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Corresponding Author	Family Name	**Chiang**
	Particle	
	Given Name	**Chung-Hsin**
	Suffix	
	Division	Department of Psychology
	Organization	National Chengchi University
	Address	No.64, Sec.2, ZhiNan Rd., Wenshan District, Taipei, 11605, Taiwan
	Division	Research Center for Mind, Brain and Learning
	Organization	National Chengchi University
	Address	Taipei, Taiwan
	Phone	
	Fax	
	Email	chchiang@nccu.edu.tw
	URL	
	ORCID	http://orcid.org/0000-0002-9640-9139
Author	Family Name	**Wu**
	Particle	
	Given Name	**Chin-Chin**
	Suffix	
	Division	Department of Psychology
	Organization	Kaohsiung Medical University
	Address	Kaohsiung, Taiwan
	Division	Department of Medical Research
	Organization	Kaohsiung Medical University Hospital
	Address	Kaohsiung, Taiwan
	Phone	
	Fax	
	Email	
	URL	
	ORCID	
Author	Family Name	**Chu**
	Particle	
	Given Name	**Ching-Lin**
	Suffix	
	Division	Department of Educational Psychology and Counseling

	Organization	National Pingtung University
	Address	Pingtung, Taiwan
	Division	Department of Psychology
	Organization	National Cheng Chung University
	Address	Chiayi City, Taiwan
	Phone	
	Fax	
	Email	
	URL	
	ORCID	
Author	Family Name	**Stewart**
	Particle	
	Given Name	**Lydia**
	Suffix	
	Division	
	Organization	Center for the Promotion of Child Development Through Primary Care
	Address	Baltimore, USA
	Division	
	Organization	Johns Hopkins University Bloomberg School of Public Health
	Address	Baltimore, USA
	Phone	
	Fax	
	Email	
	URL	
	ORCID	
Author	Family Name	**Hou**
	Particle	
	Given Name	**Yuh-Ming**
	Suffix	
	Division	Department of Psychiatry
	Organization	Chia-Yi Christian Hospital
	Address	Chiayi, Taiwan
	Division	Ditmanson Medical Foundation
	Organization	Chia-Yi Christian Hospital
	Address	Chiayi City, Taiwan
	Phone	
	Fax	
	Email	
	URL	
	ORCID	
Author	Family Name	**Liu**
	Particle	
	Given Name	**Jiun-Horng**
	Suffix	
	Division	Department of Psychiatry

Organization	Liou-Yin, Chi Mei Medical Center
Address	Tainan, Taiwan
Division	Ditmanson Medical Foundation
Organization	Chia-Yi Christian Hospital
Address	Chiayi City, Taiwan
Phone	
Fax	
Email	
URL	
ORCID	

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Abstract	The present longitudinal study examined the utility of the screening tool for autism in 2-year-olds (STAT) in detecting autism spectrum disorder (ASD) in toddlers who are less than 24 months of age. The study sample, which consisted of 119 toddlers with developmental problems, were assessed when they were between 16 and 24 months of age (Time 1) and after a period of 18 months to finalize the diagnosis (Time 2); 57 children had ASD and 62 children had developmental delays. A cutoff score of 2.5 on the STAT yielded an optimal combination of high sensitivity and specificity. The STAT demonstrated adequate predictive validity in detecting ASD in Taiwanese toddlers who are less than 24 months of age.

Keywords (separated by '-')	Autism spectrum disorder - Toddler - Screening - Sensitivity - Specificity
Footnote Information	

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The Utility of the Screening Tool for Autism in 2-Year-Olds in Detecting Autism in Taiwanese Toddlers Who are Less than 24 Months of Age: A Longitudinal Study

Chin-Chin Wu[1,2] · Ching-Lin Chu[3] · Lydia Stewart[4] · Chung-Hsin Chiang[5,6] · Yuh-Ming Hou[7] · Jiun-Horng Liu[8]

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Abstract

The present longitudinal study examined the utility of the screening tool for autism in 2-year-olds (STAT) in detecting autism spectrum disorder (ASD) in toddlers who are less than 24 months of age. The study sample, which consisted of 119 toddlers with developmental problems, were assessed when they were between 16 and 24 months of age (Time 1) and after a period of 18 months to finalize the diagnosis (Time 2); 57 children had ASD and 62 children had developmental delays. A cutoff score of 2.5 on the STAT yielded an optimal combination of high sensitivity and specificity. The STAT demonstrated adequate predictive validity in detecting ASD in Taiwanese toddlers who are less than 24 months of age. AQ1

Keywords Autism spectrum disorder · Toddler · Screening · Sensitivity · Specificity

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Autism spectrum disorder (ASD) is a neurodevelopmental disorder that emerges during early childhood. It is defined by impairments in social and communication skills, repetitive behavior patterns, and a restricted range of interests (American Psychiatric Association 2013). There are considerable individual differences in the behavioral, language, and intellectual capabilities of individuals with ASD. Past studies have shown that children with ASD who begin receiving early intervention services between the ages of 2 and 5 exhibit improved outcomes and prognosis (Dawson et al. 2010; Pickles et al. 2016). The effectiveness of early intervention highlights the importance of early diagnosis. On average, parents develop concerns about their children with ASD and seek professional help for the first time when their children are 19 and 24 months of age, respectively (Becerra-Culqui et al. 2018; De Giacomo and Fombonne 1998; Sacrey et al. 2015). There are a few factors (e.g., sex, degree of impairment that is associated with ASD) that delay the diagnosis of ASD and consequently adversely impact child and family outcomes (Wiggins et al. 2006). AQ2

The prevalence of ASD among children has increased dramatically in recent years. Indeed, estimates suggest that

✉ Chung-Hsin Chiang
chchiang@nccu.edu.tw

1 Department of Psychology, Kaohsiung Medical University, Kaohsiung, Taiwan

2 Department of Medical Research, Kaohsiung Medical University Hospital, Kaohsiung, Taiwan

3 Department of Educational Psychology and Counseling, National Pingtung University, Pingtung, Taiwan

4 Center for the Promotion of Child Development Through Primary Care, Baltimore, USA

5 Department of Psychology, National Chengchi University, No.64, Sec.2, ZhiNan Rd., Wenshan District, Taipei 11605, Taiwan

