

# Autism spectrum disorder in the second year: stability and change in syndrome expression

Katarzyna Chawarska,<sup>1</sup> Ami Klin,<sup>1</sup> Rhea Paul,<sup>1,2</sup> and Fred Volkmar<sup>1</sup>

<sup>1</sup>Yale Child Study Center, Yale University School of Medicine, New Haven, Connecticut, USA; <sup>2</sup>Department of Communication Disorders, Southern Connecticut State University, New Haven, Connecticut, USA

**Objectives:** Increasing numbers of young children referred for a differential diagnosis of autism spectrum disorders (ASD) necessitates better understanding of the early syndrome expression and the utility of the existing state-of-the-art diagnostic methods in this population. **Method:** Out of 31 infants under the age of 2 years referred for a differential diagnosis, 19 were diagnosed with autism, and 9 with pervasive developmental disorder – not otherwise specified (PDD-NOS) when reassessed at 3 years. We examined 1) the symptoms of ASD in the second year and changes in the syndrome expression by the age of three; 2) relationship between expert-assigned clinical diagnosis and diagnostic classification based on Autism Diagnostic Observation Schedule-Generic (ADOS-G) and Autism Diagnostic Interview-Revised (ADI-R) in the second year; 3) the relationship between direct observation and parental report of ASD symptoms. **Results:** Symptoms of autism and PDD-NOS in the second year were pronounced and stability of the clinical diagnosis was high. The agreement between clinician-assigned autism but not PDD-NOS diagnosis and the ADOS-G was high. However, sensitivity of the ADI-R diagnostic classification of autism was poor. Comparison of concurrent parental report and direct observation revealed discrepancies in severity ratings of key dyadic social behaviors. Changes in communication reflected acquisition of language accompanied by the emergence of unusual language characteristics. Symptoms of social dysfunction were relatively stable over time, and so was the severity of stereotyped behaviors. **Conclusions:** The study provides support for stability of clinical diagnosis and syndrome expression in the second year and highlights advantages and limitations of the ADI-R and ADOS-G for diagnosing and documenting symptoms of ASD in infants. **Keywords:** Autism, ASD, PDD-NOS, early diagnosis, ADOS-G, ADI-R, infants, toddlers, assessment, longitudinal studies.

Growing awareness of symptoms of autism spectrum disorders (ASD) in young children among parents and professionals, as well as close monitoring of infants at familial risk for developing ASD, result in a rapidly increasing number of infants and toddlers being referred to specialized clinics for a differential diagnosis. Therefore, better understanding of the syndrome's expression in the first years of life and the utility of the existing state-of-the-art diagnostic methods in this population is essential (Klin, Chawarska, Rubin, & Volkmar, 2003; Volkmar, Lord, Bailey, Schultz, & Klin, 2004).

While autism has not usually been diagnosed until the age of 3 to 4 years (Chakrabarti & Fombonne, 2005, 2001; Charman & Baird, 2002; Filipek et al., 1999), a majority of parents voice their concerns before their child's second birthday, and about 50% notice some abnormalities in the first year (Volkmar, Stier, & Cohen, 1985). Nonetheless, evidence regarding early developmental course of ASD is still limited due to scarcity of prospective follow-up studies. The first study to report on developmental course of a very small group of infant siblings at high risk for ASD suggest that symptoms of autism might be noticeable at six months and that by 12 months, they might in-

clude abnormalities in visual attention and eye contact, impaired orienting to name, delays in speech and communication, as well as temperamental abnormalities (Zwaigenbaum et al., 2005). However, it is not clear whether these symptoms are autism-specific as comparable data on developmentally delayed infants are lacking. In the second year symptoms of autism become more pronounced or, in a small fraction of the cases, after a period of apparently normal development, the onset of autism is marked by a loss of language and social interests around 18 to 24 months (Goldberg et al., 2003; Lord, Shulman, & DiLavore, 2004; Siperstein & Volkmar, 2004; Werner & Dawson, 2005). Research relying on prospective parental report (Cox et al., 1999) and an experimental study (Charman et al., 1997) suggest that compared to language-delayed peers, 20-month-olds with autism display a limited range of facial expressions, limited interest in other children, limited empathy and imitation, as well as lack joint attention and display limited use of gestures. By the age of 42 months symptoms in this sample included impairments in communicative use of pointing, sharing enjoyment, offering comfort, imaginative play, and development of conventional gestures (Cox et al., 1999).

Attempts to differentiate between autism and pervasive developmental disorder – not otherwise

Conflict of interest statement: No conflicts declared.

© 2007 The Authors

Journal compilation © 2007 Association for Child and Adolescent Mental Health.

Published by Blackwell Publishing, 9600 Garsington Road, Oxford OX4 2DQ, UK and 350 Main Street, Malden, MA 02148, USA

specified (PDD-NOS) in young children led to mixed results. For instance, in the Cox et al. (1999) study a majority of cases diagnosed with atypical autism at the age of 3.5 years had received a non-ASD diagnosis at 20 months. In other studies, a majority of PDD-NOS toddlers met full criteria for autism at follow-up (Eaves & Ho, 2004; Stone et al., 1999). At present it is not clear whether the limited diagnostic stability of atypical autism category is due primarily to the diagnostic ambiguity of this category, lower stability of symptoms, or possibly differences in amenability to treatment (Cox et al., 1999; Eaves & Ho, 2004; Stone et al., 1999; Walker et al., 2004; Volkmar et al., 1994).

Direct comparisons between studies reporting on symptoms of autism and PDD-NOS in the second year and their changes over time are difficult due to differences in sample ascertainment (employment of primary population screeners, high-risk, or clinic referred samples), type of measures used to document symptoms (parent report versus direct standardized observation), and composition of control groups (e.g., language delay versus developmental delay or typical controls). Thus, despite the current advances, the developmental course of autism and PDD-NOS in the first years of life remains to be mapped and elucidated in its entirety.

Amongst the growing number of instruments used for diagnosing and documenting autistic symptoms, two are of particular interest due to the extent of their research and clinical applications: the Autism Diagnostic Interview – Revised (ADI-R; Rutter, Le Couteur, & Lord, 2003) and the Autism Diagnostic Observation Schedule – Generic (ADOS-G; Lord, Rutter, DiLavore, & Risi, 2000b). The ADOS-G is a direct assessment procedure composed of naturalistic presses aimed at eliciting spontaneous social and communicative behaviors. Behaviors are coded in the areas of Communication (ADOS-C), Social Reciprocal Interaction (ADOS-SRI), Play (ADOS-P), and Stereotyped Behaviors and Restricted Interests (ADOS-SB). The ADOS-G provides a DSM-IV based algorithm for the diagnosis of autism, ASD (including PDD-NOS), and non-ASD. The ADI-R is an investigator-based parent interview designed to elicit information needed for documenting delays and abnormalities in Communication (ADI-C), Social Reciprocal Interaction (ADI-SRI), and Restricted, Repetitive, and Stereotyped Patterns of Behaviors (ADI-SB) in individuals with a developmental level of at least 2 years, 0 months. The diagnostic algorithms focus on a full developmental history and provide cut-off points for diagnostic classification of autism but not PDD-NOS in children between 2 and 4 years, and over 4 years. The diagnostic classification outcomes based on the ADOS-G and ADI-R are distinct from a clinical diagnosis and in cases where there is a disagreement between clinical diagnosis and the instrument-based classification outcome, standard practice dictates that clinician-assigned diagnosis takes priority (Lord et al., 2000a; Rutter et al., 2003).

