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AUTSIM SPECTRUM DISORDER: INVESTIGATING PREDICTIVE DIAGNOSTIC RELATIONSHIPS IN CHILDREN THREE YEARS-OF-AGE AND YOUNGER

By

Kaitlin Juergensen

B.S.- Centre College, Danville, KY, May 2013

A Thesis
Submitted to the Faculty of the
School of Medicine of the University of Louisville
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for the Degree of

Masters of Science
in Communicative Disorders

Department of Otolaryngology Head and Neck Surgery and Communicative Disorders
University of Louisville
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A Thesis Approved on

February 16, 2018

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DEDICATION

To the all the children with autism and their families who made an impact on my life and will always have a special place in my heart.

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ABSTRACT

AUTISM SPECTRUM DISORDER: INVESTINGATING PREDICTIVE DIANGOSTIC RELATIONSHIPS IN CHILDREN THREE YEARS-OF-AGE AND YOUNGER

Kaitlin N. Juergensen

February 16th, 2018

Autism spectrum disorder (ASD) is a heterogeneous neurodevelopmental disorder whose symptoms may involve deficits across three domains: communication, socialization, and atypical behaviors or interests. With a high prevalence across populations and a tendency to impact males more so than females, early and accurate diagnosis appears critical. The most current literature on ASD provides a myriad of difficulties associated with diagnosis under the age of three years. The purpose of this study was to determine if a predictive relationship exists between a child's individual developmental domain standard deviation (SD) subscale scores (motor, language, cognitive, social-emotional, and adaptive skills) on the Bayley III; their autism screening scores (pass or fail) on the *Modified Checklist for Autism in Toddlers, Revised* (M-CHAT/R) and on the *Screening Tool for Autism in Toddlers and Young Children* (STAT); and whether a diagnosis of ASD was applied. A retrospective file review of 151 children participating in Kentucky's early intervention program—First Steps—was completed. The children ranged in age from 18 to 35 months. A binary logistic regression was used to assess the association between the Bayley-III subscale scores, each child's pass/fail on the two ASD screeners, and whether or not an ASD diagnosis was applied following multidisciplinary evaluation. The results indicated that individual lower subscales scores in cognitive, language, adaptive, and social-emotional domains on the Bayley-III were predictive of an autism diagnosis.

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CHAPTER 1

INTRODUCTION

Background

Autism spectrum disorder (ASD) is a heterogeneous neurodevelopmental disorder characterized by impairments in social communication and restricted interests (Landa, 2007). Delayed language, abnormal language development, joint attention deficits, and atypical eye contact are commonly noticed within the first 18 months to two years of life (Charman et al., 1997; Chawaska, et al., 2007; Iverson & Wozniak, 2007). Parents, teachers, and clinicians need to be aware of these behavioral characteristics so that diagnosis can be determined as early as possible. Early diagnosis leads to early intervention which may establish a pathway for reducing symptomology and improvement in the quality of life of many children and their families (Camarata, 2014; Koegel et al., 2014).

Diagnostic Criteria

Leo Kanner, a physician and a psychiatrist, first described autism in 1943 as impairments in three categories: communication difficulties, social deficits, and restricted interests/repetitive behaviors (Kanner, 1943). In 1980, autism was officially identified as a clinical diagnosis by the American Psychiatric Association and published in the *Diagnostic Statistical Manual of Mental Disorders-III* (DSM-III). The DSM-III included criteria for infantile autism and pervasive developmental disorder (PDD). In 1994, autism criteria was again revised and published in the *Diagnostic Statistical*

Manual of Mental Disorders, fourth edition (DSM-IV); this time including five subtypes of autism: Autism Disorder (AD), Asperger Disorder, Pervasive Developmental Disorder—Not Otherwise Specified (PDD-NOS), Child Disintegrative Disorder, and Rett's Disorder. In May 2013, the *Diagnostic Statistical Manual of Mental Disorders, fifth edition* (DSM-V) released new diagnostic criteria reducing the three distinguishable categories into to two categories: social communication impairments and restricted interests.

Social communication and interaction deficits, including nonverbal communicative maladies, manifest across multiple contexts. Deficiencies may include the following characteristics: abnormal social approach, reciprocity difficulties, reduced sharing of interests, emotions (or affect), abnormal eye contact, poor interpretation of body language, and lack of facial expressions (DSM-V, 2013). Difficulties engaging in imaginative play, making friends, or a general lack of interest in peers also fall under the umbrella of social communication and interaction deficits (DSM-V, 2013). Pragmatic deficits may include difficulty initiating or maintaining a topic, lack of presuppositional skills, or inability to communicate intentions using a variety of communicative modalities (Landa, 2007).

Restricted and repetitive patterns of behavior or interests include stereotyped or repetitive motor movements, use of objects, or speech (DSM-V, 2013). A child with autism may line up toys in a particular order, insist on sameness, or resist change. Other symptoms include echolalia and/or ritualized patterns of verbal or nonverbal behavior. Hyper- or hypo-reactivity to sensory input are also included in the restricted interest domain. Some children with autism may demonstrate adverse response to specific sounds or textures or engage in excessive smelling or touching of objects (DSM-V, 2013). The symptoms from the social communication and restricted interest domains must be present in the early developmental period (DSM-V, 2013) and must not be better explained by intellectual disability or global developmental delay (DSM-V, 2013).

