An Examination of Measures Associated with the Differential Diagnosis of Autism Spectrum Disorder Within a University-Based Clinic Sample

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by

Tiffany K.N. Torigoe-Lai, M.Ed.

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Department of Human Services
Curry School of Education
University of Virginia
Charlottesville, Virginia

APPROVAL OF THE DISSERTATION

This dissertation, "An Evaluation of Measures Associated with the Differential Diagnosis of Autism Spectrum Disorder Within a University-Based Clinic Sample" has been approved by the Graduate Faculty of the Curry School of Education in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Clinical Psychology.

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Dr. Ronald Reeve (Chair)

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Dr. Jane Hilton

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Dr. Peter Patrick

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Dr. Michael Solis

_____Date

DEDICATION

I dedicate this work to my husband, Jeremy, who has always believed in me. He has been my rock throughout my time in graduate school and has given me strength when I thought I had none to give. You were right, honey. I can do it. This will be the one and only time I acknowledge that in writing.

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Overview of Three Manuscript Dissertation

This line of research investigates potential barriers in current diagnostic methods and treatment services for individuals with ASD to provide further insight into areas that can be improved and fostered. Given the vast heterogeneity of the disorder, more research is needed to examine sub-populations of ASD. My dissertation is comprised of three manuscripts that explore diagnostic and intervention methods for different sub-populations of ASD within research and clinical settings.

This dissertation adheres to the parameters set forth by the Curry School of Education Guidelines for Manuscript Style Dissertations. As required by the guidelines, I am the lead author on the first and third papers, and contributed substantially to the second paper as the second author. The first paper, "Factors Associated with the Timing of Autism Spectrum Disorder Diagnosis Amongst Simplex Families," was submitted to the *Journal of Autism and Developmental Disorders*, though it was not accepted for publication. This paper is currently being revised and will be resubmitted to a different journal in the near future. Manuscript Two, "An Evaluation of Behavioral and Developmental Communication Interventions for Children with Autism Spectrum Disorder," was submitted to the *American Journal of Speech-Language Pathology* and is currently under review. The third study, "An Examination of Measures Associated with the Differential Diagnosis of Autism Spectrum Disorder Within a

University-Based Clinic Sample," will be submitted for publication to *Research in Autism Spectrum Disorders* after successful completion of the dissertation.

Linking Document

This line of research investigates potential barriers clinicians may face when identifying appropriate diagnostic methods and treatment services when evaluating individuals for ASD within various contexts (e.g., research, clinical). Each study examines diagnostic procedures and intervention methods within different sub-populations of ASD (e.g., simplex, multiplex) with the aim to identify more effective diagnostic and treatment modalities based on different clinical phenotypes. The first and third studies explored issues surrounding diagnosis of ASD in research and clinical contexts, respectively. The first explored these issues within a homogenous simplex ASD population, whereas the third examined diagnostic procedures within a heterogeneous mixed clinical population. The second paper examined treatment outcomes and identified barriers to clinician and family adherence to a clinical intervention program developed for young, minimally verbal children with ASD.

The first paper, "Factors Associated with the Timing of Autism Spectrum Disorder Diagnosis Amongst Simplex Families," explored various demographic and clinical factors (race, ethnicity, gender, child intellectual functioning, socioeconomic status [SES], history of regression, and language development history) associated with age of ASD diagnosis using a large nationwide research sample from the Simons Simplex Collection (SSC). This initial study focused on barriers to diagnosis within research settings given that the SSC is one of the largest repositories for ASD research.

The extant literature on this topic paints a murky picture with regard to the role of child and family demographic factors of when a child receives an initial ASD diagnosis, and no study to date has examined the critical role of expressive language development in the early identification of children with ASD. Results indicated that Asian and Hispanic children are diagnosed at younger ages than Caucasian children within our sample. Additionally, children who developed phrase speech at younger ages received diagnoses earlier than those with delayed speech, and those with reported skill regression received diagnoses earlier than those with no loss of previously acquired skills. However, these characteristics only accounted for 2% of the variance in our model, implying that other factors are more salient as to when a child receives an ASD diagnosis within this population of simplex families. We hypothesize that something within current ASD assessment processes may be contributing to misdiagnosis and missed diagnoses, rather than individual child characteristics, which in turn may be influencing the timing of diagnosis.

To learn more about potential barriers and benefits of interventions for children with ASD in a clinical setting, the author aided in assessing a six-week clinic-based language intervention program aimed at improving communication skills for young, minimally verbal children with ASD. This second manuscript, “An Evaluation of Behavioral and Developmental Communication Interventions for Children with Autism Spectrum”, evaluated the feasibility of enrolling, retaining, and treating children with ASD, as well as assessed outcomes after treatment between the two intervention approaches: behavioral and developmental. Results revealed substantial gains in word count and notable gains observed in gesture use and non-word vocalizations within the

clinic setting as well as by parents at home. Verbalizations (single words and word combinations) showed the strongest increase from pre-treatment to post-treatment. Changes in overall ASD symptomatology were largely observed in the communication domain as these behaviors were most notably improved from pre-treatment to four-month follow-up. In regards to treatment effects between the two interventions, behavioral and developmental, the behavioral group had greater gains on a measure of functional communication from pre- to post-treatment, whereas the developmental group had more parent-reported gains from post-treatment to four-month follow-up. Lastly, results revealed that the intervention program was both acceptable and feasible to parents, with high rates of satisfaction and notable treatment gains. The most commonly endorsed barriers to consistent participation included the cost of the intervention as well as the amount and clarity of requested questionnaires. Feedback from clinicians was generally positive but highlighted the need for more in-depth training of each approach and modifications to the training materials to improve clarity and familiarity with the interventions.

These findings support the intervention's benefit to targeted language skills for this sub-population of young, minimally verbal children with ASD, as improvements in language exceeded other ASD related-areas, such as repetitive behaviors and social interactions. Additionally, the program was well accepted by participants with noted benefits, supporting continuation of the clinic-based program. Most importantly, this pilot data suggest that young, minimally verbal children with ASD can benefit from both short-term behavioral and developmental interventions by improving basic communication skills (e.g., increase in vocabulary, non-verbal gestures), which

subsequently reduced ASD symptomology as reported by their parents. Future, larger efficacy studies on interventions with this ASD sub-population are needed to further explore the impact of short-term targeted language interventions within a clinical setting.

The third study, "An Examination of Measures Associated with the Differential Diagnosis of Autism Spectrum Disorder Within a University-Based Clinic Sample," aims to build on informing diagnostic practices within a clinical setting. Within the literature, there is much debate as to whether past or current nosological systems possess the necessary sensitivity and specificity to accurately identify ASD (McPartland, Reichow, & Volkmar, 2012; Wilson et al., 2013). Within research settings, diagnostic batteries tend to be more rigorous and standardized, allowing for less variation in diagnostic procedures (Barbaresi, Colligan, Weaver, & Katusic, 2009; Matson & Kozlowski, 2011). There is also a further emphasis on extensive training on ASD measures; thus, researchers and clinicians working on ASD-specific research studies tend to be more experienced in working with the ASD population (Barbaresi et al., 2009; Matson & Kozlowski, 2011). In contrast, within clinical settings, batteries are more varied due to timing and availability of resources (Barbaresi et al., 2009; Matson & Kozlowski, 2011). Additionally, professionals have varying levels of expertise in making ASD diagnoses, as they have differing levels of clinical training and experience (e.g., clinical psychologist, school psychologist, speech and language pathologist) (Barbaresi et al., 2009; Matson & Kozlowski, 2011). In addition to the vast heterogeneity of diagnostic procedures across settings, a dearth of research exists on how to distinguish ASD from other neurodevelopmental or psychiatric disorders with overlapping symptoms (Matson & Cervantes, 2014). This third paper aimed to fill that gap by exploring the role cognitive,

autism-specific, adaptive, and behavioral measures play in determining a clinical classification of ASD in comparison to other neurodevelopmental or psychiatric disorders within a university-based clinic sample. Findings from this third study provided insight into which measures were most salient in the differential diagnostic process among our ASD sub-population, as well as offered preliminary data about the qualitative and quantitative utility of the ADOS in the diagnostic process.

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Factors Associated with the Timing of Autism Spectrum Disorder Diagnosis Amongst Simplex Families

Tiffany K. Torigoe-Lai & Ronald E. Reeve

University of Virginia

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Abstract

Using a large nationwide sample from the Simons Simplex Collection, the current study sought to examine which demographic (race, ethnicity, gender, socioeconomic status) and clinical factors (intellectual functioning, regression history, language development) are associated with age of receiving an ASD diagnosis. Results revealed that Asian and Hispanic children are diagnosed at younger ages than White children. Additionally, children who developed phrase speech at younger ages received diagnoses earlier than those with delayed speech. Furthermore, children with reported skill regression received diagnoses earlier than children who did loose any previously acquired skills. However, these characteristics only accounted for 2% of the variance in the model, implying that other factors are more salient in which children receive an ASD diagnosis.

Manuscript One: Factors Associated with the Timing of Autism Spectrum Disorder Diagnosis Amongst Simplex Families

Individuals with Autism Spectrum Disorder (ASD) have difficulties initiating, interpreting, and utilizing appropriate social communication behaviors as well as display rigid, restricted interests and/or repetitive behaviors that impede their daily functioning (American Psychiatric Associaton [APA], 2013). Emerging theories regarding the underlying mechanisms of ASD suggest that early intervention can reduce the severity of ASD symptoms and reroute brain development toward a normal trajectory (Ben Itzchak et al. 2008; Courchesne et al. 2007; Dawson, 2008; Just et al. 2012). Neural development and brain plasticity are most malleable in young children aged 18 to 48 months (Courchesne et al. 2007; Johnston, 2004; Rosenzweig & Bennett, 1996); thus, highlighting a sensitive period for early diagnosis and intervention for children with ASD. In addition to reducing the severity of ASD symptoms and aiding brain development, early intervention is associated with positive gains in cognitive performance, adaptive behaviors, language skills, social communication skills, and successful integration into mainstream classrooms (Ben Itzchak et al. 2008; Eldevik, Hastings, Jahr, & Hughes, 2012; Reichow, 2012; Rogers et al. 2012; Warren et al., 2011). Children aged three years and under typically make greater cognitive and social gains from these early intervention services (Ben Itzchak & Zachor, 2011; Dawson et al. 2012).

In order to access early intervention services, children generally need to obtain a formal ASD diagnosis (Barton, Dumont-Mathieu, & Fein, 2011; Mandell, Listerud, Levy, & Pinto-Martin, 2002; Rogers, 1998; Shattuck & Grosse, 2007). For example, various state-specific waivers and insurance laws provide benefits to children with ASD but are contingent on diagnosis (Shattuck & Grosse, 2007). Moreover, the Individuals with

Disabilities Education Act, 20 U.S.C. § 1400 (2004) identified "Autism" as a separate category and mandated public schools to provide special education and related services for children with ASD (National Dissemination Center for Children with Disabilities [NDCCD], 2012). However, the child must be diagnosed with ASD before receiving such services (NDCCD, 2012). Given that many intervention services hinge on a diagnosis of ASD, early identification is critical.

Research has shown that ASD can be reliably diagnosed as early as two years of age (Eaves & Ho, 2004; Kleinman et al. 2008; Stone et al. 1999). Additionally, by the age of two, children with ASD begin to demonstrate significant deficits in cognitive, social, and motor functioning in comparison to typically developing peers (Jeans, Santos, Laxman, McBride, & Dyer, 2013). However, recent studies have shown that many children with ASD are not formally diagnosed until age of four or older (Centers for Disease Control and Prevention [CDC], 2014a; Rosenberg, Landa, Law, Stuart, & Law, 2011; Shattuck et al. 2009; Valicenti-McDermott, Hottinger, Seijo, & Shulman, 2012; Wiggins, Baio, & Rice, 2006; Yeargin-Allsopp et al. 2003), potentially limiting access to early intervention services during the critical age period of early childhood.

Factors Influencing the Timing of ASD Diagnosis

Race and ethnicity

The majority of research examining factors contributing to the timing of ASD diagnosis has focused on race and ethnicity. A few studies (Mandell, Novack, & Zubritsky, 2005; Wiggins et al. 2006) suggested that race and ethnicity were not associated significantly with age of diagnosis. More recent studies suggest that the inequalities with the timing of an ASD diagnosis *are* based upon race and ethnicity

(Mandell et al. 2002; Mandell et al. 2007; Mandell et al. 2009; Rosenberg et al. 2011; Valicent-McDermott, Hottinger, Seijo, & Shulman, 2012). When reviewing the health and educational records of participants in the Autism and Developmental Disabilities Monitoring (ADDM) Network, a large population-based sample of eight-year-old children with ASD, Mandell et al. (2009) found that racial and ethnic minority children have a greater chance of being diagnosed after the age of eight, which is much later than White children. Similarly, Mandell et al. (2007) reported that Medicaid-eligible African American children were almost three times more likely than White children to receive another diagnosis before ultimately being diagnosed with ASD; thus, being at risk for delayed intervention. Valicenti-McDermott and colleagues (2012) found that Hispanic and African American children were more likely to be diagnosed with ASD after four years of age in comparison to White children. A few other studies found similar results regarding African American children on the spectrum (Mandell et al. 2002; Rosenberg et al. 2011). Collectively, Hispanic, African American, and other racial minorities have been found to be more likely to be diagnosed later than White children.

Gender

Given that ASD is five times more common among boys than girls (CDC, 2014a), one might expect gender to have a significant influence on timing of an ASD diagnosis; however, the findings are mixed. Several studies suggest that gender has little influence on the age of diagnosis (Fountain, King, & Bearman, 2011; Mandell et al. 2002; Mandell et al. 2005; Mandell et al. 2010; Rosenberg et al. 2011; Valicenti-McDermott et al. 2012), while others have found that girls are diagnosed with ASD at much later ages than boys (Beerger et al. 2013; Shattuck et al. 2009; Yeargin-Allsopp et al. 2003). This finding may

be explained by theorized gender differences within the ASD profile. A higher incidence of emotional and internalizing problems exists among females, whereas males have greater externalizing and interpersonal problems (Baron-Cohen, Knickmeyer, & Belmonte, 2005; Mandy et al. 2012), which are more readily apparent. Given this, ASD symptoms may be more discernable in males. While a few studies have found gender differences to influence the timing of ASD diagnosis, the majority of research has shown that gender does not seem to have an impact on the timing of ASD diagnosis.

Child intellectual functioning

According to data from the ADDM Network, the prevalence of intellectual disability (ID) amongst children with ASD has decreased from 47% in 2002 to 31% in 2010 (CDC, 2014a). Although higher rates of children with ASD with average to above average cognitive abilities are being identified, recent literature suggests that lower child IQ is associated with the timing of ASD diagnosis but there are inconsistent findings as to whether it is linked with earlier or later diagnosis. Various studies suggest that children with an IQ equal to or less than 70 are more likely to be diagnosed with ASD earlier than children who do not display cognitive impairment (Kalkbrenner et al. 2011; Mandell et al. 2009; Shattuck et al. 2009). In contrast, Rosenberg, Landa, Law, Stuart, and Law (2011) found that children with a co-morbid diagnosis of ID were diagnosed at later ages. Other research found no association between the IQ and age of diagnosis (Fountain et al. 2011; Mandell et al. 2005; Wiggins et al. 2006). In general, there are disparate findings within the literature, suggesting further research is needed to determine whether IQ is a salient factor in predicting the timing of ASD diagnosis.

Socioeconomic status

Several studies have evaluated proxies for socioeconomic status (SES), such as parental education and household income, to the timing of an ASD diagnosis. Similar to studies on the impact of child IQ, there are mixed results. A few studies found that families with either higher parental education or higher household income were diagnosed at earlier ages (Fountain et al. 2011; Mandell et al. 2005), and lower maternal education was associated with a later age of diagnosis (Mandell et al. 2009). In contrast, a few studies found that maternal education was not significant in predicting timing of an ASD diagnosis (Rosenberg et al. 2011; Shattuck et al. 2009; Valicenti-McDermott et al. 2012). Given the mixed findings regarding SES, additional research is also needed in this area to confirm its effect on the timing of ASD diagnosis.

Language development

Psychologists and medical practitioners rely heavily on parental report of early developmental concerns to detect ASD in children (Hess & Landa, 2012). A majority of parents of children diagnosed with ASD were first concerned about their child's language development (Anderson et al. 2007; Coonrod & Stone, 2004; Hess & Landa, 2012; Kozlowski, Matson, Horovitz, Worley, & Neal, 2011). Earlier age of first words, a more objective milestone marker than social communication behaviors (e.g., joint attention, social smiling), is predictive of later development of children with ASD (Mayo, Chlebowski, Fein, & Eigsti, 2013). Additionally, children with ASD who have less developed language abilities have poorer long-term prognoses (Anderson et al. 2007). Current literature also suggests cultural differences can influence parental report of developmental concerns. Tek and Landa (2012) found that racial and ethnic minority parents of children with ASD have difficulty identifying more subtle impairments in

social and communications skills; therefore, parents of racial and ethnic minority backgrounds might identify problem areas in more global areas, such as expressive language delays. Given the importance of these objective language milestone markers, the timing of language development might correlate with the age of ASD diagnosis. To our knowledge, however, no study has specifically examined the effect of age of first word and phrases on the timing of ASD diagnosis.

Another primary concern associated with language is regression, a loss of previously acquired abilities, characteristically in expressive language skills (Bernabei, Cerquiglini, Cortesi, & D'Ardia, 2007). The prevalence of regression in the ASD population ranges from 20 to 47% and onset can range from 10 to 42 months (Bernabei et al. 2007; Kalb, Law, Landa, & Law, 2010; Ozonoff et al. 2010; Werner, Dawson, Munson, & Osterling, 2005). The presence of developmental regression has been associated with earlier age of diagnosis (Rosenberg et al. 2011; Shattuck et al. 2009); though, only a few studies have evaluated this factor.

Study Proposal

Collectively, the extant literature paints a murky picture with regard to the role of individual development and demographic factors in the timing of ASD diagnosis, and no study to date has examined the critical role of expressive language development in the early identification of children with ASD. Moreover, many of these studies had similar limitations, such as smaller sample sizes, samples restricted to specific diagnoses (e.g., autism only) rather than a more heterogeneous population of ASD, and limited ability to confirm previously parent-reported ASD diagnosis or those obtained from medical

records (Mandell et al. 2007; Mandell et al. 2010; Mandell et al. 2005; Mandell et al. 2009; Shattuck et al. 2009; Wiggins et al. 2006).

The current study seeks to address these limitations by examining a large, nationwide (and one Canadian site) sample of children with ASD from the Simons Simplex Collection (SSC) (consisting of families in which only one child is diagnosed with ASD). Specifically, the current study explores the impact of race, ethnicity, child IQ, gender, SES, and expressive language development (age of first word, age of phrase use, presence of developmental regression) on age of initial ASD diagnosis. Given the findings reviewed above, we hypothesize non-Hispanic, Caucasian children of higher SES, below average IQ, with delayed language skills, and history of regression are diagnosed at earlier ages. Additionally, we postulate that male gender will be associated with earlier age of diagnosis.

