (labeled in green). Hand to kid one by one. Again, don't talk during this part. If kid doesn't place card, say *"Where does this one go?"*

Say, *"Great job! We're all done with that game. Now you get a prize for doing so well with all my games!"*

EF 2: Dogs—Working Memory

Get out 8 stickers and an envelope, plus 8 dogs cards.

"This game is a guessing game, and you get to win lots of stickers! Do you like stickers? I have the stickers right here, and this is an envelope where I'll put the stickers when you win them so you can take them home with you.

"I have some cards here, and each one has two pictures of dogs on it. One dog is the right one that will give you a sticker, and one is not. You have to guess which dog will give you a sticker."

Trial 1 is always correct. Say, *"Which dog do you think will give you a sticker? Good job! That's the one with the sticker!"* Follow the marks on the backs of the cards (either X's or O's) for the "correct" pattern of dogs for all remaining cards.

"Which dog do you think will give you a sticker?"
If **incorrect**, say *"Oh, that's not the one with the sticker. Try to remember this one* (point to correct dog) *for next time."*
If **correct**, say *"Good job! You got a sticker!"*
"Great job with that game! Let's give these stickers to your (mom/dad) to hold onto for later, ok?"

EF 3: Gift Delay

"I've got a prize for you since you're doing so well with my game! Let me go grab it."

Place bag with box and slinky inside on table. Say, *"I've got a prize here in this bag for you. But before you open it, I need to go get the bow for the bag. Just sit in this chair until I get back. I'm going to go get the bow now. So just stay in that chair; don't touch the bag or what's inside it, and don't peek inside the bag until I come back with the bow."*

RA codes for number of touches/peeks into the bag. Stand behind curtain for 3 minutes (RA times). Return with bow. Say, *"Great job waiting!"* Or, *"That's ok, it's really hard to wait."* Let them have prize and play with slinky for a bit. Say, *"You can play with the slinky for a bit while I set up for our next game."* Once room is re-set (curtain opened, computer and speakers shifted, table cleared for live action), encouraged child to give slinky to mom/dad so child's hands are free for the next game.

5. Live Action

Room Setup C

Have child return to large chair. Say, *"Now we're going to play a new game at this table. I'm going to go behind the curtain again, but this time I'm going to open the curtain and show you a toy. Then you'll get a chance to play with it! So you sit here, and I'll go get my toy ready behind the curtain. Watch carefully, ok?"*

Go behind curtain and prep play-doh toy. Say *"ok"* when ready, have RA open the curtain and stay hidden. Close curtain when done.

Play-Doh Toy:

- Start: 2 pieces together, mouth facing forwards. Play-doh inside tub, good amount rolled into a ball, lid on.
- Gesture to table/toy. Smile.
- Hold up elephant (both pieces together), mouth forward. Smile widely.
- Turn elephant around (eyes forward).
    - *"Ooooh!"*
- Take top of elephant off, show hole inside to kid.
    - *"Ooooh!"*
- Put top down on table (hole facing down).
- Open play-doh, take out ball.
    - **Gasp* "Wow!"*
- Roll ball into a snake.
    - *"Ooooh!"*
- Put snake of play-doh into hole.
    - As I'm doing this, *"This goes here!"*
- Put top of elephant back on bottom.
    - As I place top, *"And this goes here!"*
- Push down on ears. Tilt forward so child can see play-doh coming out of top.
    - As I do this, *"First I do this!"*
- Twist ears.
    - As I twist, *"Then I do this!"*
- Pull out 2 butterflies.
    - **Gasp* "Look what I made!"*
- Push (showing kid) and twist again.
    - *"Look! I made more!"*

- Place elephant on table. Arrange all 4 butterflies.
- Gesture to toy/table.
  - While I gesture, *"Look, all done!"*

Say, *"Ok, now it's your turn to play with that toy! Go to the small table and I'll bring it out for you."* Place toy on table for child with play-doh lid slightly open and 2 elephant pieces together. *"Try to do what I did, ok, and I'll be right back."* Bring toy to small table and focus camera on kid. RA times for 90 seconds to play with toy. RA will check off actions performed.

After 90 seconds, go out and take toy. Say, *"Great job playing with that toy! Now I'm going to ask you some questions about that toy."*

Load question set 3. Focus camera on kid. Mouse out in front for me to click through questions.

