MEASURING AUTISM TRAITS IN A WELL-DEFINED SAMPLE: A CONFIRMATORY FACTOR ANALYSIS OF THE SOCIAL RESPONSIVENESS SCALE

by

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(Under the Direction of Jonathan M. Campbell)

ABSTRACT

As autism spectrum disorders (ASD) are being increasingly conceptualized as occurring along a continuum of severity in the general population, empirical investigations of quantitative measures that account for the continuous nature of these traits are warranted. The purpose of the present study was to extend the validity evidence for the Social Responsiveness Scale (SRS), a quantitative measure of ASD symptom severity. The factorial and convergent validity of this measure was assessed based on parent and teacher responses to SRS items regarding the behaviors of a nationwide sample of 2,648 autistic probands. Confirmatory factor analyses indicated that the one-factor model provided the best fit for SRS Parent and Teacher Report data. This finding supports previous exploratory factor analyses conducted with smaller samples of SRS data. Small to moderate correlations between SRS Total and Subscale Scores and ADOS Total and Domain Scores were observed for the current study. Correlations between SRS Parent and Teacher Report Total and Subscale Scores indicated a low to moderate relationship between ratings. Discussion of these findings is presented with respect to ASD diagnosis and treatment.

INDEX WORDS: Social Responsiveness Scale, SRS, Autism spectrum disorder, ASD, Factor analysis

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Chapter One

Introduction

According to the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision* (DSM-IV-TR), pervasive developmental disorders (PDDs) are a group of disorders characterized by deficits in communication and social behavior as well as the presence of restricted and repetitive patterns of behaviors and interests. As conceptualized in the current edition of the DSM, PDDs include Autistic Disorder, Asperger's Disorder, Pervasive Developmental Disorder Not Otherwise Specified (PDD-NOS), Rett's disorder and childhood disintegrative disorder (CDD) (American Psychiatric Association (APA), 2000). Each of the five PDDs share the aforementioned triad of qualitative impairments but differ in terms of the severity and intensity of symptoms and the developmental course of the disorder (APA, 2000; Volkmar, Lord, Bailey, Schultz, & Klin, 2004).

Autism Spectrum Disorder Classification

In the current diagnostic definition, Autistic Disorder (AD) is diagnosed by the presence of restricted repetitive and stereotyped patterns of behavior and interests as well as qualitative impairments in social interaction and communication (APA, 2000). Restricted, repetitive and stereotyped patterns of interests are abnormal in either intensity or focus. Examples of such behaviors include an insistence on sameness, stereotyped body movements (e.g., hand flapping, body rocking) or preoccupation with parts of objects. Additionally, individuals diagnosed with AD must experience a delay or deficit in the development of communication skills. Such impairments may include a delay in spoken language, difficulty with pragmatics, inability to initiate or sustain conversation, as well as abnormal pitch or intonation and difficulties with comprehension (APA). Social impairments characteristic of AD are many and varied and may include difficulties with nonverbal social behaviors (e.g., eye contact), difficulties forming and maintaining friendships and lack of social or emotional reciprocity. Likewise, to receive a diagnosis of AD, an individual must have experienced delays in one of the aforementioned areas prior to age 3 years. As is the case for all PDDs, the symptom severity and developmental course associated with AD is highly variable across affected individuals (APA, 2000).

Asperger's Disorder (AspD) is distinguished from AD by typical early language development; however, individuals diagnosed with AspD experience impairment in social interaction and develop restricted, repetitive patterns of behavior and interests similar to those associated with AD (APA, 2000). Additionally, to receive an AspD diagnosis, an individual must not have experienced any delay in cognitive development or adaptive behavior. The social deficits associated with AspD are similar to those associated with AD; however, social impairment in AspD is more likely to manifest as a one-sided social approach to others rather than disinterest in social interaction (APA, 2000).

The DSM-IV-TR diagnosis of PDD-NOS, or "atypical autism," is primarily utilized when an individual experiences functional impairment stemming from deficits of reciprocal social interaction or communication skills or demonstrates stereotyped behaviors or interests but does not meet criteria for another PDD (APA, 2000). For example, individuals with an age of onset later than three for autistic symptomatology would be diagnosed with PDD-NOS even though they may meet all other diagnostic criteria for AD. As such, individuals within this diagnostic category are heterogeneous with respect to symptom presentation and developmental course (APA, 2000).

Although the DSM-IV-TR currently conceptualizes the disorders under the autism spectrum as differentiable entities, the diagnoses are increasingly being summarized under the single label of ASD. Due to the variability observed in ASD symptom severity and intensity, recent research suggests that deficits associated with ASD are distributed continuously in the general population (Constantino, Pryzbeck, Friesen, & Todd, 2000; Constantino & Todd, 2003). Likewise, subthreshold autistic traits are common in the general population (Constantino & Todd). Symptoms and traits are differentiated in that symptoms exist with varying degrees of severity among those diagnosed with a particular disorder, while traits may be observed to a greater or lesser extent among all individuals (Constantino, 2011). As such, traits are continuously distributed in a population. As a result, individuals not meeting criteria for a diagnosis may still experience functional impairment to a mild degree (Constantino, 2011).

Classification of psychiatric disorders is complex, as are the various systems used to classify disorders. All classification systems are based on distinctions between groups; however, specific schemes differ on important dimensions (Sattler, 2008). A dimensional classification system best addresses disorders based on continuously distributed traits given that, within a dimensional scheme, a disorder involves various degrees of impairment (Sattler, 2008). The alternative to a dimensional classification scheme is a categorical or diagnostic system.

The DSM-IV-TR as well as the ICD-10 are based on a categorical classification system with symptom thresholds and disorder categories that are based primarily on clinical judgment rather than empirical evidence. Within this framework, a clinician must review the symptoms with which an individual presents and determine whether those symptoms fall within a certain diagnostic category (Krueger & Bezdjian, 2009). A specific number of symptoms must be observed in order to make a diagnosis. Likewise, a diagnosis cannot be made unless symptoms are present in the correct combination and number. Within a categorical system, there are no degrees of impairment between disorder and nondisorder (Krueger & Bezdjian, 2009).

While the DSM-IV-TR is the current standard for psychiatric diagnosis, a number of problems are evident with this system. The first problem with categorical classification is the issue of comorbidity. Comorbidity occurs when an individual meets diagnostic criteria for more than one psychiatric disorder (Pennington, 2002). Comorbidity may occur as an artifact of flaws in the diagnostic system or as a result of similar disorder etiologies. If comorbidity is not an artifact of the diagnostic system, categorical boundaries between overlapping disorders may be less appropriate than dimensions of the disorder without categorical boundaries (Pennington, 2002).

Another inherent problem with the DSM classification system is that of heterogeneity within categories. Depending on the number of symptoms required for a diagnosis, it is possible for two individuals diagnosed with the same DSM-IV-TR disorder to not share any common symptoms. As such, individuals with diverse presentations are grouped into a homogeneous category, which has the potential to adversely affect investigations of treatments for the disorder (Krueger & Bezdjian, 2009). Within the text of the DSM-IV-TR, the authors acknowledge the potential for individuals with diverse symptom presentations being categorized under the same disorder (APA, 2000). Finally, the current DSM fails to address subtreshold symptomatology. An individual may experience functional impairment but fall short of the number of symptoms required to receive a diagnosis. Important information is lost by rejecting a diagnosis for such individuals, particularly for traits that are continuously distributed in populations (Krueger & Bezdjian, 2009).

The *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition* (DSM-V) is slated to include dimensional concepts while retaining aspects of the categorical classification framework. According to Georgiades et al. (2007), a dimensional classification system offers several advantages over a categorical scheme, particularly with respect to ASD diagnosis. A dimensional approach to autism classification would empirically define several dimensions of the disorder according to severity. This type of classification scheme would incorporate behavioral symptoms and comorbid impairments, provide organization and clarity for atypical autism presentations, measure symptoms quantitatively and index severity of impairment (Georgiades et al., 2007).

Diagnosis of ASD is currently based on the presence or absence of a disorder with precise symptom thresholds as well as establishing the presence or absence of categorically defined symptoms. A shift from a categorical to a dimensional classification system for autism diagnosis would signal the need for a shift in assessment practices as well as the development of new assessment measures (Bolte, Westerwald, Holtmann, Freitag, & Poustka, 2011). Consequently, the transition to dimensional autism classification will require new instruments to assess ASD traits on a quantitative scale (Constantino & Gruber, 2005). Likewise, if traits associated with ASD are assumed to be normally distributed, it will be necessary to use diagnostic measures standardized with the general population rather than clinical samples (Bolte et al., 2011).

Measurement of Autistic Traits

The social impairments faced by individuals diagnosed with ASDs have been termed deficits in reciprocal social behavior (RSB). Constantino et al. (2003a) define RSB as encompassing the awareness of social cues, appropriate responding to one's own interpretation of those cues and motivation to engage in social interaction with others. The authors further note that RSB is considered the core deficit in ASD. Using an epidemiologic sample of twin pairs, Constantino and Todd (2000) found that, similar to ASD traits in general, RSB is normally distributed. As previously noted, Asperger's Disorder and PDD-NOS can be diagnosed without deficits in language development or the presence of stereotyped behaviors and interests. As such, RSB is the only common required symptom for all ASDs and distinguishes this spectrum of disorders from other psychiatric disorders (Constantino et al., 2003a).

