DIAGNOSING AUTISM:

COMPARISON OF THE CHILDHOOD AUTISM RATING SCALE (CARS)

AND THE AUTISM DIAGNOSTIC OBSERVATION SCHEDULE (ADOS)

A Dissertation by

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I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy with a major in Psychology.

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DEDICATION

This dissertation is dedicated to all families who struggle with the difficulties inherent in the diagnosis of autism. It is also dedicated to those clinicians who also struggle to provide an accurate diagnosis and effective treatment for the families so burdened. I hope and pray that the findings herein will contribute to greater understanding of your children and help lead to more efficient interventions so that every child can succeed.

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ABSTRACT

This project sought to determine the utility in using either, or both, of two instruments to diagnose autism, the CARS (Childhood Autism Rating Scale) and the ADOS (Autism Diagnostic Observation Schedule), Modules 1 or 2. Children (n=320) who were seen in the autism diagnostic clinics at the Developmental Disabilities Center of the Kansas University Medical Center, who were under the age of 72 months (6 years), and who had been evaluated with both instruments were chosen as participants in this study. Those children who received the diagnosis of autism after being evaluated numbered 220; 100 received another or no diagnosis. Three levels of data analysis were conducted in this study. The first level included developing item-item correlation matrices for each instrument that was then compared to those in the original, normed study for internal consistency. Results indicated good internal consistency. At the second level, a factor analysis was conducted on each instrument that resulted in weighted factor scores and a correlation matrix of factors for each instrument. Factor analyses resulted in three factors identified for the CARS, two factors for ADOS, Module 1, and three factors for ADOS, Module 2. These factors are consistent with the criteria currently used for the diagnosis of autism. The third level of analysis utilized chi square and stepwise discriminant analysis to predict group membership (autism or no autism) with each instrument. From these results, it was concluded that both instruments are similar in their ability to diagnose autism, although they may be measuring somewhat different factors. Closer examination revealed that communication difficulty is the factor that most closely distinguished autism for this group of children.

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LIST OF ABBREVIATIONS

ABA	Applied Behavioral Analysis
ABC	Autism Behavior Checklist
ADI-R	Autism Diagnostic Interview - Revised
ADOS	Autism Diagnostic Observation Scale
AISEP	Autism Screening Instrument for Educational Planning
ASD	Autism Spectrum Disorders
AsD	Asperger's Disorder
CARS	Children's Autism Rating Scale
CPRS	Childhood Psychosis Rating Scale
CSI-4	Child Symptom Inventory – 4th Edition
DASH-II	Diagnostic Assessment for the Severely Handicapped-II
DD	Developmental Delays
DS	Down Syndrome
ECI-4	Early Childhood Inventory – 4th Edition
NSAC	National Society for Autistic Children
PDD	Pervasive Developmental Disorder
PL-ADOS	Pre-Linguistic Autism Diagnostic Observation Scale
PLUK	Parents Lets Unite for Kids
RLRS	Real Life Rating Scale
SCQ	Social Communication Questionnaire
WSQ	Wing Subgroup Questionnaire

CHAPTER 1

INTRODUCTION

The purpose of this study was to evaluate two well-known and highly utilized measures of autism, the Autism Diagnostic Observation Scale (ADOS) and the Children's Autism Rating Scale (CARS), to determine the utility in using either, or both, of two instruments to diagnose autism, the CARS (Childhood Autism Rating Scale) and the ADOS (Autism Diagnostic Observation Schedule), Modules 1 or 2. First, the definition of autism will be discussed, including the changes in the classification of autism over time. Second, the two instruments will be described and the relevant literature on their operating characteristics will be reviewed for each. Following these two sections, the results of the study will be described and discussed.

Currently, autism affects about 2 to 6 children in 1000 (Centers for Disease Control and Prevention, 2005; Filipek et al., 2000; Fombonne, 2003). For decades, the disorder was considered incurable and its impact has been devastating for families, emotionally and financially. The average age for diagnosis of children with an ASD is 3 to 4 years of age (Woods & Wetherby, 2003). However, the National Research Council (Lord & McGee, 2001) suggests that ASD can be reliably diagnosed at age 2 and sometimes younger. Short & Schopler (1988) lend support for an earlier diagnosis, also, by reporting symptoms that caregivers of children have described within the first two years of life. Howlin and Moore (1997) noted in their study that parents expressed concerns to their pediatricians by the time their child was 18 months old.

In recent years more efficient practices have guided early interventions that have reduced the devastating sequelae of the disorder (Lovaas, 1987). It has been found that interventions, such as applied behavioral analysis (ABA), speech and language therapy, and physical and

occupational therapy, provided before age 3 in children with autism, have a much greater impact on successful treatment (McGee, Morrier, & Daley, 1999) than interventions provided after age 5. In a well-designed, early intervention study, Lovaas (1987) reported that nearly half of the young children with autism were considered asymptomatic and impossible to differentiate from same age, typically developing peers after approximately 3 years of intensive, one-on-one ABA interventions. These academically successful children demonstrated measurable, posttreatment IQ gains to the range of average intelligence. A follow-up study with these subjects (McEachin, Smith, & Lovaas, 1993) showed that the target group maintained its gains. Woods and Wetherby (2003) reviewed multiple studies of early identification of and intervention for infants and toddlers who are at risk for autism spectrum disorders (ASD). They concluded that the studies clearly indicate that successful treatment of autism required very early identification and intensive intervention.

Since Lovaas' landmark study in 1987, many of those in the field of developmental disorders have utilized what has been called the "best practice standard" of implementing ABA interventions for children with autism. Best practice standards for ABA treatment of these young children with autism involves 25 to 40 hours per week of one-on-one instruction with a trained therapist in the child's home. The focus of this therapy is to reward desired behavior and reduce aggressive, self-stimulatory, and other negative behaviors through behavioral interventions. After a period of intensive home treatment, children are to be slowly weaned from this isolated environment and introduced gradually into regular preschools and inclusive settings. Parents, Let's Unite for Kids (PLUK) reported in 1999 that this systematic approach can cost as much as $40,000 per year per child. In considering the return on this investment, one study that PLUK reported showed that those children who respond to the ABA program are expected to

contribute an average of $1.5 million to society over their lifetime. In contrast, the cost of caring for an individual with untreated autism can average $4.4 million over their lifetime. Therefore, a clinical and financial investment in early diagnosis and early treatment for children with autism appears to have large fiscal as well as clinical return.

No professional wishes to give parents such a potentially devastating diagnosis without being sure that they are providing dependable information. Unfortunately, despite the implications for early and reliable identification, research and development of such instruments has lagged behind the demand. The problem is reliable diagnosis.

CHAPTER 2

LITERATURE REVIEW

History of Autism Diagnostic Criteria

As noted above, the clinical conceptualizations of autism have changed over time. Historically, there have been reports that children with autistic-like characteristics subsisted as "*feral"* children who were isolated from social contact from a very young age or reportedly lived with and were nurtured by wild animals. Lucien Malson in *Wolf Children* (1972) describes 46 documented cases beginning in 1344. Perhaps the best known of these children was Victor, the wild boy of Aveyron (Lane, 1976), who was captured in 1800 and treated by a French medical student, Jean-Marc Itard, until lack of progress halted the treatment. Difficulty with learning language appeared to be a primary barrier to successful reintegration of these children as most attempts to teach the children to speak failed (Crystal, 1987).

In 1828, Itard made the first systematic attempt to differentiate children with "*intellectual mutism"* (those who would now be considered to have a pervasive developmental disorder such as autism) from children with mental retardation (Carrey, 1995). Itard also developed a more comprehensive classification scheme and proposed specific methods of working with children who displayed these symptoms. Itard described key symptoms of intellectual mutism as a lack of affective abilities, preoccupation with their own needs, and language difficulties. He noted that these children had difficulty with relationships that he considered secondary to the language deficits. They would withdraw from peers and adults alike and exclude them from their own interests. Itard also described defects in attention, perception, and memory as well as a poor sense of imitation which he thought interfered with the establishment of attachment with others.

With regard to etiology, Itard considered intellectual mutism a result of intellectual lesions rather than a psychological state.

In 1911, while studying schizophrenia, Bleuler coined the term “autism”. He defined autism as detachment from reality by way of social withdrawal or lack of a social-relation system (Burger & Schorsch, 1969). In his review of the nosological history of autism, Stroemgren (1987) noted that Bleuler considered autism to be a normal phenomenon of imaginary life that was distorted by those with schizophrenia. Thus, autism came to be regarded as a central symptom of schizophrenia (Minkowski, 1927).

Kanner (1943) was the first clinician to distinguish between childhood schizophrenia and autism. He described a group of children that he identified as having “infantile autism.” He is most often credited as the first to describe the essential key features of autism. In a historical analysis of the work of both Kanner and Itard, Carrey (1995) noted that Itard’s description of the clinical symptoms was as accurate as Kanner’s, but that Kanner highlighted deficits in relationships while Itard emphasized those in language. Kanner regarded a lack of need for others and preference for aloneness as primary symptoms.

In his 1943 monograph, Kanner described about 10 diagnostic criteria that he considered relevant for a diagnosis of autism. However, Kanner was unclear regarding the number of criteria that should be used in making the diagnosis. The confusion was compounded by the fact that he also appeared to regard some of the criteria as nonessential, such as “good cognitive potentialities” and “physically essentially normal” which were considered significant only when combined with other diagnostic criteria. In a refinement of this work, Kanner and Eisenberg (1956) named five distinctive features of autism: (a) Extreme detachment from human relationship, (b) failure to use language for the purpose of communication; (c) anxiously

obsessive desire for the maintenance of sameness, resulting in a marked limitation in the variety of spontaneous activity; (d) fascination for objects which are handled with skill in fine motor movement; and (e) good cognitive potential. They noted that two features are primary and must be present: Extreme self-isolation and obsessive insistence on sameness. Lack of language skills were believed to be "derivative" of a basic disturbance in human relatedness.

The 1960s brought other major attempts in the effort to demarcate autism. The first was organized by Creak (1961) who published the results of a group of professionals in Britain who delineated the syndrome of autism from the syndrome formerly called The Schizophrenic Syndrome in Childhood. They discarded the term, schizophrenia, as they did not believe that this syndrome was analogous to adult schizophrenia. The nine criteria Creak described for the diagnosis of autism were: (a) Gross and sustained impairment of emotional relationships with people; (b) apparent unawareness of own personal identity to a degree inappropriate for age (abnormal behavior toward self); (c) pathological preoccupation with particular objects or certain characteristics without regard to their accepted functions; (d) sustained resistance to change in the environment and a striving to maintain or restore sameness; (e) abnormal perceptual experience; (f) acute, excessive and seemingly illogical anxiety; (g) lost, never acquired, or lack of development of speech, including echolalia or other mannerisms of use of diction; (h) distortion in motility patterns, (e.g., rocking, spinning, hyperkinesis, catatonia); and (i) background of serious mental retardation with areas of near normal or exceptional function or skill.

O'Gorman (1967) reviewed criticism of the Creak group's criteria and offered an alternative model. He concluded that one criterion in particular (withdrawal from people) represented all others and considered this the most important symptom of autism. Based on his

own conclusions, O'Gorman proposed six essential features of autism: (a) Withdrawal from, or failure to become involved with reality; (b) serious intellectual retardation with islets of normal, near normal, or exceptional intellectual function or skills; (c) failure to acquire speech, or to maintain or improve on speech already learned; (d) abnormal response to one or more types of sensory stimulus (usually sound); (e) gross and sustained exhibition of mannerisms or peculiarities of movement; and (f) pathological resistance to change, including rituals, attachment to objects, excessive preoccupation with certain objects, and severe anger or terror or excitement when sameness of environment is threatened by strangers.

Another important work in the 1960s was produced by Rimland (1964) who created one of the first attempts to quantify the syndrome of autism. Based on the core symptoms described by Kanner in 1943, Rimland developed the Diagnostic Checklist for Behavior-Disturbed Children. He named this checklist, Form E-1, which consisted of 76 multiple choice questions for parents about their child's birth history, speech patterns, and symptoms development.