6 Research Center for Mind, Brain and Learning, National Chengchi University, Taipei, Taiwan

7 Ditmanson Medical Foundation, Chia-Yi Christian Hospital, Chiayi City, Taiwan

8 Department of Psychiatry, Liou-Yin, Chi Mei Medical Center, Tainan, Taiwan

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1 in 59 children in the United States (Baio et al. 2018), 1.2 in 100 children in the United Kingdom (Baird et al. 2006), and 1 in 106 children in Australia (Veness et al. 2012) have ASD. The increasing prevalence of ASD and the effectiveness of early interventions highlight the need for and importance of early diagnosis. However, the prevalence of ASD is lower in Taiwan than in Western countries (Lai et al. 2012; Sun et al. 2013), and this difference can be attributed to factors such as the stigma that is associated with psychological diagnoses in Chinese culture (Pang et al. 2018), government policies (Lai et al. 2012), and the inadequacy of tools that can be used to screen for ASD among young children (Lai et al. 2011). The lower prevalence may be associated with delayed diagnoses, which in turn may cause parents to experience high levels of anxiety and frustration. Thus, it is necessary to facilitate the early diagnosis of ASD in Taiwan, especially in community-based clinical settings, such as district hospitals.

The best-estimate clinical diagnosis (BECD) is formulated based on the information that is yielded by a multidisciplinary assessment process, which includes the child's developmental history, parental concerns, and the measurement of cognitive and language abilities, adaptive functioning, and the diagnostic criteria for autism (Le Couteur et al. 2008). The Autism Diagnostic Interview-Revised (ADI-R; Le Couteur et al. 2003), autism diagnostic observation schedule (ADOS; Lord et al. 1999), and the ADOS-2 (Lord et al. 2012b) are valid measures that can be used to make diagnostic decisions about autism; in particular, a combination of the ADI-R and ADOS(-2) yields valid diagnoses. Both the BECD protocol and the combinatorial use of measurements that aid in the diagnosis of autism are time-consuming procedures. In Taiwan, only child and adolescent psychiatrists are eligible to issue documents that certify a child with a diagnosis of ASD. Child and adolescent psychiatrists typically shoulder a heavy workload, and they typically treat more than 30–40 children within a 3–4-h clinic session. They may refer the child to clinical psychologists for further assessments that could aid the diagnostic decision-making process. However, it is difficult for Taiwanese child and adolescent psychiatrists or clinical psychologists to execute the BECD protocol or administer a combination of measurements that assess the diagnostic criteria for autism. Therefore, it is important to use an affordable and easy-to-administer screening tool to facilitate the early identification and diagnosis of ASD among children in Taiwan, particularly in clinical settings.

The existing screening tools for ASD can be divided into two levels (Barton et al. 2012; Filipek et al. 1999). Level 1 screening tools are designed for use with the general population, whereas level 2 screening tools are designed for use with those who are at a high risk for ASD or with clinical samples. In Taiwan, a majority of infants and toddlers undergo physical and developmental screening in primary care settings (e.g., community clinics, health centers) when they are vaccinated. This process allows healthcare providers to examine the socioemotional functioning (e.g., response to one's name) of infants and toddlers, and identify high-risk cases that require further clinical diagnosis. One of main following referring settings is the department of child psychiatry at regional hospitals in Taiwan. Clinical psychologists are one of the key collaborative professionals for these psychiatrists to make formal diagnosis. Thus, a level 2 (rather than a level 1) screening tool that is used for differentiating between children with ASD and those with other developmental problems is urgently needed because all high-risk infants and toddlers were referred from primary care settings in Taiwan.

The American Academy of Pediatrics recommends that all toddlers who are between the ages of 18 and 24 months should be screened using an ASD-specific tool (Johnson and Myers 2007). However, there are only a few interactive screening measures for ASD that are suitable for use with toddlers who are below 24 months of age; these assessments include the screening tool for autism in 2-year-olds (STAT; Stone et al. 2004), Autism Detection in Early childhood (ADEC; Nah et al. 2014), and Rapid Interactive Screening Test for Autism in Toddlers (RITA-T; Choueiri and Wagner 2015). Among these three interactive screening measures, only the STAT and ADEC have been validated and tested using high-risk samples. The STAT consists of 12 activity-based items that measure four domains: play, requesting, directing attention (i.e., joint attention), and imitation. It was originally designed for use with young children who are between the ages of 24 and 35 months. Khowaja et al. (2012) found that a cutoff score of 2.25 on the STAT had a sensitivity and specificity of 0.75 for a sample of 24 toddlers who were less than 24 months old. On the other hand, the ADEC consists of 16 items that are suitable for use with young children who are between the ages of 12 and 36 months. A cutoff score of 11 on the ADEC yielded a sensitivity of 1 and specificity of 0.77 for 70 young children with autism ($M_{age}=29.4$ months) and 57 young children with other developmental disorders ($M_{age}=24.1$ months). The ADEC demonstrated better sensitivity and specificity than the STAT (Nah et al. 2014).

Correct identification of children with ASD (i.e., high sensitivity and positive predictive value) allows both the children and their families to receive early intervention. However, false positives (i.e., low specificity and negative predictive value) can adversely affect the misdiagnosed children and their families. Therefore, it is important to establish the predictive validity of ASD screening tools and the temporal stability of diagnostic assessment. A few recent studies have suggested that the BECD is a reliable and stable assessment that can be used to diagnose ASD in toddlers who are less than 24 months of age (Barbaro and Dissanayake 2017;

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Guthrie et al. 2013; Kim et al. 2016). However, few studies have examined the predictive validity of ASD screening tools.

