USING MULTIDIMENSIONAL SCALING TO DEVELOP COMMUNICATION PROFILES FOR CHILDREN WITH AUTISM

by

Gregory Russell Miles

A dissertation submitted to the faculty of
The University of Utah
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

Department of Educational Psychology

The University of Utah

December 2012

The University of Utah Graduate School

STATEMENT OF DISSERTATION APPROVAL

The dissertation of **Gregory Russell Miles**

has been approved by the following supervisory committee members:

		Date Approved
Lora Tuesday-Heathfield	, Chair	**10/26/12**
Elaine Clark	, Member	**10/26/12**
Dan Olympia	, Member	**10/26/12**
Michael Gardner	, Member	**10/26/12**
Judith Miller	, Member	**10/26/12**

and by **Elaine Clark**, Chair of

the Department of **Educational Psychology**

and by Charles A. Wight, Dean of The Graduate School.

ABSTRACT

Impairment in language and communication is a core deficit in autism and related autism spectrum disorders. Relatively recent research supports a co-occurrence of language impairment similar to that seen in children with structural language impairments and autism spectrum disorders. While it is not clear whether this impairment constitutes a subtype of children with autism or a convergence between two distinct disorders, language impairment is emerging as an important dimension in understanding autism spectrum disorders. In the current study, Profile Analysis via Multidimensional Scaling (PAMS) was used to create communication profiles, which were then validated in a sample of school aged children from a local school district receiving services through Special Education under the educational classification of Autism. Three profiles were supported: *High Speech vs. Low Nonverbal Communication*, *High Syntax vs. Low Context*, and *High Scripted Language vs. Low Social Relations*. These communication profiles were correlated with external variables including measures of adaptive functioning, cognitive ability, language ability, and autism symptoms. *High Speech vs. Low Nonverbal Communication* showed significant positive correlations on most external variables, while neither of the other two profiles showed significant correlations with any of the external measures. Characteristics of good fit to the profiles as well as profile differences in children identified as having structural language impairments are discussed.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Pervasive Developmental Disorders

According to the Diagnostic and Statistical Manual of Mental Disorders – 4th Edition, Text Revision (DSM-IV-TR; American Psychiatric Association, 2000), Pervasive Developmental Disorders (PDD) are characterized by severe and pervasive impairment in multiple areas of development that is distinctly deviant relative to the individual's developmental level or mental age. These impairments can include the following: reciprocal social interaction skills, communication skills, and presence of stereotyped behavior, interests, and activities. Included in the PDD category are Autistic Disorder, Rett's Disorder, Childhood Disintegrative Disorder, Asperger's Disorder, and Pervasive Developmental Disorder – Not Otherwise Specified (PDD-NOS).

Of the PDDs, autism is perhaps the best known and most widely studied. In many ways, autism is the quintessential PDD in that it consists of impairment in three areas of development: social interaction, communication, and restricted, repetitive, and stereotyped patterns of behavior, interests, and activities. According to the DSM-IV-TR diagnostic criteria, a diagnosis of autism is appropriate when six or more symptoms are present across the three areas, with at least two symptoms present in the social interaction domain and at least one symptom in each of the other domains. Symptoms in the social interaction domain include: impairment in using multiple nonverbal behaviors (i.e. eye gaze, facial expression, gestures), failure to develop developmentally appropriate peer relationships, lack of spontaneously seeking to share enjoyment or interests, and lack of social or emotional reciprocity. Communication symptoms include delay or lack of development in spoken language, impaired ability to initiate or sustain a conversation with others, repetitive or stereotyped use of language, and lack of spontaneous imitative or make-believe play. Symptoms in the restricted repetitive and stereotyped patterns of behavior domain include extreme preoccupation with one or more stereotyped patterns of behaviors, interests, or activities, inflexible adherence to specific nonfunctional routines or rituals, stereotyped and repetitive motor mannerisms, and preoccupation with parts of objects. In addition to the requisite number of symptoms, a diagnosis of autism also requires that the observed delays or abnormal functioning are present before the age of three in at least one of the following: social interaction, language as used in social communication, or symbolic or imaginative play.

In addition to the clinical criteria used to diagnose autism, an educational classification of autism has also been established to serve the educational and social needs of children with autism in the public education system. According to the Individuals with Disabilities Education Improvement Act of 2004 (IDEA 2004), autism is defined as “a developmental disability significantly affecting verbal and nonverbal communication and social interaction, generally evident before age three, that adversely affects a child’s educational performance” (sec. 300.8.c.1.i). This educational definition differs from the clinical definition outlined in the DSM-IV-TR in a number of ways. First, while the clinical definition is based on a triad of impairment (social interaction, communication, and restricted, repetitive, and stereotyped patterns of behavior, interests, and activities), the educational classification is defined by only two (verbal/nonverbal communication and social interaction). In fact, IDEA 2004 lists repetitive activities and stereotyped movements as “characteristics often associated with autism” rather than as a core deficit area central to the disorder itself (sec 300.8.c.1.i). Second, according to the IDEA educational definition, a diagnosis of autism is not enough for an educational classification; the nature of the impairment must be such that the child’s educational performance is negatively impacted to a degree that requires specialized instruction. In many instances, high functioning children with autism may not receive services through special education under the educational classification of autism because they do not require specialized instruction in academic areas. Third, the educational classification of autism may exclude many children with autism from receiving specialized instruction under the educational classification of autism because they exhibit severe externalizing and/or internalizing behaviors. IDEA 2004 states, “Autism does not apply if a child’s educational performance is adversely affected primarily because the child has an emotional disturbance” (sec 300.8.c.1.ii). Emotional disturbance includes characteristics such as an inability to build or maintain satisfactory interpersonal relationships with peers or teachers, inappropriate types of behavior or feelings, a general pervasive mood of unhappiness or depression, and a tendency to develop physical symptoms or fears associated with personal or school problems (IDEA, 2004). This adds a great deal of ambiguity into the educational classification of autism, as many children with a clinical diagnosis of autism exhibit some if not all of the above mentioned characteristics used to define emotional disturbance and suggests that how a child with a clinical diagnosis of autism is identified and served in the public school system is based on their behavioral presentation in the school setting rather than their clinical diagnosis per se.

Autism is unique among the PDDs in that it is recognized as both a clinical diagnosis and an educational classification. Autism is also the prototypical PDD; in many ways, the other PDDs function as subsets of the types of impairment seen in autism. Asperger's Disorder, for example, is differentiated from autism mainly by the absence of language or cognitive delays. The classification of PDD-NOS, on the other hand, is used when “there is severe and pervasive impairment in the development of reciprocal social interaction associated with impairment in either verbal or nonverbal communication skills or with the presence of stereotyped behavior, interests, and activities, but the criteria are not met for a specific Pervasive Developmental Disorder, Schizophrenia, Schizotypal Personality Disorder, or Avoidant Personality Disorder” (American Psychiatric Association, 2000, p. 84).

Three of the PDDs, Autism, Asperger’s Disorder, and Pervasive Developmental Disorder - Not Otherwise Specified (PDD-NOS), are now commonly referred to as Autism Spectrum Disorders (ASDs), probably in part because of the ambiguity surrounding the boundaries of these disorders. This means that instead of being clearly distinct from typical development, ASDs are better conceptualized as an "extreme point on a behavioral continuum that encompasses children who show qualitatively similar characteristics to autism in milder forms" as well as those children who are clearly identified as having autism (Bishop, Mayberry, Wong, Maley, & Hallmayer, 2006, p. 117). As such, ASDs share features across all three deficit areas (social interaction, communication, and restricted, repetitive, and stereotyped patterns of behavior, interests, and activities) to varying degrees. ASDs are neurodevelopmental disorders with characteristic features commonly seen in early childhood, the most common characteristic being a failure to socialize (Newsom & Hovanitz, 2006).

The overlap between the various ASDs is so great that the proposed revisions for the Diagnostic and Statistical Manual of Mental Disorders – Fifth Edition (DSM-V) consist of eliminating the ASD subcategories and including only a single category of ASD with more stringent criteria (i.e., must meet all three deficit areas in social communication/interaction and two of four deficits in repetitive, restrictive patterns of behavior, interests, or activities) (American Psychiatric Association, 2011, Proposed Revision section. In addition to eliminating ASD subcategories, the proposed changes to the DSM-V diagnostic criteria includes subsuming the communication domain under the social domain based on the reasoning that "communication and social behaviors are inseparable and more accurately considered as a single set of symptoms with contextual and environmental specificities" while "delays in language are not unique nor universal in ASD and are more accurately considered as a factor that influences the clinical symptoms of ASD, rather than defining the ASD diagnosis" (American Psychiatric Association, 2011, Rationale section). It remains to be seen how these proposed changes will affect the conceptualization, diagnosis and treatment of individuals with ASDs.

Given the broad range of abilities and deficits seen in individuals with ASD, it is not surprising that numerous comorbid disorders have been identified in the research literature. Disorders that have been identified as comorbid with ASDs include anxiety disorders (Generalized Anxiety Disorder, Panic Disorder, Agoraphobia, Social Anxiety Disorder, Simple Phobia, Obsessive-Compulsive Disorder), depressive disorders (Major

Depressive Disorder, Dysthymic Disorder), Oppositional Defiant Disorder (ODD), Conduct Disorder, Attention-Deficit/Hyperactivity Disorder (ADHD), enuresis, encopresis, Tourette Syndrome, Chronic Tic Disorder, and Trichotillomania (Simonoff et al., 2008). Klin, McPartland, and Volkmar (2005) identified anxiety and depression as the most common comorbid disorders for individuals with ASD with prevalence rates as high as 65%, depending on the study and sample. Simonoff et al. (2008) found that 70% of their ASD sample had at least one comorbid disorder and 41% had at least two or more. Of their sample, 41.9% were diagnosed with a comorbid anxiety disorder, 28.2% with ADHD, 28.1% with ODD, and only 1.4% with a depressive disorder. In a preschool population of children with ASDs, Hayashida, Anderson, Paparella, Freeman, and Forness (2010) found significantly higher rates of depression, with 34.3% of their sample exceeding diagnostic cutoffs for depressive disorders. In addition, many individuals with ASD suffer from various medical issues. These may include eating problems such as food selectivity, sleep disturbances including difficulty falling asleep, staying asleep, and waking too early in the morning, and gastrointestinal problems such as abdominal pain and constipation (Filipek, 2005).

Broader Autism Phenotype

Many individuals, particularly relatives of individuals with ASDs, appear to have milder characteristics of those seen in individuals with ASDs. This is generally referred to as the Broader Autism Phenotype (BAP). BAP is described as "qualitatively similar, milder phenotypes . . . thought to reflect genetically meaningful expression of various component features of autism" among first-degree relatives of individuals with autism (Losh & Piven, 2007, p. 105). Research in this area suggests that autistic traits are more common in the general population than previously thought and that those with a diagnosis of ASD fall on the more severe end of a spectrum of naturally occurring traits in the general population. According to Bolton et al. (1994), anywhere from 12% to 20% of siblings of children with autism exhibit characteristics of BAP. Schmidt et al. (2008) found that parents of children with autism displayed several neuropsychological characteristics of BAP including lower performance IQ scores and more difficulty with non-word repetition tasks requiring phonological working memory.

Genetic Research

Research into the genetics of autism has highlighted a strong heritability factor for the disorder, with monozygotic concordance rates ranging from 36% to 91% and dizygotic concordance rates ranging from 0% to 23% (Schmidt et al., 2008). These authors estimate overall heritability rates for the disorder to be as high as 90%.

Currently, several international projects are examining the genetic causes of autism. The Autism Genome Project (AGP) is one such project focused on familial aspects of autism. The AGP consortium includes over 100 researchers from 12 universities in Europe, the United States, and Canada and is designed to pool participants from all the sites meeting criteria for the project (Gallagher & Bolshakova, 2008b). Not only is this a tremendous undertaking, but it is also a significant source of current genetic-related autism research. Since 2003, researchers working on the AGP consortium have published over 200 peer-reviewed manuscripts on autism (Farrar, 2008). Another current international research project is The Autism Simplex Collection (TASC), which is designed to collect medical and DNA information on children with autism, their parents, and siblings for the purpose of building a repository of DNA information that would then be available to current and future researchers interested in conducting research in the area of autism and genetics (Gallagher & Bolshakova, 2008a). In light of such data from genetic research, autism is now seen as a genetically heterogeneous disorder in which multiple genes interact to create a predisposition for autism (Losh & Piven, 2007).

Genetic studies are also aiding in the development of new models of autism spectrum disorders and new theories about etiology. Szatmari, White, and Merikangas (2007) suggested that data from genetic studies support an etiological view of autism based on the multiple risk factor model used for many chronic diseases. According to this model, the prerequisite first hit would be a genetic mechanism that leads to social reciprocity deficits and would constitute the broader autism phenotype. Various types of second hits would determine how the autism spectrum disorder (ASD) would present itself along the spectrum. For example, a second hit of structural language deficit could result in a Pervasive Developmental Disorder - Not Otherwise Specified (PDD-NOS) presentation, while a secondary hit of insistence on sameness would result in an Asperger's presentation. According to this model, “these different 'hits,' which may be genetic, epigenetic, chromosomal, or environmental, account for the different types of ASD” (Szatmari et al., 2007, p. 492). This model could also explain the great degree of variability in cognitive functioning, functional behaviors, and symptom behaviors seen in children with ASD.

Prevalence Rates of Autism Spectrum Disorders

Though once thought to be very rare, ASDs are fast becoming mainstream. The DSM-IV TR (American Psychiatric Association, 2000), lists autism prevalence rates at 5 per 10,000 individuals. More recent publications, however, have suggested that the prevalence rates for autism and other disorders classified as autism spectrum disorders (ASD) are on the rise. Rice (2007) reported prevalence rates for ASDs as high as 1 per 150 individuals in a study surveying over 400,000 8-year-old children across 14 states in the United States. In addition to confirming this overall estimate, Fombonne (2005) gave the following as conservative estimates for various ASDs: 13/10,000 for Autistic Disorder, 21/10,000 for Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS), and 2.6/10,000 for Asperger's Disorder. Rates for ASDs have continued to increase. The latest numbers from the Centers for Disease Control and Prevention (CDC) show the rate of children with ASD has risen from one in 150 in the year 2000, to one in 110 in the year 2006, to one in 88 in the year 2008 (CDC, 2012). Autism is also largely a predominately male disorder, with a prevalence ratio of four to one for males to females (American Psychiatric Association, 2000). According to the CDC, the rate of boys with ASDs is now one in 54, while the rate of girls with ASDs is one in 252 (CDC, 2012).

Cognitive Aspects of Autism Spectrum Disorders

Cognitive abilities in individuals with ASD are extremely variable, with some individuals on the spectrum displaying savant-like splinter abilities, such as being able to mentally calculate large sums or what day of the week a given date will fall in 30 years, while others show significantly impaired cognitive functioning. Some of this variability may be due to how ASDs are diagnosed; a diagnosis of Asperger's Disorder (AS) is generally given when there is an absence of cognitive or language delays, while individuals with Autistic Disorder or PDD-NOS can fall anywhere on the intellectual spectrum. Zander and Dahlgren (2010) illustrated this in a large sample of Swedish children, where mean cognitive profiles were significantly higher for children with a diagnosis of AS than children with a diagnosis of either Autistic Disorder or PDD-NOS. In fact, the Autistic Disorder and PDD-NOS groups had very similar mean cognitive profiles.

In addition to diagnostic variations in cognitive abilities on the spectrum, prevalence rates for intellectual disability (ID) in individuals with autism have historically been very high, with researchers reporting ID prevalence rates in their samples as high as 70% to 80% (Shea & Mesibov, 2005). With the reconceptualization of autism as one of several ASDs, the prevalence rate for ID within the ASD population has gone down. In fact, while many children with ASDs still present with intellectual disabilities, the majority have normal or even above average intelligence (Klin, Volkmar, Sparrow, Cicchetti, & Rourke, 1995). Gillberg (1998), for example, estimated the prevalence of ID in the ASD population to only be 15%. There also appears to be a generation effect impacting ID prevalence rates. Byrd (2002) used record reviews to show that while the ID prevalence rate was roughly 50% in an ASD sample born between 1983 and 1985, it was only 22% for an ASD sample born between 1993 and 1995.

While cognitive profiles for individuals with ASDs tend to be heterogeneous at best, several trends have been noted in the research literature. Across the spectrum, for example, visual/spatial processing is frequently seen as a strength, while verbal comprehension tasks are more common deficit areas (Tsatsanis, 2005). The magnitude of this gap may depend in part on the level of overall intellectual abilities of the individual in question. Siegel, Minshew, and Goldstein (1996), for example, found that individuals with autism who had average intelligence showed very small differences between verbal and visual/spatial index scores. Within the autism spectrum, individuals diagnosed with AS tend to have relatively strong language skills and a concrete thinking style (Klin, McPartland, & Volkmar, 2005). In addition, nonverbal cognitive ability at the age of two appears to be one of the strongest predictors of language development in 5-year-old children with ASDs (Thurm, Lord, Lee, & Newschaffer, 2007).

Adaptive Behavior and Autism Spectrum Disorders

According to Shea and Mesibov (2005), “a robust finding in the research literature on individuals with autism is that adaptive behavior is usually markedly lower than intelligence, particularly among those with higher intelligence” (p. 294). This appears to be true regardless of the age of the individual with ASD, with lower overall adaptive skills being reported relative to IQ from preschool-age children to adults (Charwarska & Volkmar, 2005). Furthermore, the adaptive functioning deficits present in individuals with ASD are not simply the result of developmental delay, but appear to be a function of the ASD syndrome itself and persist over time and development for both high and low functioning individuals on the spectrum (Loveland & Tunali-Kotoski, 2005). Perry, Flanagan, Geier, and Freeman (2009) highlighted this in a study of matched pairs of children with autism and children with ID. Using Vineland Adaptive Behavior Scales

(VABS; Sparrow, Balla, & Cicchetti, 1984) domain scores, they identified a prototypical autism profile (highest for Motor, followed by Daily Living Skills, then Communication, then Socialization). The matched children with ID showed this same pattern, but did not score as low in the Communication and Socialization domains. The authors concluded that “there are some aspects of adaptive functioning which are especially impacted by autism and that developmental level does not entirely determine adaptive scores” (Perry et al., 2009, p. 1075).

Adaptive functioning in individuals with ASDs has also been linked to language development and severity of autism symptoms, particularly those symptoms related to socialization and communication. Kenworthy, Case, Harms, Martin and Wallace (2010), for example, found a strong negative association between autism symptom severity and adaptive functioning in a sample of high-functioning individuals with ASDs between the ages of 12 and 22. This finding was similar to outcomes reported by Perry et al. (2009), who found that symptom severity accounted for a portion of unique variance in several domain scores from the VABS, namely Socialization and Daily Living Skills. Thurm et al. (2007) also indicated that adaptive functioning level was predictive of language acquisition in 2- to 3-year-old children with ASDs.

Language and Communication Deficits in Autism

Impairment in language and communication is one of the three core features of autism. In fact, the autism phenotype is defined by these communication impairments along with social impairments, which are viewed as specific and unique deficits to autism (Tager-Flusberg, 1999). Language delays or difficulties in language acquisition are the primary referral concerns for children with autism (Rice, Warren, & Betz, 2005). Language acquisition varies greatly in children with ASDs with respect to timing and patterns of acquisition (Tager-Flusberg, Paul, & Lord, 2005). Children diagnosed with AS, for example, often do not show evidence of a significant language delay, while the majority of children diagnosed with Autistic Disorder have significant language delays. Because children are usually diagnosed with ASDs at the age of three or four, little is known about the language development of children with autism before that age. Retrospective studies suggest, however, that the language used by children with autism is qualitatively different from that of typically developing children as early as two years of age (Dahlgren & Gillberg, 1989 as cited in Tager-Flusberg et al., 2005). Even as early as one year of age, children with autism are less responsive to their own names, other people talking, the sound of their mother's voice, and have significantly delayed expressive and receptive language skills (Klin, 1991; Lord, 1995; Lord, Pickles, DiLavore, & Shulman, 1996 as cited in Tager-Flusberg et al., 2005).

Perhaps in part because autism is seen as being a predominantly male disorder, few studies have addressed whether the presentation of language difficulties differs by gender. In a study of gender differences in core symptoms of autism, Rivet and Matson (2011) examined symptoms in three populations: infants and toddlers, children and adolescents, and adults with intellectual disability. Based on the results of their study, the authors concluded that no significant gender differences could be found for either the infant/toddler or child/adolescent group on any of the core symptoms of autism, including language and communication.

While language is often delayed in autism, longitudinal studies suggest that progress within language domains (such as vocabulary and syntax) follows a pathway similar to that of typically developing children (Tager-Flusberg & Calkins, 1990 as cited in Tager-Flusberg et al., 2005). Although language acquisition and use is highly variable in the autistic population, certain factors have been linked to more favorable outcomes. Predictors of better language acquisition and outcomes include use of nonverbal skills such as initiating joint attention and imitation (Charman et al., 2003), IQ (Kjelgaard & Tager-Flusberg, 2001), comprehension ability at an early age (Paul, Cohen, & Caparulo, 1983 as cited in Tager-Flusberg et al., 2005), and absence of receptive language deficits in early childhood (Rutter, Mawhood, & Howlin, 1992 as cited in Tager-Flusberg et al., 2005).

One landmark longitudinal study examined the different patterns of development between children with early diagnosed ASD and those with later diagnosed ASD. Landa, Holman, and Garrett-Mayer (2007) collected data on 125 infants at high and low risk for autism from the age of 14 to 36 months. Based on scores from the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000) and clinical judgment, the infants were placed into three different groups: ASD (n = 30), Broader Autism Phenotype (BAP) (n = 16), and Non-Broader Autism Phenotype (Non-BAP) (n = 58). The ASD group was further divided into an early ASD diagnosis group (given a diagnostic impression of ASD at 14-month visit and clinical judgment of ASD at outcome visit) and a later ASD diagnosis group (no diagnostic impression of ASD at 14-month visit, but clinical judgment of ASD at outcome visit). Results indicated that the early diagnosed group was significantly different at 14 months of age from the other groups, including those later diagnosed with ASD, in that they had more impaired social and communication abilities.

At 24 months of age, social and communication impairments in the early diagnosed group were consistent with the group differences noted at 14 months of age, whereas the later diagnosed group did not shift away from typical development in these abilities until between 14 and 24 months. Data from the BAP and non-BAP groups provided evidence for continuously distributed traits in families at risk for ASD, rather than a discrete trait distribution.

Landa et al. (2007) also highlighted some of the social and communication characteristics of the early and later ASD diagnosed groups. Children in the early diagnosed group were characterized by abnormalities in joint attention and initiation of communication with others, and they lacked variety in their use of verbal and nonverbal communication. Children in this group also displayed an inability to integrate play into social engagement. Children in the later diagnosed group were characterized by seemingly typical development followed by a gradual departure from the typical growth pattern, including plateaus in initiation of joint attention, slowed growth in acquisition of consonants, syllables, words and word combinations, and decreases in shared positive affect and number of gestures used.

According to the DSM-IV TR, language abnormalities typically seen in children with autism can include the following: difficulty in initiating and/or sustaining conversations, use of stereotyped/repetitive or idiosyncratic language, abnormal qualities of speech (pitch, intonation, rate, rhythm), immature grammatical structures, and poor language comprehension (American Psychiatric Association, 2000). While deficits in these aspects of language vary across the spectrum, it is generally accepted that pragmatic language difficulties are the "unifying feature among all children with autism" (Rice et al., 2005, p. 17). According to Tager-Flusberg (1999), communication and pragmatic deficits are found to varying degrees across all ages, ability levels, and language levels represented on the autism spectrum. Pragmatic impairments can include the following: "a narrower range of functions served by language, problems understanding that communication is about intended rather than literal or surface meaning, failure to view conversations as a means of modifying and extending the cognitive environment of a conversational partner, and failure to view narratives as a means of communicating about both events and psychological states" (Tager-Flusberg, 1999, p. 330). Belkadi (2006) described pragmatic deficits related to comprehension found in children with autism as well as associated impairments typically linked to pragmatic impairment in speech production. These pragmatic deficits included the following: limited understanding of nonliteral sequences (metaphors, jokes, irony), poor command of indirect speech acts (questions), and difficulties with conversational conventions (politeness, turn taking, appropriate level of formality). Associated speech production impairments included personal pronoun reversal, echolalia, and difficulties using prepositions (Belkadi, 2006).

Is Language Truly a Core Deficit in Autism?

The place of language and communication difficulties as core deficits in autism has been questioned by some researchers and continues to be a source of controversy (see previous discussion on proposed changes to the DSM-V). Tanguay, Robertson, and Derrick (1998) used a factor analytic approach to examine Autism Diagnostic Interview – Revised (ADI-R; Lord, Rutter, & LeCouteur, 1994) data from 63 participants diagnosed with Autism, AS, or PDD-NOS to determine if aspects of social communication could be used to assess symptom severity in autism. A three-factor solution composed of affective reciprocity, joint attention, and theory of mind fit the data best. Based on their results, the authors concluded that DSM-IV criteria for the Social Interaction domain fit their factor model the best, while the Communication Impairments domain correlated to a lesser degree, and the third domain, Restricted Interests and Stereotyped Behavior, did not correlate to a significant degree. Given that individuals with ASD can have relatively normal semantic and syntactic skills, the authors concluded that deficits in this area should be treated as comorbid disorders; meaning that these disorders are often associated with autism, but not an integral part of the disorder.

Robertson, Tanguay, L'ecuyer, Sims, and Waltrip (1999) built on the framework laid out in Tanguay et al. (1998) with a sample of 51 participants. Using the ADOS, a factor analytic approach was again employed, with similar results. Once again, three social communication factors were highlighted: affective reciprocity, joint attention, and theory of mind. In contrast to the ADI-R factor analysis, which indicated affective reciprocity as explaining the most variance, the ADOS factor analysis suggested that joint attention was the factor responsible for the most variance. Robertson et al. (1999) concluded that social communication was the underlying core factor of autism and that the differences in the factors that explained the most variance between the two measures was a result of the ADOS and ADI-R assessing different aspects of social communication behavior.

Constantino et al. (2004) proposed the existence of a single, underlying factor that results in various phenotypes across the three core areas of autism and other ASDs. Using ADI-R and Social Responsiveness Scale (SRS; Constantino & Gruber, 2005) data from

226 children with psychiatric diagnoses including Pervasive Developmental Disorders and Attention Deficit Hyperactivity Disorder (ADHD), the researchers performed cluster and principal components factor analyses. Results of the factor analyses failed to find evidence of independent subdomains of dysfunction in autism and other ASDs. They concluded that this provided evidence supporting the existence of an underlying factor they termed "reciprocal social behavior" and suggested that deficits in reciprocal social behavior are directly related to the other subdomains such as language deficits and stereotypic behaviors/restricted range of interests.

MRI Studies of Autism and Language Deficits

The advent of magnetic resonance imaging (MRI) technologies has allowed researchers to study language deficits in autism by directly observing brain structures and electrochemical functioning. An MRI study by Herbert et al. (2005) examined whole-brain asymmetry in the brains of children with high-functioning autism (HFA) and children with developmental language disorder (DLD) compared to controls. They found that cerebral symmetry patterns for the HFA and DLD groups were similar to each other, but differed greatly from the symmetry pattern seen in the control group. A nested approach was taken, showing that while the DLD and HFA groups did not differ significantly from controls on the level of major grey and white regions or cerebral cortical lobes, they differed to a significant degree when brain areas were divided into parcellation units. At this level, increased brain asymmetries were observed in the right cerebral cortex for both the HFA and DLD groups, while only the DLD had a decrease in the volume of the left asymmetrical cerebral cortex. Several language-related differences were observed, with both HFA and DLD groups showing similar patterns of asymmetries in unimodal and higher-order association cortex. The authors concluded that these widespread shifts in cortical asymmetry for both groups were suggestive of pervasive anatomical changes that could affect connectivity within and between hemispheres, particularly in the higher-order association areas of the cortex.