Early identification of ASD has been shown to foster improvement in social, communicative and cognitive skills (Osterling, Dawson, & Munson, 2002). Likewise, early intervention for ASD improves the course and outcome of the disorder (Rogers & Vismara, 2008). These findings support the use of an ASD-specific screening measure for all children during general developmental screening. Screening tools utilizing parent and teacher ratings are particularly useful for identifying children who are in need of a more comprehensive evaluation. Screening instruments are also efficient in that they are relatively easy to administer and score (Wiggins, Bakeman, Adamson, & Robins, 2007). Although several ASD-specific screening instruments have been developed, all are limited.

Most of the available ASD screening measures are based on a categorical classification system. While categorical instruments are appropriate when looking at disorders distributed dichotomously, instruments based on dimensional classification are more appropriate for measuring continuously distributed traits that differ in severity. Developing screening instruments for the "milder" forms of autism is more difficult due to the greater heterogeneity among these disorders (Constantino & Gruber, 2002). Most ASD rating scales were designed to establish a diagnosis of Autistic Disorder and are not adequate to diagnose PDD-NOS or

Asperger's Disorder due to issues of sensitivity. Specifically, the currently available ASD rating scales are not sensitive enough to detect severity. The lack of clarity inherent in the clinical diagnosis of PDD-NOS hinders the development and implementation of successful interventions for the heterogeneous group of individuals affected by the disorder. Likewise, such disagreement has led to debate over the educational services to which children diagnosed with PDD-NOS should be entitled (Constantino & Gruber, 2002).

Rating Scales

The Social Responsiveness Scale (SRS) is a rating scale that was developed to assess "milder" symptoms such as those associated with PDD-NOS and Asperger's Disorder (Constantino & Gruber, 2005). To illustrate further the difference between measures based on categorical versus dimensional classification systems, the SRS can be compared to another ASD rating scale, the Social Communication Questionnaire (SCQ) (Rutter, Bailey, & Lord, 2003). The SCQ is a 40-item parent-report rating scale that utilizes a dichotomous response format for answering questions regarding ASD-specific behaviors. The SCQ is based upon the Autism Diagnostic Interview – Revised (ADI-R) (Lord, Rutter, & LeCouteur, 1994). Scores on the SCQ can range from 0 to 39. In contrast to the SRS, the SCQ Total Score, derived from summing endorsements of ASD symptoms, does not provide an index of symptom severity. Instead, the SCQ utilizes a cutoff score of 15 for ASD, suggesting the presence of an ASD for individuals with SCQ Total Scores greater than or equal to 15 (Rutter et al., 2003). Scores from SCQ ratings do not provide an indication of the functional impairment or level of severity of ASD symptoms. Likewise, the SCQ cannot be used to discriminate among the ASDs, as a score greater than or equal to 15 merely suggests the presence of any ASD (i.e., AD, AspD, or PDD-NOS).

The Social Responsiveness Scale (SRS)

Developed as a resolution to the subjectivity involved with assigning a DSM-IV-TR diagnosis of PDD-NOS, the Social Responsiveness Scale (SRS) was designed as a quantitative measure of ASD symptom severity standardized for rating the social behaviors of children ages 4 to 18 (Constantino & Gruber, 2005). The SRS includes 65 items rated on a 4-point Likert scale, with ratings based on the frequency of occurrence of behaviors. Items are rated on a scale of 1 to 4 and are recoded to scores of 0 to 3 when calculating the raw total score. The SRS is completed by a parent or teacher who has observed the child in a naturalistic social setting for at least two months, which allows for comparison of impairment across home and school settings (Constantino & Gruber, 2005). While the SRS includes items written to investigate communication levels and restricted and repetitive behaviors and interests typical of individuals diagnosed with ASD, the instrument predominantly focuses on deficits in reciprocal social behavior (RSB). The SRS is appropriate for use as an ASD screening measure or as part of a diagnostic assessment (Constantino & Gruber, 2005).

The SRS Total Score, expressed as both a raw score and transformed to a T score, is an index of severity of social deficits (Constantino & Gruber, 2005). Authors identify the Total Score as useful for screening and diagnosis; however, the SRS also features: Social Awareness, Social Cognition, Social Communication, Social Motivation and Autistic Mannerisms subscales. Subscales for the SRS were developed via rational item grouping and were cross-validated by expert panel review. Although test authors emphasize interpretation at the level of SRS Total Score, authors explain that the subscales may be used in designing and evaluating the effects of treatment programs (Constantino & Gruber, 2005). Total scores between 60 and 80 indicate clinically significant deficits in RSB while scores above 80 suggest even greater impairment in daily social interactions (Constantino & Gruber, 2005).

Items on the SRS were developed by the author based on clinical experience with children diagnosed with ASD. Test development of the SRS further included a review of item face validity by a panel of experts. Authors attempted to reduce the number of items on the SRS for greater efficiency; however, item reduction decreased the ability of the measure to distinguish between individuals with PDD-NOS and typical controls (Constantino & Gruber, 2005).

The SRS was standardized on over 1,600 children ages 4 to 18 from the general population with data generated from five studies (Constantino & Gruber, 2005). While population-based samples are less prone to referral biases common in clinical samples, population samples also include few individuals with clinically significant levels of symptomatology for low base-rate disorders; therefore, results of the initial SRS standardization should be interpreted with that limitation in mind. Data from the first four samples were based on parent ratings, while teacher ratings were the basis for the fifth sample. The authors conducted ANOVA analyses to test SRS Total score means in the five samples, as well as for gender, rater and age subgroups (Constantino & Gruber, 2005). Gender and rater showed demographic effects; therefore, separate norms for males and females and teachers and parents are provided for the SRS. The authors reported no relationship between age and SRS Total scores in the standardization samples (Constantino & Gruber, 2005). Norms for the SRS were created based on data collected from standardization samples. Scores were normally distributed in these samples, likely due to Likert-type response format and the large number of items. (Constantino & Gruber, 2005).

The SRS contains several features absent among other ASD measures. The SRS is the only published instrument to measure the severity of deficits in RSB. The SRS is one of few instruments available to measure PDD-NOS and Asperger's Disorder symptoms and is the only one of such instruments available that does not measure the categorical presence or absence of these disorders.

Factor Analysis

The purpose of factor analysis is to identify or understand latent constructs underlying the variables under study. Factor analysis is differentiated from component analysis in that the procedure only analyzes variance shared by the variables whereas principal component analysis (PCA) analyzes all variance (Bandalos & Finney, 2010). The purpose of PCA is data reduction with preservation of the original data to the extent possible, while EFA aims to identify latent constructs underlying a dataset. The components extracted from a PCA are not latent constructs and cannot be characterized as factors (Norris & Lecavalier, 2010). Norris and Lecavalier (2010) noted that although PCA methods are reported throughout the psychological literature, such methods are misunderstood and often misused.

Factor analysis is segmented into exploratory and confirmatory analyses. The purpose of exploratory factor analysis (EFA) is to identify latent constructs or generate hypotheses about the structures of those constructs. Confirmatory factor analysis (CFA) is used to evaluate the hypothesized structures of constructs or to better understand those structures. As such, EFA is used to develop theory, while CFA is used to test theories (Floyd & Widaman, 1995). Like PCA methods, EFA models have been criticized. Within the EFA model, factor scores cannot be calculated, an issue referred to as the “indeterminacy problem” of EFA. Likewise, EFA methods have the potential to produce communality estimates greater than 1, suggesting that a variable explains more than 100% of the variance (Floyd & Widaman, 1995).

The central concern when using EFA is the many subjective decisions that must be made throughout the analysis (e.g., number of factors to retain, method of rotation to utilize); however, this is the most appropriate procedure when only minimal research has been conducted on the structure of the measure (Bandalos & Finney, 2010). The decision on the final number of factors to retain is subjective, although "rules of thumb" are available to assist researchers with the decision (Norris & Lecavalier, 2010).

Extraction in a factor analysis refers to the methods and process by which the parameters of the factor solution are determined (Bandalos & Finney, 2010). The two procedures most often used for extraction in factor analysis are principal axis (PA) and maximum likelihood (ML). Maximum likelihood is inferential in that the method takes into account that the analysis is being conducted on a sample rather than a population and attempts to discover the solution that best represents the population correlation values. In contrast, PA methods attempt to minimize the residuals between the original correlation matrix and the factor correlations (Bandalos & Finney, 2010). Another decision that must be made by the researcher is determining the number of factors to retain. Numerous procedures and "rules of thumb" are available to aid the researcher in determining the number of factors to retain. Bandalos and Finney (2010) cautioned that the decision about the number of factors to retain should be made using multiple criteria.