While the utility of the ADOS-G and ADI-R for diagnostic purposes and documenting symptoms in preschool children is well established (Lord et al., 2000a, 2000b, 1994), their diagnostic validity may be limited in children with a mental age level below 2 years because early symptoms might be subtle and non-specific (Lord & Risi, 2000; Rutter et al., 2003). Moreover, the ADI-R tends to over-diagnose nonverbal children with mental ages below 18 months who lack the cognitive skills necessary for development of social and communicative behaviors and under-diagnose more verbal and higher-functioning children (Lord, 1995; Lord, Storoschuk, Rutter, & Pickles, 1993). Only 50% of 20-month-old children with autism were classified in congruence with clinical diagnosis based on the standard ADI-R criteria (Cox et al., 1999). Lowering a cut-off point in the ADI-SB domain resulted in increased sensitivity of the ADI-R, but reduced specificity. To date there have been no reports on the ADOS score profiles or on the efficacy of the diagnostic classification in children with mental age (MA) below 24 months.

Considering documented limitations of the current diagnostic instruments and the absence of biological markers of autism, clinician-assigned diagnosis remains the gold standard, particularly in young children (Charman & Baird, 2002; Eaves & Ho, 2004; Klin, Lang, Cicchetti, & Volkmar, 2000; Klin et al., 2003; Lord & Risi, 2000; Stone et al., 1999). Stability of the clinical diagnosis of autism assigned toward the end of the second year is very good, with 75% of cases retaining the diagnosis at 3 and the remaining 25% receiving another PDD diagnosis (Cox et al., 1999). Similar rates have been reported in 2- and 3-year-olds (Charman et al., 2005; Eaves & Ho, 2004; Gillberg et al., 1990; Lord, 1995; Stone et al., 1999). Stability of PDD-NOS diagnosis in 2-year-olds appears to be more problematic (Cox et al., 1999; Eaves & Ho, 2004; Stone et al., 1999).

*Present study.* We report data on a group of infants between 14 and 25 months of age referred to a specialized clinic for a comprehensive multidisciplinary assessment. The infants were diagnosed with autism or PDD-NOS and their diagnosis was clarified at the age of 3 years. We examined: 1) the clinical presentation of autism and PDD-NOS in the second year of life and changes in the syndrome expression in a 1- to 2-year period; 2) the relationship between the ADOS-G and ADI-R diagnostic classification and clinical diagnosis; 3) the relationship between direct observation and parental report of symptoms under the age of 2 years.

## Methods

### *Participants*

Thirty-one children aged 14 to 25 months, selected from amongst consecutive referrals for their young age, were evaluated for a differential diagnosis of ASD at a

specialized clinic. None of the infants carried an ASD diagnosis at the Time 1 assessment. The best-estimate clinical diagnosis at both times was assigned by a highly experienced clinical team consisting of a psychologist, psychiatrist, and speech-language pathologist based on medical and developmental history review, clinical observation, and review of test results. The diagnosis of autism was based on the DSM-IV criteria modified for children under the age of 3 (see Chawarska & Volkmar, 2005 for review) with emphasis on the absence of early-emerging dyadic and triadic interaction skills and limited nonverbal communication skills, with a lesser emphasis on the presence of stereotypic behaviors. PDD-NOS diagnosis was assigned in cases where social deficits appeared milder, and children displayed some emerging nonverbal communication skills and had fewer unusual sensory interests and motor mannerisms. In rare cases of disagreement, the discrepancies were reexamined and a consensus diagnosis was given. All children came from middle-class Caucasian families and were similar in terms of birth order and newborn characteristics, developmental history, and age at which abnormalities were first noticed (see Table 1).

At Time 1, twenty-one children were given a diagnosis of autism (AUT), and six received a PDD-NOS diagnosis. The remaining four were diagnosed with developmental delay (DD). At Time 2 (on average, 15 months later) the children were reassessed with an identical battery. Stability of clinical autism diagnosis was high (90%; of the original 21, 19 retained their autism diagnosis and 2 met criteria for PDD-NOS) and all ( $N = 6$ ) children diagnosed initially with PDD-NOS retained the diagnosis at follow-up. Three of four children initially diagnosed with DD remained so, while one was later diagnosed with PDD-NOS. This was a younger sibling of a child with PDD-NOS whose initially mildly delayed verbal and social skills acquired abnormal features at follow-up. The final diagnostic breakdown was: AUT ( $N = 19$ ), PDD-NOS ( $N = 9$ ) and DD ( $N = 3$ ). The last

group was excluded from the subsequent analysis due to insufficient  $N$ . While the Time 2 clinical diagnosis was not independent of Time 1, the five experienced clinicians on the staff rotated such that typically only one member of the initial team participated in the second assessment. Informed consent was obtained from all parents and the study was conducted in accordance with the Human Investigation Committee of the Yale University School of Medicine.

## Procedure

**Assessment procedures.** Developmental level was assessed at both time points with the Mullen Scales of Early Learning (Mullen, 1995), a measure of early development providing  $T$  scores in five domains: Gross Motor (GM), Fine Motor (FM), Visual Reception (VR), Receptive Language (RL), and Expressive Language (EL). The  $T$  scores in the VR and FM as well as RL and EL domains were averaged to create individual nonverbal and verbal composite scores, respectively. Spontaneous social interaction, play, and communication were assessed directly with the ADOS-G. At Time 1, ADOS-G Module 1, which was designed for pre-verbal individuals and those using single words or simple phrases, was used. At Time 2, all children were reassessed with Module 1. Due to progress in speech development, six children (2 AUT and 4 PDD-NOS) were also administered Module 2, designed for individuals with phrase speech but with an expressive language level of below 4 years. Mothers were interviewed with the Autism Diagnostic Interview-R (Lord et al., 1994) on the first day of the assessment by an interviewer blind to the child's diagnostic and developmental status. In one case no interview was conducted due to time constraints. The ADI-R diagnostic classification was based on the diagnostic algorithm for children aged 2 years 0 months to 3 years, 11 months (Rutter et al., 2003). We report ADI-R data at Time 1 only, as data collection on this sample continues and the ADI-R will be administered at the age of 5. All interviewers and examiners had previously established reliability.