Just, Cherkassky, Keller, and Minshew (2004) also argued that abnormal connectivity in higher-order processes contributed to aspects of autism, suggesting that the brains of individuals with HFA engage in less integrative aspects of language processing. Using functional magnetic resonance imaging (fMRI) technology, the authors examined the brain activity of 17 HFA participants and 17 controls while they read active or passive sentences and responded to a question asking them to identify either the agent or the recipient of the action in the sentence. Results showed a significant increase in activation in the posterior superior and middle temporal gyrus (Wernike's area) and a decrease in the left inferior frontal gyrus (Broca's area) for the HFA group compared to the controls. Just et al. (2004) interpreted this as evidence of HFA individuals engaging in a more extensive processing of single words, while exhibiting impairment in their comprehension of complex sentences. Harris et al. (2006) found similar results in an examination of the brain activity of 14 adult males diagnosed with ASD and 22 control participants on tasks of semantic and perceptual processing. The ASD group exhibited significantly decreased brain activity in the left inferior frontal gyrus (Broca's area) and increased activity in the left temporal region (Wernicke's area).

Bigler et al. (2007) examined language development in individuals with autism and its relationship to the Superior Temporal Gyrus (STG). They found no volumetric difference between the individuals with autism and typically developing controls in the STG; however, various differences were seen between the groups when STG size and function were examined. Whereas increased size in STG and receptive language function was reported in the control individuals, this was not the case for the group with autism, suggesting that, though of normal size and volume, the STG in the brains of individuals with autism is disconnected from language ability. In addition, evidence of abnormal lateralization of the language function was also observed in the group with autism. These findings are consistent with the abnormal asymmetry, lateralization, and cortical neural connectivity findings of other researchers (De Fosse et al., 2004; DiCicco-Bloom et al., 2006; Herbert et al., 2005; Just, Cherkassky, Keller, Kana, & Minshew, 2007; Just et al., 2004; Minshew & Williams, 2007; Whitehouse & Bishop, 2008).

Language Impairment Beyond Pragmatics in Autism

A relatively recent idea in the research literature is the study of children with ASD who suffer not only from the pragmatic deficits common to ASD, but also structural language deficits similar to those found in children with specific language impairment (SLI). In a review of language disorders in autism, Rapin and Dunn (2003) argued that language impairments in children with autism have been overlooked because of the samples used (verbal school-age children and adolescents) and the assumptions made, such as attributing lack of speech to mental retardation and severity of autistic features rather than an inability to decode auditory language. In a study of preschoolers with autism, the authors discovered two broad categories of language deficits; one involving reception and production of sounds of speech and syntax, and the other involving semantics and pragmatics. The first category resembled a mixed receptive/expressive disorder and was found in 63% of the preschoolers with autism, whereas the second category (termed higher order processing disorder) was found in only 37% of the autism group. No member of the autism sample was found to have typical comprehension, a finding that appears to be consistent with more current research in language development in young children with autism. Hudry et al. (2010), for example, examined language comprehension and production scores for 152 preschoolers with autism. While language ability varied widely across the sample, from non-verbal to age-appropriate, in general, comprehension and production were both impaired relative to age norms and non-verbal ability levels. Across the sample, receptive language skills were found to be more impaired than expressive language skills, though both were clearly impaired.

Rapin, Dunn, Allen, Stevens, and Fein (2009) provided support for mixed receptive/expressive disorder and higher order processing disorder in a sample of school-age children with autism. Using a cluster analytic approach, they divided a sample of 62 children with autism between the ages of seven and nine into four clusters based on phonology and comprehension scores. Individuals in clusters one and two both exhibited low phonology scores, but differed on comprehension, thus meeting criteria for a mixed receptive/expressive language disorder. Individuals in clusters three and four exhibited average to above average phonology scores, but differed on comprehension. The majority of the sample (n = 40) fell in cluster three and met criteria for a higher order processing language disorder. In this sample, 24% were identified as having “persistently and severely impaired expressive phonologic skill” (Rapin et al., 2009, p. 75), while the rest of the sample ranged from borderline to above average in expressive phonology. The authors argued that this provided evidence of multiple types of language impairment in children with autism and concluded that the majority of children with ASDs did not have structural language deficits (mixed receptive/expressive) by the time they reached school age, though higher order processing deficits were still present in many.

Research by Chan, Cheung, Leung, Cheung, and Cheung (2005) also identified structural language impairments in children with autism. Based on nonverbal intelligence and diagnosis, a group of 46 Chinese-speaking 5- and 6-year-old children (19 with autism and 27 typical) were divided into three groups: high-functioning autism (*n* = 15), low-functioning autism (*n* = 4), and control (*n* = 27). Forty-two percent of the sample was classified as language impaired in both verbal expression and comprehension, and 21% was classified with impaired expression skills. The authors concluded that children with autism are a heterogeneous group who display varying degrees of language ability and impairment not attributable to low IQ, as members of the high-functioning group also displayed language impairments.

Autism Spectrum Disorders and Specific Language Impairment

Because of the various language impairments seen in individuals with ASDs, a growing body of research has begun to address the relationship between ASD and specific language impairment (SLI). Geurts and Embrechts (2008), for example, examined language profiles from the Children's Communication Checklist – Second Edition (CCC-2; Bishop, 2003) of children diagnosed with either ASD, ADHD, or SLI. The sample included 87 children (ages 7 to 14) with diagnoses of ASD or ADHD and a second sample of 65 children (ages 5 to 7) with diagnoses of ASD or SLI. They found that CCC-2 profiles for preschoolers with ASD were similar to those of preschoolers with SLI, while profiles of school-aged children with ASD more closely matched the profiles of school-aged children with ADHD. This difference suggests that many children diagnosed with ASD tend to have many language deficits, including structural language impairment, but over the course of their development, they develop structural language skills, but not pragmatic skills. Interestingly enough, impulsivity emerged as the most powerful predictor of communication problems in their sample, regardless of group membership.

Kjelgaard and Tager-Flusberg (2001) identified a subtype of individuals with autism who have language profiles similar to those of children with SLI, which they believed suggested an overlapping etiology between the two disorders. The authors examined the scores of 89 children diagnosed with autism on language tests of phonological, lexical, and higher order language abilities. The children in the study ranged in age from four to fourteen and included 80 boys and nine girls. Based on scores from the Peabody Picture Vocabulary Test – Third Edition (PPVT-III; Dunn & Dunn, 1997), they divided 82 children with autism into three groups: normal language (SS $\geq$ 85, n = 22), borderline language impairment (SS between 70 and 84, n = 10), and impaired language (SS $<$ 70, n = 50). Seven participants were omitted because they did not have scores for all measures. he groups were then compared on various language measures including the Goldman-Fristoe Test of Articulation (GFTA; Goldman & Fristoe, 1986), Expressive Vocabulary Test (EVT; Williams, 1997), Clinical Evaluation of Language Fundamentals - Preschool (CELF-P; Wiig, Secord, & Semel, 1992), and Clinical Evaluation of Language Fundamentals – Third Edition (CELF-III; Semel, Wiig, &

Secord, 1994). Although scores on the Goldman-Fristoe were in the average range across groups, the impaired group had significantly lower scores than the other two groups. No significant differences were found between groups on the EVT. The authors then conducted a profile analysis using total scores from the CELF-III and CELF-P for those individuals who were able to complete the testing (n = 44) and divided them into the same three categories used previously: normal language (SS $\geq$ 85, n = 10), borderline language impairment (SS between 70 and 84, n = 13) and impaired language (SS < 70, n = 21). Nonverbal IQ data for this group showed that 31 of the 44 individuals able to complete some form of the CELF had nonverbal IQs above 80. Based on CELF total score groupings, no significant differences were noted on articulation scores (Goldman-Fristoe); however highly significant differences were noted between the groups' combined receptive and expressive vocabulary scores (average of PPVT-III and EVT scores).

Kjelgaard and Tager-Flusberg (2001) concluded that language ability among children with autism was heterogeneous, with some children presenting normal language abilities while other children had language abilities significantly below what would be expected for their age. While articulation was relatively good across all groups regardless of how the groups were divided, vocabulary, semantic and syntactic knowledge varied by group membership. Level of language impairment appeared to be relatively independent of nonverbal cognitive ability. Based on their profile analysis, Kjelgaard and Tager-Flusberg (2001) argued that language impaired children with autism matched the profile for children with SLI and that these children had an overlapping SLI disorder. To further back this claim, the authors pointed to genetic family studies of both autism and SLI and highlighted the overlap between incidence rates for the two disorders in families and the connection between the two disorders and certain chromosomes.

A recent study also highlighted similarities between language impaired ASD and SLI phenotypes. McGregor et al. (2012) compared the lexical knowledge and associations between syntax and lexicon in five groups of children between the ages of 9 and 14. The groups consisted of children with ASD, ASD plus structural language impairment (ASDLI), SLI, unaffected age peers (AM), and unaffected younger children (SM). The participants were administered receptive and expressive vocabulary tests, the PPVT-III and EVT, as well as given 40 words they were to use to produce sentences. Results indicated that on both the PPVT-III and EVT, the SLI and ASDLI groups performed significantly lower than the other groups. Furthermore, no difference was found between the performance of the SLI and ASDLI groups, or between the other three groups. On word definitions and word associations, the ASD and AM groups outperformed the other three groups. The authors concluded that the SLI and ASDLI groups were very similar, except in one regard; the ASDLI group did not have a large concrete-abstract gap on word associations, while the SLI group did. In fact, the ASDLI group was no different than the AM or ASD groups in this regard.

Magnetic resonance imaging (MRI) studies have shown numerous similarities in language-related brain structures in individuals with ASD and SLI, as well as highlighted important differences. De Fosse et al. (2004) examined the brains of 22 boys with autism (16 of whom also had language impairment), 9 boys diagnosed with SLI, and 11 male controls. Ages of participants ranged from 6 to 13 years of age. Using MRI brain scans, the researchers located several unusual phenomena including a reversal of the asymmetry of the language-related areas of the frontal cortex, with the language impaired individuals from the autism and SLI groups showing greater volume in the right hemisphere and the unimpaired language individuals from the autism and control groups showing the more typical pattern of greater volume in the left hemisphere. De Fosse et al. (2004) concluded that this pattern of results was consistent with evidence for a similar phenotype between language impairment in autism and SLI and that this reversed asymmetrical pattern was related to language impairment in general and not specific to autism.

Hodge et al. (2010) performed cerebellum segmentation and parcellation on MRI scans of boys with autism, autism plus language impairment (ALI), speech language impairment (SLI), and normal controls. Participants ranged from 6 to 13 years of age. They found reversed asymmetry in posterior cerebellar lobule VIIIA in both language impaired groups, but not in the language normal groups. They found abnormalities in circuits related to motor control, language processing, cognition, working memory and attention in both language impaired groups (ALI and SLI). White matter in the cerebellum, however, was significantly larger in the ALI group when compared to the SLI group, indicating possible developmental differences between the two groups as well.

Bishop (2010) examined the potential for a shared etiology between ASD and SLI by examining several proposed models of gene interactions. She found that a correlated additive risks model, while able to explain the higher than chance rate of comorbid ASD and language impairment cases, could not account for differences in performance on language measures between relatives of individuals with ASD plus language impairment and relatives of individuals with SLI. The second proposed model by Bishop (2010) was based on the notion of phenomimicry and posited that language impairment in ASD is the result of ASD risk factors and therefore fundamentally different from that seen in SLI. While this model could account for patterns of deficits seen in relatives of individuals with ASD and SLI as well as comorbidity, it could not account for why certain genes (i.e., CNTNAP2) have been associated with both conditions or why only some individuals with ASD have language impairments similar to those seen in SLI. Bishop's final proposed model integrated gene by gene interactions into a modified correlated additive risks model. Based on simulation results, Bishop argued that the modified correlated risks model with epistasis was the most reasonable because it could account for ASD and language impairment comorbidity above chance, similar levels of language impairment in children with ASD plus language impairment and children with SLI, and predicted higher rates of language impairment in relatives of children with SLI than in relatives of children with ASD plus language impairment. She concluded that this model supports an overlapping genetic etiology for ASD and SLI, though epistatic interactions might make it more difficult to tease out the delicate interconnections between the two disorders (Bishop, 2010).

The theory of overlapping etiologies between SLI and ASD is not without its critics. While some studies of ASD and SLI have pointed to similar deficits in phonology, syntax, and syntactic reception and expression, other studies have shown differences in oromotor skills, verbal short-term memory, and the types of errors made during nonword repetition between the two disorders. Williams, Botting, and Boucher (2008) argued that the majority of research comparing ASD with language impairment (ASD-LI) and SLI did not support an overlapping etiology. For example, school-age individuals with SLI tend to have mixed receptive-expressive impairment, while school-age individuals with

ASD-LI have higher order processing deficits (i.e. comprehension and discourse production) but unimpaired phonology and grammar (Williams et al., 2008). The authors suggested that the similarities in language deficits manifest in ASD-LI preschool children and children with SLI (mixed receptive-expressive deficits) were indicative of an overlap in language impairment at a certain developmental point in time rather than a shared etiology.

Demouy et al. (2011) compared children with autism, PDD-NOS, and SLI on various language measures to identify language profiles and differential language markers. The autism group consisted of 10 males and 2 females, with a mean age of 9.75 years (*SD* = 3.5). The PDD-NOS group consisted of 9 males and 1 female, with a mean age of 9.83 (*SD* = 2.17). Similarly, the SLI group consisted of 9 males and 3 females, with a mean age of 9.17 years (*SD* = 3.9). Results indicated vocabulary and phonology were impaired across all three groups, while intonation was a reliable differential marker between the two ASD groups and the SLI group. The authors concluded that their findings support the position that ASD and SLI present with different phenotypes and have different underlying mechanisms fostering their language skills and development.

While much of the research comparing ASD and SLI language impairments has used preschool or school-age samples, Riches, Loucas, Baird, Charman, and Simonoff (2010) compared language deficits in adolescents with SLI and adolescents with autism plus language impairment (ALI). The ALI group consisted of 10 males and 7 females, with a mean age of 14.4 years and a standard deviation of 4.2 years. The SLI group consisted of 13 males and 1 female, with a mean age of 15.3 and a standard deviation of 7.49 years. Using a sentence repetition task, the authors compared the two groups on various types of errors. While quantitatively similar profiles in the types of errors were reported for the two groups, the authors argued that the SLI group showed greater syntactic impairment in that they were “significantly more likely to make wholesale changes to the syntactic structure” (Riches et al., 2010, p. 56) than the ALI group. They hypothesized that the error rate interaction deficits present in SLI might be attributed in part to short-term memory deficits in children with SLI. They concluded by saying that a qualitative view of error rate analysis highlights the difference between the two groups and argues against the phenotypic overlap hypothesis (Riches et al., 2010).

In a follow-up study, Riches, Loucas, Baird, Charman, and Simonoff (2011) compared nonword utterances of typically developing, SLI and ALI adolescents. The SLI group consisted of 13 males with a mean age of 15.4 years and a standard deviation of 7.26 years. The ALI group consisted of 16 males with a mean age of 14.8 years and a standard deviation of 5.77 years. While both clinical groups performed more poorly than their typically developing peers, the ALI group outperformed the SLI group in terms of mean syllable length. The shape of the overall profile of deficits, however, was similar between the two groups. Much like the argument made in Riches et al. (2010), the authors suggested a verbal short-term memory deficit might be the reason for the difference in performance between the two clinical groups. They also acknowledged that the similarity in difficulties in the two clinical groups could be construed as support for the phenotypic overlap argument, though they stopped short of saying this directly. Rather, they claimed, “it is difficult to make any inferences about the phenotypic overlap between ASD and SLI purely on the basis of quantitative or qualitative differences in performance on a single task” (Riches et al., 2011, p. 32).

Whitehouse, Barry, and Bishop (2008) likewise argued against a shared etiology between autism and SLI, though they did acknowledge the existence of a language impaired subtype of autism. Using three groups (SLI, autism with structural language deficits, and autism without structural language deficits), they tested three alternate hypotheses: 1) SLI and autism share an etiological overlap, 2) nonword repetition deficits in autism are due to difficulties in speech-motor movements (oromotor), and 3) non-word repetition deficits in autism are associated with greater severity of autistic symptoms. The SLI group consisted of 34 children (24 male and 10 female) between the ages of 6 and 15 years of age. The autism groups consisted of 34 children (33 male and one female) between the ages of 7 and 15 years of age. The first and second hypotheses were rejected on the grounds that the SLI and autism with structural language deficits groups differed significantly on language profiles. The SLI group had significantly poorer performance on the oromotor task and a test of verbal short-term memory. The SLI group also produced more errors on the nonword repetition task as the words became longer. The third hypothesis was accepted on the grounds that children from the two autism groups who had nonword repetition deficits had significant deficits in multiple domains associated with autism and clinically significant structural language impairments. Based on these results, Whitehouse et al. (2008) argued that the structural language impairments observed in children with autism were not the result of an overlapping etiology with SLI, but the result of significant impairment across multiple domains associated with autism.

This idea that language impairment coincides with increased impairment in autistic symptoms has not gone unchallenged. Leyfer, Tager-Flusberg, Dowd, Tomblin, and Folstein (2008) compared 43 children diagnosed with ASD (ages 6 to 15 years old) to

45 children diagnosed with SLI (ages 6 to 13 years old) to determine to what extent clinical features of autism appear in children with SLI. Many of the SLI sample (41%) met criteria for ASD on the social or communication domains of the ADI-R, ADOS, or both. No relationship was found between Nonword Repetition scores (a sensitive and specific psycholinguistic marker for SLI), and autism symptoms, nor was a relationship found between receptive and expressive language scores from the CELF-III and autism symptoms. The two groups did not differ on frequency of language deficits for those children who met criteria for ASD on either the ADOS or ADI social and communication domains. Leyfer et al. (2008) concluded that these findings supported the position that severity of autism symptoms was not related to language ability, as suggested by Whitehouse et al. (2008).

Loucas et al. (2008) performed one of the few studies to compare language impaired autistic children (ALI) to children with autism and no language impairment (ALN) as well as children with specific language impairment (SLI). Inclusion criteria included a Performance or Perceptual Organization IQ of 80 or greater on the Wechsler Intelligence Scale for Children – Third Edition (WISC-III; Wechsler, 1991). Language impairment was defined as a score of 77 or lower on Receptive, Expressive, or Total Language scores on the CELF-III. Based on this criteria, the ALI group consisted of 41 children (39 of which were boys), the ALN group contained 31 children (30 boys), and the SLI group consisted of 25 children (23 boys). Ages for all participants ranged from 9 to 14 years of age. Autism symptoms were measured using the ADOS, ADI-R, Social Communication Questionnaire (SCQ; Rutter, Bailey, & Lord, 2003) and International Classification of Diseases – 10th Revision (ICD-10; World Health Organization, 1993) diagnostic criteria. Across all measures of autism symptoms, the ALI and ALN groups showed significantly higher levels of autistic symptoms than the SLI group. Across symptoms, the only difference between the ALI and ALN groups was their score on the ADI-R Social domain score, on which the ALI group scored significantly higher than the ALN group. Adaptive behavior was measured using the VABS. On the VABS, the ALI group scored significantly lower than the ALN group on the Adaptive Behavior Composite, Communication domain score, and Daily Living Skills domain score. The ALI and ALN groups did not differ on pragmatic language ability, as measured by the Children's Communication Checklist (CCC; Bishop, 1998). Language ability was measured using the CELF-III. Receptive and expressive language scores, as measured by the CELF-III, were significantly lower for the ALI group than the ALN group. When compared to the SLI group, the ALI group had similar scores for total language and expressive language, but significantly lower scores for receptive language. Based on these results, Loucas et al. (2008) concluded that the ALI and ALN groups did not differ on current autistic symptoms or pragmatic impairment, but the ALI group showed more reciprocal social impairment (as measured by the ADI-R) between the ages of four and five. The authors suggested ALI might best be represented as a co-occurrence of ASD and language impairment. In other words, ALI can best be conceptualized as the crossroads between two distinct but overlapping sets of symptoms.

In addition to the debate over whether SLI and ASD are related and what that relationship looks like, researchers have examined whether the presence or absence of language impairment is specific to certain disorders on the autism spectrum. Bennett et al. (2008) argued that specific language impairment (SLI) could be used as an indicator to categorize high functioning autism (HFA) versus Asperger’s Syndrome (AS). SLI was defined as a score 1.5 standard deviations below the mean on averaged scores from the Grammatic Completion and Grammatic Understanding subtests of the Test of Language Development-Second Edition (TOLD-2; Newcomer & Hammill, 1988). Two groupings were performed, one by clinical diagnosis and one by presence or absence of SLI. Participants were between the ages of 4 to 6 years old at time one, at which time, 83.7% (n = 38) of the children with a diagnosis of HFA were classified as SLI, as opposed to only 31.5% (n = 6) of the children diagnosed with AS. By comparing 68 children diagnosed with either autism or AS across multiple points in time, they were able to show that grouping individuals by presence or absence of language impairment accounted for greater variation at later points in time than clinical diagnosis, though the overlap between groupings by clinical diagnosis and presence of SLI was not complete. Bennett et al. (2008) concluded that using standardized language measures to distinguish between HFA and AS diminished the lack of agreement seen between professionals, reduced ambiguity, and created a more meaningful distinction between the two groups than what is currently seen in clinical practice using just the DSM-IV-TR criteria.

Profile Analysis

Profile analysis is a family of data reduction techniques commonly used in psychological research to classify data into distinguishable groups based on common characteristics shared by group members. In the field of autism research, various methods of profile analysis, such as cluster analysis, have been used to identify subtypes of ASDs or postulate unique or alternative categories to the DSM-IV-TR criteria based on behavioral presentation or symptom severity (Barrett, Prior, & Manjiviona, 2004; Bitsika, Sharpley, & Orapeleng, 2008; Eaves, Ho, & Eaves, 1994; Hu & Steinberg, 2009; Malvy et al., 2004; Prior et al., 1998; Sevin et al., 1995; Stevens et al., 2000; Wiggins, Robins, Adamson, Bakeman, & Henrich, 2012). Researchers have also attempted to identify subtypes based on more specific aspects of ASDs, such as social interaction (Merin, Young, Ozonoff, & Rogers, 2007), adaptive functioning (Perry et al, 2009), intelligence (Siegel, Minshew, & Goldstein, 1996), sensory difficulties (Ben-Sasson et al., 2008; Lane, Dennis, & Geraghty, 2011; Lane, Young, Baker, & Angley, 2010;), language impairment (Lewis, Murdoch, & Woodyatt, 2007a; Lewis, Murdoch, & Woodyatt, 2007b; Rapin et al., 2009; Smith, Mirenda, & Zaidman-Zait, 2007), and brain structures (Hrdlicka et al., 2005). More often than not, the results of these analyses have pointed to the expansive heterogeneity present in samples of individuals with ASDs rather than defining specific characteristics that can be generalized to the larger ASD population. Still, the desire to find new ways of conceptualizing the autism spectrum or draw connections between the various types of abilities and impairments manifested by individuals with ASD makes profile analysis a compelling choice for studying ASDs.

Numerous types of techniques can be used for conducting profile analyses. One such technique is multidimensional scaling (MDS), an exploratory technique “designed to reduce a large amount of data to a relatively simple structure that displays important relationships in an economical way” (Mugavin, 2008, p. 64) using Euclidean distance measures. Because it is a variable-centered approach to data analysis, rather than a person-centered approach, the focus is on the relationships between variables not individuals. Some of the advantages of this method include the ability to identify multiple group-specific profiles within a sample, minimal assumptions (mainly that the observed data are related to the profiles through Euclidean multidimensional space), profile match indices for each individual, and estimates of model fit for each individual (Ding, 2005b). As such, it has particular appeal as a means of conducting profile analysis. Perhaps most importantly for profile analysis applications, it can simultaneously represent typical profiles of variables in the population and how individuals differ from these profiles (Ding, 2006), something other profile techniques cannot do.

Profile Analysis via Multidimensional Scaling (PAMS) is a relatively new variation on MDS created by Mark Davison in 1994 (Davison, Gasser & Ding, 1996). According to Kim (2010b), PAMS differs from other variations of MDS in that it interprets each dimension as a profile pattern instead of an individual construct, thereby allowing the inclusion of multiple constructs into the same profile. Kim (2010b) points out two advantages to this approach to profile analysis: allowing the inclusion of multiple constructs provides more information without the necessity of rotation, and this pattern approach provides information about individuals, not just overall profiles. To date, PAMS has been used to study adolescent risk behaviors (Dong & Ding, 2012) and irritability patterns (Ding, 2005a), longitudinal profile patterns of math and reading skills in kindergarten (Kim, 2010a), symptom patterns in insomnia (Sanchez-Ortuno, Edinger, & Wyatt, 2011), risk perception in Asian cultures (Yen & Tsai, 2007), adult cognitive profiles (Kim, Frisby, & Davison, 2004), and adult memory profiles (Frisby & Kim, 2008). To date, there are no known studies using PAMS with populations of individuals with ASDs or with profiles of communication skills.

Under the PAMS model, dimensions are considered to represent continuous bidirectional latent profiles with one end representing a prototypical profile shape and the other its mirror image (Kim et al., 2004). The matrix is set up such that each column represents a variable of interest and each row represents an individual's scores on those variables. The PAMS model uses the following equation:

$$m_{pt} = c_p + \sum_{k=1}^{K} \omega_{pk} \cdot \chi_{tk} + \varepsilon_{pt}$$

In this equation, m_{pt} represents the observed score of person *p* on test *t*. c_p is the level parameter, an index of the overall height of an observed profile for person *p* calculated from the unweighted average of all test scores for that person. ω_{pk} is the weight for person *p* on dimension *k*. This person weight is an "index of the degree of correspondence between the actual (observed) test scores of person *p* and the tests' coordinates on a latent dimension (*k*)" (Kim et al., 2004, pp. 601-602) and is estimated by "regressing the person's observed test scores onto the scale-values with the unweighted least squares method" (p. 602). χ_{tk} represents the test parameter, the coordinate (scale-value) of test *t* on dimension *k*. ε_{pt} is the error term. According to Kim et al. (2004), the PAMS model makes the following assumptions: the mean of the scores in each dimension profile *k* equals zero, the expectation of squared correspondence weights is assumed to be one, the expectation of the cross product between the correspondence weight ω_{pk} and error ε_{pt} equals zero, and error variances are equal for all tests.

Rationale for Present Study

It is clear that autism and related ASDs share a triad of core deficits dealing with social relationships, communication and language, and repetitive and/or stereotyped movements and restricted interests. The nature and extent of these deficits, however, tends to vary within the ASD population and even within the various subdomains of ASDs. In the subdomain of language and communication this heterogeneity is clearly seen, with some children on the spectrum exhibiting just the pragmatic deficits normally associated with autism, while other children have structural language deficits in addition to pragmatic impairment. Though no firm conclusions have been reached regarding the relationship between SLI and ASD, current research appears to support language impairment as a deficit independent of autistic symptoms, but one that also co-occurs in a significant number of individuals with ASD. Furthermore, the current research literature suggests that disorders along the autism spectrum may be better differentiated by presence or absence of language impairment than by clinical diagnosis alone.