In 1966, the Group for the Advancement of Psychiatry produced a classification system of childhood disorders that classified psychoses based on age. It incorporated Creak's (1961) nine criteria describing the condition autism almost unchanged into its classification system. This system became accepted as the basis for the diagnosis of autism for the next decade.

In 1977, the National Society for Children and Adults with Autism (later known as the Autism Society of America) published a consensus definition of autism (Ritvo & Freeman, 1977) that first described autism as a developmental disorder. They defined autism as a severely incapacitating lifelong developmental disability that typically appeared during the first 3 years of life. The four criteria that they included were: (a) Disturbance in the rate of appearance of physical, social, and language skills; (b) abnormal responses to sensations; (c) absent or delayed

speech and language; and (d) abnormal ways of relating to people, objects, and events. They suggested that communication and social problems were central symptoms of autism, and placed less emphasis than Kanner on rigid adherence to behavior patterns and more emphasis on abnormal sensory responses (Cox & Mesibov, 1995). They also required that those with autism have deficits in all four areas described.

In 1978, Rutter synthesized Kanner's original description and succeeding research. He suggested that there were four features essential for the diagnosis of autism: (a) onset before 30 months of age, (b) social impairment of a type that did not simply reflect mental retardation, (c) distinctively impaired development of communication or abnormal language, and (d) stereotypical behaviors that can be subsumed under the concept of insistence on sameness. Rutter's work was influential at the time because it most closely paralleled clinical experience (Volkmar & Cohen, 1988). See Table 1 for a review of the history of autism.

TABLE 1

HISTORY OF AUTISM DIAGNOSIS

Date	Source	Key feature/s	Essential Features/ Diagnostic Criteria
1828	Itard	Deficits in language	3
1943	Kanner	Deficits in relationships	10
1956	Kanner & Eisenberg	Extreme self-isolation & obsessive insistence on sameness	5
1961	Creak	(none indicated as "key")	9
1967	O'Gorman	Withdrawal from people	6
1977	Ritvo & Freeman	Communication & social problems	4
1978	Rutter	Kanner's research	4
1980	DSM-III	Developmental characteristics	4
1987	DSM-III-R	3 categories: Impairments in reciprocal social interactions, impairments of verbal & nonverbal communication, restricted activities & interests	16
1994	DSM-IV/ICD-10	Deficits in 3 areas: Social skills, communication, behaviors	9

As noted above in Table 1, autism was first included in the third edition of the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM-III*) (American Psychiatric Association, 1980), which was grouped under the broad class of pervasive developmental disorders. The two prior editions of the DSM (Editions I and II) had excluded it. Adoption of the term *pervasive developmental disorders* (PDD) emphasized the developmental aspects, or characteristics, of abnormalities that occur during childhood during the developmental process itself. This focus is in contrast to a loss of reality (psychosis) in adolescents or adults who have previously functioned normally (Rutter & Schopler, 1995). Four criteria for autism were included in the *DSM-III*: (a) Age of onset under 30 months, (b) lack of relatedness, (c) communication deficits, and (d) perseverative behavior. As in Kanner's definition, the DSM-III criteria did not include sensory disturbances. Like Rutter (1983), it emphasized autism as a cognitive disorder that contained impaired language and problems with sequencing, abstraction, and coding functions. It also included another category, '*residual autism'*, that unfortunately implied that autism could be outgrown. In addition, in response to the early confusion about autism and schizophrenia, the two disorders were made mutually exclusive.

The *DSM-III* classification of autism was a major advancement in definition, but it was criticized as being too difficult to quantify (Cox & Mesibov, 1995). The *DSM-III* criteria were too vague which led to disparate interpretations of its criteria. In addition, it presented autism as a fixed disorder without recognizing developmental changes in symptoms of older children. Most clinicians and researchers (Ritvo & Freeman, 1977; Rutter, 1978; Volkmar & Cohen, 1988) agreed that autistic-like characteristics existed on a continuum.

The *DSM-III-R* (American Psychiatric Association, 1987) represented a major change in the conceptualization and description of autism and solved many of the criticisms leveled at the

prior edition's definition (Cox & Mesibov, 1995). Sixteen specific and definable behavioral characteristics were listed in one of three major categories: (a) qualitative impairment in reciprocal social interactions, (b) qualitative impairments of verbal and nonverbal communication skills and activities of imagination, and (c) markedly restricted repertoire of activities and interests. The diagnosis required that 8 of the 16 characteristics be present with at least two from the social category and one each from communication and restricted repertoire of activities. The diagnosis also acknowledged developmental changes in autism, allowed for a continuum from mild to severe, accepted that different individuals could exhibit different manifestations of autism, and eliminated the residual autism category and the requirement for age of onset by 30 months. More recent research had indicated that age of onset could be later (Short & Schopler, 1988; Volkmar, Stier, & Cohen, 1985). As a result of increased diagnostic clarity, autism began to be diagnosed more frequently (Volkmar & Cohen, 1988). However, the *DSM III-R* definition also had its critics (Volkmar et al., 1994). They argued that the definition was too broad which increased the diversity of clients seen. They also contended that the criteria were too cumbersome to memorize and use effectively and that they lacked empirical validation. Therefore, they questioned the reliability of the diagnosis of autism utilizing the *DSM-III-R* criteria.

In response to the criticisms leveled at the *DSM-III* and *DSM-III-R* definitions and to the impending publication of a revised definition of autism in the *International Classification of Disease (ICD-10*), a large multisite field trial with nearly 1000 cases and over 100 clinicians was undertaken (Volkmar et al., 1994). This study focused on the development of the definition of autism for *DSM-IV*. It found that reductions in the number and details of criteria from the *DSM-III-R* definition still yielded good results (Lord, Rutter, & Le Couteur, 1994; Volkmar et al.,

1994) so that the new definition of autism became more concise. Modifications were also made on the *ICD-10* definition so that the two definitions became conceptually identical. It characterizes autism by deficits in three areas: (a) social interaction, (b) communication, and (c) patterns of behavior, interests, and activities (see Appendix A). A total of six or more criteria from the three areas with at least two from social interaction, and one each from communication and patterns of behavior, interests, and activities must be present in order for a child to receive a diagnosis of autism.

Currently, certain aspects of the definition of autism still present challenges for diagnosis, especially for less experienced clinicians. First of all, there continues to be a broad range of syndrome expression among individual clients and symptoms tend to change as a function of age and developmental level (Eaves & Ho, 1996; Lord, et al., 1994). Second, many more children are now being identified who do not present with the classic characteristics of autism and are higher functioning that has added to the complexity of diagnosing autism. Also, because advances in neuroscience have not provided specific biological markers to identify autism, diagnosis continues to rely on developmental history and behavioral observations. Fortunately, the *DSM-IV* definition is now conceptually identical to the *ICD-10*. However, although several well developed diagnostic instruments are available (two will be discussed shortly), nothing substitutes for clinical expertise and experience (Lord et al., 1994). In a study that examined the interrater reliability of the *DSM-IV* criteria, Klin and Volkmer (1995) found that differences in professional background among raters was of little significance, yet differences in clinical experience regarding how long clinicians had worked with children with autism had a more marked impact on reliability coefficients. Fortunately, the coefficients of agreement for the

various criteria fell in the good to excellent range of clinical significance lending credibility to the descriptive ability of the criteria.

In a clinical science, assessment should inform intervention (Millon, 1990). Therefore, the development of reliable and valid instruments is essential for clinical practice. An important step in that process is the development of coherent taxonomies in which the categorization of clinical features is described in accord with theory (Millon, 1990). The above review reveals that the definition of autism has obviously been undergoing this process. Millon asserts that development of empirically oriented instruments to assess theoretical clinical contructs is an important feature of mature clinical sciences. These instruments must be able to identify and quantify the concepts that have been developed into the classification scheme for the disorder. Instrumentation allows the clinician to quantify, measure, and operationalize what is being studied. Then clinical techniques and strategies for effecting beneficial changes can be developed and implemented. Assessment instruments more easily permit clinicians to measure treatment progress and can provide a unified metric across clinical settings.

Measurement should lead to and guide the specific interventions that are so crucial in the field of autism treatment. This is accomplished by examining specific items on the scale that are identified as a problem for the child. The next section describes two instruments that have been developed to assist in the differential diagnosis of autism. This dissertation focuses on these instruments.

Diagnostic Tools: The Childhood Autism Rating Scale (CARS)

The CARS was first utilized in 1971 by trained diagnosticians while observing specific psychological testing sessions (Schopler, Reichler & Renner, 1988). Initially, the CARS was

primarily based on the consensual diagnostic criteria for autism as reported by Creak in 1961 and was first called the Childhood Psychosis Rating Scale (CPRS) (Reichler & Schopler, 1971).

In 1988, the present form of the CARS (Schopler, Reichler, & Renner) was released after nearly 15 years of development. It was developed to meet administrative and research objectives for TEACCH (the Treatment and Education of Autistic and related Communication Handicapped Children), a program begun in 1966 for children with autism in North Carolina. The resent version incorporates Kanner's (1943) primary autism features, Rutter's definition of autism in 1978, that of the National Society for Autistic Children (NSAC, 1978), and the *DSM-III* criteria for autism (1980). It emphasizes behavioral and empirical data rather than clinical intuition and is often used in research.

The CARS consists of a 15-item behavioral rating scale and utilizes professionals' and parents', or caregivers', observations about their child. Its purpose is to identify children with autism, and to distinguish them from other developmentally delayed children. It is especially effective in discriminating between children with autism and those who are trainably mentally retarded (Morgan, 1988; Teal & Wiebe, 1986) and is also able to distinguish among children with mild to moderate and moderate to severe autism. CARS ratings can be made from different sources, such as psychological testing, classroom participation, parental reports, and history records. Reliability and validity findings suggest that the CARS is an effective tool for research and diagnosis of autism (Schopler, Reichler, & Renner, 1988).

The procedures for making the CARS ratings will now be described in more detail. When a child is being observed, brief notes are made on the form and ratings are not completed until all data have been collected. The child's behavior is compared with that of a typically developing child of the same age and the peculiarity, frequency, intensity, and duration of

behaviors are noted. It is important to simply rate the degree to which the child's behavior deviates from normal without making judgments about cause as the total score and pattern of impairments will differentiate between autism and developmentally disorders in children. Each of the 15 items is given a rating from 1 (within normal limits for that age) to 4 (severely abnormal for that age). In fact, each item consists of a seven point scale as half steps (1.5, 2.5, and 3.5) that may be used when deemed appropriate. A total score is then computed by summing the 15 individual ratings which can range from 15 to 60. Item 15 (General Impressions) carried the same weight as the rest of the items and can be thought of as a global measurement of function, much as the Global Assessment of Function (GAF) in the *DSM-IV*. A diagnostic categorization system was established to aid in the interpretation of the total CARS score, with scores below 30 in children categorized as nonautistic, 30-36.5 indicating mild to moderate autism, and scores 37 and over as severe autism. For adults, the recommended cutoff criterion for the presence of autism is 28 with 35 as the criterion for distinguishing between moderate and severe autism. It should be noted that it is possible for a child to obtain a CARS rating of 30 or above and not meet the *DSM-IV* criteria for the diagnosis of an autistic disorder. This possibility exists because other disorders may be interfering with the child's functioning. The authors note that the CARS should be considered the first step in diagnosis and should mark the beginning of an individualized assessment process that utilizes other instruments and observations.

A comprehensive review of the literature from PsycINFO of "Autism and CARS" identified 52 studies reported as of the end of 2004. A selected review of this literature will be presented. This review is summarized in Table 2.