Prevalence

When Leo Kanner first described autism, it was thought to be an extremely rare disorder (Kanner, 1943). In the 1960s and 1970s research reported approximately four-to-five cases per 10,000 children (Christensen et al., 2016). As awareness increased and diagnostic criteria changed, prevalence continued to increase. From 2000 to 2002, studies reported one in 150 children, and in 2008, studies reported one in 88 children across the United States of America (Christensen et al., 2016). According to findings from Autism and Developmental Disabilities Monitoring (ADDM) Network the estimated percentage of children identified with ASD is currently one in 68, or about 1.5% of children across the United States of America (Christensen et al., 2016). ADDM also reports ASD is about 4.5 times more common among boys (one in 42) than among girls (one in 189) (Christensen et al., 2016). As the prevalence remains high, this highlights the importance of early diagnosis and intervention for children across the country.

Problem Statement

Currently, there is a lack of understanding of the symptomology from birth-to-age three years in children with autism contributing to the lack of diagnosis at an early age (Camarata, 2014; Koegel, et al., 2014; Landa, 2007). The first diagnostic criteria included the three core symptoms/categories discussed earlier (communication difficulties, social deficits, and restricted interest/repetitive behaviors) as evident from birth (Camarata, 2014). The DSM-III also recognized autism as beginning at birth with the inclusion of infantile autism diagnosis. Nonetheless, Camarata (2014) suggests that the majority of diagnoses occur between ages four to five because there is a high degree of accuracy in terms of correctly diagnosing ASD. Given that autism may be present in children from birth, a missed diagnosis or lack thereof during the toddler years, may negatively influence the therapeutic process and delay any potential gains.

The lack of confidence in early diagnosis arises not only in the United States of America but also in the United Kingdom. In 2007, the American Academy of Pediatrics (AAP) issued a policy statement calling for universal screening for autism by the age of 24 months. However, the National Health Service (NHS) of United Kingdom did not support the universal screening due to the lack in the current ability to correctly diagnose ASD in toddlers and preschoolers (Camarata, 2014). The literature supports the notion that early diagnosis is not made before the age of three years due to concerns about labeling or incorrectly diagnosing the child (Filipek et.al, 2000). Turner and Stone (2007) point out that the difficulty in diagnosis before 30 months may be due to the variability of symptoms across age: children at age four or five years of age differ in their behavior than their two and three-year-old counterparts. For example, it is typical for two-year-old children to demonstrate repetitive motor patterns with their hands (Camarata, 2014). However, a five-year-old child engaging in this motor behavior would be abnormal making it easier to recognize as a possible symptom of ASD (Camarata, 2014). This example provides evidence of the importance of further inquiry into the core symptomology in young children (infants and toddlers) with autism. In order to provide accurate diagnosis, the symptomology must be fully understood.

Importance of Early intervention

Under the Individuals with Disabilities Education Improvement Act (IDEIA), specifically Part C, the law defines the age range for children eligible for services as birth-to-three years of age (First Steps, 2015). Children that are not appropriately diagnosed before the age of three years miss the imperative opportunities of early intervention services which may lead to devastating consequences. These unidentified children are likely to miss important learning cues from parents, siblings, and teachers (Camarata, 2014). The absence of such learning cues can be detrimental because brain development is greatly influenced by environmental conditions and experiences (Owens, 2016). According to Owens (2016), the types of experience children encounter during cognitive and perceptual sensitive periods is extremely important for learning and development. This can be demonstrated by the development of joint attention and its impact on language development. At an early age, joint attention skills are used for communicating wants and needs and also contribute to word-learning (Landa, 2007). Children with autism may lack these skills and without early intervention this may inhibit the development of further language skills (Landa, 2007).

Koegel (2000) emphasized the importance of the type of experiences children encounter at an early age in a study that used motivational techniques in therapy for children below the age of five. Eighty-five to 90% of children with autism who received early intervention involving motivational techniques learned to use verbal communication as the primary mode of communication (Koegel, 2000). In addition, nonverbal children who began intervention in the early preschool years, were more likely to become verbal than children who began therapy after the age of five. Furthermore, the age a child begins therapy greatly impacts and predicts future developmental skills (Koegel, 2000). The majority of research agrees that early intervention for children with autism must occur at the earliest point in time in order to combat the symptomology and obtain optimal outcomes (Landa, 2007; Koegel et al., 2014; Camarata, 2014).

Early intervention may also have a positive impact on the prevention and/or reduction of secondary symptoms in children with autism. Secondary symptoms include self-injury, tantrums, and aggression most likely due to communication breakdown (Koegel et al., 2014). With early intervention, the function/underlying cause of the disruptive behavior can be addressed and likely reduced or replaced with other functional behaviors. According to Koegel et al. (2014), "early intervention techniques may prevent these secondary symptoms and reduce the need for more substantial and expensive interventions later in life" (p. 52).

Differential Diagnosis

Differentiating autism from other diagnoses (e.g., speech sound disorders, language disorders, language delay, global intellectual disability, and hearing loss) associated with children and development is difficult (Camarata, 2014). Language disorder or language delay can be especially problematic. Most parents or caregivers are the first to notice a difference in their child when the child appears as a late talker (Landa, 2007). Many children with the aforementioned diagnoses present with tantrums, have impaired verbal social skills, and are often unresponsive to verbal input (Camarata, 2014). Unfortunately, many pediatricians will adopt the “wait and see” approach contributing to the lack of diagnoses of autism under the age of three years (Koegel et al., 2014).