Live Action 1: Play-Doh

1. What did I do with the elephant? Did I use the elephant to make butterflies or did I use the elephant to roll out the play-doh on the table?
2. What came out of the elephant? Play-doh butterflies or play-doh worms?
3. What did I do with the play-doh butterflies that I made? Did I stick them back inside the toy or did I set them on the table?
4. What did I do after the butterflies came out of the top of the elephant? Did I twist the toy or did I take the butterflies out?

"Great job answering those questions!" Now I'm going to go behind the curtain again, and I'm going to open the curtain and show you another toy. Then you'll get a chance to play with it! So you sit here, and I'll go get my toy ready behind the curtain. Watch carefully, ok?"

Go behind curtain and prep star toy. Say *"ok"* when ready, RA opens curtain.

Star Toy:

- Start: All pieces to the left of pegs. Blue peg facing me.
- Gesture to toy/table. Smile.
- Hold up pink tool. Look at tool. Point to pink tool, point to pink peg, look at kid and smile.
  - *"See?"*
- Place pink tool on pink peg.
  - *"First I do this!"*
- Twist toy moving to the tool on the right. Repeat above sequence.
  - *"Then I do this!"*

- Repeat 2 more times.
- Repeat with last tool.
    - *"Then I do this!"*
- Tilt completed star towards kid.
    - *"Wow, look what I made!"*
- Gesture to toy/table.
    - *"Look, all done!"*

Say, *"Ok, now it's your turn to play with that toy! Go to the small table and I'll bring it out for you."* Put toy in front of kid with blue peg facing child. *"Try to do what I did, ok, and I'll be right back."* Bring toy to small table and focus camera on kid. RA times for 90 seconds to play with toy. RA will check off actions performed.

After 90 seconds, go out and take toy. Say, *"Great job playing with that toy! Now I'm going to ask you some questions about that toy."*

Load question set 4.

Live Action 2: Star

1. What did I make with the yarn? Did I make a circle or a star?
2. What did I do with the blue tool? Did I put the blue tool on the blue peg or did I put the blue tool on the yellow peg?
3. What did I do with the tools and the yarn? Did I stick the tools on the pegs or did I wrap the yarn around the pegs?
4. Which tool did I move first? Was it the green tool or the pink tool?

"Great job answering those questions!"

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6. Spin the Pots

Room Setup B

Tests working memory.

Set up lazy susan. Bring out set of 6 stickers and envelope. Set up: red pot towards me, scarf/stickers on side, ask mom for envelope back. RA codes on coding sheet. RA should stop me if we get past 16 trials.

"We're going to play another fun game where you get to win more stickers! Here are the stickers you get to win, and this is the envelope where we will put the stickers once you win them."

"Let's open each of these boxes." [Open each box, order: black flower, gold flower, heart, geese, blue sun, blue flower, purple flower, red.]

"Now I'll put a sticker in each of them." [Order: geese, red, gold flower, heart, purple flower, blue sun; place sticker in a box, close the lid, move on to next box.]

"We don't have enough stickers for all the boxes, so these two are empty [put sticker and then lid on each: black flower, blue flower]."

"Now I'll cover everything up [put fabric over]. *I'm going to spin the tray* [spin 180 degrees]. *Now you get to choose a box to open. Which box shall we open?"*

[Open pot child selects] If there is a sticker: *"Oh look, you found a sticker! I'll put in here for you. Let's try again!"* Cover, spin, ask child, *"Which box shall we open?"*
If no sticker: *"Oh, there's no sticker in there. Let's try again!"* Cover, spin, ask child, *"Which box shall we open?"*

Continue for a maximum of 16 trials until all 6 stickers are found.

7. Receptive Vocabulary Test (ROWPVT-4)

Room Setup B

"Great job with that game! Now we're going to play a word game."

Bring scoring sheet and test plates to small table (for both ROWPVT and EOWPVT).

"I am going to say a word and show you some pictures, and I want you to point to or tell me the number of the picture that matches the word. Let's practice first."

Do A, B, C, D. Then start at plate 1 (for 2 yr – 2 yr 11 mo) or plate 15 (for 3 yr – 3 yr 11 mo).

Establish a basal with 8 consecutive correct responses. Go backwards from start if basal is not established on first 8 items.

