

Chapter 2

Early Diagnostic Assessment

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Introduction

Access to early intervention services often depends on early in life diagnosis. The average age a child receives an ASD diagnosis varies widely internationally and nationally. A number of obstacles often dissuade or preclude an accurate ASD diagnosis and current research-based approaches capable of diagnosing ASD very early in life (i.e., less than 18 months old) are rarely available. This chapter first presents the diagnostic characteristics of ASD per the DSM-5, briefly discusses the factors hypothesized to be contributing to the rising ASD prevalence and obstacles to obtaining an accurate ASD diagnosis (e.g., access to services, pediatricians without necessary experience, etc). The most common ASD diagnostic procedures are then described and the pros and cons as well as the available psychometric data are presented in a table that enables comparison across approaches. Recent research investigating novel approaches that facilitate earlier in life diagnosis is then reviewed. The chapter concludes with suggestions for future research and guidance for practitioners.

DSM-5 Diagnostic Criteria for ASD

The Diagnostic and Statistical Manual of Mental Disorders (5th ed.; DSM-5; American Psychiatric Association, 2013) gives the comprehensive diagnostic criteria for Autism Spectrum Disorder (ASD). The DSM-5 introduced substantive

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changes in the diagnosis of ASD from previous editions. Previously, Autistic Disorder was one of five Pervasive Developmental Disorders (Autistic Disorder, Rett's Disorder, Childhood Disintegrative Disorder, Asperger's Disorder, Pervasive Developmental Disorder—Not Otherwise Specified [PDD-NOS]) under the umbrella category of Disorders Usually First Diagnosed in Infancy, Childhood, or Adolescence. The DSM-5 removed the Pervasive Developmental Disorder nomenclature entirely and classifies ASD under Neurodevelopmental Disorders. The DSM-5 also conceptualizes the clinical heterogeneity of ASD as dimensional rather than categorical, with Autism Spectrum Disorder representing Autistic Disorder, Asperger's Disorder, and PDD-NOS. Finally, ASD is now a dyad of symptom clusters rather than a triad (Social Interaction, Communication, and Restricted, Repetitive, and Stereotyped Patterns of Behavior, Interests, and Activities).

The diagnosis of ASD in the DSM-5 now requires the presence of impairments in two domains: Social Communication and Interaction and Restricted, Repetitive Patterns of Behavior, Interests, or Activities. The first domain (A) specifies deficits in social communication and social interaction across settings, with three diagnostic criteria. Individuals diagnosed with ASD must display all three criteria, either currently or by history. The four criteria are: (1) deficits in social-emotional reciprocity, (2) deficits in nonverbal communicative behavior, and (3) deficits in developing, maintaining, and understanding relationships. The text of the DSM-5 provides illustrative examples for each criterion (e.g. for A1, examples include abnormal social approach and failure of normal back-and-forth conversations).

In the second domain (B), Restricted, Repetitive Patterns of Behavior, Interests, or Activities, there are four criteria. However, individuals diagnosed with ASD are required to meet only two criteria, currently or by history. These include: (1) stereotyped or repetitive motor movements, use of objects, or speech, (2) insistence on sameness, inflexible adhere to routines, or ritualized patterns of verbal or nonverbal behavior, (3) highly restricted, fixated interests that are abnormal in intensity or focus, and (4) hyper- or hyporeactivity to sensory input or unusual interest in sensory aspects of the environment. Illustrative examples are given for each criterion (e.g. for B1, examples include lining up toys, flipping objects, and echolalia).

Three additional overarching diagnostic criteria are given. The third criterion (C) notes that symptoms must be present in the early developmental period, although impairments may not become apparent until demands are increased later in life. The fourth criterion (D) states that symptoms must cause clinically significant impairment in functioning. The last criterion (E) states that deficits should not be better explained by either Intellectual Disability or Global Developmental Delay; note, however, that Intellectual Disability and ASD can co-occur. The DSM-5 specifies that all individuals with previous well-established diagnoses of Autistic Disorder, PDD-NOS, or Asperger's Disorders should now be given the diagnosis of ASD.

The diagnosis of ASD is now made with two sets of specifiers. Severity specifiers are ratings of the level of support needed for each domain of symptoms. Domains should be rated independently as Level 1 (Requiring Support), Level 2 (Requiring Substantial Support), or Level 3 (Requiring Very Substantial Support). The text provides examples of impairments that illustrate each severity level and

Table 2.1 Diagnosis of ASD in accordance with DSM-5

Example 1.	299.00 Autism Spectrum Disorder
	Requiring support for deficits in social communication and requiring very substantial support for restricted, repetitive behavior
Example 2.	299.00 Autism Spectrum Disorder Associated with a known genetic condition (Fragile X syndrome)
	Requiring very substantial support for deficits in social communication and requiring very substantial support for restricted, repetitive behavior
	With accompanying language impairment
Example 3.	299.00 Autism Spectrum Disorder Associated with an environmental factor (fetal alcohol syndrome)
	Requiring very substantial support for deficits in social communication and requiring substantial support for restricted, repetitive behavior
	With accompanying intellectual impairment

notes that severity levels will change over the individual’s lifetime. While the diagnostic criteria only provides three levels, the supporting text in the DSM-5 states that severity could be below Level 1 at times in the individual’s life (e.g. not requiring supports).

The second set of specifiers requires the diagnosing clinician to note whether ASD is present: With or without accompanying intellectual impairment; With or without accompanying language impairment; Associated with a known medical or genetic or environmental factor (if associated); and Associated with catatonia (if associated). Therefore, a diagnosis of ASD in accordance with DSM-5 should be written as suggested in the examples in Table 2.1.

Finally, it should be noted that the diagnosis of Social (Pragmatic) Communication Disorder is a new addition to the DSM-5. It is categorized under Communication Disorder rather than Neurodevelopmental Disorders and is suggested as a differential diagnosis for individuals with social communication impairments but with no symptoms in the restricted, repetitive behaviors domains currently or by history. It should be noted that research is not conclusive about the diagnostic validity of Social Communication Disorder (Ozonoff, 2012; Skuse, 2012) and further studies are indicated.

Prevalence of ASD

The rising prevalence of ASD has been heavily reported across scientific and popular media outlets. The majority of prevalence studies conducted internationally focus on North America and Europe, although limited literature is available representing other parts of the globe. Overall, the research consensus indicates that the prevalence of more narrowly defined classical autism and broadly defined ASD are rising in global samples, beginning in the mid-1990s (Baron-Cohen et al., 2009;

Cavagnaro, 2009; Honda, Shimizu, Imai, & Nitto, 2005; Newschaffer, Falb, & Gurney, 2005; Rice et al., 2013; Sun & Allison, 2009; Taylor, Jick, & McLaughlin, 2013; Wong & Hui, 2008).

Systematic reviews have reported an aggregate prevalence of approximately 60–70 in 10,000 for ASD across the globe (Elsabbagh et al., 2012; Fombonne, 2009). The majority of the literature is focused on the United States, where the most recently reported figure is 1 in 68 children, which is an average across sites ranging from 1 in 45 (New Jersey) to 1 in 175 (Alabama) (Centers for Disease Control (CDC), 2014). Autism was identified in 1 in 42 boys and 1 in 189 girls (CDC, 2014). This represents a 30 % increase in prevalence of ASD among 8-year-olds from the previous CDC data (CDC, 2012).