Early Intervention Evaluation and Assessment

In the state of Kentucky, the First Steps program provides early intervention services for children with developmental disabilities under the age of three years (First Steps, 2015). These services are rendered under the auspices of federal law, PL 108-446, IDEIA of 2004, Part C (First Steps, 2015). In order for eligibility to be determined and for intervention to begin, a child must possess a diagnosed physical or mental condition that has a high probability of resulting in a developmental delay (e.g., autism spectrum disorder, hearing loss, Down syndrome) *or* evidence a significant developmental delay in one or more of the following developmental domains: motor, cognitive, language, social-emotional and/or adaptive skills (First Steps, 2015).

Children with documented established risk conditions are eligible to receive services until the age of three years. For those children without a documented established risk condition, eligibility is determined based on significance. A delay is considered significant if a child scores two standard deviations (-2.00) below the mean in one area (e.g., cognitive) or one-and-a-half standard deviations (-1.50) below the mean in two areas (e.g., cognitive and language) (First Steps, 2015). One commonly used norm-referenced instrument is the *Bayley Scales of Infant and Toddler Development, Third Edition* (Bayley-III) (Bayley, 2006).

In addition to the scores obtained from the Bayley-III, each child's "medical and health history and the results of the most recent physical examination" must be documented before an eligibility decision can be made (First Steps, 2015, p.59). At the recommendation of the AAP, children should be screened for autism at 18 and 24 months (CDC, 2016). This information is frequently available as a part of each child's medical record. One screening frequently used is the *Modified Checklist for Autism in Toddlers, Revised* (M-CHAT/R) (Robins et al., 2009). The M-CHAT/R contains 20 simple yes/no questions that are to be answered by parents or caregivers. If a failed score is present on the M-CHAT/R and/or a concern of autism is reported, a second face-to-face screener may be completed. This screener is known as the STAT or the *Screening Tool for Autism in Toddlers and Young Children* (Stone & Ousley, 2017). The STAT is also a simple screener consisting of 12 items that assesses social and communicative behaviors. Per First Steps policy (in Kentucky), children who are suspected as having autism are generally evaluated and a differential diagnosis determined before early intervention services are provided. The intent is to "gain in-depth information so that the child's team can develop effective interventions and services" (First Steps, 2015, p.91). The researchers acknowledge that the aforementioned process is unique to the state of Kentucky and may not be representative of all early intervention programs in other states.

Specific Aims

As research indicates, the symptomology of autism in young children (infants and toddlers) needs to be fully examined to facilitate accurate and early diagnosis in order to implement effective and appropriate intervention strategies. The specific aim of this study was to determine if a statistically significant association exists among the developmental domain standard deviation (SD) subscale scores (motor, language, cognitive, social-emotional, and adaptive skills) on the Bayley-III, autism screening scores (pass or fail) per the M-CHAT/R and the STAT, and the criterion variable of whether a diagnosis of ASD was applied following multidisciplinary evaluation. Knowledge of the predictive value of each domain, or combination thereof, may contribute to an increase in confidence when diagnosing ASD in children under the age of three years.

Research Hypotheses

The research hypotheses are as follows:

H_1: There will be a statistically significant association between autism spectrum disorder diagnosis in children ≤ three years-of-age and their developmental domain standard subscale scores on the Bayley-III and their pass/fail scores on the M-CHAT/R and/or the STAT.

H_{1a}: The motor domain standard subscale score on the Bayley-III will significantly contribute to the variance in predicting autism spectrum disorder diagnosis in children ≤ three years-of-age.

H_{1b}: The cognitive domain standard subscale score on the Bayley-III will significantly contribute to the variance in predicting autism spectrum disorder diagnosis in children ≤ three years-of-age.

H_{1c}: The language domain standard subscale score on the Bayley-III will significantly contribute to the variance in predicting autism spectrum disorder diagnosis in children ≤ three years-of-age.

H_{1d}: The social-emotional domain standard subscale score on the Bayley-III will significantly contribute to the variance in predicting autism spectrum disorder diagnosis in children ≤ three years-of-age.

H_{1e}: The adaptive skills domain standard subscale score on the Bayley-III will significantly contribute to the variance in predicting autism spectrum disorder diagnosis in children ≤ three years-of-age.

H_{1f}: The pass/fail screening score on the M-CHAT/R will significantly contribute to the variance in predicting autism spectrum disorder diagnosis in children ≤ three years-of-age.

H_{1g}: The pass/fail screening score on the STAT will significantly contribute to the variance in predicting autism spectrum disorder diagnosis in children ≤ three years-of-age.

Null Hypotheses

The null hypotheses are as follows:

H_{01}: There will not be a statistically significant association between autism spectrum disorder diagnosis in children ≤ three years-of-age and their developmental domain standard subscale scores on the Bayley-III and their pass/fail scores on the M-CHAT/R and/or the STAT.

H_{01a}: The motor domain standard subscale score on the Bayley-III will not significantly contribute to the variance in predicting autism spectrum disorder diagnosis in children ≤ three years-of-age.

H_{01b}: The cognitive domain standard subscale score on the Bayley-III will not significantly contribute to the variance in predicting autism spectrum disorder diagnosis in children ≤ three years-of-age.