If child does not select, repeat. Say, *"Can you point to ___ for me?"* If they still do not, or point to multiple, say, *"Can you choose just one for me?"* If child says he/she doesn't know, say, *"That's ok, take a guess."*

If child looks fatigued, takes more than 30 seconds to point, puts head down, etc., say, *"These words are really tough! Just a few more and then we'll be done."*

Stop when child makes 6 incorrect responses out of 8 consecutive items.

Put a slash through the number of any incorrect answers. Write in number response for each item on line.

8. Short Break!

"Great job with that game! Now it's time for a snack."

Give child 3 minutes to relax and have a snack if desired. We provide snack options to parent, parent chooses snack for child. Bring snack to child in Cairo (don't eat in Pangea!).

9. Beery- Buktenica Developmental Test of Visual-Motor Integration (VMI)

Room Setup B

Purpose**:** assesses the extent to which individuals can integrate their visual and motor abilities.
Administered: at table
<u>Visual-Motor Integration Test</u>
*Start at page 2
Watch me. I'm going to draw a line here.
Make a vertical line top down. Point to vertical line & then point to the space below.
Make one like that. Make yours right here.
Go over line again if needed.
Do that. Makes yours right here.

If child has not marked on the paper, go back to page 1 and try spontaneous scribbling
You can draw anything you want inside this box. Go ahead.

Good for you! You can draw! Now draw this (try page 2 again)

OR

If child does not spontaneously scribble do imitated scribbling
Scribble up and down in the blank box closest to you and say:
Let's scribble-scrabble like this. It's fun! Do yours in here. Stay in the box- don't go outside the lines!

If the child scribbles try page 2 again, if not skip to visual perception assessment.

<u>Page 4</u>
Make one like that. Make yours right here.
Don't call by name or let them trace.
One try per task, no erasing, single line strokes.
Make one like this.
Good. Go ahead and do the rest of them. Turn to the next page when you finish this one. Do your best on both the easy and hard ones; do not skip any.
Record score

<u>Visual Perception Test</u>

Task 1:
Where is your eye? Point to your eye!
If need be, point to the child's eye and say: *Here's your eye! Now you point to your eye!*
Where is your hair? Point to your hair.
If need be, point to the child's hair and say: *Here's your hair! Now you point to your hair!*
Where is your ear? Point to your ear.
If need be, point to the child's ear and say: *Here's your hair! Now you point to your ear!*

Task 2:
Touch the kitty. If need be, touch the kitty and say: *Here's the kitty! Now you touch it!*
Touch the dog.
Touch the pig.

Task 3:
Touch the doll's hair. If need be, touch the doll's hair and say: *Here's its hair! Now you touch its hair!*
Touch the doll's nose.
Touch the doll's ear.
Touch the doll's foot.
Touch the doll's mouth.
Touch the doll's hand.
Touch the doll's tummy.
Touch the doll's eye.

Task 4 Practice:
See this line? There is one more line that is just the same down below. Let's find it! You point to it! Good Job!
Teach the task: *It's not this one, is it? This line is smaller than the one in the box above. It's this one, isn't it? It's just the same as the one in the box above.*

Point to the other line down below that is the same as this one.
Teach the task: *It's not this one, is it? This line is going a different way than the one in the box above. It's this one, isn't it? It's just the same as the one in the box above.*

Point to the other circle down below that is the same as this one.
Teach the task: *It's not this one, is it? This line is smaller than the one in the box above. It's this one, isn't it? It's just the same as the one in the box above.*

Task 4: timed, 3 minutes
#7 & on: *Point to the other one that is just the same as this one.*
Good Job! You really tried on even the ones that are hard!

<u>Motor Coordination Test:</u> administered at the table

Task 1
Observe: child getting into chair, holding a pencil with thumb & fingertips, hold paper with one hand and scribbles or draws with the other

Task 2 Practice
Watch me draw a line from the black dot to the gray dot and try to stay inside the road. Look there is a little picture of what it should look like after. See how each has a little picture above?

Now you do it. Draw a dark line from the black dot to the gray dot. Try to stay inside the road.
If no response, try again, then guide child's hand.