Methods

Data

The current study utilized data from the Simons Simplex Collection (SSC), a publically available dataset of the Simons Foundation Autism Research Initiative (SFARI). The Institutional Review Board at the University of Virginia approved the study prior to accessing the data. The SSC is a multi-site study that collected genetic and phenotypic data on approximately 2,600 families beginning in 2007 and ending in 2011. Families who participated in the study had one child with ASD upon inclusion and no parent, sibling, or first- through third-degree relatives on the autism spectrum (i.e., simplex families; SFARI, 2014). Families were recruited through 12 university-affiliated clinics that serve children with ASD: Baylor College of Medicine, Columbia University,

Emory University, Harvard University/Children's Hospital Boston, McGill University, University of California at Los Angeles, University of Illinois at Chicago, University of Michigan, University of Missouri, University of Washington, Vanderbilt University, and Yale University (Simons Foundation Autism Research Initiative [SFARI], 2014). Among the clients each clinic was already serving, families seeking initial diagnosis of ASD were prioritized for recruitment into the SSC to prevent overlap with other large ASD repositories (Fischbach & Lord, 2010). A more detailed description of the recruitment and data collection methods can be found in other sources (Fischbach & Lord, 2010; SFARI, 2014).

Measures and Variables

ASD diagnosis

ASD diagnosis was derived from a standardized diagnostic protocol utilizing scores from the Autism Diagnostic Interview – Revised (ADI-R; Lord, Rutter, & Le Couteur, 1994; Lord, Rutter, & Le Couteur, 2003) and the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000; Lord, Rutter, DiLavore, & Risi, 2001) along with the clinician's "best estimate diagnosis" to categorize probands into one of four categories: Autistic Disorder, Autism Spectrum Disorder, Asperger's Disorder, or NonSpectrum (SFARI, 2014).

The ADI-R is a standardized, semi-structured interview conducted with parents or caregivers of individuals with ASD that provides a diagnostic algorithm consistent with the *International Classifications of Diseases, 10th Edition* (ICD-10; World Health Organization, 1992) and *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition – Revised* (DSM-IV-TR; APA, 1994) definition of autism (Lord et al. 1994). The

interview focuses on parental/caregiver report of behaviors occurring between the ages of four to five, as well as behaviors currently observed. The 93 items within the protocol are assigned a severity score based on the interviewer's judgment of the parent/caregiver report (Lord et al. 1994). The ADI-R algorithm yields excellent specificity and sensitivity, both exceeding .90, in addition to high reliability over time across each domain (inter-rater reliability ranging from .62 to .89) and high validity (.96 for the overall algorithm) (Lord, et al. 1994). The ADOS is a standardized, semi-structured assessment of communication, social interaction, play, imagination, repetitive behaviors, and restricted interests designed to complement information obtained on the ADI-R (Gotham, Risi, Pickles, & Lord, 2007). The measure is broken into four modules, which are based on developmental age and language levels, ranging from no language to verbally fluent children and adults (Gotham et al. 2007). The ADOS yields high specificity and sensitivity, generally achieving 94% correct classification (Gotham et al. 2007).

Age of diagnosis

The ADOS, ADI-R, and cognitive and adaptive measures were given as part of the clinical battery evaluating initial diagnosis at each participating clinic. The ADOS, ADI-R, and cognitive measures were collected within the same six-month period (SFARI, 2014); thus, proband age at the time of the ADOS administration was used as an estimate of age of ASD diagnosis.

Demographic data

Proband race, ethnicity, and gender were derived from the SSC Background History Form, which contains family demographic information and parental report of the

proband's developmental milestones (SFARI, 2014). Annual household income and highest level of maternal and paternal education were also obtained through the SSC Background History form. The SSC Background History form was administered to parents as a phone interview by SSC staff (SFARI, 2014).

Language and communication history

Data regarding proband age of first word and phrases were obtained from the ADI-R to determine the child's developmental language milestones. Additionally, the ADI-R also measured whether the proband experienced a loss of previously acquired language and/or communication skills (i.e., regression).

Cognitive ability

Various cognitive measures, including the Differential Ability Scales, 2nd Edition (DAS-II; Elliott, 2007), Mullen Scales of Early Learning, AGS Edition (Mullen, 1995), Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999), and the Wechsler Intelligence Scale for Children, Fourth Edition (WISC-IV; Wechsler, 2003), were used to generate a standard score reflecting Full Scale IQ that estimates overall intellectual ability for each proband (SFARI, 2014).

Results

Analyses

Descriptive analyses

The study used 2,642 probands from the SSC. Sample characteristics are presented first and then compared descriptively to US census data as well as another large, nationwide sample of children with ASD, the ADDM Network, to provide insight into the generalizability of these findings to other populations of children in the US.

Demographic variables

Table 1 provides a demographic breakdown of the SSC sample used in the analyses. Similar to the 5:1 male-to-female ratio reported by the CDC (2014a), most probands were male (86.7%). However, the male-to-female distribution significantly differed from the ADDM Network ($x^2(1) = 40.145$, $p < .001$) with more males in the SSC. In regards to race and ethnicity, there were no differences between White ($x^2(1) = 0.99$, $p = 0.32$) and Native American/Native Hawaiian ($x^2(1) = 1.41$, $p = 0.24$) populations in the SSC sample and the national average (United States Census Bureau, 2014). However, chi-square tests revealed that African American ($x^2(1) = 198.94$, $p < .001$), Asian ($x^2(1) = 6.27$, $p = .001$), multiracial ($x^2(1) = 343.07$, $p < .001$), and Hispanic ($x^2(1) = 51.39$, $p < .001$) populations in the SSC were statistically different from the 2013 US census data. There was an underrepresentation of African Americans (3.9% of probands compared to 13.2% of the US population), Asians (4.2% of probands compared to 5.3% of the US population), and Hispanics (11.1% of probands compared to 17.1% of the US population) (United States Census Bureau, 2014). Additionally, multiracial individuals comprised more of the racial distribution in the SSC (8.0%) in comparison to the national average (2.4%) (United States Census Bureau [UCSB], 2014). The median annual household income of the SSC sample fell within the range of $81,000 to $100,000 a year, in comparison to the median US household of approximately $52,000 (United States Census Bureau, 2014). Additionally, more than 50% of parents in the SSC obtained a bachelor's degree or higher compared to 32% within the US population (UCSB, 2013).

Clinical variables

Table 2 outlines the clinical characteristics of interest for the study sample. A chi-squared test revealed that the distribution of IQ was statistically different between the SSC and ADDM Network ($x^2(2) = 12.03$, $p = .002$). In the SSC sample, almost half of the probands (48.9%) had average to above average (IQ > 85) cognitive abilities in comparison to 46% of probands within the ADDM Network (CDC, 2014a). Additionally, about half of the SSC probands experienced delays in obtaining single words and phrases by developmental milestones of 18 and 24 months, respectively (CDC, 2014b). Approximately 35% of SSC probands experienced a loss of previously acquired language or communication skills per parent report in comparison to prevalence rates of 20-49% among the ASD population (Bernabei et al. 2007). Given the various demographic and clinical differences between the SSC, the ADDM Network, and the US census, the SSC sample will be described as a "nationwide" sample of families with one child with ASD, rather than a "nationally representative" sample.

Mean age of diagnosis

The mean age of diagnosis within the SSC sample was 9 years, 6 months, falling within a range of four to 18 years. The majority of the sample consisted of young children and adolescents aged between four and 12 years (83.3%). In comparison, the mean age of diagnosis in the ADDM Network is 3 years, 8 months (CDC, 2014a), which is significantly younger than the mean age within the SSC sample ($t(6462) = 67.15$, $p < .001$). However, SSC recruitment eligibility started at four years, thus contributing to a higher mean age of the sample.

Predictors of age of diagnosis: linear regression

Multicollinearity was observed (VIF ≥ 5) between the SES proxy variables (mother's highest level of education, father's highest level of education, annual household income); therefore, factor analysis was used to create a single SES variable (all factor loadings > .60)[1]. Each of the items making up the factor score had less than 5% missing values. However, the factor score had 12% missing values. To see if these could be considered missing at random, a missing value analysis was conducted in SPSS, Version 21 and indicated that the missing data could be considered missing at random. Multiple imputation was performed in SPSS, Version 21 to handle missing values. Five imputed data sets were generated and the pooled analysis results are reported here.

Using multiple linear regression with simultaneous entry, we examined the association of proband race, ethnicity, gender, IQ, age of first words, age of first phrase speech, regression history, and SES with age of ASD diagnosis (Table 3). This 18 predictor model accounted for 2% of the variance in age of diagnosis ($F(14,2641) = 4.21$, $p < .001$, $R^2 = .022$). Effect size was measured by Cohen's F, $f^2 = 0.02$, and indicated a small effect by Cohen's conventions (Cohen, 1988). Examination of Table 3 reveals that Asian probands ($B = -10.32$, $p = .015$) were, on average, diagnosed 10 months earlier than White probands. There were no differences among other races. With regard to ethnicity, Hispanic probands ($B = -7.82$, $p = .01$) were diagnosed approximately 7 months earlier than non-Hispanic probands. Probands whose parents reported that their child lost skills related to communicative intent or social engagement ($B = -9.55$, $p = .014$) and those who may have lost language or communicative skills ($B = -10.85$, $p < .001$) were both more likely to be diagnosed at an earlier later age than those who did not experience

[1] The eigenvalue for the 1-factor solution (1.93) relative to the 2-factor solution (0.58) indicated that the 3 SES proxy variables were best characterized as a single factor.

any loss of skills in the past. Probands that attained phrase speech earlier ($B = 0.25$, $p = .001$) received a diagnosis before those that spoke using phrases at older ages or did not attain phrase speech at all. Proband age of first word was not associated with age of diagnosis. Additionally, gender, IQ, and SES were not statistically significant in predicting age of diagnosis in the model.

Discussion

The results in this study suggest that race, ethnicity, and factors affecting early language and communication development are correlated with age of ASD diagnosis. Of the demographic factors, only race and ethnicity were associated with age of diagnosis. In the SSC, a child's race and ethnicity had an inverse effect on the timing of ASD diagnosis, contrary to the majority of previous research. Prior studies have found that racial minorities and Hispanic/Latino children were diagnosed later than White children (Mandell et al. 2002; Mandell et al. 2009; Rosenberg et al. 2011; Shattuck et al. 2009; Valicenti-McDermott et al. 2012; Wiggins et al. 2006). Within the SSC, Asian and Hispanic children were diagnosed 10 and 7 months earlier, respectively, than White children. Given that the SSC sample starts at age four, it is possible that those who received ASD diagnoses through the SSC clinics were not identified early and therefore more likely to be non-White. These findings can also be representing emerging trends of how state-specific insurance waivers for ASD impact access to treatment and care. Many states passed insurance mandates specific for ASD over the SSC recruitment period from 2007-2011, which may have increased awareness and access to diagnosis and subsequent services for many underserved families. Further research regarding how insurance mandates for ASD affect access to care and timing of diagnosis is warranted.

While no association between gender, SES, and age of diagnosis was found in our sample, previous research in this area is conflicting. Some studies also found no association between gender and age of diagnosis (Mandell et al. 2005; Mandell et al. 2010; Rosenberg et al. 2011), while a few studies have found that females are diagnosed later than males (Begeer et al. 2013; Shattuck et al. 2009). Additionally, half of the research including SES as a factor found no association between SES measures and age of diagnosis (Valicenti-McDermott et al. 2012), whereas the other half found greater household income and higher parental education associated with earlier diagnosis of ASD (Shattuck et al. 2009; Rosenberg et al. 2011). Based upon our findings and previous research, outreach and interventions efforts aimed at supporting earlier diagnosis should be more inclusive of people from various demographic backgrounds rather than targeting specific groups.

In regard to skill regression, the findings of the current study are consistent with past research (Rosenberg et al. 2011; Shattuck et al. 2009). Loss of previously acquired social and communication skills was associated with earlier age of diagnosis. Previous research has also suggested that children presenting with more severe ASD-profiles, like regression, are diagnosed at earlier ages (Daniels & Mandell, 2014).

Our findings indicated that the development of expressive language skills also significantly impacted the timing of ASD diagnosis. Children who developed phrase speech after 24 months were diagnosed at later ages. For example, a child who developed phrase speech at three years, a year past the appropriate milestone (CDC, 2012b), was diagnosed three months later than a child who attained phrase speech at two years. Although language delays are characteristic of ASD, they are not unique to its diagnosis;

thus, children with significantly delayed phrase speech may receive an initial diagnosis of a language disorder before receiving a diagnosis of ASD. Additionally, parents and clinicians may adopt the "wait and see" approach or focus more on language interventions, further prolonging ASD diagnosis. Research has shown that having a language disorder diagnosis at two years is a salient indicator for other various developmental issues (Buschmann et al. 2008), further emphasizing the importance of giving attention to expressive language milestones. To the authors' knowledge, this is one of the first studies to examine expressive language milestones as a factor associated with age of diagnosis; thus, more research in this area is warranted. Child IQ, an additional clinical characteristic that was studied, was not associated with age of diagnosis. These findings are consistent with previous research (Mandell et al. 2005; Wiggins et al. 2006).

While this study found statistically significant factors associated with the age of ASD diagnosis, these factors only accounted for 2% of the variance within the SSC sample. This suggests that other demographic and clinical characteristics beyond the ones presented in this study may be associated with age of ASD diagnosis. We hypothesize that state insurance mandates specific to ASD may impact the timing of ASD diagnosis for the reasons stated earlier. Additionally, geographic location may be more salient in the timing of ASD diagnosis; though, the SSC did not make these data available. Rosenberg et al. (2011) found that children living in the Northeast were diagnosed significantly earlier than in other areas of the US. Additionally, emerging research has shown that families living in rural or non-metropolitan areas have children that are diagnosed at older ages (Daniels & Mandell, 2014). Lastly, the provider and setting of the diagnosis may have an effect on whether a child receives an earlier or later diagnosis.

Prior research has found that children are diagnosed at earlier ages in areas close to medical schools that also have easy access to neurologists and psychiatrists rather than those in close proximity to primary care physicians (PCP) or providers of early intervention services (Kalkbrenner et al., 2011). Additionally, children with a history of having multiple PCPs are at risk for later diagnoses, as research has suggested that specialty referrals are linked to earlier diagnoses (Mandell et al. 2005).

Limitations and Clinical Implications

There are several limitations that should be acknowledged. First, families included in this study only had one child with ASD and no other first-degree relatives with the diagnosis, also known as simplex families. Since the SSC is a more targeted population of individuals with ASD, it difficult to compare the study results to those conducted using the ADDM network, which included simplex and multiplex families (i.e., families with more than one individual on the spectrum). Further research is needed to explore the impact of these factors among multiplex families alone to explore potential differences between these populations. Secondly, the authors were unable to obtain more specific demographic information about the proband, such as birth order, year of diagnosis, or geographic location, which may have impacted timing of ASD diagnosis. Also, there was limited diversity in regard to SES, and African American and Hispanic populations were underrepresented in comparison to the national population, possibly skewing our results. Lastly, the collection of developmental history relied solely on parental report. Limitations of precise reporting of historical information, particularly for events that took place several years prior, may have impacted the accuracy of the data. Examination of medical records may help to lessen the historical threat to validity.

Despite these limitations, this study is one of only a few to utilize a large nationwide sample to examine factors associated with age of ASD diagnosis. It also brings further clarity to the existing research in this area. Moreover, the SSC employed stringent inclusion criteria as well as standardized diagnostic protocols for clinicians across data collection sites to prevent the increased likelihood of false positives (Fischbach & Lord, 2010), an issue with previous research (Mandell et al. 2009, Shattuck et al. 2009). These findings point to a few potential areas of clinical intervention. Parental concern has yielded higher specificity when compared to standardized tests for social communication concerns for ASD (Hess & Landa, 2012); therefore, increased parental/caregiver education and awareness about the early signs of ASD may help prevent missed ASD diagnoses. Additionally, given that clinical characteristics seem to be more salient factors associated with earlier age of diagnosis, further training regarding the signs of ASD to primary care and other health care professionals may aid with earlier identification. For example, the Autism Case Training Web-Based Continuing Education course (CDC, 2014c) provides free on-line educational training for health professionals on identifying, diagnosing, and treating those with ASD. Further research on the impact of such training programs can help with empirically identifying and developing interventions to assist with earlier identification of ASD.

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Appendix

Table 1

Demographic Characteristics of SSC Sample

Variable	n	Percentage
Race		
White	2071	79.0%
African American	103	3.9%
Asian	111	4.2%
Native American/Native	8	0.3%
Hawaiian		
Other	120	4.6%
More Than One Race	209	8.0%
Ethnicity		
Non-Hispanic	2344	88.9%
Hispanic	294	11.1%
Gender		
Male	2290	86.7%
Female	352	13.3%
Mother Highest Level of Education		
Less than Ninth Grade	5	0.2%
Some High School	1	0.0%
GED	52	2.0%
High School	188	7.1%
Some College	570	21.7%
Associate Degree	207	7.9%
Bachelors Degree	943	35.9%
Graduate Degree	664	25.2%
Father Highest Level of Education		
Less than Ninth Grade	8	0.3%
Some High School	52	2.0%
GED	43	1.6%
High School	272	10.4%
Some College	506	19.4%
Associate Degree	177	6.8%
Bachelors Degree	816	31.2%
Graduate Degree	739	28.3%
Annual Household Income		
Less than $20,000	76	3.0%
$21,000-$35,000	127	5.1%
$36,000-$50,000	213	8.5%
$51,000-$65,000	272	10.9%
$66,000-$80,000	346	13.8%
$81,000-$100,000	431	17.2%
$101,000-$130,000	386	15.4%
$131,000-$160,000	235	9.4%
Over $161,000	416	16.7%

Table 2

Clinical Characteristics of SSC Sample

Variable	n	Percentage	M	SD
IQ	2637		81.24	27.91
≤ 70	807	30.6%		
71-85	541	20.5%		
> 85	1289	48.9%		
Age of First Words (in months)	2539		24.40	14.89
Age of First Phrases (in months)	2381		39.16	18.32
Regression				
No Loss	1714	64.9%		
Word Loss	385	15.5%		
Other Loss	133	5.0%		
Possible Loss	410	14.6%		

Table 3

Summary of Linear Regression for Predictors of Age of Diagnosis

Variable	*B*	SE	95% CI
Constant	105.768	4.56	[96.83, 114.71]
Race			
White (ref)	1.00		
African American	-6.67	4.35	[-15.19, 1.86]
Asian	-10.32*	4.23	[-18.60, -2.03]
Native American/Native Hawaiian	-0.23	15.15	[-27.71, 27.26]
Other	-7.66	4.52	[-16.52, 1.21]
More Than One Race	-2.46	3.19	[-8.71, 3.80]
Ethnicity			
Non-Hispanic (ref)	1.00		
Hispanic	-7.821*	3.06	[-13.81, -1.83]
Gender			
Male (ref)	1.00		
Female	1.867	2.45	[-2.94, 6.68]
SES	-1.06	1.01	[-3.03, 0.92]
IQ	-0.003	0.04	[-0.07, 0.07]
Age of First Words	-0.10	0.09	[-0.28, 0.08]
Age of First Phrases	0.25*	0.07	[0.10, 0.39]
Regression			
No Loss (ref)	1.00		
Word Loss	-4.66	3.67	[-9.89,0.58]
Other Loss	-9.55*	3.90	[-17.20, -1.90]
Possible Loss	-10.85**	2.44	[-15.64, -6.06]
R^2	.02		
F	4.21**		

Notes. SE = standard error; CI = confidence interval.

*$p < .05$. **$p < .001$

An Evaluation of Behavioral and Developmental Communication Interventions for Children with Autism Spectrum Disorder

Stephany M. Cox, Tiffany K. Torigoe-Lai, Jane C. Hilton, Casey Paul, Julie Sadoff, & Ronald E. Reeve

University of Virginia

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Manuscript Two: An Evaluation of Behavioral and Developmental Communication Interventions for Children with Autism Spectrum Disorder

Introduction

Development and Diagnosis

For many years the three core criteria for Autism Spectrum Disorder (ASD) were deficits in communication, impairment in social reciprocity, and the presence of restricted interests or repetitive behaviors (DSM-IV-TR; American Psychiatric Association; APA, 2000). The newly released Diagnostic and Statistical Manual of Mental Disorders (DSM-5; APA, 2013) has modified the above diagnostic criteria to emphasize *two* core symptom clusters: Social Communication deficits and Restricted Interests and Repetitive Behaviors. Despite these changes, the centrality of deficits in communication remains consistent for the diagnosis of ASD, emphasizing the importance of research and clinical programs focusing on this area.