Finally, the researcher must make a decision as to the appropriate method of rotation to employ. Rotation methods are either orthogonal or oblique. Orthogonal rotations produce uncorrelated factors, while oblique rotations produce correlated factors. The basis for deciding which type of rotation to use is whether the dimensions of the construct under study are correlated (Bandalos & Finney, 2010). As Bandalos and Finney (2010) noted, most constructs studied in the social and behavioral sciences are correlated. An oblique rotation is self-correcting in that, if it is applied inappropriately, an orthogonal solution will result. As such, without hypotheses suggesting that the constructs are uncorrelated, researchers are encouraged to use an oblique rotation (Bandalos & Finney, 2010).

Although both methods have useful objectives, PCA and EFA procedures are not appropriate for investigating the latent constructs of a measure with a previously hypothesized factor structure. Likewise, given the variability in methodology used in previous attempts to determine the factor structure of the SRS, a re-examination of the measure is warranted.

Prior Studies Investigating the Factor Structure of the SRS

In the first published study to examine the factor structure of the SRS, Constantino et al. (2000) utilized the SRS Teacher Report measure. The authors utilized a sample of 445 school-age children, including both typical controls and participants with psychiatric diagnoses. Using principal component analysis (PCA), the authors determined that one factor explained 70% of the total variance in SRS Teacher Report Total Scores (Constantino et al., 2000). As discussed previously, PCA is a method primarily used for data reduction rather than as a procedure for determining the latent constructs of a set of variables. As such, EFA would have been a more appropriate method of investigating the facture structure of the SRS Teacher Report.

Constantino, Hudziak, and Todd (2003b) further investigated the factor structure of the SRS by utilizing PCA with SRS Parent Report Total Scores. The authors collected SRS Parent Report data from mothers and fathers of 219 male twin pairs. While the analysis yielded 15 factors, results of the PCA suggested that the most appropriate factor solution involved retaining only one factor. The one factor solution explained 20% of the total variance in SRS Parent Report Total Scores, and the remaining factors each explained less than 5% of the total variance (Constantino et al., 2003b). The PCA method was used inappropriately by Constantino et al. (2003b), as the authors aimed to investigate the latent structure of the SRS Parent Report. The authors also interpreted the PCA as if it were an EFA by labeling the components as factors. Neither Constantino et al. (2000) nor Constantino et al. (2003b) reported methods of extraction used or rotation procedures employed. Bandalos and Finney (2010) noted the importance of reporting and justifying the use of specific procedures used in a factor or component analysis including the method of extraction, the methods used to determine the number of factors to retain and the method of rotation.

Constantino et al. (2004) investigated the factor structure of the SRS, combining Teacher and Parent Report ratings. The authors recruited a sample (N = 226) including participants with a confirmed PDD diagnosis as well as a clinical subgroup of participants with non-PDD diagnoses. Authors employed PCA with a varimax rotation. While the method of extraction was not reported, Constantino et al. determined that a one-factor solution explained 35% of the total variance in combined SRS Teacher and Parent Report Total Scores. The authors justified their use of PCA by reporting that the procedure had been used in previous investigations of the SRS (i.e., Constantino et al., 2000; Constantino, Hudziak, & Todd, 2003). They further noted that PCA is used to reduce the number of variables in a dataset by producing a smaller set of components or factors that account for the variance among the larger set of variables. While the assertions made by the authors are accurate, components produced by PCA should not be interpreted as factors. Additionally, Constantino et al. (2004) employed a varimax rotation, which is categorized as an orthogonal method. Items on the SRS are hypothesized to be correlated; therefore, an oblique rotation would have been more appropriate. Authors noted that confirmatory factor analytic techniques should be employed to test the goodness of fit of SRS data to a single factor model with a larger sample (Constantino et al., 2004).

Bolte, Poustka, and Constantino (2008) examined the German translation of the SRS Parent Report with a large population sample (*N* = 1,426), including typical control and clinical groups. The authors conducted separate PCAs for normative mother and father ratings as well as for the clinical ratings, using the scree criterion for factor extraction. Examination of the scree plot led the authors to retain one factor for each of the three PCAs; however, the percentage of total variance in SRS Total Scores explained by the first factor differed among subsamples. The first factor explained 34.9% of the total variance for maternal and paternal SRS ratings for the clinical group, while one factor explained 17.9% and 16.5% of the variance in paternal and maternal ratings for the typical control group. The single factor underlying the three domains of ASD symptomatology is considered by the authors to be RSB (Constantino et al., 2003a). In contrast to previous studies of the SRS, Bolte et al. (2008) reported the method used to determine the number of factors to retain. Similar to previous studies, the authors inappropriately employed PCA rather than EFA to examine the factor structure of the SRS. The authors did not report the method of rotation employed.

The most recent study to investigate the factor structure of the SRS utilized an epidemiological sample of participants from a longitudinal study in the United Kingdom (*N* = 500). The authors conducted a PCA with SRS Parent Report scores, using the eigenvalue greater than one rule for factor extraction. The authors determined that a one factor solution explaining 19% of the total variance was most appropriate for their data. No information regarding method of rotation was reported (Schanding, Nowell, and Goin-Kochel, in press). Findings from these studies are summarized in Table 1.

Convergent and Discriminant Validity of the SRS

Several studies have examined the convergent validity of the SRS with measures of ASD-specific symptoms as well as with measures of general social-emotional functioning (Table 2). Murray, Mayes, and Smith (2011) examined the convergent validity of the SRS Parent Report and the ADI-R. The authors reported that correlations between SRS Total raw scores and ADI-R Total raw scores were nonsignificant (Murray et al., 2011). Likewise, Pine, Luby, Abbacchi, and Constantino (2006) examined the inter-rater reliability between teacher and mother ratings of child behavior on the preschool version of the SRS. The authors reported a strong significant correlation between mother and teacher ratings (Pine et al., 2006). In contrast, Schanding, Nowell, and Goin-Kochel (in press) found small to moderate correlations between SRS Parent and Teacher Report and ADI-R Total and subscale scores in a sample of 3,375 children diagnosed with ASD and their unaffected siblings.

Bolte et al. (2008) and Bolte et al. (2011) examined the convergent validity of the German version of the SRS Parent Report with the Autism Diagnostic Interview – Revised (ADI-R), the Autism Diagnostic Observation Schedule (ADOS) and the Social Communication Questionnaire (SCQ). Both studies found moderate to high significant correlations between the SRS Parent Report Total Score and the Social Interaction, Communication, and Stereotyped Behavior scales of the ADI-R and the ADOS Social domain score. Likewise, both studies found high correlations between the SRS Total Score and the SCQ Total Score, suggesting that the instruments are measuring similar constructs. Schanding et al. (in press) examined the convergent validity of the SRS Parent Report and the SCQ – Lifetime Form and the SRS Teacher Report and the SCQ – Current Form. The authors reported a strong correlation between the SRS Teacher and the SCQ – Current and a moderate correlation between the SRS Parent and the SCQ

– Lifetime (Schanding et al., in press). Granader et al. (2010) also found a strong significant correlation between the SRS Parent Report and the SCQ in a sample of children diagnosed with tuberous sclerosis ($N = 21$). The higher correlation between the SRS and SCQ compared to those between the SRS and the ADI-R and ADOS is expected given that both the SRS and SCQ are parent-report rating scales (Bolte et al., 2008).

In an investigation of 445 participants, Constantino et al. (2000) examined the convergent validity of the SRS with the Child Behavior Checklist (CBCL), a general measure of child psychiatric symptomatology. The authors found high correlations between SRS Total Scores and the CBCL Total Problems scale ($r = .61$), the CBCL Social Problems scale ($r = .57$) and the CBCL Attention Problems scale ($r = .57$) (Constantino et al, 2000). Constantino et al. (2003b) also compared the SRS Total Score with the CBCL syndrome scales using regression analyses. Results suggested that CBCL syndrome scale scores accounted for 43% of the total variance in SRS scores (Constantino et al., 2003b).

Two studies support the criterion validity of the SRS, or the ability of the measure to differentiate individuals with ASD from both normal controls and those meeting criteria for other psychiatric diagnoses. Constantino et al. (2000) found that participants with a PDD diagnosis scored significantly higher via SRS Teacher Report ratings than non-PDD psychiatric controls ($p < 0.01$). Likewise, using the German version of the SRS Parent Report, Bolte et al. (2008) found that, with the exception of item 43 (“Separates easily from caregivers”), all SRS items discriminated between participants diagnosed with ASD and participants from the psychiatric control group ($p < 0.04$). Results suggested that the SRS Total score also discriminated between participants in the ASD group and the psychiatric control group ($p < 0.01$) (Bolte et al., 2008).

Inter-rater Reliability of the SRS

Inter-rater reliability, or the relationship between scores of independent raters, is an important consideration for third-party rating scales and has been examined for ratings on the SRS Parent and Teacher Report. Constantino et al. (2003a) employed Pearson's correlations to investigate the relationships among mother, father and teacher ratings of child behavior with a sample of 61 clinically referred children, 40 of whom carried ASD diagnoses. Authors reported strong inter-rater reliability among mother, father and teacher ratings with correlations ranging from 0.75 to 0.91 (Constantino et al., 2003a). Similarly, Constantino et al. (2007) found strong correlations between parent and teacher report on the SRS for a large clinical sample (N = 577) of children with and without ASD. In contrast, Schanding et al. (in press) found only a small significant correlation (r = .27) between SRS Parent and Teacher Report ratings for children diagnosed with ASD and their unaffected siblings.