Task 2: Timed, 5 minutes
Go ahead. Do as many as you can. But do not rush. Draw carefully. Draw the forms in order. Do not skip any.
If they need further instruction: *Draw a dark line from the clack dots to the gray dots. Try to stay inside the road.*
If they are having trouble: *One time per item. Have you done all the parts you see in the little one? Be sure to do all the parts of yours.*

Say if they get to the part without dots: *Some forms on this page have only a few dots and some do not have any dots at all. If a form has a black dot, start there. If it has no dot, start wherever you like. Stay within the roads and make each form look like the small example just above it.*

10. Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2)

Room Setup B

Purpose: Assesses motor skills, including differentiated measures of gross and fine motor proficiency.
Administered: both at table and standing

<u>Task 1: Filling in a Star</u>
<u>Set up: Sitting at table</u>
For this task you are going to use the pencil to color in the star, without going outside the lines. Do you understand?

<u>Task 2: Drawing a Path</u>
<u>Set up: sitting at table</u>

For this task you are going to draw a line from the car to the house, staying in between the lines. Ready, begin.

<u>Task 3: Copying Overlapping Circles</u>
Draw this shape. Make it look just the same. Ready? Begin.

<u>Task 4: Copying a Diamond</u>
Draw this shape. Make it look just the same. Ready? Begin.

<u>Task 5: Stringing blocks (amount in 15 seconds, 2 trials)</u>
<u>Setup: sitting at table</u>
Look at what we have here. Look how I'm holding the string in one hand and a block in my other hand. Now I am putting the string through the hole in the block. Now I want you to try. Can you show me how you can string 3 blocks?
Time: 15 Sec
Now I want you to string as many blocks as you can until I say stop. Ready? Begin. Stop.
Let's try it again.
*Note: can hold end of string lightly

Room Set Up D
***Move parent**
This next set of activities we are going to be moving around a lot so we are going to have you sit over here. Move parent over by curtain.

<u>Task 6: Touching Nose with Index Fingers- Eyes Closed (4 correct touches, 2 trials if needed)</u>
<u>Set up: standing</u>
Watch me. I am pointing my fingers and holding my arms out. Then, I am going to close my eyes and bend one arm and touch my finger to the tip of my nose, switching arms. I am not moving my head, just my arms. Do you see how I am touching my nose with my fingers? That's what I want you to do.
Max Score: 4 touches

- Repeat if does not reach max: "Let's try again"
- Requirements: must be continuous, eyes stay shut, touch nose (if not, stop, remind & go to 2nd trial)

<u>Task 7: Pivoting Thumbs and Index Fingers (5 pivots, 2 trials if needed)</u>
<u>Set up: standing</u>
Watch me. I'm going to make two L's with my fingers. Can you make two L's?
If they can't, move on. If they can, continue.
Now flip one upside down and then put your fingers together, like me. Then you let go with the bottom fingers and move them to touch again at the top. Like this, do you understand? It's just like "itsy bitsy spider". That's what I want you to do.
Max Score: 5 pivots

- Repeat if does not reach max: “Let’s try again”
- Requirements: must be continuous, fingers touch, doesn’t let go early (if not, stop, remind & go to 2nd trial)

Task 8: Walking Forward Heel-to- Toe on a Line (6 steps, 2 trials if needed)

Set up: standing

Look I’m standing with my hands on my hips. Then I walk along the line, putting one foot in front of the other. Do you see how I am walking heel-to-toe along the line? That’s what I want you to do. Okay walk heel-to-toe on the line until I tell you to stop. Ready? Begin.

Max Score: 5 pivots

- Repeat if does not reach max: “Let’s try again”
- Requirements: must be heel-to-toe, stay on line, keep hands on hips (if not, stop, remind & go to 2nd trial)

*Start at curtain

Task 9: One-Legged Side Hop (amount in 15 sec, 2 trials if needed)

Set up: standing

Look I am standing on one leg next with my hands on my hips. Then, I hop over the line, staying on one foot. Do you see how I’m hopping on one leg over the line? That’s what I want you to do. Okay, hop on one leg back and forth until I tell you to stop. Ready? Begin.

Time: 15 sec

- Repeat if stumbles or falls: “Let’s try again”
- Requirements: must keep foot up, hands on hips, move side-to-side (4 inches) (if not, remind but continue)

Task 10: Catching a Tossed Ball- One Hand (5 catches, one trial)

Set up: standing, 10 feet apart, use preferred hand

I am going to toss you the ball and you are going to try to catch it with one hand. Okay? You are going to stand over here. Put this arm behind your back. Are you ready?