H_{01c}: The language domain standard subscale score on the Bayley-III will not significantly contribute to the variance in predicting autism spectrum disorder diagnosis in children ≤ three years-of-age.

H_{01d}: The social-emotional domain standard subscale score on the Bayley-III will not significantly contribute to the variance in predicting autism spectrum disorder diagnosis in children ≤ three years-of-age.

H_{01e}: The adaptive skills domain standard subscale score on the Bayley-III will not significantly contribute to the variance in predicting autism spectrum disorder diagnosis in children ≤ three years-of-age.

H_{01f}: The pass/fail screening score on the M-CHAT/R will not significantly contribute to the variance in predicting autism spectrum disorder diagnosis in children ≤ three years-of-age.

H_{01g}: The pass/fail screening score on the STAT will significantly contribute to the variance in predicting autism spectrum disorder diagnosis in children ≤ three years-of-age.

CHAPTER 2

METHODS

Procedures

This study utilized a retrospective file review of children ($n = 151$) that participated in Kentucky's early intervention program, First Steps, between 1/1/2014 and 1/31/2017. The sample included children between the ages of 18-35 months and comprised 120 males and 31 females. Tabachnick and Fidell (2013) recommend a sample size of at least 80 where $n > 50 + 8m$ (m is the number of predictor variables). Children with and without ASD diagnosis were represented. ASD diagnosis was determined by Intensive Level of Evaluation (ILE) as completed by the University of Louisville Weisskopf Child Evaluation Center (WCEC). For the purpose of this study, an ILE is equivalent to a multidisciplinary evaluation that typically involves a Speech-Language Pathologist, Psychologist, and Developmental Pediatrician. An Occupational Therapist may also be involved on a case-by-case basis. Approval for this study was granted by the Institutional Review Boards (IRB) of the University of Louisville (IRB # 17.0220) and the Kentucky Cabinet for Health and Family Services.

Temporary statewide access was granted to First Steps' *Technology-assisted Observation and Teaming Support* (TOTS) database, an electronic record used by the Kentucky Department of Public Health to track children as they are referred, evaluated, and, in some cases, receive services through the early intervention program. The researchers used TOTS to query children referred to and evaluated by First Steps between the aforementioned date range. Specific interest centered on ASD diagnosis, M-CHAT/R and STAT pass/fail outcomes, and the developmental domain standard deviation subscale scores per the Bayley-III. Demographic information included each child's age (in months) at evaluation and gender. The above information was compiled in a Microsoft Excel spreadsheet and then exported to SPSS Version 24 for statistical analyses. Gender was coded where 1 = male and 2 = female. M-CHAT/R and STAT were coded based on pass/fail where 1 = pass and 2 = fail. ASD diagnosis was coded in the same manner where 1 = not diagnosed and 2 = diagnosed. No identifying information was recorded.

Data Analysis

A binary logistic regression was used to assess if an association exists among the developmental domain standard deviation (SD) subscale scores (motor, language, cognitive, social-emotional, and adaptive skills) on the Bayley-III, autism screening scores (pass or fail) per the M-CHAT/R and the STAT, and whether a diagnosis of ASD was applied. A binary logistic regression analysis was used, as the criterion variable, ASD diagnosis, is dichotomous (Warner, 2013). Descriptive statistics, assumption testing, and the results of the logistic regression analyses are provided in Chapter 3.

CHAPTER 3

RESULTS

Descriptive Statistics

This study comprised a retrospective file review of 151 children in the state of Kentucky; 79.5% (*n* = 120) were male and 20.5% (*n* = 31) were female. The ages ranged from 18-35 months (*M* = 27.50, *SD* = 3.99). Fifty-seven percent (*n* = 86) of the children were diagnosed with ASD; 43% (*n* = 65) did not have an ASD diagnosis.

Table 1 presents the mean and standard deviations for the predictor variables from the Bayley-III subscales (Bayley, 2006). Table 2 presents the frequency and percent pass/fail rates per the M-CHAT/R and STAT. ASD diagnosis served as the criterion variable.

Assumption Testing and Correlation Matrix

Logistic regressions are sensitive to multicollinearity. As such, a correlation matrix (Spearman's Rho) was calculated to assess multicollinearity presence. The results are presented in Table 3 and evidence violation of this assumption test. Therefore, the continuous variables and the dichotomous variable (ASD diagnosis) were mean centered. The dichotomous variable, ASD diagnosis, was also centered. This was completed by changing the values of 0 to -0.5 and 1 to 0.5. Variables were centered as a strategy to prevent errors in statistical inference.

Additionally, the SD for the language and social-emotional subscales from the Bayley-III were skewed (i.e., non-normally distributed). Given the presence of negative values, the skew was corrected by making the values positive prior to log-transformation of the data. Therefore, a constant (2.28 to the SD for language and 2.22 to SD for social-emotional) was added to the mean centered variables, so that the minimum for both variables scored 1. The variables were then log-transformed and the skew successfully addressed.

Logistic Regression Analyses

Individual logistic regression analyses were used to assess whether an association existed among the developmental domain standard deviation (SD) subscale scores (motor, language, cognitive, social-emotional, and adaptive skills) on the Bayley-III, autism screening scores (pass or fail) per the M-CHAT/R and the STAT, and whether a diagnosis of ASD was applied. The complete results of the logistic regression analyses are presented in Table 4. Due to the limited frequency count (of this sample) related to failed/passed M-CHAT/R and STAT screenings, these variables could not be entered into the logistic regression analysis as predictors of possible ASD. Consequently, logistic regression analyses were completed to explore the predictive value of the Bayley-III subscale SD scores for both the M-CHAT/R and STAT screenings, individually. The results are presented in Tables 5 and 6 respectively.

