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The Screen for Social Interaction (SSI): A Screening Measure for Autism Spectrum Disorders in Preschoolers

Jaswinder K. Ghuman¹, Sarah L. Leone², Luc Lecavalier², and Rebecca J. Landa³

Jaswinder K. Ghuman: jkghuman@email.arizona.edu; Sarah L. Leone: leonesarah@gmail.com; Luc Lecavalier: Luc.Lecavalier@osumc.edu; Rebecca J. Landa: Landa@kennedykrieger.org

¹University of Arizona, Child and Adolescent Psychiatry, 1501 N. Campbell Avenue Tucson, Arizona 85724-5002, USA

²Ohio State University, Nisonger Center, UAP, 1581 Dodd Drive, Columbus, Ohio 43210, USA

²Ohio State University, Nisonger Center, UAP, 1581 Dodd Drive, Columbus, Ohio 43210, USA

³Johns Hopkins University, Kennedy Krieger Institute, Center for Autism and Related Disorders, 3901 Greenspring Avenue, Baltimore, Maryland 21211, USA

Abstract

We report on the preliminary validity and utility of the *Ghuman-Folstein Screen for Social Interaction (SSI)*, a measure of social interaction that can serve to screen for autism spectrum disorders (ASDs) in clinical samples of young high-risk children. Caregivers of 350 children (176 younger participants, ages 24 to 42 months, mean age = 34.1 months; and 174 older participants, ages 43 to 61 months, mean age = 52.4 months) with ASDs, non-ASD developmental and/or psychiatric disorders, or without developmental concerns completed the SSI. A series of analyses resulted in shortened versions of the SSI: a 26-item SSI-Younger (SSI-Y) and a 21-item SSI-Older (SSI-O) version. The SSI-Y and SSI-O showed moderate convergence with ASD diagnostic measures and significantly differentiated ASD and non-ASD clinical groups. Sensitivity and specificity values for discriminating ASD and non-ASD clinical participants were 0.87 and 0.71, respectively for the SSI-Y and 0.81 and 0.70, respectively for the SSI-O. Scoring recommendations were made based on the ROC results.

Keywords

Autism spectrum disorders; social interaction; joint attention; preschool; screening; early identification

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Corresponding author: Jaswinder K Ghuman, M.D., University of Arizona, Room AHSC 7304, 1501 N. Campbell Avenue, Tucson, Arizona 85724-5002, Tel: 520-626-3603, Fax: 520-626-6050, jkghuman@email.arizona.edu.

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1. Introduction

Social interaction problems are considered a core deficit in autism spectrum disorders (ASDs) and are the single most powerful predictor for diagnosing ASDs (Volkmar, Chawarska, and Klin, 2005). Social interaction problems manifest early in young at-risk children. Problems in joint attention, social responsiveness, pretend play skills, motor imitation, and use of conventional gestures have been identified in a number of studies in young children with autistic disorder (Landa, Holman, & Garrett-Mayer, 2007; Ventola et al., 2007). Impairment in joint attention is one of the most reliable markers of ASDs (Ventola et al., 2007). Joint attention typically emerges between 6 and 18 months of age (Mundy & Burnette 2005) and can potentially help screen young at-risk children. On the other hand, restricted interests/repetitive (RR) behaviors that define ASDs, may begin to emerge later than other social indicators (Volkmar et al., 2005). Furthermore, there is evidence that RR behaviors failed to differentiate ASD children from non-ASD children at 20 and at 42 months of age (Cox et al., 1999; Wiggins & Robins, 2008). Screening efforts for early identification in young children should therefore attend to basic social interaction behaviors (i.e., joint attention, imitation, gestures, and play behaviors) that seem to distinguish ASDs from general developmental delay. Early identification is important as it provides the best opportunity for early intervention, thus maximizing prospects for improved short- and long-term developmental outcomes (Barbaro & Dissanayake, 2009).

Parent-report questionnaires offer a valuable, easily accessible and cost-effective format for early ASD screening in both general unselected populations, as well as high-risk clinical populations. For the purposes of this study, we focus on the use of parent report questionnaires in young high-risk clinical populations. The *Modified Checklist for Autism in Toddlers* (M-CHAT; Robins, Fein, Barton, and Green, 2001), an adaptation of the CHAT (Baron-Cohen, Allen, and Gillberg, 1992; Baron-Cohen et al., 1996) is a parent-completed screening measure that includes 23 yes/no dichotomously scored items. The M-CHAT is a first screening measure originally validated for screening in the general population. It was recently evaluated in 56 clinically-referred 18- to 48-month old children referred for possible pervasive developmental disorders and was shown to have fair sensitivity (0.70) and PPV (0.79), but lower specificity (0.38) and AUC (0.65) in the at-risk sample (Snow & Lecavalier, 2008).

The *Baby and Infant Screen for Children with aUtism Traits* (BISCUIT; Matson et al., 2009) is a three-part informant-based comprehensive assessment measure that includes assessment of the three ASD symptom domains (62-item Part 1), comorbid mental health conditions (65-item Part 2) and challenging behaviors (17-item Part 3). The items are scored on a three-point frequency scale. The BISCUIT was administered by experienced and trained professionals in a one-to-one parent interview format to the parents of 1007, 27- to 37-month old children enrolled in a program to provide services to children with developmental delay or a medical condition (Matson et al., 2009). Good sensitivity (0.84) and specificity (0.86), but lower AUC (0.55) were reported for the final selected cut points (Matson et al., 2009).

The *Early Screening for Autistic Traits* (ESAT; Dietz, Swinkels, van Daalen, van Engeland, & Buitelaar, 2006; Swinkels et al., 2006) is a 14-item parent-completed yes/no dichotomously scored screening measure. The items span across the three ASD symptom domains and also address reaction to sensory stimuli. Good sensitivity (0.88), but low specificity (0.14), Positive Predictive Value (PPV; 0.68), and Area Under the Curve (AUC; 0.58) were reported in 238 children (mean age = 29.6 ± 6.4 months) at risk for ASD (Oosterling et al., 2009).