Despite the evidence emerging in support of various language profiles for individuals with autism and related ASDs, there is much that remains unclear. Given that language impairment is emerging as an important dimension for understanding autism and related ASDs, the present study attempts to create a more meaningful picture of this relationship by examining communication profiles of children with ASDs derived through profile analysis via multidimensional scaling (PAMS) and then comparing these profiles to language, adaptive functioning, cognitive, and autism symptom severity scores. The heterogeneity of language deficits seen in ASD can be problematic for identifying meaningful profiles through many of the traditional methods used in profile analysis, such as cluster analysis. These traditional methods are not suitable for the current analysis because they cannot account for both prototypical profiles in the population and how individuals differ from those profiles (Kim et al., 2004). PAMS, however, can provide both pattern information and profile level analysis without the usual constraints placed on clustering techniques, such as the need for multivariate normality, therefore providing information about what profiles fit the data the best and how individual score patterns within the sample fit the profiles. To date, this study is the first to apply PAMS to not only the study of communication profiles, but to the ASD population as well. As such, it represents an opportunity for a unique perspective on the relationship between communication deficits and ASDs.

CHAPTER 2

METHODS

The purpose of this study was to identify communication profiles of children with ASD based on the CCC-2 as well as the relationship of these communication profiles to external variables (cognitive and language abilities, adaptive functioning, and autism symptom severity) and then validate those profiles using a sample of children from a local school district. The research questions this study attempted to answer are as follows:

1) What specific communication profiles are supported based on the CCC-2 using a clinical sample of children with autism?
2) For the communication profiles supported in the clinical sample, do they differ based on cognitive ability, adaptive functioning, language ability, or severity of autistic symptoms?
3) Are the identified profiles reliable across another clinical sample?
4) Are these communication profiles found in the clinical sample of children with ASD supported in a cross-validation sample of children with ASD in a school-based community sample?

To answer these questions, a variation on multidimensional scaling called PAMS was used to determine the number and shape of communication profiles within the clinical sample of children with ASDs, whether these profiles were statistically different, how closely data from individual participants fit each profile, and whether the identified communication profiles in the clinical sample were consistent with communication data from the cross-validation community sample.

In order to achieve these objectives, the current study was conducted in four parts using different samples of participants. First, communication profiles were created using the PAMS procedure using a clinical sample of children with ASDs (Clinical Sample A). Second, the derived profiles' relationship to the external variables of interest (cognitive ability, adaptive functioning, language ability, severity of autistic symptoms) was evaluated using the same clinical sample (Clinical Sample A). Third, the reliability of the created communication profiles was evaluated using a second clinical sample (Clinical Sample B), which was drawn from the same database used to create the first clinical sample. Finally, the derived communication profiles were validated on a sample from a school-based community setting (Community Sample C). The following sections detail the specifics of each part of the study.

Creating Communication Profiles and Evaluating Relationship of Profiles to External Variables

Participants

Individuals selected for the initial clinical sample (Clinical Sample A) used in creating the PAMS profiles were selected from the database of the Utah Autism Research Program (UARP), a well-known research program that screens families for eligibility in various ongoing studies, mainly for the purposes of researching the genetics of autism. Participants selected for Clinical Sample A were screened for UARP between the years

2004 and 2009. All participants were identified as having autism or ASD based on their scores from the ADOS, ADI-R, and clinical judgment by a licensed psychologist. Inclusion criteria were as follows: available data for all measures used in the study, acquisition of verbal language, native English speaker, absence of hearing loss, and ability to speak in sentences. Exclusion criteria for participation included having a known medical or genetic condition associated with ASD (such as Fragile X), no biological parent available to participate, or severe sensory impairments that would prevent direct assessment. Clinical Sample A consisted of 79 children (70 male, 9 female) ranging in age from 5 years to 17 years, 9 months (*M* = 9.94, *SD* = 3.56).

Measures

The external variables of interest included cognitive ability, adaptive functioning, language ability, and severity of autism symptoms. Valid scores on measures in each of these domains were requisite for inclusion in Clinical Sample A.

Cognitive ability. Nonverbal and verbal cognitive abilities were assessed in Clinical Sample A using the Differential Abilities Scales (DAS; Elliot, 1990). The DAS is administered individually to assess cognitive abilities in children ages 2:6 to 17:11. For ages 6:0 through 17:11, it provides three cluster scores (Verbal Ability, Nonverbal Reasoning Ability, and Spatial Ability) which are used in the calculation of an overall General Conceptual Ability score (GCA). For ages 3:6 through 5:11, only Verbal Ability and Nonverbal Ability cluster scores are used to calculate GCA. For ages 2:6 through 3:5, only the GCA is calculated. For certain age groups, a Special Nonverbal Composite score can also be calculated using the scores from the Nonverbal Reasoning Ability and Spatial

Ability clusters. The GCA and cluster scores all have a mean of 100 and a SD of 15.

The DAS was standardized on 3,475 children drawn from various regions around the United States. Information from the 1988 U.S. Census was used to stratify the sample by age, gender, ethnicity, parental education, region, and preschool enrollment. Special education categories were also represented in the sample, including learning disabled, speech impaired, emotionally disturbed, physically impaired, intellectually disabled, and gifted. Using item response theory, internal consistency reliabilities have been calculated for subtests (range .70 to .92), composite scores (range .88 to .92), and the GCA (range .90 to .95) for each age group. Reliabilities for the Special Nonverbal Composite range from .81 to .94 across age groups. Test-retest reliabilities range from .56 to .94 for Preschool subtests and domains and .53 to .97 for School-Age subtests and domains (Elliot, 1990). Research has demonstrated that the GCA, Verbal Cluster, and Spatial Cluster of the DAS correlate well with the Full Scale, Verbal, and Performance IQ scores of the Wechsler Intelligence Scale for Children - Third Edition (Dumont, Cruse, Price, & Whelley, 1996). In addition, Aylward (1992) states that the DAS is considerably better than other cognitive measures, such as the Wechsler Preschool and Primary Scale of Intelligence (WPPSI) or Stanford-Binet – Fourth Edition (SB-IV), for assessing children suspected of having language difficulties, mild mental retardation, learning difficulties, or developmental delays.

Adaptive functioning. Adaptive functioning was measured in Clinical Sample A using the Vineland Adaptive Behavior Scales (VABS; Sparrow et al., 1984) or the Vineland Adaptive Behavior Scales – Second Edition (VABS-II; Sparrow, Cicchetti, & Balla, 2005). The VABS and its successor, the VABS-II, are widely used measures of adaptive functioning generally administered in a semi-structured interview format. According to Sparrow et al. (2005), the VABS and VABS-II were designed to aid in the clinical diagnosis of mental retardation as well as autism spectrum disorders, genetic disorders, developmental delays, and emotional/behavior disturbances. Both versions of the Vineland contain the following domains (subdomains): Communication (Receptive, Expressive, and Written), Daily Living Skills (Personal, Domestic, and Community), Socialization (Interpersonal Relationships, Play and Leisure Time, and Coping Skills), and Motor Skills (Gross and Fine). While all four domains are used to calculate an overall Adaptive Behavior Composite (M = 100, SD = 15) for children through age six, only the first three are used to calculate this composite in ages seven through 90.

The VABS and VABS-II are perhaps the most widely used measures of adaptive functioning in psychological research today. Interrater reliabilities for the four domains represented in the VABS range from .93 to .99, while test-retest reliabilities range from .95 to .99, indicating excellent reliability (Sparrow et al., 1984). Concurrent validity with other measures of adaptive functioning such as the AAMD Adaptive Behavior Scale School Edition (Lambert, Windmiller, Tharinger, & Cole, 1981) has been evaluated and found to be acceptable as well. Similarly, the VABS-II has test-retest reliabilities ranging from .88 to .92 across domains. Correlations between domain scores on the VABS and VABS-II range from .69 to .96 though they tend to average around .70, indicating moderately strong correlations between domain scores on the VABS and comparable domain scores on the VABS-II. Both the VABS and VABS-II have been used extensively with children with autism (Burack & Volkmar, 1992; Carter, Volkmar, Sparrow, Wang, Lord, et al., 1998; Cicchetti, Sparrow, & Rourke, 1991; Perry et al., 2009; Schatz &

Hamdan-Allen, 1995; Sparrow et al., 1984). In fact, using the VABS as part of the assessment of autism spectrum disorders is considered best practice by experts in the field (Klin, Saulnier, Tsatsanis, & Volkmar, 2005).

Expressive and receptive language ability. Expressive and receptive language ability of Clinical Sample A was assessed through various versions of the Clinical Evaluation of Language Fundamentals: CELF-III (Semel et al., 1994), CELF-IV (Semel, Wiig, & Secord, 2003), and CELF-P (Wiig et al., 1992). The CELF family of language assessment instruments is a widely used set of individually administered tests designed to measure morphology, syntax, semantics and working memory for language. The Preschool version (CELF-P) has an age range of 3:0 to 6:11, while the CELF-III has a range of 6:0 to 21:11, and the CELF-IV has a range of 5:0 to 21:11. All three provide scores for Receptive, Expressive, and Total Language (called Core Language on the CELF-IV).

The standardization samples consisted of 800 children for the CELF-P, 2,450 children for the CELF-III, and 2,650 children for the CELF-IV. All samples were stratified by age, gender, ethnicity, geographic region, and parent education level. Internal consistency coefficients were generally in the .61 to .89 range for the CELF-P, while the CELF-III had coefficients ranging from .54 to .95, and the CELF-IV coefficients range from .70 to .91. Test-retest reliability coefficients for all three instruments range from .60 to .90. Concurrent validity studies suggest that the CELF-P correlates reasonably high with some measures of language such as the Preschool Language Scale – 3 (Zimmerman, Steiner, & Pond, 1992), but not others, such as the CELF-R, while the CELF-III correlates highly with the CELF-R and the Verbal and Full Scale composites of the

WISC-III. Correlations between the CELF-III and CELF-IV, however, are only moderate. This is not surprising given that the CELF-IV demonstrates better psychometric qualities than the CELF-III overall as well as higher sensitivity and specificity. Despite the issues present in the CELF family of tests, they are widely used, well represented in the research literature, and have been shown to be useful measures of language development in individuals with ASD (Kjelgaard & Tager-Flusberrg, 2001; Norbury, Nash, Baird, & Bishop, 2004).

Autistic symptoms. Severity of autism symptoms in Clinical Sample A was assessed through use of the Social Responsiveness Scale (SRS; Constantino & Gruber, 2005). The SRS was selected to measure severity of autism symptoms because SRS data were already available for the individuals in Clinical Sample A. The SRS is a 65-item questionnaire that measures social ability and is generally completed by a caregiver or teacher. For the current study, all SRS data were collected from parents. The SRS is a continuous measure where higher scores indicate greater levels of impairment and yields an overall score and domain scores in the areas of Social Awareness, Social Cognition, Social Communication, Social Motivation, and Social Mannerisms. The overall total score is designed to function as “an index of severity of social deficits in the autism spectrum” (Constantino & Gruber, 2005, p. 721). Using factor analysis, Constantino et al. (2004) concluded that deficits in the construct of social reciprocity ability is the single most important factor to consider in autism and related ASDs.

The SRS was standardized on 1,636 children across several studies. Internal consistency coefficients for parent and teacher report across studies range from .93 to .97 for the total score and .77 to .92 for the treatment subscales. Test-retest reliability was established in several studies. In one such study, the test-retest reliability coefficient obtained for 30 clinical participants was .88, while the correlation between parent and teacher agreement for 26 clinical participants was .73 (Constantino, Przybeck, Friesen, & Todd, 2000). Divergent validity has been established through studies showing that the SRS can reliably distinguish children with ASD from children with other disorders (Conway, 2007). Concurrent validity has been established with other measures of autism symptoms, most notably the ADI-R. Constantino et al. (2003), for example, found that scores from the SRS correlated highly with algorithm scores from the ADI-R and concluded that the SRS was a reliable general indicator of autism symptoms. While the total score for the SRS has been well-validated, it is still unclear whether the treatment subscales are valid. Because they were added after the total score was validated and exhibit extremely high correlations with each other, many question the validity and utility of the SRS subscales (Venn, 2007).

Dependent Variable. Scale scores from the Children's Communication Checklist – Second Edition (CCC-2; Bishop, 2003), were used to create communication profiles through the PAMS process. The CCC-2 was designed to assess pragmatic aspects of language as well as structural aspects and assesses children's communication skills in the areas of pragmatic language, syntax, morphology, semantics, and speech. It consists of a 10- to 15-minute questionnaire completed by a caregiver or teacher. For the current study, all CCC-2 data were collected from parents. The CCC-2 is intended for children ages 4:0 through 16:11 whose primary language is English and can speak in sentences. It provides scaled scores (M = 10, SD = 3) for 10 scales (Speech, Syntax, Semantics, Coherence, Initiation, Scripted Language, Context, Nonverbal Communication, Social Relations, and

Interests) and a General Communication Composite (GCC) score (*M* = 100, *SD* = 15). Each scale includes five items assessing communication deficits and two assessing communication strengths. The Speech, Syntax, Semantics, and Coherence scales are designed to assess articulation, phonology, language structure, vocabulary and discourse. Pragmatic aspects of language are assessed using the Initiation, Scripted Language, Context, and Nonverbal Communication scales. The Social Relations and Interests scales are designed to assess behaviors generally impaired in children with autism, but not in children with other language impairments. In addition to scale scores and the GCC score, the CCC-2 also computes a Social Interaction Difference Index (SIDI), designed to help identify communication profiles for children with autism and children with specific language impairment (SLI).

Psychometric properties of the CCC-2 appear to be sufficient for its intended purpose. Across all scales, raw score means and standard deviations generally decrease as age increases. For example, for the Speech scale, the mean score for the 4:0 to 4:11 group was 5.6 (*SD* = 5.0) while the mean score for the 14:0 to 16:11 group was .9 (*SD* = 1.9) (Bishop, 2003). Test-retest reliability has been calculated for three age groups: 4:0 to 6:11 (*n* = 30), 7:0 to 9:11 (*n* = 34), and 10:0 to 16:11 (*n* = 34). According to Bishop (2003), the time between administrations of the CCC-2 ranged from 1 to 28 days; no further information was provided as to whether the length of elapsed time differed across the three age groups. Reliability coefficients for the GCC have been reported as follows: 4:0 to 6:11 (*r* = 0.86), 7:0 to 9:11 (*r* = 0.96), and 10:0 to 16:11 (*r* = 0.93). Internal consistency coefficients have been calculated for each scale and the GCC across nine age groups. Scale internal consistency coefficients for the 4:0 to 4:11 group range from 0.52 on the

Interests scale to 0.86 on the Speech scale, while GCC coefficients range from 0.94 to 0.96 (Bishop, 2003). Average internal consistency coefficients have been calculated for each scale and range from a high of 0.79 for Coherence to a low of 0.65 for Interests (Bishop, 2003).

Diagnostic accuracy of the CCC-2 has been evaluated by examining the Positive Predictive Power (PPP), Negative Predictive Power (NPP), sensitivity, and specificity of the measure. Because PPP and NPP vary as a function of the cutscore and base rate of a disorder, various base rates were examined, including a screening base rate of 10% (based on the prevalence rate of language disorders in school-aged children), referral base rates of 60%, 70%, and 80% (based on reported base rates for preschool and school referrals), and a matched sample base rate of 50% (set to optimize PPP and NPP) (Bishop, 2003). According to Bishop (2003), “a primary goal in developing an assessment is to minimize false negatives as these would represent children with a disorder who remain unrecognized” (p. 43). Therefore, more concern was paid to NPP than PPP because over-identifying false positives can be corrected later down the line through more extensive evaluation. Despite this emphasis on the CCC-2 as more of a screener, it has demonstrated its ability to reliably differentiate between communication impaired children and their normal language peers. Furthermore, the CCC-2 can differentiate between subsets of communication impaired children, such as children with ADHD, children with ASD, children with SLI, and children with PLI.

Data Collection Procedures

Data for Clinical Sample A were collected from the UARP database after receiving approval from the University of Utah Institutional Review Board (IRB_00042192). Inclusion criteria for this sample consisted of having valid scores for all aforementioned measures.

Design

The PAMS procedure consisted of the following steps: 1) conducting a simple MDS on the data, 2) estimating person parameters, 3) estimating standard errors of the scale values via bootstrapping, and 4) determining statistical significance of scale values. (See Appendix A for SPSS syntax used to run the PAMS procedure.) In the first step, the matrix of persons by test scores from the first clinical sample (n = 79) was entered into SPSS and analyzed using the ALSCAL procedure (alternating least squares scaling). The resulting dissimilarity matrix contained squared Euclidean distances between each variable where larger values indicate greater dissimilarity. Fit statistics Stress-1 and squared correlation index scores (RSQ) were used to determine the number of dimensions necessary for the MDS solution. Stress-1 is an indicator of how well the model reproduces the data, with smaller numbers indicating better fit (Ding, 2005a). Kruskal (1964) gives the following guidelines for using Stress-1 to assess model fit: values of .20 or higher indicate poor fit, values below .10 indicate adequate fit, and values below .025 indicate excellent fit. Squared correlation index scores (RSQ) indicate what proportion of the scaled data are accounted for by their scale values (i.e. distance measures) (Kim et al., 2004).

In step two, person parameters were estimated by regressing the observed variable scores for person *p* onto the variable dimension coordinate values created in step one using the least squares regression method. These person weights "index the degree of correspondence between the observed score profile of person *p* and the dimension profiles as identified by PAMS" (Kim et al., 2004, p. 606). Each person has one person weight index for each identified dimension. These person weights were established using the individual fit statistic R_i^2, which operates in much the same way as RSQ (i.e. indicating the proportion of variance in the individual's profile accounted for by the group-specific profile). Once the number of dimensions (i.e., profiles) has been established and person weights estimated, group membership for each profile can be determined by profile match indices (PMI), which indicate how well the individual matches each of the group-specific profiles (Ding, 2005a).

Because ALSCAL does not provide standard errors of estimate for dimension coordinates, a bootstrapping technique was used in step three to provide these estimates. This procedure involved selecting one case from the sample at random, documenting their observed scores, returning the case to the sample, and repeating until the size of the bootstrap sample was equal to the size of the original sample. This process for creating a bootstrap sample was repeated until 200 bootstrap samples had been generated. Each bootstrap sample was then analyzed using the simple MDS method previously outlined, resulting in 200 dissimilarity matrices.

In step four, these 200 bootstrap samples were used to create sampling distributions for each scale value. From these sampling distributions, means and standard deviations were computed. According to Kim et al. (2004), this standard deviation is a bootstrap standard error which can then be "used as the denominator when the original scale-value (dimension coordinate) is evaluated for statistical significance, stating the null hypothesis that the coordinate value is equal to 0 against the alternative hypothesis that the coordinate value is not equal to 0" (p. 608). The formula for this procedure is the coordinate value minus zero divided by the bootstrap standard error estimate. *Z*-tests were then used to determine statistical significance for each scale value. Statistically significant scale values were used to define and interpret the profiles.

To determine the relationship between the identified communication profiles derived from the first clinical sample and external variables important to understanding ASDs, the scale values of the profiles were correlated with observed scores on measures from the following areas: cognitive abilities, adaptive functioning, language abilities, and autism symptom severity. The following scores were used: Verbal and Nonverbal IQ scores from the DAS; Communication, Daily Living Skills, and Socialization domain scores from the VABS and VABS2; Expressive and Receptive Language scores from the CELF family of tests; and Total scores from the SRS. Multivariate regression was used to determine the independent contribution of dimension weights and level parameter on the prediction of these external variables in the identified profiles derived from the clinical sample.

Evaluating Reliability of Communication Profiles

Participants

Individuals selected for the second clinical sample (Clinical Sample B) used in the reliability portion of the study came from the Utah Autism Research Program (UARP) database as well. Individuals included in Clinical Sample B had valid scores on the CCC-2, but did not have scores for all of the other measures, and therefore they did not meet the inclusion criteria for Clinical Sample A. Because Clinical Sample B served primarily to evaluate the reliability of the communication profiles generated from Clinical Sample A, the only required measure was the CCC-2. Similar to Clinical Sample A, participants selected for Clinical Sample B were screened for UARP between the years 2004 and 2009. All participants were identified as having autism or ASD based on their scores from the ADOS, ADI-R, and clinical judgment by a licensed psychologist. Inclusion criteria were: valid scores on the CCC-2, acquisition of verbal language, native English speaker, absence of hearing loss, and ability to speak in sentences. Exclusion criteria for participation included having a known medical or genetic condition associated with ASD (such as Fragile X), no biological parent available to participate, or severe sensory impairments that would prevent direct assessment. Clinical Sample B consisted of 48 children (41 male, 7 female) ranging in age from 5 years to 15 years, 11 months (*M* = 9.40, *SD* = 3.44).

Measures

Scores for cognitive ability, adaptive functioning, and expressive/receptive language ability were not available for all individuals in Clinical Sample B. The available scores for these domains were used only for the purpose of comparing Clinical Sample B with the other samples used in this study in order to establish whether the groups were equivalent in terms of their functioning in these domains.

Cognitive ability. Cognitive scores were available for only 16 of the 48 individuals in Clinical Sample B. For those with IQ scores, nonverbal and verbal cognitive abilities were assessed using the Differential Abilities Scales (DAS; Elliot, 1990).

Adaptive functioning. Adaptive functioning scores were available for only 25 of the 48 individuals in Clinical Sample B. Adaptive functioning was measured using the Vineland Adaptive Behavior Scales (VABS; Sparrow et al., 1984) or the Vineland Adaptive Behavior Scales – Second Edition (VABS-II; Sparrow et al., 2005).

Expressive and receptive language ability. Expressive and receptive language scores were available for only 6 of the 48 individuals in Clinical Sample B. Expressive and receptive language ability were assessed through the Clinical Evaluation of Language Fundamentals – Fourth Edition (CELF-IV; Semel et al., 2003).

Dependent Variable. As in the first part of the study, scale scores from the Children's Communication Checklist – Second Edition (CCC-2; Bishop, 2003), were used to create communication profiles through the PAMS process for Clinical Sample B. CCC-2 scores were available for all 48 participants in Clinical Sample B.

Data Collection Procedures

Data for Clinical Sample B were also collected from the UARP database after receiving approval from the University of Utah Institutional Review Board (IRB_00042192). Inclusion criteria for this sample consisted of valid CCC-2 scores.

Design

Using the PAMS procedure outlined above, CCC-2 subscale scores from Clinical Sample B were used to create communication profiles. The following procedure was then used to test the invariance of profile pattern for Clinical Samples A and B. After the communication profiles were derived and standard deviations were calculated via the bootstrap method, 95% bootstrap empirical confidence intervals (BECI) were calculated, which consisted of the 2.5 and 97.5 percentile values from the bootstrap sampling distributions created for each scale value on each dimension. After calculating BECI for each scale value on each dimension, two test statistics were used. The first, *cbv*, tests "the null hypothesis indicating that there is no difference between confidence bands of samples A and B across coordinates" (Kim, 2010b, p. 38). This statistic was calculated by dividing the mean differences between the confidence bands across the ten scale coordinates by the pooled mean standard error. According to Kim (2010b), if "*cbv* is larger than or equal to |4.472|, then according to the Chebyshev's rule, at least 95% ($1-1/4.472^2 = .95$) of the data falls within 4.472 standard deviations of the standard normal (or *z*) distribution" (p. 38). In addition to *cbv*, another test statistic was used to determine whether the bootstrapped means for the profile coordinates were significantly different between the two clinical samples. This involves computing the absolute mean difference between the samples for each mean scale coordinate and dividing this by the pooled mean standard error used in calculating *cbv*. According to Kim (2010b), if the result is equal to 1.96 or larger, the null hypothesis of invariance for the two profile patterns is rejected.

Validation of Communication Profiles in a School-Based Community Sample

Participants

A school-based sample was used for cross-validation purposes. This sample (Community Sample C) was collected from a large school district from a metropolitan city in the Western United States, and consisted of children receiving Special Education services under the educational classification of Autism. Classification information for children receiving Special Education services through the school district was obtained through their special education files. Inclusion criteria included acquisition of verbal language, native English speaker, absence of hearing loss, and ability to speak in sentences. Community Sample C consisted of 10 children (9 male, 1 female) ranging in age from 5 years to 17 years (M = 10.38, SD = 3.70).

Measures

Aside from the SRS and CCC-2 data, which were collected specifically for this study, scores for cognitive ability, adaptive functioning, and expressive/receptive language ability were collected from the Special Education files of the participants in Community Sample C. Nonverbal cognitive scores were available for all individuals in this sample; however, verbal cognitive scores, adaptive functioning scores, and expressive/receptive scores were not available for all individuals in Community Sample C. The available scores for these domains were used only for the purpose of comparing Community Sample C with the other samples used in this study in order to establish whether the groups were equivalent in terms of their functioning in these domains.

Cognitive ability. Individuals in Community Sample C had been administered a variety of cognitive tests in the school setting, including the Differential Abilities Scales (DAS; Elliot, 1990), which was used in the two clinical samples. Other cognitive measures used in the community-based sample included the Stanford-Binet – Fifth Edition (SB5; Roid, 2003), Test of Nonverbal Intelligence - Third Edition (TONI-3; Brown, Sherbenou & Johnsen, 1997), Universal Nonverbal Intelligence Test (UNIT; Bracken & McCallum, 1998), Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV; Wechsler, 2003), Wechsler Nonverbal Scale of Ability (WNV; Wechsler & Naglieri, 2006), and Woodcock-Johnson III Test of Cognitive Abilities (WJIII; Woodcock, McGrew & Mather, 2001).

The SB5 is a widely used test of cognitive ability designed for individuals aged 2 years to 85+ years of age. The SB5 is organized around five factors taken from the Cattell-Horn-Carroll (CHC) model of cognitive abilities and includes both verbal and nonverbal subtests of Fluid Reasoning, Knowledge, Quantitative Reasoning, Visual-Spatial Processing, and Working Memory. The standardization sample consisted of 4,800 individuals stratified by age, gender, ethnicity, geographic region, and parent education level into 30 age groups. Roid (2003) reported internal consistency coefficients that ranged from .91 to .98 for IQ scores. According to Bain and Allin (2005), “reliability and validity evidence confirm the test's utility for psychoeducational assessment" (p. 94).

The TONI-3 is a language-free test of nonverbal cognitive ability designed for individuals aged 6 years to 89 years, 11 months of age. It provides an overall standard score for nonverbal cognitive ability (*M* = 100, *SD* = 15). The standardization samples consisted of 3,451 individuals stratified by age, gender, ethnicity, geographic region, and parent education level. Brown et al. (1997) reported internal consistency coefficients for 20 age groups, ranging from .89 to .97, with a mean of .93. According to Atlas (2001), test-retest reliability and interrater reliability are strong for this test. Banks and Franzen (2010) found moderate correlations between the TONI-3 and the Full Scale IQ (.78) and Perceptual Reasoning Index (.70) scores from the WISC-IV.

The UNIT is a test of nonverbal cognitive ability designed for individuals 5 years to 17 years, 11 months of age. The UNIT is organized around two factors, reasoning and memory, which can then be further divided into symbolic and nonsymbolic categories. The standardization sample consisted of 2,100 individuals stratified by age, gender, ethnicity, geographic region, and parent education level. Bracken and McCallum (1998) reported internal consistency coefficients that ranged from .91 to .93 for IQ scores. According to Fives and Flanagan (2002), the psychometric qualities of the UNIT are adequate for its intended purpose.

The WISC-IV is one of the most widely used tests of cognitive ability and designed for individuals aged 6 years to 16 years, 11 months of age. The WISC-IV provides a number of standard scores (*M* = 100, *SD* = 15) including a Full Scale IQ score and four index scores (Verbal Comprehension, Perceptual Reasoning, Working Memory, and Processing Speed). The standardization sample consisted of 2,200 children stratified by age, gender, ethnicity, geographic region, and parent education level into 11 age groups. Williams, Wiess, and Rolfhus (2003) reported average internal consistency coefficients that ranged from .88 for the Processing Speed Index to .97 for Full Scale IQ score. Test-retest reliability was also high, with correlations ranging from .86 for the Processing Speed Index to .93 for the Full Scale IQ score.