Bayley-III Motor Subscale and ASD Diagnosis

Logistic regression—step 1a—entered the Bayley-III motor SD subscale score as a predictor of ASD diagnosis. The results were not significant (odds ratio = .70, 95% CI

= .48 – 1.02, p = .06). Although statistical significance was not achieved, the model explained 3.1% (Nagelkereke R^2) of the variance of ASD diagnosis.

Bayley-III Cognitive Subscale and ASD Diagnosis

Logistic regression—step 1b—entered the Bayley-III cognitive standard deviation subscale score as a predictor of ASD diagnosis. The results were statistically significant (odds ratio = .41, 95% CI = .27 – .64, p = < .001) and explained 14.9% (Nagelkereke R^2) of the variance of ASD diagnosis per this sample.

Bayley-III Language Subscale and ASD Diagnosis

Logistic regression—step 1c—entered the Bayley-III language SD subscale score as a predictor of ASD diagnosis. One outlier (> 4 *SD*) was observed and subsequently removed from the analysis. The results were statistically significant (odds ratio < .001, 95% CI = < .00001 – < .001, p = < .001) and explained 42.8% (Nagelkereke R^2) of the variance of ASD diagnosis per this sample.

Bayley-III Social-Emotional Subscale and ASD Diagnosis

Logistic regression—step 1d—entered the Bayley-III social-emotional SD subscale score as a predictor of ASD diagnosis. The results were statistically significant (odds ratio = .01, 95% CI = .001 – .099, p = < .001) and explained 47.1% (Nagelkereke R^2) of the variance of ASD diagnosis per this sample.

Bayley-III Adaptive Skills Subscale and ASD Diagnosis

Logistic regression—step 1e—entered the Bayley-III adaptive skills SD subscale score as a predictor of ASD diagnosis. The results were statistically significant (odds ratio = .48, 95% CI = .326 – .721, p = < .001) and explained 12.1% (Nagelkereke R^2) of the variance of ASD diagnosis per this sample.

CHAPTER 4

DISCUSSION

In the United States of America, the average age of autism diagnosis occurs between the ages of three and four years (Chawarska et al., 2007; Filipek et al, 1999). A common belief is that the lack of diagnoses of autism before the age of three years is due to the variability and uncertainty of symptoms at such a young age (Turner & Stone, 2007; Camarata, 2014). Nonetheless, early diagnosis is important in order to obtain the benefits of early intervention services (Landa, 2007; Koegel et al. 2014; Camarata, 2014). This study aimed to contribute to an increase in confidence when diagnosing ASD in children under the age of three years by determining if a statistically significant association was present among the developmental domain standard deviation subscale scores (motor, language, cognitive, social-emotional, and adaptive skills) on the Bayley-III, autism screening scores per the M-CHAT/R and the STAT, and the criterion variable of whether a diagnosis of ASD was applied.

In this study, individual binomial logistic regression analyses determined that lower scores on the Bayley-III subscales of cognitive, language, social-emotional, and adaptive domains were significant predictors of ASD diagnosis. It is no surprise that lower SD scores for social-emotional and language domains were associated with an increased likelihood of ASD diagnosis as both are encompassed in the diagnostic criteria for autism. Additionally, there has been an abundance of research indicating the presence of language and social-emotional deficits in children with autism under the age of three years.

The language domain encompasses both receptive (i.e. understanding of words and sounds) and expressive (i.e. production of words and sounds) skills. Landa & Garret-Mayer (2006) used the *Mullen Scales of Early Learning* (MSEL) to assess 87 participants at six, 14, and 24 months of age. Participants consisted of those with ASD, language delay, and a control group of children without any impairments. Results found that children with ASD demonstrated a progressive receptive and expressive language regression around 14 months of age. Furthermore, deficits in the frequency and prosodic features of vocalizations (Chawarska et al., 2007), delayed onset of babbling (Iverson & Wozniak, 2007) and usage of gestures and pointing as a communicative tool (Chawarska et al., 2007) have all be documented between one and two years of age.

The social-emotional domain consists of skills including social reciprocity and relatedness to others. In children with autism under the age of three years, the absence of social smiling, lack of facial expression, poor eye contact (Zwaigenbaum et al., 2005), failure to orient to name, limited interest in other children, and limited empathy and imitation (Chawarska et al., 2007), have all been documented. Even parents of children with autism, when asked to recall their child's differences in the first year of life, refer to extremes of temperament and behavior ranging from passivity to marked irritability (Zwaigenbaum et al., 2005).

Whereas development is a simultaneous process, it is not surprising that lower SD scores in both adaptive and cognitive domains presented as predictors of possible ASD. The likelihood appears increased when considering corresponding deficits involving both language and social-emotional skills. Cognition, even in infancy, involves comprehension of information, organization, storage, memory, problem-solving, sequencing and the use of knowledge/executive functioning. Stone et al. (2007) used the MSEL to test cognitive functioning of infant siblings at high risk for ASD. The results indicated that siblings at risk for ASD performed significantly lower on nonverbal problem solving (visual reception) and attentional domains than siblings of typical development. Children with autism also demonstrate cognitive deficits through symbolic play as early as 18 months (Toth et al., 2006).