The *Developmental Behavior Checklist-Early Screen* (DBC-ES; Gray, Tonge, Sweeney, & Einfeld, 2008) is a 17-item parent-completed screening measure with items relating to the three ASD symptom domains as well as behavior and emotional problems. The items are scored on a three-point frequency scale. Good sensitivity (0.83), but low specificity (0.48), and fair PPV (0.78) were reported in 207, 20–51 month old children suspected of developmental delay (Gray et al., 2008).

The *Social Communication Questionnaire* (SCQ; Berument, Rutter, Lord, Pickles, and Bailey, 1999) is a 40-item parent-completed yes/no dichotomously scored screening measure with items relating to the three ASD symptom domains based on questions from the *Autism Diagnostic Interview-Revised* (ADI-R; Rutter, LeCouteur, & Lord, 2003). It was originally validated in at-risk children who were 4 years old and older. Attempts to screen children younger than 4 years with the SCQ showed poor balance among sensitivity, specificity and discriminative validity in 208, 20–40 month old children at risk for ASDs (Oosterling et al., 2010).

In summary, currently available ASD screening instruments for use in clinical samples of young high-risk children have items that span the three ASD symptom domains; have good sensitivity, but lower specificity or lower AUC. The objective of the current study was to assess preliminary validity and utility of the *Ghuman-Folstein Screen for Social Interaction* (SSI), an instrument that emphasizes reciprocal social interaction including joint attention skills, which are of particular concern for children with ASDs (Ghuman, Peebles, & Ghuman, 1998; Mundy et al., 2005). Specifically, we wished to evaluate its utility in detecting children with ASD in a large heterogeneous high-risk clinical sample of young children with and without ASDs. A second objective was to shorten and refine the instrument for use with younger (ages 24 to 42 months) and older (ages 43 to 61 months) preschool age children.

2. Methods and materials

2.1. Study population

The study sample consisted of 350 children between the ages of 24 to 61 months. The participants included a convenience sample of 168 typically-developing children recruited during routine visits with the primary health care providers, and 182 children, hereafter referred to as the Clinical Group, recruited during clinic appointments in various psychiatry, autism, developmental, or specialty research clinics for genetic and developmental disorders. The Clinical Group included clinically-referred high risk children who were assessed for ASDs (Autistic Disorder = 66, Pervasive Developmental Disorder-Not Otherwise Specified [PDD-NOS] = 48, and those determined to have no ASDs [non-ASD clinical] = 68).

Table 1 summarizes participant characteristics. Among younger age group participants (ages 24 to 42 months), the typically-developing group was significantly younger than the other diagnostic groups. Differences in gender distribution followed the expected pattern of a larger proportion of males (approximate male:female ratio of 5:1) among the two ASD groups. Socio-economic status (SES) for the typically-developing children was significantly higher than for the PDD NOS group among older age group participants (ages 43 to 61 months). Both ASD groups had a significantly lower proportion of verbal participants and had significantly lower adaptive *Vineland Adaptive Behavior Scales* (VABS; Sparrow, Balla, and Cicchetti, 1984) Socialization domain scores than the non-ASD clinical group. The autistic disorder group had significantly lower mean IQ and adaptive behavior VABS composite scores than the non-ASD clinical group, and had significantly lower adaptive VABS Communication domain scores than both the PDD-NOS and non-ASD clinical groups.

2.2. Measure

2.2.1. Ghuman-Folstein Screen for Social Interaction (SSI)—The *Ghuman-Folstein Screen for Social Interaction* (SSI) is a 54-item parent/caregiver-report screening instrument that emphasizes reciprocal social interaction including joint attention skills. For example, the items include a child's response to social overtures by others, joint attention, initiation of social interaction by the child, interaction during meals, affectionate social interaction, playful interaction, and peer interaction. The items are positive (prosocial) and are scored on a four-point frequency scale (child displays the behavior "almost never" = 0 to "almost all the time" = 3). Thus lower scores reflect a slower or delayed development, and higher scores reflect more normative development. The SSI takes 10–15 minutes to complete. In a sample of 24 to 61 month old children (51 clinically-referred children and 60 typical healthy controls), the SSI has shown good internal consistency ($\alpha = 0.76$) and test-retest reliability ($r = 0.88$), and moderate interrater reliability. The SSI scores converged with the VABS-Socialization scores ($r = 0.67$) and with the algorithm items of the ADI-R total score and Reciprocal Social Interaction and Communication categories scores (r ranged from -0.55 to -0.88). Finally, the SSI scores differentiated the clinically-referred children who met all, part, and none of the ADI-R algorithm criteria (Ghuman, Freund, Reiss, Serwint, & Folstein, 1998).

3. Procedure

For most (95.4% of cases), the SSI was completed before the child's diagnostic assessment; mothers completed the SSI in 82% of cases. Assessment for ASD among the 182 children in the Clinical Group was done via expert clinical diagnosis (Charman & Baird, 2002) by a child psychiatrist, psychologist or multidisciplinary team consisting of child psychiatrist, psychologist, developmental pediatrician, speech and communication pathologist and/or pediatric neurologist. Additionally, clinical diagnosis of ASD was supported by the ADI-R in 106 children (58.2%); the Childhood Autism Rating Scale (CARS; Schopler, Reichler, & Renner, 1988) in 15 children (8.2%) and by both the ADI-R and the CARS in 26 children (14.3%). Diagnoses for the non-ASD clinical group included communication disorders, intellectual disability, other developmental disorders, and 17% of the children had psychiatric disorders only. Intellectual/developmental levels (IQ/DQ) were available for 79 children; the two most frequently used tests were the *Stanford-Binet Intelligence Scales*, 4th edition (Thorndike, Hagen, & Sattler, 1986) in 35 children and the *Bayley Scales of Infant and Toddler Development* (Bayley, 1993) in 19 children. Adaptive behavior was evaluated using the VABS Composite Score ($n=44$) and/or its Socialization ($n=90$) and Communication ($n=49$) subscales.