Many factors are theorized to account for the increasing prevalence of ASD. Contributors can be classified in three domains: intrinsic identification, or measurement factors involved in documenting ASD prevalence trends, extrinsic identification, or external classification and awareness factors leading to changes in case ascertainment, and risk, or possible true change in ASD symptoms in the population over time (Rice et al., 2013). In the area of intrinsic identification, study methods are frequently cited as contributing bias to the overall prevalence. Case ascertainment methods, e.g. health records vs educational records, previous vs. prospective diagnoses, parent report vs. observational diagnoses, research vs. clinical diagnoses, sampling of urban vs. rural regions, sampling of regions with free vs. paid access to screening, sampling of ages, all have systematic impacts on prevalence (e. g., Barbaresi, Colligan, Weaver, & Katusic, 2009; Baron-Cohen et al., 2009; Matson & Kozlowski, 2011; Parner et al., 2011; Williams, Higgins, & Brayne, 2006). In fact, recent global research suggests that after adjusting for systematic bias in case-finding strategies, the prevalence of ASD is actually unchanged between 1990 and 2010 (Baxter et al., 2014). The figures cited changed from 7.5 in 1000 in 1990 to 7.6 in 1000 in 2010, which approximates the global prevalence estimated by Fombonne (2009).

In the area of extrinsic identification, it is widely known that improved awareness of ASD as well as the broadening of ASD to include milder forms over time have increased prevalence rates. Studies have shown that there has been an increase in the prevalence of ASD when major changes were made to diagnostic criteria, such as when DSM-IV criteria were introduced (King & Bearman, 2009). Improved awareness has led to increased screening, with districts and countries that introduced population-level screening showing a greater prevalence (Nygren et al., 2012; Parner et al., 2011; Wing & Potter, 2002). The shift to identifying children at younger ages also explains part of the increase (Fombonne, 2009; Hertz-Picciotto & Delwiche, 2009).

Relatedly, the identification of milder forms of ASD, which is influenced by the broadening of diagnostic criteria, is associated with increasing prevalence (Hertz-Picciotto & Delwiche, 2009). Both CDC (2014) and parent-reported data (Blumberg et al., 2013) indicate that fewer children with ASD are classified as having an intellectual disability and the greatest increases in ASD report are in milder ASD (Keyes et al., 2012). Another significant factor impacting changes in prevalence is diagnostic

substitution, or the switching of a previous diagnosis or class of diagnoses to the class of ASD. Administrative data show a strong correlation between decreasing rates of other disorders like mental retardation, learning disability, or developmental language disorder and increasing rates of ASD diagnoses, suggesting diagnostic substitution (Bishop, Whitehouse, Watt, & Line, 2008; Coo et al., 2008; King & Bearman, 2009; Shattuck, 2006).

Finally, it is important to consider whether, outside of these factors, the change in prevalence is impacted by a true change in the incidence of ASD owing to environmental or other risk factors. At this point, most researchers conclude that the trend in prevalence cannot be directly attributed to increased incidence, but also that the available data are not robust enough to rule out such a hypothesis (Fombonne, 2009; Rice et al., 2013). Research continues to be conducted on environmental and biological risk factors, such as the increased viability of pre-term births, a risk factor for ASD, (Johnson et al., 2010), and others (Matson & Kozlowski, 2011; Wazana, Bresnahan, & Kline, 2007).

Obstacles to Obtaining ASD Diagnostic Assessment and/or Accurate Diagnosis

ASD can be reliably diagnosed by an experienced clinician when a child is 2 years of age (Cox et al., 1999; Kleinman et al., 2008; Lord, 1995). However, population-based estimates in the United States indicate that the median age of diagnosis ranges from 48 (CDC, 2014) to 61 months (Wiggins, Baio, & Rice, 2006) or even 58 months (Shattuck et al., 2009). This signifies a gap of several years. This gap is especially problematic given that the preponderance of evidence suggests that early intervention is most effective for improved outcome in ASD. Many parents first become concerned about their child's development before the age of 24 months (Wiggins et al., 2006) and report seeing an average of four to five doctors before receiving an ASD diagnosis (Goin-Kochel, Mackintosh, & Mysters, 2006). They report overall dissatisfaction with the process of receiving an ASD diagnosis (Smith, Chung, & Vostanis, 1994). Barriers to timely diagnosis of ASD are present at the patient, family, and community level.

Research indicates that several patient-level factors impact the timing of ASD diagnosis. Boys are diagnosed on average earlier than girls (Goin-Kochel et al., 2006), even when girls had a greater degree of cognitive impairment (Shattuck et al., 2009). Children with IQs in the range of intellectual disability were diagnosed earlier, as were children who experienced a developmental regression (CDC, 2014; Shattuck et al., 2009). Children whose symptoms are on the milder end of the spectrum are diagnosed later (Goin-Kochel et al., 2006; Mandell, Novak, & Zubritsky, 2005; Thomas, Ellis, McLaurin, Daniels, & Morrissey, 2007).

At the family level, strong associations, though not always consistent across studies, have been found between timing of diagnosis and socioeconomic status and race/ethnicity. Lower age of diagnosis has been associated with higher parental

education as well as higher family income (Fountain, King, & Bearman, 2011; Goin-Kochel, Mackintosh, & Mysters, 2006). The lowest rate of diagnosed ASD, as reported by parents, was in low-income families (Liptak et al., 2008) and families near the poverty level received diagnoses nearly a year later than those with incomes greater than 100 % of the poverty level (Mandell et al., 2005).

Although ASD does not disproportionately affect any racial or ethnic group, diagnosis rates do vary. Several studies have found that ethnic minority status is associated with lower or later diagnosis of ASD (CDC, 2014; Travers, Tincani, & Krezmien, 2011). Mandell, Listerud, Levy, and Pinto-Martin (2002) found that, of children on Medicaid, white children were diagnosed at 6.3 years of age, versus 7.9 years for African American children, and 8.8 years for Latino children. Among children who were referred to specialty care who were later diagnosed with ASD, White children were 2.6 times as likely to receive an ASD diagnosis at the first visit as African American children, who were more likely to be diagnosed with ADHD, adjustment disorder, and conduct disorder (Mandell, Iitenbach, Levy, & Pinto-Martin, 2007). The authors hypothesize that this could be related to cultural differences in how parents recognize and report symptoms, race-related differences in the clinicians' interpretation of symptoms, or a combination of the two.

Community level factors also play a role in timing of diagnosis. Children living in rural areas received diagnoses on average 0.4 years later than children living in urban areas (Mandell et al., 2005). This disparity continues to be present when accessing autism-related care, with children in nonmetropolitan areas having poorer access (Thomas et al., 2007). Proximity to a medical center is associated with earlier age of diagnosis (Kalbrenner et al., 2011). Access to specialty care improves diagnosis, with those referred to a specialist receiving a diagnosis 0.3 years earlier than those who were not (Mandell et al., 2005). Most children with ASD are identified at nonschool settings, such as hospitals and clinics (Wiggins et al., 2006), and therefore, limited access to such settings may impact diagnosis. Research conflicts on whether living in a high-income community is predictive of diagnosis; while some studies support this finding (Rosenberg, Landa, Law, Stuart, & Law, 2011; Thomas et al., 2012), others note that the effect does not remain when parental education is controlled (Fountain et al., 2011).