TABLE 2

RESEARCH OF THE CARS

Year	Researcher(s)	Type	Conclusions
1980	Schopler, Reichler, Renner	Introduced scale	.94 reliability, .71 interrater reliability
1986	Teal, Wiebe	Comparison	CARS & ASIEP best distinguished autistic children from trainable mentally retarded
1988	Schopler, Reichler, Renner	Published scale	Reliable and valid scale
1988	Garfin, McCallon, Cox	Discrimination	Discriminated nonautistic, handicapped, and autistic adolescents
1989	Mesibov, Schopler, Schaffer, Michal	Utility for diagnosing autism	Useful screening device for adolescents & adults
1992	Sevin, Matson, Coe, Fee	Comparison	CARS & RLRS correlated moderate well; ABC not correlated w/ either
1992	Sturmey, Matson, Sevin	Comparison	CARS good internal consistency; ABC & RLRS variable
1992	Van Bourgondien, Marcus, Schopler	Comparison	DSM-III-R slightly under-diagnosed autism
1993	Eaves, Milner	Comparison	Moderate relationship; CARS identified 98%, ABC 88%
1994	DiLalla, Rogers	Factor analysis	3 factors (social impairment, negative emotionality, distorted sensory response)
1994	Matese, Matson, Sevin	Comparison	Both CARS & RLRS useful in differential diagnosis of autism and psychosis
1996	Sponheim, Spurkland	Comparison	Of CARS, ICD-10, DSM-III-R, ABC; highest reliability with ICD-10, lowest with CARS
1998	Matson, Smiroldo, Hastings	Comparison	DASH-II as likely as CARS to classify autism & handicapped adults
1998	Pilowsky, Yirmiya, Shulman, Dover	Comparison	85.7% agreement between CARS & ADI-R
1999	Nordin, Gillberg	Comparison	CARS and ABC
1999	Stella, Mundy, Tuchman	Factor analysis	5 factors (social communication, emotional reactivity, social orienting, cognitive & behavioral consistency, odd sensory exploration)
2002	Stella	New scoring	Factor-based scoring
2002	Goldfischer	Alternative scoring	Primary, non-primary criteria
2003	Saemundsen, Magnusson, Smari, Sigurdardottir	Comparison	CARS more accurate than ADI-R; 66.7% agreement between

*Note: 1980 through 2004 Total of 52 studies re CARS

In 1980, Schopler, Reichler, and Renner formally introduced the original CARS in its first published article. This article investigated the definition of autism and described validity and reliability results. The authors rated 537 children with the CARS and found an internal

reliability coefficient of .94 and an interrater reliability coefficient of .71 for the diagnosis of autism. This form of the CARS included the 15 subscales that it is composed of today.

Teal and Wiebe (1986) compared the CARS with two other autism rating scales, the Autism Screening Instrument for Educational Planning (ASIEP) and the Diagnostic Checklist for Behavior Disturbed Children (Form E-2). The purpose of their study was to investigate each instrument's effectiveness in discriminating 20 autistic children from 20 trainable mentally retarded 3 to 12 year old children. Through discriminate analysis, they found that all three instruments separated both groups, but the CARS and ASIEP provided for the greatest separation between the two groups.

In 1988, the validity and reliability of the CARS was evaluated by Garfin, McCallon, and Cox with autistic children and adolescents. They compared the scores of 22 autistic children (6-10 years old), 22 autistic adolescents (13-22 years old), and 20 nonautistic, handicapped adolescents. They found that the CARS clearly discriminated between the two adolescent groups (nonautistic, handicapped vs. autistic), although the total score did not discriminate younger from older. They also investigated specific items on the CARS and recommended that one item be eliminated (Inconsistencies in Intelligence). They found that its elimination would actually increase the reliability coefficient for both children and adolescent groups as it was negatively correlated with the total CARS score.

Mesibov, Schopler, Schaffer, and Michal (1989) evaluated the utility of the CARS for diagnosing autism in adolescents and adults and came to the same conclusion as Garfin, McCallon and Cox; the CARS is a useful screening device for adolescents and adults with autism. They also assessed whether the characteristics of autism change during adolescence and

found that adolescents made significant improvements in autistic characteristics as measured in nine CARS categories.

In the 1990s, the CARS became more widely used in the autism field as indicated by the appearance of 23 published articles. Eight of these studies compared the CARS performance with other measures. The results were mixed as noted in the following review.

The first of these studies, Sevin, Matson, Coe, and Fee (1991), compared the CARS, the Autism Behavior Checklist (ABC), and the Real Life Rating Scale (RLRS). They concluded that the RLRS and CARS correlated moderately well, but that the ABC was not significantly correlated with either. They noted that 50% of the sample was misclassified by the ABC cutoff score while 92% were correctly classified using the CARS cutoff scores. Sturmey, Matson, and Sevin (1992) investigated the CARS vs. the ABC and the RLRS and found that the CARS showed good internal consistency, while the other scales were variable in their internal consistency. Van Bourgondien, Marcus, and Schopler (1992), in the comparison of the CARS and the *DSM III-R*, found that the CARS and clinical ratings diagnosed a greater number of cases as autistic, suggesting that the *DSM-III-R* slightly underdiagnosed autism. Eaves and Milner (1993) in the CARS vs. the ABC, found a moderate relationship between the two instruments with the CARS correctly identifying 98% of the autistic children and the ABC correctly identifying 88%. Matese, Matson, and Sevin (1994), in their comparison of the CARS and the RLRS (Ritvo-Freeman Real Life Rating Scale), found that both assessment instruments may be useful in differential diagnosis for autism and psychosis.

On the other hand, Sponheim and Spurkland (1996) evaluated the CARS vs. the *ICD-10*, *DSM-III-R*, and ABC. They found that the highest reliability was obtained using ICD-10 research criteria and the lowest reliability using the CARS. Matson, Smiroldo, and Hastings

(1998) compared the CARS with the DASH-II (Diagnostic Assessment for the Severely Handicapped-II) and found that the DASH-II was as likely as the CARS to classify autistic and control handicapped adults. When Pilowsky, Yirmiya, Shulman, and Dover (1998) compared the CARS and the ADI-R, they found 85.7% agreement between the two measures. And in 1999, Nordin and Gillberg concluded that the CARS distinguished reasonably well between autistic disorder and other autism spectrum disorders and that the ABC reflected autism specific behavioral problems.

Among the 23 articles appearing in the 1990s, two groups of investigators reported factor analysis of the CARS. DiLalla and Rogers (1994) found that three factors emerged from their analysis of the CARS (Social Impairment, Negative Emotionality, and Distorted Sensory Response). They noted that Social Impairment classified autistic vs. nonautistic individuals with 78% accuracy and was somewhat sensitive to the effects of treatment, with Negative Emotionality most sensitive and Distorted Sensory Response least sensitive to treatment.

Stella, Mundy and Tuchman (1999) also factor analyzed the CARS. Five factors (Social Communication, Emotional Reactivity, Social Orienting, Cognitive and Behavioral Consistency, and Odd Sensory Exploration) emerged that accounted for 64% of the variance in total CARS scores. They created factor-scales and concluded that the CARS may yield scores that are reflective of a partially independent domain within the social impairment associated with pervasive developmental disorders.

From January 2000 to May of 2004, research with the CARS continued to expand with the publication of 22 articles. The majority of the studies (18) were devoted to utilizing the CARS to diagnose subjects for participation in investigations related to the cause, characteristics, differentiation of subtypes, and treatment of autism. Three groups of investigators continued the

effort of further development of the scale itself. Stella (2002) continued her work with factor-based scales from the CARS. Her results provided additional support for the utility of new factor based scoring of the CARS.

Goldfischer (2002) asserted that the CARS is considered the "*gold standard"* for assessing autism. It has been utilized frequently since its inception and currently is used in combination with other instruments, especially the ADOS. and he also investigated the usefulness of an alternative scoring system for the CARS. His research led to the recommendation that each CARS item be considered individually as primary or non-primary according to the criteria of the *DSM-IV* with three total scores used: Total Primary Score, Total Non-Primary Score, and Total CARS score. He suggested that the new total primary score of the CARS would be more accurate and representative of DSM-IV criteria and would reduce the high amount of false positives that are reported, thus increasing its diagnostic utility.

When Saemundsen, Magnusson, Smari, and Sigurdardottir (2003) examined the agreement between the ADI-R and the CARS, they found that the CARS accurately identified more cases of autism than did the ADI-R and that an observed agreement between the two systems was 66.7% (Cohen's kappa=.40) when the ADI-R definition for autism was applied. When both instruments were used to diagnose children with autism, those children had significantly lower IQ/DQ and more severe autistic symptomatology than those classified with the CARS only.

Diagnostic Tools: The Autism Diagnostic Observation Schedule (ADOS)

The ADOS was introduced as a method of standardizing direct observations of social behavior, communication, and play in children suspected of having autism. In 1989, Lord et al. published the first version of the ADOS. It was intended for use with children and adults with

language skills at a minimum 3-year-old level. In 1995, DiLavore, Lord, and Rutter developed another version of the ADOS, the PL-ADOS (Pre-Linguistic Autism Diagnostic Observation Scale) that was developed for use with children who had limited or no language skills. Both were proposed as a complementary instrument to the Autism Diagnostic Interview (ADI; Le Couteur, Rutter, Lord, & Rios, 1989), a parent/caregiver interview that investigates history and current functioning in developmental areas related to autism. The current version of the ADOS (Lord et al., 2000) is a combination of the two earlier instruments with the addition of items developed for verbally fluent, high-functioning adolescents and adults.

The ADOS is a standardized, semi-structured, play-based observation instrument that is congruent with the *ICD-10* and *DSM-IV* diagnostic criteria used by professionals for diagnosis of autism. It assesses communication, social interaction, and play or imaginative use of materials for individuals who may have an Autistic Spectrum Disorder (ASD). The ADOS consists of four modules, each based on language and age: I –preverbal/single words; II – phrase speech; III – fluent speech, child/adolescent; IV – fluent speech, adolescent/adult. Each module contains standard activities and materials that are presented by examiners in order to elicit behaviors that have been identified as important to the diagnosis of an ASD at that age and language level (e.g., eye contact, conversation, use of speech and language, shared enjoyment, unusual sensory interests, and others). *"Presses"*, or planned social interactions, are also incorporated into each module in which a particular type of behavior is expected to appear. The object of the activities is to structure the interactions so that the child or adult being assessed is sufficiently intrigued to want to participate socially. Many times, deliberately waiting for a participant to interact can be as important as presenting materials.

As reported by Lord, Rutter, DiLavore, & Risi in the ADOS manual (2002), intraclass correlations are as follows: Interrater reliability ranged from .82 to .93 and test-retest reliability over 1-2 weeks ranged from .59 to .73. Cronbach's alphas for internal consistency were consistently highest for the Communication-Social Interaction total score (.91 to .94) and lowest for Stereotyped Behaviors and Restricted Interests scores (.63 to .65 for Modules 2 & 1, and .47 to .56 for Modules 4 and 3). Establishment of validity proceeded in a series of steps and included correlation matrices, exploratory factor analyses, fixed effect analyses of variance (ANOVAs), and comparison of domain scores. The consistent pattern across items for all modules was that scores were highest for the autism group, lower for the PDD-NOS group, and lowest for the nonspectrum group. These scores suggest that children with autism are the most impaired of the three groups of children in the areas of communication and reciprocal social interaction.

Only one module is administered to an individual at a given time and the examiner selects the module that is most appropriate for the expressive language skills and chronological age of the child or adult being tested. However, an examiner can choose to switch to another module if the language level is different than expected or the tasks seem inappropriate for other reasons. When considering which module to use, it is best not to confound language difficulties with the social demands of the instrument, but to select a module that requires fewer language skills than the individual possesses. Each module can be administered in 30-45 minutes and notes are taken by the examiner during its administration. The overall ratings are completed immediately after the administration, which are then used to formulate a diagnosis through the use of the diagnostic algorithm provided for each module. Scoring made at the end of the

module is similar across modules with some identical items, but others are relevant only for the module being used.

A search of the literature in PsycINFO identified 16 articles for Autism and ADOS for the years 1995 through 2004. A comprehensive search of Silverplatter using ADOS and Autism garnered an additional three articles for a total of five articles from that search. A selection of these articles will be discussed. This review is summarized in Table 3.