4. Statistical analysis

Since it is expected that development will impact social interaction and communication between 24 and 61 months, the sample was divided in two halves, younger (ages 24 to 42 months) and older (ages 43 to 61 months) age groups. Diagnostic validity was assessed separately for the two age groups. Factorial one-way analysis of variance (ANOVA) with three sets of planned a-priori contrasts and post-hoc comparisons were conducted on the SSI total score to determine if SSI scores differentiated the four groups (autistic disorder, PDD-NOS, non-ASD clinical and typically-developing). In addition, several other strategies were used to assess the diagnostic validity of the instrument at the item-level in the Clinical Group ($n = 182$): (a) individual SSI item-means were compared between ASD (autistic disorder and PDD-NOS combined; $n = 114$) and non-ASD clinical ($n = 68$) participants using independent samples *t*-tests, (b) binary logistic regressions were conducted to identify SSI items that predict ASD diagnostic group membership and (c) inter-item Pearson

correlations were examined within younger and older age groups to detect and eliminate redundancy between SSI items.

Binary logistic regressions used SSI items as predictor variables and ASD diagnostic membership as the binary outcome variable. Items were entered in seven separate blocks to maintain a cases-to-predictors ratio of approximately 10:1 or higher, as recommended by Peduzzi et al. (1996). Backward stepwise procedure was chosen in light of the exploratory nature of the analyses, the relative number of cases and predictors, and its ability to uncover suppressor effects among independent variables (Menard, 2002). SSI items whose removal would significantly impact the ability to predict diagnostic membership in the regression model were deemed critical items (using the significance in change of the -2 log likelihood statistic; significance level was set at $p < 0.01$ due to multiple analyses conducted).

Based on the results of the above item-level analyses, several items were dropped and two separate scales for younger and older age groups were developed. The relationship was assessed (via two-tailed Spearman's or Pearson product-moment correlations) between the total summary scores for the revised SSI scales and age, IQ/DQ, VABS and ASD diagnostic measures (ADI-R and CARS).

4.1. Determination of scoring system

Receiver Operating Characteristic (ROC) curve analyses were conducted to determine cutoff scores for optimal sensitivity and specificity for the younger and older age groups. Emphasis was placed on the discrimination between combined ASD (autistic disorder or PDD-NOS; $n = 114$) and non-ASD clinical ($n = 68$) groups. To ensure that the differences in the SSI scores across groups are based on the behaviors measured by the SSI rather than as a function of age or IQ/DQ level of the children, participants from the ASD and non-ASD clinical groups were individually matched on age (within 6.5 months of each other) and IQ/DQ level (within 12 full scale IQ or DQ points of each other). Narrow matching criteria were chosen so the group comparisons were well controlled within the available sample. This resulted in 10 matched pairs ($n = 20$) for the younger and 17 matched pairs ($n = 34$) for the older age groups. Differences in verbal ability, gender, ethnicity, and SES in the matched ASD and non-ASD clinical groups were examined. The mean SES score for the older non-ASD matched participants was higher than the mean SES score for the older ASD matched participants ($t = -2.89$; $p = 0.008$); no other differences were found.

5. Results

Kolmogorov-Smirnov test for normality for the SSI score distributions within the Clinical Group and the typically-developing participants was non-significant, indicating each to be normally distributed (Z values = 0.74, and 0.83, respectively).

5.1. Diagnostic validity

5.1.1. Group comparisons—Factorial ANOVA were conducted on the SSI total scores, and assessment for and correction of any violation of equal variances were addressed, as described in Table 2. The SSI total scores significantly differentiated each one of the four diagnostic groups ($F = 79.32$ and 40.34 , respectively for the younger and older age groups; $p < 0.001$ in both cases). As expected, the autistic disorder group had the lowest scores, the PDD-NOS and the non-ASD clinical groups had intermediate scores, and the typically-developing group had the highest scores; all contrasts were significant (see Table 2).

To examine if SSI total scores differed based on age or verbal ability, we conducted an ANOVA by verbal ability and age group in the 132 children who were administered the

ADI-R. Verbal ability was defined via ADI-R classification of a presence of daily functional speech of at least three-word phrases. There were no differences in the mean SSI total scores among younger ($n = 59$) or older ($n = 73$) or among non-verbal ($n = 58$) and verbal ($n = 74$) preschoolers. No interaction effect for verbal ability and age group was found.

5.1.2. Item-level contribution and scale refinement—Using independent samples t -tests, comparison of the individual SSI item-mean scores between the ASD (combined autistic disorder and PDD-NOS) and non-ASD clinical groups identified 31 items among the younger children and 26 items among the older children that were significantly different ($p < 0.01$) in the anticipated direction.

The binary logistic regressions identified ten items from the younger and eight items from the older age group that predicted ASD diagnostic group membership ($p < 0.01$). However, even though item 49 (*takes toys from siblings or other children*) met criteria as a critical item in both age groups; it was dropped because there was no difference in the item-mean scores between the ASD and non-ASD clinical group participants. Hence, nine critical items (reflecting the expression and detection of emotion, praise-seeking, and peer play-related behaviors) were identified for the younger participants. Seven critical items (reflecting display of greeting, reading and expressing emotions, praise-seeking, pretend play, and peer play-related behaviors) were identified for the older age group participants (see Table 3). Three common critical items emerged for both the younger and older participants: *seeks praise by showing what s/he did* (item #25), *joins play when invited by other children* (item #40), and *shares favorite items or toys with other children* (item #54). All items, except one critical item from each age group, were also identified in the above analysis as items that significantly differentiated the ASD and non-ASD clinical group participants.

Six SSI items were highly intercorrelated with the other SSI items ($r \geq 0.70$) and were chosen for elimination in each age group. Items 19 (*looks at you during meals*), 35 (*can see you are angry by your face or voice*) and 46 (*other children his/her age want to play/be around him/her*) were highly intercorrelated with the other items for the younger age group; items 10 (*greet your return by seeking proximity*), 37 (*shows interest in other children by moving towards them*) and 53 (*shares favorite items or toys with adults*) were highly intercorrelated with the other items for the older age group; and items 39 (*tries to play with other children*), 43 (*can join in social exchange with other children*) and 44 (*can maintain social exchange with other children*) were highly intercorrelated with the other items for both age groups; range of intercorrelations were 0.70 through 0.92. In most cases, the item with the lesser discriminative power was dropped. There was one exception to this criterion. Even though both SSI items 5 (*tries to get attention to show things*) and 25 (*seeks praise by showing what s/he did*) were highly intercorrelated, neither item was dropped since both of the items related to joint attention, an especially clinically relevant indicator for young children with ASDs.