**Table 1** Sample characteristics (Mean, SD): grouping based on clinical diagnostic classification at Time 2

Characteristic	Autism ( $N = 19$ )	PDD-NOS ( $N = 9$ )
Age at Time 1 (months)	21.6 (3.2)	21.6 (2.5)
Age at Time 2 (months)	34.8 (3.9)	38.1 (8.3)
Male (%)	56	100
Firstborn (%)	47	63
Birth weight (g)	3265 (439)	3266 (842)
Gestational age (wks)	38.8 (1.8)	39.3 (1.8)
Maternal age (yrs)	35 (2.4)	32 (3.7)
Age of concern	11.6 (5.6)	12.6 (2.5)
First concern < 12 month (%)	47	25
Developmental milestones (mo):		
Sitting	6.8 (1.5)	7.1 (1.8)
Walking	14.1 (2.5)	13.1 (1.5)
Words	17.3 (10)	16.4 (5.1)
Mullen $T$ score Time 1		
Verbal	28 (11)	30 (8)
Nonverbal	38 (10)	45 (6)
Mullen $T$ score Time 2		
Verbal	36 (13)	46 (9)
Nonverbal	33 (12)	46 (9)

## Results

**Verbal and nonverbal functioning.** At Time 1, both the AUT and PDD-NOS groups showed comparable verbal and nonverbal  $T$  scores, but their nonverbal scores exceeded their language scores,  $F(1, 26) = 31.69$ ,  $p < .001$  (see Table 1). At Time 2, there was no significant difference between the scales, but the PDD-NOS group had higher  $T$  scores in both verbal and nonverbal domains,  $F(1, 26) = 6.33$ ,  $p < .02$ . Analysis of the within-group differences over time suggests that in the AUT group there was a marginally significant increase in verbal ( $t(36) = 1.93$ ,  $p < .061$ ) but not in nonverbal scores. A similar pattern was noted in the PDD-NOS group with a significant increase only in verbal ( $t(16) = 4.28$ ,  $p < .001$ )  $T$  scores. To address the issue of individual changes of  $T$  scores, difference scores between Time 1 and 2 for verbal and nonverbal domains were

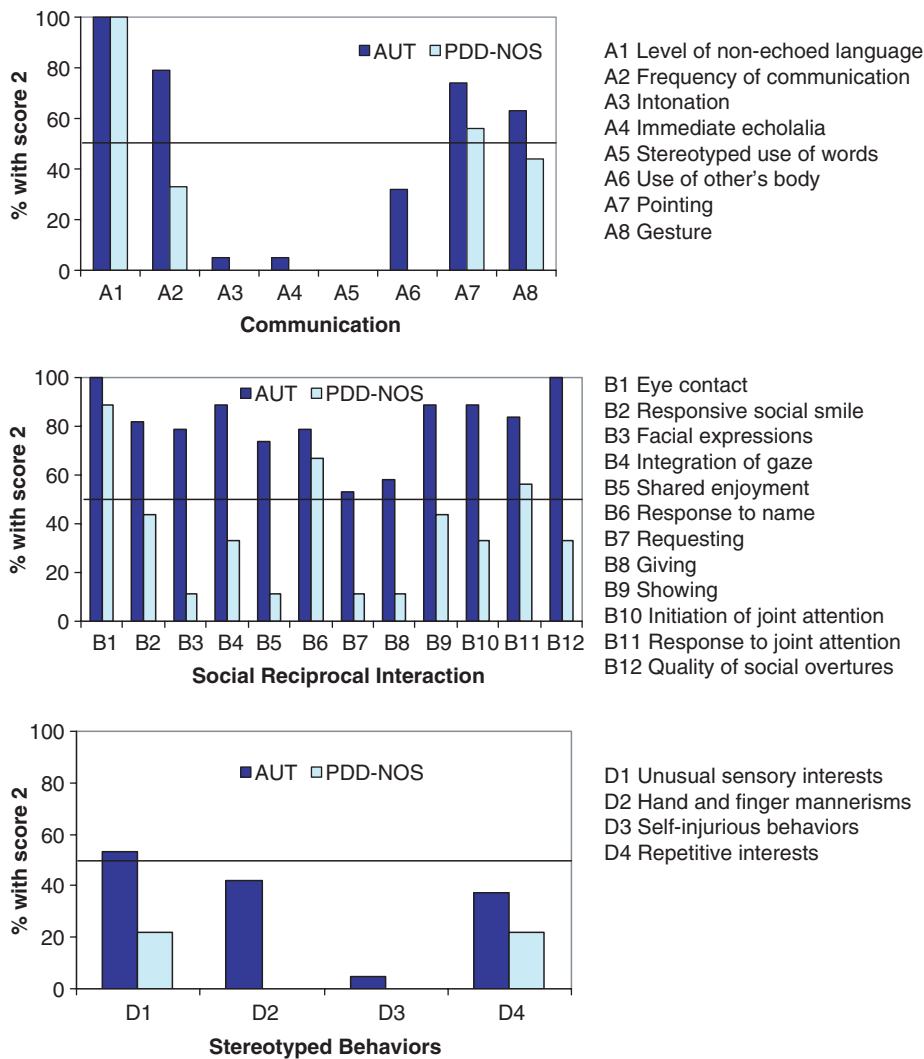
computed. Children with AUT showed a marginally lower increase in verbal scores ( $M = 7.26, SD = 14$ ), as compared to those with PDD-NOS ( $M = 16.33, SD = 8$ ),  $F = (1, 27), p < .08$ . There was no significant difference between the groups in the rate of nonverbal skills acquisition.

**Syndrome expression in the second year and changes over time**

To facilitate analysis of changes in syndrome expression over time we focused on the ADOS-G Module 1 results (see Lord et al., 2000a, 2000b). Behavioral responses were coded on a 0 to 3 scale, where 0 = no evidence of abnormality, 1 = mild abnormality; 2 = definitive abnormality; and 3 = severe abnormality or absence of the behavior in question (e.g., little or no reciprocal interaction). To enhance variability in the sample we retained this four-level system, rather than collapse levels 2 and 3 (Lord, personal communication). Scores greater than 3 signify lack of mastery of the skill in question and

were converted to 0 in accordance with the ADOS-G manual, with one exception: item A1 (overall level of non-echoed language), where score 8, signifying lack of words or word approximations, was coded as 3 for the purpose of the item-by-item analysis only to facilitate comparison over time. A series of ANOVAs using the Proc Mixed SAS procedure was conducted for individual items with diagnosis and time as between- and within-group factors, respectively. A conservative alpha level of .002 was adopted to control for Type I error (Bonferroni correction). Higher alpha levels were reported but not interpreted. To determine which behaviors were most likely to be rated as highly pathological in infants below 25 months, we graphed percentages of children receiving scores of 2 or 3 on individual items (see Figure 1).

**Communication Scale.** As shown in Figure 1, relatively few Communication items were endorsed by clinicians as highly abnormal in the second year due to nonverbal status of the infants. However, a



**Figure 1** Percentage of infants with autism and PDD-NOS receiving the most pathological scores on the ADOS-G Module 1 in the 2nd year of life

majority of infants with AUT showed severe deficits in frequency of vocalizations directed to others and use of pointing and other communicative gestures. A majority of infants with PDD-NOS scored in the highly pathological range only on the pointing item. As indicated by a series of diagnosis  $\times$  time ANOVAs (see Table 2), the only item on the Communication scale that differentiated between the groups at both times was frequency of vocalizations directed to others. There were no significant diagnosis  $\times$  time interactions, suggesting relative stability of the between-group differences over time.