The WNV is relatively new test designed to measure general cognitive ability nonverbally. It is designed for individuals aged 4 years to 21 years, 11 months of age. The standardization sample consisted of 1,323 individuals stratified by age, gender, ethnicity, geographic region, and parent education level into 15 age groups. Wechsler and Naglieri (2006) reported an average internal consistency coefficient of .91 for the full scale score. Criterion validity was established by correlating the WNV Full Scale score with scores from other measures, including the WISC-IV FSIQ (.76) and the UNIT (.73). In a review of the WNV, Maddux (2010) felt these correlations were rather low, considering that these measures (particularly in the case of the UNIT) were meant to be nonverbal measures of ability.

The WJIII is one of the most widely used tests of cognitive ability in the public school system. It is designed for individuals aged 2 years to 90+ years of age. The WJIII was designed around the Cattell-Horn-Carroll (CHC) model of cognitive abilities. The standardization sample consisted of 8,818 individuals, including 1,143 preschool-aged children and 4,783 school-aged children, stratified by age, gender, ethnicity, geographic region, and parent education level. Internal consistency coefficients are generally in the .90s for cluster scores (Woodcock et al., 2001).

Adaptive functioning. Adaptive functioning scores were available for only 6 of the 10 individuals in Community Sample C. Individuals in this sample had been administered one of two tests of adaptive functioning in the school setting; the Vineland Adaptive Behavior Scales – Second Edition (VABS-II; Sparrow, et al., 2005), which was used in the two clinical samples, or the Adaptive Behavior Assessment System – Second Edition (ABAS-2; Harrison & Oakland, 2003).

The ABAS-2 is a norm-referenced assessment of adaptive functioning designed to be used with individuals from birth to 89 years of age. It provides scaled scores for 10 skill areas, standard scores for three domains (Conceptual, Social, and Practical), and an overall standard score for a General Adaptive Composite (GAC). Scaled scores have a mean of 10 and a standard deviation of 3, while the standard scores have a mean of 100 and a standard deviation of 15. The ABAS-2 comes in multiple forms, divided by age group. These are: Parent/Primary Caregiver (ages 0-5), Teacher/Daycare Provider (ages 2-5), Parent (ages 5-21), Teacher (ages 5-21), and Adult (ages 21 to 89). Standardization samples for the ABAS-2 ranged from of 750 to 1,690 individuals, depending on the test form. The samples were stratified by age, gender, ethnicity, geographic region, and parent education level. Average internal consistency coefficients ranged from .97 to .99 between samples, and ranged from .91 to .98 across domains. The test-retest reliability coefficients for GAC were above .90 in all samples, while domain score coefficients were generally above .80. According to Meikamp and Suppa (2005), the ABAS-2 had relatively high convergent validity correlations with the VABS.

Expressive and receptive language ability. Language testing was available for only 8 of the 10 individuals in Community Sample C. Individuals in this sample had been administered a variety of tests of language functioning in the school setting, including the

Clinical Evaluation of Language Fundamentals – Fourth Edition (CELF-IV; Semel, Wiig, & Secord, 2003), which was used with the two clinical samples. Other measures of language ability in the community-based sample included the Expressive One-Word Picture Vocabulary Test – Third Edition (EOWPVT-3; Brownell, 2000), Expressive Vocabulary Test – Second Edition (EVT-2; Williams, 2007), and Peabody Picture Vocabulary Test – Fourth Edition (PPVT-4; Dunn & Dunn, 2007).

The EOWPVT-3 is a widely used norm-referenced test of expressive vocabulary designed for individuals aged 24 months to 18 years, 11 months old. It provides an overall standard score for expressive vocabulary (*M* = 100, *SD* = 15). The standardization samples of the EOWPVT-3 consisted of 3,661 individuals stratified by age, gender, ethnicity, geographic region, and parent education level. Internal consistency coefficients ranged from .93 to .98. According to Longo (2003), test-retest reliability and interrater reliability are strong for this test. Correlations of the EOWPVT-3 with other vocabulary measures had a median of .79.

The EVT-2 is another widely used norm-referenced test of expressive vocabulary designed for individuals aged 2 years 6 months to 90 years old. It provides an overall standard score for expressive vocabulary (*M* = 100, *SD* = 15). The standardization sample for the EVT-2 consisted of 3540 individuals aged 2:6 to 90 years old, and 2003 children in grades kindergarten through twelfth grade. The samples were stratified by age, gender, ethnicity, geographic region, and parent education level. Internal consistency coefficients were .94 for the age norms and .93 for the grade norms and test-retest reliability coefficient for age norms was .95. Concurrent validity correlations for the EVT-2 ranged from .75 to .80 for the CELF-4 and .82 for the PPVT-4 (Williams, 2007).

The PPVT-4 is probably the most widely used norm-referenced test of receptive vocabulary. It is designed for individuals aged 2 years 6 months to 90 years old and provides an overall standard score for receptive vocabulary (*M* = 100, *SD* = 15). The PPVT-4 was co-normed with the EVT-2. Internal consistency coefficients were .94 for the age norms and .95 for the grade norms. The test-retest reliability coefficient for age norms was .93. Concurrent validity correlations for the PPVT-4 ranged from .67 to .75 for the CELF-4 and .82 for the EVT-2 (Dunn & Dunn, 2007).

Autistic symptoms. A measure of the severity of autism symptoms was obtained for all ten of the participants in Community Sample C in order to demonstrate equivalence with participants in the two clinical samples. Severity of autism symptoms in the community-based sample was assessed using the same procedure as Clinical Sample A, using the Social Responsiveness Scale (SRS; Constantino & Gruber, 2005). See previous section for more specific information on the SRS.

Dependent Variable. Structural and pragmatic language skills for Community Sample C were assessed through the Children's Communication Checklist – Second Edition (CCC-2; Bishop, 2003), as were the two clinical samples. See previous section for more detailed information about the CCC-2.

Data Collection Procedures

To validate the communication profiles generated from Clinical Sample A, a community-based sample of children with ASDs (Community Sample C) was used. CCC-2 and SRS data were collected from a sample of children from a local school district who were receiving Special Education services under the classification of Autism.

After approval was received from the Institutional Review Board for the University of Utah (IRB_00048072) and the participating local school district (IRB_12001), the principal investigator obtained classification information for children receiving Special Education services with the assistance of an ASD specialist working in the school district. Based on the inclusion criteria listed above, the ASD specialist was able to provide a list of thirty children receiving school-based services under the classification of Autism in nearby schools. A letter containing consent forms, questionnaires and a self-addressed envelope was then sent to the parents of these thirty children asking if they would be willing to participate in the research study and complete questionnaires related to their child's communication abilities and autism symptoms. Ten parents returned signed consent forms and completed the CCC-2 and SRS questionnaires; they were the only individuals included in Community Sample C. Previous assessment data regarding participants' cognitive abilities, adaptive behavior, and language ability were obtained via their Special Education files with parent consent.

Design

Using the same procedure described in step 2 of the PAMS procedure, person weights were estimated for each child in Community Sample C and matched against the established communication profiles from the initial clinical sample. Though the current assessment protocol for assessing autism in the targeted school district now includes both the ADOS and ADI-R, most students currently eligible under this classification in school districts across the country have not received both, nor have they been assessed by a licensed psychologist. Because the methods used to qualify the community-based participants as eligible to receive special education services under the classification of autism or related ASD was not standardized, SRS data were also collected in order to establish equivalency of the school district sample with the initial clinical sample in terms of autism symptom severity.

CHAPTER 3

RESULTS

Characteristics of Study Samples

Nonverbal IQ scores were used as a means of comparison across samples, as all of Clinical Sample A, Community Sample C, and 16 individuals of Clinical Sample B had nonverbal IQ scores. (See Appendix B for further sample comparisons on the CCC-2 and other variables of interest.) Clinical Sample A, which was used to create the PAMS profiles, consisted of 79 participants (70 male, 9 female) ranging in age from 5 years, 0 months to 17 years, 9 months (*M* = 9.94, *SD* = 3.56). Nonverbal IQ scores were taken from the Nonverbal Reasoning Ability cluster score of the Differential Abilities Scales (DAS; Elliot, 1990). The mean nonverbal IQ score for this sample was 90.56 (*SD* = 20.24), the median score was 93, and the range of scores was 44 to 133. Nonverbal IQ scores for 15 children were below 70 (range of 44 to 67), while 64 had nonverbal IQ scores at or above 70 (range of 71 to 133).

Clinical Sample B, which was used to create a second set of PAMS profiles for reliability purposes, consisted of 48 participants (41 male, 7 female) ranging in age from 5 years, 0 months to 15 years, 11 months (*M* = 9.40, *SD* = 3.44). Nonverbal IQ scores were only available for 16 individuals from this sample. For these individuals, nonverbal IQ scores also were taken from the Nonverbal Reasoning Ability cluster score of the

Differential Abilities Scales (DAS; Elliot, 1990). The mean nonverbal IQ score for this sample was 84 (*SD* = 21.42), the median score was 83, and the range of scores was 48 to 130. Nonverbal IQ scores for three children were below 70 (range of 48 to 65), while 13 had nonverbal IQs at or above 70 (range of 74 to 130).

The school-based community sample (Community Sample C), used for cross-validation purposes, consisted of 10 participants (9 male, 1 female) ranging in age from 5 years, 0 months to 17 years, 0 months (*M* = 10.38, *SD* = 3.70). A review of these participants' Special Education files indicated that a variety of cognitive measures were used to assess the individuals used in this sample. The mean nonverbal IQ score for this sample was 87.10 (*SD* = 19.46), the median score was 85.5, and the range of scores was 54 to 122. Only one individual had a nonverbal IQ score below 70. Independent *t* tests were used to determine if any significant differences existed between Clinical Sample A, which was used to create the communication profiles, and the other two samples used for reliability and validation purposes. No significant differences were found for age, sex or Nonverbal IQ scores between the Clinical Sample A and the other two samples. Clinical Sample A had significantly higher mean scores than Clinical Sample B on two CCC-2 scales: Speech ($t = 3.1$, $df = 125$, and $p < .05$) and Syntax ($t = 2.114$, $df = 125$, and $p < .05$). Clinical Sample A also had significantly higher mean scores than Community Sample C on four CCC-2 scales: Scripted Language ($t = 2.457$, $df = 87$, and $p < .05$), Context ($t = 2.473$, $df = 87$, and $p < .05$), Nonverbal Communication ($t = 2.682$, $df = 87$, and $p < .05$) and Social Relations ($t = 2.803$, $df = 87$, and $p < .05$). The mean elevation (level parameter) of Community Sample C was also significantly lower than Clinical Sample A ($t = 3.609$, $df = 87$, and $p < .01$). No significant difference was found between SRS scores for Clinical Sample A and Community Sample C suggesting similar severity of autism symptoms in the two samples. SRS scores were not available for Clinical Sample B.

<u>Creating Communication Profiles</u>

Dimensionality

Following the PAMS procedure outlined above, profile analysis of Clinical Sample A began with a simple MDS run through the SPSS 20.0. Stress -1 and RSQ values were as follows for solutions supporting one to four dimensions: one dimension (0.117, 0.963), two dimensions (0.049, 0.992), three dimensions (0.015, 0.999), and four dimensions (0.006, 0.999). Because both two and three dimensional models had Stress values below 0.05, one of the criteria outlined by Kruskal and Wish (1978), further steps were taken to ensure an appropriate MDS solution. Stress-1 values were plotted in an attempt to determine whether a clear "elbow" was present in the number of dimensions, in much the same way that eigenvalues are plotted to determine dimensionality in factor analysis. While no definitive elbow was present in the graph, the location of the bend in conjunction with Stress – 1 and RSQ values supported a three dimension solution (see Figure 1). Visual examination of the three dimension solution also appeared to be interpretable, so no rotation was necessary (see Figure 2).

Person Parameters

After determining the correct number of dimensions, the next step in the PAMS procedure was estimating person parameters for each individual in the first clinical sample. The level parameter (C_p) was depressed for all individuals in the sample, with a

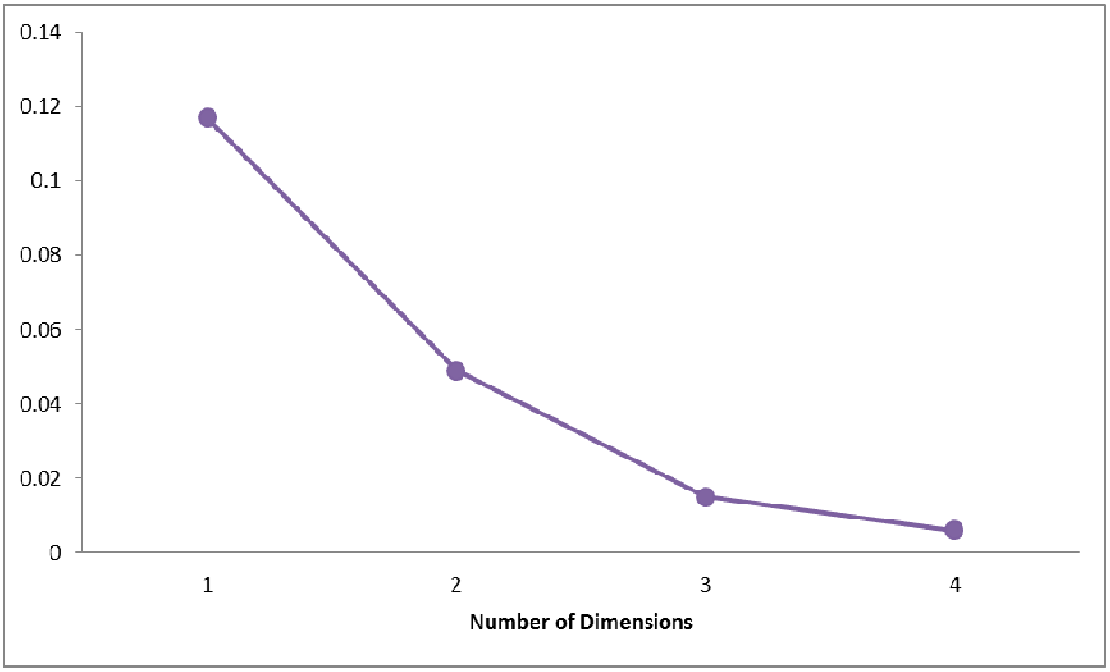

Figure 1. Stress plot for interpreting dimensionality of the multidimensional scaling solution.

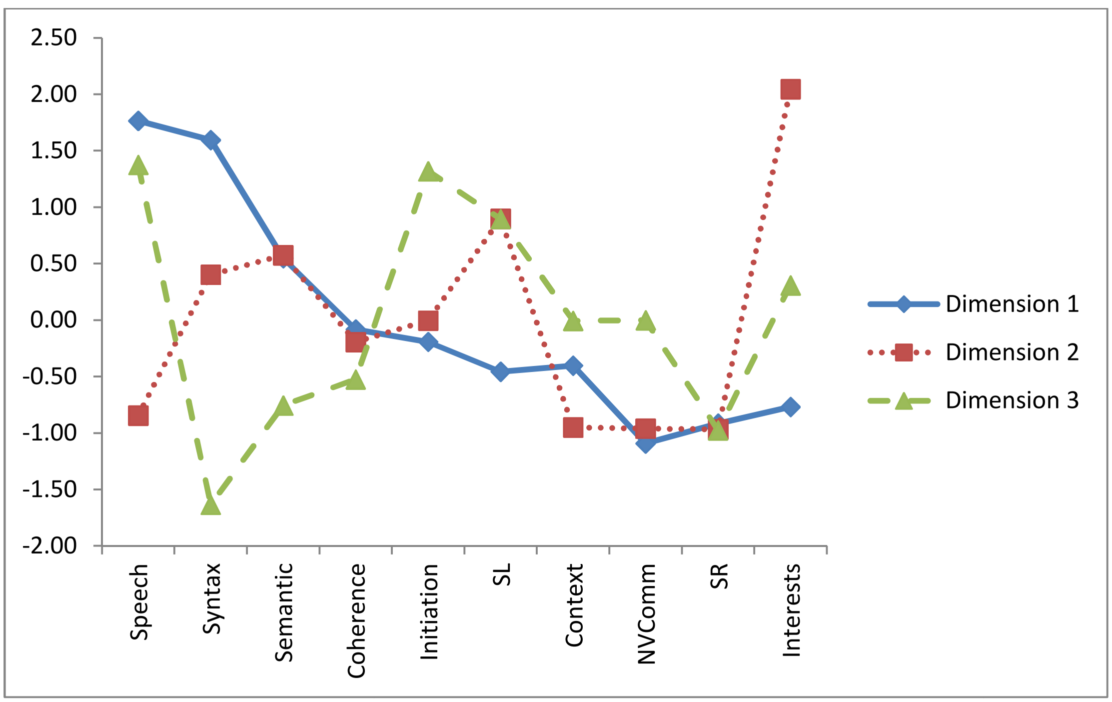

Figure 2. Three dimension solution.

range of -2.8 to -0.13. The average C_p was -1.52 with a standard deviation of 0.50. Values for the individual fit statistic R_i^2 ranged from 0.09 to 0.96, with an average of 0.65 and astandard deviation of 0.21. In other words, the overall accounted variance for the observed profiles of 79 individuals was 0.65, based on three dimensions. Profile match indices (PMI) were calculated for each individual across profiles. On the first dimension, PMI values ranged from -0.53 to 1.43, with an average of 0.41 and a standard deviation of 0.46. PMI values for the second dimension ranged from -0.49 to 0.92, with an average of 0.12 and a standard deviation of 0.28. PMI values for the third dimension ranged from -1.03 to 0.61 with an average of 0.01 and a standard deviation of 0.27.

Determining Statistical Significance of Scale-Values

Using the bootstrap method described previously, 200 bootstrap samples were created from Clinical Sample A. Simple MDS procedures were performed on each bootstrap sample, resulting in a sampling distribution for each of the original scale values. The standard deviations of these sampling distributions were then used to determine the statistical significance of the original scale values. All scale values for the first dimension were significant (at $\alpha = 0.05$), while Speech, Syntax, Coherence, Initiation, and Context were significant on the second dimension, and Coherence, Scripted Language, Context, Nonverbal Communication, and Social Relations were significant on the third dimension (see Table 1).

The first dimension was identified by significant peaks for Speech and Syntax and significant valleys for Nonverbal Communication and Social Relations, thus this profile was titled *High Speech vs. Low Nonverbal Communication* (see Figure 3). The second

Table 1
Scale-values and Standard Errors Estimated from 200 Bootstrap Replicated Samples

Observed Variables	Scale Values and Standard Deviations					
	Dimension 1		Dimension 2		Dimension 3	
Speech	**1.77**	(0.42)	**-0.84**	(0.50)	1.38	(0.57)
Syntax	**1.60**	(0.24)	**0.40**	(0.43)	-1.63	(0.62)
Semantics	**0.55**	(0.21)	0.58	(0.52)	-0.76	(0.51)
Coherence	**-0.08**	(0.17)	**-0.20**	(0.33)	**-0.52**	(0.33)
Initiation	**-0.19**	(0.18)	**0.00**	(0.42)	1.32	(0.53)
Scripted Language	**-0.46**	(0.31)	0.90	(0.53)	**0.90**	(0.41)
Context	**-0.40**	(0.19)	**-0.95**	(0.46)	**-0.01**	(0.40)
Nonverbal Communication	**-1.09**	(0.27)	-0.96	(0.53)	**0.00**	(0.36)
Social Relations	**-0.92**	(0.36)	-0.97	(0.66)	**-0.98**	(0.42)
Interests	**-0.77**	(0.26)	2.05	(0.97)	0.31	(0.60)

Notes: Statistically significant scale-value estimates at α = 0.05 are in bold print. Standard deviations are in parentheses.

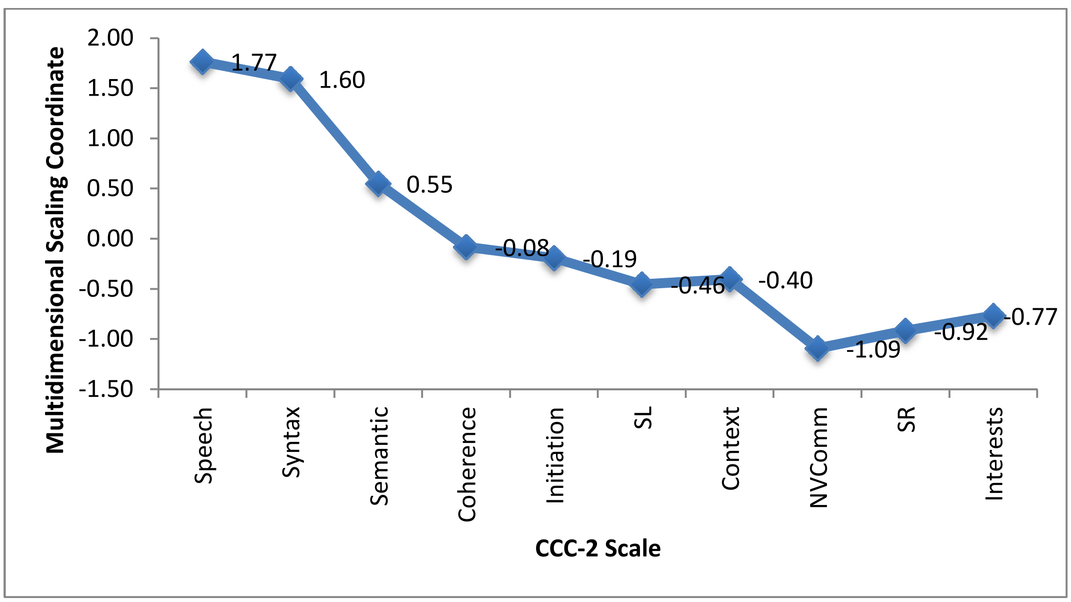

Figure 3. Dimension 1 profile: *High Speech vs. Low Nonverbal Communication*.
Note: Statistically significant coordinates at the 0.05 level are identified with filled-in markers.

dimension had a significant peak for Syntax and significant valleys for Speech and Context, thus this profile was titled *High Syntax vs. Low Context* (see Figure 4.) The third dimension had a significant peak for Scripted Language and significant valleys for Coherence and Social Relations, thus this profile was titled *High Scripted Language vs. Low Social Relations* (see Figure 5).

Interpreting Profile Match Indices

Because three profiles were identified, each individual participant was assigned three person weights (i.e. profile match indices). Individuals with a high PMI score on Dimension 1, for example, would be expected to have an observed profile very similar to that of the first dimension profile. If an individual had a substantial negative PMI score for a given dimensional profile, then the individual's observed profile would be expected to resemble a mirror image of the dimensional profile in question. If an individual had a substantial PMI score on multiple dimension profiles, then the individual's observed profile would resemble some linear combination of the dimensional profiles in question. Data from several individuals' profiles illustrate the interpretation of person profiles versus dimensional profiles (see Figures 6, 7, 8, and 9).

Individual #37 had a substantial positive weight on Dimension 1 ($V_{p1} = 1.08$) and small weights on Dimensions 2 and 3 ($V_{p2} = -0.14$, $V_{p3} = 0.04$). The proportion of explained variance for Individual #37's observed profile was 0.94 and the elevation of the observed profile was depressed ($C_{p37} = -1.70$). Individual #52, on the other hand, had a substantial positive weight on Dimension 2 ($V_{p2} = 0.92$) and small weights on the other two dimensions ($V_{p1} = -0.08$, $V_{p3} = 0.07$). The proportion of explained variance for

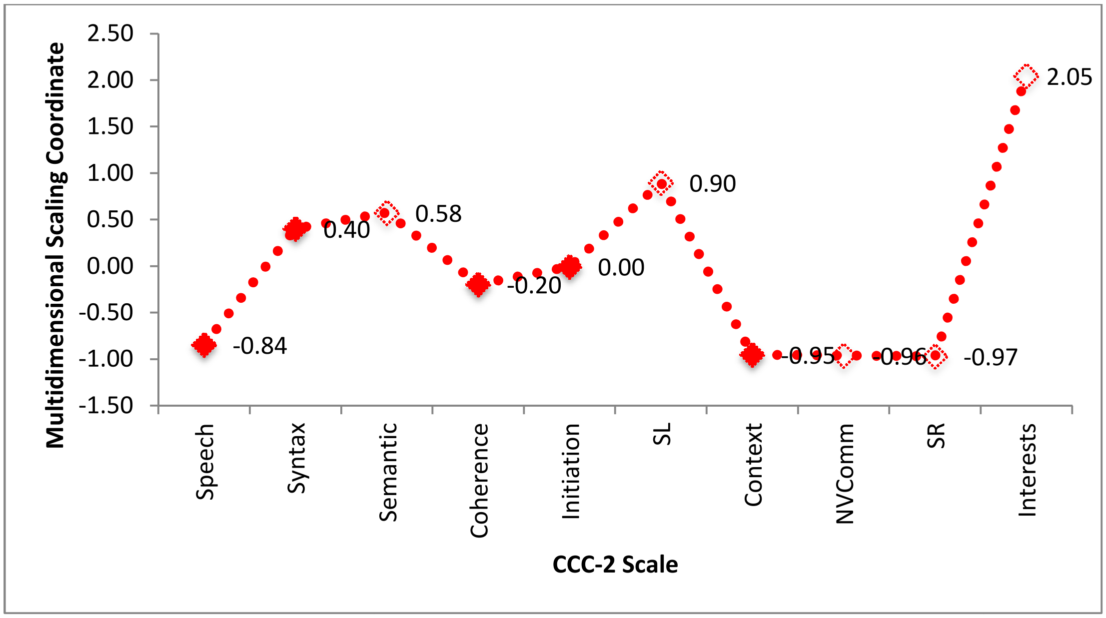

Figure 4. Dimension 2 profile: *High Syntax vs. Low Context*.
Note: Statistically significant coordinates at the 0.05 level are identified with filled-in markers.

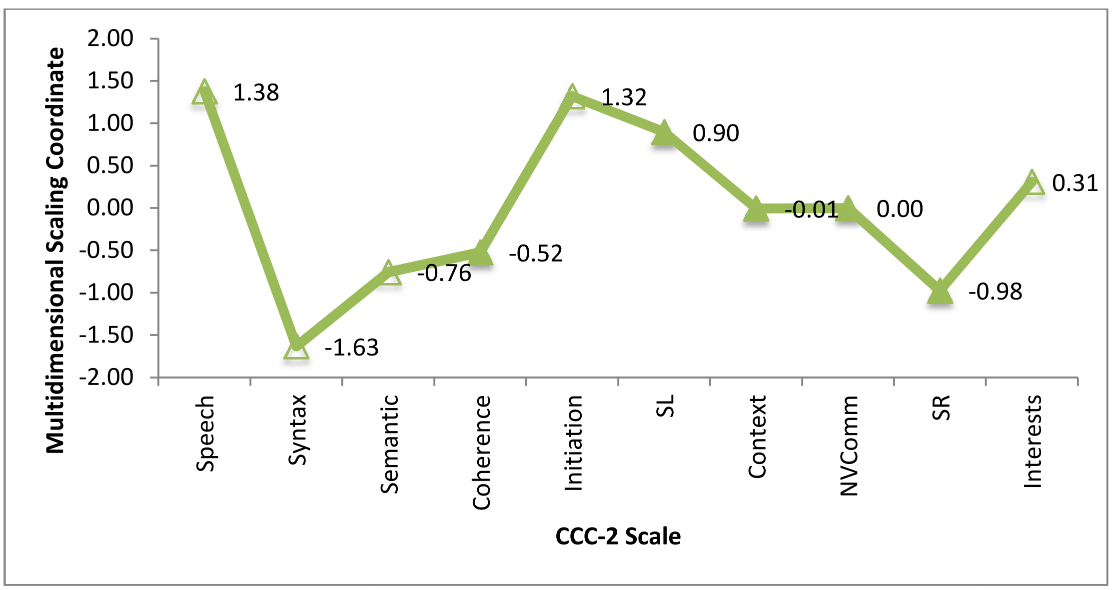

Figure 5. Dimension 3 profile: *High Scripted Language vs. Low Social Relations*.
Note: Statistically significant coordinates at the 0.05 level are identified with filled-in markers.