Max Score: 5 catches

- Repeat if does not reach max: “Let’s try again”
- Requirements: incorrect is catches with other hand, uses body, or uses both hands

Readminister is you throw a bad pass

Task 11: Dribbling a Ball- Alternating Hands (10 dribbles, 2 trials if needed)

Set up: standing

Look I am going to dribble the ball. See I let the ball bounce and then I hit it with my hand, changing hands. Do you see how I’m bouncing the ball with one hand and then with my other hand? That’s what I want you to do.

Max Score: 10 dribbles

- Repeat if does not reach max: “Let’s try again”

- Requirements: must alternate hands, can't catch ball, allows ball to bounce more than once (if not, stop, remind & go to 2nd trial)

<u>Task 12: Full Push-ups (amount in 30 sec, 1 trial)</u>
Look at me- my toes and my hands are on the floor and my back is straight. Then I bend my arms and lower my body until it almost touches the floor and then I push myself back up. Do you see how I am doing push-ups? That's what I want you to do.
Time: 30 sec

OR use alternative if it seems they are unable to do full push-ups

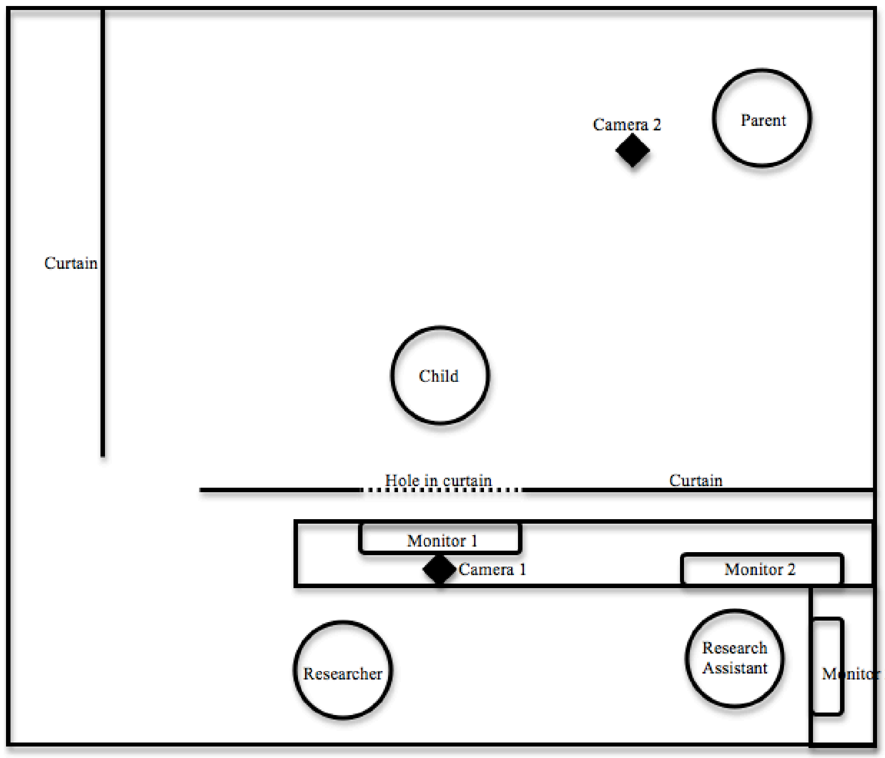
Task 12: Knee Push-ups (amount in 30 sec, 1 trial)
Look at me- my knees and my hands are on the floor. My ankles are crossed and my back is straight. Then I bend my arms and lower my body until it almost touches the floor and then I push myself back up. Do you see how I am doing knee push-ups? That's what I want you to do.
Time: 30 sec

11. Child Receives Prize, Parents are Debriefed

Debriefing: Ask the parents if they have any specific questions about the study. Say something like, "Overall, we were looking at how kids process action. The first task, with the two videos playing, looked at their preference for action. We also measured how they process action with the computer mouse-clicking game. We had some developmental measures as well, such as the gift delay task. That one was pretty tough! A lot of kids want to open the bag right away, but we wanted to see if he/she could wait. Erika's games were testing his/her motor skills to see if they are related to action processing skills. Do you have any questions? Thank you so much for coming in today! We really appreciate it!"