These refinements resulted in a 26-item instrument for the younger (24- to 42-month old), and a 21-item instrument for the older (43- to 61-month old) participants. The shortened instruments are labeled “SSI-Younger” (SSI-Y), and “SSI-Older” (SSI-O), respectively. The two sets of critical items are labeled as “SSI-Brief” (SSI-Brief-Y and SSI-Brief-O for the younger and older age groups, respectively).

The mean SSI-Y and SSI-O total scores did not differ based on gender among the four diagnostic groups (autistic disorder, PDD-NOS, non-ASD clinical and typically-developing) or based on verbal ability among the three clinical groups (autistic disorder, PDD-NOS, non-ASD clinical). We examined the relationship of the mean SSI-Y and SSI-O total scores with age, IQ/DQ, and adaptive behavior. The SSI-Y and SSI-O total scores did not significantly

correlate with age ($r = -0.07$ and $r = 0.02$, respectively). IQ/DQ and adaptive behavior scores were coded ordinally into eight bands, each 15 IQ/DQ points (one standard deviation) apart. The mean SSI-Y total scores did not significantly correlate with IQ/DQ scores in the younger age group ($p = 0.10$; $n = 31$). The mean SSI-O total scores were significantly correlated with the available IQ/DQ scores in the older preschool age group ($p = 0.47$, $p < 0.01$, $n = 48$). The mean SSI-Y and SSI-O total scores correlated with the VABS Socialization domain ($p = 0.38$, $p < 0.05$, $n = 39$; and $p = 0.58$, $p < 0.01$, $n = 51$, respectively) and VABS Communication domain scores ($p = 0.50$, $p < 0.05$, $n = 18$; and $p = 0.65$, $p < 0.01$, $n = 31$, respectively).

All correlations between the SSI-Y and SSI-O total scores and the ADI-R social and communication subscale scores were significant at $p < 0.0001$. The relationships are negative because SSI scores increase with typicality, whereas the ADI-R scores decrease with typicality. The strongest correlation occurred with the ADI-R social subscale ($r = -0.75$ and -0.76 , respectively for SSI-Y and SSI-O), followed by the ADI-R communication subscale ($r = -0.55$ and -0.62 , respectively for SSI-Y and SSI-O) and the ADI Restrictive/Repetitive subscale ($r = -0.45$ and -0.39 , respectively for SSI-Y and SSI-O, $p < 0.001$ for both the SSI-Y and SSI-O). The correlation of the SSI with the ADI-R total score was much higher ($r = -0.72$, $p < 0.0001$ for both the SSI-Y and SSI-O) than with the CARS ($r = -0.48$ and -0.55 , $p < 0.05$ for SSI-Y and SSI-O respectively).

5.1.3. Determination of scoring system—Table 4 depicts the ROC discriminations of greatest clinical interest: participants with ASD (both autistic disorder and PDD-NOS) versus non-ASD clinical participants for both the unmatched and the subset of matched participants. For each comparison, the cutoff score judged to have the optimal balance of both sensitivity and specificity is placed in the middle, in boldface, between nearby cutoff scores. Optimal balance of sensitivity and specificity was achieved with a screen cutoff score of 45 or lower for the SSI-Y (PPV = 0.87 and Negative Predictive Value [NPV] = 0.70), 37 or lower for the SSI-O (PPV = 0.78 and NPV = 0.76), ≤ 17 for the SSI-Brief-Y (PPV = 0.86 and NPV = 0.76), and ≤ 13 for the SSI-Brief-O (PPV = 0.76 and NPV = 0.77). Comparatively, the screen cutoff scores for the matched group were higher by three to five points for the SSI-Y and SSI-O and by one to two points for the SSI-Brief-Y and SSI-Brief-O scales.

ROC analyses to examine the impact of verbal ability on diagnostic discrimination showed that the nonverbal younger age group ($n = 28$) had slightly higher levels of sensitivity (0.91) and specificity (0.83) than the verbal younger age group ($n = 31$; 0.85 and 0.64, respectively) on the SSI-Y. The nonverbal older participants ($n = 30$) had slightly higher levels of sensitivity (0.87) than the verbal older participants ($n = 43$; 0.79) and had similar specificity (0.71 for both) on the SSI-O.

5.1.4. Evaluation of false negatives—The optimal screen cutoff scores for the shortened SSI and/or the critical items scales together failed to identify 7 of the 52 (13.5%) younger and 11 of the 62 (17.8%) older preschoolers with ASD. Both the younger and the older preschool-age false negatives had lower mean ADI-R total, Social and Communication scores (27.6 ± 6.3 and 23.8 ± 5.9 ; 13.2 ± 3.9 and 11.3 ± 4.2 ; and 9.2 ± 4.4 and 8.6 ± 2.6 , respectively) compared to the younger and the older preschool-age true positives (33.0 ± 12.0 and 34.3 ± 8.6 ; 17.8 ± 6.7 and 18.3 ± 5.7 ; and 11.9 ± 6 and 11.8 ± 4.3 , respectively). However there were no differences in the Restrictive/Repetitive subscale scores. The false negative younger preschoolers had somewhat lower IQ scores (69.4 ± 12.7) compared to the true positive younger preschoolers (77.1 ± 25.2), and the false negative older preschoolers had somewhat higher IQ scores (66.4 ± 18.4) compared to the true positive older preschoolers (57.2 ± 20.3). Type of ASD diagnosis differed for the older preschoolers, but

not for the younger preschoolers. Nearly all (91%) of the false negative older preschoolers (10 of 11) had a diagnosis of PDD-NOS, versus 16 of 51 (31%) for the true positive older preschoolers. In other words, 69% of the true positive older preschoolers had a diagnosis of autistic disorder, compared to 9% of the false negative older preschoolers. No significant differences were observed for age, ethnicity, or presence of verbal ability for false negative and true positive younger and older preschoolers.