The pattern of symptom change in both groups indicated marked improvement of some and worsening of other aspects of communication. The level of language improved significantly in both groups, as did the frequency of communication directed to others, although the latter remained in the pathological range, especially in the autism group. However, as language began to emerge, so did the unusual linguistic features, including echolalia and abnormal pitch or intonation.

**Social Reciprocal Interaction Scale.** A large majority of AUT infants scored in a highly abnormal range on all Socialization items (Figure 1). Only two behaviors were less frequently rated as pathological: the ability to make requests and to give objects to others. Fewer items were endorsed as pathological in the PDD-NOS group; these included abnormal eye contact, abnormalities in responding to joint attention, and lack of response to name. The between-group differences were consistent at both time points, as indexed by the absence of significant time  $\times$  diagnosis interaction effects (see Table 3). The PDD-NOS group was more likely to display elementary dyadic interaction skills including social smiling, directing facial expressions at others, integrating gaze during social overtures, initiating joint attention, showing, and

sharing enjoyment. The overall quality of social interactions was judged by the examiners as more appropriate in the PDD-NOS than in the AUT group.

There were, however, very limited changes over time in the individual item scores. Significant improvement was noted in both groups in responsiveness to bids for joint attention. At the Time 2 assessment, 16% in the AUT and 57% in the PDD-NOS group, respectively, were able to follow the gaze of the examiner, as compared with 0% in both groups at Time 1. There was also a significant diagnosis  $\times$  time interaction involving the show gesture (B9), suggesting improvement only in the PDD-NOS group.

**Play and Stereotypic Behaviors Scales.** Functional and symbolic play skills were rated by clinicians at Time 1 as highly abnormal in both groups and improved somewhat over time (see Table 4). The most frequently recorded in both groups were unusual sensory interests and repetitive behaviors, but not self-injurious or aggressive behaviors (Figure 1). Children with PDD-NOS had significantly fewer motor mannerisms as compared to the AUT group. Scores in the Stereotypic Behaviors domain were stable over time in both groups.

**ADOS-G Diagnostic Algorithm Scores.** Algorithm scores were computed based on Module 1 results. Scores of 3 were converted to 2 following the ADOS-G scoring procedures (see Figure 2). Verbal and non-verbal Mullen scores were included in the model as covariates in examining the between-group effects.

Children with AUT had significantly more pathological ADOS-G scores than the PDD-NOS group at both times in all domains but Play and Imagination. There was a significant drop over time of the algorithm scores in both groups in all domains except for the ADOS-SB domain. To examine the relationship

**Table 2** Means (SD) of individual item scores for the ADOS-G Module 1 Communication Scale in the Autism and PDD-NOS groups

Communication items	Diagnosis	Time 1	Time 2	Effect	
				Diag.	Time
A1 – Overall level of non-echoed language	Autism	2.0 (0)	.126 (.87)	–	.001
	PDD-NOS	2.0 (0)	.88 (.78)		
A2 – Frequency of vocalization to others	Autism	2.21 (.79)	1.37 (.68)	.001	.001
	PDD-NOS	1.33 (.87)	.44 (.73)		
A3 – Intonation of vocalization	Autism	.10 (.46)	.89 (.94)	–	.002
	PDD-NOS	.11 (.33)	.56 (.53)		
A4 – Immediate echolalia	Autism	.21 (.71)	.84 (.76)	–	.001
	PDD-NOS	.11 (.33)	.56 (.53)		
A5 – Stereotyped/idiosyncratic words	Autism	0 (0)	.58 (.77)	–	.006
	PDD-NOS	0 (0)	.56 (.53)		
A6 – Use of other's body to communicate	Autism	.74 (.93)	.58 (.90)	–	–
	PDD-NOS	.33 (.50)	.11 (.33)		
A7 – Pointing	Autism	2.37 (.89)	1.84 (1.21)	.008	.05
	PDD-NOS	1.77 (1.30)	.89 (.60)		
A8 – Gestures	Autism	1.63 (.68)	1.05 (.62)	.009	.008
	PDD-NOS	1 (1.0)	.44 (.73)		

**Table 3** Means (SD) of individual item scores for the ADOS-G Module 1 Social Reciprocal Interaction Scale in the Autism and PDD-NOS groups

Socialization items	Diagnosis	Time 1	Time 2	Effect	
				Diag.	Time
B1 – Unusual eye contact	Autism	2.00 (0)	2 (0)	.05	–
	PDD-NOS	1.77 (.67)	1.77 (.67)		
B2 – Responsive social smile	Autism	1.89 (.66)	1.56 (.15)	.001	–
	PDD-NOS	1.33 (.71)	.78 (.67)		
B3 – Facial expressions directed to others	Autism	1.79 (.42)	1.26 (.56)	.001	–
	PDD-NOS	.89 (.61)	1 (.50)		
B4 – Integration of gaze during social overtures	Autism	2.26 (.65)	1.58 (.84)	.001	.05
	PDD-NOS	1.0 (1.12)	.67 (.70)		
B5 – Shared enjoyment in interaction	Autism	1.68 (.58)	1.26 (.73)	.002	–
	PDD-NOS	.78 (.67)	.67 (1.0)		
B6 – Response to name	Autism	2.00 (.67)	1.58 (1.07)	.03	.02
	PDD-NOS	1.44 (.88)	.78 (.97)		
B7 – Requesting	Autism	1.74 (.93)	.84 (.69)	.03	.01
	PDD-NOS	.89 (.93)	.56 (.53)		
B8 – Giving	Autism	1.58 (.51)	.95 (.62)	.006	.006
	PDD-NOS	.89 (.60)	.56 (.73)		
B9 – Showing	Autism	1.89 (.31)	1.73 (.45)	.0001	.002 <sup>1</sup>
	PDD-NOS	1.22 (.83)	.56 (.53)		
B10 – Spontaneous initiation of joint attention	Autism	1.89 (.32)	1.53 (.70)	.0001	.04
	PDD-NOS	.89 (.93)	.44 (.53)		
B11 – Response to joint attention	Autism	1.89 (.46)	1.31 (.82)	.003	.0001
	PDD-NOS	1.56 (.53)	.44 (.53)		
B12 – Quality of social overtures	Autism	2.26 (.45)	1.89 (.81)	.0001	.04
	PDD-NOS	1.33 (.87)	.89 (.78)		

<sup>1</sup>Significant diagnosis × time interaction (see text).