TABLE 3

RESEARCH OF THE ADOS

Year	Researcher(s)	Type	Conclusions
1995	DiLavore, Lord, Rugger	Introduced earliest version (PL-ADOS)	Reliably diagnose and discriminate between autistic and nonautistic
1998	Mahoney et al.	Used ADOS	To evaluate ability of DSM-IV criteria to differentiate PDD subtypes
1999	Robertson, Tanguay, L'Ecuyer, Sims, Waltrip	Factor Analysis	3 factors (Joint Attention, Affective Reciprocity, Theory of Mind)
2000	Noterdaeme, Sitter, Mildenberger, Amorosa	Internal consistency, discrimination	Clearly discriminate children with with autism from those with severe receptive language disorders
2000	Lord et al.	Latest form	4 modules – based on age, language
2001	Noterdaeme, Mildenberger, Sitter, Amorosa	Discrimination	Further evidence of ability for differential diagnosis of autism and language disorders
2001	Feinberg	Diagnosis	Autism severity was best predictor of child's total social skills score
2002	Noterdaeme et al.	Comparison	With ADI for diagnosis of autism; both performed well.
2002	Bishop, Norbury	Comparison	Poor agreement between ADI, SCQ, ADOS
2003	Gudaitis	Diagnosis	Validity of ECI-4, CSI-4 as screening
2004	deBildt	Interrelationship	Among ADOS, ADI-R, & DSM-IV; valid & reliable autism measurement
2004	Ozonoff et al.	Diagnosis	Frontal lobe function deficits

DiLavore, Lord, and Rutter (1995) authored the first article which described the PL-ADOS, the semi-structured observation scale for diagnosing children who are not yet using phrase speech and are suspected of having autism. They concluded that this scale could be used to reliably diagnose videotaped assessments by naïve raters and could discriminate between developmentally disabled children with autism or no autism. This became Module 1 of the present ADOS.

In 1998, Mahoney et al. evaluated the ability of the *DSM-IV* criteria for pervasive developmental disorders to reliably and accurately differentiate PDD subtypes. The diagnosis of their sample of 143 children with various types of developmental disabilities was made by clinicians using the ADOS and ADI-R (Autism Diagnostic Interview-Revised). They found that the *DSM-IV* criteria showed good to excellent reliability for the diagnosis of PDD NOS, Asperger's disorder (AsD), and autism, but they showed poor reliability for the diagnosis of atypical autism.

Robertson, Tanguay, L'Ecuyer, Sims, and Waltrip (1999) performed a factor analysis to investigate whether specific social communication handicaps could be identified in ASD using the ADOS, separating social communication from the other primary factors in autism. The results were then compared with those from a previous factor analysis (Tanguay, Robertson, & Derrick; 1998) using the ADI-R and the same three factors were identified: Joint Attention, Affective Reciprocity, and Theory of Mind. These were the same social communication domains identified in the previous study.

In 2000, a group of German researchers, Noterdaeme, Sitter, Mildenberger, and Amorosa again assessed the reliability and diagnostic validity of the ADOS and examined its usefulness in differentiating between children with autism and those with a severe specific receptive language

disorder. They utilized the ICD-10 algorithm for comparison. Their results again indicated that the ADOS has good internal consistency and that various ADOS items clearly discriminate both groups.

Also in 2000, Lord et al. presented the latest form of the ADOS, the ADOS-Generic, that now includes the four modules described as before. In this study, their results indicated substantial interrater and test-retest reliability for individual items, excellent interrater reliability within domains, and excellent internal consistency. Comparisons of means indicated consistent differentiation of ASD from nonspectrum participants, with less consistent differentiation between autism and PDD NOS.

In 2001, Noterdaeme, Mildenberger, Sitter, and Amorosa presented further evidence that the ADOS was useful in differential diagnosis between children with autism and those with language disorders. They noted that their results with the ADOS indicated that the autistic children had scores that were clearly more deviant with no significant differences between two groups of language impaired children. The authors also recommended that additional information from parents is required to make a reliable diagnosis. Noterdaeme et al. continued their work with the same groups of children and compared the usefulness of the ADI-R and the ADOS for differential diagnosis. In their results, all 11 children in the autism group were correctly classified as having autism on the ADOS with 10 of the 11 children correctly identified by the ADI-R. They noted that the two instruments are complementary in diagnosing autism.

Bishop and Norbury (2002) refuted this claim based on the results of their study that explored whether pragmatic language impairment was simply another term for autistic disorder or PDD NOS. In this study, parents completed two self-report measures (the ADI-R and the Social Communication Questionniare – SCQ) while participant children were given the ADOS.

Results demonstrated good agreement between the parental report measures, but poor agreement between diagnoses made from parental report measures and those based on the ADOS.

In 2004, deBildt examined the interrelationship between the ADOS and the ADI-R, and the *DSM-IV-TR* diagnostic criteria. He found that the agreement between the ADI-R and the ADOS was fair and, when compared with the *DSM-IV-TR* diagnostic criteria, that both instruments measure autism or PDD validly and reliably. He noted that the interrelationship between both instruments and the clinical classification was satisfactory even among low-functioning children.

In 2001, investigators began to use the ADOS to investigate the efficacy of treatments for autism. Feinberg (2001) designed a study to teach children with developmental disorders appropriate social behaviors through social stories and used the ADOS to diagnosis autism in her participants. She noted that autism severity, as measured by the ADOS, was the best predictor of a child's total social skills score.

In 2003, Gudaitis examined the validity of the Early Childhood Inventory-4 (ECI-4) and the Childhood Symptom Inventory-4 (CSI-4) as screening measures for PDD by utilizing the ADOS for a comparison of scores from ECI-4 and CSI-4 parent and teacher checklists. It also compared these checklists to clinical diagnoses from a team of clinicians that included a specialist in autism. They concluded that the ECI-4 and the CSI-4 should be useful measures for identifying autism in a clinical setting where the full range of clinical disorders present themselves and where initial impressions are collected. They also found that the teacher checklist appeared to have greater validity for identifying children with autism than the parent checklist.

In 2004, researchers (Ozonoff et al.) investigated the role of frontal lobe function in people with autistic disorder measuring autism with the ADOS and ADI-R. Significant differences were found between children with autism and typical controls. The autism group showed deficits in planning efficiency and extradimensional shifting relative to controls. These impairments did not predict autism severity or specific autism symptoms as measured by the ADI-R and ADOS, but it was correlated with adaptive behavior.

Diagnostic Tools: Comparison of CARS and ADOS

A review of the PsychINFO literature identified no studies that examined the relationship between the ADOS and CARS when diagnosing autism. A search entitled ADOS and CARS returned a single article, a validity study of the Wing Subgroup Questionnaire (WSQ) for assessing autism subtypes in young nonverbal children. In this study (Fitton, 2000), scores on the WSQ were compared to all three instruments to address overall applicability of the WSQ with preschool children. Scores on the WSQ were compared to scores on an earlier version of ADOS (the PL-ADOS) and the CARS. They found that the WSQ accurately classified autistic and nonautistic children in all but two cases. They also suggested that there are three subtypes of autism: aloof, passive, and active-but-odd. After dividing their sample of 33 autistic children into these three subtypes, they found that children with the aloof subtype of autism demonstrated high scores on the older ADOS and the CARS when compared with the WSQ. Children in the passive subgroup showed inconsistent data on the CARS and PL-ADOS. And children in the active-but-odd subgroup were not identified as autistic on the CARS and PL-ADOS.

Problem Statement

The goal of this research project was to determine the utility in using either, or both, of two instruments (the CARS and the ADOS, Modules 1 or 2) to diagnose autism. Although the

ADOS and the CARS are widely used, a review of the literature revealed that there are no studies that examine both instruments directly. Clinical observation suggests excellent concordance between the CARS and ADOS, Module 1, but this concordance appears to be lower between the CARS and the ADOS, Module 2. This study empirically tested the veracity of this observation. It was predicted that the CARS and the ADOS, Module 1 would covary more highly than the CARS and the ADOS, Module 2.

Conceptual Framework

Despite an increase in the awareness and treatment of autism, professionals continue to struggle to find the best method to identify children with autism. Currently, a variety of instruments are being utilized as no one tool has been developed that will reliably diagnose autism. Two methods that are commonly employed for diagnosis are interview and direct observation. The instruments employed in this study utilize both.

CHAPTER 3

METHOD

Design

A retrospective design was used with participants below the age of 6 who attended the autism diagnostic clinics at the Developmental Disabilities Center of the University of Kansas Medical Center in Kansas City, Kansas. For the purposes of this study, two groups were formed; the first one received a diagnosis of autism; the second group attended the same clinics and received the same measures, but received a diagnosis other than autism. Data were gathered from existing charts and participants' identity was protected by de-identification according to university policies.

Participants were described as to age at diagnosis, gender, ethnicity, rural or city residence, developmental status, with prior and current diagnosis(es). Statistical analysis included basic psychometrics for each instrument so that a comparison of the group being used for this study could be contrasted with those utilized for standardization of each instrument. A correlational analysis between the CARS and ADOS, Module 1 and Module 2, was conducted resulting in a correlation matrix. This matrix was used to investigate the degree of covariation between the CARS and each ADOS module. Corrected item-sum correlations were also compared to the established norms from each instrument. Cronbach's alpha was calculated for each instrument to examine the relative degree of internal consistency and relative freedom from error. Factor analysis was also completed on each instrument to assess their dimensionality in the present sample and compared to those completed in other samples. Factor analysis simplified the data by reducing the number of necessary variables, or dimensions, on each scale.

Finally, stepwise discriminant analysis was used to predict group membership (autism or no autism) for each instrument.

Procedure

The evaluation setting consisted of an evaluation room within a complex of examination rooms, offices, and other evaluation rooms with a common waiting room where children with possible and actual developmental delays and associated disorders are seen by a number of professionals. When the family arrived for their appointment, they signed in at the front office and were then sent to the nearby waiting room where the coordinator of the clinic met with them for introductions, explanation of the process, and to answer any questions. During that time, the evaluation team met in the evaluation room to review the child's chart and discuss the case, made a decision as to what tests were necessary, and assembled the equipment necessary for those tests. The evaluation team included at least one psychologist, speech-language pathologist, social worker, occupational and/or physical therapist, and developmental pediatrician. All professionals were cross-trained on a number of the instruments used in this setting including the ADOS and CARS. Graduate students often accompanied these professionals and generally were active participants in the testing process provided that they had been appropriately introduced to the instruments and procedures.

The evaluation room was a large, open, sunny room with cabinets of toys and supplies at the entry end and small tables and chairs for evaluating children at the other end. Two small observation rooms provided access along one side for students and other professionals to observe who did not actively participate in the evaluation. The parents, or other caretakers, were interviewed near the cabinets facing down the room where they could also observe the evaluation conducted with their child, and the child could go to them for comfort, if needed. The child was

generally asked to sit in a chair with arms so they could not easily escape the demands of the testing. A parent, or other familiar adult, might occasionally hold the child if attention was unable to be acquired otherwise.

The evaluation began when the family was conducted into the room by the clinic coordinator and introductions were made. The parents sat in chairs near the entry and their interview began while the child was escorted to the testing area at the far end of the room with the enticement of bubbles or other activities that would catch their attention. The evaluation began with the ADOS as soon as the child was seated at the table. Generally one professional conducted the evaluation while another one or two recorded observations and assisted in the management of child behaviors that might be interfering with the test. Other evaluations were then performed as a part of the complete evaluation of the child, such as intelligence testing or motor function.

Once those tests and the parents' interview were complete, the family was accompanied back to the waiting room where the child was weighed and measured and the family waited to be seen by the developmental pediatrician. The rest of the team moved to another room where scoring of the tests took place and discussion ensued, culminating in scoring of the CARS as a team. The developmental pediatrician met with the team for initial impressions before s/he saw the family and again after the medical evaluation was finished. Once the physician returned to the team, the diagnosis was discussed and confirmed by the entire team utilizing the *DSM-IV* criteria (see Appendix A). A short report was then prepared by the team for the family to take with them that included the child's strengths and areas of concern, the evaluation tests utilized, the criteria for autism that are met and not met, the team's impressions (diagnosis), and their initial recommendations.

The family, who had been in the waiting room again, was then accompanied back to the evaluation room where the team completed the clinic process by explaining the diagnosis, giving recommendations, and answering questions. The brief report was given to the family at the conclusion of the evaluation. Initial follow-up was conducted by the clinic coordinator who called the family the week after the clinic was conducted to answer any further questions the family might have had. A full report is sent within about 3 weeks after all professionals had completed their analyses and written their conclusions.