In order to validate the STAT, Stone et al. (2008) recruited 71 toddlers who were between the ages of 12 and 23 months (M_{age} = 16.4 months). Of these, 59 toddlers had an older sibling with ASD and 12 toddlers were referred for an assessment of ASD. All the participants (including the 19 children with ASD and 52 children without ASD) were retested when they were between the ages of 24 and 42 months (M_{age} = 31.3 months). A cutoff score of 2.75 on the STAT yielded a predictive sensitivity of 0.95 and specificity of 0.73 for toddlers who were less than 24 months old. However, their findings entailed a high number of false positives for toddlers who were less than 13 months of age. Dix et al. (2015) assessed 53 toddlers who were between the ages of 18 and 47 months (M_{age} = 32.2 months). Of these, 32 children received a diagnosis of ASD (M_{age} = 41.2 months, range = 22–65 months), and all the participants were retested when they were between the ages of 48 and 97 months (M_{age} = 74.5 months). A cutoff score of 11 on the ADEC yielded a predictive sensitivity of 0.88 and specificity of 0.62 for 2-year-old toddlers. Contrary to the concurrent validity results of the two assessments, the STAT demonstrated better predictive validity than the ADEC.

The sensitivity of the STAT and T-STAT (i.e., the Taiwanese version of the STAT) was tested using a hospital-based clinical sample of 24–36-month-old children with ASD and developmental delays (DD; Chiang et al. 2012, 2013). A cutoff score of 2 on the T-STAT yielded acceptable sensitivity (0.94–0.97) and specificity indices (0.82–0.93). Additionally, a study that examined the validity of the STAT in ascertaining the risk of ASD among 2-year-old children in Taiwan yielded promising results. However, there is a need to examine the predictive validity of the STAT using samples of toddlers who are older than 24 months. Thus, the primary purpose of the present study was to examine the predictive validity of the STAT as a screening tool for ASD using a hospital-based clinical sample. Specifically, we examined the utility of the STAT in detecting ASD in toddlers who are less than 24 months of age (Time 1). Additionally, we examined the predictive validity of the STAT by readministering it to the participants after a period of 18 months (Time 2).

Methods

Participants

The present study was approved by the Ditmanson Medical Foundation Chia-Yi Christian Hospital Research Ethics Committee (CYCH-IRB101022; CYCH-IRB102045). All parents provided informed consent prior to the administration of the assessment. A total of 139 toddlers who were between the ages of 16 and 24 months (Time 1) participated in the study, and they were all recruited from a teaching hospital in the Chia-Yi area. After 18 months had passed, the participants were invited for a reassessment. A total of 119 children who were between the ages of 35 and 46 months (Time 2) underwent follow-up assessment; the remaining 20 children did not attend the follow-up assessment. None of the participants had sensory or motor impairments, or previously diagnosed genetic disorders. The average period of time that had elapsed between the initial and follow-up assessments was 18.64 months (SD = 1.09).

All participants were diagnosed with either ASD or DD in accordance with the Diagnostic and Statistical Manual of Mental Disorders, Fifth edition (DSM-5; APA 2013) criteria and the results of the follow-up assessment. According to the DSM-5 criteria for ASD, a child must exhibit a minimum of three deficits in social communication/interaction skills and two restricted/repetitive behaviors. However, previous studies (e.g., Frazier et al. 2012) have shown that these DSM-5 criteria have a lower sensitivity than those of the Diagnostic and Statistical Manual of Mental Disorders, Fourth edition, Text Revision (DSM-IV-TR; APA 2000). Thus, participants that did not meet the criteria for ASD according to the DSM-5 still had significant impairments related to the core symptoms of ASD. Participants that no longer met the DSM-5 criteria for ASD may not be classifiable into DD groups. Using the strict diagnostic criteria of the DSM-5 may impede early intervention for children with ASD and family services. Thus, to increase sensitivity, Frazier et al. (2012) have proposed a set of less stringent criteria based on which a child may be considered to meet the DSM-5 criteria for ASD. Accordingly, the following criteria were used in the present study: (1) three deficits in social communication/interaction skills and one restricted/repetitive behaviors, and (2) two deficits in social communication/interaction skills and two restricted/repetitive behaviors. All participants with ASD were assessed and diagnosed based on their developmental history, the current concerns of the parents, the results of tests that measure cognitive and adaptive functioning, clinical observations of the child, and the results of ADOS (Lord et al. 1999) by a multidisciplinary team that included two senior clinical child psychologists with doctoral degrees and two senior child and adolescent psychiatrists constituted the diagnostic team. The participants who failed to reach a total score of 85 on the Mullen Scales of Early Learning (MSEL; Mullen 1995) or a T-score of 35 on any of the four cognitive scales (i.e., visual reception, fine motor, receptive language, and expressive language) were considered to have DD. Finally, there were 57 children who had ASD and 62 children who had DD. Of the 57 children who had ASD, 43 children met the strict DSM-5 criteria

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whereas the others met the less stringent DSM-5 criteria that have been suggested by Frazier et al. (2012).

All the study participants were assessed using the MSEL (Mullen 1995), which measures the four domains of developmental abilities. The mental age was computed by averaging the age equivalents across the four domains. The results of an independent-samples *t*-tests showed that the ASD and DD groups were of comparable chronological age at both Time 1 and Time 2. In addition, the *t*-tests showed that children with DD had a higher mental age than those with ASD at both Time 1 and Time 2. The results of the *t*-tests also showed that children with ASD obtained higher scores than children with DD on ADOS at both Time 1 and Time 2. The results of a chi-squared test showed that there was no significant difference in the gender ratios of the two groups. The demographic characteristics of the sample that were included in the present study are presented in Table 1.

Procedures and Measures

During the initial and follow-up assessments, all the participants were subjected to the STAT (Stone et al. 2008), MSEL (Mullen 1995), and ADOS (Lord et al. 1999). The examiners who administered the STAT were agnostic to the diagnostic information of the participants as well as to the concerns of the caregivers prior to administration. In addition, the examiners who administered the ADOS were not provided with any information about the STAT prior to the administration procedure. For each child, a different examiner administered the STAT during the initial and follow-up assessments.