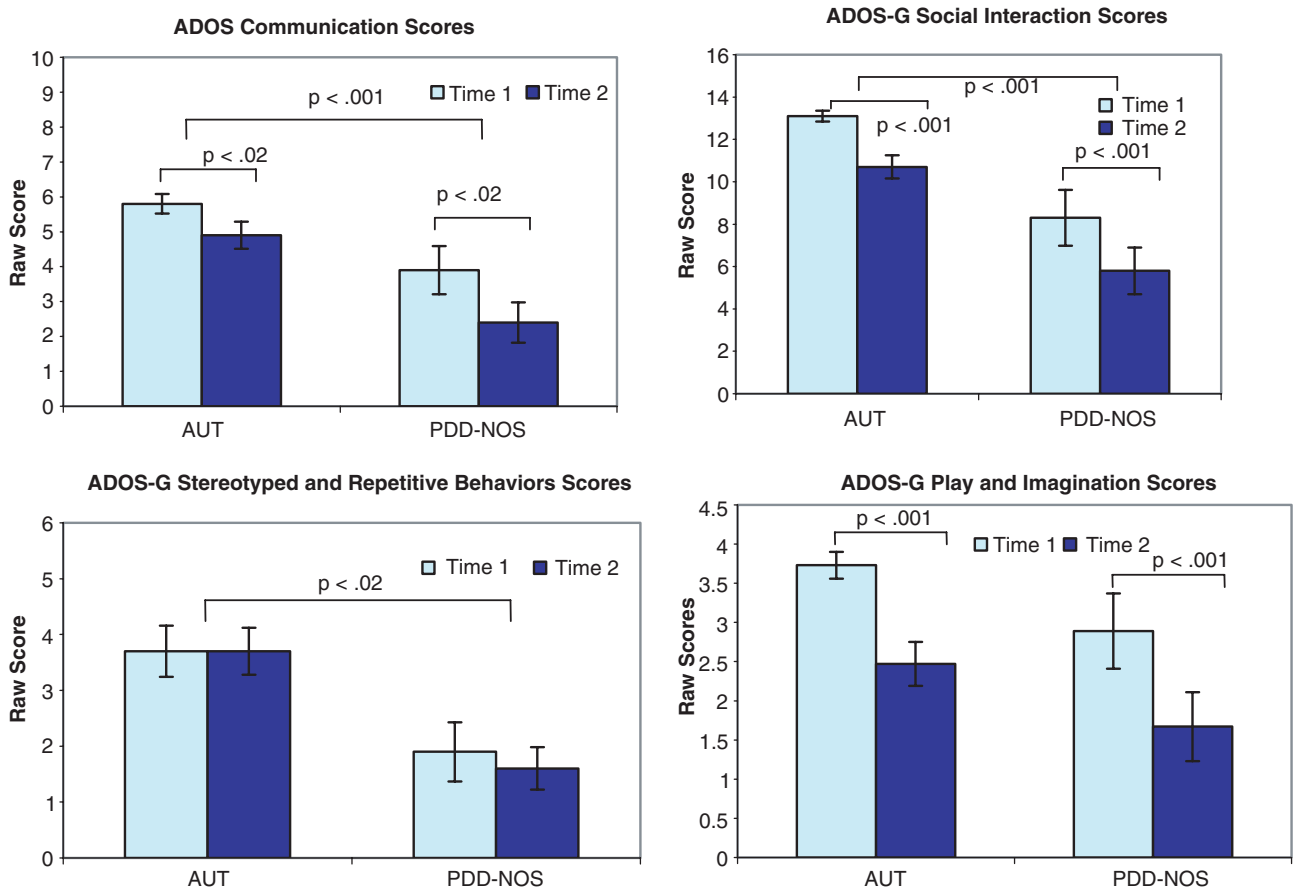
**Table 4** Means (SD) of individual item scores for the ADOS-G Module 1 Play and Stereotyped Behaviors Scales in the Autism and PDD-NOS groups

	Diagnosis	Time 1	Time 2	Effect	
				Diag.	Time
Play					
C1 – Functional play with objects	Autism	2.00 (.74)	.89 (.94)	.02	.002
	PDD-NOS	1.22 (.97)	.56 (.73)		
C2 – Imagination	Autism	2.73 (.56)	1.79 (.85)	–	.0001
	PDD-NOS	2.33 (1.0)	1.22 (.97)		
Repetitive behaviors					
D1 – Unusual sensory interest in play material	Autism	1.47 (.61)	1.58 (.50)	.003	–
	PDD-NOS	1.0 (.70)	.77 (.83)		
D2 – Hand, finger, and other mannerisms	Autism	1.05 (.91)	1.0 (.88)	.002	–
	PDD-NOS	.11 (.33)	.22 (.44)		
D3 – Self-injurious behavior	Autism	.21 (.53)	.05 (.22)	–	–
	PDD-NOS	.11 (.33)	0 (0)		
D4 – Unusually repetitive interest/behavior	Autism	1.21 (.85)	1.32 (1.1)	.02	–
	PDD-NOS	.78 (.83)	.55 (.73)		

between verbal and nonverbal skill acquisition and changes in the ADOS scores, we compared difference scores across subscales of the Mullen and the ADOS. Increase in verbal *T* scores was associated with a drop of ADOS-SRI ( $r = -.45$ ,  $p < .01$ ), ADOS-SB ( $r = -.46$ ,  $p < .02$ ) and ADOS-P ( $r = -.50$ ,  $p < .01$ ) scores. Similarly, gains in the nonverbal domain were associated with a drop in the ADOS-C ( $r = -.41$ ,  $p < .05$ ) and ADOS-P ( $r = -.50$ ,  $p < .01$ ), and marginally ADOS-SB ( $r = -.37$ ,  $p < .06$ ) and ADOS-SRI ( $r = -.37$ ,  $p < .054$ ) scores.

#### ADOS-G and ADI-R diagnostic classification

At Time 1, in all but one (95%) case there was an agreement between the ADOS-G Module 1 diagnostic classification outcomes and clinician-assigned diagnosis of autism. However, only 33% of PDD-NOS children received a classification congruent with their clinical diagnosis. At Time 2, the diagnostic classification based on either Module 1 or Module 2 resulted in agreement in 15 (79%) cases of autism, but only 33% of PDD-NOS.



**Figure 2** Mean (std. error) of ADOS-G Module 1 domain scores in autism and PDD-NOS groups at Times 1 & 2

To assess the relationship between the outcome of the ADOS classification and verbal and nonverbal developmental levels, we compared those with perfect agreement between ADOS and clinical diagnosis ( $N = 39$ ), cases where the ADOS-G based classification suggested a *lesser* diagnosis (i.e., under-diagnose AUT as PDD-NOS, or PDD-NOS as Non-PDD) ( $N = 11$ ) and those who, based on the ADOS-G, were classified with a *more severe* disorder (i.e., over-diagnose PDD-NOS as AUT) ( $N = 6$ ). Agreement  $\times$  time ANOVAs on verbal and nonverbal  $T$  scores indicated that regardless of the time of visit, the under-diagnosed cases had higher verbal,  $F(1, 53) = 12.37, p < .001$ , and nonverbal,  $F(1, 53) = 7.84, p < .01$ , skills than those classified in concordance with clinical diagnosis. There were no differences in verbal and nonverbal scores in the cases over-diagnosed as autistic.

At Time 1, only 48% of autism cases were classified as such by the ADI-R; 88% of children with PDD-NOS fell into the non-autistic ADI-R classification. There were no systematic differences in verbal and nonverbal functioning in children whose clinical diagnosis diverged from diagnostic assignment based on the ADI-R. Lowering the criteria for classification by dropping the ADI Repetitive Behaviors score resulted in a correct classification of 78% of AUT cases, with a slight increase in the likelihood of over-inclusion of PDD-NOS cases into the autism

category from 12% to 38%. Mean scores (SD) for AUT and PDD-NOS groups, respectively, were: Social Interaction: 16.6 (5.8) and 11.1 (6.9), Nonverbal Communication: 10.4 (2.2) and 7.1 (4.2), and Stereotyped Behaviors: 3.6 (2.4) and 2.5 (1.7). A between-group ANOVA indicated significantly higher scores for the AUT group in Social Interaction ( $F(1, 26) = 4.55, p < .05$ ) and Nonverbal Communication ( $F(1, 26) = 6.69, p < .02$ ) domains only.

