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Sally Ozonoff, Mikle South and Judith N. Miller

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DSM-IV-defined Asperger syndrome: cognitive, behavioral and early history differentiation from high-functioning autism

SALLY OZONOFF *University of Utah, USA*
MIKLE SOUTH *University of Utah, USA*
JUDITH N. MILLER *University of Utah, USA*

ABSTRACT This study compared 23 children with high-functioning autism with 12 children with Asperger syndrome, both defined according to strict DSM-IV diagnostic criteria. The groups were well matched on chronological age, gender and intellectual ability. Three possible sources of difference between Asperger syndrome and high-functioning autism were examined: cognitive function, current symptomatology and early history. We found few group differences in current presentation and cognitive function, but many early history differences. The Asperger syndrome group generally demonstrated less severe early symptoms, a milder developmental course and better outcome than the high-functioning autism group. Many of the group differences appeared secondary to the initial group definition process, however. Overall, the results suggest that Asperger syndrome and high-functioning autism involve the same fundamental symptomatology, differing only in degree or severity.

ADDRESS *Correspondence should be addressed to:* SALLY OZONOFF, PHD, *Department of Psychology, 390 South 1530 East, Room 502, University of Utah, Salt Lake City, UT 84112-0251, USA*

KEYWORDS *Asperger syndrome; autism; external validity; neuropsychological function*

Introduction

Kanner's (1943) and Asperger's (1944) respective accounts of socially unusual children with narrow interests and repetitive behavior were published only a year apart and coexisted peacefully in the English and German language literatures for approximately 40 years. Recently, however, there has been considerable debate about the relationship between higher-func-

tioning forms of autism and Asperger syndrome. One group points to differences in the initial descriptions of the syndromes that suggest that they may diverge in critical ways, requiring different interventions or leading to different prognoses. This position is well represented by researchers at Yale University, who have studied Asperger syndrome for many years, and have data suggesting that the neuropsychological profiles and behavioral strengths and weaknesses of Asperger syndrome and high-functioning autism differ (Klin et al., 1995). The opposite end of the opinion continuum is perhaps most vocally represented by Schopler (1996; 1998), who has argued that there is little empirical evidence of a distinction between the syndromes and that political issues, including insurance reimbursement and educational classification, suggest that the use of two different labels for essentially the same condition is unwise.

A powerful method of deciding whether two related conditions are truly different is the process of external validation. The most essential component of this process is examining whether the conditions differ on external criteria not involved in the original definition of the syndromes (Fletcher, 1985). Typical means of establishing external validity involve comparison of the conditions' early history, developmental course and outcome, neuropsychological profiles, etiologies and treatment. Distinct syndromes should differ along at least one of these dimensions (Fletcher, 1985; Pennington, 1991). What is essential to external validation is that the dimensions on which the two conditions are compared fall outside the measurement domains used to initially define the syndromes.

An impediment to the external validation process has been the lack of consensus regarding diagnostic criteria for Asperger syndrome. Prior to the publication of the DSM-IV (American Psychiatric Association, 1994), a number of different diagnostic systems for Asperger syndrome had been proposed (Gillberg and Gillberg, 1989; Szatmari et al., 1989b; Tantam, 1988; Wing, 1981). These diagnostic definitions overlapped, but were not identical. Ghaziuddin and colleagues (1992) illustrated this by applying six different systems for diagnosing Asperger syndrome to a high-functioning group of individuals with pervasive developmental disorders, finding that only about half of the participants met all six sets of criteria. The majority of previous studies also did not make clear the criteria for *excluding* a diagnosis of autism in Asperger syndrome subjects and, thus, it was not always clear that the Asperger and autism groups defined were mutually exclusive and non-overlapping. Thus, it has been quite difficult to use the results of early studies to evaluate the external validity of Asperger syndrome. With the advent of the DSM-IV in 1994, however, a set of clear, standardized diagnostic criteria for Asperger syndrome has become available. Some problems with the DSM-IV definition of Asperger syndrome have been

