Accuracy of Three Screening Instruments in Identifying Preschool Children at Risk for Autism Spectrum Disorder

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Abstract: An efficient approach for screening and identifying children at risk for autism spectrum disorder (ASD) remains a pressing need. The aim of this exploratory study was to examine the ability of two general developmental screening tests to identify children at risk for ASD. We compared the accuracy of one general developmental screening instrument, Ages and Stages Questionnaires (ASQ), and one general social emotional screening instrument, the Ages and Stages Questionnaire: Social Emotional (ASQ:SE), with the Social Communication Questionnaire (SCQ), an ASD-specific screening instrument.

Two hundred eight children between 36 and 66 months were recruited through 19 community ASD programs, websites, and magazines. The three screening instruments were given to 285 parent/child dyads with and without a diagnosis of ASD, online *via* a screening website linked to a university. Sixty-four children had been diagnosed with ASD and were receiving special education services (e.g., behavioral interventions) prior to their participation. The classification agreement of the ASQ (i.e., sensitivity = 84.38%, specificity = 81.45%) outperformed the other two screening instruments; classification agreement of the SCQ was sensitivity = 70.31% and specificity = 87.33%; and of the ASQ: SE, sensitivity = 82.81% and specificity = 72.40%. Agreement among the questionnaires ranged from moderate to strong as measured by Pearson Product Moment Correlation Coefficients. Children diagnosed with ASD had scores below the screening cutoff points, indicating risk, most often on three ASQ domains: (a) communication, (b) gross motor, and (c) personal social. This exploratory study indicated the feasibility of using the ASQ in screening clinics for finding children at risk for ASD, if the ASQ is followed by specific ASD assessments. Design limitations, including a sample of children with ASD already receiving intervention services may explain the somewhat lower sensitivity of the SCQ.

Keywords: Autism Spectrum Disorder, Developmental-Behavioral Screening Instruments, ASQ, ASQ:SE, SCQ.

INTRODUCTION

The prevalence of autism spectrum disorders (ASD) has increased in the United States. According to findings of the Autism and Developmental Disabilities Monitoring (ADDM) Network's survey of 11 sites in the United States, the prevalence of ASD is 1:68 in eight-year-old children— with a higher prevalence among boys than girls –1:42 and 1:189 respectively [1]. Although some symptoms of ASD may manifest when children are between 12 and 24 months old, the manifestation of ASD symptoms is often later than 24 months old [2]. Eighty-two percent of children with ASD in the U.S. are diagnosed at the age of four and above [1-3]. The delay in diagnosis may be explained by a number of factors including: (a) detection of ASD symptoms varies from case to case depending on the severity of the symptoms, (b) ASD screening and diagnostic instruments are still under development for children younger than two years old, and (c) developmental profiles of children with ASD show considerable changes during preschool years [4, 5].

For the identification of ASD, a number of professional organizations (e.g., American Academy of Pediatrics [AAP] and American Academy of Neurology [AAN]) have recommended developmental surveillance and screening, which includes a two-level screening process [6-8]. The first level of screening is carried out with standardized developmental screening instruments, while the second level utilizes a battery of diagnostic tests. The AAP [6, 7] reported that a number of screening instruments have been recommended for identifying children at risk for ASD, primarily parent-completed developmental questionnaires, which have been shown to be effective for early identification [9-12]. Although there has been an increase in the number of pediatricians using standardized screening instruments from 2002 to 2009, 23%- 47.7% respectively, more than 50% of pediatricians are not compliant with the AAP screening recommendations [13]. Even when compliant, pediatricians often have neither the time nor office support to follow up and track screening results, resulting in children not being referred for further assessment, even when developmental concerns are indicated by the screening test [14]. Moreover, a majority of pediatricians fail to complete a screen on children over two-years-old, stating difficulties with office systems and referrals [10]. Although the AAP guidelines suggest this

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comprehensive screening approach, it has not been adopted by a majority of pediatric practices due to procedural and financial costs [13]. A more efficient screening protocol with fewer steps is needed that targets developmental-behavioral areas, with ASD follow-up as indicated by screening results and caregiver concerns.