*Comparison between concurrent parental report and clinical observation.* The overlap in the ADOS-G and ADI-R diagnostic classification of autism was low when classification was based on all three domains of the ADI-R (36%), but it increased to 73% when only the ADI-C and ADI-SRI criteria were considered. There were moderate correlations between the algorithm scores based on parental report and clinician's impression in Communication ( $r = .49, p < .01$ ) and Social Reciprocal Interaction ( $r = .46, p < .02$ ), but not in the Stereotyped Behaviors domains ( $r = .27, p < .17$ ). However, the algorithm item overlap between the two instruments was not perfect, which might have contributed to the modest correlations. We isolated and compared ten items that were very similar in both instruments. A series of repeated measures ANOVAs with clinical diagnosis and birth order as between-group factors on the pairs of corresponding items suggest that after

the effects of degree of impairment (diagnosis) and parental expertise (birth order) were accounted for, parents still rated as more typical nonverbal behaviors used to regulate social interactions including eye contact ( $F(1, 23) = 12.68, p < .002$ ), social smiling ( $F(1, 23) = 5.94, p < .05$ ), and facial expressions ( $F(1, 23) = 6.91, p < .02$ ) than did the clinicians. They also reported fewer unusual preoccupations ( $F(1, 23) = 7.15, p < .02$ ) and slightly better pointing ( $F(1, 23) = 3.61, p < .067$ ). Corresponding items on the Communication scales were rated similarly on both instruments, in particular, use of other's body to communicate and other gestures. There was also little discrepancy in relation to motor mannerisms, which were in general infrequent, and presence of unusual sensory interests, which in turn, were most prevalent in this sample.

## Discussion

*Early diagnosis.* Consistent with other reports (Cox et al., 1999), short-term stability of the autism diagnosis assigned in the second year was high. All infants diagnosed with ASD retained the diagnosis at the age of 3, with the autism diagnosis stability reaching 90%; improvements in two cases warranted a change to a PDD-NOS diagnosis. Unlike in other studies, we also documented a very high short-term stability of the PDD-NOS diagnosis and a consistent pattern of differences between classic autism and its apparently lesser variant, PDD-NOS.

*Symptoms of autism and PDD-NOS in the second year.* Several behaviors captured by the ADOS-G were endorsed as highly pathological in all nonverbal infants with ASD: 1) limited response to name, 2) poor eye contact, 3) limited response to joint attention bids, 4) lack of pointing, and 5) delays in functional and symbolic play. However, differences between autism and PDD-NOS at both time points were pronounced and stable.

A majority of infants with autism did not direct their vocalizations (e.g., grunts) to others, nor did they compensate for lack of speech with gaze as well as conventional, physical, or depictive gestures. While experiencing some emotions, they typically did not share them with others. They were unlikely to monitor behaviors of others, follow nonverbal cues for their attention, or respond when their name was called. Play with objects was primarily exploratory and interest in details of objects and their sensory characteristics was frequent. Motor mannerisms such as jumping, hand-flapping, or toe-walking were occasionally observed. Self-injurious behaviors were absent in most cases.

In comparison to autism, children with PDD-NOS, while socially impaired, were more likely to engage in dyadic exchanges and show emerging intentional communication skills (Bates, 1979). They directed

vocalizations and facial expressions toward others, smiled socially, and shared enjoyment more frequently. Although their eye contact in general was abnormal, they integrated gaze into social overtures more frequently. Despite lack of language, they were more likely to engage in spontaneous initiation of joint attention and showing. While present, unusual sensory interests and motor mannerisms were less frequent than in the autism group.

While a previous study based on parent interview reported that differences between autism and PDD-NOS in the second year might be restricted to lack of pointing (Cox et al., 1999), direct observation suggests that, like older children (Walker et al., 2004) on the autism spectrum, infants and toddlers with autism and PDD-NOS show differences that are extensive, relatively stable, and could not be attributed to disparities in the levels of verbal and nonverbal functioning in the second year. In both groups symptoms were expressed in the context of severely delayed verbal and moderately affected nonverbal skills. However, those diagnosed with PDD-NOS tended to have a better developmental outcome at the age of 3 in verbal and nonverbal domains and showed a more rapid rate of verbal skills acquisition. These findings are consistent with reports suggesting that greater attunement to the social world expressed through emerging joint attention and communication skills predicts greater gain in language acquisition in young children with social disabilities (Bono et al., 2004; Mundy, Sigman, & Kasari, 1994; Siller & Sigman, 2002). Moreover, the advantage over autism in cognitive and communicative skills reported in older children with PDD-NOS (e.g., Cohen et al., 1986; Walker et al., 2004) begins to emerge already in the third year of life. More rapid acquisition of verbal and nonverbal skills in the entire sample was associated with a decline in the level of stereotyped behaviors and severity of social and communication symptoms, as well as an increase in the level of play skills over time. While in the present study the direction of this influence is difficult to determine, the relationship between changes in severity of the autistic symptoms and verbal and nonverbal functioning is likely to be complex and moderated by intervention efforts.

*Changes in the syndrome expression between the 2nd and 3rd years.* Changes in symptoms were limited and their pattern was similar in both diagnostic groups. While the overall level of language improved over time, it acquired atypical features such as echolalia and unusual intonation. Emergence of speech was not accompanied by more frequent and spontaneous use of pointing and only a marginal increase in the use of other communicative gestures, which might suggest dissociation between verbal and nonverbal modes of communication in ASD, a finding previously highlighted in preschool-



ers (Carpenter, Pennington, & Rogers, 2002). Interestingly, there was a significant increase in responsiveness to bids for joint attention in both groups; however, it was not accompanied by the acquisition of the ability to initiate joint attention, as seen in typically and developmentally delayed children. It is not clear whether the emergence of responsiveness to bids for attention reflects understanding of the attentional significance of gaze and distal gestures, or is indicative of an instrumental response acquired in the course of treatment.

The other key symptoms remained stable and included: very limited or absent coordination of social-communicative behaviors, eye contact, initiation of joint attention, inability to direct facial expressions to others, and limited response to name. Consistent with a recent report by Charman and colleagues (2005), we did not observe an increase in repetitive behaviors and restricted interests between the 2nd and 3rd years of life. An increase in the frequency and range of these behaviors has not been typically reported until the age of 4 (Charman et al., 2005; Lord, 1995).