Bolte et al. (2008) utilized Pearson's correlations to investigate the inter-rater reliability between mother and father ratings with the German adaptation of the SRS for both normative and clinical samples. The authors reported a correlation of 0.97 between mother and father SRS ratings in the clinical sample (n = 172) and a correlation of 0.76 for the normative sample (n = 427). Pine et al. (2006) examined the inter-rater reliability of parent and teacher ratings of child behavior with a sample of preschoolers with and without ASD. Using ratings on the preschool version of the SRS Parent and Teacher Report, the authors reported a strong correlation (r = 0.75) between teacher and mother ratings (Pine et al., 2006).

Purpose of the Present Study

The purpose of the present study is to further investigate the factor structure of the SRS via confirmatory factor analysis using data from a large national sample. Additionally, the purpose of the study is to examine the convergent validity of the SRS with the Autism Diagnostic Observation Schedule (ADOS), a current "gold standard" ASD assessment instrument (Lord, Rutter, DiLavore, & Risi, 1999). The study contributes new knowledge to the literature on the SRS by (a) utilizing confirmatory factor analysis with SRS item-level data, (b) further examining the convergent validity of the SRS by exploring its relationship with the ADOS, a well-established measure of autism symptomatology, and (c) further examining inter-rater reliability of the SRS for parents and teachers. The current study seeks to answer the following research questions:

(a) Does a single underlying factor best explain the shared variance among SRS Parent and Teacher Report items or is a five-factor model more appropriate?

(b) How well do SRS Parent and Teacher Report Total Scores correlate with ADOS Total Scores?

(c) How well do SRS Parent and Teacher scores correlate with one another?

Chapter Two

Method

Participants

The sample for the current study consisted of 2,648 families participating in a national genetic and phenotypic data collection (Fishbach & Lord, 2010). The 2,648 autistic probands consisted of 86.8% (*n* = 2298) males and 13.2% (*n* = 350) females. Proband age was reported at the time of Autism Diagnostic Observation Schedule (ADOS) administration. The minimum proband age was 48 months and the maximum age was 18 years old at the time of ADOS administration with an overall mean of 108.48 months (*SD* = 42.90). Proband ethnicities were 78.4% (*n* = 2077) White; 7.9% (*n* = 209) More than one race; 4.5% (*n* = 120) Other; 4.2% (n = 111) Asian; 3.9% (*n* = 103) African-American; 0.8% (*n* = 20) Not specified; 0.2% (*n* = 6) Native-American; and 0.1% (*n* = 2) Native-Hawaiian. Additionally, 11.1% (*n* = 295) of autistic probands were of Hispanic origin. The mean Full Scale IQ of probands was 81.2 (*SD* = 27.9).

Inclusion Criteria

Participant inclusion was based on criteria determined by the Simons Foundation Autism Research Initiative (SFARI) investigators. Children selected to participate in the Simons Simplex Collection assessment were required to be between the ages of 4 years and 17 years, 11 months at the time of evaluation. In order to be included in the dataset, participants must have received an Autism Diagnostic Interview – Revised (ADI-R) rating above the cutoff for the Social and Communication domains. Participants were also included if they met the cutoff for one domain and were within 2 points of the cutoff for the other, or if they were 1 point from the cutoff for both domains of the ADI-R. Additionally, participants were required to meet cutoff scores for autism spectrum or autism on the

Autism Diagnostic Observation Schedule (ADOS) for inclusion. Inclusion criteria for cognitive abilities varied by age. Participants age 4 years were required to have a nonverbal IQ score greater than or equal to 60, participants ages 5-8 were required to have a nonverbal IQ score greater than or equal to 40, and those ages 8 years and older were required to have a nonverbal mental age of 36 months or older, as measured by standardized cognitive assessment instruments. Likewise, participants were required to have a "best estimate diagnosis" of Autistic Disorder, Asperger's Disorder, or PDD-NOS as per the DSM-IV-TR diagnostic criteria. Finally, the biological parents and at least one sibling of the participant must not have been diagnosed with an ASD for inclusion.

Exclusion Criteria

Participant exclusion criteria were also developed by SFARI researchers. Children were excluded from the study if they were delivered at fewer than 36 weeks gestation, experienced significant birth complications or weighed less than 2,000 grams at birth. Participants diagnosed with Down Syndrome or for whom genetic testing had confirmed a diagnosis of Fragile X Syndrome were excluded. Likewise, children with a history of severe nutritional or psychological deprivation or those with sensory or motor difficulties that would preclude the valid use of diagnostic instruments were excluded.

Data Collection

The current study utilizes extant data. These data were collected by the Simons Foundation as part of a nationwide study to examine linkages between genotype and phenotypic features of children who are well-characterized as having autism. Per SFARI procedures, identifying information is excluded from the database made available for researchers. The researchers were granted access to the database of phenotypic variables by the Simons Foundation. The analyses conducted as part of the current study utilized Version 13 of the Simons Simplex Collection, which included data from 226 new families that were not included in previous versions of the dataset. One primary caregiver completed the SRS Parent

Report and one teacher completed the SRS Teacher Report for each proband. Protocols were scored and recorded by SFARI researchers.

Analysis Logic and Procedures

Confirmatory factor analysis (CFA) comprised the majority of the analyses. Confirmatory factor analysis is a specific method within the family of structural equation models (SEM). Confirmatory factor analysis was deemed appropriate given that the goal of the analysis was to evaluate the hypothesized structure of the latent constructs underlying the SRS (Bandalos & Finney, 2010). Despite being designed to measure theoretically continuous latent constructs, items on the SRS are ordinally scaled (e.g., 0 = *Not True*, 1 = *Sometimes True*, 3 = *Often True*, 4 = *Almost Always True*). The most common type of model parameter estimation used in CFA is maximum likelihood (ML). The ML estimator is the default estimator for CFA in most statistical software programs and assumes multivariate normality, meaning that indicators are continuous and normally distributed. Use of ML estimation when fitting CFA models for ordered categorical data, such as SRS item-level data, may lead to problems with fit and violation of the assumptions underlying the statistical model (Flora & Curran, 2004). As such, use of ML estimation was deemed inappropriate for SRS item data.

Problems with using ML estimation with categorical indicators include: inflation of the chi-square model fit statistic, underestimation of parameters, and biased standard error estimates (Muthen & Kaplan, 1992). In order to conduct a CFA with categorical variables, polychoric correlations are employed rather than covariances, as used in ML estimation. A polychoric correlation estimates the relationship between two categorical variables, assuming that the observed values represent one or more continuously distributed latent variables (Flora & Curran, 2004).

Based on previous PCAs utilizing SRS Parent and Teacher Report scores (Bolte et al., 2008; Constantino et al., 2000; Constantino et al., 2003b; Constantino et al., 2004; Wigham et al., 2012), the researchers hypothesized that a one-factor solution would provide the best fit for the data. A one-factor CFA was conducted at the item level using ordered-categorical data to determine whether variance in item scores could be better accounted for by a single underlying latent factor. A five-factor model was also investigated given that five subscales (i.e., Social Awareness, Social Cognition, Social Communication, Social Motivation and Autistic Mannerisms) purported to measure domains of ASD symptomatology are derived from SRS item ratings (Constantino & Gruber, 2005).

In order to measure the convergent validity of the SRS, or the relationship between measures designed to tap similar constructs across varied methods, Pearson's correlations were employed. To determine if the relationship between SRS Parent and Teacher Report Total Scores and ADOS Total Scores differs across age groups, Pearson's correlations between SRS Parent and Teacher Report Total Scores and ADOS Total Scores were calculated separately for participants completing each ADOS Module. Pearson's correlations were also calculated between SRS Parent and Teacher Total and Subscale Scores to investigate the inter-rater reliability between parent and teacher ratings.

Chapter Three

Results

Descriptive Statistics

Simons Foundation researchers configured the database to calculate the Parent or Teacher SRS raw scores if ten or fewer items were missing. In situations in which ten or fewer items were missing from one form, the raw score was calculated with the missing items scored as zero.

Descriptive statistics for each item are presented in Table 3. Examination of descriptive statistics indicated that responses to Item 59 for both Parent and Teacher Report were considerably non-normal as evidenced by skewness and kurtosis values greater than |2.0|. Additionally, responses to Item 57 on the SRS Teacher Report were significantly kurtotic. Upon examination, the researchers determined that these cases should remain in the data set given the large sample size and lack of theoretical justification suggesting otherwise.

Confirmatory Factor Analyses

The statistical software package Mplus Version 6 (Muthen & Muthen, 2010) was used for all CFAs. Based on previous EFAs utilizing SRS Parent and Teacher Report Total Scores, the researchers hypothesized that a one-factor solution would provide the best fit for the data. A five-factor model was also investigated given that five subscales purportedly measuring domains of ASD symptomatology are estimated by SRS ratings. Confirmatory factor analyses were conducted with item-level ordered-categorical data for both Parent and Teacher Report data. Means and Variance Adjusted Weighted Least Square (WLSMV) estimator was employed. For all CFAs, each item loaded on only one factor and measurement errors were uncorrelated. Latent variables were standardized to a mean of 0 and a standard deviation of 1 prior to analysis.