Table 1 Demographic characteristics of the participants

Variable	ASD group ($n=57$)	DD group ($n=62$)	p
Time 1			
Mean (SD): CA[a]	21.37 (1.97)	21.21 (1.93)	0.658
Mean (SD): MA[a]	13.96 (3.32)	16.23 (2.96)	0.000
Mean (SD): composite score of ADOS	16.04 (4.90)	5.26 (3.98)	0.000
Time 2			
Mean (SD): CA[a]	39.93 (2.23)	39.92 (1.89)	0.978
Mean (SD): MA[a]	31.11 (9.74)	35.92 (6.88)	0.002
Mean (SD): composite score of the ADOS	14.30 (3.74)	2.76 (2.21)	0.000
Gender ratio			
Male: female	47:10	44:18	0.140

CA chronological age, *MA* mental age, *ADOS* autism diagnostic observation schedule, *ASD* autism spectrum disorder, *DD* developmental delays

[a]In months

However, due to a limited number of research staff, a majority of the ADOS administrations were undertaken by the first and second authors who had received research training and certification in Taiwan (i.e., by Dr. Catherine Rice's team at Pingtung county). The authors did not review participants' ADOS scores at Time 1 before administering and scoring the ADOS at Time 2.

The STAT was administered by examiners who were graduate students (i.e., Master of Science) in the discipline of clinical psychology and had received prior training on the administration and scoring of the assessment. The clear operationalization of each item and provision of examples that aid the scoring process minimize the subjective interpretations of the examiner (Nah et al. 2014). Prior to the administration of the assessments, an 8-h training course was conducted for the examiners who were required to administer the STAT. The examiners were trained with the objective of familiarizing them with the standardized test administration protocol; interrater reliability between these examiners and the first author who had been trained in the administration and scoring of the STAT was high (i.e., 0.90). In order to enhance interrater reliability, the examiners periodically discussed the manner in which they scored the STAT and ADOS.

Mullen Scales of Early Learning (MSEL; Mullen 1995)

The MSEL is a standardized comprehensive developmental test that was designed for use with preschool children whose ages range from 0 to 68 months. It consists of four cognitive scales: visual reception, fine motor, receptive language, and expressive language. The four cognitive scales yield *T*-scores, which have a mean of 50. The four subscale scores can be used to compute a composite score, which is an indicator of early learning and has a mean of 100. The MSEL has demonstrated concurrent validity against other well-known developmental tests of language and cognitive development (e.g., Bayley Scales of Infant Development; Bayley 1969). In addition, it has demonstrated acceptable internal consistency and test–retest reliability.

Screening Tool for Autism in 2-Year-Olds (STAT; Stone et al. 2004, 2008)

The STAT is an interactive measurement instrument that was originally designed to screen for autism in children who are between the ages of 24 and 35 months. The STAT is an individually administered assessment that consists of 12 activity-based items and takes approximately 20 min to complete. It measures four early social-communicative skills: play (two items), requesting (two items), joint attention (four items), and imitation (four items). All of the items are scored as either a "pass" or a "fail." The failed items of

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each domain are converted into scores. The scores of the two-item domains can be 0, 0.5, or 1, whereas the scores for the four-item domains can be 0, 0.25, 0.50, 0.75, or 1. Thus, the scores for each domain of the STAT can range from 0 to 1. In addition, the total STAT score can be computed by summing the four domain scores. Therefore, the composite score can range from 0 to 4; higher scores are indicative of greater levels of impairment. The STAT has demonstrated a good level of accuracy in identifying autism and DD in children who are between the ages of 24 and 35 months. Item descriptions and the scoring procedure have been provided by Stone et al. (2004).

Autism Diagnostic Observation Scale (ADOS; Lord et al. 1999)

The ADOS is a semi-structured play-based and observational assessment that is divided into four modules. Each module is selected based on the age and expressive language of the respondent. The ADOS is considered to be the best diagnostic tool for ASD because it serves as a standardized means by which language and communication skills, reciprocal social and stereotypic behaviors, and restricted interests can be observed and scored. Each module provides an algorithm that entails cutoffs that can be used to assign respondents to one of the following three categories: autism, autism spectrum (i.e., pervasive developmental disorder-not otherwise specified; PDD-NOS), or non-ASD. In the present study, both autism and PDD-NOS were merged into one category, namely, ASD. Due to the relatively young age of the children who participated in the present study, Module 1 was administered at Time 1 and either Module 1 or 2 was administered at Time 2. A modified version of the ADOS, namely, the ADOS-2: Toddler Module (Lord et al. 2012a), is commonly used with toddlers who are between the ages of 12 and 30 months. However, this assessment was not used in the present study due to constraints that were related to cultural adaptation and validation. Thus, we used Module 1 of the ADOS to diagnose ASD in 24-month-old toddlers.

Analysis

Statistical Package for the Social Sciences (SPSS) was used to conduct the statistical analyses that were used in the present study. Independent-samples *t*-tests were used to compare children with ASD and DD on the STAT scores across Time 1 and Time 2. To avoid alpha inflation, only results that corresponded to *p*-values that were less than 0.01 (i.e., 0.05/5) were considered to be statistically significant. In addition, the screening properties of the STAT were examined using receiver operating characteristics (ROC). The ROC was examined to select the optimal range of cutoff scores and consequently examine the sensitivity and specificity of the STAT. Finally, we tested the diagnostic accuracy of the STAT by examining the area under the curve (AUC), as per the specifications that have been provided by Cicchetti et al. (1995). Specifically, values that are less than 0.70, between 0.70 and 0.79, between 0.80 and 0.89, and above 0.90 are indicative of poor, fair, good, and excellent sensitivity and specificity, respectively.