The acquisition and developmental trajectory of early communication skills for individuals with ASD differs widely across the population. Parents often report a delay in expressive language as the first indication of their child's atypical development (De Giacomo & Fombonne, 1998; Wetherby et al., 2004). Research has consistently reported variability in nonverbal and verbal communication skills among older children with ASD (Charman, 2003; Fernell et al., 2010; Matson, Kozlowski, & Matson, 2012; Wetherby et al. 2004), leading to numerous studies investigating early predictors of language development and future outcomes. It has been demonstrated that imitation (Stone & Yoder, 2001; Thurm, 2007), play skills (McCune, 1995; Ungerer & Sigman, 1984), joint attention (Dawson et al., 2004; Mundy, Sigman, & Kasari, 1990; Sigman et al., 1999), and cognitive ability (Lord & Schopler, 1989; Sigman et al., 1999) are predictive of

future communication outcomes.

Early Intervention

Research also has indicated that early communication skills can predict developmental trajectory and future outcomes (Dawson et al., 2004; Harris & Handleman, 2000; Stone & Yoder, 2001). Even though these early milestones inform later development, clinicians and researchers emphasize that early identification and intervention provide crucial contributions to more positive outcomes (Ben Itzack & Zachor, 2010; Landa, 2008; Wallace & Rogers, 2010).

Experimental research has demonstrated numerous positive effects of communication intervention for children with ASD including improved comprehension, production, and social use of language (Goldstein, 2002; Paul, 2008). Families and professionals are faced with a wide and assorted range of choices when selecting treatment approaches for individuals with ASD. Substantial evidence exists that there are efficacious interventions to promote language development in children with ASD (Goldstein, 2002; Koegel, 2000); however, researchers have emphasized the need for repeated empirical investigations into the numerous methods available (Boyd, Odom, Humphreys, & Sam, 2010; Howlin, Magiati, & Charman, 2009; Paul, 2008). As early diagnosis and intervention programs continue to be developed across the country, research has not yet identified the most effective method (or methods) of treatment for Autism Spectrum Disorder (Rogers & Vismara, 2008).

Intervention Methods

Behavioral Approaches. Behavioral approaches to intervention are based on the principles of learning theory and operant conditioning. At the core of this method is the

principle that human behavior is learned and governed by antecedents and consequences. Therefore, as it applies to children with ASD, individuals can learn new skills by presenting and/or modifying a given stimulus and providing reinforcement. During the implementation of these interventions, treatment goals are typically broken down into discrete steps, which are presented in a predetermined order that is guided by standard developmental sequences. Research has demonstrated that behavioral interventions have been implemented successfully to decrease negative behaviors as well as increase language, social, play, and academic behaviors (Schreibman, 2000). These programs are typically one-on-one in clinical or home settings, and emphasize the importance of consistent, intensive levels of treatment for up to 40 hours per week (Reichow, 2012).

Investigations into behavioral approaches dominate the literature; although these studies exhibit methodological differences and varied outcomes, there is clear evidence of the efficacy of this approach. Published studies to date have demonstrated that behavioral interventions result in increased adaptive functioning, language proficiency, and IQ scores (Eikeseth, Smith, Jahr, & Eldevik, 2002; Lovaas, 1987; Smith, Groen, & Wynn, 2000). Limitations of this approach have also been identified (Schreibman, 2000). Critics attest that due to the highly structured environments and dependence on prompts and reinforcers, language and other behaviors taught by this method often do not generalize to other environments (Schreibman, 1997). Additionally, reliable comparisons have not been made between behavioral methods and alternative treatment methods (reword and move to beginning of criticisms).

Developmental Approaches. Developmental approaches, which have also been referred to as relationship-based, focus on enhancing interactions and improving

relationships between the child and parent (or other involved individuals) by facilitating positive exchanges and promoting reciprocity. Research has supported the relational foundation of Developmental interventions, demonstrating that increased synchrony and responsive interactions encouraged by this approach result in increased communication skills (Siller & Sigman, 2002). Developmental impairments associated with ASD affect a child's ability to connect with others, specifically caregivers, resulting in fewer positive, reciprocal interactions. Emphasizing that key emotional, social, and language skills are obtained through such interactions, this approach promotes these exchanges by following the child's lead.

Although developmental, relationship-based methods of intervention are commonly utilized in clinical practice and partially developed out of criticisms of intensive behavioral interventions, there are notably fewer published studies evaluating this approach. The studies available have shown increases in emotional, social, cognitive, and language functioning (Greenspan & Wieder, 1997; Rogers, Hall, Osaki, Reaven, & Herbinson, 2000; Solomon, Necheles, Ferch, & Bruckman, 2007). A commonly cited advantage of this approach is that it is easier for parents and other nonprofessionals to learn, and responses are more easily generalized to other contexts. In addition to noting the small number of research studies examining this approach, criticisms have also addressed the variation of administration due to a lack of set protocols and differences between individual therapists (Zachor, Ben Itzchack, Rabinovitch, & Lahat, 2007).

Design and Research of Intervention Programs

From October 2002 to May 2004, a working group sponsored by the National Institute of Mental Health (NIMH) convened to address methodological challenges in

research on psychosocial interventions for Autism Spectrum Disorder (Lord et al., 2005; Smith et al., 2007). The group developed a model to systematically validate and disseminate interventions in a sequence of steps. The guidelines and recommendations were two-fold: 1) provide guidance to researchers on designing and conducting investigations on interventions for ASD; and 2) assist funding agencies in identifying current needs of the field and developing standardized criteria for assessing research proposals. As discussed above, previous research and literature reviews (Goldstein, 2002; Koegel, 2000) have documented efficacious intervention techniques to enhance language and communication skills for individuals with ASD; however, they are often missing the necessary components of monitoring the implementation and outcomes (Lord et al., 2005). Furthermore, the working group echoed the concerns of the American Psychological Association (APA) Task Force on Promotion and Dissemination of Psychological Procedures drawing attention to the *setting* where these interventions are evaluated (APA, 1995; Smith et al., 2007). Both groups called for adjusting the focus from *efficacy* of interventions in controlled treatment studies to *effectiveness*, "real-world" investigations in community settings. To successfully apply and disseminate effective interventions the group identified four phases for researchers to follow: (a) formulation and systematic application of the intervention method, (b) development of a manual and a predefined plan for the evaluation of the intervention across sites, (c) running randomized clinical trials (RCTs), and (d) conducting effectiveness studies on interventions in real world settings, conducted by community providers (Smith et al. 2007).

Rationale, Significance, and Purpose

Our previous investigation (see manuscript 1) compared outcomes of four language intervention approaches utilized by the UVA SPeech Language Intensive Summer Help (SPLISH) program during the summers of 2008, 2009, 2011, and 2012. The first two summers consisted of combined interventions, with two administration orders (Behavioral-Developmental or Developmental-Behavioral). The following two summers consisted of two individual approaches (Behavioral Only or Developmental Only). Results of pre-post analyses revealed improvement across a broad range of nonverbal and verbal communication skills (as measured by the Communication and Symbolic Behavior Scales; CSBS, Wetherby & Prizant, 1999). Notably those who received the individual approaches yielded more gains than those who received the combined approaches across several subtests and overall communication composite scores of the CSBS (see Table 1 on page 47).

The summer language program conducted in 2013 built upon the previously established intervention design and procedure, expanding the battery of measures as well as the time points at which data were collected. The intervention approaches utilized in this program were *Behavioral* and *Developmental,* a combination of the approach was not used due to previous findings noted above. The 9 children between ages 3 and 5 (*M =4.59,* SD = 0.91) who enrolled in this 6-week program were randomly assigned to receive either a *Behavioral* or *Developmental* approach. In addition to the clinical and communication measures administered at pretest and posttest, additional measures were collected at 2 and 4-months following the intervention. The battery of child measures and parent questionnaires collected at each time point was expanded to provide more

information about communication as well as ASD symptomatology, cognitive abilities, adaptive skills, intervention history, and satisfaction with the program (Table 1).

Aims and Hypotheses. The primary aims of this study were to evaluate the feasibility of enrolling, retaining, and treating children with ASD, and tracking outcomes after treatment. Secondary aims were the preliminary examination of treatment outcomes and therapist acceptance of the protocol. Due to the size of the study sample (N=9), these assessments were primarily conducted on the combined group, and then the two approaches were qualitatively examined separately.

Regarding the intervention program's feasibility/accessibility, we hypothesized the six-week intensive language intervention would be achievable and manageable for participants, their families, and therapists, with the following expectations: (a) All 9 participants would participate in the pretest, posttest, 2-month follow-up, and 4-month follow-up visits (0% attrition); (b) To account for an expected small number of unreturned questionnaires, we anticipated participants would complete over 90% of program requirements (treatment sessions, parent questionnaires, and child clinical measures); (c) Parents and clinicians would find both treatment approaches acceptable (as measured by Client Satisfaction Questionnaire-8 and Summary Therapist Feedback Form); (d) Greater perceived barriers of participation identified by parents (as measured by the Barriers to Treatment Participation Scale) would be positively correlated with rates of missed sessions and percentage of incomplete parent questionnaires and child measures.

Regarding preliminary efficacy evaluations, we hypothesized verbal and nonverbal communication outcomes, as measured by the CSBS and parent-report

language questionnaires (detailed below), would demonstrate greater gain by posttest, with maintenance and a more gradual increase in skills observed at the 2-month and 4-month follow-ups.

Method

Intervention Design and Procedures

Intervention Approaches. The summer programs utilized *Behavioral* and *Developmental* approaches to intervention. Both approaches were designed with goals established to focus on speech and language skills. These goals were broken down into separate steps, then sequentially taught to each child.

The *Behavioral* intervention involved a behavior modification approach for increasing desired behaviors in a client. The steps of this program included: 1) Child chooses reward; 2) Antecedent (stimulus) was presented; 3) Behavior was observed and child was prompted if necessary; 4) Behavior reinforced with token; 5) Reward provided after 10 tokens.

The *Developmental* intervention involved following the child's actions and expanding their communication to increase desired behaviors. Children who received this intervention approach had access to the same toys, materials, media, and activities as those who received the *Behavioral* approach; however, the children were allowed to direct the session by selecting which activity to begin. The steps of the *Developmental* intervention program included: 1) Observe client behavior; 2) Open circle of communication; 3) Follow the child's lead; 4) Expand or extend; 5) Close circle of communication.

Group Assignment. In order to control for internal validity threats from possible between-subject variables, participants were carefully screened and paired before pairs were randomly assigned to the intervention groups. Participants were manually matched as closely as possible on the following criteria: gender, chronological age, pre-test communication skills and functional language stage (CSBS, PPVT-4), ASD symptoms and severity (ADOS-2), adaptive skills (ABAS-II) and amount of intervention previously received. The amount of intervention received was reviewed by Dr. Hilton who qualitatively matched participants based on overall amount and intensity of past intervention. They then were randomly assigned in pairs to the *Behavioral* and *Developmental* intervention groups to match the groups on these variables (see Table 2). Details of these measures are included below.

Treatment Sessions. Each intervention session consisted of three 50-minute blocks of intervention, with 10-minute breaks between each block. Following pretest sessions (week 1), all participants received three-hour intervention sessions, four days per week for six consecutive weeks (weeks 2-7), followed by the posttest assessment session (week 8).

Clinician Training and Scheduling. In the month prior to the start of the intervention, graduate students from the UVA Speech and Language Pathology program were identified and underwent a two-week training, covering both methods of intervention. The selected students have approximately equivalent experience with children diagnosed with ASD. A certified Speech and Language Pathologist, Dr. Jane Hilton, who has experience in both *Behavioral* and *Developmental* intervention approaches, supervised all student trainings with the assistance of Clinical Instructors.

Clinical Instructors have their Masters' degree in Speech and Language Pathology and have received a Certificate of Clinical Competence. All student clinicians received an introductory training packet that included relevant literature on each approach and the steps (outlined above) to be followed during the sessions. Dr. Hilton and the Clinical Instructors reviewed these steps in live training sessions and assessed each student clinician for adherence to the treatment protocols. During the training period, the students' progress was monitored as they practiced each approach with other students as well as supervising clinicians. Training was completed when all supervising clinicians agreed that the student implemented the steps of each program correctly in these practice settings with 90% accuracy across three consecutive sessions.

One treatment block (50 minutes) of each intervention session was monitored by Dr. Hilton or a "floating" student clinician (not assigned to work with a child for the current block). These observers monitored clinicians' performance in one of two areas, on alternating weeks: (1) adherence to steps outlined below, and (2) data collection. Thus, one-third of every intervention session was reviewed to corroborate accurate data collection *or* proper implementation of the assigned intervention approach. Students were then scheduled so that all participating children have equal time with each student clinician, and students administered both methods of intervention equally over the six weeks of intervention.

In order to track treatment outcomes, child clinical measures and/or parent questionnaires were completed at various intervals across the four time points: pre-treatment, post-treatment, 2-month follow-up, and 4-month follow-up. These included assessments of language, nonverbal communication, ASD symptomatology, adaptive

behavior, and cognitive ability. See below for a description of the measures utilized; the schedule of measures is provided in Table 1.

Pretest and posttest. Participants completed a pretest visit in the week prior to the start of the 6-week intervention program, and a posttest visit the week following the last session.

Follow-Up. Two months following the intervention posttest (October 2013), participants were mailed a packet containing several parent questionnaires measuring communication skills. Four months following the intervention posttest (December 2013), a final visit was conducted at the Sheila Johnson Center, at which time additional parent-report measures were completed once more and clinical assessments administered to the participating children.

Participants

Nine children (8 male, 1 female) between 3 and 5 years of age (*M =4.59,* SD = 0.91) participated in the SPLISH program during the summer of 2013. Children with ASD were identified from the communities surrounding the University by local service providers (e.g., Speech and Language Pathologists and early intervention personnel), who were provided with materials to distribute to interested families. Additionally, eligible families who were seen at the Sheila Johnson Center for speech therapy or assessment services were given information about the summer program. Inclusion criteria included: a documented diagnosis of Autism Spectrum Disorder, between 2 (2:0) and 7 (7:0) years of age, English as a primary language, and no other co-morbid disorder (e.g., Tourette's, Obsessive Compulsive Disorder). ASD diagnosis was confirmed by the administration of the ADOS-2 pre-treatment. Groups were matched on chronological age, pre-treatment

language skills (as measured by the PPVT-4 and CSBS), and qualitative examination of the amount of intervention received. No significant group differences were observed (see Table 2).

Rates of treatment attrition were low, with one participant who did not respond to correspondence and scheduling phone calls between the 2-month follow-up mailing and 4-month follow-up visit; so, no data is available for this participant. The 8 remaining participants completed the program through the 4-month follow-up visit. One of the nine participants utilized a voice-generating augmentative/alternative communication (AAC) device; therefore clinical measures of language and communication were not comparable to other participants. This participant was excluded from all analyses of clinical measures and parent questionnaires, including rates and percentages, since many of the forms were considered invalid. However, service satisfaction measures were collected from this child's parents and included in the feasibility and accessibility analyses presented below.

The University of Virginia Institutional Review Board approved the protocol, and parents of all participants signed corresponding informed consent form for treatment and participation in research program.

Measures

This study is focused on the development and successful implementation of the SPLISH intervention program. Given the size of the sample, and the preliminary nature of this investigation, several measures collected were used for descriptive purposes only at this time, to characterize our sample.

Measures: Characterization of Subjects

For this initial investigation, chronological age will be used as descriptive variable only. Additionally, the following measures were used as descriptive variables for our initial evaluation of the intervention program: (a) Comparison Score from the ADOS-2, (b) Nonverbal Abilities, Verbal Abilities, and GCA scores from the DAS-II, and (c) Conceptual, Communication, and Practical Domain Scores, as well as overall General Adaptive Composite from the ABAS-II (Table 2).

Adaptive Behavior Assessment System – Second Edition (ABAS-II; Harrison & Oakland, 2003). The ABAS-II is a parent questionnaire that assesses adaptive skill functioning and provides 10 subscales that are used to calculate composites for Conceptual, Social, and Pragmatic domains as well as an overall score, the General Adaptive Composite (GAC). The ABAS-II demonstrates excellent internal consistency for all age groups, as measured by reliability coefficients, for the GAC (α =. 97-.99) and three domains (α = .91-.99). Internal consistency for these scores remains strong for clinical populations, including Autism, PDD-NOS, and Receptive/Expressive Language Disorder (GAC: α =.97-.98; domains: α = .92-.98) (Harrison & Oakland, 2003). The validity of this measure is supported by large magnitude correlations with the Vineland Adaptive Behavior Scales – Interview Edition (VABS-IE) on overall composite score (r = .70) and across the included three primary domains (r = .71-.77). Additionally, results of clinical validity studies indicate that the ABAS-II demonstrates good levels of sensitivity in differentiating between clinical and nonclinical samples (Harrison & Oakland, 2003). The ABAS-II was collected pre-treatment.

Autism Diagnostic Observation Schedule – Second Edition (ADOS-2; Lord et al., 2012). The ADOS-2 (Lord et al., 2012) is a 45-minute semi-structured play assessment

with strong predictive validity relative to best estimate diagnoses (Gotham, Risi, Pickles, & Lord, 2007), and is considered by many to be the "gold standard" for classifying ASD. There are explicit standards for establishment of research reliability in its administration and scoring which, when upheld, results in relatively consistent scores and classifications. All administrations of the ADOS-2 were scored by a clinical psychology doctoral student, who has extensive experience with the measure and is both research and clinically reliable on the measure. The ADOS-2 provides a Social Affect (SA; Communication and Reciprocal Social Interaction) and Restricted and Repetitive Behavior (RRB) scores as well as an overall score (sum of SA & RRB). Internal consistency of these subtests as measured by coefficient alpha were consistently high for the SA domain (0.87–0.92) and ranged from 0.51 to 0.66 in the Restricted, Repetitive domain. Test developers caution against using the raw scores as they are heavily influenced by age and verbal IQ (Gotham, Pickles, & Lord, 2009; Jones & Lord, 2012). To address these concerns, a Comparison Score is calculated, allowing for ASD severity to be quantified with relative independence from age and verbal skills. This score also allows for standardized, within- and between-child comparison of functioning over time and module for children of varying age and verbal ability. Gotham and colleagues (2009) reported using these comparison scores in place of raw scores reduced the amount of variance in severity scores accounted for by Verbal IQ from 43% to 10%. This study administered the ADOS-2 pre-treatment to confirm participant diagnosis and as a measure of ASD severity.

Differential Ability Scales – Second Edition (DAS-II; Elliot, 2007a). The DAS-II is an objective cognitive instrument used to measure cognitive abilities in children as

young as 2 years, 6 months. The DAS-II Early Years was administered to all participants at posttest to balance testing time for the pretest and posttest visits. The Lower Level (ages 2:6 to 3:5) or Upper Level (ages 3:6 to 6:11) of the Early Years Battery was administered to all children based on their chronological age. An overall score, General Conceptual Ability Composite (GCA), as well as Verbal and Nonverbal Ability Cluster scores, were obtained for all participants. The GCA is composed of four subtests for the Lower-Level Battery and six subtests for the Upper-Level. The Special Nonverbal Composite (SNC) and Spatial Ability Cluster are calculated only for the Upper-Level Battery and therefore will not be used in descriptive characterization for this sample. The reliability and validity of this measure are well known, and include mean internal consistency reliability coefficients of .89-.95 for the above scaled scores. Concurrent validity of the Early Years Battery is considered satisfactory, as evidenced by high correlations (r = .62-.81) with other measures of intelligence, academic achievement, mathematics, and reading and written language (*DAS-II;* Elliot, 2007b).