Adaptive skills encompass those abilities that foster independence and self-care. In essence, this domain addresses a child's ability to participate in activities of daily living. For children under the age of three years, parents or caregivers tend to perform/aid many of these tasks. Green & Carter (2014) conducted a three-year longitudinal study of 162 children with autism between 18-33 months of age and their adaptive behaviors. To assess change, the children were given a series of tests including the MSEL, the *Vineland Adaptive Behavior Scales* (VABS), and the *Brief Infant Toddler Social and Emotional Assessment* (BITSEA) annually over the course of two years. Results indicated that participants with autism gained daily living skills but did so at a slower rate than typically developing children. In addition, developmental level and autism symptom severity predicted daily livings skills. Children who were older with a higher developmental level at the beginning of the study made more rapid gains in daily living skills than those who were younger or had a lower developmental level at the beginning of the study. Children with more severe autism symptoms made slower gains in daily living skills than those children with less severe autism symptoms (Green & Carter, 2014). This is supportive of our findings that lower scores on the adaptive domain subscale of the Bayley-III may be predictive of an autism diagnosis.

The results of the current study were not significant for the Bayley-III motor standard deviation subscale score as an individual predictor of ASD diagnosis. The motor domain of the Bayley-III includes assessment of both fine (e.g., visual tracking, reaching, grasping) and gross motor skills (e.g., static positioning, dynamic movements, coordination, balance). Autism is not perceived as a syndrome with obvious motor impairment. The literature however, seems controversial. Some literature contained supporting evidence of motor impairments in children with autism (Provost et al., 2009) and other literature contained evidence supporting the motor skills domain as a strength in children with autism (Ming et al., 2007). In addition, there seems to be a paucity of research completed involving children below the age of three years.

In one of the few studies examining motor delay in preschool children with autism, Provost et al. (2009) found the motor skills as a relative weakness. In addition, Provost et al. (2009) found that motor signs may be difficult to distinguish from other types of disorders. The study was conducted using two groups of children: one group with autism and one group with developmental delay all aged from 21- 41 months. Fine motor and gross motor skills of both groups of children were assessed using the *Peabody Developmental Motor Scales- 2nd Edition* (PDMS-2). Results demonstrated that children with autism have motor skills ranging from average to very poor. These motor skills vary in degree as some children displayed equal development of gross and fine motor skills, some displayed greater development of gross motor skills than fine motor skills and some with greater development of fine motor skills than their gross motor skills (Provost et al., 2009). The overall motor skills of children with autism and children with developmental delay were very similar to each other (Provost et al., 2009).

Conversely, Ming et al. (2007) found gross motor skills in children with autism to be a strength. One-hundred and fifty-four children with autism were assessed and results indicated only 12 of the children (10%) between the ages of two and six displayed a history of gross motor delay but all had reached the target milestones of walking independently, walking steps or ramps, and jumping by initiation of the study (Ming et al, 2007). With such scarce research regarding motor development in children with autism below the age of three years, it would be advantageous to further study this developmental domain.

The current study also found that lower subscale scores (for each domain) on the Bayley-III predicted a “fail” on both the M-CHAT/R and the STAT. Given this information, we can be confident that these screeners and the Bayley provide valuable information which may assist in the autism diagnostic process. We can imply that if a child is demonstrating apparent deficits in any developmental domain, it is it important they are assessed rather than a “wait-and-see” approach. In addition, our findings may provide important implications regarding early intervention treatment strategies. Developing treatment plans that target skills not only in the language and social-emotional domains but also in the cognitive and adaptive skills domains may benefit children with autism. Specifically, early intervention targeting play skills, imitation skills, and joint attention skills have been documented to show improvement in communication development in children with autism (Kasari et al., 2006; Ingersoll and Schreibman, 2006). In fact, evidence shows that intervention in just one area of communication can positively improve other areas of communication as well (Ingersoll and Screibman, 2006). With the abundance of research demonstrating the remarkable results of early intervention, it is important children at risk for autism under the age of three years receive these services.

The researchers acknowledge the study has several limitations. Obtaining only the pass/fail scores on the M-CHAT/R and the STAT limited our study due to a lack of variability of responses. In future studies, individual scores on these screeners should be obtained in order to allow for a more robust variance as opposed to simple dichotomous variables (e.g., pass or fail). Secondly, the Bayley-III is only one option for assessment of autism under the age of three years. Future research may utilize other valid assessment tools. Lastly, the current study patterned the assessment protocol after the Kentucky First Steps Program. Other states may have different government directed procedures in place for diagnosing children with autism under the age of three years.

Future research opportunities may be warranted using the Bayley-III. The Bayley-III compartmentalizes the language, motor, and adaptive developmental domains into further subgroups that are scored individually (e.g. language subgroups include receptive and expressive language). These subgroups contribute to the overall developmental domain score. Obtaining the individual subgroup scores may provide more descriptive information regarding which specific aspects/deficits of the aforementioned domains are more likely to appear in a child with autism under the age of three years.