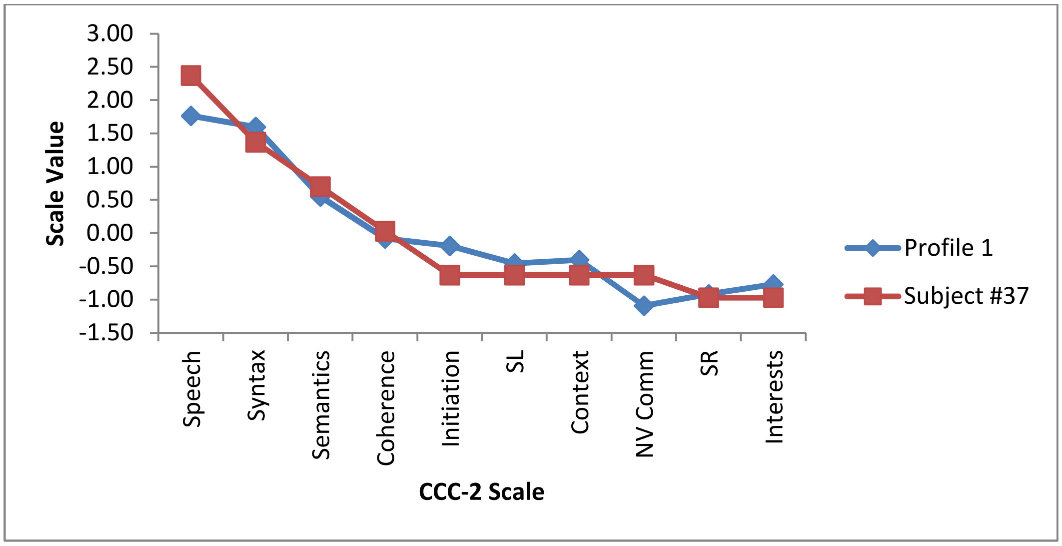

Figure 6. Individual #37 observed profile superimposed on dimension 1 profile.

Individual #52's observed profile was 0.73 and the elevation of the observed profile was depressed (C_{p52} = -1.17). Individual #51 had a substantial positive weight on Dimensions 1 and 3 (V_{p1} = 0.52, V_{p3} = 0.61) and a trivial weight on Dimension 2 (V_{p2} = -0.01). The proportion of explained variance for Individual #51's observed profile was 0.79 and the elevation of the observed profile was depressed (C_{p51} = -1.37). Individual #26 had a substantial negative weight on Dimension 3 (V_{p3} = -1.03), a substantial but smaller positive weight on Dimension 1 (V_{p1} = 0.60), and a smaller weight on Dimension 2 (V_{p2} = 0.30. This profile is essentially a mirror image of Profile 3. The proportion of explained variance for Individual #26's observed profile was 0.82 and the elevation of the observed profile was depressed (C_{p26} = -1.83). Individual #1 had trivial weights on all three dimensions (V_{p1} = -0.11, V_{p2} = 0.29, V_{p3} = 0.14), but the proportion of explained variance for Individual #1's observed profile was 0.94, suggesting a very good fit between Individual #1's observed profile and the combination of profiles from all three dimensions. The elevation of Individual #1's observed profile was depressed as well (C_{p1} = -2.80).

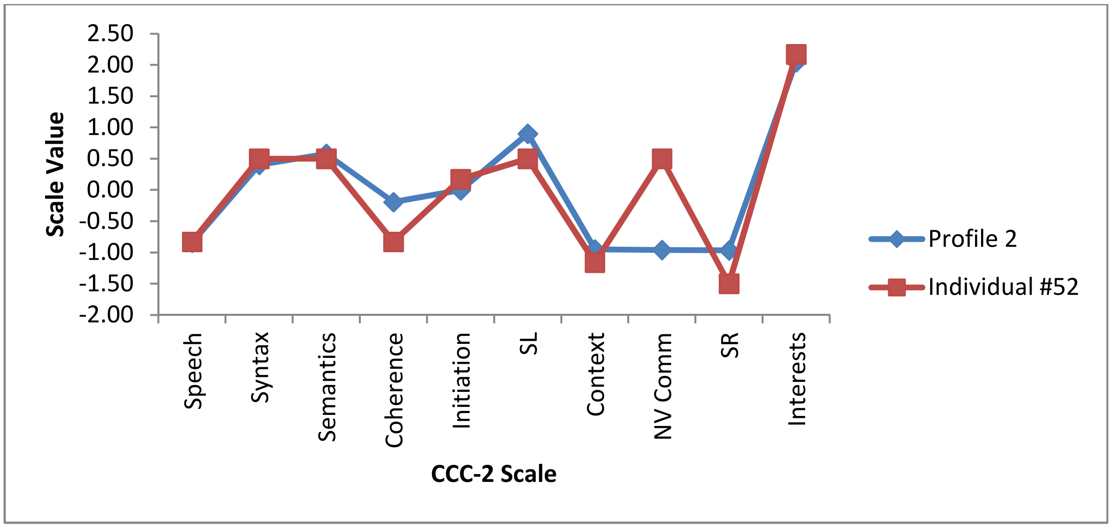

Figure 7. Individual #52 observed profile superimposed on dimension 2 profile.

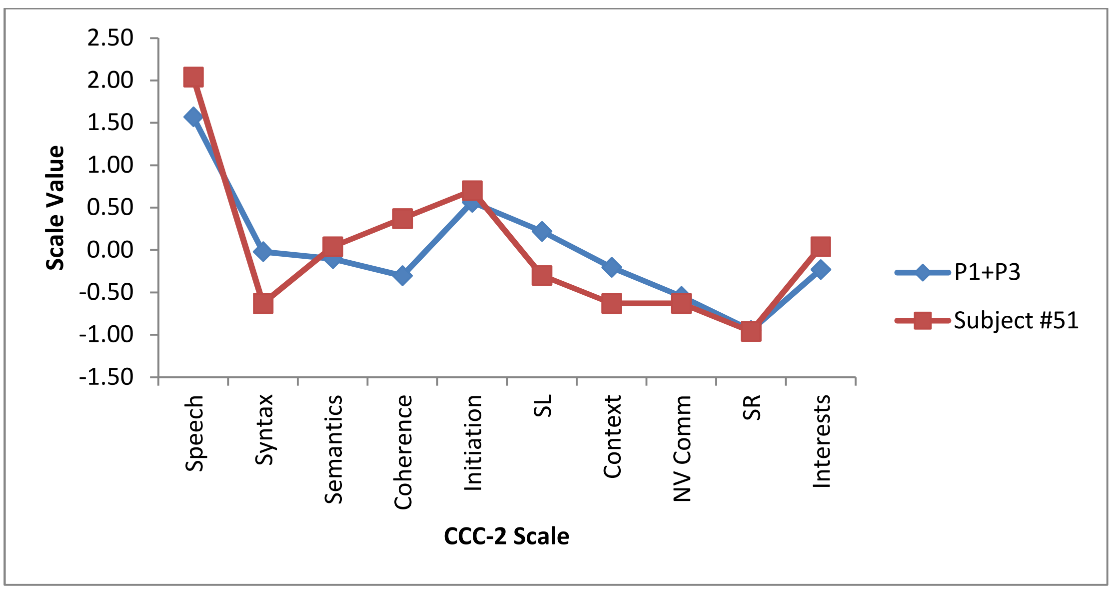

Figure 8. Individual #51 observed profile superimposed on linear combination of dimensions 1 and 3 profiles.

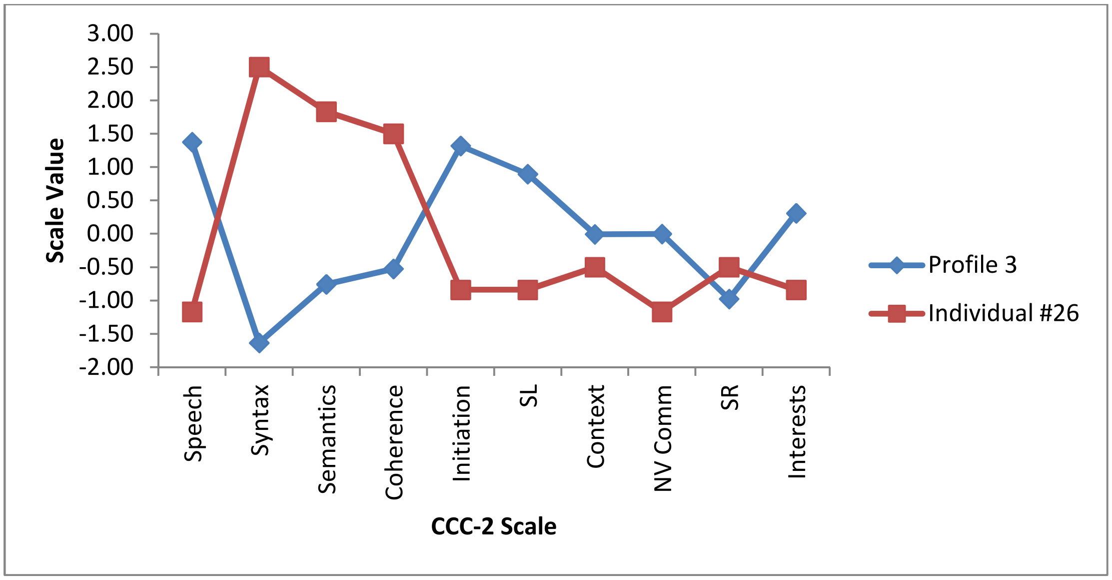

Figure 9. Individual #26 observed profile superimposed on dimension 3 profile.

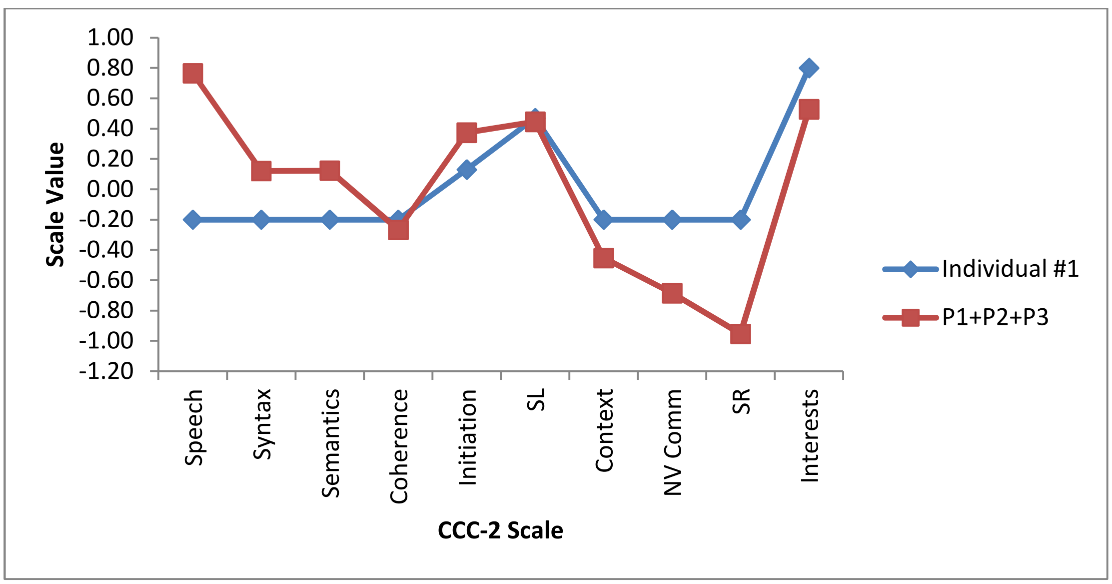

Figure 10. Individual #1 observed profile superimposed on linearly combined dimensions.

Relationships Between Person Parameters and External Variables

Three communication profiles were supported in the multidimensional solution. The next step was determining how these profiles related to scores on measures of cognition, adaptive functioning, language, and autism symptoms (see Table 2). The level parameter showed significant positive correlations with the Daily Living Skills, Socialization, and Communication domains from the Vineland (r = .382 and .370, p, <.01; r = .273, p < .05), as well as the Expressive Language composite from the CELF (r = .224, p < .05) and Verbal Intelligence Quotient from the DAS (r = .248, p < .05). The level parameter also showed a significant negative correlation with the SRS total score (r = -.630, p < .01). Profile 1 showed significant positive correlations with all external variables except the Daily Living Skills and Socialization domains from the Vineland (r = .288 ~ .495, p < .01; for SRS, r = .244, p < .05). No significant correlations were shown between profiles 2 or 3 and external variables, though a significant negative correlation was found between profile match indices for profiles 1 and 2 (r = -.312, p, <.01).

In addition to examining the linear relationship between the profiles and external variables, a hierarchical multivariate regression was conducted to determine the independent contribution of dimension weights (i.e., dimension profiles) and the level parameter on the prediction of external variable scores. Dimension weights and then the level parameter were entered into the regression. Dimension weights explained 24.5% of Receptive language scores, 28% of Expressive language scores, 22.1% of Verbal IQ scores, 12.4% of Nonverbal IQ scores and 11.7% of SRS scores. Dimension weights did

Table 2
Correlations of Person and Level Parameters with External Variables

Variable	C_p	R^2	V_{p1}	V_{p2}	V_{p3}
Expressive language	0.224*	0.284*	0.483**	-0.046	-0.047
Receptive language	0.182	0.313**	0.494**	-0.003	-0.142
Communication	0.273*	0.068	0.288**	-0.093	-0.108
Daily Living Skills	0.383**	-0.042	0.105	0.006	0.140
Social	0.371	-0.117	-0.062	-0.159	0.005
Verbal IQ	0.247*	0.279*	0.464**	-0.083	-0.084
Nonverbal IQ	0.140	0.279*	0.295**	0.073	0.063
Social Reciprocity Scale	-0.630**	0.193	0.244*	-0.092	0.217

Note: * $p < .05$, ** $p < .01$. C_p = level, V_{p1} = variance in person parameters for profile one, V_{p2} = variance in person parameters for profile two, V_{p3} = variance in person parameters for profile three.

not explain an appreciable amount of variance in any of the other external variables (range of 3.5% to 9%). The level parameter explained 15% of Daily Living Skill scores, 15.1% of Socialization scores and 40.4% of SRS scores. The level parameter did not explain an appreciable amount of variance in any of the other external variables (range of 1.3% to 4.1%). Together, dimension weights and level parameter accounted for 52.1% of the variance in SRS scores.

Reliability of Profiles

Following the PAMS procedure, profile analysis of the reliability sample began with a simple MDS run through SPSS 20.0. Stress -1 and RSQ values were 0.050 and 0.979, respectively, for a three-dimensional solution (see Figures 11-13 for Clinical Samples A and B dimension comparisons). The level parameter (C_p) was depressed for all individuals in the second clinical sample, with a range of -2.90 to -0.13. The average C_p was -1.49 with a standard deviation of 0.66. Values for the individual fit statistic R_i^2 ranged from 0.13 to 0.94, with an average of 0.60 and a standard deviation of 0.19. In other words, the overall variance accounted for by the observed profiles of 48 individuals was 0.60, based on three dimensions. Profile match indices (PMI) were calculated for each individual across profiles. On the first dimension, PMI values ranged from -0.51 to 1.02, with an average of 0.69 and a standard deviation of .33. PMI values for the second dimension ranged from -0.98 to 0.63, with an average of -0.13 and a standard deviation of 0.34. PMI values for the third dimension ranged from -0.75 to 0.85 with an average of 0.17 and a standard deviation of 0.33.

BECI, *cbv* and the bootstrap means statistic were calculated for samples A (first

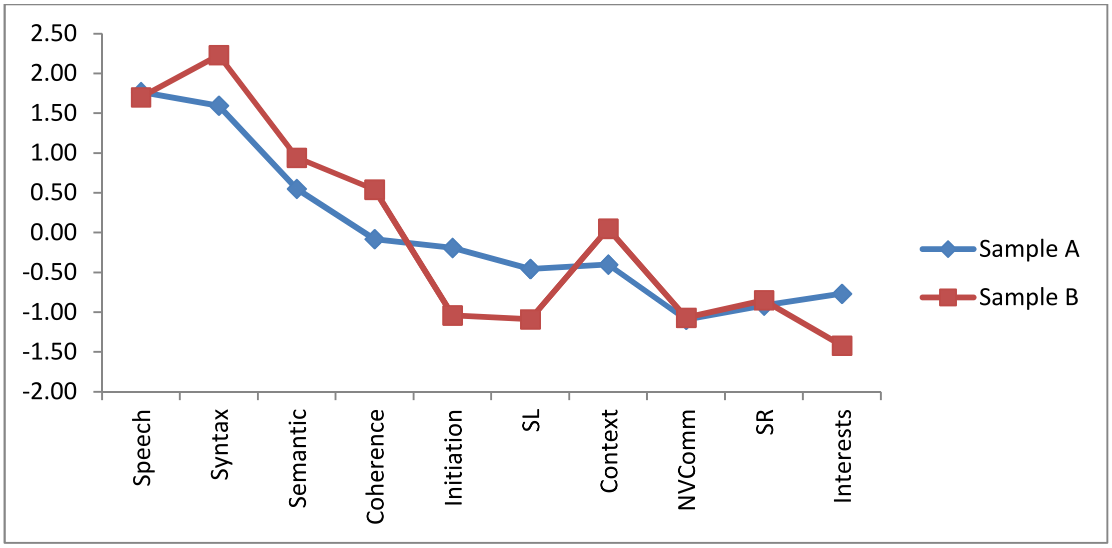

Figure 11. Dimension 1 profiles: Clinical Sample A vs. Clinical Sample B.

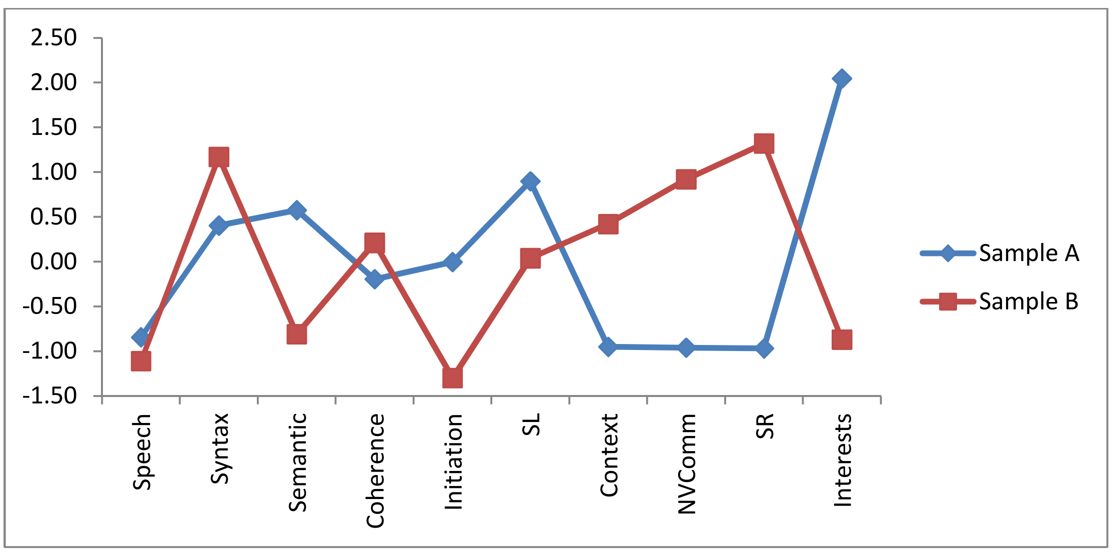

Figure 12. Dimension 2 profiles: Clinical Sample A vs. Clinical Sample B.

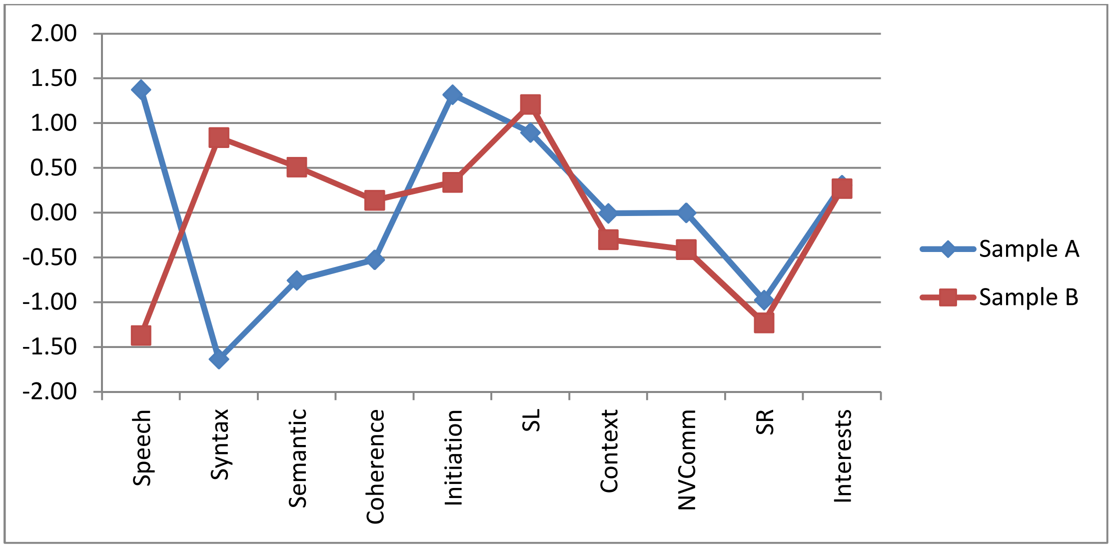

Figure 13. Dimension 3 profiles: Clinical Sample A vs. Clinical Sample B.

Table 3

Coordinate Information of Dimension 1 Profile from Clinical Samples A and B

	Dim 1 A						Dim 1 B								
				95 % BECI						95% BECI					
CCC-2 Scale	Original	*SD*	*M*	2.5%ile	97.5%ile	WD	Original	*SD*	*M*	2.5%ile	97.5%ile	WD	WD Diff	Pld Var	AM Diff
Speech	1.77	0.26	2.76	2.22	3.16	0.94	1.70	0.81	1.52	-0.24	2.74	2.98	-2.04	0.36	1.24
Syntax	1.60	0.20	2.58	2.17	2.92	0.75	2.23	1.55	1.49	-2.42	2.85	5.27	-4.52	1.21	1.09
Semantic	0.55	0.17	0.91	0.59	1.20	0.61	0.94	0.65	0.73	-1.06	1.52	2.58	-1.97	0.22	0.18
Coherence	-0.08	0.17	-0.14	-0.48	0.20	0.67	0.54	0.45	0.27	-0.72	1.15	1.87	-1.20	0.12	0.41
Initiation	-0.19	0.18	-0.32	-0.65	0.04	0.69	-1.04	0.93	-0.66	-2.08	1.75	3.83	-3.14	0.45	0.35
SL	-0.46	0.18	-0.86	-1.21	-0.53	0.68	-1.09	0.61	-0.87	-1.72	0.66	2.38	-1.70	0.20	0.01
Context	-0.40	0.19	-0.72	-1.12	-0.34	0.78	0.05	0.32	-0.06	-0.79	0.53	1.32	-0.54	0.07	0.66
NVComm	-1.09	0.18	-1.68	-2.01	-1.30	0.71	-1.07	0.72	-0.85	-1.69	1.42	3.12	-2.41	0.28	0.83
SR	-0.92	0.18	-1.42	-1.75	-1.06	0.69	-0.85	0.91	-0.61	-2.09	1.86	3.95	-3.26	0.43	0.81
Interests	-0.77	0.22	-1.12	-1.56	-0.65	0.91	-1.42	1.00	-0.96	-1.98	1.78	3.76	-2.85	0.52	0.15
													(1)	(2)	(4)
													-2.36	3.87	0.57
														(3)	(5)
														-0.61	0.15

Notes: Original = scale values from original sample; *SD* = bootstrapped standard error estimates; *M* = mean scale values from bootstrapped replicates; WD = width between upper and lower values in 95% BECI; WD Diff = width difference between Samples A and B; Pld Var = pooled variance; AM Diff = absolute mean difference between Samples A and B; (1) = average of WD Diff; (2) = PMSE; (3) = *cbv*; (4) = average of AM Diff; (5) = bootstrap means test statistic.

Table 4

Coordinate Information of Dimension 2 Profile from Clinical Samples A and B

	Dim 2 A						Dim 2 B								
				95 % BECI						95% BECI					
CCC-2 Scale	Original	*SD*	*M*	2.5%ile	97.5%ile	WD	Original	*SD*	*M*	2.5%ile	97.5%ile	WD	WD Diff	Pld Var	AM Diff
Speech	-0.84	0.55	-0.49	-1.51	0.79	2.30	-1.11	1.08	-0.67	-2.01	2.22	4.23	-1.93	0.73	0.19
Syntax	0.40	0.43	0.31	-0.50	1.08	1.59	1.17	0.85	0.77	-1.30	2.16	3.46	-1.87	0.46	0.46
Semantic	0.58	0.58	0.28	-0.91	1.15	2.06	-0.81	0.79	-0.26	-1.66	1.29	2.95	-0.90	0.48	0.54
Coherence	-0.20	0.33	0.05	-0.51	0.65	1.16	0.21	0.47	0.16	-0.70	1.02	1.72	-0.56	0.17	0.11
Initiation	0.00	0.43	-0.11	-0.80	0.59	1.39	-1.30	0.82	-0.54	-1.64	1.20	2.84	-1.45	0.43	0.43
SL	0.90	0.55	0.12	-0.83	0.92	1.75	0.04	0.80	0.23	-1.52	1.49	3.01	-1.26	0.47	0.11
Context	-0.95	0.48	-0.17	-0.85	0.69	1.53	0.42	0.35	0.21	-0.47	0.79	1.26	0.27	0.18	0.38
NVComm	-0.96	0.63	-0.16	-1.00	0.92	1.92	0.92	0.80	0.21	-1.30	1.37	2.67	-0.75	0.52	0.36
SR	-0.97	0.70	-0.13	-1.15	1.04	2.19	1.32	1.30	0.33	-1.96	2.02	3.98	-1.79	1.10	0.46
Interests	2.05	1.08	0.30	-1.57	1.68	3.25	-0.87	0.67	-0.44	-1.46	0.94	2.40	0.84	0.80	0.73
													(1)	(2)	(4)
													-0.94	5.34	0.38
														(3)	(5)
														-0.18	0.07

Notes: Original = scale values from original sample; *SD* = bootstrapped standard error estimates; *M* = mean scale values from bootstrapped replicates; WD = width between upper and lower values in 95% BECI; WD Diff = width difference between Samples A and B; Pld Var = pooled variance; AM Diff = absolute mean difference between Samples A and B; (1) = average of WD Diff; (2) = PMSE; (3) = *cbv*; (4) = average of AM Diff; (5) = bootstrap means test statistic.