This study represents a first step in studying the accuracy of two general screening tests widely used in pediatric practices—the Ages & Stages Questionnaires Third Edition (ASQ-3) [15] and the Ages & Stages Questionnaires: Social-Emotional (ASQ:SE) [12]—and one ASD-specific screen, the Social Communication Questionnaire (SCQ) [16]. The ASQ-3 and the ASQ: SE have been widely used to screen for developmental and social emotional delays respectively [9, 10, 13]. Recently, a study examined the agreement between the ASQ-3, Modified Checklist for Autism in Toddlers (M-CHAT) and, the SCQ in children between 12 and 72 months old; the researchers found that the relation between ASQ-3 domains, the M-CHAT, and the SCQ had at least a medium effect size [17]. In addition, children's abilities on the ASQ-3 domains had no relation with their parents' concerns of ASD [17]. Additional studies investigating the sensitivity and specificity of the SCQ with preschoolers have shown acceptable values of sensitivity and specificities [18-20]. Studies have used the SCQ with children younger than four-years-old. For instance, a study by Wiggins *et al*. [20] used the SCQ with children between the ages of 17 and 45 months; in this study the values of sensitivity and specificity were 89%. The current study focused on comparing the accuracy of the ASQ, ASQ: SE, and SCQ in identifying children with ASD. Our study targeted children with ASD who were three-years-old and above because children in the U.S.A are on average diagnosed with ASD after the age of four, and most subtle symptoms of ASD manifest after the age of 24 months [1, 2]. In addition, developmental screening is recommended up to school entry although it is performed less frequently as children age [13, 14].

METHOD

Children between 36 and 66 months of age with and without ASD were recruited across the United States; recruitment letters were mailed and emailed to 25 directors of programs serving children with ASD, parenting magazines, the websites of US organizations focused on ASD (e.g., Autism society), and electronic parenting bulletin boards (i.e., www.valerieslist.com). Data on participants were collected online *via* a university research website (i.e., http://www.asqoregon.com). Parents reported that their children with ASD received either a medical or educational diagnosis and were receiving special education services in autism programs. Parents' zip codes were checked against the nearest autism program contacted by the first researcher of this study, to verify the referral source.

Nineteen directors (76%) of autism programs agreed to disseminate information to the families of children with ASD in their programs. Two hundred and eighty-five participants throughout the United States completed the ASQ, the ASQ: SE and the SCQ online.

Parents completed the measures online by answering a demographic checklist, the ASQ, the ASQ: SE and the SCQ. The demographic checklist asked questions regarding the socioeconomic status and educational attainment of parents, and the ethnicity, age, disability status, and gender of the child. Parents were not asked to report their children's intelligent quotients (IQ), but rather if their child had a disability and was receiving specialized services. Participants received a $25 gift card in the mail after completing the following online: the demographic checklist, the ASQ, the ASQ: SE and the SCQ. Online data collection procedures were used, as these have been shown to be equivalent to pencil and paper data collection with the ASQ and ASQ:SE [21].

Screening Instruments

Ages and Stages Questionnaires (ASQ)-Third Edition

The ASQ-3, by J. Squires & D. Bricker, [15] was published in 2009 and is a broadband first-level screening instrument used for children between two and 66 months old. It is a parent report tool consisting of 21 intervals, each with 30 items grouped in five domains: (a) communication, (b) gross motor, (c) fine motor, (d) problem solving, and (e) personal social, and can be completed in 10-15 minutes. Parents answer *yes* (10 points), *sometimes* (5 points), or *not yet* (0 points) based on whether their child can perform the targeted tasks. Scores in each domain are totaled and compared with empirically derived cutoff points. Children receive a "risk" classification result if their scores in any one domain fall below the cutoff points established for that interval.