5.1.5. Scoring recommendations—Recognizing that discrimination in a matched sample is a more stringent test, together with the potentially greater statistical power of the larger unmatched sample, it was decided that the mean of the unmatched and the matched optimal screen cutoff scores for each of the SSI scales would be used as the recommended clinical cutoff thresholds. Thus, for younger preschoolers, recommended clinical cutoffs are a score of ≤ 47 on the SSI-Y items, or a score of ≤ 18 on the SSI-Brief-Y critical items. For older preschoolers, the recommended clinical cutoffs are a score of ≤ 40 on SSI-O items, or a score of ≤ 14 on the SSI-Brief-O critical items.

6. Discussion

The results of this study indicated that the SSI can discriminate children diagnosed with ASDs from children with other developmental and/or psychiatric disorders, and can be helpful in screening young at-risk children in clinical high-risk populations. Diagnostic validity was found to be equally strong for both the matched and the unmatched samples of younger (24–42 months old) and older (43–61 months old) preschool-age children. The SSI performance was not markedly affected by presence or absence of verbal ability. High sensitivity and specificity was obtained with the screening cutoff scores established through ROC analysis. Scoring recommendations were provided based on stringent diagnostic comparisons between overall ASD (autism and PDD-NOS combined) and non-ASD clinical referrals, and incorporated the relative benefits of both the greater experimental control of the matched and the greater statistical power of the larger unmatched samples.

As expected, the SSI-Y and SSI-O showed moderate correlation with the ADI-R and its subscales indicating shared variance on one hand and independence of the SSI construct from the ADI-R on the other hand. The relationship of the SSI-Y and SSI-O to the CARS was notably lower than for the ADI-R total score, which is likely explained by much greater focus on communication, sensory issues, and repetitive behaviors in the CARS. Associations between SSI-Y and SSI-O scores and IQ/DQ and adaptive levels were lower for the younger than the older preschoolers. However, this finding may be due to the lower number of younger preschoolers with available cognitive/developmental/adaptive scores.

The SSI-Y and SSI-O, and the SSI-Brief-Y and SSI-Brief-O held up to stringent tests of diagnostic validity. The levels of accuracy for younger and older preschool-age discriminations were similar to one another. The levels of accuracy for the matched and unmatched samples were likewise high and remarkably similar to one another. The matched sample provided control for the impact of participant age and developmental level. Some small differences were found for verbal ability. As expected, the nonverbal participants had slightly higher sensitivity levels compared to verbal participants for both age groups. The overall levels of sensitivity for the SSI were similar to other screening instruments used with young high-risk children; however specificity rates, AUC and PPV for the SSI were higher. For instance, M-CHAT had specificity of 0.38 and AUC of 0.65 (Snow & Lecavalier, 2008), ESAT had specificity of 0.14, AUC of 0.58 and PPV of 0.68 (Oosterling et al., 2009), and DBC-ES achieved specificity of 0.48 (Gray et al., 2008) compared to specificity of 0.70, AUC of 0.82 and PPV of 0.87 for the SSI-Y and specificity of 0.71, AUC of 0.85 and PPV of 0.78 for the SSI-O. The PPV value for the SSI-O was similar to the M-CHAT (Snow &

Lecavalier, 2008) and DBC-ES (Gray et al., 2008). The BISCUIT had higher specificity (0.86) but lower balance between sensitivity and specificity as depicted by AUC value of 0.55 (Matson et al., 2009).

Both younger and older preschool-age false negatives had less severe autism symptoms on the ADI-R and its subscales (with the exception of restrictive/repetitive behaviors) than true positives. The false negative older preschoolers were almost exclusively diagnosed with PDD-NOS and may point to limitation of the SSI-O in screening older preschool children with PPD-NOS. The false negative younger preschoolers had lower IQ than true positive younger preschoolers, and the false negative older preschoolers had higher IQ than true positive older preschoolers. However, it is difficult to draw any conclusions based on this finding due to the limited range of IQ/DQ levels of the children in this study sample.

6.1. Limitations

Due to the clinical and heterogeneous nature of the sample, a standard assessment battery was not administered across participants. As recommended by Charman and Baird (2002), ASD diagnoses were determined via detailed clinical assessment by experienced professionals in all cases, and were aided by the ADI-R and/or the CARS in most cases. Additionally, cognitive and communication assessments were not available for all the children, and there were few participants with severe developmental delays in the study sample, such that the findings may not generalize to these groups. Further validation studies in a larger matched sample with a broad range of intellectual abilities will confirm utility of the SSI in children of higher and lower reaches of intellectual ability. Another limitation of the study was the relatively small number of available positive cases with ASD diagnosis ($n=114$) to the number of predictors (54 SSI items) for the binary logistic regression analysis to identify the critical items. As already discussed, SSI items were entered in seven separate blocks to maintain a cases-to-predictors ratio of approximately 10:1 or higher, as recommended by Peduzzi et al. (1996). Additionally, due to the relatively small number of ASD participants, we were not able to identify a matched group for the regression analysis to identify critical items.

6.2. Conclusions

The findings support preliminary validity and utility of the SSI-Y and SSI-O as a screening tool in clinical settings for detection of young at-risk children in order to facilitate referrals for appropriate assessment and treatment services for ASDs. This study was conducted in a heterogeneous clinic sample of children with a variety of suspected delays or abnormalities and used expert clinical diagnosis. This likely increases generalizability of the findings to many types of clinical populations, and avoids some of the potential bias associated with single-clinic referrals. The SSI provides a picture of the relative presence of many social interaction behaviors that appear to be continuously distributed within different samples of individuals with and without social or general developmental delay and can add to the body of research on the autism phenotype.