Intervention History Form. Parents completed an Intervention History form (developed for this study) detailing their child's previous interventions including the method, duration, and intensity (i.e., number of hours per week). This form included services provided by private practitioners and/or through the child's school program. This form was collected pre-treatment, 2-month follow-up and 4-month follow-up; the primary purpose of this measure was to provide information regarding timing and amount of intervention (hours/week) participants received prior to, during, and following the intervention.

Measures: Feasibility & Acceptability

Given the feasibility and acceptability goals of this study, the following measures were used to measure satisfaction with the program as well as identify potential obstacles to completing the program.

Attendance and task engagement. To assess attendance and task engagement during the intervention, rates and percentages were calculated for the following variables: (a) missed sessions, (b) partial sessions (i.e., arrived late, left early), (c) missing or incomplete questionnaires, (d) attrition rates. Missing/incomplete questionnaires and attrition rates were calculated also at the 2-month and 4-month follow-ups to examine feasibility of following participants across multiple follow-up periods.

Barriers to Treatment Participation Scale (BTPS-Parent; Kazdin et al., 1997a; Kazdin et al., 1997b). The BTPS is a 44-item questionnaire assessing potential barriers to treatment completion. There are two parallel forms: parent and therapist. The BTPS utilizes a 5-point rating scale from 1 (never a problem) to 5 (very often a problem); in addition to an overall barriers score, there are four subscales: *Competing Activities/Life Stressors, Perceived Relevance of Treatment, Relationship with Therapist,* and *Treatment Issues/Logistics.* The BTPS also includes a separate scale reflecting the presence or absence of *Critical Events,* consisting of 14 dichotomous (yes/no) items. The parent version of this form was used in this study to identify barriers associated with treatment participation and correlate these perceived barriers with missing sessions, incomplete or missing questionnaires, any post-treatment attrition and need of engagement in additional intervention following treatment completion. Currently, there are no known studies within the ASD literature that have utilized this measure; therefore, details of its reliability and validity are provided here.

The BTPS has demonstrated good internal consistency as well as convergent and discriminant validity in an outpatient treatment setting (Kazdin et al., 1997b). Internal consistency, as measured by coefficient alpha, for the Parent and Therapist versions was .86 and .90, respectively. To measure discriminant validity, correlations were conducted to measure the extent to which perceived barriers can be explained by other parent and child characteristics known to be related to participation treatment (discriminant validity; e.g., parent stress, life events, adverse child-rearing practices, depression and other psychopathology, and parent history of antisocial behavior). Although many of these were significant, they were in the low to moderate range (r= .15-.25), with a maximum shared variance of 6% with the Total Barriers Score (Kazdin et al., 1997a). Investigation of the subscales (Kazdin et al., 1997b) revealed high convergent validity as evidenced by significant positive relations between treatment participation (as measured by attendance rates) and all subscales, except *Treatment Demands.* The presence of critical events was not significantly related to participation in treatment ($p > .05$). Perceived barriers to treatment participation were examined using the parent version of the BTPS completed at 4-month follow-up (Table 3). In addition to an overall barriers score, the four subscales (*Competing Activities/Life Stressors, Perceived Relevance of Treatment, Relationship with Therapist,* and *Treatment Issues/Logistics*) were computed to examine targets for improving intervention completion and trial retention rates.

Client Satisfaction Questionnaire (CSQ-8; Attkisson & Greenfield, 2004; Larsen, Attkinson, Hargreaves, & Nguyen, 1979). The Client Satisfaction Questionnaire (CSQ-8) is an eight-item, self-report measure utilized to assess client satisfaction with mental health services across various dimensions: physical surroundings, procedures, method of

treatment, clinicians, quality of service, length and quantity of treatment, outcome of treatment, and overall satisfaction. The CSQ-8 items are scored on a Likert-type scale ranging from 1 to 4 (total range: 8-32), with higher scores reflecting greater satisfaction. In the present study, total scores were used to measure parent satisfaction with the treatment program. Responses to individual items were assessed qualitatively to determine areas rated as needing improvement. Internal consistency reported for this measure has been high with alpha coefficients ranging from .84 to .93 (Attkisson & Greenfield, 2004; Larsen et al., 1979). Factor analyses have repeatedly yielded one factor (Gaston & Sabourin, 1992; Nguyen, Attkinson, & Stegner, 1983). This measure was used to assess overall parent satisfaction with the program, and was collected at the 4-month follow-up (Table 4).

Summary Therapist Feedback Form (STFF; Crawley et al., 2013). The STFF is a 7-item therapist rating developed by Crawley and colleagues (2013) to measure the therapists' views on the appropriateness and ease of manual implementation as well as the session content and format. There are currently no reported validity or reliability estimates for this measure. All therapists who administered treatment during the 2013 program completed two STFFs following the 4-month follow-up visit, thus providing separate evaluations of. Therapist-rated feasibility was assessed by examining therapist ratings (n = 12) on each of the seven Summary Therapy Feedback Form (STFF; Crawley et al., 2013) items on both the *Behavioral* and *Developmental* methods (24 forms total; Table 5).

Measures: Preliminary Efficacy Outcomes

Given the feasibility/acceptability goals of the current study, evaluation of treatment efficacy and impact on targeted communication skills represents a secondary, exploration aim. The goal of the interventions was to improve expressive language; therefore, well-validated measures of nonverbal and verbal communication were selected as the primary outcome variables.

Communication and Symbolic Behavior Scales (CSBS; Wetherby & Prizant, 1999). Preliminary outcomes in this investigation were primarily assessed using the CSBS and the MacArthur-Bates Communicative Developmental Inventories (detailed below). The CSBS is a widely accepted diagnostic protocol and designed to be used with children demonstrating a functional communication age between 8 months and 2 years (Wetherby & Prizant, 1999). It measures 22 factors related to communication that fall into seven communication clusters: communicative function, communication means-gestural, communication means-vocal, communication means-verbal, reciprocity, social-affective signaling, and symbolic behaviors. A Communication Composite score is calculated from six of the Cluster scores (not including Symbolic). Additionally, constructive and symbolic (pretend) play are assessed by the CSBS. During administration, the examiner allows the child to use communication skills in a natural environment by prompting and responding to communication initiated by the child. Scores are based on the types of interactions a child demonstrates during the administration (e.g., behavior regulation, joint attention, and sociability of communication function) as well as patterns of interaction with toys, caregivers, and examiners.

Internal consistency as measured by coefficient alpha for the Communication Composite is excellent (.91); coefficients for the included Clusters range from acceptable to excellent (.58 to .91), with one outlier, social-affective signaling (.17) (Wetherby & Prizant, 1999). Wetherby and Prizant (1999) report generally high interrater reliability with medians ranging from .83 to .90 across the 22 factors. Predictive validity was examined using a standardization sample and two groups of children with significant delays: Speech Language Impairments (SLI) and Pervasive Developmental Disorders (PDD). Correct classification was considerably higher than chance, 85% for PDD and 60% for SLI, and only 2 children (2.4%) of the standardization sample were misclassified using the CSBS. For this study, the rates of correct classification for PDD and misclassification are especially pertinent (Wetherby & Prizant, 1999). Standard scores from three CSBS subscales (Communicative Means-Verbal, Communicative Means-Vocal, Communicative Means-Gestures) were selected *a priori* to assess expressive language across the pre-treatment, post-treatment, and 4-month follow-up assessments. The CSBS was conducted by trained examiners providing treatment for the children but blinded to study hypotheses. All CSBS testing sessions were videotaped and coded by independent examiners blind to study hypotheses and session (e.g., pre-treatment, post-treatment).

MacArthur-Bates Communicative Developmental Inventories (MacArthur-Bates CDI; Fenson et al., 2007). The MacArthur-Bates CDI was completed by parents to gather information about their child's communication skills. Both the *Words and Gestures* and *Words and Sentences* forms were completed on all participants to provide a comprehensive nonverbal and verbal communication inventory for all children. Test

developers (Fenson et al., 1993; 2007) report a high degree of reliability for all major components of both inventory forms: *Words and Gestures* Total Gestures (.88), *Words and Gestures* Vocabulary (.95), *Words and Sentences* Vocabulary (.96), and *Words and Sentences* Complexity Scale (.95). For children over 12 months of age, test-retest reliability was stable across time for vocabulary production (> .90), vocabulary comprehension (>.80), and gestures (>.80) scores. The CDI has also demonstrated evidence for the predictive validity in the first 2 years, with 6 months between Time 1 and 2. Significant ($p < .01$) correlations for vocabulary produced (.38), vocabulary comprehension (.44), and total gestures (.44). Stronger predictions were found across the third year of life for vocabulary produced (.58) and the complexity scale (.54; Fenson et al., 2007). We selected the Words Produced and Total Gestures subscales *a priori* to assess parental perception of their child's expressive language at pre-test, post-test, 2-month follow-up, and 4-month follow-up.

Peabody Picture Vocabulary Test – Fourth Edition (PPVT-4; Dunn & Dunn, 2007). The PPVT-4 is a widely used, norm-referenced assessment and was used to assess gains in receptive vocabulary from pre-treatment to 4-month follow-up. This measure has two forms, allowing for a second administration to be conducted within a short period of time. Alternate-form reliability for this measure is very high, falling between .87 and .93. The PPVT-4 demonstrates excellent reliability and validity; with internal consistency averaging .94 (Form A) and .95 (Form B) and moderate to high correlations with other measures of expressive and oral language. Total standard scores on the PPVT-4 expressive language test served as a measure of receptive language. This measure was

administered at pre-treatment (Form A) and 4-month follow-up (Form B) by trained examiners blind to group assignment (at 4-month follow-up, n/a at pretest).

Rossetti Infant-Toddler Checklist (Rossetti, 1990). The Rossetti Infant Toddler Checklist is a criterion-referenced instrument that assesses Interaction-Attachment, Pragmatics, Gesture, Play, Language Comprehension, and Language Expression. This measure was used as parent report of verbal and nonverbal communication outcomes. Unfortunately, although over 120 research articles and publications have cited this instrument, the authors have not provided information on reliability or validity. The Rossetti was collected pre-treatment, post-treatment, 2-month follow-up, and 4-month follow-up.

Social Responsiveness Scale – Second Edition (SRS-2; Constantino & Gruber, 2012). The SRS-2 is a widely used screener and diagnostic tool used to identify individuals with Autism Spectrum Disorder in clinical and research settings. In addition to an overall score, the SRS-2 provides scores for five treatment subscales: Social Awareness, Social Cognition, Social Communication, Social Motivation, and Restricted Interests and Repetitive Behaviors. The total score and four of the treatment subscales (all except Social Communication) from the SRS-2 serve to measure changes in the other two core symptom areas of ASD: socialization and repetitive behaviors/restricted interests. Constantino and Gruber (2012) report multiple investigations of the SRS-2 have yielded an overall internal consistency, as measured by coefficient alpha, of greater than .95 for both clinical and nonclinical groups. Particularly of interest for this study, retest correlations (r) have averaged .90. Additionally, the measure demonstrates strong sensitivity (.78-.91), and specificity (.75-.90) with mixed diagnoses and typically

developing contrast groups. The SRS-2 also correlates well (.60-.77) with the time-intensive Autism Diagnostic Interview- Revised (ADI-R; Rutter, Le Couteur, & Lord, 2003), considered to be the "gold-standard" autism interview protocol. This measure reflects the two domain factors used within the DSM-5: Social Communication and Interaction (SCI) and Restricted Interests and Repetitive Behavior (RRB). Factor analyses indicate both one (overall score) and two factor models (4 social subscales, 1 RRB) are appropriate to quantitatively map autism symptomatology (Frazier et al., 2014). Parents completed the SRS-2 at pre-treatment and 4-month follow-up. We selected the age-referenced Total Score and scores on the Restricted Interests and Repetitive Behaviors factor to provide an initial examination of potential generalized symptom changes outside of the targeted Communication domain.

Data Analysis

The primary aims of the study involved feasibility/acceptability assessment; therefore, these data were assessed via rates and percentages. Treatment acceptability was measured using rates of perceived benefit from treatment, whether respondents would recommend the program to others, and parent satisfaction with the program. Feasibility was assessed by rates of recruitment, attendance, retention, and attrition, as well as perceived barriers to treatment participation and feedback from the clinicians.

Preliminary efficacy evaluation reflects a secondary aim in the current pilot trial. Given power issues associated with the group and total sample sizes, we examined evidence of potential efficacy using the combined sample ($N = 9$); differential trends across the ABA and DIR groups were examined qualitatively and displayed in Figures 1, 2, 3, 4, and 5. All analyses were conducted using SPSS version 21.

Results

Acceptability

Responses from parents on the CSQ-8 indicated that they were generally pleased with the program (Table 4). Parents' ratings indicated they were satisfied with the quality of the intervention, found it helpful for their children, and noted their child's progress. All parents rated the quality of service they received as excellent (87.5%) or good (12.5%). Respondents indicated that most (50%) to almost all (50%) of their needs were met, and that they received the kind of service and quantity of help they wanted. Overall, parents reported that they were "mostly satisfied" (25%) to "very satisfied" (75%) with the intervention program, would be likely to recommend the program to a friend, and indicated they would return to the program if they were to seek services in the future.

Feasibility

Attendance and attrition. Overall, participation and retention were high. All nine participants were characterized as treatment completers – 100% completed the post-treatment and 2-month follow-up assessments. One family was lost to 4-month follow-up, resulting in an 89% completion rate at that time point. Attendance was also high across the 6-week intervention (91.7%). Six of the nine children (66.7%) missed two or fewer of the 24 intervention sessions, and no participants attended partial sessions (arriving late or leaving early). Total sessions attended ranged from 19 to 24 (M = 22, SD = 1.87). Parents completed 89.3% of clinical questionnaires and 88.9% of client satisfaction questionnaires across all four time points; 94.6% of the planned clinical measures were successfully administered to children.

Barriers to participation. The BTPS was used to identify barriers associated with treatment participation (Table 3). Eight of the nine participating families completed this form (89%), which was administered at the 4-month follow-up. Attempts to contact the one additional family were unsuccessful, and so drop-out reason is unknown. These families generally identified very few problems affecting their participation, and endorsed the lowest rating ("not a problem") for 77.3% of all items. Among the subscales, respondents rated the Perceived Relevance of Treatment (mean rating = 1.4; SD = 0.29) and Treatment Issues/Logistics (mean rating = 1.4; SD = 0.25) subscales as the biggest barriers to participation; ratings for these items ranged from "not a problem" (k = 1-8) to "sometimes a problem" (k = 0-4). Examination of individual item endorsements suggests that parents did not have enough time to complete the paperwork/questionnaires (mean rating = 1.86; range = 1-3) and the program's cost (mean rating = 2; range = 1-3) as the primary obstacles. Handout clarity was generally good, with ratings generally suggesting that they were "somewhat" or "a little" confusing (mean rating = 1.63; range = 1-3). Half of respondents rated the quantity of work associated with the intervention as "a little more" to "more" than expected (mean rating = 1.63; range = 1-3).

To better understand the association between perceived barriers and treatment engagement, we correlated BTPS subscale scores, parent CSQ-8 ratings, and child attendance rates (number of missed sessions). As shown in Table 4, higher CSQ-8 satisfaction ratings on the quality of help received were strongly associated with fewer missed sessions (r = .87, p = .005). Surprisingly, competing activities/life stressors (BTPS) were also negatively related to the number of missed sessions (r = .86, p = .006).

In other words, families with better attendance records reported higher program satisfaction but more life stressors than lower attending families. Qualitative review of the Competing Activities/Life Stressors items suggests that parents whose child missed fewer sessions tended to endorse higher ratings for "During the course of treatment I experienced a lot of stress in my life" and "Treatment added another stressor to my life." Finally, Ratings on the Treatment Issues/Logistics subscale were inversely correlated with the number of completed questionnaires (r = .82, p = .025). Within this subscale, parents who rated the cost of the program as more problematic were less likely to miss sessions (r = .73, p = .040) and also less likely to complete all requested questionnaires.

Therapist-rated acceptability. All clinicians (k = 12) completed the STFF twice at 4-month follow-up, once with regards to the *Behavioral* program and once with regard to the *Developmental* program (24 forms total) (Table 5). These ratings were collected to inform the adjustment and refinement of training procedures for future intervention programs. As shown in Table 5, most masters degree student clinicians reported that the manuals for both approaches were generally easy to understand, and believed the manuals contained the important elements and were absent superfluous elements. In contrast, a majority (66.7%) indicated that the number of sessions was too few to accomplish all treatment goals, and several (33.3%) reported difficulty conducting the treatment as outlined in the manual.

Preliminary Efficacy

Treatment-related changes in the primary outcome variables are shown in Figures 1, 2, 3, 4, and 5. All results should be considered preliminary given the small sample size of this pilot study. Overall, the results revealed significant gains in language and gestures

from pre-treatment to 4-month follow-up, with the largest magnitude improvements detected on parent-reported clinical measures across pre-treatment, post-treatment, and 2-month follow-up.

CSBS. As shown in Figures 1, 2, and 3, the interventions were associated with increases in in verbalizations, vocalizations, and gestures from pre-treatment to 4-month follow-up. Participants made the largest gains in verbalizations from pre-treatment (*M* = 10.00, SD = 1.83) to post-treatment (*M* = 11.71, SD = 2.36) d = -0.88, with a more gradual increase from post-treatment to 4-month follow-up (*M* = 12.14, SD = 2.34). The opposite pattern was observed for communicative vocalizations, with smaller gains from pre-treatment (*M* = 8.57, SD = 3.21) to post-treatment (*M* = 8.71, SD = 2.93) and larger standard score increases between post-treatment and 4-month follow-up (*M* = 9.43, SD = 3.21). Participants demonstrated a steady increase in gesture use from pre-treatment (*M* = 5.43, SD = 2.37) to 4-month follow-up (*M* = 6.00, SD = 1.53), with the largest gains being observed between pre-treatment and post-treatment (*M* = 5.86, SD = 1.95).

MacArthur-Bates CDI. Parents reported statistically significant improvements in their child's expressive language and gestures as measured by the MacArthur-Bates CDI (Figures 4 and 5). According parent report, the average number of words produced increased from 172 to 261 between pre-treatment and 4-month follow-up (p = .004), with the bulk of this increase occurring between post-treatment and 2-month follow-up. A similar pattern was observed for total gestures, which increased from 32 at pre-treatment to 41 at 4-month follow-up (p = .006) primarily due to large gains between post-treatment and 2-month follow-up.

PPVT-4. A non-significant trend toward improved receptive language was observed on the PPVT-4 between pre-treatment (standard score *M* = 79.33, SD = 16.93) and 4-month follow-up (*M* = 82.00, SD = 18.06), (d = 0.17).

SRS-2. Parents reported overall lower ASD symptomatology at 4-month follow-up (Total *T*-score *M* = 70.40, SD = 11.42) relative to pre-treatment (*M* = 76.40, SD = 11.93) (d = -0.57). However, there was a smaller magnitude change observed within the Restricted Interests and Repetitive Behavior factor (d = -0.47).