In terms of psychometric properties, overall agreement between the results of ASQ and the Battelle

Developmental Inventory, II [22] on the classification of children's abilities ranged from 83% to 88%; sensitivity and specificity were 0.83 and 0.91 respectively [15, 23]. Test-retest reliability was 92% on children's classifications [15].

Ages and Stages Questionnaires: Social Emotional (ASQ: SE)

The ASQ: SE, authored by J. Squires and D. Bricker [12] is a parent-report questionnaire focusing on the social and emotional competence of children from 3 to 66 months. The ASQ: SE has eight age intervals and includes 19 to 33 items per interval that measure social emotional areas such as autonomy, communication, and peer relationships [12, 24, 25]. Parents indicate whether their child does the targeted items *most of the time*, *sometimes*, or *never or rarely*, and check a box to indicate if the behavior is of concern. Responses are transferred to point values of 0, 5, or 10, with a high total score indicative of problems, while low scores suggest the child's social-emotional behavior is considered competent by parents. Empirically-based cutoffs have been established according to total scores by interval, based on ROC analyses. Studies have examined the reliability and validity of the ASQ: SE with internal consistency ranging from 67% to 91%, and sensitivity and specificity of 78% and 95% respectively [26]. Its test-retest reliability was 94% [27]. The concurrent validity of the ASQ: SE was calculated with a number of norm-referenced tests (e.g., Child Behavior Checklist and Social-Emotional Early Childhood Scale); the concurrent validity with these instruments ranged from 81% to 95% with an overall agreement of 89%, while the ASQ: SE sensitivity ranged from 75% to 88%, and specificity from 82% to 92% [27]. All procedures were approved by an IRB previous to implementation.

Social Communication Questionnaire (SCQ)

The SCQ was designed to be a companion screening tool with the Autism Diagnostic Interview-Revised (ADI-R) [16]. Developed by M. Rutter, A. Bailey, and C Lord, the SCQ is a 40-item ASD screening instrument completed by parents or caregivers for children above four years of age [16]. Because of its validity with younger children [28], the SCQ is also used with children younger than four years old. The SCQ was validated on a sample of children with and without ASD with sensitivity at 88% and specificity at 72% [16]. It has shown to have excellent psychometric properties in terms of sensitivity and specificity for ASD identification [16]. For this study, the SCQ cutoff score of 11 was used for children younger than four-years-old, and the SCQ cutoff score of 15 used for children four-years-old and above [18, 20, 28].

Data Analysis

Agreement between Questionnaires

Pearson Product Moment Correlation Coefficients were used to calculate agreement between the ASQ, and the ASQ: SE, with the SCQ [29]. A classification matrix was developed to measure the sensitivity and specificity of each individual tool, as well as to calculate the negative predictive value and positive predictive value of each tool.

RESULTS

Two hundred and eighty-five children were screened with the ASQ, the ASQ: SE and the SCQ by their parents. Table **1** summarizes the descriptive statistics of the sample. Children were between 35.98 and 62.85 months old, with a mean of 47.68 and a standard deviation of 7.19. The sample included 64 (22.5%) children with ASD, and 221 (77.5%) typically developing children. Of these 64 children, 45 had received intensive behavioral treatment for more than one year. Children's scores on the ASQ, ASQ:SE, and SCQ are summarized in Table **2**.

General Agreement among Questionnaires

Pearson Product Moment Correlation Coefficients were calculated to measure the magnitude of the general agreement between the total scores of each ASQ domain and the total score of the SCQ as well as the total score of the ASQ: SE and the total score of the SCQ. Although the scores were not normally distributed, the Pearson-product correlation coefficient is a robust test for non-normal data [30-32]. The scatter plot showed that scores had approximately bivariate linear distributions; the few outliers represented scores of children with ASD. A Spearman correlation – a nonparametric test- was calculated to measure if these outliers had attenuated the correlation between screening instruments [33, 34].