The length of the clinic assessment varied, but generally took about 4 hours. The families were urged to come in comfortable clothing and to bring along preferred snacks and toys, especially for the child being tested. All efforts were made to assist the family in feeling comfortable and relaxed with the process so that a complete and valid evaluation would be accomplished. Families who came from a distance were urged to come the night before so that they were as rested as possible and were given information about the Ronald McDonald House that sits less than a block from the center.

Participants

Description of the combined sample. The sample of this study consisted of 320 children under the age of 6 years (71 months and younger). These children were seen in the Developmental Disabilities Center at the University of Kansas from 1998 through May 2004 for evaluation of autism.

The demographics of this sample are summarized in Table 4. Ages of the participants ranged from 17 to 71 months with a mean age of 42.6 months (3 years, 7 months; SD 13.49). There were 270 males (84.4%), 20 females (6.3%), and 30 unidentified (9.4%). Ethnic origin was: 215 Caucasian (67.2%), 35 Black (10.9%), 18 Hispanic (5.6%), 8 Asian (2.5%), 4 Middle

Eastern (1.3%), 3 American Indian (0.9%), 11 mixed race or other (3.4%), and 26 missing (8.1%). Most of the participants were from urban areas. About 2/3 (192, 60.0%) of the children lived in the Kansas City metro area; 43 (13.5%) lived in populous counties close to Kansas City; and 5 (1.6%) were residents of Sedgwick County. Most of the rest of the participants lived in rural counties of Kansas (66, 14.5%) and Missouri (5, 1.6%) with populations of less than 50,000. One participant (0.3%) was from Nebraska; the residences of 8 participants (2.5%) were unknown.

TABLE 4

DEMOGRAPHIC INFORMATION FOR BOTH GROUPS AND THE COMBINED SAMPLE

Sample	Autism		No autism		Combined	
Variable	N	%	N	%	N	%
Gender						
Male	188	85.5%	82	81.5%	270	84.4%
Female	2	.9%	18	17.6%	20	6.3%
Unknown	28	12.7%	2	.9%	30	9.4%
Ethnicity						
Caucasian	146	66.4%	69	69.0%	215	67.2%
Black/African	26	11.8%	9	9.0%	35	10.9%
Hispanic	12	5.5%	6	6.0%	18	5.6%
Asian	4	1.8%	4	4.0%	8	2.5%
Middle Eastern	4	1.8%	0	0.0%	4	1.3%
American Indian	2	.9%	1	1.0%	3	0.9%
Mixed race/other	10	4.6%	1	1.0%	11	3.4%
Unknown	16	7.3%	10	10.0%	26	8.1%
Residence						
Urban	168	76.4%	73	73.0%	240	75.1%
Rural	49	22.2%	22	22.0%	72	22.4%
Unknown	3	1.4%	5	5.0%	8	2.5%

Mean age of developmental milestones between the two groups (autism and no autism) Differed based on visual inspection in most categories (see Table 5). Participants in the group with autism were developmentally ahead of those without autism in crawling (average age = 8.7

months vs. 14.2 months) and walking (14.3 months vs. 28.1 months). Participants in the group with autism were developmentally behind those without autism in speaking (average age at first word was 17.4 months vs. 10.4 months; speaking in sentences was 31.4 months vs. 17.4 months). Average age at sitting was similar (7.0 months vs. 6.8 months) as was toilet training (41.8 months vs. 36.9 months).

TABLE 5

DEVELOPMENTAL MILESTONES FOR BOTH GROUPS AND THE COMBINED SAMPLE

Sample		Autism			No autism			Combined	
Variable	N	Range	Avg. Age	N	Range	Avg. Age	N	Range	Avg. Age
Sitting	191	2-40 mo.	7.0 mo.	88	2-28 mo.	6.8 mo.	279	2-40 mo.	6.9 mo.
Missing	29	(13.2%)		12	(12%)				
Crawling	182	3-24 mo.	8.7 mo.	94	9-32 mo.	14.2 mo.	276	3-32 mo.	10.6 mo.
Not Crawling	6	(2.7%)		0					
Missing	32	(14.5%)		6	(6.0%)				
Walking	202	6-54 mo.	14.3 mo.	66	7-60 mo.	28.1 mo.	268	17.7 m	
Not walking	3	(1.5%)		12	(12.0%)				
Missing	15	(6.8%)		22	(22.0%)		15	(5.3%)	
Feeding self	180	4-44 mo.	11.4 mo.	88	3-30 mo.	8.8 m	268	10.5 mo.	
Missing	40	(18.2%)		12	(12.0%)				
Speaking first word	140	3.5-65 mo.	17.4 mo.	79	5-30 mo.	10.4 mo.	219	14.9 mo.	
Not speaking words	41	(22.7%)		1	(1.0%)				
Missing	39	(17.7%)		20	(20.0%)		42	(16.1%)	
Speaking in sentences	77	6-63 mo.	31.4 mo.	80	6-41 mo.	17.4 mo.	157	24.3 mo.	
Not speaking sent.	117	(60.3%)		2	(2.0%)				
Missing	26	(11.8%)		18	(18.0%)		119	(43.1%)	
Toilet trained	30	24-54 mo.	41.8 mo.	42	24-54 mo.	36.9 mo.	72	39.0 m	
Not toilet trained	168	(76.4%)		41	(41.0%)				
Missing	22	(10.0%)		17	(17.0%)		209	(74.4%)	
Average age at dx	220		40.5 m	100		47.2 m	320		42.6 m

Table 6 compares ethnicity and residence (urban vs. rural) of this sample to that of the Kansas City metro area, the state of Kansas, and the United States. This sample most closely approximated that of the United States and least closely that of the state of Kansas in ethnicity and place of residence (urban vs. rural).

TABLE 6

ETHNIC INFORMATION FOR THE COMBINED SAMPLE COMPARED TO KANSAS CITY, STATE OF KANSAS, AND THE UNITED STATES

Sample Variable	This Study (corrected*) %	Kansas City metro area %	State of Kansas %	United States %
Ethnicity				
Caucasian	73.0%	77.0%	81.0%	75.1%
Black/African	11.9%	13.0%	6.0%	12.3%
Hispanic	6.1%	5.0%	7.0%	5.5%
Asian	2.7%	2.0%	--	3.6%
American Indian	1.0%	<0.5%	--	0.9%
Mixed race/other	3.7%	2.5%	7.0%	2.4%
Residence				
Urban	77.0%		65.0%	82.0%
Rural	23.0%		35.0%	18.0%

* Corrected = recalculation of categories after missing data are removed.

Measures

Descriptive statistics of the measures and the combined sample. A summary of gender and ethnic characteristics of the normed group for each instrument and for the combined sample of this study is presented in Table 7. As shown, more females were included in the original ADOS and CARS normed studies than in this study; approximately 1 female for every 3 males. This study has a much higher proportion of males to females; 17 males to one female of those that reported their gender. The male to female ratio for autism overall is about 4:1. The ADOS study and this study's participants were similar in ethnic origin while the original CARS study consisted of about 2/3 Caucasian and 1/3 Black/African participants.

TABLE 7

DEMOGRAPHIC INFORMATION FOR THE SAMPLES OF THE TWO INSTRUMENTS AND THIS STUDY SAMPLE

Sample	CARS		ADOS		This study (corrected*)	
Variable	N	%	N	%	N	%
Gender						
Male	407	75.7%	96	74.4%	270	93.1%
Female	130	24.3%	33	25.6%	20	6.9%
Ethnicity						
Caucasian	359	66.9%	103	80.0%	215	73.0%
Black/African	162	30.2%	14	11.0%	35	11.9%
Hispanic			5	4.0%	18	6.1%
Asian			2	2.0%	8	2.7%
American Indian					3	1.0%
Mixed race/other	16	2.9%	3	2.0%	11	3.7%

* corrected = recalculation of categories after missing data are removed.

CARS item statistics of the autism and no autism samples. Data from the CARS were collected and analyzed on all 320 participants. The means and standard deviations of the individual CARS items and total scores for both samples and the combined group are presented in Table 8. As noted, visual inspection of the means for each of the items for the Autism group (n = 220) suggested that all were higher than those for the no autism group (n = 100). The mean of the total score for the autism group was 37.6 (*SD* 4.96) and for the no autism group was 26.2 (*SD* 3.45).

TABLE 8

MEANS AND STANDARD DEVIATIONS FOR ALL CARS SCORES OF BOTH GROUPS

Sample	Autism		No Autism	
CARS Scores	M	SD	M	SD
1: Relating to People	2.6	.53	1.8	.40
2: Imitation	2.6	.77	1.3	.44
3: Emotional Response	2.4	.54	1.8	.48
4: Body Use	2.3	.60	1.8	.51
5: Object Use	2.6	.50	1.7	.42
6: Adaptation to Change	2.4	.58	1.8	.48
7: Visual Response	2.6	.51	1.8	.44
8: Listening Response	2.5	.49	1.8	.47
9: Taste, Smell, & Touch Response	2.4	.60	1.8	.48
10: Fear or Nervousness	2.5	.60	1.9	.56
11: Verbal Communication	2.8	.53	1.9	.46
12: Nonverbal Communication	2.6	.49	1.6	.50
13: Activity Level	2.1	.65	1.8	.55
14: Level & Consistency of Intellectual Response	2.4	.32	1.7	.63
15: General Impressions	2.7	.39	1.8	.34
Total	37.6	4.96	26.2	3.45

ADOS, Module 1, item statistics of the autism and no autism samples. Data from the ADOS, Module 1 were collected and analyzed on 220 participants. The means and standard deviations of the individual ADOS, Module 1 items that determine the diagnosis of autism and total scores for the two groups are presented in Table 9. As noted, visual inspection of the means for each of the items for the autism group (n = 190) appeared to be higher than those for the no autism group (n = 30), except for one item which was the same. The mean of the total score for the autism group was 17.7 (*SD* 2.97) and for the no autism group was 6.97 (*SD* 5.32).

TABLE 9

MEANS AND STANDARD DEVIATIONS FOR ALL ADOS, MODULE 1 SCORES OF BOTH GROUPS

Sample	Autism		No Autism	
ADOS, Module 1 Scores	M	SD	M	SD
Communication				
A-2: Frequency of Vocalization…	1.7	.50	.9	.76
A-5: Stereotype/Idosyncratic …	.3	.66	.3	.66
A-6: Use of Other's Body …	.9	.90	.2	.56
A-7: Pointing	1.7	.59	.7	.76
A-8: Gestures	1.5	.60	.7	.66
Communication Total	6.3	1.5	2.6	1.89
Reciprocal Social Interaction				
B-1: Unusual Eye Contact	2.0	.26	1.0	1.00
B-3: Facial Expressions Directed…	1.5	.51	.8	.65
B-5: Shared Enjoyment in …	1.2	.66	.3	.57
B-9: Showing	1.9	.33	1.0	.78
B-10: Spontaneous Initiation of …	1.7	.51	.7	.66
B-11: Response to Joint Attention	1.6	.61	.6	.75
B-12: Quality of Social Overtures	1.7	.45	.8	.73
Social Interaction Total	11.5	2.01	4.4	3.70
ADOS, Module 1 Total	17.7	2.97	7.0	5.33

ADOS, Module 2, item statistics of the autism and no autism samples. Data from the ADOS, Module 2 were collected and analyzed on 100 participants. The means and standard deviations of the individual ADOS, Module 2 items that determine the diagnosis of autism and total scores for the two groups are presented in Table 10. As noted, visual inspection of the means for each of the items for the autism group (n = 34) appeared to be higher than those for the no autism group (n = 66). The mean of the total score for the autism group was 17.2 (*SD* 4.04) and for the no autism group was 9.54 (*SD* 4.32).