*Utility of the ADOS-G and ADI-R for early diagnosis.* The ADOS-G was highly sensitive in classifying autism in the second and third years of life. However, specificity of the autism classification was poor, as almost half of PDD-NOS cases were over-diagnosed as autistic and 22% under-diagnosed as non-ASD, which undermines the idea of differentiating subtypes of ASD based on the existing cut-off scores. Within the ASD spectrum, the ADOS-G tended to under-diagnose children with higher verbal and nonverbal skills. Other reports (Chawarska et al., submitted) suggest that when a range of developmental disabilities is considered, the ADOS-G also tends to over-include severely delayed toddlers in the autism category. Consistent with concerns regarding the validity of the ADI-R diagnostic classification in children with a mental age below 2 years (Cox et al., 1999; Lord, 1995; Rutter et al., 2003), its agreement with the clinical diagnosis was poor. The agreement increased considerably when only ADI-C and ADI-SRI criteria were considered. The latter, however, led to over-inclusion of PDD-NOS cases in the autism category. Unlike the ADOS-G, the ADI-R does not systematically under- or over-classify infants with specific verbal and nonverbal levels. These findings suggest that further examination of the cut-off points of the ADI-R and the ADOS might be warranted to modify these diagnostic instruments for use in younger children (e.g., Cox et al., 1999; Gotham, Risi, & Lord, 2005).

*Comparison of concurrent clinical observation and parent report.* Very few studies to date directly compared the results of diagnostic classification based on the ADOS-G and ADI-R. In school-age children the correlation between algorithm scores

was reported to be moderate and percent agreement after correcting for chance ( $\kappa$ ) was low (de Bildt et al., 2004). This might have resulted from the fact that in school-age children current behaviors (ADOS-G) are usually compared with past behaviors as measured by the ADI-R. Our study afforded a direct comparison between concurrent parental and clinician ratings, revealing, however, very limited overlap. A comparison of the corresponding items on both instruments suggests that while parental ratings were in general congruent on items pertaining to use of 'hand-over-hand', and communicative gestures, parents reported fewer abnormalities in dyadic social skills, such as eye contact, social smiling, and directing facial expressions to others. Parents were also less likely to endorse the presence of unusual preoccupations. These effects extended beyond the influence of the child's level of social-communicative impairment and parental expertise in child development as captured by the child's birth order. While it is plausible that parents might have more opportunities to elicit and observe certain behaviors (e.g., social smile), they may also have difficulties in judging the typicality of such behaviors (e.g., discriminate between a smile elicited by touching or anticipatory routine versus a purely affiliative behavior). Along with other studies (Baird et al., 2000; Stone, Hoffman, Lewis, & Ousley, 1994), the present findings suggest important limitations of parent reporting on key autism-related behaviors in infants. Parents might be more likely to focus on the presence of abnormal behaviors (which are less frequent at this age) or lack of speech, which is non-specific to ASD, but be less sensitized to more subtle impairments in critical areas of social dyadic interaction. It might be necessary to address empirically the reliability of parental reporting on specific classes of infant social and communicative behaviors relevant to the diagnosis of developmental disorders. This line of research would have great practical significance for designing valid and reliable screening questionnaires and diagnostic interviews.

*Limitations.* Current data do not answer the question of the sensitivity and specificity of the diagnostic classification and specific symptoms in infants with ASD due to lack of non-ASD comparison groups. The purpose of this paper, however, was to highlight the behavioral presentation of a relatively large and very young sample with autism and PDD-NOS, as well as to document changes that occur within the one- to two-year period. Also, clinical diagnosis at follow-up was not fully independent of the initial diagnosis; however, only one clinician participated in both assessments and a full consensus between all three participating clinicians was necessary for diagnostic assignment. Rates regarding the stability of the diagnosis are consistent with other reports.

*Clinical significance.* The study provides crucial information regarding the utility of the ADI-R and ADOS-G in diagnosing infants with autism and PDD-NOS. While there is some divergence between clinical diagnosis and ADOS-G classification, the ADOS-G is a more sensitive measure than the ADI-R in this age group. The report identifies specific behaviors that are highly abnormal in a majority of infants with ASD; it also provides information regarding behaviors that are likely to differentiate infants with classic autism from those with PDD-NOS. It maps changes in behavioral symptoms, linking them to verbal and nonverbal developmental gains, and provides information regarding both advantages and limitations of parental reporting on social-communicative deficits in infants.

## Acknowledgements

This study was supported by the NAAR grants and NIMH STAART Grant # U54 MH66494 awarded to Fred Volkmar, Katarzyna Chawarska, Ami Klin, and Rhea Paul. Selected results of this study were presented at the Autism-Europe Conference, Lisbon, 2003 and START/CPEA Network Meeting, Washington, 2004. We would like to thank the children and their parents who participated in the study.

## Correspondence to

Katarzyna Chawarska, Yale Child Study Center, 40 Temple Street, Suite 7I, New Haven, CT 06511, USA; Tel. 203 764-5931; Fax: 203 737-4197; Email: Katarzyna.Chawarska@Yale.edu

## References

- Baird, G., Charman, T., Baron-Cohen, S., Cox, A., Swettenham, J., Wheelwright, S., & Drew, A. (2000). A screening instrument for autism at 18 months of age: A 6-year follow-up study. *Journal of the American Academy of Child and Adolescent Psychiatry*, 39, 694-702.
- Bates, E. (1979). *The emergence of symbols: Cognition and communication in infancy*. New York: Academic Press.
- Bono, M.A., Daley, T., & Sigman, M. (2004). Relations among joint attention, amount of intervention and language gain in autism. *Journal of Autism and Developmental Disorders*, 34, 495-505.
- Carpenter, M., Pennington, B.E., & Rogers, S.J. (2002). Interrelations among social-cognitive skills in young children with autism. *Journal of Autism and Developmental Disorders*, 32, 91-106.
- Chakrabarti, S., & Fombonne, E. (2001). Pervasive developmental disorders in preschool children. *Journal of the American Medical Association*, 285, 3093-3099.
- Chakrabarti, S., & Fombonne, E. (2005). Pervasive developmental disorders in preschool children: Confirmation of high prevalence. *American Journal of Psychiatry*, 126, 1133-1141.
- Charman, T., & Baird, G. (2002). Practitioner review: Diagnosis of autism spectrum disorder in 2- and 3-year-old children. *Journal of Child Psychology and Psychiatry*, 43, 289-305.
- Charman, T., Swettenham, J., Baron-Cohen, S., Cox, A., Baird, G., & Drew, A. (1997). Infants with autism: An investigation of empathy, pretend play, joint attention, and imitation. *Developmental Psychology*, 33, 781-789.
- Charman, T., Taylor, E., Drew, A., Cockerill, H., Brown, J.A., & Baird, G. (2005). Outcome at 7 years of children diagnosed with autism at age 2: Predictive validity of assessments conducted at 2 and 3 years of age and pattern of symptom change over time. *Journal of Child Psychology and Psychiatry*, 46, 500-513.
- Chawarska, K., Klin, A., Paul, R., & Volkmar, F. (submitted). Diagnostic and developmental profiles of 2-year-olds with autism spectrum disorders. *Journal of Autism and Developmental Disorders*.
- Chawarska, K., & Volkmar, F. (2005). Autism in infancy and early childhood. In F. Volkmar, A. Klin, & R. Paul (Eds.), *Handbook of autism and pervasive developmental disorders* (3rd edn). New York: John Wiley & Sons.
- Cohen, D., Paul, R., & Volkmar, F. (1986). Issues in the classification of pervasive and other developmental disorders: Toward DSM-IV. *Journal of American Academy of Child Psychiatry*, 25, 213-220.
- Cox, A., Klein, K., Charman, T., Baird, G., Baron-Cohen, S., Swettenham, J., Drew, A., & Wheelwright, S. (1999). Autism spectrum disorders at 20 and 42 months of age: Stability of clinical and ADI-R diagnosis. *Journal of Child Psychology and Psychiatry*, 40, 719-732.
- de Bildt, A., Sytema, S., Ketelaars, C., Kraijer, D., Mulder, E., Volkmar, F., & Minderaa, R. (2004). Interrelationship between Autism Diagnostic Observation Schedule-Generic (ADOS-G), Autism Diagnostic Interview-Revised (ADI-R), and the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR) classification in children and adolescents with mental retardation. *Journal of Autism and Developmental Disorders*, 34, 129-137.
- Eaves, L.C., & Ho, H.H. (2004). The very early identification of autism: Outcome to age 41/2-5. *Journal of Autism and Developmental Disorders*, 34, 367-378.
- 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, 439-484.
- Gillberg, C., Ehlers, S., Schaumann, H., Jakobsson, G., Dahlgren, S.O., Lindblom, R., BÅgenholm, A., Tjuus, T., & Blidner, E. (1990). Autism under age 3 years: A clinical study of 28 cases referred for autistic symptoms in infancy. *Journal of Child Psychology and Psychiatry*, 31, 921-934.
- Goldberg, W.A., Osann, K., Filipek, P.A., Lualhere, T., Jarvis, K., Modahl, C., Flodman, P., & Spence, M.A. (2003). Language and other regression: Assessment and timing. *Journal of Autism and Developmental Disorders*, 33, 607-616.