The SSI-Y and SSI-O have a number of desirable features as autism screening instruments. First, emphasis is placed on presence of joint attention and other social initiation and response behaviors which have been found to discriminate young children with ASDs from those with other developmental delays much more reliably than language delay, sensory processing issues, or repetitive behaviors (Ventola et al., 2007). Of note, the three common critical items that emerged for the younger- and older preschool-age participants reflected joint attention and development of peer relationships, which are both specifically noted as clinically-significant deficits in children with ASDs in the DSM-IV (APA, 2000). Additionally, identification of social interaction and joint attention deficits can aid in

implementing specifically targeted interventions. A second desirable feature of the SSI is that it can be completed independently by caregivers, such that expert administration or guidance are not required. Third, most of the items tap into typical behaviors with a positive valence, which may be more appealing and easier for caregivers to recognize and report upon. Additionally, the items are presented with varying developmental gradations so they are appropriate for children with or without speech or cognitive delay and can tap into the expanding repertoire of a child's early social interaction development period. Fourth, the four-point scoring method allows for detection of subtle differences and may be helpful in gauging response to targeted therapies aimed at improving social interaction and social communication behaviors. Finally, the two versions for younger and older preschoolers (the SSI-Y and SSI-O) allow for capture of age-specific social communication behaviors. This is especially relevant given that symptom profiles and severity seem to change significantly for many children with ASD between two to four years of age (e.g., Chawarska, Klin, Paul, Macari, and Volkmar, 2009; Cox et al., 1999).

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APPENDIX

Final shortened screening instruments

Social Screen for Interaction-Younger (SSI-Y)

Social Screen for Interaction-Older (SSI-O)

SCREEN FOR SOCIAL INTERACTION – YOUNGER VERSION (SSI-Y) - 24–42 Months Screen with Scoring Template				
YOUR OBSERVATION	ALMOST NEVER	SOME OF THE TIME	MOST OF THE TIME	ALMOST ALL OF THE TIME
*1. When you talk to your child, does s/he look at you?	0	1	2	3
5. Does your child try to get your attention to show you things?	0	1	2	3
6. Does your child interact with you back and forth over a few turns using speech or sounds?	0	1	2	3
12. Does your child show affection by cuddling up to you?	0	1	2	3
<i>Does your child respond playfully by:</i>				
*15. laughing when you make silly sounds?	0	1	2	3
17. playing “dressing up” games?	0	1	2	3
18. playing pretend games with dolls, cars, action figures, dollhouse?	0	1	2	3
20. During meals does your child interact with you by making sounds or talking?	0	1	2	3
<i>During meals does your child show what food s/he likes by:</i>				
21. making sounds or talking?	0	1	2	3
22. pointing or other gestures?	0	1	2	3
23. speech or making sounds?	0	1	2	3
24. Does your child copy you by washing dishes, pretending to cook or mow the lawn, etc.?	0	1	2	3
*25. Does your child show you things that s/he had done and wants you to praise?	0	1	2	3
26. Does your child smile when you praise him/her?	0	1	2	3
*31. Is your child shy around people s/he does not know well?	0	1	2	3
<i>Does your child:</i>				
*32. have a blank face?	3	2	1	0
*33. look distant or removed?	3	2	1	0
*34. Can your child tell from the look on your face or the tone of your voice that you are happy?	0	1	2	3
<i>Does your child show interest in other children by:</i>				

SCREEN FOR SOCIAL INTERACTION – YOUNGER VERSION (SSI-Y) - 24–42 Months Screen with Scoring Template				
YOUR OBSERVATION	ALMOST NEVER	SOME OF THE TIME	MOST OF THE TIME	ALMOST ALL OF THE TIME
36. watching them?	0	1	2	3
*40. joining in the play if they invite him/her?	0	1	2	3
41. showing concern if another child is upset?	0	1	2	3
42. Is your child able to start a social exchange with other children?	0	1	2	3
45. Do other children (of his/her age) like him/her?	0	1	2	3
51. Is your child able to take turns in play?	0	1	2	3
52. Does your child have playmates who s/he prefers to play with?	0	1	2	3
*54. Does your child share toys and favorite objects with siblings or other children his/her age?	0	1	2	3

Bolded items are unique to SSI-Y and do not overlap with SSI-O

* Items constitute the SSI-Y-Brief Scale;

/ Items are reverse scored

Cutoff score of 45 or less on the SSI-Y identifies younger preschoolers at risk of ASD

Cutoff score of 17 or less on the SSI-Y-Brief identifies younger preschoolers at risk of ASD

SCREEN FOR SOCIAL INTERACTION – OLDER PRESCHOOL VERSION (SSI-O) 43–61 Months Screen with Scoring Template				
YOUR OBSERVATION	ALMOST NEVER	SOME OF THE TIME	MOST OF THE TIME	ALMOST ALL OF THE TIME
1. When you talk to your child, does s/he look at you?	0	1	2	3
5. Does your child try to get your attention to show you things?	0	1	2	3
6. Does your child interact with you back and forth over a few turns using speech or sounds?	0	1	2	3
<i>Does your child greet you when you return home by:</i>				
*9. making sounds or talking to you?	0	1	2	3
11. hugging you?	0	1	2	3
<i>Does your child respond playfully by:</i>				
17. playing “dressing up” games?	0	1	2	3
*18. playing pretend games with dolls, cars, action figures, dollhouse?	0	1	2	3
20. During meals does your child interact with you by making sounds or talking?	0	1	2	3
23. During meals does your child show what food s/he likes by speech or making sounds?	0	1	2	3

SCREEN FOR SOCIAL INTERACTION – OLDER PRESCHOOL VERSION (SSI-O) 43–61 Months Screen with Scoring Template				
YOUR OBSERVATION	ALMOST NEVER	SOME OF THE TIME	MOST OF THE TIME	ALMOST ALL OF THE TIME
24. Does your child copy you by washing dishes, pretending to cook or mow the lawn, etc.?	0	1	2	3
*25. Does your child show you things that s/he had done and wants you to praise?	0	1	2	3
26. Does your child smile when you praise him/her?	0	1	2	3
*35. Can your child tell from the look on your face or the tone of your voice that you are angry?	0	1	2	3
<i>Does your child show interest in other children by:</i>				
36. watching them?	0	1	2	3
38. staying close to them?	0	1	2	3
*40. joining in the play if they invite him/her?	0	1	2	3
41. showing concern if another child is upset?	0	1	2	3
*42. Is your child able to start a social exchange with other children?	0	1	2	3
51. Is your child able to take turns in play?	0	1	2	3
52. Does your child have playmates who s/he prefers to play with?	0	1	2	3
*54. Does your child share toys and favorite objects with siblings or other children his/her age?	0	1	2	3