TABLE 10

MEANS AND STANDARD DEVIATIONS FOR ALL ADOS, MODULE 2 SCORES OF BOTH GROUPS

Sample	Autism		No Autism	
ADOS, Module 2 Scores	M	SD	M	SD
Communication				
A-2: Amount of Social Overtures…	1.5	.63	.8	.58
A-5: Stereotype/Idosyncratic …	1.1	.68	.5	.56
A-6: Conversation	1.9	.31	1.2	.66
A-7: Pointing	.5	.78	.4	.57
A-8: Descriptive, Conventional,…	1.0	.67	.3	.56
Communication Total	6.9	1.80	3.4	2.05
Reciprocal Social Interaction				
B-1: Unusual Eye Contact	1.9	.40	1.4	.91
B-2: Facial Expressions Directed…	1.1	.48	.7	.59
B-6: Spontaneous Initiation of …	.5	.68	.1	.36
B-8: Quality of Social Overtures	1.4	.50	.9	.40
B-9: Quality of Social Response	1.7	.45	1.0	.70
B-10: Amount of Reciprocal …	1.5	.63	.9	.58
B-11: Overall Quality of Rapport	.3	.63	.3	.63
Social Interaction Total	10.3	2.42	6.1	2.68
ADOS, Module 2 Total	17.2	4.04	9.5	4.32

Cells or subgroups. In order to better understand this study and its analyses, please refer to Table 11 that indicates the number of participants within each subgroup, or cell. All participants (320) were assessed with the CARS and either the ADOS, Module 1 (190), or ADOS, Module 2 (100). These participants were further divided into two subgroups (autism or no autism) that formed the individual cells of the study.

TABLE 11

PARTICIPANT SUBGROUPS/CELLS

Instruments	Subgroups/Cells		
	Combined	Autism	No Autism
CARS	320	220	100
ADOS, Module 1	220	190	30
ADOS, Module 2	100	34	66

CHAPTER 4

RESULTS

Statistical Analysis

Levels of analysis. Three levels of analysis were conducted in this study. The first level included developing item-item correlation matrices for each instrument that was then compared to those in the original, normed study for internal consistency. At the second level, a factor analysis was conducted on each instrument that resulted in weighted factor scores and a correlation matrix of factors. Using weighted factor scores is a more efficient method of predicting the relative contribution of each factor to the total score. The third level of analysis utilized chi square and discriminant analysis to predict group membership (autism or no autism).

Level one (patterns of covariation). First, an item-item correlation matrix was generated for all items for the CARS (see Appendix B) and for the items associated with the diagnosis of autism in the ADOS, Modules 1 (see Appendix C) and 2 (see Appendix D). The correlations that appear in the lower half of the matrix are taken from each instrument's normed group and the correlations in the top half of the matrix are those from the present sample.

According to Cohen (1988), correlation coefficients are best interpreted in terms of magnitude of effects sizes as "small" (.10-.29), "medium" (.30-.49), and "large" (.50 and greater). For the CARS, the item intra-correlations in the matrix ranged from .21 to .81 with a median of .47; correlations ranged between .10-.29 = 56 and .30 & over = 2. For the ADOS, Module 1, the item intra-correlations for the 12 items used to determine an autism diagnosis ranged from .09 to .97 with a median of .47; correlations ranged between .10-.29 = 51 and .30 & over = 15. For ADOS, Module 2, item intra-correlations for the 12 items used to determine an autism diagnosis ranged from .09 to .97 with a median of .43; correlations ranged between .10-

.29 = 56 and .30 & over = 27. In general, the patterns of item-item correlation in the instruments used in this sample were fairly similar to those in their respective norm group as most of the correlations were less than .10 or between .10 and .29.

Level one (internal consistency). Corrected item-sum correlations were also calculated for each instrument to determine the degree to which each item related to the scale score. The correction was made by deleting the contribution of each item from the sum score, thereby eliminating the contribution of that particular item. For the CARS, the corrected item-total correlations ranged from .45 to .91 with a median of .72. The Cronbach's alpha was .93 which demonstrates high internal consistency. For the ADOS, Module 1, corrected item-total correlations ranged from .38 to .69 with a median of .60 and an alpha of .80. For the ADOS, Module 2, corrected item-total correlations ranged from .16 to .68 with a median of .51 and an alpha of .80. Again, items for the ADOS, Modules 1 and 2, appear to possess similar high reliability.

Level two (CARS factor analysis). Correlations among the 15 CARS items were factor analyzed via principal components analysis using the FACTOR program of the Statistical Package for the Social Sciences (SPSS), Version 11.5. The number of factors to extract and rotate was determined via the Kaiser-Guttman rule of eigenvalues, and the Scree Test as well as simple structure and psychological meaningfulness. These strategies attempt to extract the most meaningful number of factors by excluding potential factors that do not account for significant proportions of variance in the items being factor analyzed. Because we assumed the scales were not orthogonal, we used the Promax (oblique) rotation method.

Using the criteria noted above, the decision was made to rotate three factors which accounted for 58.5% of the variance. It might be noted that two-, five-, and seven-factor

solutions were disregarded as they provided a less than satisfactory solution. Analysis indicated that those factor solutions were unclear with trivial and murky factors that did not contribute to the clarity of the explanation.

Item factor weights of $\geq$ .40 are considered to be meaningfully related to the factor. The rotated factor solution is summarized in Table 12.

TABLE 12

FACTOR WEIGHTS ON CARS ITEMS: ROTATED FACTOR SOLUTION, OBLIQUE (PROMAX)

	Factor			
CARS item	Meaningful Communication	Emotional Adaptability	Intellectual Ability	Communalities
C1 Relating to people	.68			.50
C2 Imitation	.93			.74
C3 Emotional response		.74		.58
C4 Body use			.47	.46
C5 Object use		.50		.64
C6 Adaptation to change		.97		.70
C7 Visual response	.64			.51
C8 Listening response		.54		.54
C9 Taste, smell, touch response			.90	.48
C10 Fear or nervousness	.47			.28
C11 Verbal communication	.85			.59
C12 Nonverbal communication	.73			.51
C13 Activity level		.71		.67
C14 Intellectual response*			-.89	.80
C15 General impressions	.66			.78

*NOTE: A high score on this item of the CARS reflect low intelligence.

Based on a review of the pattern of the weights, the first factor was called Meaningful Communication. It seems to be related to relationships, imitation, and verbal and nonverbal communication. The CARS items associated with this major factor reflect social and communication deficits associated with autism. Factor 2 was named Emotional Adaptability. It seems to be related to emotional reaction, especially as it was associated to changes in their lives,

and level of activity related to life situations. The CARS items associated with this factor reflect the inflexibility and high level of activity associated with many children who have autism. Factor 3 was called Sensory and Intellectual Response. It seems to be related to the lower consistency and level of intellectual ability compared to children his/her own age, plus response to sensory stimuli. The CARS items associated with this factor reflect the impairment of sensory and intellectual reactions that many children with autism demonstrate.

Level two (ADOS factor analyses). Using the criteria noted above, the decision was made to rotate two factors for ADOS, Module 1, which accounted for 57.6% of the variance. It was quite clear that there was no need to conduct further rotations. Again, item factor weights of $\geq$ .40 were considered to be meaningfully related to the factor. The rotated factor solution is summarized in Table 13 below.

TABLE 13

FACTOR WEIGHTS ON ADOS, MODULE 1 ITEMS: ROTATED FACTOR SOLUTION, OBLIQUE (PROMAX)

	Factor		
ADOS, Module 1 item	Social Interaction	Impaired Communication	Communalities
A2 Frequency of vocalization directed to others		.66	.61
A5 Stereotyped/idiosyncratic use of words or phrases		.63	.47
A6 Use of other's body to communicate		.91	.56
A7 Pointing		.71	.65
A8 Gestures	(.36)	(.37)	.43
B1 Unusual eye contact	1.0		.71
B3 Facial expressions directed to others	.59		.54
B5 Shared enjoyment in interaction	.61		.53
B9 Showing	.85		.60
B10 Spontaneous initiation of joint attention	.67		.67
B11 Response to joint attention		.43	.56
B12 Quality of social overtures	.59		.59

Based on a review of the pattern of the weights, the first factor was called Impaired Communication. It seems to be related to frequency of vocalizations, use of stereotyped

/idiosyncratic words, pointing, and use of another's body to communicate. The ADOS, Module 1, items that loaded on this major factor reflect the communication deficits associated with autism. The second factor was named Social Interaction. It seems to be related to shared enjoyment, showing, joint attention, and the quality of social overtures. The items associated with this factor reflect the difficulty that children with autism have in socializing effectively with other people.

Using the criteria noted above, the decision was made to rotate three factors for ADOS, Module 2, which accounted for 59.6% of the variance. It was quite clear that there was no need to conduct further rotations. Again, item factor weights of $\geq$ .40 were considered to be meaningfully related to the factor. The rotated factor solution is summarized in Table 14 below.

TABLE 14

FACTOR WEIGHTS ON ADOS, MODULE 2 ITEMS: ROTATED FACTOR SOLUTION, OBLIQUE (PROMAX)

	Factors			
ADOS, Module 2 items	Social Communication	Social Language	Joint Attention	Communalities
A2 Amount of social overtures /maintenance of attention	.71			.55
A5 Stereotyped/idiosyncratic use of words or phrases		.82		.57
A6 Conversation	.89			.72
A7 Pointing			.88	.74
A8 Descriptive, conventional, instrumental, or Informational gestures		.40		.52
B1 Unusual eye contact		.74		.51
B2 Facial expressions directed to others		.59		.62
B6 Spontaneous initiation of joint attention			.81	.73
B8 Quality of social overtures	.70			.66
B9 Quality of social response	.80			.63
B10 Amount of reciprocal social communication .	.87			.70
B11 Overall quality of rapport	.43			.21

Based on a review of the pattern of the weights, the first factor was called Social Communication. It seems to be related to the amount and quality of social overtures and response. Again, the items that loaded on this factor reflect the communication and social deficits associated with autism. The second factor was named Social Language. It seems to be related to eye contact, facial expressions, and unusual use and/or formation of words or sounds. The items associated with this factor reflect the difficulty that many children with autism have in making direct eye contact and utilizing appropriate facial expression and language. Factor 3 was named Joint Attention. It seems to be related to pointing and the spontaneous initiation of joint attention. The items associated with this factor reflect the difficulty with joint attention that children with autism often have.

Level 3 (Stepwise discriminant analysis of diagnosis by factor scale. In order to determine whether there was a significant difference between using the CARS or the ADOS to predict the ultimate diagnosis of children with autism, two discriminant function analyses (DFA) were performed using weighted factor scores of each instruments (CARS, and ADOS, Module 1 or 2) as predictors of group membership.

The first DFA was then performed (CARS and ADOS, Module 1 factor scores). Box's M was computed to determine whether the difference in group size (and, thus, variances) would be problematic. According to Tabachnick and Fidell (1996) Box's M test is a notoriously sensitive test of homogeneity of variance-covariance matrices. If sample sizes are unequal and Box's M test is significant at $p < .001$, then robustness of the DFA is not guaranteed. This analysis yielded a Box's M *F* ratio (*df* 15, 19277) of 105.381, $p<.001$ which suggests lack of homogeneity of variance across the two comparison groups. However, due to the robustness of the effect size of the DFA, the analysis was accepted. A single canonical function was used and

produced an eigenvalue of 2.173. A Wilks' Lambda of .399 was produced that indicated that there was considerable discrimination between the groups. Wilks' Lambda represents something of an inverse effect size or the amount of variance not shared between the variable sets. Therefore, by taking 1 – Wilks' Lambda we find an overall effect size of 1 - .399 = .601 or 60% = R_c^2, that is the predictors predicted 60 percent of the variance in group membership, which is a large effect size. The chi square reflecting this solution was 207.421.

Group centroids and structure functions are presented in Table 15.