pointed out, including the possibilities that the criteria may be underinclusive, underestimating the prevalence of Asperger syndrome, and may not capture the spirit of Asperger's original description of the condition (Eisenmajer et al., 1996; Miller and Ozonoff, 1997; Szatmari et al., 1995). While they may not be perfect, however, the DSM-IV criteria for Asperger syndrome are certainly standardized and provide clear inclusion and exclusion criteria. In the present study, we used strict DSM-IV definitions of Autistic disorder and Asperger syndrome in the group assignment process. We then compared the groups on a number of dimensions potentially informative to the external validation process, including early history, current behavior and presentation, and cognitive functioning. In the cognitive domain, three specific areas of function were examined – intellectual, executive and language – to see if any differentiated the two groups. The intellectual domain was chosen to permit a test of the hypothesis that Asperger syndrome is simply 'high-IQ autism' (Szatmari et al., 1995, p. 1667). The executive function domain was chosen because it is clearly independent of the original diagnostic process and thus relevant to external validation. Finally, the language domain was chosen because it has yielded the most robust differences between Asperger syndrome and high-functioning autism in past studies (Klin et al., 1995; Szatmari et al., 1995).

Method

Participants

Entire PDD sample Thirty-nine non-retarded children previously diagnosed with some form of PDD were recruited through the Autism Society of Utah, local clinics serving individuals with PDD, and the statewide autism conference. Participants ranged in age from 6 years 6 months to 20 years 9 months (mean = 13.5 years, SD = 4.0 years). Three were members of ethnic minority groups (two Asian-American and one Hispanic-American) and five were female. All demonstrated IQ scores in the average range or above (full scale IQ $>$ 85). The sample was in fact quite high-functioning for the PDD spectrum, with a group mean full scale IQ of 111 (SD = 15.0).

The PDD sample was then split into the two groups of primary interest to the study (high-functioning autism and Asperger syndrome) by an evaluator blind to performance on the dependent measures, in the following manner. Employing DSM-IV procedure (the so-called precedence rule), the diagnosis of Autistic disorder was considered first. Using information collected through parent interview (the Autism Diagnostic Interview–Revised) and direct observation and testing (the Autism Diagnostic

Observation Schedule–Generic), it was determined which of the 12 DSM-IV symptoms the participant demonstrated. To meet criteria for Autistic disorder, individuals had to demonstrate at least six symptoms from the list of 12, two of which had to fall in the social relatedness domain and one each in the communication and restricted behaviors/interests domains respectively. Difficulties in at least one domain had to be documented as present prior to age 3. Additionally, participants had to function intellectually above the retarded range (FSIQ $>$ 70). If all of these criteria were met, the participant was assigned to the high-functioning autism group. Only if any criterion was not met was the diagnosis of Asperger syndrome considered. Assignment to the Asperger group was made if the participant did not meet DSM-IV criteria for Autistic disorder, demonstrated at least two DSM-IV symptoms in the social domain and at least one in the repetitive behaviors/restricted interests domain, had a history of 'normal' language acquisition (defined in DSM-IV as single words by age 2 and phrase speech by age 3), and was functioning intellectually and adaptively in the non-retarded range. If Asperger syndrome criteria were not met either, but the individual evidenced social, communication and/or repetitive symptoms characteristic of an autism spectrum disorder, a diagnosis of pervasive developmental disorder not otherwise specified (PDDNOS) was given. Twenty-three individuals (two female) were assigned to the high-functioning autism group, 12 to the Asperger syndrome group (two female), and four to the PDDNOS group (one female). Since the size of the third group was too small to permit valid statistical comparisons and since the primary objective of the study was to examine differences between high-functioning autism and Asperger syndrome, the four PDDNOS individuals were excluded from the remainder of the study and analyses. The high-functioning autism and Asperger groups were matched on chronological age (high-functioning autism mean age = 13.3 years, SD = 3.9; Asperger syndrome mean age = 13.9 years, SD = 4.5).