The first point of contact for diagnosis is typically the pediatrician or primary care physician. Many research studies have focused on barriers to accurate diagnosis in primary care settings. Primary barriers include awareness, time, cost and reimbursement, and training. Although developmental screeners have been shown to more accurately identify children at risk for ASD (Miller et al., 2011), pediatricians have reported that they trust clinical acumen over such screeners (Morelli et al., 2014). Others report that they do not know how to use screeners or which screeners to use (Dosreis, Weiner, Johnson, & Newschaffer, 2006). Over 70 % of ASD diagnoses are made without using standardized instruments (Wiggins et al., 2006). Most practices do not get reimbursed at sustainable rates for providing developmental screening (Filipek et al., 2000; Shattuck & Grosse, 2007). Patients with ASD in states with better reimbursement rates have less trouble accessing care

(Thoas, Parish, Rose, & Klany, 2011). They also report not having time to do screenings (Dosreis et al., 2006; Filipek et al., 2000; Morelli et al., 2014).

Pediatrician training has become a high-priority public policy initiative, with national campaigns through the American Academy of Pediatrics (Johnson, Meyers, & The Council on Children with Disabilities, 2007) and the Centers for Disease Control. Medical students receive little focused training about diagnosis ASDs (Shah, 2001). Pediatrician training studies are overall positive but suggest caution. Many awareness building initiatives increase pediatrician knowledge but do not necessarily lead to referrals, nor is there adequate follow-up data to understand whether the referrals were appropriate and effective (Daniels, Halladay, Shih, Elder, & Dawson, 2014). While some studies show increased identification and referral (Guevara et al., 2012; Swanson et al., 2014), others show inconsistent results. Of children who screened positive for developmental delay, only 30 % (Windham et al., 2014) to 65 % (Morelli et al., 2014), were referred to treatment and of those who were referred, only half followed through (Morelli et al., 2014; Windham et al., 2014). At least one study suggests that over identification may be an issue (Zachary, Stone, & Humberd, 2009). A study in which practice parameters were distributed and publicized showed a decrease of 1.5 years in average age of ASD diagnosis; however, results were not maintained at 2-year follow-up (Holzer et al., 2006). Therefore, sustainability of such campaigns is important to consider. Some innovative models, such as telephone screening of low-resource communities (Roux et al., 2012), and screening of children using videos uploaded to smartphones (Oberleitner, Reischel, Lacy, Goodwin, & Spitalnick, 2011) are currently being evaluated, with promising results.

Assessment Practices

In response to the increasing prevalence of ASD and in the face of obstacles to accurate diagnostic assessment, health care professionals have adopted new practices to systematically detect ASD in young children. Best-practice guidelines set by the American Academy of Pediatrics now call for routine surveillance at every well-child visit, with the use of ASD-specific screening tools at 18 and 24 months (Johnson et al., 2007). Positive screen results prompt clinicians to initiate further assessment, which may lead to a diagnosis of ASD. Effective screening practices for ASD are essential in early childhood, as the majority of parents first recognize abnormalities prior to the second birthday (Baghdadli, Picot, Pascal, Pry, & Aussilloux, 2003; Chawarska et al., 2007; De Giacomo & Fombonne, 1998; Tolbert, Brown, Fowler, & Parsons, 2001). But despite the early age of parental recognition, on average, children are not diagnosed with ASD until 48 months, well after initial concerns have been noted (Centers for Disease Control, 2012). Early diagnosis of ASD increases children's access to early intervention services, which is central to achieving positive outcomes (Lovaas, 1987; National Research Council, 2001; Rogers & Vismara, 2008).

Screening for ASD

A number of autism-specific screeners have been developed to facilitate accurate detection of ASD in young children. Some systems are designed for population-based screening and, others are designed to screen children already suspected of ASD. These types of screenings are referred to as level one and level two, respectively.

To understand the utility and efficacy of a particular screening or diagnostic instrument, it is essential to have knowledge of its psychometric properties, especially the indices of sensitivity and specificity. *Sensitivity* refers to a measure's ability to correctly identify children who are at risk for the disorder; *specificity* refers to its ability to correctly rule out children who are not at risk for the disorder. According to Coonrod and Stone (2005), acceptable levels of sensitivity are specificity are .80 and higher. Although both metrics of sensitivity and specificity are relevant to accurate diagnosis, maximum sensitivity is generally achieved at the cost of lower specificity, and vice versa. Recently, several ASD-specific screeners have been developed; however, few have been carefully evaluated. Therefore, clinicians must use some caution when selecting instruments for routine clinical practice (Charman & Gotham, 2013).

Level One

Level one ASD screeners typically use the reports of parents and caregivers to measure broad developmental constructs suggestive of ASD. They are easy and quick to administer and interpret, and they are characterized by high sensitivity. High sensitivity is favorable in level one screeners because their purpose is to identify the maximum number of children at risk for developing the disorder. But, they also lead to over-identification (i.e., false positives) due to low specificity; many children identified as at-risk following the level one screening will be determined to be unaffected by ASD after further evaluation. However, it is likely that these children have related developmental disorders (Dietz, Swinkels, van Daalen, van Engeland, & Buitelaar, 2006; Pierce et al., 2011). When it comes to level one screeners for ASD, high sensitivity is more important than high specificity, because the consequences of missing a child with ASD are far more significant than evaluating a child who is unaffected (Barton, Dumont-Mathieu, & Fein, 2012).

Several level one screening measures for ASD have been developed for clinical use in children 18-months and older (see Table 2.2). Widespread level one tools include: (a) the Checklist for Autism in Toddlers (CHAT; Baron-Cohen et al., 1992), (b) the Modified Checklist for Autism in Toddlers (M-CHAT; Robins et al., 2001), and (c) the Early Screening for Autistic Traits (ESAT; Swinkels et al., 2006).

Baron-Cohen et al. (1992) developed and validated the first level one screener for ASD in Great Britain, called the CHAT. The 14-item CHAT was designed to identify

Table 2.2 Screening instruments for ASD

Instrument	Developers	Age	Format	Administration time (min)	Level of training	Sensitivity	Specificity
Level one							
CHAT	Baron-Cohen, Allen, and Gillberg (1992)	18–24 months and older	Parent questionnaire; clinician observation	5	Minimal	.18–.38	.98–.1
M-CHAT	Robins, Fein, Barton, and Green (2001)	16–30 months	Parent questionnaire	Not reported 10	None	.87 ^a	.99 ^a
ESAT	Dietz et al. (2006)	14–15 months	Parent questionnaire; clinician observation	5	Minimal	Not reported	Not reported
Level two							
CARS2	Schopler, Van Bourgondien, Wellman, and Love (2010)	2 years and older	Clinician behavioral checklist	5–10	Minimal	.81	.87
GARS and GARS-2	Gilliam (1995) Gilliam (2006)	3–22 years	Clinician behavioral checklist	5–10	Minimal	.38–.83	.68
SCQ	Rutter, Bailey, et al. (2003)	4–18 years	Parent questionnaire	10	None	.71–.88	.54–.79
SRS-2	Constantino (2012)	4–18 years	Parent questionnaire	15	None	.23–.80	.67–.96

^a Estimated

children who show signs of ASD at 18 months old. Items focus on the attainment of key social communication milestones, such as pretend play and two aspects of joint attention. These include protodeclarative pointing (e.g., pointing at an object for the purpose of directing another person to look at it) and gaze monitoring (e.g., looking in the same direction as another person). Nine items on the CHAT are based on parent report; the remaining five are based on in-home observations conducted by health practitioners. Validation studies with high-risk and general populations indicate that although the CHAT nearly always identifies children with ASD correctly, it also misses many children (Baird et al., 2000; Baron-Cohen et al., 1996; Scambler, Rogers, & Wehner, 2001).