The results of Spearman Correlation of the ASQ domains with the SCQ were similar to the results of Pearson product moment correlations. Results of the general agreement between the ASQ domains, total scores of the ASQ: SE and the total scores of the SCQ are summarized in Table **3**.

Table 1: Demographic Characteristics of the Participants

Demographic variables	At risk for ASD	Typically developed	Total
Gender			
Male	41 (64.1%)	117 (52.9%)	158 (55.4%)
Female	23 (35.9%)	104 (47.1%)	127 (44.6%)
Total	64 (100%)	221 (100%)	285 (100%)
Birth condition			
Premature	18 (28.1%)	27 (12.2%)	45 (15.8%)
Mature	46 (71.9%)	190 (86.0%)	236 (82.8%)
Do not know	0 (0.0%)	4 (1.8%)	4 (1.4%)
Socioeconomic status			
0-12,000	5 (7.8%)	21 (9.5%)	26 (9.1%)
12,001-24,000	4 (6.3%)	25 (11.3%)	29 (10.2%)
24,001-40,000	16 (25.0%)	33 (14.9%)	49 (17.2%)
40,001 and above	38 (59.3%)	131 (59.3%)	169 (59.3%)
Do not know	1 (1.6%)	11 (5.0%)	12 (4.2%)
Mother's educational level			
Less than high school	2 (3.1%)	9 (4.1%)	11 (3.9%)
High school diploma	13 (20.3%)	56 (25.3%)	69 (24.2%)
Associate degree	12 (18.8%)	31 (14.0%)	43 (15.1%)
Four years college and above	37 (57.8%)	120 (54.3%)	157 (55.1%)
Not reported	0 (0.0%)	5 (2.3%)	5 (1.8%)
Ethnicity			
African American	0 (0.0%)	8 (3.8%)	8 (3.0%)
Asian	2 (3.3%)	12 (5.7%)	14 (5.2%)
Caucasian	45 (73.8%)	163 (78.0%)	208 (77.0%)
Hispanic	6 (9.8%)	10 (4.8%)	16 (5.9%)
Mixed	7 (11.5%)	15 (7.2%)	22 (8.1%)
Native American	0 (0.0%)	1 (0.5%)	1 (0.4%)
Pacific Islander	1 (1.6%)	0 (0.0%)	1 (0.4%)
Receiving special education	62 (96.9%)	0 (0.0%)	62 (96.9%)

Table 2: Descriptive Statistics of the Scores on the ASQ, ASQ: SE, and SCQ

Variables	*n*	*M*	*SD*	Min - Max
ASQ				
Communication	285	45.72	16.78	0.00 - 60.00
Gross motor	285	48.44	13.66	10.00 - 60.00
Fine motor	285	40.32	17.91	0.00 - 60.00
Problem solving	285	49.12	13.70	15.00 - 60.00
Personal social	285	46.40	15.62	0.00 - 60.00
ASQ:SE total score	285	73.14	66.10	0.00 - 325.00
SCQ total score	285	8.62	7.00	0.00 - 32.00

Note. Min/Max indicates minimum and maximum scores.

Table 3: Pearson Product Moment Correlation Coefficient for the ASQ, the ASQ: SE, with the SCQ

Variables	SCQ		
	R	r_s	R^2
ASQ			
Communication	-0.66***	-0.57***	.44
Gross motor	-0.57***	-0.53***	.33
Fine motor	-0.57***	-0.55***	.33
Problem solving	-0.57***	-0.55***	.33
Personal social	-0.64***	-0.61***	.41
ASQ:SE total score	0.84***	0.77***	.71

Note. ***p < .0001. r = Pearson product moment correlation, r_s = Spearman's rank-order correlation, and R^2 = Coefficient of determination of Pearson product moment correlation.