Control sample Twenty-seven individuals without developmental problems were recruited from an existing research database maintained by our laboratory. Participants were screened for symptoms of autism, learning disorders, attention problems, and several other neurodevelopmental conditions (e.g. Tourette syndrome, obsessive-compulsive disorder) through interview and screening measures, as described in previous papers (Ozonoff and Jensen, 1999; Ozonoff et al., 1998). The control sample ranged in chronological age from 7 years 3 months to 18 years 7 months (mean = 12.5 years, SD = 3.2) and all participants demonstrated intellectual function in at least the average range. There were no statistically significant differences between the control group and the Asperger syndrome

and high-functioning autism samples in chronological age or intellectual ability (VIQ, PIQ or FSIQ).

Measures

Autism Diagnostic Interview–Revised (ADI–R: Lord et al., 1994) This parent report measure collects information about behaviors relevant to the diagnosis of pervasive developmental disorders. It contains three scales that correspond with the three DSM-IV symptom categories of social interaction, communication and repetitive/stereotyped behavior impairments. Each scale contains detailed questions about both current functioning and early development. Responses are coded on a four-point scale according to the quality and severity of symptoms (0 = normal for developmental level, 3 = severely autistic). Scores in each of the three domains are summed according to a research-derived algorithm that distinguishes autistic from non-autistic cases. Separate summary scores for current behavior and behavior during the 4- to 5-year age period are obtained. The ADI–R has excellent reliability and validity when used by trained examiners (Lord et al., 1994).

Autism Diagnostic Observation Schedule–Generic (ADOS–G: Lord et al., 1998) The ADOS–G is a standardized interview and observational assessment that provides a number of opportunities for interaction (e.g. play, conversation, telling a story etc.) and measures social and communicative behaviors diagnostic of pervasive developmental disorders. Designed by the same team that created the ADI–R, the ADOS–G supplements the information gained in the parent interview. It taps the same domains as the ADI–R, providing opportunities for the examiner to observe behaviors reported by parents in the interview. Four modules of the ADOS–G, with four slightly different task batteries, have been designed for different functioning levels; modules 3 and 4, developed for individuals with fluent language (children versus adolescents and adults, respectively), were used in the present study. A benefit of the ADOS–G is its explicit presentation of opportunities to demonstrate symptoms. Multiple 'presses' for the social and communicative behaviors seen in typically developing individuals are provided. If, after multiple opportunities, these behaviors have not been either spontaneously displayed or elicited, evidence of an autism spectrum disorder is strong. Like the ADI–R, algorithm scores for social interaction, communication, stereotyped behavior and imagination are obtained. The ADOS–G's predecessor, the ADOS, demonstrated good reliability and validity when used by trained examiners and differentiates well between autistic and non-autistic individuals with developmental disabilities (Lord et al., 1989).

Wechsler Intelligence Scale for Children–Third Edition (WISC–III) This widely used intelligence test is appropriate for individuals aged 6 years 0 months to 17 years 11 months (individuals 18 and older were administered the Wechsler Adult Intelligence Scale–Third Edition, which mirrors the WISC–III in most respects). It comprises a verbal scale and a performance (non-verbal) scale which each contain five different subtests that are summed to provide an intelligence quotient (VIQ and PIQ, respectively). The digit span subtest, a supplementary subtest not included in the scale totals, was also administered in this study.

Clinical Evaluation of Language Fundamentals–Third Edition (CELF–III: Semel et al., 1995) This test measures language skills in children and adolescents. Six subtests which assess abilities in specific language content and form are summarized in two indices, a receptive language score and an expressive language score. The CELF–III is well standardized with excellent reliability and has been used extensively in both research and clinical practice with autistic populations.

Cambridge Neuropsychological Test Automated Battery (CANTAB: Robbins et al., 1994) Two subtests from this computerized battery were used, the intradimensional/extradimensional shift task (ID/ED) and the Stockings of Cambridge/Tower of London task. Directions are clearly presented, participants are given multiple training trials to learn the requirements of each task, and responses are recorded directly with a touch-sensitive screen, making these tasks applicable for a wide range of functioning levels. CANTAB has been used successfully with humans of all ages (4–90+ years), including both low- and high-functioning autistic individuals (Hughes et al., 1994; Turner, 1997), as well as with non-human primates.