Bolded items are unique to SSI-O and do not overlap with SSI-Y

* Items constitute the SSI-O-Brief Scale

Cutoff score of 37 or less on the SSI-O identifies older preschoolers at risk of ASD

Cutoff score of 13 or less on the SSI-O-Brief identifies older preschoolers at risk of ASD

Highlights

- Caregivers of 350 preschoolers (ages 24 to 61 months) with ASDs, non-ASD developmental and/or psychiatric disorders, or without developmental concerns completed the Ghuman-Folstein Screen for Social Interaction (SSI).
- Two shortened versions were derived for younger (SSI-Y) and older (SSI-O) children.
- The SSI-Y and SSI-O showed moderate convergence with ASD diagnostic measures and significantly differentiated ASD and non-ASD clinical groups.
- Sensitivity was .87 and .81, and specificity was .71 and .70, respectively for the SSI-Y and SSI-O.

Table 1

Characteristics of participants in the four diagnostic groups ($N = 350$)

Characteristic	Autistic disorder ^a	PDD-NOS ^b	Non-ASD clinical ^c	Typically- developing ^d	Significance test ^e /test value	Post-hoc test
<i>Demographics of Younger Participants (ages 24–42 months): n = 176</i>						
Subgroup n:	30	22	21	103		
Age in months: mean (SD)	36.4 (4.8)	35.0 (6.5)	36.0 (5.1)	32.9 (5.8)	F= 4.17**	a>d [#]
Gender: n (%) male	24 (80%)	18 (82%)	15 (71%)	53 (52%)	$\chi^2= 13.50^{**}$	
Ethnicity: n (%) Caucasian	22 (73%)	18/20 ^e (90%)	13 (62%)	63 (61%)	$\chi^2= 7.12$	
Mother's education: High school or beyond: n (%)	26/27 ^e (96%)	20 (91%)	14/19 ^e (74%)	83/101 ^e (82%)	$\chi^2= 5.70$	
SES: n; Mean (SD)	26; 32.2 (17.2)	21; 32.1 (20.0)	19; 40.2 (23.1)	100; 44.1 (22.3)	F= 3.30**	NS [#]
<i>Demographics of Older Participants (ages 43–61 months): n = 174</i>						
Subgroup n:	36	26	47	65		
Age in months: n; mean (SD)	52.9 (6.0)	52.5 (5.8)	52.5 (4.9)	52.1 (5.3)	F= .179	
Gender: n (%) male	29 (81%)	22 (85%)	32 (68%)	35 (54%)	$\chi^2= 11.85^{**}$	
Ethnicity: n (%) Caucasian	28/35 ^e (80%)	20 (77%)	28 (60%)	42/64 ^e (66%)	$\chi^2= 4.99$	
Mother's education: High school or beyond: n (%)	33/35 ^e (94%)	21/25 ^e (84%)	38/41 ^e (93%)	53 (82%)	$\chi^2= 4.82$	
SES: n; Mean (SD)	35; 34.0 (21.4)	22; 29.6 (18.8)	35; 42.4 (20.0)	62; 46.3 (23.9)	F= 4.42**	b<d [#]
<i>Cognitive and Adaptive Levels--All Ages</i>						
Full group n:	66	48	58			
Verbal [†] : n (%)	23/47 ^e (49%)	16/37 ^e (43%)	35/48 ^e (73%)	-	$\chi^2= 8.97^*$	
IQ/DQ: n; mean (SD)	20; 61.8 (21.9)	22; 70.6 (22.3)	37; 80.9 (17.4)	-	F= 6.14**	a<c [#]
VABS-Socialization: n; mean (SD)	32; 57.7 (11.6)	25; 65.6 (17.7)	33; 75.6 (14.2)	-	F= 12.63**	a,b<c [#]
VABS-Communication: n; mean (SD)	20; 60.0 (13.5)	14; 74.6 (15.9)	15; 80.3 (17.5)	-	F= 8.08**	a<b,c [#]
VABS Composite: n; mean (SD)	19; 60.5 (9.8)	12; 68.6 (11.2)	13; 80.5 (18.8)	-	F= 8.59**	a<c [†]

PDD-NOS=Pervasive developmental disorder-not otherwise specified; ASD=Autism spectrum disorder; SD=Standard deviation; IQ=Intelligence quotient; DQ=Developmental quotient; VABS= Vineland Adaptive Behavior Scales; SES = Socioeconomic status (Hollingshead four-factor method), NS = Not significant

[†] ANOVA or Chi Square comparisons by group

[#] ANOVA post-hoc (Sheffé) comparisons (significance value of $p<.05$)

« Denominator differs from the total number of participants in the subgroup due to missing data

^ Verbal ability as determined by ADI-R functional language definition

‡ ANOVA post-hoc (Tamhane due to unequal variances among samples, significance value of $p<.05$)

* $p<.05$;

** $p<.01$

Group comparisons of Screen for Social Interaction (SSI) total scores in the four diagnostic groups and by age group ($N = 350$)

Table 2

SSI Total Score (54 items)	Autistic disorder ^a	PDD-NOS ^b	Non-ASD clinical ^c	Typically-developing ^d	Test value
<i>Younger Age Group</i>					
Number of participants	30	22	21	103	
Mean (SD)	70.0 (27.6)	79.2 (19.4)	106.6 (25.7)	124.8 (14.8)	$F^{\wedge} = 79.32^*$
<i>Older Age Group</i>					
Number of participants	36	26	47	65	
Mean (SD)	72.6 (23.4)	86.6 (31.2)	105.7 (24.5)	122.7 (18.3)	$F^{\wedge} = 40.34^*$

PDD-NOS=Pervasive developmental disorder-not otherwise specified; ASD=Autism spectrum disorder;

* $p<.001$

[^] One-way ANOVAs conducted along with three sets of a-priori contrasts and post-hoc tests. All a-priori contrasts significant for both Younger and Older Participants: a<b,c,d; a,b<c,d; a,b,c<d. Tamhane Post-hoc comparisons conducted due to unequal variances (significance level of $p<.05$ chosen in light of conservative test used).