Table 5

Coordinate Information of Dimension 3 Profile from Clinical Samples A and B

	Dim 3 A						Dim 3 B								
				95 % BECI						95% BECI					
CCC-2 Scale	Original	*SD*	*M*	2.5%ile	97.5%ile	WD	Original	*SD*	*M*	2.5%ile	97.5%ile	WD	WD Diff	Pld Var	AM Diff
Speech	1.38	0.72	0.06	-1.07	1.13	2.21	-1.37	0.97	-0.28	-1.80	1.57	3.37	-1.17	0.72	0.34
Syntax	-1.63	0.65	-0.14	-1.09	0.95	2.04	0.84	0.91	0.04	-1.57	1.49	3.06	-1.03	0.62	0.18
Semantic	-0.76	0.59	0.06	-0.93	1.06	1.99	0.51	0.55	0.33	-0.90	1.28	2.18	-0.19	0.33	0.27
Coherence	-0.52	0.36	-0.03	-0.69	0.64	1.34	0.14	0.58	0.07	-0.86	1.09	1.95	-0.61	0.24	0.11
Initiation	1.32	0.53	0.08	-0.74	0.88	1.62	0.34	0.63	0.18	-1.04	1.23	2.27	-0.65	0.34	0.09
SL	0.90	0.37	0.13	-0.57	0.73	1.30	1.21	0.87	0.33	-1.37	1.46	2.83	-1.53	0.45	0.20
Context	-0.01	0.38	-0.05	-0.67	0.65	1.32	-0.30	0.28	-0.11	-0.67	0.42	1.09	0.23	0.11	0.07
NVComm	0.00	0.38	-0.08	-0.81	0.67	1.48	-0.41	0.53	-0.23	-1.09	0.84	1.94	-0.45	0.21	0.15
SR	-0.98	0.42	-0.16	-0.87	0.64	1.51	-1.23	0.87	-0.42	-1.57	1.38	2.95	-1.45	0.47	0.26
Interests	0.31	0.61	0.12	-1.18	1.09	2.27	0.27	0.54	0.09	-0.96	1.22	2.18	0.09	0.33	0.03
													(1)	(2)	(4)
													-0.68	3.82	0.17
														(3)	(5)
														-0.18	0.04

Notes: Original = scale values from original sample; *SD* = bootstrapped standard error estimates; *M* = mean scale values from bootstrapped replicates; WD = width between upper and lower values in 95% BECI; WD Diff = width difference between Samples A and B; Pld Var = pooled variance; AM Diff = absolute mean difference between Samples A and B; (1) = average of WD Diff; (2) = PMSE; (3) = *cbv*; (4) = average of AM Diff; (5) = bootstrap means test statistic.

clinical sample) and B (second clinical sample) (see Tables 3-5). The *cbv* statistic was below |4.472| for all three dimensions (-0.61, -0.18, -0.18), indicating no statistical difference between the 95% confidence bands of the original clinical and the reliability samples. The bootstrap means statistic was below 1.96 for all three dimensions (0.15, 0.07, and 0.04), indicating the null hypothesis of invariance of the two profile patterns was not rejected.

Validation of Profiles

Similar to Clinical Sample A, the level parameter (C_p) was depressed for all individuals in Community Sample C, with a range of -2.87 to -1.60. The average C_p was -2.13 with a standard deviation of 0.49. Values for the individual fit statistic R_i^2 ranged from 0.19 to 0.89, with an average of 0.58 and a standard deviation of 0.27. In other words, the overall variance accounted for in the observed profiles of 10 individuals was 0.58, based on three profiles. Profile match indices (PMI) were calculated for each individual across profiles. On Profile 1, PMI values ranged from -0.13 to 1.13, with an average of 0.39 and a standard deviation of .41. PMI values for Profile 2 ranged from -0.05 to 0.39, with an average of 0.17 and a standard deviation of 0.14. PMI values for Profile 3 ranged from -0.57 to 0.33 with an average of 0.02 and a standard deviation of 0.24.

Comparisons with Clinical Sample A showed that Community Sample C was very similar in terms of average scores for each of the CCC-2 scales used to create the profiles, but was more depressed overall than Clinical Sample A (see Figure 14). Independent *t* tests were used to determine if any significant differences existed between

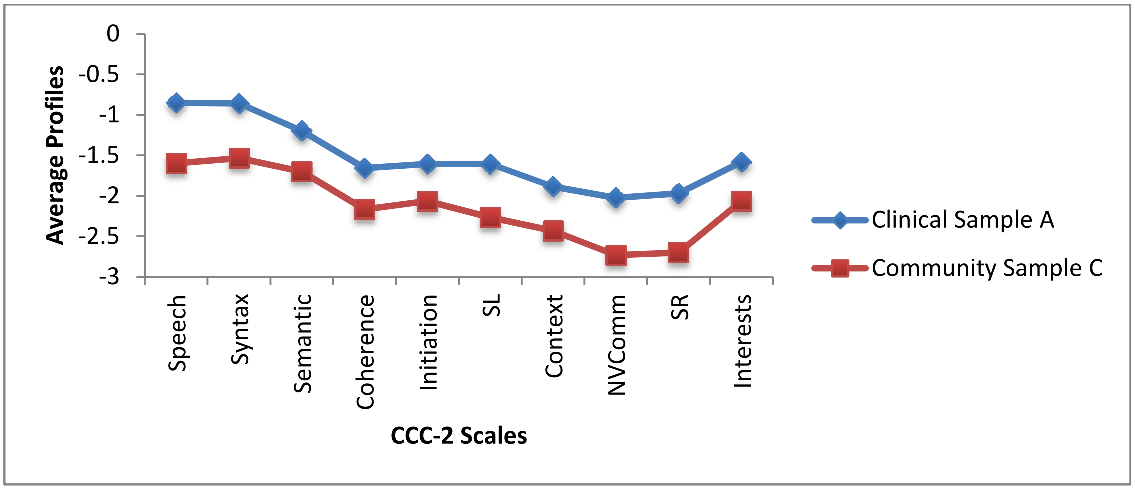

Figure 14. Averaged profiles for Clinical Sample A and Community Sample C.

the two samples. Significant differences were found for Scripted Language (t = 2.457, df = 87, and p <.05), Context (t = 2.473, df = 87, and p <.05), Nonverbal Communication (t = 2.682, df = 87, and p <.01), Social Relations (t = 2.803, df = 87, and p <.01), and level (t = 3.609, df = 87, and $p \leq$.001). Across the variables where significant differences were noted between the two samples, Community Sample C showed more impairment (i.e. had more depressed scores). As in Clinical Sample A, roughly 30% of Community Sample C matched to Profile 1. No individuals in Community Sample C matched to either Profiles 2 or 3, while only a few individuals matched to these profiles in Clinical Sample A. Similar to Clinical Sample A, several individuals in Community Sample C had profiles that were best described by a linear combination of all three profiles.

Post Hoc Analysis: ALI vs. ALN

Using the research standard for defining SLI of language skills 1.5 standard deviations below the mean, 41 children from Clinical Sample A met criteria to be considered language impaired based on their CELF total score. In a post-hoc analysis,

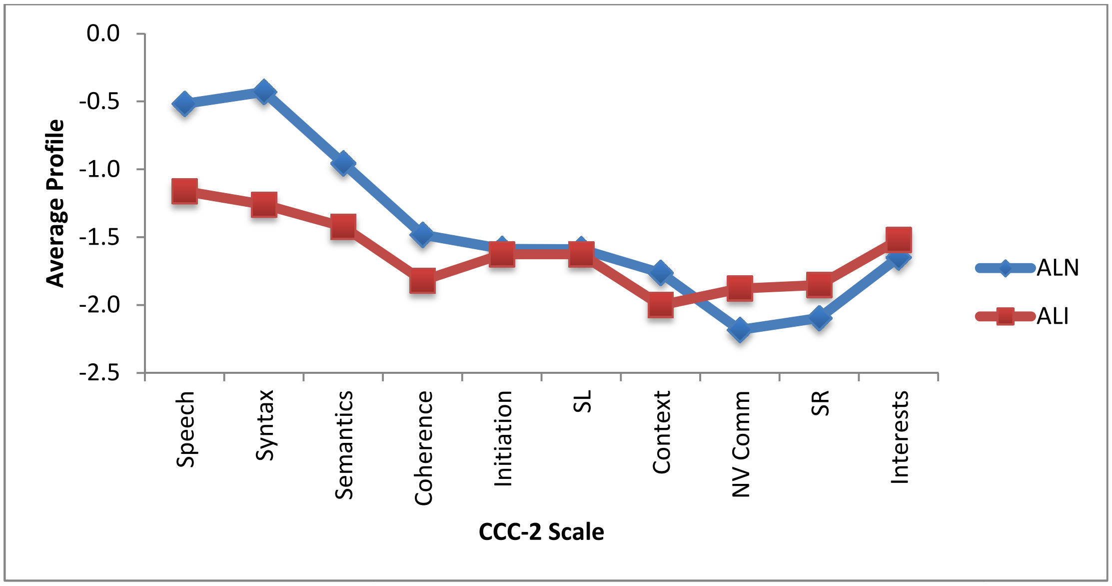

Figure 15. Average profiles for post-hoc ALN and ALI groups.

Clinical Sample A was divided into ALI (n = 41) and ALN (n = 38) groups based on participants' CELF scores (see Figure 15). One way ANOVA was used to determine significant mean differences between the two groups (see Tables 6 and 7). As expected, the ALI group showed significantly lower scores for Speech, Syntax, Semantics, and Coherence on the CCC-2, expressive and receptive language scores on the CELF and the Communication domain of the Vineland. Members of the ALI group also had significantly lower Verbal and Nonverbal IQ scores on the DAS and lower R_i^2 indices. No significant difference was found between the groups' mean scores on the SRS or in the elevation (level parameter) of individual profiles.

In addition to examining the linear relationship between the three communication profiles and external variables for each group, hierarchical multivariate regressions were conducted to determine the independent contribution of dimension weights and the level parameter on the prediction of external variable scores. Dimension weights and then the

Table 6

Summary of Analysis of Variance of Profile Variables with Group Membership as the Factor

Dependent Variable	SS	*df*	F	sig.	Comparison
High Speech vs. Low Nonverbal Communication	2.491	1	13.521	.000***	ALN>ALI
High Syntax vs. Low Context	0.005	1	0.060	0.806	ALN=ALI
High Scripted Language vs. Low Social Relations	0.067	1	0.930	0.338	ALN=ALI
Elevation	0.725	1	3.013	0.087	ALN=ALI
R^2	0.280	1	6.602	0.012*	ALN>ALI
Age	12.707	1	1.001	0.320	ALN=ALI
Nonverbal IQ	14.638	1	8.850	0.004**	ALN>ALI
Verbal IQ	77.997	1	86.264	0.000***	ALN>ALI
Social Domain	0.128	1	0.145	0.708	ALN=ALI
Daily Living Skills Domain	3.946	1	3.124	0.081	ALN=ALI
Communication Domain	18.617	1	18.369	0.000***	ALN>ALI
Social Reciprocity Scale	0.009	1	0.009	0.924	ALN=ALI

Notes: SS = sums of squares; *df* = degrees of freedom; sig. = statistical significance. *$p<.05$; **$p<.01$; ***$p<.001$

Table 7

Summary of Analysis of Variance of CCC-2 Scales with Group Membership as the Factor

CCC-2 Scale	SS	*df*	F	sig.	Comparison
Speech	8.208	1	6.815	0.011*	ALN>ALI
Syntax	13.620	1	12.486	0.001***	ALN>ALI
Semantics	4.290	1	6.600	0.016*	ALN>ALI
Coherence	2.254	1	4.030	0.048*	ALN>ALI
Initiation	0.030	1	0.051	0.822	ALN=ALI
Scripted Language	0.028	1	0.041	0.839	ALN=ALI
Context	1.118	1	2.487	0.119	ALN=ALI
Nonverbal Communication	1.842	1	2.833	0.096	ALN=ALI
Social Relations	1.168	1	1.800	0.184	ALN=ALI
Interests	0.327	1	0.376	0.542	ALN=ALI

Notes: SS = sums of squares; *df* = degrees of freedom; sig. = statistical significance. *$p\leq.05$; **$p\leq.01$; ***$p\leq.001$.

level parameter were entered into the regression. In the ALN group, dimension weights explained 12.5% of Receptive language scores, 14.3% of Expressive language scores, and 30.1% of SRS scores. Dimension weights did not explain an appreciable amount of variance in any of the other external variables (range of 0.9% to 5.8%). The level parameter explained 11.6% of Daily Living Skill scores, 14.9% of Socialization scores and 34.7% of SRS scores. The level parameter did not explain an appreciable amount of variance in any of the other external variables (range of 0.1% to 3.4%).

In the ALI group, dimension weights explained 24.5% of Receptive language scores, 34.5% of Expressive language scores, 14.2% of Daily Living scores, 19.4% of Socialization scores, 17.7% of Verbal IQ scores, and 15.5% of Nonverbal IQ scores. Dimension weights did not explain an appreciable amount of variance for Communication scores (4.6%) or SRS scores (4.3%). The level parameter explained 12.5% of Daily Living Skill scores, 11.6% of Verbal IQ scores and 35.8% of SRS scores. The level parameter did not explain an appreciable amount of variance in any of the other external variables (range of 1% to 9.4%). Dimension weights and level parameter combined to account for 64.8% of the variance in SRS scores in the ALN group, while only accounting for 40.1% in the ALI group (mainly due to the contribution of the level parameter).

CHAPTER 4

DISCUSSION

The present study applied profile analysis via multidimensional scaling (PAMS) to create communication profiles for children with autism based on the CCC-2, which assesses pragmatic and structural aspects of language. While other research has used various profile analytic techniques, particularly cluster analysis variations, to identify subgroups of individuals within the autism spectrum, to date this is the first study to apply the PAMS approach to developing specific communication profiles for children with ASD. The advantage of the PAMS approach over other profile analytic techniques is that it provides information about each individual included in the analysis as well as the overall profiles of the group. Once these profiles were developed, this study explored the relationship between the identified communication profiles and external variables of interest in the study of ASD, namely estimates of verbal and nonverbal intelligence, adaptive functioning skills, expressive and receptive language skills, and severity of ASD symptoms. This study then assessed the reliability of the derived profiles in a second clinical sample and finally, attempted to validate the PAMS-derived communication profiles in a real world setting using a school-based community sample.

Creating Communication Profiles

Using the PAMS procedure outlined earlier, a three dimension solution was supported, indicating that three communication profiles should be retained. Because the ten scales of the CCC-2 were used to create the communication profiles, interpretation of the profiles was based on the language constructs associated with each of these scales to develop a better understanding of the constellation of language-related strengths and weaknesses relevant to each profile. R_i^2 values were used to determine how well each individual fit the three dimensional model. An R_i^2 value of 0.60 or higher indicated a reasonable fit to the model, with higher values reflecting better overall fit with the model. Of the 79 individuals in the first clinical sample, 49 (62.0%) had R_i^2 values of 0.60 or higher. While R_i^2 values were used to determine how well an individual fit the three dimensional model as a whole, values of profile match indices (PMI) were used to determine how well an individual fit a specific profile. An individual was said to match a profile if they had PMI value of 0.60 or higher for that profile. Profile 1 had the highest number of individuals matching to it (n = 27), followed by Profile 3 (n = 4), then Profile 2 (n = 3). Fifteen other individuals had R_i^2 values of 0.60 or higher, which indicated a fit to the three dimension model, but they did not match to any of the profiles, indicating that some linear combination of the three profiles best accounted for those individuals' communication skills.

Interpretation of the three profiles was based on the statistically significant scale values from each profile which were obtained via the bootstrapping procedure used as part of the PAMS process. Profile 1 (*High Speech vs. Low Nonverbal Communication*) was characterized by individuals exhibiting few problems with the grammatical structure of language or the quality of their speech production (i.e., no articulation errors, relatively fluent speech, etc), but many problems with social relations (i.e., teased by others, trouble showing concern or interest in others, anxious around others) and nonverbal communication (i.e., gestures, body language, expressions, proximity). The second profile, *High Syntax vs. Low Context*, was characterized by individuals who have may have a few problems with syntax and grammar, but who show marked deficits in the quality of their speech, such as fluency or sound production, and struggle to understand or use humor, or may be too literal. The third profile, *High Scripted Language vs. Low Social Relations*, was characterized by individuals who have few problems with over-precise language or using phrases inappropriately or out of context, but who are still not easy to understand, possibly because they do not provide background information for what they are talking about or wander between thoughts and ideas. Perhaps as a result of this, they struggle with relating to others.

The first profile, *High Speech vs. Low Nonverbal Communication*, was the easiest to interpret. Individuals matching to Profile 1 were older (t = 2.477, df = 77, p <.05) with a mean age of 11.24 (SD = 3.36) compared to the rest of Clinical Sample A (M = 9.23, SD = 3.50). This profile appears to be consistent with the research literature on language skills in school-aged children with ASD (i.e., relatively intact structural language with poor pragmatic language). Geurts and Embrechts (2008), for example, found school-aged children with ASD to have intact structural language compared to their pragmatic language skills, while preschoolers with ASD exhibited comparable deficits across both structural and pragmatic language skills. Likewise, Rapin et al. (2009) found that most children with ASD did not have structural language impairments by the time they reached school age. While values for Speech and Syntax were still relatively low for participants matching Profile 1 (Speech *z* score *M* = .0257, *SD* = .894; Syntax *z* score *M* = -.118, *SD* = .591), these values were much higher than the other values along this profile, indicating relatively intact structural language in comparison to their pragmatic language skills.

The second and third profiles, *High Syntax vs. Low Context* and *High Scripted Language vs. Low Social Relations* were not as easy to interpret as the first profile. Though both profiles were supported in the dimensional analysis, very few individuals matched either of these two profiles, nor was there a clear description of these profiles in the research literature. Given that the research literature has generally focused on examining either a common ASD communication profile or language profiles based on the presence or absence of structural language impairments, it is not surprising that these two profiles are unique to this study. More concerning is the fact that neither profile was well matched in Clinical Sample A. The fact that both profiles had a few individuals that matched to them suggests that these profiles are consistent with real communication profiles for some individuals with ASD and not just statistical anomalies. Their lack of greater support in the sample suggests that that these may be relatively rare communication profiles within a low incidence disability population of children with ASD or may be indicative of the incredibly diverse range of communication abilities among individuals with ASD.

Relationship Between Person Parameters and External Variables

Elevation of individual communication profiles, identified by the level parameter, was positively correlated with expressive language scores, verbal IQ scores, and adaptive functioning scores (Communication, Daily Living Skills, and Socialization) in Clinical Sample A (see Table 2). In other words, individuals with high scale scores on the CCC-2 tended to have better expressive language, higher verbal IQs, and better developed adaptive functioning than those with lower scores on the CCC-2. While it may not be surprising that the elevation of profiles based on a communication measure (CCC-2) was positively correlated with other measures also tapping aspects of language (e.g., expressive language, verbal IQ), it is interesting to note that the two adaptive functioning areas not directly linked to language or communication (Daily Living Skills and Socialization) also shared this positive correlation, while receptive language was not significantly correlated at all with profile elevation. Likewise, elevation shared a relatively strong negative correlation with SRS scores, which indicates that individuals with higher elevated communication profiles tended to have lower SRS scores. This suggests that individuals with better developed structural and pragmatic language skills, as indicated by their scores on the CCC-2, showed less severe autism symptoms. At first glance, this appears to be in contrast to the conclusion reached by Leyfer et al. (2008), who found that autism symptom severity was independent of language skills, but consistent with the results reported by Whitehouse et al. (2008), where language impairment was found to be related to impairment across multiple autism domains. On closer examination, whether the results of the current study are discrepant with the results of Leyfer et al. (2008) seems to be a matter of interpretation. In the present study, correlations between receptive and expressive scores from the CELF and the SRS were not significant, a finding that is consistent with the results from Leyfer et al. (2008) (r = .001, df = 77, p = .994; r = .010, df = 77, p = .931, respectively). Like the correlation between profile elevation and the SRS, the correlation between the Global Communication Composite score from the CCC-2 and the SRS was significant (r = -.510, df = 77, p <.001), a finding that is consistent with Whitehouse et al. (2008). This suggests that autism symptom severity may not be related to structural language deficits, but rather autism symptom severity may be related to more global communication deficits (i.e. both pragmatic and structural deficits).

Because so few individuals matched to Profiles 2 or 3, mean comparisons were only done with those that matched to Profile 1 (n = 28) versus those who did not (n = 51). Independent t tests between these groups indicated that individuals matching to Profile 1 had significantly higher scores for receptive language (t = 3.998, df = 77, p <.001), expressive language (t = 4.131, df = 77, p <.001), verbal IQ (t = 3.069, df = 77, p <.01), and nonverbal IQ (t = 2.387, df = 77, p <.05). This means that individuals who matched to Profile 1 exhibited higher receptive and expressive language ability than those individuals who did not match to this profile, as well as better developed verbal and nonverbal cognitive abilities. While a small positive correlation (see Table 2) was found between SRS scores and Profile 1, results of the independent t tests failed to show a significant difference between group means (t = 1.802, df = 77, p = .075). This suggests that while individuals who matched to Profile 1 were more likely to exhibit more severe autism symptoms on the SRS, there was no meaningful difference in symptom severity between Profile 1 and the rest of the clinical sample. Further research using a larger sample would be needed to determine whether there was, in fact, a reliable link between Profile 1 (*High Speech vs. Low Nonverbal* Communication) presented here and autism severity.

Reliability of Profiles

Two statistical tests (*cbv* and the bootstrap means statistic) were used to test the invariance of the three profiles derived through the PAMS process using Clinical Sample A and Clinical Sample B. The two samples differed in terms of sample size (n = 79 and n = 48 respectively) and had statistically significant differences in scores for the Speech (t = 3.100, df = 125, p <.01) and Syntax (t = 2.114, df = 125, p <.05) scales from the CCC-2. The Clinical Sample A had higher means for both scales, indicating less structural language impairment than was reported for individuals in Clinical Sample B. Visual representations of the profiles likewise appeared to be different (see Figures 11 - 13), particularly on Dimensions 2 and 3 (*High Syntax vs. Low Context* and *High Scripted Language vs. Low Social Relations*). Despite the apparent visual differences between the two clinical samples and the higher structural language scores in Clinical Sample A, both test statistics supported invariance for all three profiles across the two samples meaning that the three profile solution derived from the PAMS procedure in Clinical Sample A was successfully replicated in Clinical Sample B, despite the differences in sample size and CCC-2 scale scores. The fact that invariance was supported despite these differences suggests it is likely these results are generalizable to other clinical ASD samples of children that might be used for this purpose. Whether invariance would be supported in community samples, which may not be as tightly controlled as clinical samples, remains unknown.

Validation of Profiles

Community Sample C had a very similar, though significantly more depressed, communication profile to that of Clinical Sample A (t = 3.609, df = 87, p < .001). The two samples showed no significant differences in terms of age (t = .366, df = 87, p = .715), individual fit statistics (t = 1.261, df = 87, p = .369), profile match indices (PMI1: t = .135, df = 87, p = .893; PMI2: t = .593, df = 87, p = .555; PMI3: t = .078, df = 87, p = .938), or severity of autism symptoms (t = 1.636, df = 87, p = .105). Individuals matching to Profile 1 (*High Speech vs. Low Nonverbal Communication*) were proportionally similar between groups: Profile 1 accounted for 34.2% of Clinical Sample A and 30% of Community Sample C. Though no individuals in the community sample matched to the second or third profiles, this may be due to the extremely small sample size of the school-based community sample, since a very small proportion of individuals matched to Profile 2 or Profile 3 in the larger clinical samples. It is unclear how large of a community sample would be necessary to include individuals that may match to Profiles 2 or 3. Similar to Clinical Sample A, roughly 20% of the community sample was best accounted for by a linear combination of profiles (18.99% in Clinical Sample A and 20% in Community Sample C). Though small, the community sample appeared to capture similar qualities to the first clinical sample in terms of pragmatic and structural communication profiles, particularly for Profile 1.

While no difference was found in autism symptom severity (as measured by the

SRS) between Clinical Sample A and Community Sample C, the overall communication profile elevation of the school-based community sample was significantly more depressed than the clinical sample, suggesting that participants in Community Sample C had more impaired communication skills on average than the participants in Clinical Sample A. This may be due in part to the classification differences between the two samples. In the public education system, Special Education classifications such as Autism are based on whether the child needs additional supports to achieve success either academically, socially or both. Classification is commonly based on what is the most pressing problem for the individual from an educational standpoint. While many children with high-functioning autism carry an educational classification of Autism, other common classifications can include Emotional Disturbance and Specific Learning Disability. Lower functioning children with autism may be classified under Intellectual Disability or, if they are below the age of 8 years, Developmental Delay. Therefore, it is possible that the children with Special Education classifications of Autism in the schools may represent a more restricted range of children with autism than is actually the case in the general population. Further research comparing the communication profiles of individuals with ASD being served under a variety of Special Education classifications would need to be conducted in order to determine whether this is the case.

Post Hoc ALN vs ALI Comparisons

Post hoc analyses using the methods and criteria defined in the research literature for identifying language impairment in individuals with ASD were conducted to tie the findings of this unique exploratory study to the body of research in this area. Based on the research criteria for structural language impairment (expressive and/or receptive language scores 1.5 standard deviations below the mean), a little over half of Clinical Sample A (*n* = 41) was identified as ASD with language impairment (ALI), and the remainder (n = 38) were identified as ASD without language impairment (ALN). Individuals who matched to Profile 1 (*High Speech vs. Low Nonverbal Communication*) tended to fall more in the ALN category than the ALI category; in fact, 68% of the individuals matching to Profile 1 fell in the ALN category. This makes sense, as Profile 1 was identified by relatively high Speech and Syntax scores, which would be more likely among those without a language impairment. What is not as clear is why 32% of those individuals matching to Profile 1 fell in the ALI category. Perhaps the most likely explanation is the difference between measuring receptive and expressive language through the CELF, used to define ALI, and measuring structural and pragmatic language with the CCC-2, which was used to create the communication profiles. While both assessment tools measure language constructs, it is very likely that they capture somewhat different aspects of language. Furthermore, scores for the CCC-2 are based on parent ratings, while the scores from the CELF are based on a series of structured subtests administered by a clinician. All three individuals in Clinical Sample A who matched to Profile 2 (*High Syntax vs. Low Context*) fell in the ALN category, along with only 1 of the four individuals who matched to Profile 3 (*High Scripted Language vs. Low Social Relations*). Of the 15 individuals in Clinical Sample A best described by a linear combination of the three profiles, 5 fell in the ALN category. Of the 30 individuals in Clinical Sample A who did not match to any of the profiles or linear combination of the three profiles, 21 fell in the ALI group. Overall, Profile 1 had the most overlap with the

ALN group. Given that ALN is defined by relatively normal structural language and relatively intact structural language was a defining feature of Profile 1, this overlap between the two appears to be reasonable. It is interesting to note that ALI, on the other hand, was better represented in Profile 3 and the linear combination of profiles, and was predominate among those individuals who did not match any profile. A potential explanation for this may have to do with the diverse range and severity of language-related symptoms that are possible in the overlap between ASD and SLI. If ALI is truly a crossroads between ASD and SLI, the overlap could create an even more heterogeneous group of individuals than that present in individuals with ASD alone.

No significant differences were noted between the ALN and ALI groups in elevation of profiles (see Table 6). This suggests that on average, the profiles of ALN and ALI group members were equally depressed. The fact that certain profile points were significantly different between groups and certain profiles matched better to the ALN group suggests that the specific areas of communication impairment differed between groups, a fact that was masked by the average of the scores marking each profile. Despite the fact that more than half of Clinical Sample A could be identified as ALI, individual profile match indices for ALI individuals were significantly lower than for individuals identified as ALN. ALI R_i^2 indices were also significantly lower. While the connection between the ALN group and Profile 1 was quite clear, the lower PMI and R_i^2 indices in the ALI group provide further support for ALI as a more heterogeneous group.