In order to estimate and compare the fit of competing models, the Root Mean Square Error of Approximation (*RMSEA*; Steiger & Lind, 1980) and the Comparative Fit Index (*CFI*; Bentler, 1990) were employed. The RMSEA estimates how well the model would fit the population correlation matrix if it were to exist and represents a lack of fit. Both the RMSEA and the CFI are calculated independent of sample size. Hu and Bentler (1999) recommend that a RMSEA value of .06 serve as an upper boundary for demonstrating an acceptable fit. The authors also suggest that CFI values ≥ .95 are indicative of good model fit (Hu & Bentler, 1999). Fit index values for each of the tested models are presented in Table 5.

The RMSEA value of 0.045 for the one-factor model indicates that the solution provides a "good" fit for the SRS Parent Report data, based on the criteria according to Hu and Bentler (1999). The five-factor model of the SRS Parent Report data also provided a good fit for the data, with a slightly higher RMSEA value (RMSEA = 0.051). The one-factor model representing SRS Teacher Report ratings also provided a better fit to the data when compared to the five factor-model (RMSEA = 0.072; RMSEA = 0.091); however, neither of the RMSEA values were in the acceptable range. The CFI values for both Parent and Teacher Report models fell below Hu and Bentler's ≥ .95 criterion. Nonetheless, the models indicated as the best fit by the RMSEA values were also supported by CFI values.

Item factor loadings and standard errors are reported in Table 6. In CFAs with continuous indicators, r-square values are interpreted as the proportion of variance explained by each factor; however, r-square values are not interpreted in this way when indicator variables are categorical. As such, r-square values are not reported.

Convergent Validity

SPSS 19.0 was used for Pearson correlations between SRS Parent and Teacher Total and Subscale Scores and ADOS Domain and Total Scores. The SRS Parent and Teacher Report Total Scores correlated positively and significantly ($p<.01$) with ADOS Total Scores for Modules 1-3. Although significant, correlations were weak in magnitude with the exception of the correlation between Teacher SRS Total Scores and ADOS Module 2 scores ($r = .360$). SRS Parent and Teacher Report Total Scores were not correlated significantly with ADOS Module 4 Total Scores. Of note, sample sizes for Module 4 were significantly smaller than for Modules 1-3. SRS Parent Report data were present for 72 cases, while only 15 cases included SRS Teacher Report data. Correlations between SRS Subscale and Total Scores and ADOS Domain and Total Scores are reported in Tables 9-16.

Inter-rater Reliability

Inter-rater reliability was calculated via correlations between SRS Parent and Teacher Report Total and Subscale Scores. All correlations were significant at the $p < .01$ level. The strength of the correlations was small in magnitude with the exception of the relationship between SRS Parent and Teacher Total Scores ($r = .301$), between SRS Parent and Teacher Report Social Communication Subscale Scores ($r = .310$), and between SRS Teacher Report Total Score and Parent Report Social Communication Subscale score ($r = .305$).

Chapter Four

Discussion and Conclusions

Although the DSM-IV-TR currently conceptualizes the disorders under the autism spectrum as differentiable entities, the diagnoses are being summarized increasingly under the single label of ASD. Due to the variability observed in ASD symptom severity and intensity, recent research suggests that deficits associated with ASD are distributed continuously in the general population (Constantino et al., 2000; Constantino & Todd, 2003). The proposed transition from categorical to dimensional DSM-V diagnostic criteria for ASDs has underscored the need for further examination of diagnostic and screening instruments based on a continuous distribution of ASD symptomatology. Most of the available third-party rating scales designed to detect ASD symptomatology are based on a categorical classification system; however, instruments based on dimensional classification are more appropriate for measuring continuously distributed traits that differ in severity.

The primary purpose of the present investigation was to examine the factor structure of the SRS, a quantitative third-party rating scale designed to assess ASD symptom severity in children and adolescents. As such, researchers aimed to determine if a one-factor model, with a single latent factor as suggested in previous studies of the SRS, or a five-factor model, with five latent factors representing each of the rationally derived subscales of the SRS, provided a better fit for the data. Additionally, researchers sought to investigate the convergent validity of the SRS Parent and Teacher Report with the ADOS, a measure considered the “gold standard” in ASD assessment. Researchers also investigated the inter-rater reliability between ratings on the SRS Parent and Teacher Report.

Consistent with findings from previous exploratory factor analyses of the SRS conducted with samples including both typical and clinical samples (Bolte et al., 2008; Constantino et al., 2000;

Constantino et al., 2003b; Constantino et al., 2004), examination of confirmatory factor analyses in the current study with confirmed ASD cases indicated that a one-factor model provided a better fit for both the SRS Parent and Teacher Report data when compared to the rationally derived five-factor model. As such, the results of the current study indicate a lack of evidence for the existence of five latent traits underlying ASD symptomatology, as suggested by the five independent subscales of the SRS (Constantino & Gruber, 2005). Deficits in domains considered independent by SRS authors may be attributable to a single latent variable (Constantino & Gruber, 2005).

Previous investigations of the convergent validity of the SRS and ADOS have combined ADOS scores across modules for correlational analyses (Bolte et al., 2008; Bolte et al., 2011). While combining scores from different ADOS modules increases the sample size available for each analysis, the magnitude of the scores may be artificially dampened due to the developmental variability among participants for whom different modules of the ADOS are appropriate. As such, Pearson's correlations between SRS and ADOS data were conducted separately for each ADOS module in the current study. The analyses were conducted separately by ADOS module in an effort to ascertain whether the relationship between SRS and ADOS scores differs across developmental groups, for which ADOS module served as a proxy.

A pattern of stronger correlations between SRS Teacher Report Total Score and ADOS Total Score when compared with the SRS Parent Report – ADOS correlations emerged across ADOS Module groups. This finding may indicate that teachers and clinicians administering the ADOS are more congruent in their observations and interpretations of child behavior than parents and clinicians. Likewise, correlations between SRS Parent Report Total Scores and ADOS Total Scores for Modules 3 and 4 were lower compared with the SRS Parent – ADOS correlations for Modules 1 and 2; however, the same pattern was not observed for SRS Teacher – ADOS correlations across groups. This finding may indicate that parent access to or interpretation of child behavior is more discrepant from teacher and clinician interpretation for older children and adolescents.

Previous investigation of inter-rater reliability for the SRS Parent and Teacher Report with a sample of clinically referred children with and without ASD diagnoses indicated strong correlations among mother, father and teacher ratings. Low correlations between parent and teacher subscale and total scores were expected given that interactions between students and parents and teachers occur in different environments.

Implications for Use of the Social Responsiveness Scale

In light of results of the current study confirming a one-factor model for SRS Parent and Teacher Report data along with EFAs in previous studies supporting a unitary latent factor underlying SRS data, use of SRS clinical subscale scores versus total score is questionable (Bolte et al., 2008; Constantino et al., 2000; Constantino et al., 2003b) . Subscales for the SRS were developed via rational item analysis and, to date, no factor analytic evidence supporting the validity of the subscales exists (Constantino & Gruber, 2005). Authors explain that the subscales may be used in designing and evaluating the effects of treatment programs; however, factor analysis of SRS data in the current and previous studies does not support the interpretation of discrete subscales for the SRS (Constantino & Gruber, 2005; Bolte et al., 2008; Constantino et al., 2000; Constantino et al., 2003b).

An additional implication for use of the SRS involves the age-dependent changes in ADOS – SRS correspondence observed for the current sample. As mentioned previously, correlations between SRS Parent Report Total Scores and ADOS Total Scores for Modules 3 and 4 were lower compared with the SRS Parent – ADOS correlations for Modules 1 and 2, while the same pattern was not observed for SRS Teacher – ADOS correlations. Such findings imply that obtaining SRS Teacher Report data may become more important for older children and adolescents as part of a diagnostic assessment.

Despite previous findings of strong correlations between SRS Parent and Teacher Report ratings (Constantino et al., 2003a), low inter-rater reliability observed in the current study underscores the importance of collecting assessment data across informants and settings. In a meta-analysis of 119 studies with ratings of child behavior across informants, Achenbach, McConaughy, and Howell (1987) observed only modest mean correlations for different types of informants. As such, Achenbach et al. recommend obtaining data from more than one informant of a particular type to account for variations in functioning across settings. Examination of data from multiple informants appears particularly important because some parent – ADOS correlations were low when compared to teacher – ADOS correlations in the current study.