TABLE 15

DISCRIMINANT FUNCTION ANALYSIS GROUP CENTROIDS AND STRUCTURE MATRIX FOR FACTOR SCORES OF CARS AND ADOS, MODULE 1

Group Centroid Functions		Structure Matrix Functions	
Autism	1.609	ADOS1 factor score 1 (Impaired Communication)	.830
No autism	- .720	CARS factor score 1 (Meaningful Communication)	.808
		CARS factor score 2 (Emotional Adaptability)	.461
		ADOS1 factor score 2 (Social Interaction)	.370
		CARS factor score 3 (Sensory & Intellectual Response)	.336

Group centroids can be thought of as the center in three dimensional space of the total of scores describing each group (autism and no autism). If an apple can be thought of in three dimensional space, then the seeds would be the centroids. The functions (based on weighted factor scores) provide an indication of the distance each predictor is to the two centroids. The functions are reported as correlations or weights (loadings). Examination of the relations of the five functions (loadings) to the group centroids are summarized in Table 15 above. The group centroid of the group with autism was 1.609 and for the no autism group was -.720. It can be

seen that ADOS factor score 1 (loading = .830, Impaired Communication) was the best predictor of membership in the autism group. The second most powerful predictor was CARS factor score 1 (loading = .808, Meaningful Communication); third was CARS factor score 2 (loading = .461, Emotional Adaptability); fourth was ADOS factor score 2 (loading = .370, Social Interaction); and fifth was CARS factor score 3 (loading = .336, Sensory & Intellectual Response). No test of the degree of significance of the distance from the loading to the group centroid is available. The loadings can be interpreted much as we interpret loadings in factor analysis. Basically, high scores on the five weighted factor scores, especially in the case of communication skills, clearly predicted membership in the autism group. In terms of distance from the group centroids, the five factor scores were far from the group centroid for the no autism group as compared to the analogous centroid for the autism group. In sum, the predictors clearly tended to define group membership.

The second DFA was then performed (CARS and ADOS, Module 2 factor scores). Box's M was again computed to determine whether the difference in group size would be problematic. This analysis yielded a Box's M *F* ratio (*df* 21, 12424) of 31.916, *p*=.109. This Box's M test was not significant which indicates robustness. A single canonical function was used and produced an eigenvalue of 1.183. A Wilks' Lambda of .458 was produced that indicated that there was considerable discrimination between the groups. By taking 1 – Wilks' Lambda, we find an overall effect size of 1 - .458 = .542 or 54% = R_c^2. That is, the predictors predicted 54% of group membership which is a large effect size. The chi square reflecting this solution was 71.833. The group centroid for the group with autism was .561 and for the group without autism was -2.665. Group centroids and Structure functions are listed in Table 16.

Examination of the relations of the six functions (loadings) to the group centroids are also summarized in Table 16.

TABLE 16

DISCRIMINANT FUNCTION ANALYSIS GROUP CENTROIDS AND STRUCTURE MATRIX FOR FACTOR SCORES OF CARS AND ADOS, MODULE 2

Group Centroid Functions		Structure Matrix Functions	
Autism	.561	CARS factor score 1 (Meaningful Communication)	.859
No autism	-2.665	CARS factor score 2 (Emotional Adaptability)	.619
		ADOS2 factor score 1 (Social Communication)	.554
		ADOS2 factor score 2 (Social Language)	.554
		ADOS2 factor score 3 (Joint Attention)	.297
		CARS factor score 3 (Sensory & Intellectual Response)	.275

It can be seen that CARS factor score 1 (loading = .859, Meaningful Communication) was the best predictor of membership in the autism group. It should be noted that a function may possibly be larger or smaller than group centroid. What "matters" is the relative distance from the function to the group centroid. The second most powerful predictor was CARS factor score 2 (loading = .619, Emotional Adaptibility); third was ADOS factor score 1 (loading = .554, Social Communication) and fourth was ADOS factor score 2 (loading = .554, Social Language); fifth was ADOS factor score 3 (loading = .297, Joint Attention); and sixth was CARS factor score 3 (loading = .275, Sensory & Intellectual Response). Basically high scores on the six weighted factor scores, again especially in the case of communication skills, clearly predicted membership in the autism group. Each of the six functions was far from the group centroid for the no autism group.

Level 3 (Chi square). An additional step was performed to clarify the meaning of the results of the DFA. A one-way chi square was used with each instrument and between instruments. A one-way chi square is called the goodness of fit test and is used when data consists of frequencies with which participants belong to the different categories of one variable (in this case, autism). The relationship between the different categories of the variable (autism or no autism) and the frequency with which participants fall into each was examined. The larger the chi square obtained, the larger the differences between the observed and expected frequencies. A significant chi square indicates that the observed frequencies are unlikely to represent the distribution of frequencies in the expected relationship. The chi squares obtained in this study are presented in Table 17. As can be seen, the percentage correct is similar throughout.

TABLE 17

CHI SQUARES OBTAINED

Group		Autism	No autism	% correct	Significance
		CARS			
Diagnosis	Autism	210	10	91.9%	p<.001
	No autism	16	84		
		ADOS 1			
Diagnosis	Autism	181	8	92.8%	p<.001
	No autism	8	26		
		ADOS 2			
Diagnosis	Autism	28	2	81.4%	p<.001
	No autism	16	51		
		CARS			
ADOS1	Autism	216	4	88.1%	p<.001
	No autism	34	66		
		CARS			
ADOS2	Autism	206	14	92.5%	p<.001
	No autism	10	90		

CHAPTER 5

DISCUSSION

The goal of this research project was to determine the utility in using either, or both, of two instruments (the CARS and the ADOS, Modules 1 or 2) to diagnose autism. Although the ADOS and the CARS are widely used, a review of the literature revealed that no published evidence exists regarding their agreement. Clinical observation suggests excellent concordance between the CARS and ADOS, Module 1, but this concordance appears to be lower between the CARS and the ADOS, Module 2. This study empirically tested the veracity of this observation. It was predicted that the CARS and the ADOS, Module 1 would covary more highly than the CARS and the ADOS, Module 2. Children (n=320) who were seen in the autism diagnostic clinics at the Developmental Disabilities Center of the Kansas University Medical Center, who were under the age of 72 months (6 years), and who had been evaluated with both instruments were chosen as participants in this study. Children who had received the diagnosis of autism after being evaluated numbered 220; 100 children received another, or no, diagnosis.

Three levels of data analysis were conducted in this study. The first level included developing item-item and item-sum correlation. Generally, the two instruments correlated highly. Corrected item-sum correlation matrices for each instrument were then compared to those in the original, normed study for internal consistency. Both instruments had good internal consistency as the alpha scores ranged from .80 to .93. At the second level, a factor analysis was conducted on each instrument that resulted in weighted factor scores and a correlation matrix of factors for each instrument. Factor analyses resulted in three factors identified for the CARS, two factors for ADOS, Module 1, and three factors for ADOS, Module 2. This factor solution is consistent with those found in the previous studies. The third level of analysis utilized stepwise

discriminant analysis and chi square to predict group membership (autism or no autism) with each instrument. From these results, it was concluded that the CARS and ADOS are similar in their ability to contribute to the diagnosis of autism, although they may be measuring somewhat different dimensions of autism. Further, it is evident that the clinicians making the ultimate diagnosis seemed to be more influenced by the communication factor in these children than the other dimensions measured by the two instruments.

One prior factor analytic study of the CARS was identified from the literature. In their study, DiLalla and Rogers' (1994) also discovered three factors in their factor analysis of the CARS. These three factors are consistent with the results found in this study. Their primary factor identified items that were related to communication and relationships that they called Social Impairment (this study called the first factor Meaningful Communication). The second factor, Negative Emotionality, was also closely aligned to this study (Emotional Adaptability). The third factor was called Distorted Sensory Response, called Sensory and Intellectual Response in this study.

One factor analysis was also identified from the literature for the ADOS (Robertson et al., 1999). However, it was not necessarily useful for this study because it factored an earlier version of the ADOS, the PL-ADOS, which is represented in the present ADOS as Module 1. The authors identified three factors which they labeled Joint Attention, Affective Reciprocity, and Theory of Mind. The present study identified two factors for Module 1 (Impaired Communication and Social Interaction). Although similar in nature, the items were not exactly identical, so direct comparison was not possible.

In the literature review for this paper, it was noted that for several decades researchers have attempted to clearly define the diagnosis of autism. The CARS is based on earlier

representations of that work; the ADOS on later investigations. Despite the theoretical changes in the conceptualization of autism over time, both instruments appear to assess similar dimensions of autism. Although the order of magnitude of the factors identified by the two DFAs performed in this study varied slightly, the same three factors carried the greatest weight in both solutions. The primary predictor was problems with communication which is consistent with the *DSM-IV* as one of the primary criteria for the diagnosis of autism. The other major predictor was emotional adaptability, a well-recognized deficit of flexibility in children with autism. Thus the results of the factor analyses and discriminate analyses were similar to those already performed and to the criteria represented in the *DSM-IV* for the diagnosis of autism.

It should be noted that an examination of the literature indicates that this study is unique in that both the CARS and the ADOS were used in tandem. No other study has employed both instruments. Thus, the findings from this study will add to the body of knowledge in the rapidly growing field of autism. It can also provide information that will guide clinicians in their work with families and children through a profile analysis of the results that can guide therapeutic strategies.

The major practical clinical question addressed by this study concerned the administrative decision regarding the use of both instruments. The CARS is an older established instrument; the ADOS is a newer, less studied instrument. This research indicated that they are measuring the same diagnosis, but may not be measure similar dimensions of that diagnosis. Thus, it is reasonable to ask if both are really necessary. Perhaps the same degree of clinical predictive efficiency could be reached by using only one instrument. The answer to this question is complex and several factors would have to be taken into consideration in making this decision. Cost of purchasing and administering the instrument would, of course, have to be taken into

consideration. Yet, as noted in the introduction, the cost of missing the diagnosis of autism and, thus, failing to launch early treatment interventions would also have to be considered. This study does not address these issues. However, the results of the DFA are relevant. Recall that the SPSS DFA program used in this study will not print (identify) a variable's relationship to the group membership if it does not contribute additional information to the prediction. This study found that both instruments made important contributions to the prediction of group membership. Although related psychometrically, they each appear to be making unique contributions to the prediction process. Thus, it would appear that, if possible, it would be desirable to continue to utilize both instruments to assist in making the final diagnosis of autism.

Limitations of the Study

A limitation of this study concerns the relative contribution of each instrument to the prediction. This study found that the CARS seemed to have a slight edge over the ADOS in predicting the diagnosis of autism. However, the order of the listing of relative strength of prediction in DFA is highly dependent on sample characteristics. For example, if this study had been conducted on a sample having slightly different clinical and/or demographic characteristics the order of magnitude of prediction might be different. Hence, it would appear to be very cautious in declaring the superiority of one instrument over the other, especially since the loadings of the factors on the group centroids were generally high for both instruments. Thus, even a few cases could reverse the results.

Another potential limitation is observer bias. The ADOS was given first in the sequence of the evaluation and the CARS last, just before diagnosis was made. It could be argued that anchoring bias regarding diagnosis could occur because the sequence of the administration of the instruments did not vary. In this case, the evaluation team was acutely aware of this possibility

and made a coordinated effort at every clinic to examine all the evidence before agreeing on a diagnosis.

A third potential limitation is that this investigation appears to be a study of the consistency, reliability, and validity of the two instruments in their ability to predict the ultimate diagnosis of autism. However, there are no true external criteria for the diagnosis of autism at this time so this task will be left to future research.

Future Research

The beneficial clinical effects of diagnosing autism cannot be overemphasized. It is important that future studies continue to clarify the factors involved in autism. More factor analytic studies need to be conducted on both instruments. As the work progresses, diagnostic criteria can be clarified, leading to more accurate and quicker diagnosis.

Also, only two modules of the ADOS were compared to the CARS. A larger study could scrutinize the relationship, if any, among all four ADOS modules with the CARS. Clinicians have noted that the relationship appears to decrease between the instruments as the modules increase by number related to language and age. That observation needs to be examined.

In order to assess for bias and the independence of measurement by the instruments, an experimental design could be set up to increase understanding of whether the instruments function independently. For instance, Team One could perform both instruments and Team Two could utilize just one of the instruments in their assessment. The results could then be compared.

Another area that deserves research attention is the ability of both instruments to separate different types of Pervasive Developmental Disorders. It is recognized that autism and other PDD diagnoses appear to exist along a continuum that may predict clinical progress. Does either instrument have the ability to recognize levels of autism and other types of PDD diagnoses?