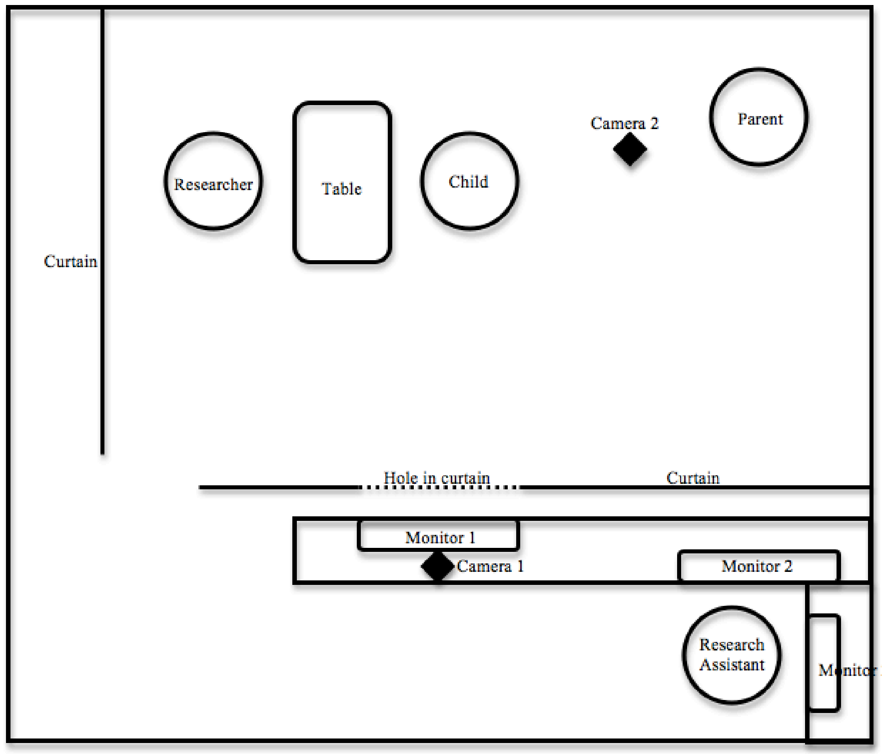
Appendix C: Room Setups Across Study

Room Setup A



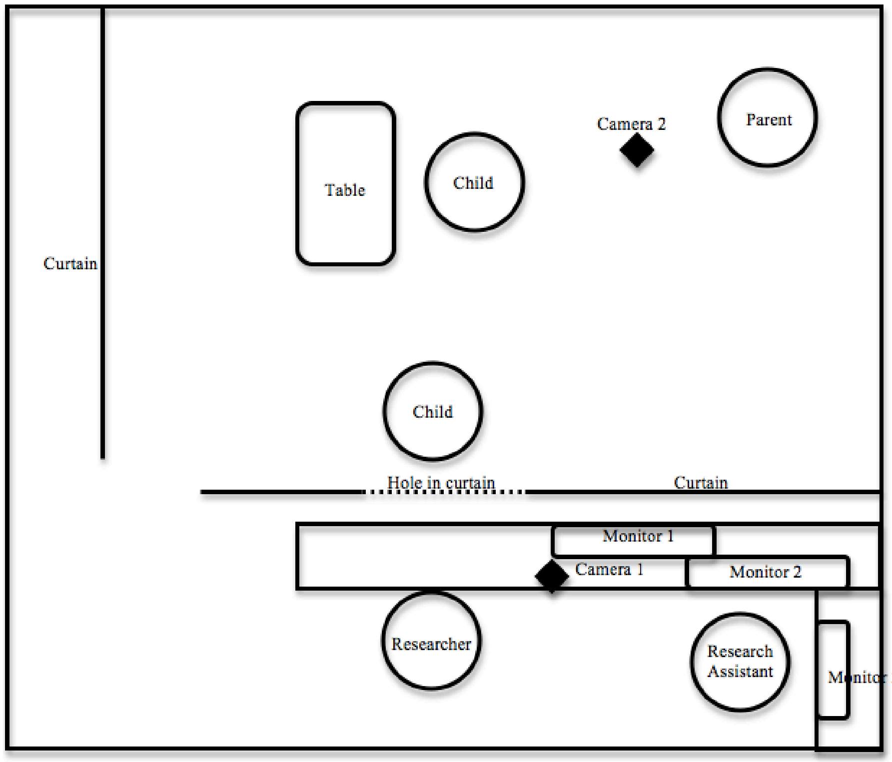
- Child sits in front of hole in curtain and watches stimuli on Monitor 1 through hole in curtain.
- Research assistant controls stimuli presentation with Monitor 2 and codes live feed from Monitor 3.
- Parent fills out forms.
- Camera 1 records child, Camera 2 records Monitor 1.