The M-CHAT is an extension of the CHAT. It is in the public domain and can be accessed at <https://www.m-chat.org>. It includes the nine parent-rated items from the CHAT and 14 original items (Robins et al., 2001). The authors of the M-CHAT created additional items in order to assess a broader range of symptoms in children aged 16- to 30-months, and to increase the sensitivity of the measure. They included parent-rated items only to account for the absence of health visitor observations in the United States (Robins et al., 2001). The original validation sample included 1293 children who were screened at the 18- and 24-month well-child visit, 58 of whom received diagnostic evaluations, and 39 of whom were diagnosed with a spectrum disorder. Although sensitivity and specificity cannot be determined until follow-up of the initial sample is complete, estimates are very promising (e.g., .87 and .99, respectively; Robins et al., 2001).

The ESAT is a 14-item parent rating scale for children between the ages of 14- and 15-months in the general population. During development, Dietz et al. (2006) screened 31,724 children for ASD in the Netherlands using a two-pronged approach. First, parents completed a four-item prescreening questionnaire at well-child appointments. Second, children with positive results were observed in the home by a mental health professional who completed the 14-item ESAT measure. Of the children who participated, 18 were diagnosed with ASD and 55 were identified as having other developmental disorders, such as language disorder ($n=18$) and intellectual disability ($n=13$). Although sensitivity and specificity data are not yet available, prevalence data suggest the sensitivity of the ESAT is relatively low. Further, a large number of false-positive results were generated following the prescreening phase (Dietz et al., 2006).

The Communication and Symbolic Behavior Scales Developmental Profile (CSBS DP; Wetherby & Prizant, 2002) Infant/Toddler Checklist and Pervasive Developmental Disorders Screener Screening Test, Second Edition (PDDST-II; Siegel, 2004) are two measures that offer level one and level two screening. The CSBS DP is comprised of a 24-item parent questionnaire (level one) and follow-up behavioral observation (level 2) with the Scale of Red Flags (SORF; Wetherby & Woods, 2002). The PDDST-II contains caregiver-rating forms for three settings; primary care centers, developmental disabilities clinics, and autism clinics. While the CSBS targets very young children (6–24 months) only, the PDDST is intended for use with toddlers and children under the age of 6. The CSBS and PDDST continue to be under investigation.

Level Two

In contrast to level one, level two screeners contain high specificity. High specificity is an important quality of level two screeners because it allows practitioners to discriminate developmental disabilities from other disorders and pinpoint the specific developmental condition (Bishop, Luyster, Richler, & Lord, 2008). Commonly used level two screeners include: (a) the Social Communication Questionnaire (SCQ; Rutter, Bailey, & Lord, 2003), (b) the Social Responsiveness Scale, Second Edition (SRS-2; Constantino, 2012), (c) the Childhood Autism Rating Scale, Second Edition (CARS2; Schopler et al., 2010), and (d) the Gilliam Autism Rating Scale, Third Edition (GARS-3; Gilliam, 2014).

The SCQ is 40-item caregiver questionnaire based on, and strongly correlated with ($r = .71-.73$; Berument, Rutter, Lord, Pickles, & Bailey, 1999; Corsello et al., 2007), the Autism Diagnostic Interview (ADI; Lord, Rutter, & Le Couteur, 1994) and Autism Diagnostic Interview-Revised (ADI-R; Rutter, Le Couteur, & Lord, 2003). Although it was originally developed for research, the SCQ is now commonly used in both research and practice (Charman & Gotham, 2013). The initial SCQ validation study conducted by Berument et al. (1999) included 160 individuals previously diagnosed with ASD and 40 without ASD. Participants ranged from ages 4 to 40 years old and were primarily British. Sensitivity and specificity were high, with values of .85 and .75, respectively. Subsequent investigations, which focused on younger participants (2–16 years old) and included American samples, showed mixed findings. Chandler et al. (2007) reported comparable sensitivity (.88) and specificity (.72) in children between the ages of 9 and 10 years old. Eaves, Wingert, Ho, and Mickelson (2006) also reported moderate sensitivity (.71) and specificity (.79) in a study with children between ages 3 and 7 years old; however, in a related study with children between the ages 4 and 6 years old, Eaves et al. (2006) reported lower sensitivity (.74) and specificity of (.54). The work of Corsello et al. (2007) provides further evidence to suggest age plays a role in the accuracy of the measure: higher sensitivity was found when the SCQ was used to screen children 11 years and older (.80), compared to children under the age of 5 years (.68). Although the utility of the SCQ has been primarily studied in the context of at-risk populations, there is some evidence to suggest it may also be an effective population-based screening tool (Chandler et al., 2007).

The SRS-2 is a 65-item rating scale for parents and teachers. Items address characteristics of autism and total scores discriminate between people with and without ASD. Like the SCQ, the SRS is strongly correlated with validated diagnostic measures, such as the ADI-R ($r = .65-.77$; Constantino et al., 2003). Several studies have shown that the SRS-2 effectively discriminates between children with ASD, non-ASD disorders, and those who are typically developing. Constantino et al. (2004) reported high sensitivity (.85) and specificity (.75) in their sample of 259 children with ASD and non-spectrum disorders. In a later study of 119 children between 9 and 13 years of age, Charman et al. (2007) reported sensitivity of .78 and specificity of .67. German and Japanese translations of the SRS-2 have also been studied

(Bölte, Westerwald, Holtmann, Freitag, & Poustka, 2011; Kamio et al., 2013). When comparing ASD and non-spectrum disorders with the German version, sensitivity was .80 and specificity was .69 (Bölte et al., 2011). For the Japanese version, indices were contrasted across girls and boys, with alternate cutoff points used for each group. The results show the measure performed equally well with girls and boys. Sensitivity for girls was .32 and specificity was .95; sensitivity for boys was .23 and specificity was .96 (Kamio et al., 2013).

The CARS2 (Schopler et al., 2010) is a clinician rating system for detecting symptoms of ASD. The CARS2 is comprised of standard (CARS2-ST) and high-functioning (CARS2-HF) forms. The CARS2-ST is for children between the ages 2 and 5 years old and older individuals with below average intellectual functioning. The CARS2-HF is for children 6 years and older who are verbally fluent and have IQ in the Low Average range, or higher. The CARS2 ratings are based on an unstructured observation session and information gathered from a caregiver (Schopler et al., 2010). The CARS2 has strong technical properties. Data obtained from the verification sample indicate the indices of sensitivity (.81) and specificity (.87) are strong. Correlations between the CARS and other autism instruments are high, and the original CARS was used extensively in clinical intervention to monitor symptom severity (Schopler et al., 2010).