Consistent with the findings of Loucas et al. (2008), receptive and expressive language scores were significantly lower for the ALI group than the ALN group. Likewise, the only CCC-2 scales that the two groups differed on were the structural language scales, a finding consistent with the literature suggesting ALI functions as an overlap between two separate disorders, ASD and SLI. The ALI group also scored significantly lower than the ALN group on the Communication domain from the Vineland. This is similar to the results of Joseph, Tager-Flusberg, and Lord (2002) who found that communication functioning based on the Communication Domain score from the ADOS was related to verbal IQ (VIQ) scores, but not nonverbal IQ (NVIQ) scores.

While the ALN group in the current study had significantly higher VIQ and NVIQ scores than the ALI group, Loucas et al. (2008) only reported a significant difference between groups on VIQ scores. This may be due to the fact that Loucas et al. controlled for NVIQ group differences by only including individuals who had a NVIQ score of 80 or higher in their analysis. The current study did not control for this and 25 individuals with NVIQ scores below 80 were included in Clinical Sample A. Twenty of these 25 individuals were classified ALI. The mean of the ALN group's NVIQ was 67 (*SD* = 9.56), while the mean of the ALI group's NVIQ was 66 (*SD* = 11.06). Independent samples *t* tests confirmed there was no significant difference between the groups in terms of NVIQ, or in R_i^2 elevation of Profiles 2 or 3. The only significant difference between the two groups' NVIQ scores was found for Profile 1, with the ALI mean of 0.136 significantly lower than the ALN mean of 0.669. Paired samples *t* tests were also run to determine the relationship of VIQ to NVIQ within the two groups. Within the ALN group, no significant difference was found between VIQ and NVIQ (t = 0.833, df = 37, and p <.05), while the ALI group had a significantly lower VIQ than NVIQ mean (t = -5.287, df = 40, and $p \leq .000$). Based on these analyses, the ALN group had relatively evenly developed VIQ and NVIQ scores that were higher than the ALI group scores, while the ALI group had lower VIQ and NVIQ scores when compared to the ALN group in addition to having significantly lower VIQ scores than NVIQ scores. This suggests that the overall difference in NVIQ between the ALN and ALI groups was not a result of low IQ per se, but rather that lower NVIQ may be a factor that coincides with lower structural language abilities.

As in Loucas et al. (2008), no significant differences were found between the ALI and ALN groups in terms of severity of autism symptoms (see Table 6), supporting the theory that ALI can best be conceptualized as the crossroads between two distinct but overlapping sets of symptoms. In light of the group differences in VIQ and NVIQ scores, this suggests that autism symptom severity is independent of cognitive functioning, as measured by standard IQ tests.

Limitations

The present study contains several limitations. The comparability of the samples used in this study is somewhat questionable, as multiple measures and versions of measures were used from sample to sample. In Clinical Sample A, for example, both the Vineland and Vineland II were used to assess adaptive functioning, while three different versions of the CELF were used to assess expressive and receptive language skills. Although the two versions of the Vineland and the three versions of the CELF are highly correlated, any differences between versions of these measures may contribute to differences between the participant samples.

Another limitation has to do with the range of ages of the participants in this study. While many studies of language in individuals with ASD have used a more restricted age range, the samples used in the current study had an age range of 5 to 17. It is possible that different pragmatic or structural language components are more impaired at different ages for children with ASD, and using such a broad age range may mask some of these effects in the profile analysis. Because the CCC-2 is age-normed, however, this should be accounted for to some degree by the standardized scores derived from the CCC-2. When Clinical Sample A was divided into age groups for comparison, the younger age groups tended to have similar scores across scales, while the older groups had somewhat different scores, particularly for the Speech and Syntax scales (see Appendix B). This suggests the possibility that communication profiles may differ across ages which was not specifically addressed in the current study.

Another limitation has to do with the comparison of measures used to assess aspects of language. The CCC-2 is based on parent report, which can be seen as less reliable than what might be found through a standardized clinical evaluation. That being said, standardized, clinician administered tests of pragmatic language are in short supply and suffer from their own set of problems, namely the difficulty of accurately measuring pragmatic impairment through a structured test format. In many ways, the CCC-2 is superior to this type of assessment of pragmatic difficulties because it assesses the everyday use of language skills in a natural setting rather than what can be observed during the course of a relatively brief testing session in a somewhat artificial testing environment. Because parents tend to see their children respond to a variety of situations and spend more time with them, a parent-report based measure such as the CCC-2 may be a more reliable indicator of difficult to assess language aspects like pragmatic language.

Another set of limitations has to do with the nature of the samples used in this study. By their very nature, clinical samples tend to suffer from selection bias. In the case of the clinical samples used in this study, it is possible that they are not representative of children with ASD as a whole. Families seen at UARP are generally families from the local geographic area. Some of these families express a strong belief that contributing to research will benefit either their child or future generations, while others see this as an opportunity to receive a free assessment to determine whether their child is on the spectrum. It remains unknown how self-selection of those families who participated in the UARP may have impacted the constellation of these clinical samples in comparison with other families of children with ASD.

The school-based community sample was extremely small when compared to the sample sizes generally used in conducting profile analysis research. The small size of the community sample was the result of a number of factors including the relatively short time in which the data were collected, low incidence rate of individuals with ASD receiving services through the public school system under the classification of Autism, difficulty gaining access to data on individuals with ASD within the public school system, and the lack of standardized procedures for assessing and classifying individuals with ASD within the public school system, all of which make targeting this school-based population challenging. The CCC-2 and SRS data as well as the information from Special Education files used in the community sample were collected over the course of a few months, while the data used in the two clinical samples had been collected over the course of 5 years. Because ASD is a low incidence disability, large participant samples are difficult to obtain outside of large funded research projects like UARP.

Despite the rapid increase in the number of individuals being diagnosed with ASD over the past 10 years, the actual number of children with ASD receiving Special Education services through the public school system remains relatively small. In a study examining changes in the administrative prevalence of ASD, Pinborough-Zimmerman et al. (2012) found that while the number of children with an educational classification of autism doubled between 2002 and 2008, the overall percentage of children being served under this classification was still quite small (5%). Brock (2006) found that while rates of autism classifications in Special Education were increasing at a rate change of +3.91, rates of classifications in other categories including intellectual disability, emotional disturbance and specific learning disability were decreasing at a rate change of -7.14, possibly due to a number of children being reclassified under autism due to increased awareness of ASDs and the increasing acceptability of autism over other diagnoses like intellectual disability and mental retardation. This suggests that many children with a clinical diagnosis of ASD were previously receiving services through Special Education under a disability category other than autism. Even if students with ASDs are receiving special education services under the autism classification, the services received may not address all areas of deficits. Dekeyzer (2010), for example, found that individuals receiving Special Education services under the classification of autism actually received fewer language services as they got older, despite the fact that their language deficits were still evident.

Related to the issues surrounding identifying individuals with ASD in a public school setting, is the fact that in school settings, assessments for these students vary significantly. While steps are being taken towards developing a standard assessment protocol for evaluating children with ASD in the school district where this sample was collected, many aspects of the assessment of children with ASD in the schools are not standardized. The sheer number of different measures used to assess cognitive and language abilities, adaptive functioning, and ASD symptoms in the public school system increases the difficulty of interpreting results based on the data gathered. Because of the variety of measures in the public school setting, further research using individuals from this population would benefit greatly from an established standardized assessment protocol (i.e., specific cognitive, language, adaptive behavior, language, and autism batteries).

Implications and Future Directions

This study attempted to establish the utility of the PAMS procedure in identifying meaningful communication profiles based on structural and pragmatic aspects of language for individuals with autism. The PAMS procedure has a significant advantage over other forms of profile analysis in that it can provide both group and individual level information about specific profiles. This is particularly useful when exploring ASD samples because individuals with ASD are a notoriously heterogeneous group. While less than half the clinical sample appeared to match well to one of the three communication profiles identified using PAMS, this may in fact illustrate an important dimension in autism research, namely the range of communication deficits seen in individuals on the autism spectrum. As a group, the clinical sample resulted in a three-dimensional solution of communication profiles. On an individual level, however, Profile 1 was most strongly supported, while the other two profiles appeared to apply to very few individuals from

Clinical Sample A. These results suggest a much greater diversity of communication abilities along the autism spectrum than can be captured via analytic techniques that rely on mean differences in scores. Further research and analysis also is needed to determine whether factors like age may impact the type of communication profiles identified here. One of the main questions to be answered is whether different age groups have different communication profiles. Profile 1 had the strongest support in the current study using a broad age range of participants, but it is possible that Profiles 2 and 3 may have stronger support for specific age groups.

Based on results of the post hoc analysis grouping participants into ALN and ALI groups, severity of autism symptoms did not appear to be related to structural aspects of language ability. This suggests that structural language impairments can be found across the spectrum of behavioral symptoms manifest by individuals with autism, regardless of how mild or severe those symptoms may be. Even high functioning individuals with ASD may exhibit a range of language-based impairments that require attention. If the communication skills of individuals on the autism spectrum are truly as diverse as the results of this study suggest, it follows that more focus should be placed on determining the specific communication skill levels of individuals with ASD in order to design the most effective interventions based on individual strengths and weaknesses rather than an expected pattern of communication skills.

While the results of the PAMS profiles were compared to a small school-based community sample, research with larger community samples is needed to provide further confirmation of the profiles created through the clinical samples used in this study. Because of the very large sample requirements for confirmatory methods such as confirmatory factor analysis, empirical confidence intervals could be created from bootstrapped sampling distributions to compare invariance of samples, much like what was conducted in this study. One key area to explore in a larger school-based community sample is whether individuals matching to different communication profiles differ in their behavioral presentation in the school setting. Though no significant differences were noted between communication profiles in terms of severity of autism symptoms, the question remains whether behavioral presentations may vary based on profile. For example, are individuals who fit one particular profile more likely to struggle academically or have greater difficulty managing externalizing or internalizing behaviors? Are individuals associated with a particular profile more likely to be depressed or anxious or display inattentive or hyperactive symptoms? Are individuals identified with a certain profile more likely to receive an educational classification other than Autism such as Speech/Language Impairment, Emotional Disturbance, or Other Health Impaired? Relatedly, are individuals associated with a particular communication profile more or less likely to receive speech and language services? This information may be helpful in designing more effective educational interventions for this population.

As evidenced by the proposed changes to the DSM-5, the very nature of what it means to be on the autism spectrum is being considered anew. The proposal to combine Autistic Disorder, Asperger's Disorder, Childhood Disintegrative Disorder, and Pervasive Developmental Disorder Not Otherwise Specified into a single diagnostic category of Autism Spectrum Disorder, is indicative of a shift from the more traditional categorical view of ASDs to a dimensional view of autism and related disorders. Categorical versus dimensional classification of ASDs has been central to much of the profile analysis research done with ASD populations to date, with numerous subtypes of ASDs being proposed as a means to aid clinicians in the differential diagnosis of the current ASDs (e.g. Barrett et al, 2004; Stevens et al., 2000), while the results of other studies have argued for a dimensional view of autism and related ASDs (e.g. Lewis et al., 2007a, 2007b; Wiggins et al., 2012). According to the American Psychiatric Association, this shift to a dimensional view of ASDs is designed to include the common set of behaviors shared by those on the spectrum while still including clinical specifiers, such as severity of symptoms and verbal abilities (American Psychiatric Association, 2011). These clinical specifiers can then be used to develop individual profiles of strengths and weaknesses, which can then aid in designing appropriate interventions and treatment protocols. It is interesting to note that while language has been removed as one of the diagnostic domains in the proposed DSM-5 criteria and communication has been combined with the social domain, the inclusion of verbal abilities as a clinical specifier suggests that language is still seen as an important aspect of ASD and that language features are considered an important facet in the clinical presentation of individuals with ASD. While it remains to be seen whether the proposed changes to the DSM help clinicians and researchers to better understand the needs of this rather broad and diagnostically fuzzy population, the shift to a dimensional view of ASD appears to be a move in the right direction, particularly with regard to the assessment and treatment of language impairments related to ASD. As Lewis et al. (2007b) succinctly stated, “a dimensional view of ASD necessitates a comprehensive language assessment for each diagnosed individual, which then facilitates individualized planning of language support and intervention” (p. 96).

This is particularly true in the case of assessing and treating language impairments in ASD individuals in the school setting. Severity of communication problems may be a key factor in determining how children are identified in the school setting, the classification they receive, and the services provided for them. The most noticeable concern regarding a particular student is often the one that is targeted by school teams, which may result in many individuals with ASD being improperly classified. In fact, in a sample of 2,198 four- to nine-year-old British children with a diagnosis of autism receiving services through Special Education, Coo et al. (2008) found that 23.5% had been served under a Special Education classification other than autism. Of those children who had been served under another classification, 67.3% had been served under another classification prior to their autism classification, while 19% had been served under the classification of autism before being changed to a different classification. In the public school setting, a child with ASD who is considered to be “high functioning” and is aggressive and defiant may very well end up classified under Emotional Disturbance, while a “high functioning” child with ASD who exhibits extremely low academic performance may end up classified under Specific Learning Disability. Children with ASD exhibiting high impulsivity and/or hyperactivity may end up being served under the classification of Other Health Impaired because of their ADHD-like presentation. Many children with ASD who have severe language impairments may end up receiving services under the classification of Speech/Language Impairment. Despite the range of potential classifications in Special Education, all of these different presentations of children with ASDs may still warrant speech and language interventions in the schools based on their structural and pragmatic language and communication needs, so accurate assessment is necessary.

In terms of educational programming, information about a student's communication profile (including both structural and pragmatic aspects of language) could be useful in terms of identifying individual patterns of strengths and weaknesses that could then be addressed in the student's Individualized Education Program (IEP). Furthermore, given the variability in language development and the evidence for overlap between ASD and SLI, assessment of these students' communication profiles is a critical component of a comprehensive evaluation prior to development of an IEP. Ironically, while pragmatic deficits are considered to be a universal feature of ASDs, school-based psychoeducational evaluations rarely include measures of pragmatic language. Measures such as the CCC-2 could provide valuable insights into the nature of pragmatic and structural language deficits seen in children with ASDs being served in the school setting, thus providing data that could then be used as the foundation for meaningful IEP goals and services. Brief, easily administered measures, like the CCC-2, as well as narrative samples and measures of social language could all be used during the evaluation for Special Education services to create individualized communication profiles which could then be used for effective educational programming.

In addition to exploring communication profiles for children with autism as a whole, the current study also explored the differences between individuals fitting the diagnostic criteria for ALI and those who did not in post hoc analyses. Since group differences were evident in the clinical sample in the current study, confirmatory studies of the relationship between the profiles uncovered in this study and ALI are needed. One way this could be done would be to conduct separate PAMS analyses on two larger ALI and ALN samples to determine whether separate sets of profiles are necessary. It might be even more beneficial to include an SLI sample to directly compare the ALI group to another language impairment group not exhibiting autism symptoms. A closer look at the relationship between language impairment and nonverbal IQ is also warranted, since the ALI group in the current study had a significantly lower nonverbal IQ score than the ALN group. This is a finding unique to this study, as most studies of ALN/ALI samples have excluded individuals with lower nonverbal IQ scores.

Conclusions

Although the present study has its limitations, the findings hold some promise for the use of PAMS-derived communication profiles in the study of autism and related ASDs. The outcomes of this study suggested a three profile solution for children with autism. The first profile, *High Speech vs. Low Nonverbal Communication*, appeared to be the most common profile in the first clinical sample and resembled the prototypical CCC-2 profile for children with autism. The second and third profiles, *High Syntax vs. Low Context* and *High Scripted Language vs. Low Social Relations*, were more difficult to interpret and did not have a large presence among individuals in the clinical sample. Linear combinations of the three profiles, however, were evident. The community sample from the public school system, though very small, was similar to the clinical sample, particularly in terms of Profile 1.

Ironically, one of the most consistent findings in the ASD literature seems to be that individuals with ASDs are an extremely heterogeneous group displaying a wide range of symptoms, many of which are not specific to ASDs. This makes the task of creating meaningful profiles based on some pattern of scores in a particular domain a difficult task at best. Perhaps the most meaningful message stems from this very difficulty; instead of looking for ways in which individuals with ASDs can be grouped based on similarities, perhaps we should embrace the fact that each person with ASD is a unique individual with a unique compilation of symptoms, strengths and weaknesses. In the school setting, this is the intended purpose of the IEP; it is supposed to reflect the individual needs of the student with services specifically designed to meet those needs based on goals designed with the individual's strengths and weaknesses taken into consideration. The proposed changes to the DSM-V and the research literature on language impairment in ASD provide a compelling argument for the importance of language as key clinical specifier in the assessment and treatment of individuals with ASD. The results of the present study suggest the PAMS methodology is one way in which this information can be gathered and tailored to the specific needs of the individual.

APPENDIX A

SPSS SYNTAX FOR PAMS PROCEDURE

```
DATASET ACTIVATE DataSet1.
PROXIMITIES Speech Syntax Semantics Coherence Initiation SL Context NVComm SR
Interests
/matrix=out(*)
  /VIEW=VARIABLE
  /MEASURE=SEUCLID

ALSCAL
/matrix=in(*)
/outfile='K:\Dissertation\April 2012\ReliabilityPAMS.sav'
/level=ordinal
/plot=default
/criteria=dimens(3)
descriptives
variables=DIM1 DIM2 DIM3/save

MATRIX.
Get M
   /file='K:\Dissertation\April 2012\Reliability Sample.sav'
   /variables=Speech Syntax Semantics Coherence Initiation SL Context NVComm SR
Interests.
Get X
   /file='K:\Dissertation\April 2012\ReliabilityPAMS.sav'
   /variables=P1 P2 P3.
Get ID
/file='K:\Dissertation\April 2012\Reliability Sample.sav'
/variables=STUDY_ID.
Compute R=NROW(X).
Compute col=make(R,1,1).
Compute x1={X, col}.
Compute m1=transpos(x1)*x1.
Compute m2=transpos(x1)*transpos(m).
Compute w=solve(m1,m2).
```

```
Compute tw=transpos(w).
Compute m1=tw*t(x1).
Compute k=ncol(M).
Compute r=nrow(m).
Compute col=make(1,K,1).
Compute pvar=rssq(m1-(rsum(m1)*col)/k).
Compute var=rssq(m-(rsum(m)*col)/k).
Compute col=pvar/var.
Compute w={id,TW,col}.
Save w
/OUTFILE='K:\Dissertation\April 2012\Reliability Subjects.sav'.
End matrix.
```

Bootstrap Syntax

```
INPUT PROGRAM.
loop samp=1 to 200.
+ LOOP #i=1 to 79.
+ compute id=trunc(uniform (79))+1.
+ end case.
+ end loop.
+ leave samp.
end loop.
end file.
END INPUT PROGRAM.
EXECUTE.
sort cases by ID.
match files file=* /table='I:\Dissertation\July 2011\Working Sample UARP.sav' /by ID.
sort cases by samp.
split file by samp.
execute.
```

Bootstrap MDS Syntax

```
SORT CASES by samp.
split file by samp.
PROXIMITIES  Speech Syntax Semantics Coherence Initiation SL Context NVComm
SR Interests
  /PRINT NONE
  /MATRIX OUT(*)
  /MEASURE=SEUCLID
  /VIEW=VARIABLE.
ALSCAL
   /MATRIX=IN(*)
/outfile='K:\Dissertation\July 2011\BOOTPAMS.sav'
  /LEVEL=ORDINAL
/plot=default
  /CRITERIA=dimens(3)
```

APPENDIX B

TABLES 8-10

Table 8. *Means and standard deviations of CCC-2 scales by age group for Clinical Sample A*

	Ages 5-6 *N* = 18	Ages 7-8 *N* = 22	Ages 9-11 *N* = 19	Ages 13-17 *N* = 20
Scale	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Speech	-1.11 (1.00)	-1.11 (1.01)	-0.49 (1.14)	-0.68 (1.33)
Syntax	-1.43 (1.05)	-1.18 (1.07)	-0.40 (0.88)	-0.43 (1.16)
Semantics	-1.15 (0.92)	-1.39 (0.83)	-0.93 (0.60)	-1.28 (1.06)
Coherence	-1.69 (0.69)	-1.82 (0.65)	-1.68 (0.72)	-1.43 (0.96)
Initiation	-1.56 (0.74)	-1.58 (0.80)	-1.56 (0.65)	-1.74 (0.88)
Scripted Language	-1.20 (0.71)	-1.65 (0.68)	-1.81 (0.93)	-1.73 (0.89)
Context	-1.82 (0.69)	-2.08 (0.50)	-1.68 (0.73)	-1.93 (0.76)
Nonverbal Communication	-1.80 (0.94)	-1.97 (0.71)	-2.35 (0.57)	-1.98 (0.95)
Social Relations	-1.83 (0.97)	-1.80 (0.72)	-2.21 (0.50)	-2.05 (0.97)
Interests	-1.17 (1.13)	-1.50 (0.85)	-1.91 (0.67)	-1.73 (0.93)

Table 9. *Means and standard deviations for external variables of interest by sample*

Variable	Clinical Sample A *N* = 79	Clinical Sample B *N* = 48	Community Sample C *N* = 10
	M (*SD*)	*M* (*SD*)	*M* (*SD*)
Age in years	9.94 (3.56)	9.40 (3.44)	10.38 (3.70)
Expressive language	75.61 (21.18)	81.33 (21.59)	79.29 (25.22)
Receptive language	79.26 (23.18)	77.67 (16.31)	78.13 (28.46)
Communication	79.26 (23.18)	68.36 (13.09)	**
Daily Living Skills	75.62 (21.17)	65.28 (20.35)	**
Social	90.56 (20.24)	65.24 (9.59)	**
Nonverbal IQ	90.56 (20.24)	84.00 (21.42)	87.10 (19.46)

Note: ** Domain scores not available

Table 10. *Means and standard deviations of CCC-2 scales by sample*

	Clinical Sample A *N* = 79	Clinical Sample B *N* = 48	Community Sample C *N* = 10
Dependent Variable	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Speech	7.45 (3.41)	5.54 (3.26)	5.20 (3.26)
Syntax	7.42 (3.36)	6.02 (4.00)	5.40 (4.06)
Semantics	6.41 (2.60)	6.69 (2.55)	4.90 (2.60)
Coherence	5.03 (2.29)	5.35 (2.47)	3.50 (2.55)
Initiation	5.18 (2.29)	5.83 (2.68)	3.80 (2.30)
Scripted Language	5.18 (2.47)	5.88 (3.07)	3.20 (1.62)
Context	4.34 (2.03)	5.02 (2.61)	2.70 (1.42)
Nonverbal Communication	3.93 (2.45)	4.63 (2.44)	1.80 (1.40)
Social Relations	4.09 (2.43)	4.46 (2.75)	1.90 (1.10)
Interests	5.25 (2.79)	5.94 (2.87)	3.80 (2.15)

REFERENCES

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th ed. text rev.). Arlington, VA: Author.

American Psychiatric Association. (2011). *DSM-5 development: Autism Spectrum Disorder.* Retrieved from http://www.dsm5.org/proposedrevision/pages/proposedrevision.aspx?rid=94.

Atlas, J. (2001). Test of Nonverbal Intelligence – Third Edition. In B. Plake & J. Impara (Eds.), *The fourteenth mental measurements yearbook.* Lincoln, NE: The University of Nebraska Press.

Aylward, G. (1992). Differential Ability Scales. In J. Kramer & J. C. Conoley (Eds.), *The eleventh mental measurements yearbook.* Lincoln, NE: The University of Nebraska Press.

Bain, S. & Allin, J. (2005). Test Review: Stanford-Binet Intelligence Scales, Fifth Edition. *Journal of Psychoeducational Assessment, 23*, 87-95.

Banks, S. & Franzen, M. (2010). Concurrent validity of the TONI-3. *Journal of Psychoeducational Assessment, 28*(1), 70-79.

Barrett, S., Prior, M., & Manjiviona, J. (2004). Children on the borderlands of autism: Differential characteristics in social, imaginative, communicative and repetitive behaviour domains. *Autism, 8*, 61-87.

Belkadi, A. (2006). Language impairments in autism: Evidence against mind-blindness. *SOAS Working Papers in Linguistics, 14*, 3-13.

Ben-Sasson, A., Cermak, S., Orsmond, G., Tager-Flusberg, H., Kadlec, M., & Carter, A. (2008). Sensory clusters of toddlers with autism spectrum disorders: Differences in affective symptoms. *Journal of Child Psychology and Psychiatry, 49*(8), 817-825.

Bennett, T., Szatmari, P., Bryson, S., Volden, J., Zwaigenbaum, L., Vaccarella, … Boyle, M. (2008). Differentiating autism and Asperger syndrome on the basis of language delay or impairment. *Journal of Autism and Developmental Disorders 38*, 616-625.

Bigler, E., Mortensen, S., Neeley, S., Ozonoff, S., Krasny, L., Johnson, M., … Lainhart, J. (2007). Superior temporal gyrus, language function, and autism. *Developmental Neuropsychology, 31*(2), 217-238.

Bishop, D. (1998). Development of the Children's Communication Checklist (CCC): A method for assessing qualitative aspects of communicative impairment in children. *Journal of Child Psychology and Psychiatry, 39*, 879–891.

Bishop, D. (2003). *Children's Communication Checklist – 2. United States Edition Manual.* San Antonio, TX: PsychCorp.

Bishop, D. (2010). Overlaps between autism and language impairment: Phenomimicry or shared etiology? *Behavioral Genetics*, *40*, 618-629.

Bishop, D., Mayberry, M., Wong, D., Maley, A., & Hallmayer, J. (2006). Characteristics of the broader phenotype in autism: A study of siblings using the Children's Communication Checklist - 2. *American Journal of Medical Genetics Part B (Neuropsychiatric Genetics) 141B*, 117-122.

Bitsika, V., Sharpley, C., & Orapeleng, S. (2008). An exploratory analysis of the use of cognitive, adaptive and behavioural indices for cluster analysis of ASD subgroups. *Journal of Intellectual Disability Research*, *52*(11), 973-985.

Bolton, P., MacDonald, H., Pickles, A., Rios, P., Goode, S., Crowson, M., … Rutter, M. (1994). A case-control family history study of autism. *Journal of Child Psychology and Psychiatry, 35*, 877-900.

Bracken, B. & McCallum, S. (1998). *Universal Test of Nonverbal Intelligence*. Itasca, IL: Riverside Publishing.

Brock, S. (2006). An examination of the changing rates of autism in special education. *The California School Psychologist, 11*, 31-39.

Brown, L., Sherbenou, R., & Johnsen, S. (1997). *Test of Nonverbal Intelligence – Third Edition*. Austin, TX: PRO-ED.

Brownell, R. (2000). *Expressive One-Word Picture Vocabulary Test, Third Edition* (EOWPVT). Novato, CA: Academic Therapy Publications.

Burack, J. A., & Volkmar, F. R. (1992). Development of low- and high-functioning autistic children. *Journal of Child Psychology and Psychiatry, 33*, 607–616.

Byrd, R. (2002). Report to the legislature on the principle findings from the epidemiology of autism in California: A comprehensive pilot study. University of California Davis, MIND Institute. Retrieved from http://www.ucdmc.ucdavis.edu/mindinstitute/html/news/autismreport.htm.

Carter, A. S., Volkmar, F. R., Sparrow, S. S., Wang, J. J., Lord, C., Dawson, G., … Schopler, E. (1998). The Vineland Adaptive Behavior Scales: Supplementary norms for individuals with autism. *Journal of Autism and Developmental Disorders*, *28*(4), 287–302.

Centers for Disease Control and Prevention. (2012). Prevalence of autism spectrum disorders – Autism and developmental disabilities monitoring network, 14 sites, United States, 2008. *Morbidity and Mortality Weekly Report Surveillance Summary, 61*(SS3), 1-19.

Chan, A., Cheung, J., Leung, W., Cheung, R., & Cheung, M. J. (2005). Verbal expression and comprehension deficits in young children with autism. *Focus on Autism and Other Developmental Disabilities, 20*(2), 117-124.