Room Setup B



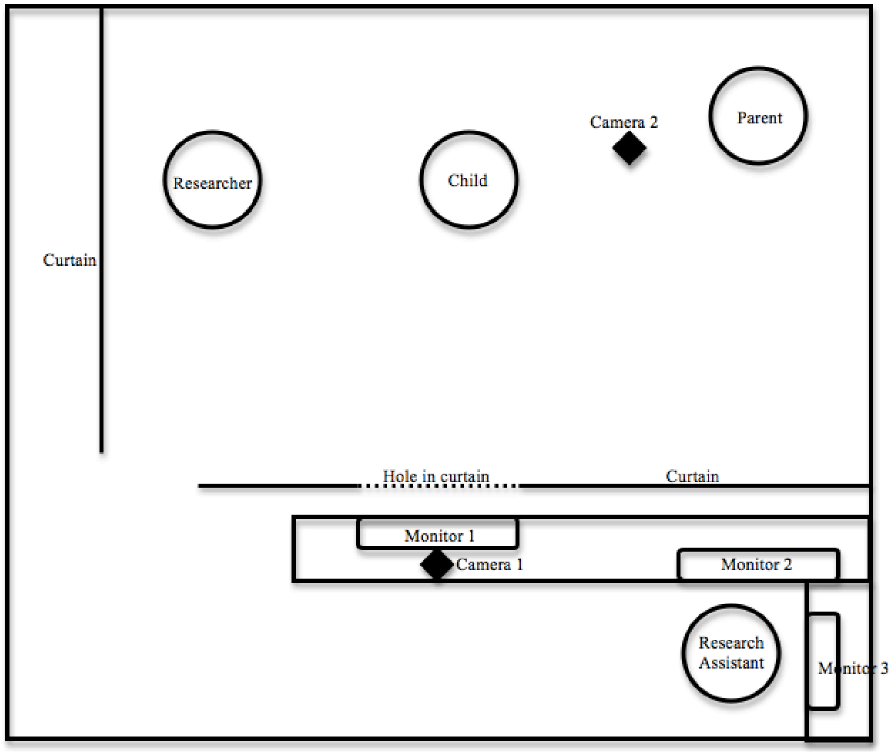
- Child sits with researcher at Table to do tasks.
- Camera 1 records Table, Child, and Researcher.
- Research Assistant codes behavior from Monitor 3.
- Parent fills out forms.

Room Setup C



- Monitor 1 and Camera 1 are moved to the right.
- Researcher sits behind Hole in Curtain and demonstrates toy actions.
- Child sits in front of Hole in Curtain and watches the demonstration.
- Camera 1 records Child, Camera 2 records Researcher.
- After demonstration, Child moves to Table. Researcher brings Child the toy, Child imitates at the table.
- Research Assistant codes behavior from live feed on Monitor 3.
- Parent fills out forms.

Room Setup D



- Monitor 1 and Camera 1 are moved to the right.
- Researcher sits behind Hole in Curtain and demonstrates toy actions.
- Child sits in front of Hole in Curtain and watches the demonstration.
- Camera 1 records Child, Camera 2 records Researcher.
- After demonstration, Child moves to Table. Researcher brings Child the toy, Child imitates at the table.
- Research Assistant codes behavior from live feed on Monitor 3.
- Parent fills out forms.

Appendix D: Parent Form: Motor Development

Parent Motor Development Checklist

For each activity listed below, please use the associated scales to rate various aspects of your child's motor skill.

*Note: The activities listed represent motor tasks with a wide range of difficulty. We are also studying a broad age range. Therefore, it is likely and completely normal for your child not be able to do all of these activities.