The GARS-3 is a clinician-rated scale for children 3–22 years old. The GARS-3 is based on the DSM-5 criteria for ASD. Similar to the CARS2, scores are classified by likelihood of ASD and severity of symptoms. To date, no independent replication studies have been published on the sensitivity and specificity of the GARS-3. Past reports of the GARS (Gilliam, 1995) and GARS-2 (Gilliam, 2006) have generally found low sensitivity and specificity, and thus indicate limited clinical utility (Norris & Lecavalier, 2010; Pandolfi, Magyar, & Dill, 2010; Sikora, Hall, Hartley, Gerrard-Morris, & Cagle, 2008).

The Screening Test for Autism in 2-Year-Olds (STAT; Stone Coonrod, & Ousley, 2000) is a level two screener for children between the ages of 24 and 36 months. The STAT involves direct assessment by a clinician. It is comprised of 12 items that cover four domains: play, requesting, directing attention, and motor imitation. Although the STAT is completed by a clinician, it is relatively brief and does not require substantial training. Psychometric data are not widely available for the STAT.

Although they CARS and GARS are intended for screening, they are sometimes used in clinical practice as diagnostic tools (Bishop, Luyster, et al., 2008). The CARS2 and GARS-3 may be appealing to clinicians because they are time-efficient and require minimal training to administer. However, these instruments should not be used in place of robust diagnostic instruments, as described below.

Diagnosing ASD

Children who perform below an established cut-off score on a level two screening, and those who demonstrate unusual patterns of development should receive an in-depth diagnostic assessment using validated instruments (see Table 2.3). Evidence

Table 2.3 Diagnostic instruments for ASD

Instrument	Citation	Age (months)	Administration time (min)	Level of training	Strengths	Limitations
Interviews						
ADI-R	Lord et al. (1994)	12 and older	90–250	Requires substantial training	Appropriate for clinical and research purposes	Does not correspond to DSM-5
					Provides guidelines for classification	Toddler Module not yet available for clinical use
					Extensively studied	Time consuming
3di	Skuse et al. (2004)	36 and older	45–120	Requires moderate training	Appropriate for clinical purposes	Does not correspond to DSM-5
					Produces computer generated reports with algorithm scores and classification	Intended for use with individuals with average IQ
						Independent replication validity studies needed
DISCO	Wing, Leekam, Libby, Gould, and Larcombe (2002)	All ages	120–180	Not reported	Appropriate for clinical purposes	Does not correspond to DSM-5
					Provides profile of skills that directly relate to treatment planning	
					Computerized diagnostic algorithms available	Limited data on use with young children and individuals with intellectual disabilities
						Validity studies have focused on discriminations between ASD and typically developing populations

(continued)

Table 2.3 (continued)

Instrument	Citation	Age (months)	Administration time (min)	Level of training	Strengths	Limitations
Observation systems						
ADOS-2	Lord, Rutter et al. (2012), Lord, Luyster, Gotham, and Guthrie (2012)	12 and older	40–60	Requires substantial training	Appropriate for clinical and research purposes	Current version is not developmentally appropriate for older adolescents and adults with limited speech
					Corresponds to DSM-5; provides guidelines for classification and severity scores	
					Extensively studied	
AOSI	Bryson, McDermott, Rombough, Brian, and Zwaigenbaum (2000)	6–18	20	Requires moderate training	Appropriate for research purposes	Severity scores have not been widely studied
					Measures symptoms of ASD in very young children	Not appropriate for clinical purposes
						Limited age range

suggests clinical diagnoses of ASD can be made reliably as early as 2 years (Cox et al., 1999; Kleinman et al., 2008; Lord, 1995). Because there are not yet biological markers for ASD, the gold standard for diagnosing ASD in a child is a best-estimate clinical diagnosis, provided by qualified and experienced clinicians (Chawarska, Klin, Paul, & Volkmar, 2007; Klin, Lang, Cicchetti, & Volkmar, 2000; Stone et al., 1999). Several areas of functioning are impacted by ASD and therefore the process of diagnosing ASD is complex and requires a multidimensional approach (Lord & Corsello, 2005). The National Research Council (2001) recommends that the identification of ASD include a “multidisciplinary evaluation of social behavior, language, and nonverbal communication, adaptive behavior, motor skills, atypical behaviors, and cognitive status by a team of professionals experienced with autism spectrum disorders” (p. 214). To this end, clinicians use assessment data collected through ratings scales, semi-structured interviews, and clinical observation to make ASD diagnoses (Bishop, Luyster et al., 2008; Lord, Petkova et al., 2012). Integrating information from multiple sources (e.g., caregivers, teachers and experienced clinicians) is especially useful for complex cases (Kim & Lord, 2012a).

Autism Diagnostic Tools

The Autism Diagnostic Interview-Revised (ADI-R; Lord et al., 1994) is the most widely used instrument for making diagnoses of ASD in individuals with a nonverbal mental age above 24 months (Rutter, Le Couteur, et al., 2003). The ADI-R is comprised of 93 items that address (a) background information and early development (e.g., family, education, previous diagnoses, and medications); (b) communication; (c) reciprocal interactions; (d) restricted, repetitive behaviors and interests; and (e) general behavior. The majority of items include separate codes to account for the target behavior at different points in the child’s life, such as the present time, between the child’s fourth and fifth birthday, and when the behavior was regarded as most atypical. Clinicians score individual items based on their judgments about the target behavior (e.g., presence and severity). Appropriate use of the ADI-R is dependent on correct administration and accurate interpretation of informant responses. Therefore, specialized training is required to learn the administration and coding procedures (Lord et al., 1994).

In addition to scoring individual items, clinicians complete diagnostic algorithms based on the child’s language level. The algorithms, which include the ADI-R items that most closely map onto the clinical descriptions and diagnostic guidelines, provide cutoff scores for determining classification (Lord et al., 1994). In order to reach the ADI-R classification of “autism,” individuals must meet or exceed the algorithm thresholds in communication, social reciprocity, and restricted, repetitive behaviors and interests; they must also have evidence of onset before 36 months (Rutter, Le Couteur, et al., 2003). The algorithms for children 4 years and older have not changed since they were originally published by Western Psychological Association (WPS) in 2003; however, several investigators have proposed alternate

thresholds to identify the more broadly defined ASD, rather than autism only (e.g., International Molecular Genetic Study of Autism Consortium, 2001; Risi et al., 2006; Sung et al., 2005). Adapting the original algorithm to reflect a wider range of symptoms is particularly pressing in light of the DSM-5 diagnostic criteria for ASD (De Bildt et al., 2013).

A 'Toddler' version of the ADI-R has also been developed for children 4 years and younger with a nonverbal mental age above 10 months. This version includes 32 new items that assess the onset of symptoms and the child's general development (Kim & Lord, 2012b). All other items in the Toddler ADI-R are identical to the standard ADI-R, with the exception of codes for behaviors observed between the fourth and fifth birthday (theses are omitted from the Toddler ADI-R). Although the Toddler ADI-R has been used in research for several years, it is not yet published.