Preliminary Comparison of Intervention Approaches

Qualitative examination across the *Behavioral* (n=4) and *Developmental* (n=4; n=3 at 4-month follow-up) interventions suggest that both approaches had high rates of acceptability and feasibility and yielded positive treatment effects, but demonstrated some differences in trajectory of skill development. Overall, the *Developmental* group tended to miss more intervention sessions (*M* = 2.20) than the *Behavioral* group (*M* = 1.75). The *Developmental* group also had a lower rate of questionnaire completion (*M* = 85.7%) than the *Behavioral* group (*M* = 100%). It is important to note, the child who did not complete the study was in the *Developmental* group, and accounts for a majority of outstanding questionnaires and measures. There were no notable differences in satisfaction and perceived barriers to participation between groups, as measured by the CSQ-8 total score, BTPS total score, or BTPS subscales (Tables 3 and 4).

Clinician ratings on the STFF did highlight some differences in the manuals and training for the different approaches (Table 5). According to responses on the STFF, clinicians found the training materials for the *Behavioral* approach easier to understand (*M* = 5.17) than those for the *Developmental* approach (*M* = 4.75), with 4 of the 12

clinicians rating the latter as "somewhat" easy to understand or lower. In line with the premise of the approaches, Clinicians also indicated that the *Developmental* approach allowed for more flexibility than the *Behavioral* approach.

A preliminary examination of the child clinical and parent report measures of verbal and nonverbal communication also revealed some differences between the two approaches (Figures 1-5). In general, the *Behavioral* group demonstrated larger gains than the *Developmental* group on the CSBS subscales (Figures 1-3). The overall pattern of treatment effect was also notably different – with the Behavioral group showing larger gains from pre-treatment to post-treatment, and minimal change from post-treatment to the 4-month follow-up. In contrast, the *Developmental* group, who obtained higher scores at pre-treatment on both the Communicative Means-Verbal and Communicative Means-Vocal subscales, showed minimal gains from pre-treatment to post-treatment on the CSBS but had larger gains from post-treatment to the 4-month follow-up. The other primary child clinical measure of communication obtained was the PPVT-4. A preliminary comparison of standard scores on the PPVT for the *Developmental* group shows a mean gain of 9.67 standard score points from pre-treatment to 4-month follow-up, while the *Behavioral* group had a mean loss of 4.33 standard score points.

According to parent report on the MacArthur-Bates CDI, the *Developmental* group obtained higher scores on all subscales at pre-treatment and demonstrated larger gains overall (Figures 4 and 5). Both groups showed minimal gains from pre-treatment to post-treatment and more substantial gains from post-treatment to 2-follow-up, and then minimal changes from 2-month follow-up to 4-month follow-up on all the Words Produced and Total Gestures subscales.

Discussion

A 6-week, 24-session intervention program (SPLISH) targeting communication skills was evaluated. This initial investigation found the program to be feasible, acceptable, and beneficial for young children with ASD. The program consisted of two approaches, *Behavioral* and *Developmental*, with the ultimate goal of making a direct comparison of these popular approaches to speech and language intervention within a clinical setting. Dr. Jane Hilton, a doctoral-level speech-language pathologist with extensive experience with the ASD population led the trainings of both approaches. Graduate students from the UVA Speech-Language pathology program served as clinicians for this summer program. Their training and supervision included introductory materials for both approaches, live training sessions, evaluation of administration prior to the start of the program, and continued assessment to ensure adherence to the treatment protocols during the program.

This preliminary examination identified high rates of satisfaction and notable treatment gains as well as descriptive barriers and needed protocol revisions to inform future efforts to increase access and refine best practices to improve outcomes for children and families affected by ASD. The present findings indicate that this intensive communication intervention program was both acceptable and feasible to parents. Parents reported being satisfied with the program, with high rates of attendance and completion of the included questionnaires. The most commonly endorsed potential barriers to participation included the cost of the intervention as well as the amount and clarity of requested questionnaires. With continued documentation of the speech and language skills observed during and following future summer programs, it is hoped additional

funding will be obtained to help reduce the cost to parents. As this was an initial assessment of the program, a large number of parent-report measures was included to provide comprehensive information about the program. Results revealed which forms provided the most information needed to track progress. Most notably, the Rossetti Infant-Toddler Checklist was most commonly noted as confusing to parents (i.e., incomplete forms, questions directed to clinicians) and did not provide usable data to track communication skills. Therefore, future programs will reduce and refine the parent-report battery to minimize the amount of work for parents. Additionally, an in-person overview of all forms to be collected at pre-treatment may help reduce future confusion when completing questionnaires.

Feedback from clinicians was generally positive but highlighted the need for more in-depth training of each approach and modifications to the training materials to improve clarity and familiarity with the interventions. Clinician feedback also indicated that more sessions may be needed to accomplish all the treatment goals. Gathering this information at multiple time points may provide more detailed information to guide instructors during the training and intervention program. These areas will need to be adjusted and piloted prior to the initiation of a larger RCT.

The initial outcomes of the SPLISH program are promising. Given the small sample it is important to consider these as primarily descriptive and qualitative. Overall, significant gains were reported in word count and notable gains observed in gesture use and non-word vocalizations within the clinic setting and by parents. Both the MacArthur-Bates CDI and CSBS showed improvements in these areas but the trajectories differed across the targeted skill and between parent report and clinical measures. Verbalizations

(words and word combinations) from the CSBS showed the strongest increase from pre-treatment to post-treatment, with minimal change from post-treatment to 4-month follow-up. In contrast, Words Produced from the MacArthur-Bates CDI and gains on the CSBS were most notable from post-treatment to 2-month follow-up, with minimal changes reported from pre-treatment to post-treatment or 2-month to 4-month follow-up.

Because the CSBS centers around an interactive assessment with clinicians it is reasonable to assume children would demonstrate increased language skills in the same clinical setting immediately following 6 weeks of working with the same clinicians. This discrepancy requires further evaluation, but a possible explanation lies in the timing of the intervention and follow-up time points. Two months following the intervention is approximately when school programs would have started and parents may have then had more opportunity to observe their children in similar interactive environments with other children and professionals. Additionally, because a (wait list) control group was not utilized, we are unable to assess the possibility that these gains are not due to maturation or other factors (e.g., age, intervention history) unrelated to our intervention program. Further evaluation of scores obtained on the Communicative Means-Verbal subscale of the CSBS revealed that many participants reached the maximum score for their language stage by the four-month follow-up time point. Therefore, the scores reported may underestimate the gains made following the intervention program. Changes in overall ASD symptomatology as reported by the SRS-2 total score and RRB subscale demonstrate that communication is the area most notably improved from pre-treatment to 4-month follow-up. These findings support the intervention's benefit to targeted language

skills and suggest that improvements in language exceed those in other areas, such as repetitive behaviors and social interaction.

Preliminary comparisons of the groups suggest that the *Behavioral* approach was related to gains on the CSBS while parent-report measures indicated a trend toward overall greater gains by children in the *Developmental* approach. Additionally, the trajectory of skill development varied by approach, most notably on the CSBS where there was a trend toward the *Behavioral g*roup showing more gains pre-treatment to post-treatment, whereas the *Developmental* group demonstrated minimal improvement pre-treatment to post-treatment but more from post-treatment to 4-month-follow-up than the *Behavioral* group. Based on parent-report on the MacArthur-Bates CDI, the pattern of word and gesture use across the four time points was very similar for both groups; however, the *Developmental* group showed a steeper increase over time, resulting in larger gains overall.

There are several considerations to be made when reviewing these preliminary findings. As indicated above, many children reached the maximum score on the Communicative Means-Verbal subscale of the CSBS. At the 4-month follow-up all three children in the *Developmental* group achieved the maximum score, and two of the four children in the *Behavioral* group. Given this information additional measures of expressive language will need to be incorporated into the pre-treatment, post-treatment, and 4-month follow-up to ensure these gains will be accurately measured. Although there were no significant differences in age or pre-treatment scores on communication measures, these may also play a role in the different trajectories observed and need to be further evaluated. It is also important to note that parents were not blinded to treatment

and were invited to observe sessions, therefore some differences between parent report and measures conducted within the clinic could reflect expectancy effect and/or changes in parent-child interactions fostered by these observations. Additionally, although information was collected on the interventions pursued prior to, during, and following the intervention we have not yet established a way to uniformly quantify this information to determine how these other programs may have influenced observed gains.

Overall these results indicate substantial gains in expressive language and gesture during and immediately following the intervention program for both *Behavioral* and *Developmental* approaches. This preliminary investigation of the program finds it to be well accepted by participants with noted benefits, supporting continuation of the program. Future evaluations, augmented training procedures, and a modified battery of measures will help to better define and understand these developmental trajectories as well as establish refined protocols for future, larger efficacy studies.

Limitations

This study serves as a preliminary investigation to inform future ASD intervention programs at the University of Virginia and elsewhere. As emphasized throughout this manuscript, the primary aims were to evaluate the feasibility and acceptability of implementing and evaluating a communication intervention for children with ASD to inform the need for larger scale efficacy evaluations and direct comparisons among *Behavioral*- and *Developmental*-based approaches.

A primary limitation of this study is the small sample size, particularly for group comparisons. Additionally, six of the nine participants had enrolled in previous SPLISH programs. Although this speaks to parent satisfaction and the program is tailored

according to the child's current language level it is possible this may have influenced treatment effects. Regarding parent satisfaction and barriers to participation, because the one participant who did not complete the study also did not complete service satisfaction forms we were unable to ascertain the factors that influenced the family's decision to cease involvement in the program. Some limitations were also identified due to the battery of measures administered. As discussed above, the primary measure used to evaluate communication skills during visits to the clinic, the CSBS, proved not to be appropriate to capture the higher level of verbalizations demonstrated by many of the participants at later visits. Lastly, it is important to consider the reliability of parent report; there were a few time points that reported small decreases in skills (number of gestures and/or words) from the previous time point. Although losses are possible within this population, these discrepancies highlight the potential for errors in parent-report measures.

Limitations regarding clinicians and their training are also important to consider. Because the SPLISH program is conducted within a University clinic that focuses on student training, these clinicians do not have the level of in-depth training and/or experience with these intervention methods that would be ideal for a direct comparison study and likely increase overall treatment outcomes of the intervention program. Additionally, in order to control for differences between clinicians, they were rotated each session so all students worked with all participants and therefore trained on both approaches. This may have inadvertently led to crossover in the administration of the two approaches. Although adherence to the program was recorded because this is a small,

unfunded pilot trial the level of treatment fidelity was limited as we were not able to utilize blinded observers.

Despite these limitations, feedback from satisfaction questionnaires as well as interviews with parents confirmed their confidence in the effectiveness of the program. The augmented battery and extended collection period also provided valuable insight for the revision of future programs, laying the groundwork for larger, standardized, empirical comparative investigations of intervention approaches.

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Appendix

Table 1. *Child Clinical and Parent-Report Measures Schedule*

	Pre- Intervention	**Post- Intervention**	**+2 Month (Mailing)**	**+4 Month Visit**
Child Clinical Measures				
ADOS-2	x			
CSBS	x	x		x
DAS-II		x		
PPVT-4	x			x
Parent-Report Clinical Questionnaires				
ABAS-II	x			
Intervention History Form	x		x	x
MacArthur Bates CDI	x	x	x	x
Rossetti Infant Toddler Checklist	x	x	x	x
SRS-2	x			x
Accessibility & Feasibility				
BTPS				x
CSQ-8				x
Clinician Feedback				
STFF				x

Table 2. *Group Comparison of Age, ABAS, ADOS-2, CSBS, DAS, and PPVT-4 Mean Scores at Pre-Treatment*

	All (n=8)		Behavioral (n=4)		Developmental (n=4)		Analysis		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	***t***	***p***	x^2
Age (years)	4.59	0.91	4.83	0.80	4.35	1.08	0.72	0.50	
CSBS Language Stage	3.38	.916	3.25	.957	3.50	1.00		0.55	1.20
ABAS-II Communication	74.17	22.60	72.67	21.50	75.67	28.50	-0.15	0.89	
ABAS-II Conceptual	76.50	21.40	73.67	18.15	79.33	28.15	-0.29	0.78	
ABAS-II Practical	59.17	14.91	58.00	11.30	60.33	20.60	-0.17	0.87	
ABAS-II GAC	66.17	20.05	64.00	15.52	68.33	27.39	-0.24	0.82	
ADOS-2 CS	6.13	0.99	5.50	0.58	6.75	0.96	-2.24	0.07	
CSBS CM Gestural	5.62	2.26	5.50	3.11	5.75	1.50	-0.15	0.89	
CSBS CM Verbalizations	9.88	1.73	9.25	0.50	10.50	2.38	-1.03	0.34	
CSBS CM Vocalizations	8.75	3.01	7.25	3.86	10.25	0.50	-1.54	0.17	
DAS-II GCA	55.63	21.32	50.50	17.14	60.75	26.40	-0.65	0.54	
PPVT-4	78.29	15.70	81.33	13.20	76.00	18.99	0.41	0.70	

Note. CSBS Language Stage: 1 = prelinguistic; 2 = early one word; 3 =late one word; 4 = multiword

Table 3. *Mean Ratings and Range of Barriers to Participation Scale (BTPS) Subscales and Four Highest Rated Items*

	All (n=8)		Behavioral (n=4)		Developmental (n=4)	
	M(SD)	Range	M(SD)	Range	M(SD)	Range
Competing Activities/Life Stressors	1.20(.26)	1-4	1.21(.23)	1-3	1.88(.32)	1-4
Relevance of Treatment	1.36(.29)	1-3	1.38(.37)	1-3	1.35(.24)	1-3
Relationship with Therapist	1.10(.22)	1-2	1.21(.25)	1-2	1.00(.14)	1-2
Treatment Issues (Logistics)	1.35(.25)	1-3	1.38(.15)	1-3	1.33(.34)	1-3
9. *I felt the treatment cost too much.*	2.00(.54)	1-3	2.00(0.00)	2	2.00(.82)	1-3
12. *Information in the session and handouts seemed confusing.*	1.63(.92)	1-3	2.00(1.56)	1-3	1.25(.50)	1-2
22. *I felt this treatment was more work than expected.*	1.63(.74)	1-3	1.75(.96)	1-3	1.50(.58)	1-2
34. *I did not have enough time for the assigned work.*	1.86(.69)	1-3	2.00(.86)	1-3	1.67(.58)	1-2

Note. Likert scale responses by question were as follows: Question (9) 1 = Cost was fine, 2 = Cost was about right, 3 = Cost was sort of high, 5 = Cost was too high; Question (12): 1 = Not confusing at all, 2 = A little confusing, 3 = Somewhat confusing, 4 = Often confusing. 5 = Very often confusing; Question (22): 1 = Not more work than expected, 2 = A little more work than expected, 3 = More than expected, 4 = Quite a bit more than expected, 5 = Very much more work than expected; Question (34): 1 = Never a problem, 2 = Once in a while, 3 = Sometimes a problem, 4 = Often a problem, 5 = Very often a problem.

Table 4. *Parent ratings on the Client Satisfaction Questionnaire (CSQ-8)*

	All (n=8)		Behavioral (n=4)		Developmental (n=4)	
	M(SD)	Range	M(SD)	Range	M(SD)	Range
1. How would you rate the quality of service you received?	3.88(.35)	3-4	3.75(.50)	3-4	4.00(0)	4-4
2. Did you get the kind of service you wanted?	3.38(.52)	3-4	3.25(.50)	3-4	3.50(.58)	3-4
3. To what extent has our program met your needs?	3.50(.54)	3-4	3.25(.50)	3-4	3.75(.50)	3-4
4. If a friend were in need of similar help, would you recommend our program to him or her?	3.50(.54)	3-4	3.25(.50)	3-4	3.75(.50)	3-4
5. How satisfied are you with the amount of help you have received?	3.63(.52)	3-4	3.50(.58)	3-4	3.75(.50)	3-4
6. Have the services you received helped you to deal more effectively with your [child's] problems?	3.50(.54)	3-4	3.25(.50)	3-4	3.75(.50)	3-4
7. In an overall, general sense, how satisfied are you with the service you have received?	3.75(.46)	3-4	3.75(.50)	3-4	3.75(.50)	3-4
8. If you were to seek help again, would you come back to our program?	3.75(.46)	3-4	3.75(.50)	3-4	3.75(.50)	3-4

Table 5. *Clinician Ratings on the Summary Therapist Feedback Form (STFF)*

	All	Behavioral	Developmental
How easy was it to understand the content of the manual?			
M(SD)	4.96(1.08)	5.17(1.03)	4.75(1.14)
How easy was it to conduct the treatment as outlined by the manual?			
M(SD)	4.54(1.44)	4.50(1.45)	4.58(1.51)
How user-friendly were the treatment materials (manual, workbook)?			
M(SD)	4.79(1.10)	4.83(1.03)	4.75(1.22)
Did the manual allow for enough flexibility?			
M(SD)	4.67(1.40)	4.08(1.38)	5.25(1.22)
Did you feel the number of sessions were sufficient to accomplish all of the treatment goals?			
M(SD)	4.71(1.37)	4.58(1.56)	4.83(1.19)
Were there any unnecessary elements included in the manual?			
M(SD)	5.25(1.11)	5.08(1.08)	5.42(1.17)
Were there any important elements missing from the manual?			
M(SD)	5.29(1.40)	5.42(1.56)	5.17(1.27)

Note. Items rated on a 1 to 7 Likert scale where 1="Not at all," 4="Somewhat," 7="Very Much."