Results

The performances of the two groups on the STAT are shown in Table 2. The results revealed significant group differences in the four subscale scores (i.e., play, requesting, joint attention, and imitation domain) as well as the composite STAT score at Time 1. Further, when mental age (MA) at Time 1 was controlled for, significant group differences emerged for three subscale scores (i.e., play, requesting, and joint attention) and the composite STAT score at Time 1. However,

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Table 2 Significance of the difference in performance on the STAT between the ASD and DD groups

Variable	ASD ($n=57$)	DD ($n=62$)	*p*	Cohen's *d*
Time 1				
Mean (SD): play	0.75 (0.33)	0.40 (0.34)	0.000	1.045
Mean (SD): requesting	0.79 (0.34)	0.33 (0.39)	0.000	1.257
Mean (SD): joint attention	0.85 (0.21)	0.52 (0.29)	0.000	1.303
Mean (SD): imitation	0.69 (0.25)	0.52 (0.25)	0.001	0.680
Mean (SD): total score	3.08 (0.84)	1.76 (0.75)	0.000	1.658
Time 2				
Mean (SD): play	0.30 (0.41)	0.07 (0.18)	0.000	0.726
Mean (SD): requesting	0.56 (0.44)	0.22 (0.37)	0.000	0.836
Mean (SD): joint attention	0.78 (0.24)	0.37 (0.29)	0.000	1.540
Mean (SD): imitation	0.32 (0.28)	0.26 (0.25)	0.175	0.226
Mean (SD): total score	1.96 (0.92)	0.92 (0.71)	0.000	1.266

ASD autism spectrum disorder, *DD* developmental delays

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there was a marginally significant group difference in imitation subscale scores ($p=0.024$) at Time 1. Similarly, there were significant group differences in three subscale scores (i.e., play, requesting, and joint attention domain) and the composite STAT score at Time 2. There was no significant group difference in imitation subscale scores at Time 2. Further, when MA at Time 2 was controlled for, significant group differences emerged for two subscale scores (i.e., requesting and joint attention) and the composite STAT score at Time 2. Additionally, group differences were marginally significant for play subscale scores ($p=0.011$) and nonsignificant for imitation subscale scores at Time 2.

An examination of the ROC revealed that 2.25–2.75 was the optimal range based on which cutoff scores for the STAT should be derived for Time 1 (see Table 3). The sensitivity and specificity of the total STAT scores at Time 1 are presented in Table 4. For a cutoff score of 2.25, the positive predictive value (PPV) was 74.6%, and the negative predictive value (NPV) was 86.5%. For a cutoff score of 2.50, the PPV was 80.3%, and the NPV was 86.2%. For a cutoff score of 2.75, the PPV was 85.7%, and the NPV was 78.6%. The AUC was 0.87 at Time 1. The predictive validity of Module 1 of the ADOS at Time 1 was examined by comparing the resultant classification with the participants' clinical diagnoses (see Table 4). The PPV was 84.4%, the NPV was 94.5%, and the AUC was 0.93.

An examination of the ROC revealed that 1.25–1.50 was the optimal range based on which the cutoff scores for the STAT should be derived for Time 2 (see Table 3). The sensitivity and specificity of the total STAT scores at Time 2 are presented in Table 5. For a cutoff score of 1.25, the PPV was 73.1%, and the NPV was 84.6%. For a cutoff score of 1.50, the PPV was 75.5%, the NPV was 74.2%, and the AUC was 0.82 at Time 2.

Table 3 The sensitivity and specificity of different STAT Cutoff Scores

Cutoff[a]	Sensitivity	Specificity
Time 1		
1.50	0.93	0.34
1.75	0.90	0.50
2.00	0.90	0.63
2.25	0.88	0.73
2.50	0.86	0.81
2.75	0.74	0.89
3.00	0.67	0.90
Time 2		
0.25	1	0.07
0.50	0.98	0.24
0.75	0.97	0.39
1.00	0.91	0.61
1.25	0.86	0.71
1.50	0.70	0.79
1.75	0.58	0.81

[a]A score that is greater than or equal to the cutoff score is indicative of a risk for autism spectrum disorder (ASD)

Table 4 The predictive validity of the STAT and ADOS category (Time 1) with regard to clinical diagnosis (Time 2)

STAT risk category	Clinical diagnosis	
	ASD ($n=57$)	DD ($n=62$)
Cutoff = 2.25		
High risk	50 (87.7%)	17 (27.4%)
Low risk	7 (12.3%)	45 (72.6%)
Cutoff = 2.50		
High risk	49 (86.0%)	12 (19.4%)
Low risk	8 (14.0%)	50 (80.6%)
Cutoff = 2.75		
High risk	42 (73.7%)	7 (11.3%)
Low risk	15 (26.3%)	55 (88.7%)
ADOS		
ASD	54 (94.7%)	10 (16.1%)
Non-ASD	3 (5.3%)	52 (83.9%)

STAT screening tool for autism in 2-year-olds, *ADOS* autism diagnostic observation schedule, *ASD* autism spectrum disorder, *DD* developmental delays

Discussion

The purpose of the present study was to examine whether the STAT is suitable for use with toddlers who are less than 24 months of age. If this is indeed the case, then the STAT can be used to promote early screening for ASD in toddlers in clinical settings in Taiwan.

In accordance with past findings (e.g., Stone et al. 2008; Watson et al. 2007), toddlers with ASD who participated in

Table 5 The concurrent validity of the STAT risk categories (Time 2) with regard to clinical diagnosis (Time 2)

STAT risk category	Clinical diagnosis	
	ASD ($n=57$)	DD ($n=62$)
Cutoff = 1.25		
High risk	49 (86.0%)	18 (29.0%)
Low risk	8 (14.0%)	44 (71.0%)
Cutoff = 1.50		
High risk	40 (70.2%)	13 (21.0%)
Low risk	17 (29.8%)	49 (79.0%)

STAT screening tool for autism in two-year-olds, *ASD* autism spectrum disorder, *DD* developmental delays