Risi et al. (2006) assessed the sensitivity and specificity of the ADI-R for children 3 years and older using a sample from the U.S. ($N=960$) and Canada ($N=232$). Results indicate the ADI-R has strong sensitivity (.89–.95) and adequate specificity (.56–.59) when discriminating autism plus other spectrum disorders from non-spectrum disorders (Risi et al., 2006). De Bildt et al. (2013) found comparable results in their sample of Dutch children ($N=1204$). However, the ADI-R has been found to be less effective at identifying children whose mental age is below 24 months, and those with profound intellectual disability (Chawarska, Klin, et al., 2007; Cox et al., 1999; Lord, 1995; Risi et al., 2006). Although the ADI-R accurately differentiates between ASD and other developmental disorders in older preschool and school-age children, several investigators have reported lower sensitivity for toddlers, due to subthreshold scores in the area of restricted, repetitive behaviors and interests (Chawarska, Klin, et al., 2007; Cox et al., 1999; Ventola et al., 2006; Wiggins & Robins, 2008).

In response, Kim and Lord (2012b) created new diagnostic algorithms for toddlers and early preschool students using assessment data from 829 children between the ages of 12 and 47 months. These algorithms include only items represented in both standard and toddler versions (Kim & Lord, 2012b). Distinct cutoff scores for research and clinical purposes were created. While the clinical cutoffs were selected to maximize sensitivity and maintain adequate specificity (above .70) for the comparison of ASD to non-spectrum disorders, research cutoffs were selected to maximize specificity (above .80) and maintain adequate sensitivity for the comparison of a narrower definition of ASD (e.g., autism) to non-spectrum disorders. Scores on the Toddler algorithm fall into two categories, which complement the DSM-5 criteria for ASD: social communication and restricted and repetitive behaviors and interests. They also correspond to three ranges of concern based ASD symptom severity: Little-to-No Concern, Mild-to-Moderate Concern, and Moderate-to-Severe Concern.

Kim, Thurm, Shumway, and Lord (2013) confirmed the diagnostic validity of the toddler algorithms in their replication study using two large independent samples provided by research sites in the U.S. and Canada. Across both datasets, and taking into account characteristics of age and language level, when applying the clinical cutoff score, sensitivity for ASD compared to non-spectrum disorders ranged from

Table 2.4 Guidelines for selecting) ADOS-2 modules

ADOS-2 module	Chronological age range	Expressive language level
Toddler	12–30 months	No speech, single words
1	31 months and older	No speech, single words
2	Any age	Phrase speech
3	Child, young adolescent)	Fluent speech
4	Older adolescent, adult	Fluent speech

.89 to .97 and specificity ranged from .58 to .94. The research cutoff for autism yielded sensitivity and specificity ranges of .69–.97 and .64–.94, respectively.

The Autism Diagnostic Observation Schedule, Second Edition (ADOS-2) is a semi-structured observational assessment for diagnosing ASD. The ADOS-2 is a revision of the Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, DiLavore, & Risi, 1999) and is presented in two parts: ADOS-2 Modules 1–4 (Lord, Rutter, et al., 2012) and ADOS-2 Toddler Module (Lord, Luyster, et al., 2012). It includes five development and language-dependent assessment modules across both parts, which support its use with toddlers, school age children, and adults with a range of abilities (Lord, Rutter, et al., 2012). The appropriateness of a given module relies on the individual’s age, verbal abilities, and interests (see Table 2.4). Currently, Lord and Hus are conducting validity testing for an adapted protocol, which is intended for use with older individuals with limited language.

The Diagnostic Interview for Social and Communication Disorders (DISCO; Wing et al., 2002) and the Development, Diagnostic and Dimensional Interview, Third Edition (3di; Skuse et al., 2004) are other interview systems used to diagnosis ASD. The DISCO (Wing et al., 2002) is a semi-structured standardized interview comprised of 362 items that target ASD and related developmental and psychiatric disorders. Administration is approximately 3 h (Wing et al., 2002). Although the DISCO was designed for the purpose of systematically collecting information about a child’s presenting symptoms and informing treatment recommendations, it also contains algorithms for diagnostic classification. Studies of the DISCO conducted in the US and Sweden (Nygren et al., 2009; Wing et al., 2002) revealed robust sensitivity (.82–1) and good specificity (.55–.83) for discriminating ASD from non-spectrum disorders.

The 3di (Skuse et al., 2004) is a computer-based standardized parent interview administered face-to-face by a trained clinician. It’s comprised of mandatory and optional modules, including the Pervasive Developmental Disorder (PDD) Module, which targets ASD symptoms. The PDD Module takes approximately 90 min to complete. When comorbid symptoms are present, examiners administer additional modules. Following the interview, computer-generated reports are provided to inform diagnosis (Skuse et al., 2004). In contrast to semi-structured diagnostic interviews (e.g., ADI-R, DISCO), the 3di requires minimal training to administer (Skuse et al., 2004). Further, findings from Skuse et al.’s (2004) original paper of 120 children indicate the 3di accurately discriminated between children with ASD,

children with non-spectrum disorders, and typically developing children with very high sensitivity (.98) and specificity (1). Psychometric properties are also strong for the abbreviated 3di (3di-sv; Santosh et al., 2009). The DISCO and 3di show great promise however; further study is necessary to truly understand their utility for diagnosing in ASD across clinical populations and settings.

The ADOS-2 is a 40–60 min play and activity based standardized assessment for observation of social and communication behaviors relevant to the clinical diagnosis of ASD (e.g., eye contact, gestures, social overtures and responses, sensory interests, restricted and repetitive behaviors, and others). During the ADOS-2, examiners deliver structured and semi-structured presses for social interaction and then code behaviors associated with particular test items. Examiners also give ratings of their overall impressions of the child's social communication skills (Lord, Rutter, et al., 2012).

In the updated revision, the authors provide unique algorithms for each of the five modules. Each module has a new algorithm in the ADOS-2, with the exception of Module 4; the Module 4 algorithm in the ADOS-2 is identical to the Module 4 algorithm in the original ADOS. However, Hus and Lord (2014) released a revised Module 4 algorithm shortly after the ADOS-2 was published by WPS. All future mentions of the Module 4 algorithm are in reference to the Hus and Lord (2014) algorithm.

For Modules 1 through 4, the algorithms provide cutoff score for determining instrument classification. Keeping in-line with the DSM-5 diagnostic criteria, the ADOS-2 algorithms for Modules 1 through 4 provide thresholds for autism *and* ASD based on the domains of “social affect” and “restricted and repetitive behavior” (Hus & Lord, 2014; Lord, Rutter, et al., 2012). They also provide Comparison Scores, which indicate an individual's severity of autism spectrum-related symptomatology compared to children with ASD who are the same age and language level. ADOS-2 Comparison Scores range from 1 to 10 and correspond to the following interpretive categories: Minimal-to-No Evidence, Low Level, Moderate Level, and High Level. These standardized severity scores not only assist clinicians in formulating their clinical impressions, but they also afford them the opportunity to monitor changes in an individual's presentation over time (Hus & Lord, 2014; Lord, Rutter, et al., 2012).