Figure 1. *Standard Scores on CSBS Communicative Means-Gestural Subscale at Pre-Intervention, Post-Intervention, and 4-month Follow-Up*

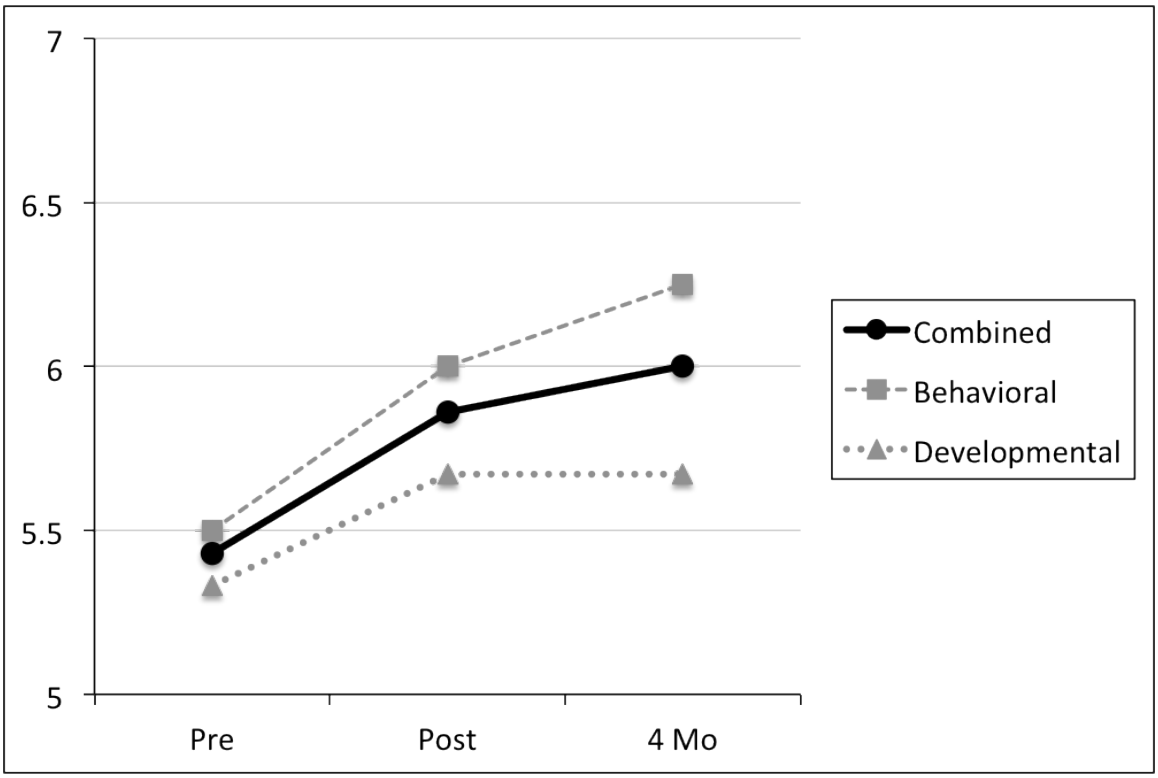


Figure 2. *Standard Scores on CSBS Communicative Means-Verbal Subscale at Pre-Intervention, Post-Intervention, and 4-Month Follow-Up*

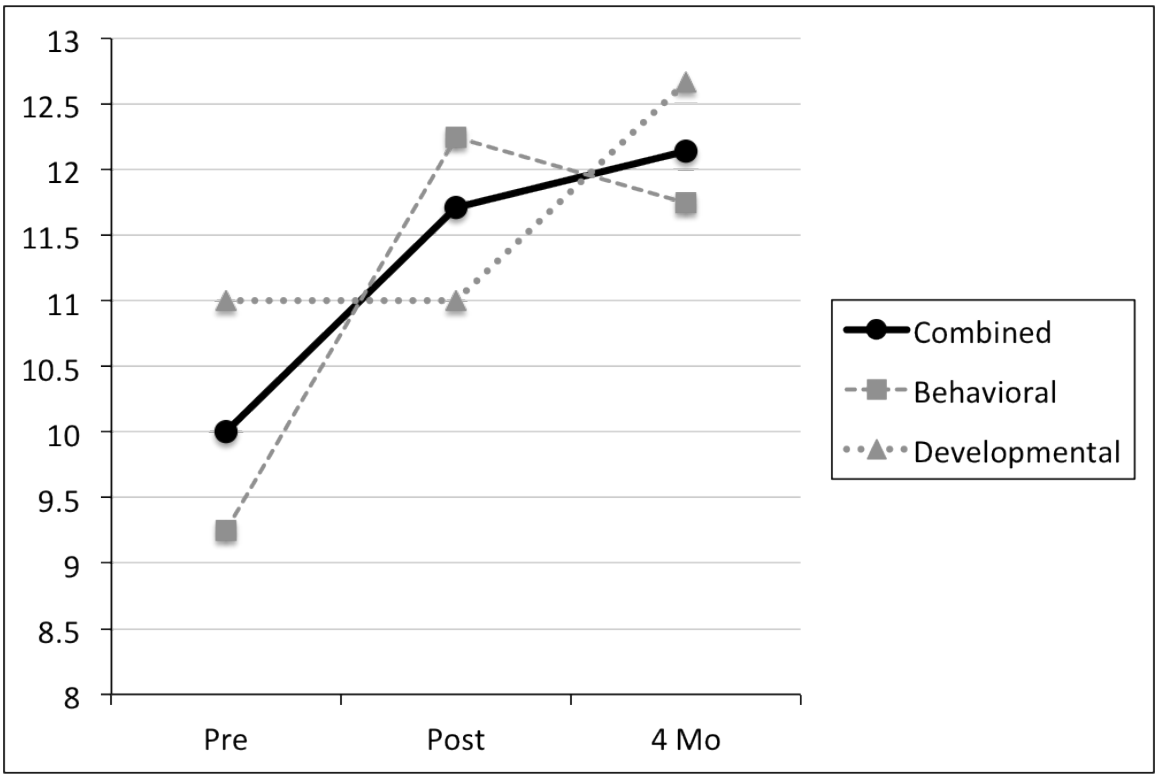


Figure 3. *Standard Scores on CSBS Communicative Means-Vocal Subscale at Pre-Intervention, Post-Intervention, and 4-Month Follow-up*

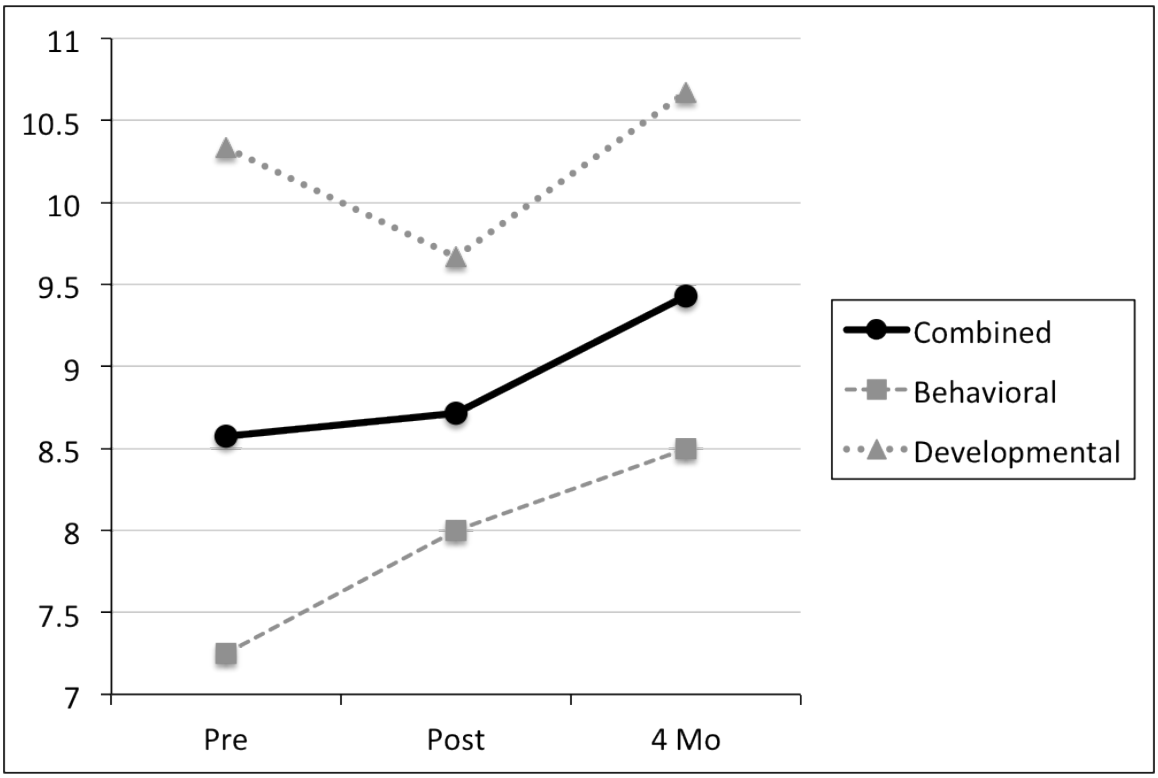


Figure 4. *MacArthur-Bates CDI Words Produced Reported at Pre-intervention, Post-Intervention, and 4-month Follow-Up*

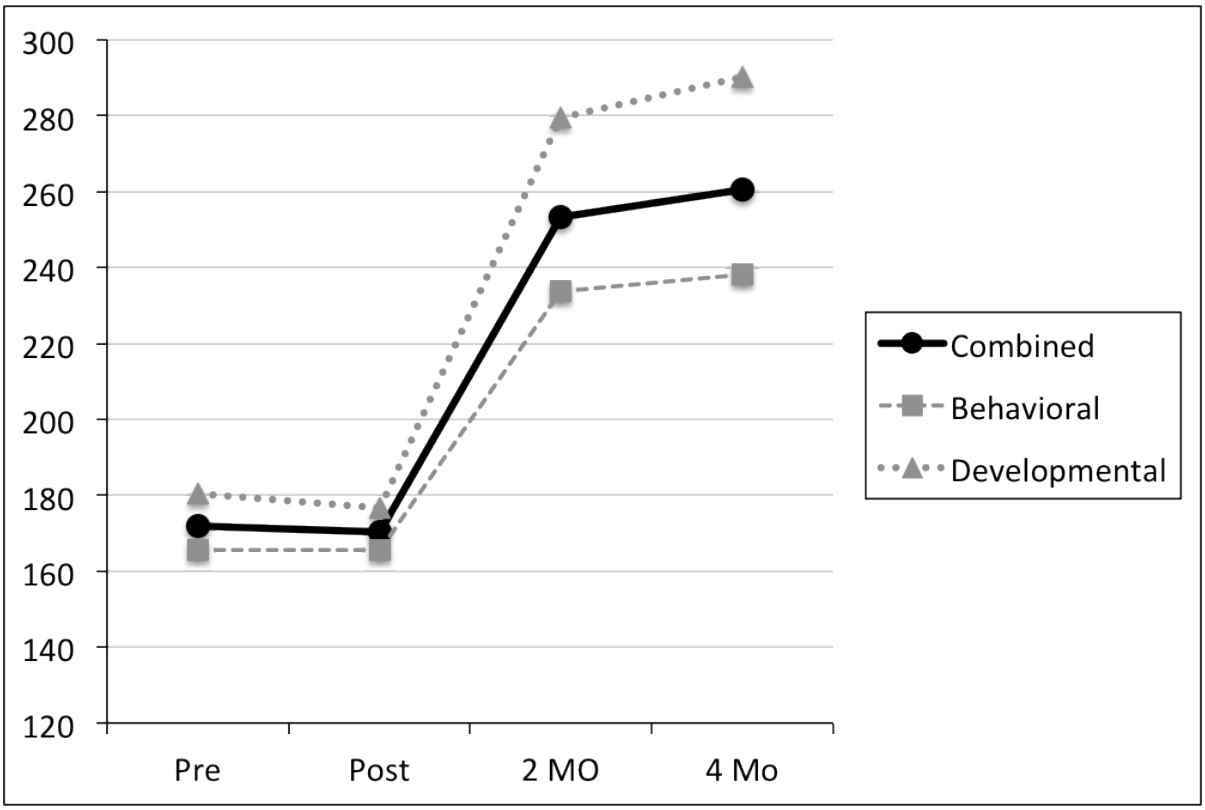
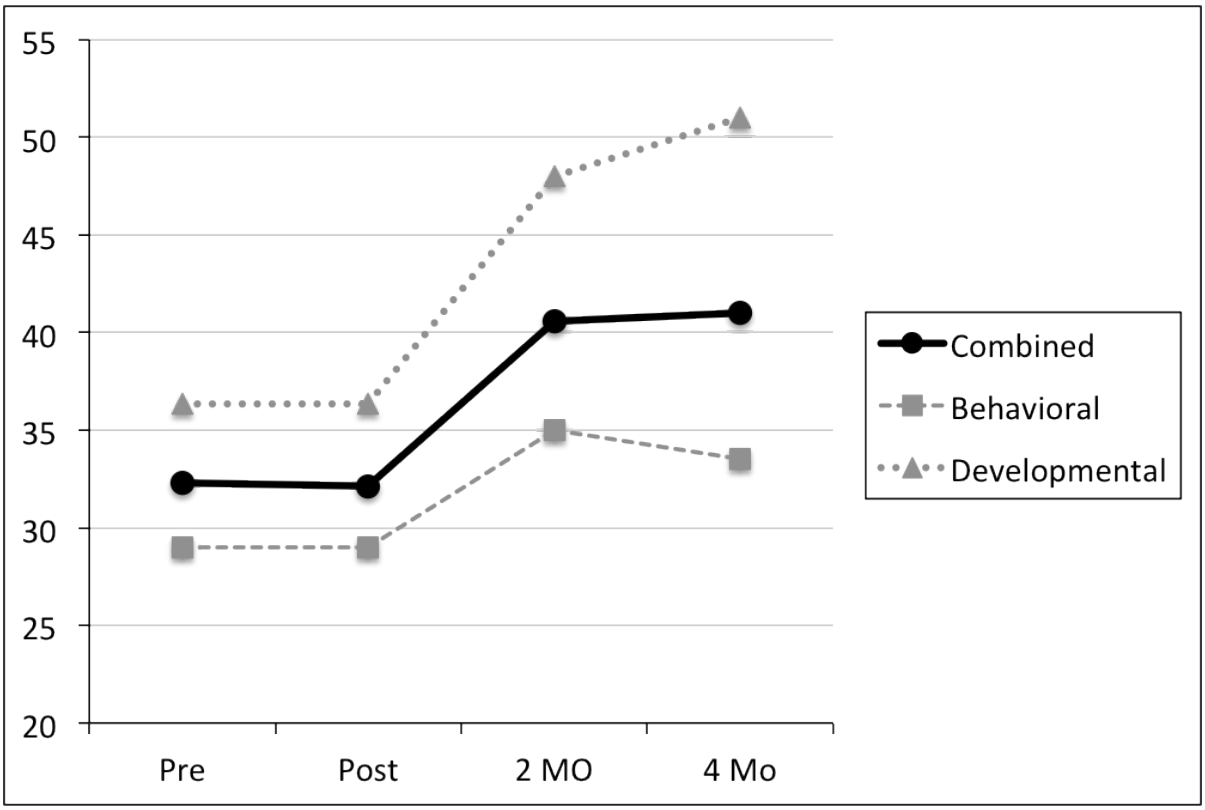


Figure 5. *MacArthur-Bates CDI Words Total Gestures Reported at Pre-Intervention, Post-Intervention, and 4-Month Follow-Up*



An Examination of Measures Associated with the Differential Diagnosis of Autism Spectrum Disorder Within a University-Based Clinic Sample

Tiffany K. Torigoe-Lai & Ronald E. Reeve

University of Virginia

Manuscript Three: An Examination of Measures Associated with the Differential Diagnosis of Autism Spectrum Disorder Within a University-Based Clinic Sample

Prevalence rates of Autism Spectrum Disorder (ASD) have dramatically increased over the course of a recent 10-year period, with current estimates at one in 68 in the United States (Centers for Disease Control and Prevention [CDC], 2014). Various explanations have been postulated regarding these growing prevalence numbers, with one common hypothesis suggesting that changes in diagnostic systems, procedures, and tools have led to the proliferation of ASD diagnoses (Barbaresi, Colligan, Weaver, & Katusic, 2009; Leonard et al., 2010; Matson & Kozlowski, 2011). Additionally, studies have found significantly overestimated incidence rates for clinically-derived ASD diagnoses compared to research-identified ones (Barbaresi et al., 2009; Matson & Kozlowski, 2011). The literature suggests that the discrepancy is most likely due to the variation in clinician experience and methodology within clinical practice in comparison to the more stringent standardized batteries utilized by professionals with more ASD experience in research settings (Barbaresi et al., 2009; Matson & Kozlowski, 2011). In addition to over identification in clinical settings, there has been an increase in substitution of diagnoses, where initial non-ASD diagnoses (e.g., Attention-Deficit/Hyperactivity Disorder, anxiety disorders, psychotic disorders) are replaced with a primary diagnosis of ASD. This is likely due to greater awareness of the disorder within the professional community, as well as potential access to more comprehensive interventions (Leonard et al., 2010). Given the vast heterogeneity of diagnostic procedures utilized for diagnosing ASD, it is arguable that an over-inflation of identified ASD cases exists (Barbaresi et al., 2009; Matson & Kozlowski, 2011). Thus, there is a pressing need to develop and evaluate more effective diagnostic methods to differentiate ASD from other disorders within clinical settings.

Current Practices for Diagnosing ASD

The two most common diagnostic systems used for conceptualizing and diagnosing ASD are the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition* (DSM-5; American Psychiatric Association [APA], 2013) and the *International Classification of Diseases and Related Health Problems, Tenth Revision, Clinical Modification* (ICD-10-CM; World Health Organization [WHO], 2010). Recent changes in the classification of ASD from the fourth to fifth edition of the *Diagnostic and Statistical Manual of Mental Disorders* have spurred controversy over whether the modification from a categorical classification (e.g., Autistic Disorder, Asperger's Disorder, Pervasive Developmental Disorder-Not Otherwise Specified) to a single dimensional diagnostic model (e.g., Autism Spectrum Disorder) is the best fit for conceptualizing the disorder. Despite these changes, the broad core symptoms of ASD remain the same across all three diagnostic systems: 1) social communication deficits, and 2) evidence of restricted, repetitive behaviors and/or interests.

Standard ASD assessment. To assess core symptomology, the "gold standard" ASD evaluation involves a multidisciplinary team (MDT) assessment in which information is gathered from multiple sources and settings and evaluated within a developmental context (Andersson, Miniscalco, & Gillberg, 2013; Falkmer, Anderson, Falkmer, & Horlin, 2013; Ozonoff, Goodlin-Jones, & Soloman, 2005; Volkmar et al., 2014). The MDT is typically comprised of psychologists, psychiatrists, other medical specialists such as neurologists, and speech and language pathologists (Ozonoff et al., 2005). The MDT approach has evidenced solid diagnostic validity through high rates of correct clinical classification of ASD (Falkmer et al., 2013). As part of the standard MDT

assessment, research suggests that the battery should assess four core domains: 1) ASD symptomology, 2) intellectual functioning, 3) language functioning, and 4) adaptive behaviors (Ozonoff et al., 2005; Volkmar et al., 2014). ASD symptoms are generally assessed by conducting a parental interview to obtain background information on early development as well as current concerns; gathering information from multiple proxy reporters, such as parents and teachers, through questionnaires; and administering ASD-specific diagnostic tools with the client (Falkmer et al., 2013; Ozonoff et al., 2005; Volkmar et al., 2014). Presently, the "gold standard" ASD measures (Falkmer et al., 2013; Ozonoff et al., 2005) are considered to be the Autism Diagnostic Interview-Revised (ADI-R; Rutter, Le Couteur, & Lord, 2003) and the Autism Diagnostic Observation Schedule-Second Edition (ADOS-2; Lord, Rutter, DiLavore, Risi, Gotham, & Bishop, 2012).

Assessment of cognitive abilities, adaptive functioning, and language abilities provides a framework for understanding behaviors in relation to the individual's overall development (Andersson et al., 2013; Ozonoff et al., 2005; Volkmar et al., 2014). These areas are also strong predictors of future outcomes and aid in identifying appropriate goals for treatment (Ozonoff et al., 2005; Volkmar et al., 2014). Intellectual functioning, language abilities, and adaptive behaviors are often assessed using common standardized measures, such as the Wechsler Intelligence Scale for Children-Fifth Edition (WISC-V; Wechsler, 2015), Peabody Picture Vocabulary Test-Fourth Edition (PPVT-4; Dunn & Dunn, 2007), and Vineland Adaptive Behavior Scales-Second Edition (VABS-II; Sparrow, Cicchetti, & Balla, 2005). Additional, non-core domains that are frequently assessed are academic and behavioral functioning to determine the presence of comorbid

disorders (Ozonoff et al., 2005). The last necessary component of the "gold standard" ASD diagnostic formulation is clinical judgment (Andersson et al., 2013; Matson & Jang, 2014), highlighting the importance of experienced clinicians who have worked extensively with the ASD population.

Comorbid disorders. Individuals with other neurodevelopmental and psychological disorders (e.g., Intellectual Disability [ID], Attention-Deficit/Hyperactivity Disorder [ADHD], anxiety disorders, communication disorders) can display overlapping symptoms similar to that of ASD, including increased motor activity, obsessive-compulsive traits, self-injurious behaviors, aggression, anxiety, social skills deficits, and language abnormalities. Therefore, it is critical to make these diagnostic distinctions in order to plan for and implement appropriate intervention methods (Andersson et al., 2013; Volkmar et al., 2014). The process of distinguishing whether these behaviors qualify as an additional co-occurring, comorbid disorder or a distinctly different syndrome is rather complex, as evidenced by mixed findings within the literature. Described below are a few disorders that commonly have overlapping symptomatology with ASD.