Activity	**Able to Perform** (Circle one)	**Frequency** (Circle one) 1= less than once a week, 2= once a week, 3= a few times a week, 4= daily, 5= multiple times a day	**Independence** (Circle one) 1= cannot complete without help, 5= can complete entirely without help	**Frustration** (Circle one) 1= very frustrated, 5= not at all frustrated	**Enjoyment** (Circle one) 1= does not enjoy, 5= really enjoys
Effectively clean teeth with tooth brush	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Accurately copy a circle or cross (not tracing)	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Use scissors to cut following a line	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Use hammer to drive pegs into holes	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Hold utensil with fingers & feed self without mess	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Hold crayon/ pencil with fingers	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Activity	**Able to Perform**	**Frequency** 1= less than once a week, 2= once a week, 3= a few times a week, 4= daily, 5= multiple times a day	**Independence** 1= cannot complete without help, 5= can complete entirely without help	**Frustration** 1= very frustrated, 5= not at all frustrated	**Enjoyment** 1= does not enjoy, 5= really enjoys
String small beads onto a shoelace	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Manipulate play dough to roll into a ball/snake or flatten into a pancake	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Manipulate play dough to assemble or sculpt recognizable objects	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Wiggle fingers independently of each other	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Paint using wrist action as opposed to whole arm	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Nail into wood	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Activity	**Able to Perform**	**Frequency** 1= less than once a week, 2= once a week, 3= a few times a week, 4= daily, 5= multiple times a day	**Independence** 1= cannot complete without help, 5= can complete entirely without help	**Frustration** 1= very frustrated, 5= not at all frustrated	**Enjoyment** 1= does not enjoy, 5= really enjoys
Play with small objects (dress a Barbie® build using LEGO®)	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Turn pages of a paperback book one at a time	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Tie shoes effectively	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Use a finger to press an individual keys on a computer keyboard or piano	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Successfully button buttons	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Successfully zip up a zipper	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Activity	Able to Perform	Frequency 1= less than once a week, 2= once a week, 3= a few times a week, 4= daily, 5= multiple times a day	Independence 1= cannot complete without help, 5= can complete entirely without help	Frustration 1= very frustrated, 5= not at all frustrated	Enjoyment 1= does not enjoy, 5= really enjoys
Get dressed (able to put on shirt or pants)	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Run	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Jump with two feet in the air	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Hop on one foot	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Kick a soccer-sized ball	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Stack large blocks with attention to balance	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Stack small wooden blocks several blocks high	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Stand on tiptoe & balance	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Throw ball underhand	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Throw ball overhand	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Catch a soccer-sized a ball	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Activity	**Able to Perform**	**Frequency** 1= less than once a week, 2= once a week, 3= a few times a week, 4= daily, 5= multiple times a day	**Independence** 1= cannot complete without help, 5= can complete entirely without help	**Frustration** 1= very frustrated, 5= not at all frustrated	**Enjoyment** 1= does not enjoy, 5= really enjoys
Catch a tennis- sized ball	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Pedal a tricycle (3-wheel bike)	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Climb onto and off from furniture (eg chair) safely	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Walk up & down stairs using two feet on each step, holding on to railing	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Walk up & down stairs using two feet on each step	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Walk up & down stairs, alternating foot on each step, holding railing	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Walk up & down stairs, alternating foot on each step	Yes No N/A	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Children often favor one hand over the other, please indicate along this scale, which hand your child favors (if either).
***Note: If your child does not favor either hand at this point, this is not a developmental problem!**

Left Hand		No Preference		Right Hand
1	2	3	4	5

What is your child's daily activity level?

Relatively Inactive		Moderately Active		Highly Active
1	2	3	4	5

How often does your child seek out opportunities to learn a new motor task?

Rarely		Sometimes		All the time
1	2	3	4	5

What is your child's level of motor skill?

Clumsy				Coordinated
1	2	3	4	5

What kind of motor skills does your child engage in frequently? (Check area & then list specific activities)

☐Sports (e.g. baseball, basketball, hockey, bochii ball, skiing, crocket, swimming, tree climbing, dance, gymnastic, taekwondo, yoga)

______________________________________-
____
____

☐Music (e.g. piano, drumming, stringed instruments, wind instruments)

______________________________________-
____
____

☐Toys & Games (e.g. video games, checkers, pick up sticks, jenga, monkeys & barrel, playing with blocks)

______________________________________-
____
____

☐Crafts (e.g. beading, knitting, sewing, weaving, woodwork, gluing, collage-making, cooking)

______________________________________-
____
____

☐Art (e.g. painting, drawing, sculpturing, potting)

______________________________________-
____
____

☐Games (e.g. tag, twister, playing on the jungle gym)

______________________________________-
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VI. REFERENCES

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