- Gotham, K., Risi, S., & Lord, C. (2005). *The Autism Diagnostic Observation Schedule (ADOS): Revised algorithms for improved diagnostic validity*. Talk presented at the International Meeting for Autism Research, Boston, MA.
- Klin, A., Chawarska, K., Rubin, E., & Volkmar, F. (2003). Clinical assessment of young children at risk for autism. In R. DelCarmen-Wiggins, & A. Carter (Eds.), *Handbook of infant and toddler mental health assessment*. New York: Oxford University Press.
- Klin, A., Lang, J., Cicchetti, D.V., & Volkmar, F.R. (2000). Brief report: Interrater reliability of clinical diagnosis and DSM-IV criteria for autistic disorder: Results of the DSM-IV autism field trial. *Journal of Autism and Developmental Disorders*, *30*, 163–167.
- Lord, C. (1995). Follow-up of two-year-olds referred for possible autism. *Journal of Child Psychology and Psychiatry*, *36*, 1365–1382.
- Lord, C., & Risi, S. (2000). Diagnosis of autism spectrum disorders in young children. In A. Wetherby, & B.M. Prizant (Eds.), *Autism spectrum disorders: A transactional developmental perspective. Communication and language intervention series* (vol. 9, pp. 11–30). Baltimore, MD: Paul Brookes Publishing.
- Lord, C., Risi, S., Lambrecht, L., Cook, E.H., Leventhal, B.L., DiLavore, P.C., Pickles, A., & Rutter, M. (2000a). The Autism Diagnostic Observation Schedule–Generic: A standard measure of social and communication deficits associated with the spectrum of autism. *Journal of Autism and Developmental Disorders*, *30*, 205–223.
- Lord, C., Rutter, M., DiLavore, P.C., & Risi, S. (2000b). *Autism Diagnostic Observation Schedule*. Los Angeles, CA: Western Psychological Services.
- Lord, C., Rutter, M., & Le Couteur, A. (1994). Autism Diagnostic Interview–Revised: A revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. *Journal of Autism and Developmental Disorders*, *24*, 659–685.
- Lord, C., Shulman, C., & DiLavore, P. (2004). Regression and word loss in autistic spectrum disorders. *Journal of Child Psychology and Psychiatry*, *45*, 936–955.
- Lord, C., Storoschuk, S., Rutter, M., & Pickles, A. (1993). Using the ADI–R to diagnose autism in preschool children. *Infant Mental Health Journal*, *14*, 234–252.
- Mullen, E. (1995). *Mullen Scales of Early Learning. AGS Edition*. Circle Pines, MN: American Guidance Service, Inc.
- Mundy, P., Sigman, M., & Kasari, C. (1994). Joint attention, developmental level, and symptom presentation in autism. *Development and Psychopathology*, *6*, 389–401.
- Rutter, M., Le Couteur, A., & Lord, C. (2003). *ADI–R: Autism Diagnostic Interview–Revised*. Los Angeles, CA: Western Psychological Services.
- Siller, M., & Sigman, M. (2002). The behaviors of parents of children with autism predict the subsequent development of their children’s communication. *Journal of Autism and Developmental Disorders*, *32*, 77–89.
- Siperstein, R., & Volkmar, F. (2004). Brief report: Parental reporting of regression in children with pervasive developmental disorders. *Journal of Autism and Developmental Disorders*, *34*, 731–734.
- Stone, W.L., Hoffman, E.L., Lewis, S.L., & Ousley, O.Y. (1994). Early recognition of autism: Parental report vs. clinical observation. *American Journal of Diseases of Children*, *148*, 174–179.
- Stone, W.L., Lee, E.B., Ashford, L., Brissie, J., Hepburn, S.L., Coonrod, E.E., & Weiss, B.H. (1999). Can autism be diagnosed accurately in children under 3 years? *Journal of Child Psychology and Psychiatry*, *40*, 219–226.
- Volkmar, F.R., Klin, A., Siegel, B., Szatmari, P., Lord, C., Campbell, M., Freeman, B.J., Cicchetti, D.V., Rutter, M., & Kline, W. (1994). Field trial for autistic disorder in DSM-IV. *American Journal of Psychiatry*, *151*, 1361–1367.
- Volkmar, F.R., Lord, C., Bailey, A., Schultz, R.T., & Klin, A. (2004). Autism and pervasive developmental disorders. *Journal of Child Psychology and Psychiatry*, *45*, 135–170.
- Volkmar, F.R., Stier, D.M., & Cohen, D.J. (1985). Age of recognition of pervasive developmental disorder. *American Journal of Psychiatry*, *142*, 1450–1452.
- Walker, D.R., Thompson, A., Zwaigenbaum, L., Goldberg, J., Bryson, S.E., Mahoney, W.J., Strawbridge, C.P., & Szatmari, P. (2004). Specifying PDD-NOS: A comparison of PDD-NOS, Asperger syndrome, and autism. *Journal of the American Academy of Child and Adolescent Psychiatry*, *43*, 172–180.
- Werner, E., & Dawson, G. (2005). Validation of the phenomenon of autistic regression using home videotapes. *Archives of General Psychiatry*, *62*, 889–895.
- Zwaigenbaum, L., Bryson, S., Rogers, T., Roberts, W., Brian, J., & Szatmari, P. (2005). Behavioral manifestations of autism in the first year of life. *International Journal of Developmental Neuroscience*, *23*, 143–152.

Manuscript accepted 24 July 2006