Intellectual disability. About 31% of individuals with ASD have a comorbid diagnosis of ID (CDC, 2014). Individuals with a sole ID diagnosis often exhibit communication problems as well as stereotypical behaviors, but these beahviors are qualitatively different than those seen in individuals with ASD (Matson & Jang, 2014). Individuals with ID *and* ASD may have limited functional communication skills; however, a person with ASD may have more echolalic speech and speech abnormalities (e.g., incorrect pronoun usage) than an individual with ID alone (Matson & Jang, 2014).

Moreover, individuals with ID tend to be more socially engaged than people with ASD (Matson & Jang, 2014), though the quality of their social interactions is equally limited. Some research suggests that individuals with ASD *and* comorbid ID tend to display more severe ASD symptomatology during adolescence and adulthood with little improvement over time in comparison to those with ASD alone (Taylor & Seltzer, 2010). However, the literature is mixed as to whether there is significantly differing symptomatology among those with ASD *and* ID in comparison to ASD alone (Goldin, Matson, & Cervantes, 2014; Tureck, Matson, Cervantes, & Konst, 2014).

Attention-deficit/hyperactivity disorder. ASD and ADHD were previously thought to be two divergent disorders as evidenced by the strict criteria in the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision* (DSM-IV-TR; APA, 2000), which stipulated that these disorders could not be diagnosed in conjunction with one another. With the release of the DSM-5, ASD and ADHD are now recognized as potentially co-occurring disorders and can be diagnosed jointly (APA, 2013). Individuals with ASD and ADHD display many overlapping features, such as inattentiveness, hyperactivity, impulsivity, executive functioning deficits, slower processing speed, and motor control issues (Mannion & Leader, 2013; Mayes, Calhoun, Mayes, & Molitoris, 2012). However, research studies vary regarding descriptions of clinical profiles of solely ASD, solely ADHD, and comorbid ASD *and* ADHD. Some findings indicate individuals with ASD can be distinctly distinguished from those with ADHD, as individuals with ASD scored higher on a checklist of ASD-related traits (e.g., problems with social interactions, perseverations, atypical communication and development, mood disturbance) than those with ADHD (Mayes et al., 2012). In contrast,

ADHD-like characteristics of inattention, impulsivity, and hyperactivity as well as similar executive functioning deficits are often observed in children with ASD, suggesting that ADHD symptoms are observed in ASD but not vice versa (Konst, Matson, Goldin, & Rieske, 2014; Mayes et al., 2012). Additionally, other studies have found that individuals with comorbid ASD *and* ADHD have a unique cognitive, social, and adaptive functioning profile compared to ASD alone; individuals with comorbid ASD *and* ADHD have greater cognitive delays, exhibit more ASD-like (e.g., stereotyped behaviors) and maladaptive behaviors (e.g., aggression, defiance), and have poorer adaptive functioning skills (Rao & Landa, 2013). Alternatively, other researchers argue that there are no significant differences between the two (Hattori, Ogino, Abiru, Nakano, Oka, & Ohtsuka, 2006; Hartley & Sikora, 2009). These findings further complicate diagnostic decisions for clinicians as to whether a differential or comorbid diagnosis is warranted.

Anxiety disorder. Anxiety disorders and ASD are arguably the most commonly co-occurring disorders, especially among those with higher functioning ASD (Kerns, Kendall, Zickgraf, Franklin, Miller, & Herrington, 2015). Research has shown that communication deficits and level of intellectual functioning can influence the expression of anxiety behaviors in those with ASD (Grondhuis & Aman, 2012). Additionally, individuals with comorbid ASD and an anxiety disorder display more self-injurious behaviors and depressive symptoms (Kerns et al., 2015). While there is no universal profile of this comorbid combination, much of the literature suggests that there are notable qualitative differences between the social and communicative impairments of the two disorders as well as the function the symptom serves. For example, characteristics of obsessions, repetitive behaviors, compulsions, and restricted interests can overlap with

ASD and Obsessive Compulsive Disorder (OCD), though the function of these behaviors differs for each (Jang & Matson, 2015). Individuals with OCD often engage in these behaviors to reduce their anxiety, whereas those with ASD do so for more self-stimulatory reasons (Jang & Matson, 2015). Moreover, individuals with social phobia or social anxiety display similar social skills deficits to those with ASD; thus, the onset, quality of social interactions, and function of the avoidance may help differentiate between the two (Jang & Matson, 2015). These subtle differences in symptom profiles again highlight the need for clinical experience in diagnosing ASD.

Language disorders. Individuals with ASD are known to have communication deficits, as it is part of the core criteria for the disorder. Research has shown that individuals with ASD have reduced or impaired expressive and receptive language skills (Kwock, Brown, Smyth, & Cardy, 2015). However, there is still debate as to whether these skills are equally poor or if expressive language abilities are stronger than receptive language skills; therefore, expressive-receptive language profiles might not be the best marker for distinguishing comorbidity (Kwock et al., 2015). While classic cases of ASD and Speech Language Impairment (SLI) may be easily discernible, there is research suggesting that these groups have similar language symptomatology (Taylor, Mayberry, Grayndler, & Whitehouse, 2014). For example, individuals with Pragmatic Language Impairment (PLI), a subgroup of SLI, have similar social communication deficits to those with ASD, such as problems identifying social cues, difficulty sustaining reciprocal conversations, making inappropriate social comments, and engaging in tangential speech (Reisinger, Cornish, & Fombonne, 2011; Scheeringa, 2001). Individuals with PLI and SLI often meet criteria for social and communication deficits on behavioral ASD

measures, such as the ADOS, and continue to display these impairments into older adolescence and adulthood (Reisinger et al., 2011; Taylor, Mayberry, & Whitehouse, 2012; Taylor et al., 2014). Previous research highlights the debate about whether PLI and ASD are separate diagnostic entities or variations of the same condition (Reisinger et al., 2011; Scheeringa, 2001). However, with the emergence of Social Communication Disorder (SCD) as a separate disorder in the DSM-5, further research needs to be conducted to evaluate the differences between ASD, SCD, and other language deficits. Given that there is no universal "gold standard" for diagnosing PLI, clinical judgment plays a crucial role in the diagnostic process (Reisinger et al., 2011), and further emphasizes the need for a MDT assessment for ASD.

In sum, researchers are still struggling to characterize the profiles of comorbid neurodevelopmental and/or psychiatric disorders and ASD. There are several overlapping symptoms observed in individuals with ASD and commonly co-diagnosed disorders, such as social communication deficits, inattentiveness, maladaptive behaviors, anxiety, depression, and executive functioning difficulties. The presence of these co-occurring behaviors makes it extremely difficult for clinicians to differentiate between ASD and other neurodevelopmental or psychiatric disorders, or to determine if multiple diagnoses are warranted. Some research has shown quantitative differences between these three profiles in regards to IQ and adaptive functioning, whereas others have noted qualitative differences, such as the varying functions of the behaviors. However, there is little consensus as to which symptoms clinicians should focus on in order to achieve diagnostic clarity.

These murky diagnostic distinctions have also impacted the precision of prevalence rates. While some studies have reported high overall comorbidity incidence rates (71-74%) for children with at least one comorbid diagnosis and ASD (Leyfer et al., 2006; Mattila et al., 2010; Simonoff, Pickles, Charman, Chandler, Loucas, & Baird, 2008), there continue to be mixed reports within the literature regarding the prevalence rates of individual comorbid psychiatric disorders among those with ASD (Mannion & Leader, 2013; Tsai, 2014; Volkmar et al., 2014). A few have argued that the variability in comorbidity rates is due to the limited number of studies, small samples sizes, and lack of instruments designed to screen for comorbidities and differential diagnoses for those with ASD (Mannion & Leader, 2013; Tsai, 2014; Volkmar et al., 2014). Another possible explanation for the variability in comorbidity rates could be the false positive rate of identified ASD cases. As previously stated, clinically-diagnosed ASD rates seem to be overinflated in comparison to research-derived ASD diagnoses due to differences in diagnostic practices and clinical experience (Barbaresi et al., 2009; Matson & Kozlowski, 2011). Moreover, given the vast heterogeneity of ASD, it could be that comorbidity rates might reflect poor diagnostic boundaries and overlapping symptomatology of other neurodevelopmental and psychiatric disorders. Research exploring sub-threshold ASD traits have found interrelated characteristics (i.e., social-emotional deficits, cognitive inflexibility) similar to those with ASD among individuals within a typically developing population that exhibit ASD-like qualities (Gokcen, Petrides, Hudry, Frederickson, & Smillie, 2014).

Differential diagnosis. To the author's knowledge, there is a dearth of research on the incidence of differential diagnosis of ASD as well as false positive, or

misdiagnosis, rates. Much of the current research focuses on initial diagnosis of children age three and under (Trammell et al., 2013). However, parents of older adolescents and adults often seek a secondary differential diagnosis due to ineffectiveness of interventions or the individual's changing needs (Matson & Cervantes, 2014; Trammell et al., 2013). Despite this, there is little research examining ASD symptoms and severity and comorbid psychopathology across the lifespan (Matson & Cervantes, 2014; Trammell et al., 2013). Moreover, given the variety of assessment tools used to make differential diagnoses, many of which are not validated with an ASD subgroup, there is currently no best practice in conducting differential diagnostic evaluations (Matson & Cervantes, 2014). Only a few vague guidelines have been published regarding differential diagnostic procedures; most note that clinician experience with ASD and clinical judgment are paramount when making diagnostic distinctions (Andersson et al., 2013; Matson & Jang, 2014; Ozonoff et al., 2005; Trammell et al., 2013) and recommend using the DSM-5 criteria to rule in or out possible diagnoses (Volkmar et al., 2014). Lastly, there are notable differences between diagnostic practices within clinical and research settings. There is comparably less research examining more heterogeneous clinical populations of ASD than the more homogenous autism research samples, the findings of which are harder to generalize to community populations. Given that ASD frequently co-occurs with multiple medical and psychiatric disorders (Leyfer et al., 2006; Mattila et al., 2010; Simonoff et al., 2008), there is a great need to examine the ASD profile within a mixed clinical population so that findings can be translated into more applied clinical practice.

Purpose of Study

The primary aim of this study was to add to the literature regarding differential diagnostic practices for ASD. Specifically, this pilot study explored the role cognitive, autism-specific, adaptive, and behavioral measures play in determining a clinical classification of ASD in comparison to other neurodevelopmental or psychiatric disorders within a university-based clinic sample. Much of the research in ASD focuses on how to define the disorder using the two broad core domains, leading to vast heterogeneity. Additionally, the numerous overlapping symptoms seen in other neurodevelopmental and psychiatric disorders with ASD make it difficult for even the most skilled clinician to discriminate a comorbid versus differentially distinct diagnosis. Therefore, the present study sought to identify which standardized measures might aid in distinguishing an ASD profile within a collection of individuals initially identified as having ASD-like deficits (i.e., social communication impairments and/or restricted, repetitive behaviors and interests).

Broadly, this study provides preliminary information concerning which standardized measures clinicians and researchers might prioritize to more efficiently diagnose ASD within a mixed clinical population. This study proposed to answer a series of questions. First, consistent with the MDT ASD assessment standards, are results from autism-specific, behavioral, and adaptive measures associated with a clinically-derived ASD diagnosis in our sample, while controlling for level of cognitive functioning? Based on the literature, it was hypothesized that scores on autism-specific, behavioral, and adaptive measures aided in distinguishing ASD from profiles of other neurodevelopmental and psychological disorders, when controlling for intellectual functioning. Second, do the ADOS and Social Responsiveness Scale (SRS), a parent-

reported measure of ASD symptomatology, provide sufficient differential data about social communication skills and restricted, repetitive behaviors (RRB) between individuals who received an ASD diagnosis and those who received another neurodevelopmental or psychological disorder diagnosis? Based on existing research, we expected the ASD group to have higher scores in both domains on the ADOS, indicating more observed ASD symptoms, and a higher overall SRS score, suggestive of more severe ASD symptomatology. Finally, is there a way to distinguish a true ASD profile among false positives on the ADOS? It was hypothesized that individuals who were given a clinical diagnosis of ASD would have higher social communication and RRB scores on the ADOS than those who had another neurodevelopmental disorder, again, indicating more observed ASD characteristics.

Methods

Participants

A total of 76 individuals between the ages of two and a half and 53 years of age were evaluated through an ASD specialty sub-clinic within a university-based training clinic between 2011 and 2014. The university-based clinic provided integrated clinical services under the leadership of licensed clinical professionals in conjunction with graduate training programs. The ASD specialty sub-clinic provided comprehensive multidisciplinary evaluations for individuals who reported ASD symptoms, in line with current research recommendations. The multidisciplinary team was comprised of clinical psychologists, a neuropsychologist, speech and language pathologists, post-doctoral psychology fellows, and clinical psychology doctoral students. All team members had at least one-year experience working directly with individuals with ASD. Each family was

assigned a lead clinician, who worked directly with the family and the broader team to complete the evaluation. The lead clinician was either a licensed clinical psychology, psychology post-doctoral fellow, or clinical psychology doctoral student. The four core team members that administered ASD-specific assessments had at least three years experience working directly with individuals with ASD and received extensive clinical training on administering and interpreting the ADOS and ADOS-2. Individuals seen through the ASD specialty sub-clinic were parent- or self-referred or referred by a medical or mental health professional for a comprehensive psychological evaluation. Upon intake, all individuals were reported to have presented with ASD-like characteristics (e.g., social communication deficits and/or evidence of restricted, repetitive behaviors and interests) and/or had a previous diagnosis of Autistic Disorder, Asperger's Disorder, Pervasive Developmental Disorder – Not Otherwise Specified, or Autism Spectrum Disorder. Of the 76 individuals seen, 39 consented to have their information used for research purposes. The final sample utilized for this study consisted of 28 individuals after screening for missing data as well as outliers.

The majority of the individuals in our sample are Caucasian (92.9%), male (89.3%), children and adolescents. Sample age ranged from 4 years, 6 months to 21 years, 5 months with a mean age of 9.16 years. Table 1 provides a further demographic breakdown of our sample. Table 2 provides an overview of sample clinical characteristics. In regards to clinical characteristics, the majority of individuals were born full-term (range: 26-46 weeks; M=37.81) and did not have a history of any significant prenatal (60.7%) or perinatal (57.1%) events. However, the majority experienced medical issues following birth, as 64.3% had one or more previous or current comorbid medical

diagnoses (e.g., seizures, chronic otitis media, asthma, strabismus, nystagmus), and 50% had a positive surgical history. Most individuals in our sample did not obtain speech milestones within the expected ranges (64.3%), while the majority achieved motor milestones on time (57.1%). Almost all of the individuals in our sample had a preexisting educational or psychological disorder diagnosis prior to evaluation (96.4%), with the majority being previously diagnosed with ASD (64.3%). Most did not have a family history of ASD (64.3%). Of the 28 participants, 10 were given a primary clinical diagnosis of Autistic Disorder, Asperger's Disorder, Pervasive Developmental Disorder – Not Otherwise Specified, or ASD. The remaining 18 individuals were diagnosed with one or more different neurodevelopmental (e.g., ID, ADHD) or psychological (e.g., Anxiety Disorder, Depressive Disorder) disorder. Lastly, our sample was generally higher-functioning as most individuals displayed average cognitive abilities (M=90.79, SD=28.11) [Table 2], consistent with current research regarding the cognitive functioning of individuals with ASD (CDC, 2014). The majority of individuals were also largely verbal, as most individuals were administered module 3 of the ADOS, which is given to verbally fluent children and adolescents (Table 3).

Measures

While each lead clinician determined the overall assessment battery for each evaluation, five core areas were assessed: 1) medical, developmental, and psychosocial history; 2) cognitive functioning; 3) ASD symptomatology; 4) adaptive skills; and 5) behavioral functioning. Several clients also had a speech and language evaluation conducted at the clinic, which was supervised by a speech and language pathologist experienced in working with individuals with ASD. However, there were not consistent

standardized measures conducted across all speech and language assessments to permit use of the data in these analyses.

Medical, developmental, and psychosocial history. Demographic and background historical information was gathered through the clinic's client history form, which was completed by either the client's primary caregiver or the young adult individual being seen. More comprehensive information about the client's medical, developmental, and psychosocial history as well as current presenting issues were obtained through a formal clinical interview with the lead clinician and the parent/caregiver. Clinical interviews were individualized and tailored by the lead clinicians; however, each interview addressed important areas associated with ASD, such as early childhood development, peer relationships, and the presence of restricted, repetitive behaviors.

Cognitive functioning. Various cognitive measures, including the Differential Ability Scales, Second Edition (DAS-II; Elliott, 2007), Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999), Wechsler Adult Intelligence Scales, Fourth Edition (WAIS-IV, Wechsler, 2008), Wechsler Preschool and Primary Scale of Intelligence, Third Edition (WPPSI-III; Wechsler, 2002), Wechsler Intelligence Scale for Children, Fourth Edition (WISC-IV; Wechsler, 2003), and Woodcock-Johnson III, Tests of Cognitive Abilities (WJTCA-III; Woodcock, McGrew, & Mather, 2001), were administered to the client based on chronological age. They were used to generate standard scores reflecting a Full Scale IQ (FSIQ) that estimated the individual's intellectual abilities.

ASD symptomatology. Each client was administered the Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, DiLavore, & Risi, 2000) or the Autism Diagnostic Observation Schedule-Second Edition (ADOS-2; Lord et al., 2012) based on the year of assessment. The ADOS/ADOS-2 is a standardized, semi-structured assessment of communication, social interaction, play, imagination, repetitive behaviors, and restricted interests (Gotham, Risi, Pickles, & Lord, 2007). The ADOS-2 administration procedures, basic activities, and coding items are generally identical to the ADOS, with a slight change in the revised algorithm items of the ADOS-2 in modules 1-3 to align with DSM-5 criteria (Lord et al., 2012). The measure is broken into four modules, which are based on developmental age and language levels, ranging from no language to verbally fluent children and adults (Gotham et al., 2007). The measure yields an overall total score based on algorithm items, which is used as a cut-off score for a classification of "autism," "autism spectrum," or "not autism." Both the ADOS and ADOS-2 has been reported to yield high specificity and sensitivity for a classification of ASD (Gotham et al., 2007) and are considered to be one of the "gold standard" tools for assessing ASD (Ozonoff et al., 2005). One of four clinically-trained raters with established inter-rater reliability administered the ADOS or ADOS-2 for each assessment.

Additionally, at least one primary caregiver was asked to complete the Social Responsiveness Scale, Second Edition (SRS-2; Constantino & Gruber, 2012). The SRS-2 is a widely used diagnostic tool to identify individuals with ASD across the two core ASD domains. The SRS-2 yields high overall internal consistency in both clinical and non-clinical groups with strong sensitivity and specificity among mixed clinical groups

and typically developing controls (Constantino & Gruber, 2012). It generates a total T-score reflecting severity of social deficits related to ASD and individual T-scores for the five treatment subscales (Social Awareness, Social Cognition, Social Communication, Social Motivation, and Restricted Interests and Repetitive Behaviors).

Adaptive skills and behavioral assessment. To assess the presence of other internalizing and externalizing behaviors as well as adaptive skills, primary caregiver(s) were asked to complete the Parent Rating Scales form of the Behavior Assessment System for Children, Second Edition (BASC-2; Reynolds & Kamphaus, 2004). The BASC-2 was developed to assess the presence of externalizing, internalizing, and adaptive behaviors in both children and adolescents. There are three clinical composites (Externalizing Problems, Internalizing Problems, and Behavioral Symptoms Index) and one adaptive composite (Adaptive Skills) with nine clinical and five adaptive subscales. The BASC-2 has been found to be a reliable and valid measure of internalizing, externalizing, and maladaptive behavioral issues as well as adaptive skills as it yields moderate to high internal consistency for the composite scales and individual scales across all forms as well as high construct validity (Reynolds & Kamphaus, 2004).