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the present study demonstrated early social-communicative impairments at 24 months of age. Even after controlling for mental age, early social-communicative impairments were evident in toddlers with ASD. The emergent effect size suggests that toddlers with ASD experience substantial joint attention deficits. The findings also suggest that requesting capabilities are also a second challenge for toddlers with ASD and that integrations of multiple nonverbal communication skills (e.g., coordinated eye contact and gesture, vocalization) can be used to differentiate toddlers with ASD and DD who are less than 24 months of age. At Time 2, children with ASD demonstrated significantly higher levels of social-communicative impairments than children with DD; the one exception to this finding pertained to the imitation subscale. Again, joint attention domain and requesting capabilities were better discriminators of the two groups. These findings underscore the temporal stability of impairments in the integration of multiple nonverbal communication skills in children with ASD. Previous studies have shown that children with ASD do not exhibit significant impairments on tasks that require the imitation of meaningful actions that involve objects (e.g., Hepburn and Stone 2006; Wu and Chiang 2014). Accordingly, given that the imitation subscale of the STAT has three items that necessitate imitation of meaningful actions that involve objects, the 3-year-old children with ASD may not have demonstrated significantly greater impairments than their counterparts with DD. In addition, the findings suggested that significant changes in social-communicative development across follow up time in children with ASD, except for domain of Joint Attention. These findings support the contention that joint attention deficits are the most important indicators of ASD during the early years.

Consistent with past findings (Stone et al. 2008), the present study showed that the STAT has high sensitivity, specificity, PPV, and NPV in differentiating between toddlers with ASD and DD who are less than 24 months of age. A cutoff score of 2.50 yielded good predictive sensitivity (86%) and specificity (80.6%) indices. Further, a cutoff score of 2.25 demonstrated good predictive sensitivity (87.7%) and fair predictive specificity (72.6%). On the other hand, a cutoff score of 2.75 yielded fair predictive sensitivity (73.7%) and good predictive specificity (88.7%) indices. Additionally, an examination of the AUC revealed that the STAT can reliably identify toddlers with ASD who are less than 24 months of age. In contradistinction to Stone et al.'s (2008) use of 2.75 as the cutoff score, the present findings suggest that a score of 2.50 yields better differentiation. One of the possible explanations for this difference may pertain to the characteristics of the samples that were used in the two studies. First, Stone et al. (2008) used a sample of toddlers whose ages ranged from 12 to 23 months; on the other hand, the sample that was used in the present study consisted of toddlers whose ages were between 16 and 24 months. Stone et al. (2008) has suggested that the rate of failure on scale items may be higher for younger toddlers. Second, the non-ASD sample that was used in Stone et al.'s (2008) study consisted of those who exhibited a broad autism phenotype (BAP); in contrast, our control sample consisted of only toddlers with DD. Third, a majority of the participants in Stone et al.'s (2008) study were high-risk siblings. On the other hand, our sample consisted of children whose parents brought them to clinical facilities due to concerns about their developmental problems.

Module 1 of the ADOS yielded either good or excellent predictive sensitivity (0.95), specificity (0.84), PPV (84.4%), and NPV (94.5%) at Time 2. In addition, the AUC (0.93) was also excellent. These findings suggest that module 1 of the ADOS can be used to diagnose ASD in toddlers who are less than 24 months of age. This is a significant finding because the ADOS-2: Toddler Module was unavailable in Taiwan during the time period of the present study. Module 1 of the ADOS was more accurate in short-term predictive classification (e.g., sensitivity, specificity) than the STAT. The ADOS is a diagnostic tool, and it can be mapped in accordance with the DSM-5 diagnostic criteria for ASD. In addition, whereas the ADOS is a comprehensive diagnostic assessment, the STAT is a time-effective screening instrument. Thus, it is reasonable that the accuracy of the ADOS was higher than that of the STAT. Despite the lower accuracy, the STAT must be used to screen for ASD in toddlers who are less than 24 months of age because it is a less time-consuming screening tool that one can easily be trained to use; further, its validity is only marginally lower than that of the ADOS.

Past studies have shown that a cutoff score of 2 on the STAT can be used to reliably identify young children with autism who are between the ages of 24 and 35 months (Stone et al. 2004). In the present study, a cutoff score of 1.25 on the STAT exhibited good current sensitivity (0.86) and NPV (84.6%), and fair current specificity (0.71) and PPV (73.1%) in differentiating between children with ASD and DD who are older than 3 years. In addition, an examination of the AUC revealed that the STAT can reliably identify children with ASD who are between the ages of 36 and 48 months. The results of the present study suggest that, in order to be effective, different cutoff scores must be used for children with ASD who are between the age of 16 and 24, and 35 and 46 months.

In the present study, 43 and 14 children with ASD met the strict and relaxed DSM-5 criteria for ASD, respectively. At Time 1, a cutoff score of 2.50 reliably identified 39 (90.7%) and 10 (71.4%) children with ASD who met the strict and relaxed DSM-5 criteria for ASD, respectively. In addition, at Time 2, a cutoff score of 1.25 reliably detected 38 (88.4%) and 11 (78.6%) children with ASD who met the strict and

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relaxed criteria for DSM-5, respectively. Children with ASD who met the relaxed DSM-5 criteria for ASD demonstrated higher mental ages at Time 1 (15.50 months vs 13.46 months, $p < .05$) and lower total score of the ADOS at both Time 1 (11.64 vs 17.47, $p < .001$) and Time 2 (11.78 vs 15.12, $p < .001$). In accordance with past studies that have used the STAT to detect autism in children who are between the ages of 25 and 35 months (e.g., Stone et al. 2004), the present findings suggest that the STAT can be used to reliably detect severe rather than mild symptoms of ASD across two different time points. However, future studies must recruit larger samples of children with ASD who meet the relaxed DSM-5 criteria in order to ascertain the cutoff scores and examine the sensitivity and specificity of the assessment.