Much like its companion measure, the Toddler ADI-R, the ADOS-2 Toddler Module algorithm takes a more cautious approach to summarizing symptoms by providing three ranges of concern, rather than diagnostic classification. This approach is ideal for the Toddler Module because it reflects the uncertainty of diagnosis in young children based on clinical observation alone (Lord, Luyster, et al., 2012).

The first step in the ADOS-2 revision process was to improve the diagnostic validity of the ADOS algorithms. Gotham, Risi, Pickles, and Lord (2007) used a large sample ($N=1139$) of children and adolescents aged 14 months to 16 years to update the algorithms for Modules 1 through 3. Approximately one third of the participants had enrolled in earlier studies and therefore were linked to data from multiple ADOS administrations. In total, 1630 assessments comprised of an ADOS

administration, a measure of verbal IQ, and the best-estimate clinical diagnosis were reviewed. Two comparisons were conducted: autism versus non-spectrum cases ($n=1157$) and non-autism ASD versus non-spectrum cases ($n=685$). The results of Gotham et al.'s (2007) analyses indicate that across modules, for children with a nonverbal mental age above 15 months, the new algorithms demonstrated adequate sensitivity (.72–.97) for both diagnostic comparisons. Specificity was also very high for discriminating autism from non-spectrum disorders (.84–.95). Specificity was slightly lower for discriminating non-autism ASD from non-spectrum disorders, though it was still strong (.76–.83).

A replication study by Gotham et al. (2008) confirmed the predictive validity of the algorithms for Modules 1 through 3. In this multisite study, data from 1282 cases were reviewed. Sensitivity was high for autism versus non-spectrum disorders comparisons (.82–.94) though slightly lower for non-autism ASD versus non-spectrum disorders comparisons (.60–.95). As expected, specificity was very high for discriminating autism from non-spectrum disorders (.80–1) and slightly lower for discriminating non-autism ASD from non-spectrum disorders (.75–1).

Hus and Lord (2014) demonstrated strong sensitivity and specificity for the ADOS-2 Module 4 algorithm in their sample of 393 young adolescents and adults ($M=21.56$) with 437 assessments. Overall, the revised algorithm demonstrated very high sensitivity (.95) and specificity (.82) for discriminating between individuals with ASD and non-ASD disorders.

The ADOS-2 Toddler validation sample included 182 young children between the ages of 12 and 30 months. Many children were enrolled in longitudinal studies resulting in multiple assessments. In total, 360 comprehensive evaluations comprised of the ADI-R, standardized cognitive and language testing, and best-estimate clinical diagnosis were analyzed. Children were assigned to one of two developmental groups, based on their chronological age and language ability: (a) children between the ages of 12 and 30 months with few to no words and (b) children between the ages of 21 and 30 months with some words. Sensitivity and specificity were excellent for both developmental groups. For the group of children with few to words, sensitivity for contrasting ASD cases with non-spectrum plus typically developing cases was .91 and specificity was .94. For the group with some words, sensitivity for contrasting ASD cases with non-spectrum plus typically developing cases was .88 and specificity was .94.

Although the ADI-R and ADOS-2 provide some overlapping information, they lead to more accurate diagnostic formulations in young children and adolescents when used in combination, rather than individually (De Bildt et al., 2004, 2013; Kim & Lord, 2012a; Le Couteur, Haden, Hammal, & McConachie, 2008; Risi et al., 2006). In effect, the sensitivity and specificity for the combined use of the two measures is better balanced than each instrument's individual properties (Kim & Lord, 2012a; Risi et al., 2006). Consequently, experts in the field recommend the use of both the ADI-R and ADOS-2 to inform diagnostic decision-making (Kim & Lord, 2012a; Risi et al., 2006). In addition to complementing each other well, the ADI-R and ADOS-2 represent the most rigorously evaluated diagnostic tools for ASD. Although other measures show great promise, they have not undergone the

same degree of testing. When selecting diagnostic instruments, clinicians should carefully review the available research, including independent replication studies, and compare findings with their goals for assessment.

Developmental Assessment

In addition to administering instruments that target ASD symptoms, clinicians should complete a developmental assessment using a core battery that includes tests of cognitive abilities, language skills, and adaptive functioning, to inform diagnosis (Ozonoff, Goodlin-Jones, & Solomon, 2005). Such measures provide a context for determining whether or not a child's social, communication and play behaviors are developmentally appropriate (Bishop, Luyster et al., 2008). They also provide information relevant to effective treatment planning. The Mullen Scales of Early Learning (MSEL; Mullen, 1995) and the Differential Ability Scales, Second Edition (DAS-II; Elliott, 2007) are two cognitive tests that are frequently used in research and clinical evaluations for children suspected of ASD (Akshoomoff, 2006; Bishop, Guthrie, Coffing, & Lord, 2011; Lord, Petkova et al., 2012). Both of these measures are ideal for testing children suspected of ASD because they involve lesser demands for language compared to cognitive tests used in typically developing populations, such as the Wechsler Preschool and Primary Scale of Intelligence, Third Edition (WPPSI-III; Wechsler, 2002) and the Wechsler Intelligence Scale for Children, Fourth Edition (WISC-IV; Wechsler, 2003).

The MSEL is a comprehensive developmental assessment for infants and preschool children from birth to 68 months (Mullen, 1995). It provides a global estimate of intellectual functioning, in addition to subtest scores in five core areas: expressive language, receptive language, visual problem solving, fine motor skills, and gross motor scores. Data from multiple studies demonstrate the MSEL has good internal, test-retest, and inter-rater reliabilities, along with adequate internal consistency (Mullen, 1995). Comparisons to other established measures, such as the Bailey Scales for Infant Development (BSID; Bayley, 2005), confirm the validity of the MSEL as an effective measure of global cognitive ability.

The DAS-II is also commonly used to assess cognitive abilities in children suspected of ASD. The DAS-II is a revision of the DAS, which was published in 1990 (Elliott, 1990). The DAS-II is appropriate for children between the ages of 2 and 17. It's comprised of two batteries, based on age: Early Years (ages 2–6) and School-Age (ages 7–17). Each battery contains ten core subtests plus ten diagnostic subtests. Data from DAS-II validity studies indicate that it has strong psychometric properties, including internal, test-retest, and interrater reliabilities (Elliott, 2007). It also demonstrates adequate convergent validity with other established measures, such as the WPPSI-III (Wechsler, 2002) and WISC-IV (Wechsler, 2003). Finally, several subtests have extended norms, which increase its application to children with a broad range of abilities (Sattler, 2008).

Assessment of adaptive functioning is also crucial during autism diagnostic assessments. Adaptive skills are defined as conceptual, social, and practical skills that children develop in order to function in everyday situations (American Association on Intellectual and Developmental Disabilities, 2013). Assessment of adaptive functioning is critical to diagnosing ASD because it allows clinicians to appraise how the children's cognitive assets translate into successful functioning in everyday life (Saulnier & Klin, 2007). One of the most extensive and commonly used measures of adaptive functioning in children is the Vineland Adaptive Behavior Scales, Second Edition (Vineland-II; Bishop, Luyster et al., 2008; Sparrow, Cicchetti, & Balla, 2006). The Vineland-II system contains interview and rating forms that can be used with parents and teachers, and it is normed for people from birth through 90 years. The scales of the Vineland-II correspond to broad domains of adaptive functioning: communication, daily living skills, and socialization. Supplemental sections address motor skills and maladaptive behavior.