Limitations and Directions for Future Research

Regarding limitations, generalization of the results of the current study may be limited. Results should be interpreted keeping in mind the difficulties inherent in using a population-based measure with a sample of confirmed ASD cases. The sample sizes were large, which is necessary for factor analysis; however, the sample only included participants with confirmed ASD diagnoses. A related limitation was the distribution of developmental levels for the current study. The majority of participants were administered ADOS Modules 2 and 3, with significantly fewer participants in the Modules 1 and 4 groups. Results of the correlational analyses for the Module 1 and 4 subgroups may be affected by the small samples available within each group. Likewise, the sample utilized in the current study was not representative of the U.S. population with regards to racial composition, which is likely due to recruitment through research centers rather than community settings, and with regards to the number of female participants included in the sample. Future research is warranted to further examine the clinical validity of the SRS, specifically as an ASD screening tool and as an indicator of ASD severity. Future investigations of the factor structure of the SRS utilizing confirmatory factor analysis with a large, population-based sample will be necessary to identify whether the one-factor model provides the best fit for those data. Further research is also needed regarding the predictive validity of the SRS for ASD diagnosis, as this line of investigation could provide further evidence for use of the SRS as an ASD screener. Additionally, the investigators of the current study intend to conduct multi-group CFAs with SRS Parent and Teacher Report data across both gender and level of IQ. A multi-group CFA across IQ levels is important particularly in light of the lower correlations observed between SRS and ADOS scores for older, higher functioning individuals in the current study.

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Table 1

Social Responsiveness Scale Factorial Validity Studies

Study	Sample	Form	Factor Analysis	Rotation	Method of extraction	Number of Factors Retained	% Variance explained by each factor
Bolte, Poustka, & Constantino (2008)	*N*= 1436 (*n*=838 typical controls, *n=367* clinical controls; *n*=160 clinical ASD)	Parent, German version	PCA	Varimax	Scree criterion	1 factor for each of the 3 PCAs	clinical sample: 1 factor explained 34.9%; normative mother rating sample: 1 factor explained 17.9%; normative father rating sample: 1 factor explained 16.5%
Constantino et al. (2000)	*N*=445 (*n*=287 school sample of typical controls, *n*=158 child psychiatric sample)	Teacher	PCA	Not Reported	Not reported	1 factor (school sample)	1 factor explained 70% of the variance for school sample
Constantino, Hudziak, & Todd (2003b)	Epidemiological sample of male twins (*N*=219 twin pairs)	Parent (Maternal and Paternal ratings not differentiated)	PCA	Not reported	Not reported	1 factor	1 factor explained 20% of the total variance
Constantino et al. (2004)	Clinical participants with and without PDD diagnosis (*N* = 226)	Parent and Teacher, combined	PCA	Varimax	Not reported	1 factor	1 factor explained 35% of the total variance

Wigham, McConachie, Tandos, & Le Couteur (2012)	Epidemiological sample of children ages 5-8 from a UK longitudinal study (*N* = 500	Parent (Maternal and Paternal ratings not differentiated)	PCA	Not reported	Eigenvalue >1	1 factor	1 factor explained 19% of the variance

Table 2

Social Responsiveness Scale Convergent and Discriminant Validity

Study	Sample	Form	Convergent Validity	Discriminant Validity
Bolte, Poustka, & Constantino (2008)	*N*= 1436 (*n*=838 typical controls, *n=367* clinical controls; *n*=160 clinical ASD)	Parent, German version	Between SRS and ADI-R domain scores (*r*=0.46 for social interaction, *r*=0.40 for communication, *r*=0.38 for stereotyped behavior), ADOS social domain score (*r*=0.35), SCQ total score (*r*=0.58)	N/A
Bolte, Westerwald, Holtmann, Freitag, & Poustka (2011)	*N*= 480 (*n*=148 clinical ASD, *n*=225 clinical controls, *n*=77 typical controls	Parent, German version	Between SRS and ADI-R domain scores (*r*=0.45 for social interaction, *r*=0.39 for communication, *r*=0.31 for stereotyped behavior), ADOS domain scores (*r*=0.35 for social, *r*=.32 for communication), SCQ total score (*r*=0.50)	N/A
Constantino et al. (2000)	*N*=445 (*n*=287 school sample of typical controls, *n*=158 child psychiatric sample)	Teacher	Between SRS and ASEBA CBCL (*r*=.67 for CBCL Total Problems, *r*=.61 for CBCL Thought Problems, *r*=.57 for CBCL Social Problems, *r*=.57 for CBCL Attention Problems)	Participants with PDD diagnosis scored higher than non-PDD controls (*F*=11.7, *p*<0.01)

Constantino et al. (2003a)	*N*=61 (*n*=40 clinical ASD, *n*=21 non-PDD controls)	Parent (Maternal and Paternal ratings), Teacher	Between SRS and ADI-R domain scores for maternal ratings (*r*=0.74 for social, *r*=0.74 for verbal communication, *r*=0.65 for non-verbal communication, *r*=0.77 for stereotypic behavior); for paternal ratings (*r*=0.74 for social, *r*=0.73 for verbal communication, *r*=0.60 for non-verbal communication, *r*=0.79 for stereotypic behavior); for teacher ratings (*r*=0.67 for social, *r*=0.65 for verbal communication, *r*=0.52 for non-verbal communication, *r*=0.70 for stereotypic behavior)	N/A
Constantino, Hudziak, & Todd (2003b)	Epidemiological sample of male twins (*N*=219 twin pairs)	Parent (Maternal and Paternal ratings not differentiated)	Regression analyses suggest that CBCL syndrome scale scores account for 43% of the variance in SRS scores; 44% of causal influences on SRS scores are independent of CBCL syndrome scores	N/A
Granader et al.	*N* = 21 children	Parent (Maternal	Between SRS Total	N/A

(2010)	diagnosed with tuberous sclerosis	and Paternal ratings not differentiated)	*T* score and SCQ Total score, *r* = 0.61; significant correlations between SCQ Total and all SRS subscales	
Murray, Mayes, & Smith 92011)	Clinical sample of adolescents with suspected ASD (*N* = 29)	Parent (Maternal and Paternal ratings not differentiated)	Between SRS and ADI-R Total scores was nonsignificant	N/A
Pine, Luby, Abbacchi, & Constantino (2006)	*N* = 73 preschool children (*n* = 51 clinical ASD; *n* = 22 non-ASD)	Parent and Teacher, Preschool version	Between SRS and ADI-R Social Impairment Subscale, *r* = 0.63; Between SRS and Vineland ABC, *r* = -0.86	N/A
Schanding, Nowell, & Goin-Kochel (in press)	*N* = 3,375 children (*n* = 1,663 clinical ASD; *n* = 1,712 unaffected siblings of ASD probands)	Parent and Teacher	Between SRS Teacher and ADOS Total and subscale scores *r* = 0.33-0.38; SRS Teacher and ADI-R Total and subscale scores *r* = 0.08-0.25; SRS Teacher and SCQ-Current *r* = 0.73; SRS Parent and ADOS Total and subscale scores *r* = 0.12-0.16; SRS Parent and ADI-R Total and subscale scores *r* = 0.25-0.39; SRS Parent and SCQ-Lifetime *r* = 0..35	N/A

Table 3

Proband Characteristics

Sex		
Male	2298 (86.8%)	
Female	350 (13.2%)	
Race		
White	2077 (78.4%)	
More than one race	209 (7.9%)	
Other	120 (4.5%)	
Asian	111 (4.2%)	
African-American	103 (3.9%)	
Not Specified	20 (0.8%)	
Native-American	6 (0.2%)	
Native-Hawaiian	2 (0.1%)	
ADOS		
Module 1	487 (18.4%)	
Module 2	582 (22%)	
Module 3	1507 (56.9%)	
Module 4	72 (2.7%)	
Developmental Data	*M*	*SD*
Age (months)	108.48	42.90
Full Scale IQ	81.20	27

Note: *M* = mean; *SD* = standard deviation

Table 4

Social Responsiveness Scale Parent Report Score Characteristics

	Mean	SD	Range	Possible Range
Total Score				
ADOS Module 1	110.24	23.59	43-177	0-195
ADOS Module 2	97.53	25.98	13-169	0-195
ADOS Module 3	94.15	27.24	11-168	0-195
ADOS Module 4	99.3	25.91	34-151	0-195
Social Awareness				
ADOS Module 1	14.35	3.61	1-24	0-24
ADOS Module 2	12.60	3.468	3-24	0-24
ADOS Module 3	11.95	3.54	1-24	0-24
ADOS Module 4	12.53	3.749	4-22	0-24
Social Cognition				
ADOS Module 1	20.61	4.61	7-32	0-36
ADOS Module 2	18.95	5.30	2-33	0-36
ADOS Module 3	17.77	5.84	1-34	0-36
ADOS Module 4	18.18	5.87	6-31	0-36
Social Communication				
ADOS Module 1	38.45	8.46	16-59	0-66
ADOS Module 2	33.13	9.44	3-60	0-66
ADOS Module 3	31.92	10.02	2-56	0-66
ADOS Module 4	34.14	9.87	7-53	0-66
Social Motivation				
ADOS Module 1	16.90	5.10	2-31	0-33
ADOS Module 2	14.51	5.50	1-29	0-33
ADOS Module 3	14.16	5.81	0-32	0-33
ADOS Module 4	16.25	5.85	5-29	0-33
Autistic Mannerisms				
ADOS Module 1	19.96	6.67	4-36	0-36
ADOS Module 2	18.33	6.96	1-35	0-36
ADOS Module 3	18.34	6.80	0-35	0-36
ADOS Module 4	18.25	6.21	4-30	0-36