The present study sought to investigate the utility, concurrent validity, and predictive validity (i.e., at follow-up) of the STAT using a Taiwanese sample. The first assessment (Time 1) was administered to a sample of toddlers who were less than 24 months of age and the second assessment (Time 2) was administered after a year and a half to finalize the diagnosis. The present findings suggest that the STAT can reliably detect high-risk children with ASD who are situated within the developmental period that ranges from toddlerhood to preschool age. The healthcare providers referred infants and toddlers suspected to have developmental problems to child psychiatrists at local or metropolitan general hospitals for clinical diagnosis. However, the diagnostic decision-making process may require diagnostic recommendations from other professionals, mainly by clinical psychologists. The STAT which is level 2 screening tool takes only 20 min to complete, and it is easy to administer; therefore, its use must be promoted among practitioners (e.g., clinical psychologists) who work at district or regional hospitals, aid in differentiating toddlers with ASD from those with other developmental problems, and collaborate mainly with the child psychiatrists for making formal diagnosis of ASD and following evidence-based treatments.

Limitations and Future Directions

In conclusion, the present study used the STAT as a Level 2 screener for ASD among young at-risk toddlers. The results suggest that STAT has a high level of predictive and concurrent validity and can therefore be used as an autism-specific screening tool for children who are situated within the developmental period that ranges from toddlerhood to preschool age. However, the present study has a few limitations. First, the present study was conducted in only one clinical setting, and the sample size was not large; therefore, future research studies should validate the STAT using a larger sample that is recruited from diverse hospital-based clinical settings. Second, the ADI-R was not used in the present study, and this may adversely influence the accuracy of the clinical diagnosis. Third, children with ASD who met the relaxed DSM-5 criteria for ASD demonstrated higher mental ages and mild autistic symptoms. Future studies should recruit more participants for a distinct category for examining the cutoff of the STAT. Fourth, contrary to previous studies (e.g., Stone et al. 2004), the sample was not large enough and we could not conduct a scoring algorithm and validation data split to generate or test the potential cut-offs. Thus, again, future research should include a higher number of participants to validate the cutoffs.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval In the present study, all the procedures that involved human participants were conducted in accordance with the ethical standards of the institutional and/or national research committee as well as the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This study was approved by the Ditmanson Medical Foundation Chia-Yi Christian Hospital Research Ethics Committee (CYCH-IRB101022; CYCH-IRB102045).

Informed Consent Informed consent was obtained from all the individuals who participated in this study.

References

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, DC: American Psychiatric Association.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC: American Psychiatric Association.

Baio, J., Wiggins, L., Christensen, D. L., Maenner, M. J., Daniels, J., Warren, Z., et al. (2018). Prevalence of autism spectrum disorder among children aged 8 years—Autism and developmental disabilities monitoring network, 11 sites, United States, 2014. *MMWR Surveillance Summaries, 67*(6), 1–23.

Baird, G., Simonoff, E., Pickles, A., Chandler, S., Loucas, T., Meldrum, D., et al. (2006). Prevalence of disorders of the autism spectrum in a population cohort of children in South Thames: The special needs and autism project (SNAP). *The Lancet, 368*(9531), 210–215.

Barbaro, J., & Dissanayake, C. (2017). Diagnostic stability of autism spectrum disorder in toddlers prospectively identified in a