Charman, T., Baron-Cohen, S., Swettenham, J., Baird, G., Drew, A., & Cox, A. (2003). Predicting language outcome in infants with autism and pervasive developmental disorder. *International Journal of Language & Communication Disorders, 38*(3), 265-285.

Charwarska, K. & Volkmar, F. (2005). Autism in infancy and early childhood. In F. Volkmar, R. Paul, A. Klin, & D. Cohen (Eds.), *Handbook of autism and pervasive developmental disorders, Volume 1: Diagnosis, development, neurobiology, and behavior* (3rd ed., pp. 223-246). Hoboken, NJ: John Wiley & Sons.

Cicchetti, D. V., Sparrow, S. S., & Rourke, B. P. (1991). Adaptive behavior profiles of psychologically disturbed and developmentally disabled children. In J. L. Matson & J. Mulich (Eds.), *Handbook of mental retardation* (pp. 222–239), New York, NY: Pergamon.

Constatino, J., Davis, S., Todd, R., Schindler, M., Gross, M., Brophy, S., …Reich, W. (2003). Validation of a brief quantitative measure of autistic traits: Comparison of the Social Responsiveness Scale with the Autism Diagnostic Interview – Revised. *Journal of Autism and Developmental Disorders, 33*(4), 427-433.

Constantino, J. N., & Gruber, C. P. (2005). *Social Responsiveness Scale Manual*. Los Angeles, CA: Western Psychological Services.

Constantino, J. N., Gruber, C. P., Davis, S., Hayes, S., Passanante, N., & Przybeck, T. (2004). The factor structure of autistic traits. *Journal of Child Psychology and Psychiatry, 45*(5), 719-726.

Constantino, J. N., Przybeck, T., Friesen, D., & Todd, R. D. (2000). Reciprocal social behavior in children with and without pervasive developmental disorders. *Journal of Developmental and Behavioral Pediatrics, 21,* 2–11.

Conway, F. (2007). Social Responsiveness Scale. In K. Geisinger, R. Spies, J. Carlson, & B. Plake (Eds.), *The seventeenth mental measurements yearbook.* Lincoln, NE: The University of Nebraska Press.

Coo, H., Ouellette-Kuntz, H., Lloyd, J., Kasmara, L., Holden, J., & Lewis, S. (2008). Trends in autism prevalence: Diagnostic substitution revisited. *Journal of Autism and Developmental Disorders, 38*, 1036-1046.

Davison, M., Gasser, M., & Ding, S. (1996). Identifying major profile patterns in a population: An exploratory study of WAIS and GATB patterns. *Psychological Assessment, 8*(1), 26-31.

De Fosse, L., Hodge, S. M., Makris, N., Kennedy, D. N., Caviness, V. S., McGrath, L., … Harris, G. (2004). Language-association cortex asymmetry in autism and specific language impairment. *Annals of Neurology, 56*, 757-766.

Dekeyzer, L. (2010). Investigation of the characteristics of students classified under autism and their educational services. *Dissertation Abstracts International Section A: Humanities and Social Sciences, 71*(1-A), 80.

Demouy, J., Plaza, M., Xavier, J., Ringeval, F., Chetouani, M., Perisse, D., … Robel, L. (2011). Differential language markers in pathology in autism, pervasive developmental disorder not otherwise specified and specific language impairment. *Research in Autism Spectrum Disorders, 5*, 1402-1412.

DiCicco-Bloom, E., Lord, C., Zwaigenbaum, L., Courchesne, E., Dager, S. R., Schmitz, C., … Young, L. (2006). The developmental neurobiology of autism spectrum disorder. *The Journal of Neuroscience, 26*(26), 6897-6906.

Ding, C. (2005a). Applications of multidimensional scaling profile analysis in developmental research: An example using adolescent irritability patterns. *International Journal of Behavioral Development, 29*(3), 185-196.

Ding, C. (2005b). Determining the significance of scale values from multidimensional scaling profile analysis using a resampling method. *Behavior Research Methods, 37*(1), 37-47.

Ding, C. (2006). Multidimensional scaling modeling approach to latent profile analysis in psychological research. *International Journal of Psychology 41*(3), 226-238.

Dong, Y. & Ding, C. (2012). Adolescent risk behaviors: Studying typical and atypical individuals via multidimensional scaling profile analysis. *Journal of Adolescence, 35*(1), 197-205.

Dumont, R., Cruse, C.L., Price, L., & Whelley, P. (1996). The relationship between the

DAS and the WISC-III for students with learning disabilities. *Psychology in the Schools, 33*(3), 203-209.

Dunn, L. & Dunn, L. (1997). *Peabody Picture Vocabulary Test – Third Edition (PPVT-III)*. Circle Pines, MN: American Guidance Service.

Dunn, L. & Dunn, D. (2007). *Peabody Picture Vocabulary Test – Fourth Edition (PPVT-4)*. San Antonio, TX: Pearson Assessment.

Eaves, L., Ho, H., & Eaves, D. (1994). Subtypes of autism by cluster analysis. *Journal of Autism and Developmental Disorders, 24*(1), 3-22.

Elliott, C. (1990). *Differential Abilities Scale*. San Antonio, TX: The Psychological Corporation.

Farrar, P. (2008). *Autism Genome Project*. Retrieved December 8, 2008, from http://www.well.ox.ac.uk/monaco/autism/AGP.shtml.

Filipek, P. (2005). Medical aspects of autism. In F. Volkmar, R. Paul, A. Klin, & D. Cohen (Eds.), *Handbook of autism and pervasive developmental disorders, Volume 1: Diagnosis, development, neurobiology, and behavior* (3rd ed., pp. 243-254). Hoboken, NJ: John Wiley & Sons.

Fives, C. & Flanagan, R. (2002). A review of the Universal Nonverbal Intelligence Test (UNIT): An advance for evaluating youngsters with diverse needs. *School Psychology International, 23*(4), 425-448.

Fombonne, E. (2005). The changing epidemiology of autism. *Journal of Applied Research in Intellectual Disabilities, 18,* 281-294.

Frisby, C. & Kim, S. (2008). Using profile analysis via multidimensional scaling (PAMS) to identify core profiles from the WMS-III. *Psychological Assessment, 20*(1), 1-9.

Gallagher, L., & Bolshakova, N. (2008a). *The Autism simplex collection*. Retrieved December 8, 2008, from http://www.medicine.tcd.ie/psychiatry/research/neuropsychiatry/autism/tasc.php.

Gallagher, L., & Bolshakova, N. (2008b). *The international multi-centre Autism Genome Project*. Retrieved December 8, 2008, from http://www.medicine.tcd.ie/psychiatry/research/neuropsychiatry/autism/agp.php.

Geurts, H. & Embrechts, M. (2008). Language profiles in ASD, SLI, and ADHD. *Journal of Autism and Developmental Disorders, 38,* 1931-1943.

Gillberg, C. (1998). Asperger syndrome and high-functioning autism. *British Journal of Psychiatry, 172,* 200-209.

Goldman, R. & Fristoe, M. (1986). *Goldman-Fristoe Test of Articulation.* Circle Pines, MN: American Guidance Service.

Harris, G. J., Chabris, C. F., Clark, J., Urban, T., Aharon, I., Steele, S., … Tager-Flusberg, H. (2006). Brain activation during semantic processing in autism spectrum disorders via functional magnetic resonance imaging. *Brain and Cognition, 61*, 54-68.

Harrison, P. & Oakland, T. (2003). *Adaptive Behavior Assessment System – Second Edition*. San Antonio, TX: Psychological Corporation.

Hayashida, K., Anderson, B., Paparella, T., Freeman, S., & Forness, S. (2010). Comorbid psychiatric diagnoses in preschoolers with autism spectrum disorders. *Behavioral Disorders*, *35*(3), 243-254.

Herbert, M. R., Ziegler, D. A., Deutsch, C. K., O'Brien, L. M., Kennedy, D. N., Filipek, P. A., … Caviness, V. (2005). Brain asymmetries in autism and developmental language disorder: A nested whole-brain analysis. *Brain, 128*, 213-226.

Hodge, S., Makris, N., Kennedy, D., Caviness, V., Howard, J., McGrath, L., . . . Harris, G. (2010). Cerebellum, language and cognition in autism and specific language impairment. *Journal of Autism and Developmental Disorders, 40*, 300-316.

Hrdlicka, M., Dudova, I., Beranova, I., Lisy, J., Belsan, T., Neuwirth, J., . . . Urbanek, T. (2005). Subtypes of autism by cluster analysis based on structural MRI data. *European Journal of Child and Adolescent Psychiatry, 14*, 138-144.

Hu, V. & Steinberg, M. (2009). Novel clustering of items from the Autism Diagnostic Interview-Revised to define phenotypes within autism spectrum disorders. *Autism Research, 2I*, 67-77.

Hudry, K., Leadbitter, K., Temple, K., Slonims, V., McConachie, H., Aldred, C., . . . Charman, T. (2010). Preschoolers with autism show greater impairment in receptive compared with expressive language abilities. *International Journal of Language and Communication Disorders, 45*(6), 681-690.

Individuals With Disabilities Education Act, 20 U.S.C. § 1401 (2004). Retrieved from idea.ed.gov/explore/view/p/,root.regs.300,A,300%252E8,.

Joseph, R. M., Tager-Flusberg, H., & Lord, C. (2002). Cognitive profiles and social-communicative functioning in children with autism spectrum disorder. *Journal of Child Psychology and Psychiatry, 43*(6), 807-821.

Just, M. A., Cherkassky, V. L., Keller, T. A., Kana, R. K., & Minshew, N. J. (2007). Functional and anatomical cortical underconnectivity in autism: Evidence from an fMRI study of an executive function task and corpus callosum morpometry.

Cerebral Cortex, 17, 951-961.

Just, M. A., Cherkassky, V. L., Keller, T. A., & Minshew, N. J. (2004). Cortical activation and synchronization during sentence comprehension in high-functioning autism: Evidence of underconnectivity. *Brain, 127*, 1811-1821.

Kenworthy, L., Case, L, Harms, M., Martin, A., & Wallace, G. (2010). Adaptive behavior ratings correlate with symptomatology and IQ among individuals with high-functioning autism spectrum disorders. *Journal of Autism and Developmental Disorders, 40*, 416-423.

Kim, S. (2010a). Comparing longitudinal profile patterns of mathematics and reading in early child longitudinal study, kindergarten: The profile analysis via multidimensional scaling (PAMS) approach. *Asia Pacific Education Review, 11*(2), 189-198.

Kim, S. (2010b). Evaluating the invariance of cognitive profile patterns derived from profile analysis via multidimensional scaling (PAMS): A bootstrapping approach. *International Journal of Testing 10*, 33-46.

Kim, S., Frisby, C., & Davison, M. (2004). Estimating cognitive profiles using profile analysis via multidimensional scaling (PAMS). *Multivariate Behavioral Research, 39*(4), 595-624.

Kjelgaard, M., & Tager-Flusberg, H. (2001). Investigation of language impairment in autism: Implications of genetic subtypes. *Language and Cognitive Processes, 16*(2/3), 287-308.

Klin, A., McPartland, J., & Volkmar, F. (2005). Asperger's syndrome. In F. Volkmar, R. Paul, A. Klein, & D. Cohen (Eds.), *Handbook of autism and pervasive developmental disorders, Volume 1: Diagnosis, development, neurobiology, and behavior* (3rd ed., pp. 88-125). Hoboken, NJ: John Wiley & Sons.

Klin, A., Saulnier, C., Tsatsanis, K., & Volkmar, F. (2005). Clinical evaluation in autism spectrum disorders: Psychological assessment within a transdisciplinary framework. In F. Volkmar, R. Paul, A. Klein, & D. Cohen (Eds.), *Handbook of autism and pervasive developmental disorders, Volume 2: Assessment, interventions, and policy* (3rd ed., pp. 772-798). Hoboken, NJ: John Wiley & Sons.

Klin, A., Volkmar, F. R., Sparrow, S. S., Cicchettie, D. V., & Rourke, B. P. (1995). Validity and neuropsychological characterization of Asperger syndrome: Convergence with nonverbal learning disabilities syndrome. *Journal of Child Psychology & Psychiatry & Allied Disciplines, 36*(7), 1127-1140.

Kruskal, J. B. (1964). Multidimensional scaling by optimizing goodness-of-fit to a nonmetric hypothesis. *Psychometrika, 29*, 1-28.

Kruskal, J. B. & Wish, M. (1978). *Multidimensional scaling*. Beverly Hills, CA: Sage.

Lambert, N., Windmiller, M., Tharinger, D., & Cole, L. (1981). *AAMD Adaptive Behavior Scale—School Edition.* Monterey. CA: Publishers' Test Service.

Landa, R. J., Holman, K. C., & Garrett-Mayer, E. (2007). Social and communication development in toddlers with early and later diagnosis of autism spectrum disorders. *Archives of General Psychiatry, 64*(7), 853-864.

Lane, A., Dennis, S., & Geraghty, M. (2011). Further evidence of sensory subtypes in autism. *Journal of Autism and Developmental Disorders, 41*, 826-831.

Lane, A., Young, R., Baker, A., & Angley, M. (2010). Sensory processing subtypes in autism: Association with adaptive behavior. *Journal of Autism and Developmental Disorders*, *40*, 112-122.

Lewis, F., Murdoch, B., & Woodyatt, G. (2007a). Communicative competence and metalinguistic ability: Performance by children and adults with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 37*, 1525-1538.

Lewis, F., Murdoch, B., & Woodyatt, G. (2007b). Linguistic abilities in children with autism spectrum disorders. *Research in Autism Spectrum Disorders, 1*, 85-100.

Leyfer, O., Tager-Flusberg, H., Dowd, M., Tomblin, B., & Folstein, S. (2008). Overlap between autism and specific language impairment: Comparison of Autism Diagnostic Interview and Autism Diagnostic Observation Schedule scores. *Autism Research, 1*, 284-296.

Longo, A. (2003). Expressive One-Word Picture Vocabulary Test. In B. Plake, J. Impara, & R. Spies (Eds.), *The fifteenth mental measurements yearbook.* Lincoln, NE: The University of Nebraska Press.

Lord, C., Risi, S., Lambrecht, L., Cook, E. H., Leventhal, B. L., DiLavore, P. C., … Rutter, M. (2000). The Autism Diagnostic Observation Schedule - Generic: A standard measure of social and communication deficits associated with the spectrum of autism. *Journal of Autism and Developmental Disorders, 30*(3), 205-223.

Lord, C., Rutter, M., & LeCouter, A. (1994). Autism Diagnostic Interview - Revised: A revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. *Journal of Autism and Developmental Disorders, 24*(5), 659-685.

Losh, M., & Piven, J. (2007). Social-cognition and the broad autism phenotype:

Identifying genetically meaningful phenotypes. *Journal of Child Psychology and Psychiatry, 48*(1), 105-112.

Loucas, T., Charman, T., Pickles, A., Simonoff, E., Chandler, S., Meldrum, D., … Baird, G. (2008). Autistic symptomatology and language ability in autism spectrum disorder and specific language impairment. *Journal of Child Psychology and Psychiatry, 49*(11), 1184-1192.

Loveland, K., & Tunali-Kotoski, B. (2005). The school-age child with an autistic spectrum disorder. In F. Volkmar, R. Paul, A. Klin, & D. Cohen (Eds.), *Handbook of autism and pervasive developmental disorders, Volume 1: Diagnosis, development, neurobiology, and behavior* (3rd ed., pp. 247-287). Hoboken, NJ: John Wiley & Sons.

Maddux, C. (2010). Wechsler Nonverbal Scale of Ability. In R. Spies, J. Carlson, & K. Geisinger (Eds.), *The eighteenth mental measurements yearbook.* Lincoln, NE: The University of Nebraska Press.

Malvy, J., Barthelemy, C., Damie, D., Lenoir, P., Bodier, C., & Roux, S. (2004). Behaviour profiles in a population of infants later diagnosed as having autistic disorder. *European Journal of Child and Adolescent Psychiatry, 13*, 115-122.

McGregor, K., Berns, A., Owen, A., Michels, S., Duff, D., Bahnsen, A., & Lloyd, M. (2012). Associations between syntax and the lexicon among children with or without ASD and language impairment. *Journal of Autism and Developmental Disorders, 42*, 35-47.

Meikamp, J. & Suppa, C. (2005). Adaptive Behavior Assessment System-Second Edition. In R. Spies & B. Plake (Eds.), *The sixteenth mental measurements yearbook.* Lincoln, NE: The University of Nebraska Press.

Merin, N., Young, G., Ozonoff, S., & Rogers, S. (2007). Visual fixation patterns during reciprocal social interaction distinguish a subgroup of 6-month old infants at-risk for autism from comparison infants. *Journal of Autism and Developmental Disorders*, *37, 108-121*.

Minshew, N. J., & Williams, D. L. (2007). The new neurobiology of autism: Cortex, connectivity, and neuronal organization. *Archives of Neurology, 64*(7), 945-950.

Mugavin, M. (2008). Multidimensional scaling: A brief overview. *Nursing Research 57*(1), 64-68.

Newcomer, P. & Hammill, D. (1988). *Test of Language Development -2*. Toronto, Canada: Psycan.

Newsom, C., & Hovanitz, C. A. (2006). Autistic spectrum disorders. In E.J. Mash & R.A.

Barkley (Eds.), *Treatment of childhood disorders* (pp. 455-511). New York, NY: Guilford Press.

Norbury, C. F., Nash, M., Baird, G., & Bishop, D. V. M. (2004). Using a parental checklist to identify diagnostic groups in children with communication impairment: A validation of the Children's Communication Checklist - 2. *International Journal of Language & Communication Disorders, 39*(3), 345-364.

Perry, A., Flanagan, H., Geier, J., & Freeman, N. (2009). The Vineland Adaptive Behavior Scales in young children with autism spectrum disorders at different cognitive levels. *Journal of Autism and Developmental Disorders, 39*, 1066-1078.

Pinborough-Zimmerman, J., Bakian, A., Fombonne, E., Bilder, D., Taylor, J., & McMahon, W. (2012). Changes in the administrative prevalence of autism spectrum disorders: Contribution of special education and health from 2002-2008. *Journal of Autism and Developmental Disorders, 42*, 521-530.

Prior, M., Eisenmajer, R., Leekam, S., Wing, L, Gould, J., Ong, B., & Dowe, D. (1998). Are there subgroups within the autistic spectrum? A cluster analysis of a group of children with autistic spectrum disorders. *Journal of Child Psychology and Psychiatry, 39*, 893-902.

Rapin, I., & Dunn, M. (2003). Update on the language disorders of individuals on the autistic spectrum. *Brain & Development, 25*, 166-172.

Rapin, I., Dunn, M., Allen, D., Stevens, M., & Fein, D. (2009). Subtypes of language disorders in school-age children with autism. *Developmental Neuropsychology, 34*(1), 66-84.

Rice, C. (2007). Prevalence of autism spectrum disorders: Autism and developmental disabilities monitoring network, 14 sites, United States, 2002. *Mortality and Morbidity Weekly Report, 56*(SS01), 12-28.

Rice, M., Warren, S., & Betz, S. (2005). Language symptoms of developmental language disorders: An overview of autism, Down syndrome, fragile X, specific language impairment, and Williams syndrome. *Applied Psycholinguistics, 26*, 7-27.

Riches, N., Loucas, T., Baird, G., Charman, T., & Simonoff, E. (2010). Sentence repetition in adolescents with specific language impairments and autism: An investigation of complex syntax. *International Journal of Language and Communication Disorders, 45*(1), 47-60.

Riches, N., Loucas, T., Baird, G., Charman, T., & Simonoff, E. (2011). Non-word repetition in adolescents with specific language impairment and autism plus language impairments: A qualitative analysis. *Journal of Communication Disorders, 44*, 23-36.

Rivet, T. & Matson, J. (2011). Gender differences in core symptomatology in autism spectrum disorders across the lifespan. *Journal of Developmental and Physical Disabilities, 23*, 399-420.

Robertson, J., Tanguay, P., L'ecuyer, S., Sims, A., & Waltrip, C. (1999). Domains of social communication handicap in autism spectrum disorder. *Journal of the American Academy of Child and Adolescent Psychiatry, 38*(6), 738-745.

Roid, G. (2003). *Stanford-Binet Intelligence Scales – Fifth Edition.* Itasca, IL: Riverside Publishing.

Rutter, M., Bailey, A., & Lord, C. (2003). *Social Communication Questionnaire*. Los Angeles, CA: Western Psychological Services

Sanchez-Ortuno, M., Edinger, J., & Wyatt, J. (2011). Daytime symptom patterns in insomnia sufferers: Is there evidence for subtyping insomnia? *Journal of Sleep Research 20*(3), 425-433.

Schatz, J., & Hamdan-Allen, G. (1995). Effects of age and IQ on adaptive behavior domains for children with autism. *Journal of Autism and Developmental Disorders*, *25*(1), 51–60.

Schmidt, G., Kimel, L., Winterrowd, E., Pennington, B., Hepburn, S., & Rojas, D. (2008). Impairments in phonological processing and nonverbal intellectual function in parents of children with autism. *Journal of Clinical and Experimental Neuropsychology, 30*(5): 557-567.

Semel, E., Wiig, E., & Secord, W. (1994). *Clinical Evaluation of Language Fundamentals - Third Edition (CELF-III)*. San Antonio, TX: Psychological Corporation.

Semel, Wiig, & Secord (2003). *Clinical Evaluation of Language Fundamentals – Fourth Edition (CELF-IV).* San Antonio, TX: Psychological Corporation.

Sevin, J., Matson, J., Coe, D., Love, S., Matese, M., & Benavidez, D. (1995). Empirically derived subtypes of pervasive developmental disorders: A cluster analytic study. *Journal of Autism and Developmental Disorders, 25*(6), 561-578.

Shea, V. & Mesibov, G. (2005). Adolescents and adults with autism. In F. Volkmar, R. Paul, A. Klin, & D. Cohen (Eds.), *Handbook of autism and pervasive developmental disorders, Volume 1: Diagnosis, development, neurobiology, and behavior* (3rd ed., pp. 288-311). Hoboken, NJ: John Wiley & Sons.

Siegel, D., Minshew, N., & Goldstein, G. (1996). Wechsler IQ profiles in diagnosis of high-functioning autism. *Journal of Autism and Developmental Disorders*, *26*(4), 389-406.

Simonoff, E., Pickles, A., Charman, T., Chandler, S., Loucas, T., & Baird, G. (2008). Psychiatric disorders in children with autism spectrum disorders: Prevalence, comorbidity, and associated factors in a population-derived sample. *Journal of the American Academy of Child and Adolescent Psychiatry, 47*(8), 921-929.

Smith, V., Mirenda, P., & Zaidman-Zait, A. (2007). Predictors of expressive vocabulary growth in children with autism. *Journal of Speech, Language, and Hearing Research, 50*, 149-160.

Sparrow S., Balla D. & Cicchetti D. (1984) *Vineland Adaptive Behavior Scales*. Circle Pines, MN: AGS Publishing.

Sparrow S., Cicchetti D. & Balla D. (2005) *Vineland Adaptive Behavior Scales*, 2nd ed. Circle Pines, MN: AGS Publishing,Circle.

Stevens, M., Fein, D., Dunn, M., Allen, D., Waterhouse, L, Feinstein, C., & Rapin, I. (2000). Subgroups of children with autism by cluster analysis: A longitudinal examination. *Journal of the American Academy of Child and Adolescent Psychiatry, 39*(3), 346-352.

Szatmari, P., White, J., & Merikangas, K. R. (2007). The use of genetic epidemiology to guide classification in child and adult psychopathology. *International Review of Psychiatry, 19*(5), 483-496.

Tager-Flusberg, H. (1999). A psychological approach to understanding the social and language impairments in autism. *International Review of Psychiatry, 11*, 325-334.

Tager-Flusberg, H., Paul, R., & Lord, C. (2005). Language and communication in autism. In F. Volkmar, R. Paul, A. Klin, & D. Cohen (Eds.), *Handbook of autism and pervasive developmental disorders, Volume 1: Diagnosis, development, neurobiology, and behavior* (3rd ed., pp. 335-364). Hoboken, NJ: John Wiley & Sons.

Tanguay, P., Robertson, J., & Derrick, A. (1998). A dimensional classification of autism spectrum disorder by social communication domains. *Journal of the American Academy of Child and Adolescent Psychiatry, 37*(3), 271-277.

Thurm, A., Lord, C., Lee, L., & Newschaffer, C. (2007). Predictors of language acquisition in preschool children with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 37*, 1721-1734.

Tsatsanis, K. (2005). Neuropsychological characteristics in autism and related conditions. In F. Volkmar, R. Paul, A. Klin, & D. Cohen (Eds.), *Handbook of autism and pervasive developmental disorders, Volume 1: Diagnosis, development, neurobiology, and behavior* (3rd ed., pp. 365-381). Hoboken, NJ: John Wiley &

Sons.

Venn, J. (2007). Social Responsiveness Scale. In K. Geisinger, R. Spies, J. Carlson, & B. Plake (Eds.), *The Seventeenth Mental Measurements Yearbook.* Lincoln, NE: The University of Nebraska Press.

Wechsler, D. (1991). *Wechsler Intelligence Scale for Children - Third Edition.* San Antonio, TX: Harcourt Brace Jovanovich.

Wechsler, D. (2003). *Wechsler Intelligence Scale for Children - Fourth Edition.* San Antonio, TX: Psychological Corporation.

Wechsler, D. & Naglieri, J. (2006). *Wechsler Nonverbal Scale of Ability*. San Antonio, TX: Harcourt Assessment.

Whitehouse, A., Barry, J., & Bishop, D. V. M. (2008). Further defining the language impairment of autism: Is there a specific language impairment subtype? *Journal of Communication Disorders, 41*, 319-336.

Whitehouse, A., & Bishop, D. V. M. (2008). Cerebral dominance for language function in adults with specific language impairment or autism. *Brain*, *131*(12), 3193-3200.

Wiig, E., Secord, W., & Semel, E., (1992). *Clinical Evaluation of Language Fundamentals* - *Preschool Edition (CELF-P)*. San Antonio, TX: Psychological Corporation.

Wiggins, L., Robins, D., Adamson, L., Bakeman, R., & Henrich, C. (2012). Support for a dimensional view of autism spectrum disorders in toddlers. *Journal of Autism and Developmental Disorders, 42*, 191-200.

Williams, D., Botting, N., & Boucher, J. (2008). Language in autism and specific language impairment: Where are the links? *Psychological Bulletin, 134*(6), 944-963.

Williams, K. (1997). *Expressive Vocabulary Test*. Circle Pines, MN: American Guidance Service.

Williams, K. (2007). *Expressive Vocabulary Test- Second Edition*. San Antonio, TX: Pearson Assessment

Williams, P., Weiss, L., & Rolfhus, E. (2003). *WISC-IV technical report #2: Psychometric properties*. Retrieved from http://www.pearsonassessments.com/hai/Images/pdf/wisciv/WISCIVTechReport2.pdf.

Woodcock, R., McGrew, K. & Mather, N. (2001). *Woodcock-Johnson III Tests of*

Cognitive Abilities. Itasca, IL: Riverside Publishing.

World Health Organization. (1993). Mental disorders: A glossary and guide to their classification in accordance with the 10th revision of the international classification of diseases – research diagnostic criteria (ICD-10). Geneva, Switzerland: Author.

Yen, N. & Tsai, F. (2007). Risk perception in Taiwan. *Asian Journal of Social Psychology, 10*(2), 77-84.

Zander, E. & Dahlgren, S. (2010). WISC-III index score profiles of 520 Swedish children with pervasive developmental disorders. *Psychological Assessment, 22*(2), 213-222.

Zimmerman, I., Steiner, V., & Pond, R. (1992). *Preschool Language Scale–3.* San Antonio, TX: The Psychological Corporation.