Post-hoc comparisons for Younger Participants: a,b<c<d. Post hoc comparisons for Older Participants: a<c<d; b<d.

Table 3

Binary logistic regression analyses to predict membership in autism spectrum disorders (autistic disorder or PDD-NOS) versus Non-ASD Clinical Group ($n = 182$)

Predictors ^a : Item and description	β	Change in -2 Log Likelihood ^{b,c}
Statistically significant ($p < 0.05$) items for younger age group (24–42 months of age): $n = 73$		
1. looks at you when you talk to him/her	-1.10	6.87^d
2. smiles at you when you talk to him/her	1.05	5.04
6. interacts with you via speech or sounds	-0.87	4.89
7. interacts with you via gestures	-0.79	5.37
8. greets your return by looking at you	0.84	4.61
11. greets your return by hugging you	-0.97	6.34
12. shows affection by cuddling	-0.92	4.35
15. laughs when you make silly sounds	-1.59	11.02^d
25. seeks praise by showing what s/he did	-1.02	12.98^e
31. shy around people s/he doesn't know well	-1.06	9.95^d
32. has a blank face (reverse scored)	-0.92	7.37^d
33. looks distant/removed (reverse scored)	-1.98	12.24^e
34. can see you are happy by your face or voice	-0.95	9.14^d
38. stays close to other children	1.22	6.49
40. joins play when invited by other children	-1.21	7.69^d
41. shows concern if another child is upset	-0.96	5.46
42. can start social exchange with other children	-0.67	4.62
45. is liked by other children his/her age	-0.81	5.47
49. takes toys from siblings or other children (reverse scored)	0.86	7.07 ^d
54. shares favorite items or toys with children	-0.98	8.13^d
Statistically significant ($p < 0.05$) items for older age group (43–61 months of age): $n = 109$		
1. looks at you when you talk to him/her	-0.72	6.07
9. greets your return with sounds or talking	-0.74	12.43^e
18. plays pretend games (dolls, cars)	-0.66	8.08^d
25. seeks praise by showing what s/he did	-1.12	27.98^e
35. can see you are angry by your face or voice	-0.74	9.32^d
42. can start a social exchange with other children	-1.31	35.42^e
40. joins play when invited by other children	-1.09	31.03^e
49. takes toys from siblings/other children (reverse scored)	0.71	8.01 ^d
54. shares favorite items or toys with children	-0.99	17.62^e

PDD-NOS=Pervasive developmental disorder-not otherwise specified

^a Items were entered using Backward Stepwise method in seven separate blocks

^b Change in model if item removed

^c Boldface indicates critical items chosen

^d $p < 0.01$

^e $p < 0.001$

Sensitivity and specificity for discriminating between autism spectrum disorder (ASD) and Non-ASD clinical participants

Table 4

Discrimination: ASD (autism and PDD-NOS) vs. Non-ASD Clinical Group (<i>n</i> = 182)						
Test variable and Groups:	<i>n</i>	SSI mean (SD); range	ROC (AUC)	Screen Score [^]	Sensitivity	Specificity
Younger – SSI-Y (26 items):						
ASD	52	30.8 (12.8); 10–68		44	0.85	0.71
Non-ASD Clinical	21	52.7 (13.8); 25–76	0.88	46	0.87	0.71
					0.89	0.67
Younger – 9 Critical SSI items:						
ASD	52	12.3 (4.4); 4–24		16	0.75	0.90
Non-ASD Clinical	21	19.6 (4.4); 9–26	0.89	17	0.85	0.71
				18	0.92	0.62
Older – SSI-O (21 items):						
ASD	62	24.8 (13.7); 4–58		36	0.76	0.74
Non-ASD Clinical	47	42.5 (11.0); 14–63	0.84	37	0.81	0.70
				38	0.84	0.68
Older – 7 Critical SSI items:						
ASD	62	7.6 (4.8); 0–19		12	0.77	0.77
Non-ASD Clinical	47	14.6 (4.0); 5–21	0.86	13	0.82	0.72
				14	0.86	0.64

Discrimination: Matched [†] ASD (autism and PDD-NOS) vs. Non-ASD Clinical (<i>n</i> = 54)						
Test variable and Groups:	<i>n</i>	SSI mean (SD); range	ROC (AUC)	Screen Score [^]	Sensitivity	Specificity
Younger – SSI-Y (26 items):						
ASD	10	36.0 (12.4); 16–54		46	0.70	0.70
Non-ASD Clinical	10	52.8 (14.3); 25–73	0.82	48	0.80	0.70
				52	0.90	0.60
Younger – 9 Critical SSI items:						
ASD	10	13.4 (3.5); 9–19		17	0.80	0.70
Non-ASD Clinical	10	19.0 (4.8); 9–25	0.83	18	0.90	0.70
				19	0.90	0.50
Older – SSI-O (21 items):						
ASD	17	29.2 (15.0); 4–58		38	0.77	0.88
Non-ASD Clinical	17	46.6 (8.9); 30–60	0.85	42	0.82	0.71
				45	0.88	0.59

Discrimination: Matched [‡] ASD (autism and PDD-NOS) vs. Non-ASD Clinical (<i>n</i> = 54)						
Test variable and Groups:	<i>n</i>	SSI mean (SD); range	ROC (AUC)	Screen Score [^]	Sensitivity	Specificity
Older – 7 Critical SSI items:						
ASD	17	9.2 (5.0); 1–17		14	0.77	0.82
Non-ASD Clinical	17	16.1 (3.0); 11–21	0.89	15	0.88	0.65
				16	0.94	0.59

PDD-NOS=Pervasive developmental disorder-not otherwise specified

[^] Cutoffs refer to screen scores equal to or less than the score(s) listed

[‡] Matched participants are a subset of the participants depicted in the top half of the table