Table 4: Classifications of Children as at Risk for ASD Using One or More Domains of the ASQ and the Parent Report of Disability Status

All age intervals		Disability status		
		At risk for ASD	Not at risk for ASD	
ASQ classification	At risk	54	41	95
	Not at risk	10	180	190
	Total	64	221	285

Sensitivity	Specificity	PPV	NPV
84.38%	81.45%	56.84%	94.74%

Note. ASD = autism spectrum disorders; PPV = positive predictive value; NPV = negative predictive value.

Table 5: Classifications of Children as at Risk for ASD Using the Cutoff Scores of the ASQ: SE and the Parent Report of Disability Status

All age intervals		Disability status		
		At risk for ASD	Not at risk for ASD	
ASQ:SE classification	At risk	53	61	114
	Not at risk	11	160	171
	Total	64	221	285

Sensitivity	Specificity	PPV	NPV
82.81%	72.40%	46.49%	93.58%

Note. ASD = autism spectrum disorders; PPV = positive predictive value; NPV = negative predictive value.

Table 6: Classification of Children as at Risk for ASD Using the Cutoff Score of the SCQ and Parent Report of Disability Status

All age intervals		Disability status		
		At risk for ASD	Not at risk for ASD	
ASQ classification	At risk	45	28	73
	Not at risk	19	193	212
	Total	64	221	285

Sensitivity	Specificity	PPV	NPV
70.31%	87.33%	61.64%	91.03%

Note. ASD = autism spectrum disorders; PPV = positive predictive value; NPV = negative predictive value.

Classification Agreement

This analysis was conducted on 285 participants, comparing results from ASQ, ASQ:SE, and SCQ. Table **4** displays the results of the ASQ classification agreement, calculated as "risk" if the child failed one ASQ domain as per developer's recommendations. Tables **5** and **6** display the results of the classification of the ASQ: SE and the SCQ; participants scoring above the cutoff scores of these tests were at risk for ASD.

DISCUSSION

Screening is an initial step in early identification of children at risk for disability or delay [6, 27]. If general

developmental screening tests can be used both to screen for developmental delays and to point to children who should receive a more in-depth screen for ASD, follow up screening steps could be eliminated. That is, children with screening profiles indicating ASD symptoms could be referred immediately for an ASD evaluation. Benefits include: (a) less expensive instruments, (b) less time consuming, (c) more economical, (d) accelerated process of providing service to children at risk for disability. The ASQ and ASQ: SE showed an acceptable level of sensitivity (i.e., > 80%) when they were used with a sample of children with ASD. The SCQ showed slightly lower sensitivity (70.31%) and higher specificity value than those of the ASQ and the ASQ: SE.

IMPLICATIONS

These results support the use of general screening measures such as the ASQ and the ASQ: SE to identify children at general risk for ASD. The ASQ demonstrated acceptable agreement; its classification agreement was consistent with the recommended values of the sensitivity and specificity in the literature, 80% or above. Also, ASQ domains had moderate correlation with the total score of the SCQ, while children's total scores on the ASQ: SE had a strong agreement with those of the SCQ.

This study is an exploratory examination of the classification and general agreement of the ASQ-3, the ASQ: SE and the SCQ. The results indicated the possibility of using of the ASQ-3 and/or the ASQ: SE for identifying children at risk for ASD, with ASD-specific follow up as confirmation. For instance, 17 children with ASD scored more than three standard deviations below the mean in all domains of the ASQ-3, indicating critically low skills on the general developmental screening instrument. Specifically, these 17 children scored significantly low in the following ASQ-3 domains: communication, gross motor, and personal-social. These ASQ-3 domains might be used as indicators for identifying children at risk for ASD. However, further examinations of these outcomes are warranted with a larger, more diverse sample.

A recent study [34] investigated the ASQ-3 and its ability to identify ASD in toddlers. For toddlers who screened positive on the M-CHAT-R (including using the follow-up interview), the ASQ-3 identified 87% of these children as well as 95% of children diagnosed subsequently with an ASD, using the ASQ-3 monitoring and fail cutoff scores on any domain as criteria. This study, while preliminary, included a large sample of 2848 toddlers in 20 pediatric clinics.