All scores reported are raw scores

Table 5

Social Responsiveness Scale Teacher Report Score Characteristics

	Mean	SD	Range	Possible Range
Total Score				
ADOS Module 1	113.66	24.70	41-179	0-195
ADOS Module 2	95.80	29.33	23-166	0-195
ADOS Module 3	83.95	30.85	5-162	0-195
ADOS Module 4	99.93	29.371	36-134	0-195
Social Awareness				
ADOS Module 1	14.65	3.44	5-24	0-24
ADOS Module 2	12.50	3.78	2-24	0-24
ADOS Module 3	10.48	3.87	1-22	0-24
ADOS Module 4	11.67	3.37	6-16	0-24
Social Cognition				
ADOS Module 1	20.93	4.62	10-34	0-36
ADOS Module 2	18.54	5.59	4-30	0-36
ADOS Module 3	15.54	6.50	0-35	0-36
ADOS Module 4	17.87	7.53	1-28	0-36
Social Communication				
ADOS Module 1	40.14	9.13	13-60	0-66
ADOS Module 2	33.12	10.52	4-30	0-66
ADOS Module 3	29.04	11.24	0-59	0-66
ADOS Module 4	37.53	9.68	20-49	0-66
Social Motivation				
ADOS Module 1	17.67	5.33	3-32	0-33
ADOS Module 2	14.93	6.13	0-29	0-33
ADOS Module 3	13.59	6.09	0-30	0-33
ADOS Module 4	15.60	7.25	3-26	0-33
Autistic Mannerisms				
ADOS Module 1	20.29	7.14	2-36	0-36
ADOS Module 2	16.71	7.55	0-33	0-36
ADOS Module 3	15.30	7.50	0-34	0-36
ADOS Module 4	17.27	7.23	5-29	0-36

All scores reported are raw scores

Table 6

Item Characteristics for Social Responsiveness Scale Items for Parent and Teacher Ratings of 2,648 Individuals with Autism Spectrum Disorders

Parent Report Item	Mean	SD	Skewness	Kurtosis	Teacher Report Item	Mean	SD	Skewness	Kurtosis
1	2.57	0.993	-0.024	-1.051	**1**	2.33	0.976	0.217	-0.947
2	1.72	0.81	0.901	0.088	**2**	1.84	0.864	0.757	-0.224
3	2.12	0.87	0.45	-0.443	**3**	2.08	0.9	0.453	-0.606
4	2.72	1.009	-0.199	-1.082	**4**	2.77	1.027	-0.279	-1.098
5	3.11	0.943	-0.71	-0.557	**5**	2.6	1.109	-0.093	-1.339
6	2.47	0.969	0.184	-0.953	**6**	2.46	1.017	0.162	-1.088
7	1.86	0.748	0.689	0.38	**7**	1.83	0.802	0.807	0.253
8	2.45	0.844	0.176	-0.566	**8**	2.41	0.925	0.211	-0.792
9	1.92	0.92	0.72	-0.391	**9**	1.8	0.904	0.911	-0.097
10	2.79	0.955	-0.264	-0.926	**10**	2.48	1.047	0.057	-1.185
11	2.31	0.881	0.233	-0.64	**11**	2.26	0.906	0.252	-0.732
12	2.21	0.816	0.371	-0.283	**12**	2.11	0.84	0.466	-0.294
13	2.85	0.974	-0.281	-1.1028	**13**	2.7	1.045	-0.167	-1.188
14	2.28	1.016	0.271	-1.039	**14**	2.12	0.976	0.49	-0.761
15	2.38	0.84	0.31	-0.548	**15**	2.38	0.897	0.202	-0.703
16	2.65	0.962	-0.04	-1.009	**16**	2.59	1.049	0.005	-1.122
17	2.23	0.95	0.337	-0.804	**17**	2.13	1.02	0.399	-1.033
18	2.86	1.032	-0.382	-1.073	**18**	2.56	1.092	-0.019	-1.305
19	2.68	0.937	-0.075	-0.937	**19**	2.32	0.97	0.269	-0.894
20	2.4	1.109	0.135	-1.322	**20**	2.31	1.19	0.269	-1.451
21	2.72	0.891	-0.032	-0.888	**21**	2.7	0.925	-0.089	-0.915
22	2.03	0.833	0.544	-0.197	**22**	2.1	0.915	0.533	-0.498
23	2.78	0.994	-0.222	-1.078	**23**	2.77	1.084	-0.282	-1.246
24	2.85	0.993	-0.364	-0.971	**24**	2.79	1.053	-0.292	-1.173
25	3.12	0.932	-0.747	-0.454	**25**	3.07	0.992	-0.705	-0.667
26	2.31	0.976	0.651	-0.849	**26**	1.86	0.927	0.887	-0.109
27	2.43	1.051	0.161	-1.169	**27**	2.39	1.088	0.227	-1.236
28	2.9	1.005	-0.503	-0.863	**28**	2.53	1.089	-0.043	-1.29
29	2.85	0.95	-0.273	-0.968	**29**	2.37	1.074	0.228	-1.199
30	2.73	0.965	-0.124	-1.03	**30**	2.52	1.047	0.046	-1.19
31	2.87	0.954	-0.387	-0.847	**31**	2.71	1.014	-0.221	-1.072
32	2.69	0.982	-0.152	-1.025	**32**	3.31	0.941	-1.115	0.042
33	2.77	0.937	-0.206	-0.916	**33**	2.66	1	-0.067	-1.11
34	1.72	0.844	0.997	0.24	**34**	1.79	0.893	0.916	-0.055
35	3	0.956	-0.477	-0.903	**35**	2.82	1.068	-0.324	-1.197

36	2.18	0.981	0.421	-0.831	**36**	2.25	1.011	0.394	-0.922
37	2.95	0.909	-0.398	-0.805	**37**	2.85	0.967	-0.299	-0.994
38	2.08	0.811	0.514	-0.092	**38**	1.99	0.852	0.601	-0.227
39	2.72	1.043	-0.231	-1.146	**39**	2.54	1.067	-0.062	-1.233
40	2.22	1.017	0.354	-0.992	**40**	2.01	0.98	0.598	-0.729
41	1.99	0.958	0.661	-0.537	**41**	2.14	1.047	0.469	-0.999
42	2.74	1.031	-0.246	-1.117	**42**	2.4	1.094	0.129	-1.287
43	2.99	0.985	-0.556	-0.822	**43**	3.02	0.994	-0.603	-0.814
44	2.76	0.977	-0.222	-1.004	**44**	2.66	1.063	-0.168	-1.214
45	2.2	0.774	0.481	0.055	**45**	2.17	0.87	0.495	-0.334
46	1.75	0.903	0.987	0.001	**46**	1.89	0.939	0.776	-0.385
47	2.28	0.926	0.279	-0.76	**47**	2.03	0.948	0.571	-0.628
48	2.37	0.931	0.197	-0.813	**48**	2.15	0.949	0.389	-0.801
49	2.5	0.969	0.062	-0.973	**49**	2.23	0.962	0.295	-0.884
50	2.2	1.139	0.401	-1.269	**50**	2.15	1.19	0.443	-1.364
51	2.5	1.026	0.068	-1.133	**51**	2.39	1.085	0.154	-1.258
52	1.7	0.854	1.101	0.476	**52**	1.81	0.981	0.984	-0.162
53	1.86	1.012	0.832	-0.569	**53**	1.91	1.087	0.801	-0.78
54	1.56	0.787	1.316	1.037	**54**	1.58	0.835	1.317	0.858
55	1.75	0.913	1.035	0.118	**55**	1.81	0.943	0.942	-0.137
56	2.61	0.983	-0.084	-1.021	**56**	2.51	1.042	0.065	-1.175
57	1.97	0.964	0.692	-0.539	**57**	1.46	0.766	1.732	2.393
58	2.43	1.026	0.078	-1.126	**58**	2.37	1.068	0.167	-1.215
59	1.3	0.661	2.441	5.661	**59**	1.32	0.689	2.302	4.771
60	1.72	0.866	1.032	0.235	**60**	2.04	1.011	0.614	-0.758
61	2.55	0.982	-0.003	-1.02	**61**	2.49	1.003	0.09	-1.066
62	1.94	0.955	0.674	-0.584	**62**	1.77	0.936	0.952	-0.177
63	1.91	1.022	0.752	-0.698	**63**	1.83	1.039	0.904	-0.548
64	2.18	0.985	0.405	-0.864	**64**	2.05	0.966	0.535	-0.742
65	2.16	0.93	0.4	-0.709	**65**	2.6	1.029	-0.055	-1.151