Considerations for High-Risk Siblings

Practitioners should be particularly vigilant of children who have older siblings diagnosed with ASD. Studies have consistently shown that children with older siblings on the spectrum are at an increased risk for the disorder, due to its strong genetic basis (Chakrabarti & Fombonne, 2001; Constantino et al., 2013; Ozonoff et al., 2011). Recent findings from Ozonoff et al.'s (2011) prospective study of 664 infants, suggest the recurrence rate is as high as 18.7%. In light of these findings, considerable attention has been directed toward identifying ASD in high-risk infants.

The Autism Observation Scale for Infants (AOSI) is a 20-min behavioral observation system developed by Bryson et al. (2000) to detect symptoms of ASD in high-risk infants (e.g., 6–18 months) with older siblings on the spectrum. Unlike the ADOS-2, The AOSI was created for research purposes only, specifically, to provide a method for systematically studying symptoms of ASD in early life (Bryson et al., 2000). Although the measure is not yet recommended for clinical and diagnostic use due to low sensitivity, it has been shown to reliably measure the behavioral signs of ASD in very young high-risk sibling populations (Bryson & Zwaigenbaum, 2014).

Novel Approaches to Diagnostic Assessment

More research has recently focused on novel approaches to diagnostic assessment. Diagnostic biomarkers are being studied more intensely, with potential promise for identifying autism before behavioral indicators are reliably present. Separately, computer-aided diagnosis is being used to screen for autism more quickly and reduce the burden of screening and comprehensive diagnostic assessment.

Biomarkers are biological indicators of the presence of ASD. Although candidate biomarkers to date have not been sensitive enough and continue to be quite expensive and/or laborious (Walsh, Elsabbagh, Bolton, & Singh, 2011), researchers continue to study several different possibilities. These include gene expression profiles from blood samples, proteomic profiles from serum samples, metabolomics profiles from urine samples, hormonal markers, immunological markers, morphological markers such as head size, electrophysiological markers, neuro-anatomical markers such as brain size and structure, brain function, and neuropsychological markers such as visual scanning (Ruggeri, Sarkans, Schumann, & Persico, 2013; Voineagu & Yoo, 2013; Walsh et al., 2011). Given that the biological underpinnings of ASD appear to be complex, it is likely that a panel of biomarkers will prove to have higher sensitivity than any single biomarker (Anderson, 2015; Ruggeri et al., 2013). Selecting a subgroup of individuals with ASD may have more promise than searching for a biomarker applicable to all individuals (Voineagu & Yoo, 2013). Large biobanks, such as the Simons Simplex Collection and the Autism Genetic Resource Exchange, which contain biological data from individuals diagnosed with ASD using gold-standard instruments, will be helpful in generating these panels (Ruggeri et al., 2013). This research also has implicated for targeted psychopharmacological treatment based on an individual's neurodevelopmental pathology (Ruggeri et al., 2013). The research community has been vocal about the potential for ethical considerations with respect to the use of biomarkers (Anderson, 2015; Voineagu & Yoo, 2013).

Computer-aided diagnosis is another novel approach to diagnostic assessment currently being researched. These efforts are based on the concept of using artificial intelligence to mine available data. The artificial intelligence technology discerns patterns that allow it to make decisions that are reliable with trained experts. One such tool has been used to create a 5-min online questionnaire that caregivers fill out and preliminary results have found very high sensitivity and high specificity (Duda, Kosmicki, & Wall, 2014). Other computer-aided diagnostic tools make a digital real-time map of an individual's movements in space, which have been found to be associated with an ASD diagnosis (Hashemi et al., 2012; Torres et al., 2013). These innovations may eventually make it possible to create efficient screening and diagnostic tools that can be disseminated to large groups of people.

Future Research

Diagnostic assessment is a well-researched topic in ASD; however, there are several future research directions for this topic. Foundationally, efforts are currently being made to capture more accurate prevalence data. Current sampling methods vary widely across studies and therefore limit comparisons across subgroups and comparisons within subgroups over time. The recent changes to the DSM diagnostic criteria may allow for more standardization that will improve comparability of prevalence research. The question of whether incidence of ASD is actually rising can

only be answered with better designed research that controls for the systematic biases in prevalence data.

While several screeners are available for general developmental delay and for ASD, there is limited psychometric data or poor psychometric data available on many widely distributed screeners. Further study is important to refine these tools and understand which screeners are best suited for which populations. It is particularly important, given the consistent finding that some populations are under-identified with ASD, to focus on designing and validating screeners in special populations. The diagnostic instruments for ASD continue to be a relatively high clinical burden, requiring a great deal of training, time, and clinician expertise. Continued research is necessary to design tools that reduce this burden to make comprehensive diagnosis accessible to more families and to exert downward pressure on the age of diagnosis to ensure early intervention is available to all children with ASD. Research on novel approaches, including biomarkers and computer-aided diagnosis, is being conducted with larger and larger datasets and may yield more efficient diagnostic tools.

Although enormous public health efforts have been made to introduce and improve universal screening for ASD, these initiatives have not been carefully evaluated for effectiveness over the long-run. It is important that universal screening initiatives are designed to specifically address the reported barriers to obtaining an accurate, timely diagnosis of ASD. Screening initiatives have primarily focused on pediatricians, and preliminary results suggest that multi-pronged approach, where non-medical professionals are also trained to look for signs of developmental delay, may be more effective. Longer-term studies need to follow not just screening rates, but referral, entrance, and engagement with treatment. It is important to understand whether early screening is translating into children accessing evidence-based treatments. Work in this vein should also study how early diagnosis truly affects treatment trajectories and outcomes in the long run, to help the field understanding how much earlier diagnoses need to occur to have real effects for the child and family.

Implications for Practitioners and/or Families

Accurate, early diagnosis is the key to early intensive evidence-based treatment for children with ASD. Research suggests that, while the prevalence of ASD continues to grow, there are several barriers for families seeking diagnosis. A multi-pronged strategy is important to identify children at risk for ASD.

Aggressive, routine screening is recommended for young children, given that research shows that developmental delay may be present in the absence of either parent or physician concern. Given physician concerns about familiarity, time, and cost of using screeners, public health interventions for physician training continue to be important. Training should focus on identifying level one or level two screeners that are appropriate for community practices and how to accurately use these screeners. In addition, given the evidence the pediatric practices do not routinely

screen, and that screening in non-medical settings is also effective in capturing developmental delay, public health efforts should equip schools and other community centers with training. Research shows that even children who screen positive for a developmental delay may not be referred for further evaluation or treatment. Training efforts therefore cannot stop teaching how to screen, but must also teach next steps.

It is particularly important that practitioners and families remain aware that certain sociodemographic markers, including minority status and lower socioeconomic status, are associated with greater delays to screening, diagnosis and treatment. It is unclear whether this is due to different symptom presentation in these groups, different levels of awareness or recognition in the family or clinician, or other potential influences. Regardless, training efforts should focus on the importance of capturing all children with a developmental delay and include strategies for screening and referring children and families in these risk groups.

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