Finally, for current treatment protocols to be effective, it is critical that children with autism be diagnosed early. This is important clinically because of the effect that early intervention has on the status of children with autism by the time they reach school. Any research that will assist in this goal and in developing effective treatments and measuring progress is crucial for children with autism and their families.

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APPENDICES

APPENDIX A

DSM-IV CRITERIA FOR THE DIAGNOSIS OF AUTISM

A. A total of six (or more) items from (1), (2), and (3), with at least two from (1), and one each from (2) and (3):

1. Qualitative impairment in social interaction, as manifested by at least two of the following:
    a. marked impairment in the use of multiple nonverbal behaviors such as eye-to-eye gaze, facial expression, body postures, and gestures to regulate social interaction.
    b. failure to develop peer relationships appropriate to developmental level.
    c. a lack of spontaneous seeking to share enjoyment, interests, or achievements with other people (e.g., by a lack of showing, bringing, or pointing out objects of interest).
    d. lack of social or emotional reciprocity.

2. Qualitative impairments in communication as manifested by at least one of the following:
    a. delay in, or total lack of, the development of spoken language (not accompanied by an attempt to compensate through alternative modes of communication such as gesture or mime).
    b. in individuals with adequate speech, marked impairment in the ability to initiate of sustain a conversation with others.
    c. stereotyped and repetitive use of language or idiosyncratic language.
    d. lack of varied spontaneous make-believe play or social imitative play appropriate to developmental level.

3. Restricted, repetitive, and stereotyped patterns of behavior, interests, and activities, as manifested by at least one of the following:
    a. encompassing preoccupation with one or more stereotyped and restricted patterns of interest that is abnormal either in intensity or focus.
    b. apparently inflexible adherence to specific, nonfunctional routine or rituals.
    c. stereotyped and repetitive motor mannerisms (e.g., hand or finger flapping or twisting, or complex whole body movements).
    d. persistent preoccupation with parts of objects.

B. Delays or abnormal functioning in at least one of the following areas, with onset prior to age 3 years: (1) social interaction, (2) language as used in social communication, or (3) symbolic or imaginative play.

C. The disturbance is not better accounted for by Rett's disorder or childhood disintegrative disorder.

APPENDIX B

COVARIATION AMONG 15 CARS ITEMS.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
C1	--	.74	.51	.47	.67	.37	.71	.61	.47	.48	.68	.71	.36	.40	.81
C2	.80	--	.47	.45	.66	.33	.65	.60	.47	.45	.75	.76	.31	.51	.78
C3	.61	.57	--	.37	.43	.50	.46	.51	.35	.51	.48	.44	.29	.38	.57
C4	.63	.66	.51	--	.75	.25	.52	.43	.41	.30	.43	.42	.32	.24	.53
C5	.67	.68	.50	.65	--	.41	.69	.58	.47	.42	.63	.64	.35	.48	.72
C6	.53	.50	.73	.37	.45	--	.40	.40	.34	.37	.31	.31	.30	.35	.50
C7	.70	.61	.52	.42	.41	.36	--	.63	.49	.45	.60	.68	.34	.42	.77
C8	.51	.48	.38	.20	.29	.35	.55	--	.48	.44	.56	.62	.32	.42	.68
C9	.29	.44	.43	.31	.40	.34	.35	.52	--	.43	.48	.45	.39	.28	.55
C10	.19	.20	.59	.22	.24	.51	.12	.11	.22	--	.47	.43	.41	.35	.55
C11	.65	.74	.56	.59	.60	.47	.57	.41	.40	.37	--	.74	.29	.55	.77
C12	.72	.74	.57	.60	.68	.34	.52	.37	.40	.23	.72	--	.29	.50	.79
C13	.46	.47	.23	.41	.45	.19	.39	.18	.21	.20	.44	.44	--	.21	.44
C14	.48	.43	.45	.40	.36	.47	.34	.24	.09	.17	.57	.36	.25	--	.56
C15	.89	.79	.67	.72	.71	.56	.70	.43	.36	.30	.70	.77	.44	.46	--

Note. N = 320. Original CARS study lower left; this study upper right. Differences of $\geq$ 0.1 = (.10-.19 = 43, .2.0-.29 = 13, .30 & over = 2)

APPENDIX C

COVARIATION AMONG 12 ADOS, MODULE 1 ITEMS

	A2	A5	A6	A7	A8	B1	B3	B5	B9	B10	B11	B12	COM Total	SOC Total	C+S Total
A2	--	.48	.36	.60	.42	.33	.43	.44	.42	.51	.52	.55	.36	.48	.49
A5	.57	--	.25	.48	.31	.24	.39	.32	.32	.43	.49	.45	.21	.43	.40
A6	.41	.33	--	.39	.27	.09	.31	.26	.18	.28	.29	.27	.18	.25	.25
A7	.63	.48	.34	--	.49	.34	.46	.45	.37	.59	.54	.47	.49	.53	.57
A8	.52	.38	.34	.70	--	.36	.44	.37	.41	.45	.51	.40	.55	.47	.53
B1	.63	.64	.37	.75	.66	--	.49	.43	.54	.53	.42	.46	.57	.74	.73
B3	.51	.72	.43	.65	.57	.78	--	.59	.42	.52	.46	.47	.41	.62	.57
B5	.46	.52	.23	.44	.45	.54	.61	--	.41	.56	.49	.56	.36	.61	.55
B9	.61	.56	.41	.70	.63	.83	.73	.50	--	.58	.44	.52	.58	.69	.70
B10	.60	.59	.32	.65	.61	.62	.70	.47	.59	--	.54	.59	.52	.68	.67
B11	.56	.36	.50	.54	.47	.45	.42	.18	.43	.48	--	.53	.50	.62	.62
B12	.59	.55	.38	.71	.65	.79	.69	.51	.74	.65	.49	--	.45	.64	.61
Ctotal	.75	.75	.62	.83	.80	.79	.74	.54	.78	.70	.62	.76	--	.69	.86
Stotal	.71	.70	.47	.80	.72	.90	.88	.67	.87	.80	.62	.87	.88	--	.94
C+S	.75	.73	.54	.83	.77	.88	.85	.64	.86	.79	.63	.85	.95	.98	--

Note. N = 224. COM/C = Communication; SOC/S = Social; C + S = Communication + Social. Original ADOS study
lower left; this study upper right. Differences of $\geq$0.1 (.10-.19 = 23, .20-.29 = 38, .30 & over = 15).

APPENDIX D

COVARIATION AMONG 12 ADOS, MODULE 2 ITEMS

	A2	A5	A6	A7	A8	B1	B2	B6	B8	B9	B10	B11	COM Total	SOC Total	C+S Total
A2	--	.25	.51	.20	.45	.33	.41	.36	.46	.47	.63	.37	.73	.72	.76
A5	.31	--	.19	.10	.35	.21	.38	.21	.16	.29	.22	.26	.64	.44	.55
A6	.44	.66	--	.21	.48	.25	.46	.30	.51	.69	.60	.34	.58	.65	.64
A7	.49	.43	.54	--	.28	.11	.10	.52	.39	.14	.26	.26	.30	.36	.35
A8	.54	.58	.57	.68	--	.33	.31	.43	.44	.44	.42	.28	.65	.60	.65
B1	.41	.47	.62	.62	.57	--	.44	.21	.23	.25	.26	.09	.47	.59	.56
B2	.63	.54	.53	.61	.67	.61	--	.19	.40	.42	.38	.36	.52	.68	.64
B6	.54	.37	.50	.67	.61	.59	.54	--	.43	.23	.31	.48	.42	.43	.45
B8	.50	.61	.54	.53	.59	.63	.68	.54	--	.50	.62	.46	.46	.68	.61
B9	.56	.64	.60	.50	.57	.57	.66	.61	.64	--	.50	.25	.70	.77	.77
B10	.46	.63	.77	.55	.62	.67	.60	.58	.61	.64	--	.45	.60	.73	.70
B11	.51	.59	.63	.56	.53	.55	.55	.42	.57	.61	.66	--	.39	.55	.53
Ctotal	.72	.75	.81	.80	.86	.68	.76	.69	.70	.73	.76	.71	--	.84	.95
Stotal	.63	.68	.75	.72	.73	.83	.81	.76	.82	.82	.85	.77	.89	--	.97
C+S	.68	.73	.79	.77	.81	.79	.81	.75	.79	.81	.84	.77	.96	.98	--

Note. N = 96. COM/C = Communication; SOC/S = Social; C + S = Communication + Social. Original ADOS study lower left;
this study upper right. Differences of $\geq$ 0.1 (.10-.19 = 29, .20-.29 = 27, .30 & over = 27)

APPENDIX E

FACTOR WEIGHTS ON CARS ITEMS: ROTATED FACTOR SOLUTION, OBLIQUE (PROMAX)

	Factor			
CARS item	Meaningful Communication	Emotional Adaptability	Intellectual Ability	Communalities
C1 Relating to people	**.68**	-.03	.12	.50
C2 Imitation	**.93**	-.10	*.01*	.74
C3 Emotional response	*.01*	**.74**	-.01	.58
C4 Body use	.23	.24	**.47**	.46
C5 Object use	.40	**.50**	-.36	.64
C6 Adaptation to change	-.42	**.97**	-.00	.70
C7 Visual response	**.64**	*.01*	*.01*	.51
C8 Listening response	.30	**.54**	-.20	.54
C9 Taste, smell, touch response	.29	.27	**.40**	.48
C10 Fear or nervousness	**.47**	.11	-.22	.28
C11 Verbal communication	**.85**	-.27	*.01*	.59
C12 Nonverbal communication	**.73**	-.02	-.01	.51
C13 Activity level	-.04	**.71**	.38	.67
C14 Intellectual response	*.01*	.22	**-.89**	.80
C15 General impressions	**.66**	.29	.13	78

APPENDIX F

FACTOR WEIGHTS ON ADOS, MODULE 1 ITEMS: ROTATED FACTOR SOLUTION, OBLIQUE (PROMAX)

ADOS, Module 1 item	Factors: Social Interaction	Factors: Impaired Communication	Communalities
A2 Frequency of vocalization directed to others	.17	**.66**	.61
A5 Stereotyped/idiosyncratic use of words or phrases	*.00*	**.63**	.47
A6 Use of other's body to communicate	(-.37)	**.91**	.56
A7 Pointing	.14	**.71**	.65
A8 Gestures	(.36)	(.37)	.43
B1 Unusual eye contact	**1.0**	(-.35)	.71
B3 Facial expressions directed to others	**.59**	.21	.54
B5 Shared enjoyment in interaction	**.61**	.18	.53
B9 Showing	**.85**	- .12	.60
B10 Spontaneous initiation of joint attention	**.67**	.21	.67
B11 Response to joint attention	(.40)	(.43)	.56
B12 Quality of social overtures	**.59**	.25	.59

APPENDIX G

FACTOR WEIGHTS ON ADOS, MODULE 2 ITEMS: ROTATED FACTOR SOLUTION, OBLIQUE (PROMAX)

ADOS, Module 2 item	Factors: Social Communication	Social Language	Joint Attention	Communalities
A2 Amount of social overtures/ maintenance of attention	**.71**	*.00*	*.00*	.55
A5 Stereotyped/idiosyncratic use of words or phrases	.18	**.82**	*.00*	.57
A6 Conversation	**.89**	*.00*	*.00*	.72
A7 Pointing	*.00*	-.10	**.88**	.74
A8 Descriptive, conventional, instrumental, or informational gestures	.20	**.40**	(.34)	.52
B1 Unusual eye contact	*.00*	**.74**	*.00*	.51
B2 Facial expressions directed to others	(.36)	**.59**	.18	.62
B6 Spontaneous initiation of joint attention	*.00*	.14	**.81**	.73
B8 Quality of social overtures	**.70**	-.13	(.30)	.66
B9 Quality of social response	**.80**	*.00*	-.16	.63
B10 Amount of reciprocal social communication	**.87**	-.11	*.00*	.70
B11 Overall quality of rapport	**.43**	*.00*	.11	.21