The overarching intent of this study was to contribute to the knowledge base on ASD diagnosis. The focus centered specifically on young children under the age of three years. The results obtained are consistent with the current body of literature on ASD with respect to deficits in the areas of cognitive, language, social-emotional and adaptive skills (Cognition: Stone et al., 2007, Toth et al., 2006; Language: Chawarska et al., 2007; Iverson & Wozniak, 2007; Landa & Garret-Mayer, 2006; Social-emotional: Chawarska et al., 2007; Zwaigenbaum et al., 2005; Adaptive: Green & Carter, 2014).

Whereas ASD is a heterogeneous neurodevelopmental disorder whose symptoms may involve deficits across three primary domains—communication, socialization, and atypical behaviors or interests—it is vitally important that researchers, physicians, and therapists alike routinely consider secondary related deficits in the areas of cognitive and adaptive development. For this sample and this context, use of the Bayley-III proved to be a beneficial tool for use in evaluating children under the age of three years suspect as having ASD. It is important to note, however, that the Bayley-III is, but one available option. The researchers are also quick to stress the importance of thorough and routine screening for ASD using the aforementioned M-CHAT/R and STAT instruments. Lastly, timely intervention necessitates timely evaluation and diagnosis. It is our hope that the limited knowledge base on early ASD diagnosis in young children has been increased and the gap in the available literature narrowed.

Table 1

Descriptive Statistics for the Bayley-III Scales (n = 151)

Subscale	*M*	*SD*
Motor	-1.17	0.88
Cognitive	-1.66	0.84
Language	-2.72	0.72
Social-Emotional	-1.78	0.91
Adaptive	-1.89	0.91

Table 2

Descriptive Statistics for the M-CHAT/R and STAT (*n* = 151)

M-CHAT/R	*Frequency*	*Percent*
Pass	32	21.2
Fail	119	78.8
STAT		
Pass	16	10.6
Fail	135	89.4

Table 3

Spearman's Rho Correlation Matrix (*n* = 151)

	Motor	Cognitive	Language	Social-Em.	Adaptive	M-CHAT/R	STAT
Motor	-						
Cognitive	.59**	-					
Language	.32**	.56**	-				
Social-Em.	.25**	.37**	.43**	-			
Adaptive	.38**	.42**	.42**	.55**	-		
M-CHAT/R	-.17*	-.25**	-.33**	-.35**	-.34**	-	
STAT	-.16*	-.31**	-.37**	-.37**	-.38**	.85**	-

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4

Individual Binomial Logistic Regression: Predictors of ASD Diagnosis Using the Bayley-III

Subscale	Odds Ratio	95% (CI)	% Variance	*p*
Motor	.70	.48 – 1.02	3.1%	.06
Cognitive	.41	.276 - .641	14.9%	<.001
Language	.000001	.00000001 - .0001	42.8%	<.001
Social-Emotional	.01	.001 - .099	47.1%	<.001
Adaptive	.48	.326 - .721	12.1%	<.001

Table 5

Individual Binomial Logistic Regression: Predictors of a "failed" Score on the M-CHAT/R Using the Bayley-III

Subscale	Odds Ratio	95% (CI)	*p*
Motor	.616	.385 - .983	.04
Cognitive	.432	.258 - .723	≤.001
Language	.002	.00007 - .061	<.001
Social-Emotional	.005	.0003 - .070	<.001
Adaptive	.367	.225 - .600	<.001

Table 6

Individual Binomial Logistic Regression: Predictors of a “failed” Score on the STAT Using the Bayley-III

Subscale	Odds Ratio	95% (CI)	*p*
Motor	.618	.394 - .970	.04
Cognitive	.366	.218 - .614	<.001
Language	.0005	.00002 - .016	<.001
Social-Emotional	.005	.0003- .062	<.001
Adaptive	.335	.205 - .547	<.001

Table 7

Summary of Tested Null Hypotheses

Hypothesis	Statement	Overall Model/R^2	Results
H_{01}	There will not be a statistically significant association between autism spectrum disorder diagnosis in children ≤ three years-of-age and their developmental domain standard subscale scores on the Bayley-III and their pass/fail scores on the M-CHAT/R and/or the STAT.	--	Failed to Reject
H_{01a}	The motor domain standard subscale score on the Bayley-III will not significantly contribute to the variance in predicting autism spectrum disorder diagnosis in children ≤ three years-of-age.	3.1%	Failed to Reject
H_{01b}	The cognitive domain standard subscale score on the Bayley-III will not significantly contribute to the variance in predicting autism spectrum disorder diagnosis in children ≤ three years-of-age.	14.9%	Reject
H_{01c}	The language domain standard subscale score on the Bayley-III will not significantly contribute to the variance in predicting	42.8%	Reject

	autism spectrum disorder diagnosis in children ≤ three years-of-age.		
H_{01d}	The social-emotional domain standard subscale score on the Bayley-III will not significantly contribute to the variance in predicting autism spectrum disorder diagnosis in children ≤ three years-of-age.	47.1%	Reject
H_{01e}	The adaptive skills domain standard subscale score on the Bayley-III will not significantly contribute to the variance in predicting autism spectrum disorder diagnosis in children ≤ three years-of-age.	12.1%	Reject
H_{01f}	The pass/fail screening score on the M-CHAT/R will not significantly contribute to the variance in predicting autism spectrum disorder diagnosis in children ≤ three years-of-age.	--	Failed to Reject
H_{01g}	The pass/fail screening score on the STAT will significantly contribute to the variance in predicting autism spectrum disorder diagnosis in children ≤ three years-of-age.	--	Failed to Reject