Table 7

One-Factor Model Standardized Factor Loadings

SRS Parent Item	Standardized Factor Loading	Standard Error	SRS Parent Item	Standardized Factor Loading	Standard Error
1	0.035	0.028	34	-.240	0.030
2	-0.437	0.028	35	-0.022	0.032
3	0.515	0.027	36	0.098	0.034
4	-0.113	0.029	37	0.144	0.033
5	-0.095	0.027	38	0.083	0.033
6	-0.007	0.032	39	0.069	0.034
7	0.401	0.031	40	0.228	0.33
8	-0.484	0.026	41	0.221	0.032
9	-0.574	0.025	42	0.190	0.034
10	-0.024	0.033	43	0.094	0.034
11	0.485	0.026	44	-0.020	0.035
12	0.206	0.030	45	-0.074	0.032
13	0.055	0.030	46	-0.040	0.031
14	0.038	0.031	47	-0.025	0.032
15	0.022	0.032	48	-0.015	0.034
16	0.257	0.032	49	-0.003	0.034
17	-0.027	0.033	50	-0.021	0.034
18	-0.454	0.025	51	-0.028	0.034
19	-0.170	0.031	52	-0.119	0.032
20	0.356	0.030	53	-0.217	0.031
21	0.369	0.029	54	-0.283	0.031
22	-0.120	0.032	55	-0.239	0.031
23	-0.107	0.029	56	-0.252	0.030
24	0.179	0.030	57	-0.260	0.031
25	0.287	0.031	58	-0.276	0.031
26	-0.001	0.032	59	-0.165	0.033
27	-0.205	0.027	60	-0.181	0.032
28	-0.170	0.029	61	-0.181	0.033
29	-0.074	0.030	62	-0.118	0.033
30	0.100	0.031	63	-0.088	0.034
31	0.083	0.033	64	-0.085	0.033
32	-0.239	0.030	65	-0.064	0.033
33	-0.280	0.029			

Table 8

One-Factor Model Standardized Factor Loadings

SRS Teacher Item	Standardized Factor Loading	Standard Error	SRS Teacher Item	Standardized Factor Loading	Standard Error
1	0.424	0.024	34	0.553	0.020
2	0.520	0.022	35	0.753	0.015
3	0.556	0.022	36	0.727	0.015
4	0.610	0.020	37	0.829	0.012
5	0.533	0.023	38	0.507	0.024
6	0.606	0.019	39	0.631	0.019
7	0.512	0.024	40	0.507	0.023
8	0.709	0.016	41	0.542	0.020
9	0.420	0.024	42	0.507	0.022
10	0.462	0.023	43	0.142	0.029
11	0.470	0.023	44	0.710	0.016
12	0.574	0.022	45	0.448	0.024
13	0.661	0.019	46	0.307	0.026
14	0.316	0.027	47	0.349	0.026
15	0.506	0.022	48	0.575	0.020
16	0.586	0.020	49	0.448	0.025
17	0.537	0.022	50	0.598	0.020
18	0.666	0.017	51	0.501	0.022
19	0.475	0.022	52	0.473	0.024
20	0.667	0.018	53	0.429	0.025
21	0.177	0.028	54	0.590	0.021
22	-0.209	0.024	55	0.532	0.023
23	0.687	0.018	56	0.553	0.020
24	0.561	0.021	57	0.231	0.029
25	0.435	0.026	58	0.434	0.023
26	-0.340	0.028	59	0.243	0.031
27	0.641	0.018	60	0.574	0.020
28	0.463	0.023	61	0.544	0.021
29	0.653	0.018	62	0.339	0.025
30	0.576	0.020	63	0.530	0.022
31	0.494	0.023	64	0.509	0.022
32	0.345	0.027	65	0.526	0.021
33	0.737	0.015			

Table 9

Summary of Confirmatory Factor Analysis Goodness of Fit Indices for the Social Responsiveness Scale

Model	RMSEA	CFI
Parent		
One-factor	0.045	0.282
Five-factor	0.051	0.058
Teacher		
One-Factor	0.072	0.756
Five-Factor	0.091	0.613

Note: RMSEA = Root-Mean-Square Error of Approximation; CFI = Comparative Fit Index

Table 10

Correlations Between Social Responsiveness Scale Parent and Teacher Report (n = 282)

		Teacher SRS					
		1	2	3	4	5	6
Parent SRS	1	.293**	.205**	.249**	.148**	.233**	.256**
	2	.186**	.262**	.208**	.173**	.218**	.240**
	3	.276**	.247**	.310**	.227**	.254**	.305**
	4	.140**	.151**	.208**	.291**	.153**	.219**
	5	.180**	.194**	.198**	.176**	.279**	.237**
	6	.254**	.253**	.284**	.244**	.272**	.301**

Note. * $p<.05$, ** $p<.01$

Domains: 1 = Social Awareness; 2 = Social Cognition; 3 = Social Communication; 4 = Social Motivation; 5 = Autistic Mannerisms; 6 = Total; All scores are raw scores.

Table 11

Correlations Between Social Responsiveness Scale Parent Report and Autism Diagnostic Observation Schedule Module 1 Scores (n =479)

	ADOS Social	ADOS Communication	ADOS Total
SRS Social Awareness	.216**	.159**	.197**
SRS Social Cognition	.131**	.116*	.122**
SRS Social Communication	.143**	.126**	.143**
SRS Social Motivation	.154**	.104*	.137**
SRS Autistic Mannerisms	.127**	.153**	.097*
SRS Total Score	.179**	.158**	.162**

* p<.05, ** p<.01

Table 12

Correlations Between Social Responsiveness Scale Teacher Report and Autism Diagnostic Observation Schedule Module 1 Scores (n =282)

	ADOS Social	ADOS Communication	ADOS Total
SRS Social Awareness	.181**	.125*	.167**
SRS Social Cognition	.179**	.115	.130*
SRS Social Communication	.160**	.106	.156**
SRS Social Motivation	.173**	.153*	.153*
SRS Autistic Mannerisms	.163**	.155**	.154**
SRS Total Score	.201**	.156**	.182**

Note. * p<.05, ** p<.01

Table 13

Correlations Between Social Responsiveness Scale Parent Report and Autism Diagnostic Observation Schedule Module 2 Scores (n =581)

	ADOS Social	ADOS Communication	ADOS Total
SRS Social Awareness	.211**	.218**	.193**
SRS Social Cognition	.108**	.140**	.102**
SRS Social Communication	.224**	.226**	.233**
SRS Social Motivation	.146**	.124**	.148**
SRS Autistic Mannerisms	.140**	.215**	.205**
SRS Total Score	.200**	.215**	.205**

* p<.05, ** p<.01

Table 14

Correlations Between Social Responsiveness Scale Teacher Report and Autism Diagnostic Observation Schedule Module 2 Scores (n =301)

	ADOS Social	ADOS Communication	ADOS Total
SRS Social Awareness	.322**	.397**	.356**
SRS Social Cognition	.296**	.340**	.336**
SRS Social Communication	.268**	.352**	.311**
SRS Social Motivation	.230**	.285**	.270**
SRS Autistic Mannerisms	.273**	.355**	.320**
SRS Total Score	.213**	.393**	.360**

* $p<.05$, ** $p<.01$

Table 15

Correlations Between Social Responsiveness Scale Parent Report and Autism Diagnostic Observation Schedule Module 3 Scores (n =1505)

	ADOS Social	ADOS Communication	ADOS Total
SRS Social Awareness	.059*	.038	.053*
SRS Social Cognition	.073**	.054*	.075**
SRS Social Communication	.092**	.055*	.074**
SRS Social Motivation	.094**	.031	.055*
SRS Autistic Mannerisms	.089**	.107**	.082**
SRS Total Score	.099**	.070**	.083**

* $p<.05$, ** $p<.01$

Table 16

*Correlations Between Social Responsiveness Scale Teacher Report and Autism Diagnostic Observation Schedule Module 3 Scores (n =*712)

	ADOS Social	ADOS Communication	ADOS Total
SRS Social Awareness	.200**	.216**	.220**
SRS Social Cognition	.222**	.239**	.245**
SRS Social Communication	.215**	.212**	.215**
SRS Social Motivation	.201**	.173**	.177**
SRS Autistic Mannerisms	.211**	.250**	.227**
SRS Total Score	.241**	.250**	.248**

* $p<.05$, ** $p<.01$

Table 17

Correlations Between Social Responsiveness Scale Parent Report and Autism Diagnostic Observation Schedule Module 4 Scores (n = 72)

	ADOS Social	ADOS Communication	ADOS Total
SRS Social Awareness	.009	-.134	-.051
SRS Social Cognition	.075	-.121	.117
SRS Social Communication	.049	-.120	-.016
SRS Social Motivation	.161	-.004	.117
SRS Autistic Mannerisms	.159	-.107	.071
SRS Total Score	.112	-.119	.031

* $p<.05$, ** $p<.01$

Table 18

Correlations Between Social Responsiveness Scale Teacher Report and Autism Diagnostic Observation Schedule Module 4 Scores (n =15)

	ADOS Social	ADOS Communication	ADOS Total
SRS Social Awareness	.193	-.077	.113
SRS Social Cognition	-.167	-.215	-.206
SRS Social Communication	.404	-.008	.296
SRS Social Motivation	.513	.010	.383
SRS Autistic Mannerisms	-.112	-.159	-.144
SRS Total Score	.212	-.103	.116

* p<.05, ** p<.01