In regard to the ASQ: SE, this instrument can be used with a general developmental screen such as the ASQ-3 because of its broad focus on social emotional skills, which children with ASD lack [2]. Table **5** shows that 82.81% of participants with ASD captured by the ASQ:SE as children lacked social emotional competency. Thus, the ASQ:SE might be used with the ASQ to identify children at risk for ASD if the ASQ domains (especially communication and personal-social) confirmed that they were indicators for identifying children at risk for ASD. The ASQ:SE was recently revised (Ages and Stages Questionnaires, Social-Emotional-2nd Edition) [35] (ASQ:SE-2) with specific items added that focus on early communication and self-regulation skills associated with ASD. Future studies are needed to investigate the sensitivity and specificity of the ASQ:SE-2 in identifying children with ASD, including both toddlers and preschool children.

To summarize, given that the classification agreement of the ASQ slightly outperformed the SCQ and the ASQ:SE in this sample, it may be that the ASQ can be used in pediatric clinics as a general screener followed by an ASD specific screen based on specific ASQ results. Use of one screening tool in the office, rather than two, may encourage more regular screening by physician, as well as be more economical. Both the ASQ and the ASQ:SE are cost-effective and have been used as first level screenings for developmental disability; however, further evaluation is needed before using them with the ASD population.

LIMITATIONS

The sample size of the study was one of its limitations. As well, a convenience sample was recruited, possibly influencing outcomes. Third, the study was conduct on-line, which excluded some parents who do not have computer access. Fourth, the sample was weighted towards Caucasian white participants, perhaps due to methods for recruitment in which ASD programs were contacted whose populations often lack diversity. Fifth, the heterogeneity of the participants with ASD might have affected the results of the classification agreement because the participants manifested a range of ASD symptoms. Some participants had comorbid disabilities such as ADHD and ASD. In addition, 64 participants with ASD

were receiving special educational services prior to their participation in the study. Therefore, their scores varied on the domains of the ASQ and the items of the ASQ: SE and SCQ. A larger sample of children with ASD and typically developing children might have strongly supported the results of the classification agreement and general agreement of the questionnaires. Finally, the study relied on parents to verify their children's diagnoses of ASD. Information about medical and educational diagnoses was also collected, however, and it was concluded that all children had been given the diagnosis of ASD by either a medical or educational team. Limitations in resources prohibited the administration of the Autism Diagnostic Observation Schedule (ADOS) or a diagnostic evaluation by a clinical team.

The high specificity of the SCQ might be explained because the SCQ is a targeted screening instrument designed for identifying ASD. However, given that the sensitivity and specificity values of the ASQ were above 80%, the ASQ had a slightly higher and more balanced classification agreement than the other screening instruments. While the SCQ identified fewer children at risk for ASD and developmental disability than the ASQ and the ASQ: SE, this was a small sample of children already receiving services.

CONCLUSION

This initial study indicates that a simplified developmental screening protocol may be viable for pediatric providers in which general developmental tests are administered at regular intervals, followed up with ASD and other specific assessments based on screening results. In this study, a general developmental screen, the ASQ, identified 84.38% of children with an ASD diagnosis. Thirty-nine out of 64 children with ASD had communication scores below the cutoff point on the ASQ, and 34 out of 64 children with ASD had personal-social scores in the referral range. Children with low scores in these two areas, as well as those with parent or caregiver concerns might then be followed up with an ASD specific test. This streamlined protocol may result in larger numbers of children receiving a general developmental screening assessment, with targeted follow up as indicated by screening results; however, further evaluation of the classification agreement and general agreement of the ASQ and the ASQ: SE are required prior to using these instruments with the ASD population. This study demonstrated that general developmental and social emotional screening instruments can be used to detect ASD in young children. Early detection of ASD can improve developmental and behavioral outcomes for young children and their families.

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