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APPENDIX: ABBREVIATIONS

AAP	American Academy of Pediatrics
ADDM	Autism and Developmental Disabilities Monitoring Network
AD	Autistic Disorder
ASD	Autism Spectrum Disorder
Bayley-III	Bayley Scales of Infant and Toddler Development, 3rd Edition
BITSEA	Brief Infant Toddler Social and Emotional Assessment
CI	Confidence Interval
DLS	Daily Living Skills
DSM-III	Diagnostic Statistical Manual of Mental Disorders, 3rd Edition
DSM-IV	Diagnostic Statistical Manual of Mental Disorders, 4th Edition
DSM-V	Diagnostic Statistical Manual of Mental Disorders, 5th Edition
IDEIA	Individuals with Disabilities Education Improvement Act
ILE	Intensive Level of Evaluation
IRB	Institutional Review Board
M	Mean
M-CHAT/R	Modified Checklist for Autism in Toddlers, Revised
MSEL	Mullen Scales of Early Learning
N	Number of participants
NHS	National Health Service

PDMS-2	Peabody Developmental Motor Scales, 2^{nd} Edition
PDD	Pervasive Developmental Disorder
PDD-NOS	Pervasive Developmental Disorder – Not otherwise Specified
SD	Standard Deviation
SPSS	Statistical Package for Social Sciences
STAT	Screening Tool for Autism in Toddlers and Young Children
TOTS	Technology - assisted Observation and Teaming Support
WCEC	Weisskopf Child Evaluation Center

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OTHER POSITIONS AND EMPLOYMENT:

Behavior Technician
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Provide Applied Behavioral Analysis (ABA) therapy to children ages 7-21.
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Provide ABA therapy to children ages 2-12.
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Behavior Technician
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Provide ABA therapy to children ages 2-7
June 2013-December 2014

CERTIFICATION AND LICENSURE:

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July 2015-2016

PROFESSIONAL MEMBERSHIPS AND

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Member of National Student Speech-Language-Hearing Association (NSSLHA)
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Member of Omicron Delta Kappa
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Member of Gamma Sigma Alpha
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Member of Psi Chi
2010-2013

HONORS AND AWARDS:

Dean's list
Fall 2009, Fall 2011, Spring 2011, Spring 2013

Steckol Kentucky Speech-Language-Hearing Association (KSHA) scholarship
February 2017

EDUCATIONAL ACTIVITIES:

Stuttering Support Group Leader, Louisville, KY
Assisted development of and led support group for school age children and their parents.
September- December 2017

Frazier Rehab Aphasia Group Volunteer, Louisville, KY
Facilitated small and large group discussions to encourage verbal expression and comprehension using supported communication techniques.
September- November 2017

CLINICAL ACTIVITIES:

Associates in Pediatric Therapy, Pediatric Private Practice Practicum Site, Shepherdsville, KY
Provided and evaluated children with speech and language deficits secondary to diagnoses of Autism Spectrum Disorder and Verbal Apraxia. Utilized play based and milieu teaching therapy styles. Also gained valuable experience coaching and encouraging children using Accent 1000 augmentative devices.
January 2018- current

Baptist Eastpoint, Pediatric Outpatient Services Practicum Site, Louisville, KY

Primarily provided therapy to children with speech and language deficits secondary to diagnoses of Down Syndrome, Cerebral Palsy, and Autism Spectrum Disorder. Other populations in which I provided therapy included clients with selective mutism, fluency disorders, oral-motor dysfunctions, and auditory processing disorders. Coached children using augmentative communication devices including the Tobii Dynavox Eye Tracking Device, Tobii Dynavox t10 with Compass and Communicator5 software, and Boardmaker.
August- December 2017

University of Louisville Hospital, Acute Care Inpatient Services Practicum Site, Louisville, KY
Performed and provided therapy for clients with dysarthria, aphasia, cognitive, and voice disorders secondary to diagnoses of stroke, trauma, tracheostomies, and laryngectomees. Assessments included beside swallow examinations and Modified Barium Swallow Studies (MBSS). Also, participated in treatment of clients to facilitate verbal communication using tracheoesophageal prosthesis (TEPs), esophageal speech, and electrolarynx.
June- August 2017

Shelby Traditional Academy Elementary School, ***Mini-Practicum Site***, Louisville KY
Planned and administered therapy to diverse groups of children. Therapy included articulation, social skills, cognitive skills, and receptive and expressive language goals.
October- December 2016

Behavioral Analysis Center for Autism (BACA), Behavior Technician, Fishers, IN
Provided one-on-one ABA therapy and social groups for children with autism aged 2- 7 years old. Also, trained incoming therapists on ABA therapy. Assisted in developing goals for my clients and administered the VB-MAPP (Verbal Behavior Milestones Assessment and Placement Program), a criterion-referenced assessment tool for children with autism.

Worked under the supervision of Barbara Esch, BCBA-D, CCC-SLP, creator of *Early Echoic Skills Assessment*, part of VB-MAPP.

My therapy sessions featuring therapy-through-play approach were video recorded and presented at national conferences including Hoosier Association Behavior Analysis conference and KY ABA conference. My videos are currently still being used by Mark and Carl Sundberg (authors of the VB-MAPP) in

conferences around the US to help train parents and educators of children with autism.
2014-2015