Clinical diagnosis. Clinical diagnosis was compiled from the comprehensive report in each client's file. Final clinical diagnosis was determined following a case conference involving at least the lead clinician and supervising psychologist, considering all information gathered during the assessment process.

Results

Analyses

Data screening. The original dataset included 39 consented individuals. Of the 39 individuals, five had partially missing files and/or protocols; thus their data was unavailable for analyses. Three were not administered the ADOS or ADOS-2, so they were not included in our analyses, bringing our sample to 31. Assumptions were checked and revealed non-normality for two variables (BASC-2 Internal composite score and age of testing). Two outliers were identified and removed, resulting in normality being upheld. Skewness and kurtosis both fell within acceptable ranges for the remainder of the independent variables (FSIQ, ADOS/ADOS-2 total algorithm score, ADOS/ADOS-2 Social Affect algorithm score, ADOS/ADOS-2 RRB algorithm score, SRS-2 total T-score, and all BASC-2 composite and subscale scores). No other outliers were identified. Multicollinearity was not observed in any of the independent variables. Leverage and influence also fell within acceptable ranges for all variables of interest. Levene's test revealed non-significant results for all independent variables, suggesting homogeneity of variance was not violated. After checking for assumptions, our final sample size was 28. Three individuals were missing BASC-2 data and one was missing SRS-2 data, which was more than 5% of our sample size. To see if these could be considered missing at random (MAR), a missing value analysis was conducted in SPSS, Version 23 and indicated that the missing data could be considered MAR. Multiple imputation was performed in SPSS, Version 23 to handle missing values for BASC-2 composite scores and SRS-2 total T-score. Five imputed data sets were generated. Imputed data sets and pooled analysis results are reported here. See Figure 1 for data workflow.

Predictors of diagnostic outcome

A binary logistic regression with hierarchical entry was performed in SPSS, Version 23 to ascertain the effect of ADOS/ADOS-2 (which will be referred to as "ADOS") classification, behavioral functioning, and adaptive skills scores on the likelihood that participants would have an ASD diagnosis, with IQ as a covariate. Groups were divided by clinical diagnosis: 1) ASD and 2) other neurodevelopmental or psychiatric disorder (which will be referred to as "other"). Our small sample size (n=28) limited the number of predictive variables in our model to three; thus, independent variables were reduced to FSIQ, ADOS/ADOS-2 classification, and BASC-2 Adaptive Skills composite score. Behavioral functioning was not evaluated in our model as originally intended given multiple variables distinguishing behavior on the BASC-2 (Internal, External, and Behavioral Symptoms composite scores) and the aforementioned variables were of higher theoretical importance. High correlations were observed between Nonverbal IQ (NVIQ), Verbal IQ (VIQ), and FSIQ; thus, NVIQ and VIQ were not utilized in our analyses. ADOS classifications were condensed to "ASD" or "not ASD" from their original categories of "autism," "autism spectrum," and "non-spectrum" due to the small sample size of those classified as "autism spectrum" (n=2). Those classified as "autism spectrum" were subsumed into the "autism" group.

After controlling for IQ, our results revealed that none of our predictors were significant in our pooled model (ρ>.05). Due to non-statistical significance of our predictors and small sample size, BASC-2 Adaptive Skills composite score was removed from our model to see if the ADOS retained any predictive value upon diagnostic group membership. Our reduced model revealed that ADOS classification was also not significant (ρ>.05). We conducted a third exploratory analysis to see if ADOS total

algorithm score would be more predictive than ADOS classification. Using FSIQ as a covariate, change in chi-square from the first block model to the full model containing ADOS total algorithm score revealed significant results ($\chi^2(2)$=7.36, ρ=.025) across all five imputed models. Nagelkerke $\mathcal{R}^2$ indicated that our predictor variables accounted for 31.7% of variability in diagnostic group membership across all five imputed models. Model classification accuracy was 78.6% (60% for ASD and 88.9% for Not ASD), which was a 14.3% increase from our base model with no predictors. At the predictor level, FSIQ was not significant when entered in the first block as a covariate (Wald=1.597, *p*=.206). In the full model after controlling for FSIQ, ADOS total algorithm score was significant (Wald=4.515, *p*=.034, OR=1.198), suggesting that the likelihood of having an ASD diagnosis increases by one unit of ADOS total algorithm score by a factor of 1.198. Our results suggest that individuals with an elevated ADOS total algorithm score of 20, which exceeds classification cutoffs across all modules, have a 72% probability of being diagnosed with ASD in comparison to those with lower scores of 5, which only have a 15% probability of being diagnosed with ASD.

Between-group analysis on ASD-specific measures

To address our second research question, between-group differences on ASD-specific measures were analyzed by performing independent t-tests using ADOS algorithm scores and SRS-2 total score as our independent variables. Initial analyses included conducting ANCOVAs between our two groups with our intended independent variables and FSIQ as a covariate; however, again due to our small sample size, we did not have a sufficient n for each group analyzed.

ADOS total algorithm score was broken down by algorithm sub-scores, Social Affect (SA) and Restricted Repetitive Behaviors (RRB), to see if there were any differences between diagnostic groups. We used our original dataset for these analyses, as all individuals were given the ADOS and only one individual was missing SRS-2 data (<5% of total sample). Results revealed that SA algorithm score ($t(26)=-2.297$, $p=.030$) and RRB algorithm score ($t(26)=-2.998$, $p=.006$) were statistically significant. The ASD group was observed having a higher mean score on SA (M= 10.60, SD=4.90) and RRB (M=4.50, SD=2.84) scores in comparison to those that had a different developmental or psychiatric diagnosis (Table 5). However, there were no significant differences between group means on the SRS-2 total score ($t(25)=-.245$, $p=.809$). Group means were almost identical between the ASD (M=80.00, SD=7.93) and other neurodevelopmental or psychiatric disorder (M=80.78, SD=7.46) groups (Table 4).

Within-group analysis on the ADOS

Eighteen of the 28 individuals in our sample were classified as ASD using the recommended ADOS classification cutoffs through the ADOS; however, only 10 out of the 28 were given a clinical diagnosis of ASD. Thirty-nine percent of those that were given a clinical diagnosis of ASD were positively classified as having ASD through the ADOS (n=7). The remaining 51% were false positives, meaning they were classified as ASD on the ADOS but given a clinical diagnosis of another neurodevelopmental or psychiatric disorder.

In order to examine if there were diagnostic group differences among those that were classified as ASD on the ADOS in regards to our third research question, we conducted independent t-tests on the ADOS SA and RRB algorithm scores using the

original dataset. Again, our original intended analyses included ANCOVAs on both groups with FSIQ as a covariate, but we did not have sufficient group sizes to warrant those analyses.

Independent t-tests revealed statistically significant differences on both SA ($t(16)=-2.372$, $p=.031$) and RRB ($t(16)=-4.98$, $p<.001$) scales between the ASD and other diagnostic group within our sub-sample. Individuals that had a clinical diagnosis of ASD *and* were classified as ASD on the ADOS had a higher mean on SA (M=13.14, SD=3.24) and RRB (M=6.14, SD=1.21) scores in comparison to those who were classified as ASD on the ADOS but were diagnosed with a different neurodevelopmental or psychological diagnosis (see Table 5).

Discussion

This study examined whether cognitive, ASD-specific, and/or adaptive functioning measures were salient to the differential diagnostic process between ASD and other neurodevelopmental or psychological disorders in a clinical sample of individuals identified as having ASD-like behaviors. It is generally recommended that clinicians utilize a MDT approach to evaluate ASD symptoms among three areas of functioning: cognitive, behavioral, and adaptive. However, the extant research provides vague guidelines as to how to identify a comorbid neurodevelopmental or psychiatric disorder *and* ASD or how to differentiate ASD from commonly occurring disorders with overlapping symptomatology. The present study seeks to add to the literature regarding differential diagnostic practices of ASD and provides preliminary information to aid in clinical practice.

Binary logistic regression results indicated that higher total algorithm scores on the ADOS were predictive of a clinical ASD diagnosis, consistent with our hypothesis. ADOS total algorithm score appeared to provide more predictive value than ADOS classification, suggesting that the ADOS classifications may not be stringent enough when distinguishing ASD within a mixed clinical sample. Given that all individuals in our study were referred for an evaluation because they were exhibiting ASD-like behaviors, many most likely exhibited several social communication impairments; thus, their total ADOS algorithm scores easily met the threshold for a classification of "autism" or "autism spectrum" on the ADOS. Our results suggest that in a more heterogeneous clinical sample, ADOS total algorithm scores may be more meaningful than ADOS classification when differentiating between ASD and another neurodevelopmental or psychiatric disorder. More elevated scores could suggest more observed and severe social communication and restricted repetitive behaviors, which would be expected within an ASD profile. Sensitivity (60%) of our logistic regression model using the ADOS total algorithm score was significantly lower than reported by the ADOS authors (86-100% across all four modules) (Lord et al., 2012). Given the lower proportion of ASD cases (n=10) and higher number of individuals with other neurodevelopmental or psychiatric disorders (n=18) in our sample, the ADOS may function differently in more heterogeneous clinical populations than the research samples it was normed on, as suggested by Molloy et al. (2011) who also found lower sensitivity rates of the ADOS within their larger clinical sample. However, in contrast to our original hypothesis, adaptive and cognitive functioning was not statistically significant in our model. While research has recommended that cognitive and adaptive functioning should

be considered in a MDT assessment of ASD, our preliminary data suggests that this information may not be as paramount when making differential diagnostic decisions between ASD and other neurodevelopmental or psychological disorders within higher-functioning clinical samples (e.g., average cognitive abilities, verbally fluent). These factors may be more salient when scores indicate severe cognitive impairment or giftedness.

In regards to our second research question, the ADOS provided sufficient differential data regarding ASD symptoms between those with ASD and those with another neurodevelopmental or psychiatric disorder, as predicted. Results from independent t-tests demonstrated that the ASD group had significantly higher scores on both SA and RRB algorithm domains on the ADOS than the "other" group. Surprisingly, there were no significant mean differences on the parent-reported SRS-2 between our diagnostic groups. The ASD and other neurodevelopmental or psychiatric disorder groups had almost identical means, which suggests that the SRS-2 may not be a good tool in differentiating ASD from other neurodevelopmental and psychiatric disorders with overlapping symptomatology within a clinical sample. Few studies have found similar results that examined the utility of the SRS in differentiating ASD from other neurodevelopmental or psychiatric disorders, suggesting that the SRS has better predictive value between ASD and typically developing individuals (Cholemkery, Mojica, Rohrmann, Gensthaler, & Freitag, 2014; Hus, Bishop, Gotham, Huerta, & Lord, 2013). An alternative explanation for the similar means between groups is that the parent-reported SRS alone is not as sensitive in a mixed clinical sample with higher numbers of other neurodevelopmental and psychiatric disorders. Research has shown that parent- and

teacher-reported SRS scores in conjunction with ADOS findings are more sensitive for broader ASD profiles (Duvekot, van der Ende, Verhults, & Greaves-Lord, 2015).

Lastly, while the ADOS was more prone to false positives within our mixed clinical sample, within the group classified as ASD by the ADOS, the ASD clinical diagnostic group had significantly higher scores on the SA and RRB algorithm domains on the ADOS than the other group, as hypothesized. Independent t-test results suggest that individuals with ASD have more observed and severe social communication deficits and restricted, repetitive behaviors on the ADOS as measured by elevated algorithm total and sub-domain algorithm scores in comparison to those that exhibit ASD-like behaviors but ultimately have a different neurodevelopmental or psychiatric disorder. Our results suggest that the ADOS algorithm scores may have more qualitative utility (e.g., higher scores indicate more observed and more severe social communication impairment) in the differential diagnostic process than as quantitative cut-offs (i.e., ASD classification), consistent with our logistic regression results. A recent study examining ADOS algorithm total scores between individuals with ASD, ADHD, and ASD *and* ADHD found similar results stating that the ASD group had the highest score on the communication and social interaction total in comparison to the ASD *and* ADHD, and ADHD alone group, which had the lowest scores (Salley, Gabrielli, Smith, & Braun, 2015).

Limitations and Future Directions

Given the small sample size, all results should be interpreted within the context of a small clinical sample. Furthermore, we were unable to include all variables of intended interest due to limited power. Additionally, participants were recruited through convenience sampling methods; individuals were self-selected for assessments for an

ASD specialty clinic. Thus, findings cannot be generalized to the larger ASD population or wider clinical populations. Lastly, our sample was generally high-functioning as the majority of the children and adolescents had average cognitive abilities and were verbally fluent; thus, our results should be interpreted within this sub-population.

Despite these limitations, this study adds to the literature by providing preliminary information regarding which measures appear to have greater salience in differentially diagnosing ASD. Furthermore, the mixed clinical population sample used in this study adds to the limited extant research regarding diagnostic procedures within clinical settings. Given the large discrepancy in clinician experience and methodology for diagnosing ASD within clinical practice, these results can aid in developing better diagnostic practices within clinical settings. While further research is needed before any definitive conclusions can be made regarding the utility of the measures used in this study, it is hoped that our findings can provide initial guidance regarding future studies seeking to better understand the predictive power of various assessment measures in accurately diagnosing ASD. Future research should include larger clinical samples to examine ADOS scores at the item-level to see if there are quantitative differences for different diagnostic groups. We did not have a large enough sample size to warrant looking at item-level responses and their predictive value, as we feel they would provide greater insight into differing clinical presentations between ASD and other neurodevelopmental and psychiatric disorder, given that the current ADOS classification system was not particularly robust at distinguish between these two groups. Ultimately, the ADOS provides significant qualitative information over and above other cognitive and adaptive measures, further supporting its use as a “gold standard” instrument in the

evaluation of ASD. Results of this study suggest there is a need for further study of its use in mixed clinical populations given the growing number of individuals with ASD and comorbid developmental or psychiatric disorders.

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Appendix

Table 1

Demographic Characteristics of Overall Sample

	Percentage
Race	
Caucasian	92.9
African American	3.6
Asian	3.6
Gender	
Male	89.3
Female	10.7
Adopted	
Yes	21.4
No	78.6
Parental/Guardian Marital Status	
Married	85.7
Divorced/Separated	7.1
Never Married	7.1

Table 2

Clinical Characteristics of Overall Sample

	Percentage
Prenatal Events	
Yes	35.7
No	60.7
Unknown	3.6
Perinatal Events	
Yes	35.7
No	57.1
Unknown	7.1
Speech Milestones	
Within Normal Ranges	35.7
Delayed	64.3
Motor Milestones	
Within Normal Ranges	57.1
Delayed	42.9
Past or Present Medical Comorbidities	
Yes	64.3
No	35.7
Significant Surgical History	
Yes	50.0
No	50.0
Previous Educational or Psychological Disorder Diagnosis	
Yes	96.4
No	3.6
Previous ASD Diagnosis	
Yes	64.3
No	35.7
Family History of Genetic, Psychological, or Learning Disorder	
Yes	78.6
No	14.3
Unknown	7.1
Family History of ASD	
Yes	28.6
No	64.3
Unknown	7.1
IQ [M(SD)]	
Full-scale	90.79 (28.11)
Nonverbal	95.86 (26.40)
Verbal	94.11 (28.14)

Table 3

Distribution of ADOS Modules Administered

Module	**N**	**Percentage**
1	1	3.6
2	6	21.4
3	19	67.9
4	2	7.1

Table 4

Between-Group Mean Differences

	Group	N	M	SD
ADOS SA	ASD	10	10.60	4.90
	Other	18	6.28	4.70
ADOS RRB	ASD	10	4.50	2.84
	Other	18	1.94	1.70
SRS Total	ASD	10	80.00	7.93
	Other	18	80.78	7.46

Table 5

Within-ADOS Group Mean Differences

	Group	**N**	**M**	**SD**
ADOS SA	ASD	7	13.14	3.24
	Other	10	9.09	3.70
ADOS RRB	ASD	7	6.14	1.22
	Other	10	2.55	1.63

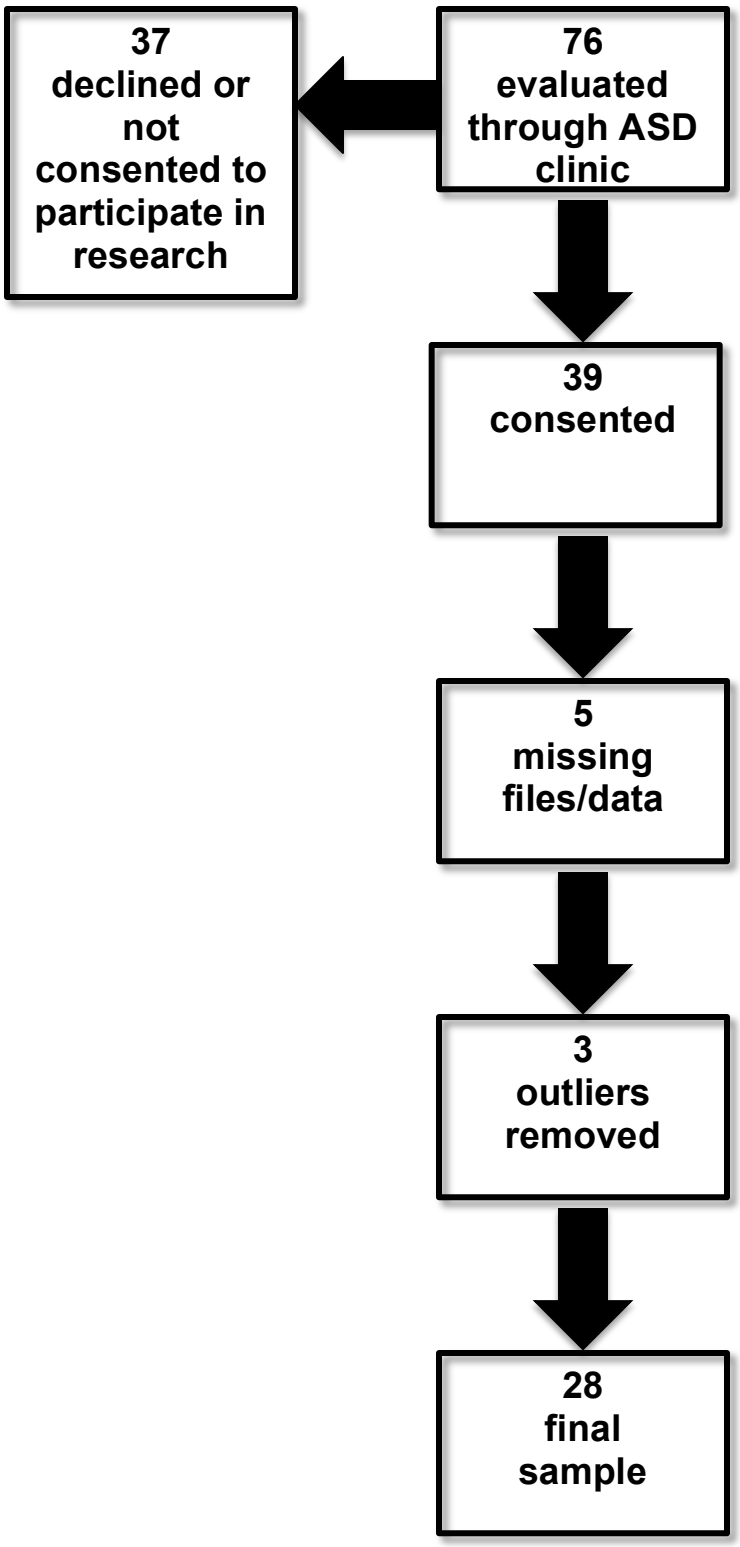

Figure 1. Data screening workflow