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community-based setting: Behavioural characteristics and predictors of change over time. *Autism, 21*(7), 830–840.
Barton, M. L., Dumont-Mathieu, T., & Fein, D. (2012). Screening young children for autism spectrum disorders in primary practice. *Journal of Autism and Developmental Disorders, 42*(6), 1165–1174.
Bayley, N. (1969). *Bayley scales of infant development*. San Antonio, TX: The Psychological Corporation.
Becerra-Culqui, T. A., Lynch, F. L., Owen-Smith, A. A., Spitzer, J., & Croen, L. A. (2018). Parental first concerns and timing of autism spectrum disorder diagnosis. *Journal of Autism and Developmental Disorders, 48*(10), 3367–3376.
Chiang, C. H., Wu, C. C., Liu, J. H., & Hou, Y. M. (2012). 2–3歲自閉症幼兒篩檢量表的發展: T-STAT的初究 (Development of a screening tool for Autism in two-year-olds, Taiwan Version (T-STAT): A preliminary study). *Formosa Journal of Mental Health, 25*(1), 135–154.
Chiang, C. H., Wu, C. C., Hou, Y. M., Chu, C. L., Liu, J. H., & Soong, W. T. (2013). Development of T-STAT for early autism screening. *Journal of Autism and Developmental Disorders, 43*(5), 1028–1037.
Choueiri, R., & Wagner, S. (2015). A new interactive screening test for autism spectrum disorders in toddlers. *The Journal of Pediatrics, 167*(2), 460–466.
Cicchetti, D. V., Volkmar, F., Klin, A., & Showalter, D. (1995). Diagnosing autism using ICD-10 criteria: A comparison of neural networks and standard multivariate procedures. *Child Neuropsychology, 1*(1), 26–37.
Dawson, G., Rogers, S., Munson, J., Smith, M., Winter, J., Greenson, J., et al. (2010). Randomized, controlled trial of an intervention for toddlers with autism: The early start Denver model. *Pediatrics, 125*(1), e17–23.
De Giacomo, A., & Fombonne, E. (1998). Parental recognition of developmental abnormalities in autism. *European Child and Adolescent Psychiatry, 7*(3), 131–136.
Dix, L., Fallows, R., & Murphy, G. (2015). Effectiveness of the ADEC as a level 2 screening test for young children with suspected autism spectrum disorders in clinical setting. *Journal of Intellectual & Developmental Disability, 40*(2), 179–188.
Filipek, P. A., Accardo, P. J., Baranek, G. T., Cook, E. H., Dawson, G., Gordon, B., et al. (1999). The screening and diagnosis of autistic spectrum disorders. *Journal of Autism and Developmental Disorders, 29*(6), 439–484.
Frazier, T. W., Youngstrom, E. A., Speer, L., Embacher, R., Law, P., Constantino, J., et al. (2012). Validation of proposed DSM-5 criteria for autism spectrum disorder. *Journal of the American Academy of Child and Adolescent Psychiatry, 51*(1), 28–40.
Guthrie, W., Swineford, L. B., Nottke, C., & Wetherby, A. M. (2013). Early diagnosis of autism spectrum disorder: Stability and change in clinical diagnosis and symptom presentation. *Journal of Child Psychology and Psychiatry, 54*(5), 582–590.
Hepburn, S. L., & Stone, W. L. (2006). Longitudinal research on motor imitation in autism. In S. J. Rogers & J. H. G. Williams (Eds.), *Imitation and the social mind: Autism and typical development* (pp. 310–328). New York, NY: The Guilford Press.
Johnson, C. P., & Myers, S. M. (2007). Identification and evaluation of children with autism spectrum disorders. *Pediatrics, 120*(5), 1183–1215.
Khowaja, M., Robins, D. L., & Adamson, L. B. (2012). *A preliminary analysis of multi-level ASD screening: M-CHAT-R & STAT*. Poster presented at the International Meeting for Autism Research, Toronto, Ontario.
Kim, S. H., Macari, S., Koller, J., & Chawarska, K. (2016). Examining the phenotypic heterogeneity of early autism spectrum disorder: Subtypes and short-term outcomes. *Journal of Child Psychology and Psychiatry, 57*(1), 93–102.
Lai, D. C., Tseng, Y. C., & Guo, H. R. (2011). Gender and geographic differences in developmental delays among young children: Analysis of the data from the national registry in Taiwan. *Research in Developmental Disabilities, 32*(1), 63–69.
Lai, D. C., Tseng, Y. C., Hou, Y. M., & Guo, H. R. (2012). Gender and geographic differences in the prevalence of autism spectrum disorders in children: Analysis of data from the national disability registry of Taiwan. *Research in Developmental Disabilities, 33*(3), 909–915.
Le Couteur, A., Haden, G., Hammal, D., & McConachie, H. (2008). Diagnosing autism spectrum disorders in pre-school children using two standardised assessment instruments: The ADI-R and the ADOS. *Journal of Autism and Developmental Disorders, 38*(2), 362–372.
Le Couteur, A., Lord, C., & Rutter, M. (2003). *The autism diagnostic interview-revised (ADI-R)*. Los Angeles, CA: Western Psychological Services.
Lord, C., Luyster, R. J., Gotham, K., & Guthrie, W. (2012a). *Autism Diagnostic observation schedule, second edition (ADOS-2) manual (part II): Toddlers module*. Torrance, CA: Western Psychological Services.
Lord, C., Rutter, M., DiLavore, P. C., & Risi, S. (1999). *Autism diagnostic observation schedule (ADOS)*. Los Angeles, CA: Western Psychological Services.
Lord, C., Rutter, M., DiLavore, P. C., Risi, S., Gotham, K., & Bishop, S. L. (2012b). *Autism diagnostic observation schedule, second edition (ADOS-2) manual (part I): Modules 1–4*. Torrance, CA: Western Psychological Services.
Mullen, E. M. (1995). *Mullen scales of early learning*. Circle Pines, MN: American Guidance Service.
Nah, Y. H., Young, R. L., Brewer, N., & Berlingeri, G. (2014). Autism detection in early childhood (ADEC): Reliability and validity data for a level 2 screening tool for autistic disorder. *Psychological Assessment, 26*(1), 215–226.
Pang, Y. L., Lee, C. M., Wright, M., Shen, J., Shen, B., & Bo, J. (2018). Challenges of case identification and diagnosis of autism spectrum disorders in China: A critical review of procedures, assessment, and diagnostic criteria. *Research in Autism Spectrum Disorders, 53*, 53–66.
Pickles, A., Le Couteur, A., Leadbitter, K., Salomone, E., Cole-Fletcher, R., Tobin, H., et al. (2016). Parent-mediated social communication therapy for young children with autism (PACT): Long-term follow-up of a randomised controlled trial. *The Lancet, 388*(10059), 2501–2509.
Sacrey, L.-A. R., Zwaigenbaum, L., Bryson, S., Brian, J., Smith, I. M., Roberts, W., et al. (2015). Can parents' concerns predict autism spectrum disorder? A prospective study of high-risk siblings from 6 to 36 months of age. *Journal of the American Academy of Child and Adolescent Psychiatry, 54*(6), 470–478.
Stone, W. L., Coonrod, E. E., Turner, L. M., & Pozdol, S. L. (2004). Psychometric properties of the STAT for early autism screening. *Journal of Autism and Developmental Disorders, 34*(6), 691–701.
Stone, W. L., McMahon, C. R., & Henderson, L. M. (2008). Use of the screening tool for autism in two-year-olds (STAT) for children under 24 months: An exploratory study. *Autism, 12*(5), 557–573.
Sun, X., Allison, C., Matthews, F. E., Sharp, S. J., Auyeung, B., Baron-Cohen, S., et al. (2013). Prevalence of autism in mainland China, Hong Kong, and Taiwan: A systematic review and meta-analysis. *Molecular Autism*. https://doi.org/10.1186/2040-2392-4-7.
Veness, C., Prior, M., Bavin, E., Eadie, P., Cini, E., & Reilly, S. (2012). Early indicators of autism spectrum disorders at 12 and 24 months of age: A prospective, longitudinal comparative study. *Autism, 16*(2), 163–177.
Watson, L. R., Baranek, G. T., Crais, E. R., Reznick, S., Dykstra, J., & Perryman, T. (2007). The first year inventory: Retrospective parent response to a questionnaire designed to identify one-year-olds

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at risk for autism. *Journal of Autism and Developmental Disorders, 37*(1), 49–61.

Wiggins, L. D., Baio, J., & Rice, C. (2006). Examination of the time between first evaluation and first autism spectrum diagnosis in a population-based sample. *Journal of Developmental and Behavioral Pediatrics, 27*(2), S79–S87.

Wu, C. C., & Chiang, C. H. (2014). The developmental sequence of social-communicative skills in young children with autism: A longitudinal study. *Autism, 18*(4), 385–392.

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