The ID/ED task measures the ability to attend to specific attributes of compound stimuli, shifting attention from one attribute to another when required. Participants are presented with a series of multidimensional stimuli consisting of shapes and lines. Through trial and error, they learn to respond selectively to one of the attributes (e.g. a shape). They go through a number of stages (nine in all), each with different stimuli, but for the first seven stages they apply the same rule (e.g. respond to the same dimension, the shape) for all stimuli. The attentional shifts in stages 1 through 7 are considered intradimensional, and are not thought to be primary measures of flexibility, since participants need only maintain focus on the same dimension of each stimulus to perform successfully. At stage 8, during the critical extradimensional shift, however, the correct rule now changes to the other dimension (e.g. the line) that has been irrelevant for

the preceding dozens of trials. Errors committed at the ED shift and the highest stage passed (e.g. whether the participant successfully reaches and completes stage 8, the ED shift) are considered the most sensitive indices of cognitive flexibility on the task.

CANTAB's Stockings of Cambridge task is a computerized version of the traditional Tower of London test thought to measure planning efficiency and working memory capacity. Participants are asked to move colored balls between three piles to match a configuration shown on the computer screen, following several specific rules. This task forces participants to plan several moves ahead, anticipate potential consequences of each move, and hold this information in working memory. The key variable is the number of items the participant passes in the minimum number of moves. Tower tasks (the Tower of London and the Tower of Hanoi) have been used frequently with autistic samples and all studies report large performance deficits relative to control groups (reviewed in Pennington and Ozonoff, 1996).

Social Skills Rating System (SSRS: Gresham and Elliott, 1990) This parent-report instrument provides a broad assessment of social behavior. Parents estimate the frequency with which a variety of specific social skills are displayed, including: demonstrating interest in others, initiating conversations, inviting peers to the home, joining group activities and waiting turns in games. Raw scores are converted to standard scores ($M = 100$, $SD = 15$) on the basis of age and gender, using national norms. The SSRS demonstrates good reliability and validity (Gresham and Elliott, 1990).

Repetitive Behavior Questionnaire (Turner, 1997) This parent-report questionnaire measures the presence, frequency and duration of repetitive behavior and has been used with both autistic and non-autistic samples. Questions regarding 11 topographical classes of repetitive behavior are summarized into four categories: repetitive movements (including both motor mannerisms and stereotyped use of objects), sameness behavior (e.g. insistence on sameness in the environment and routines, obsessional attachments to objects and hoarding), repetitive use of language (e.g. echolalia, stereotyped phrases and vocal tics), and circumscribed interests (intense focus on narrow and/or unusual topics). Using this measure, Turner (1997) found that 98 percent of both low- and high-functioning individuals with autism demonstrated at least one category of repetitive behavior, as compared to only 17 percent of sex-, age-, and IQ-matched developmentally disabled controls.

School Interventions Checklist Parents were asked to list, for every year

their child had been enrolled in school, what specific special education services they had received and the number of hours per day these services were provided. Number of years in special education was then calculated. A strict definition of special education was used: essentially, *any* educational assistance received under an Individualized Education Plan (IEP) was considered special education. Even if, for example, a child received the majority of his programming in the regular classroom environment, but had an aide assist him with schoolwork one hour a day, or went to the resource room weekly, he was counted as receiving special education services. Calculation of the 'grade mainstreamed' variable also used this strict definition of special education. The highest grade at which the child permanently stopped receiving any extra educational assistance was defined as the grade mainstreamed.

Procedure

All participants were tested at the Psychology Department of the University of Utah. Informed consent was obtained from both parents and participants before beginning the testing. Complete participation required one 3 hour testing session. The measures were administered in a consistent order: Tower of London, ID/ED, CELF–III, WISC–III or WAIS–III, ADOS–G. Two graduate students conducted the testing. One was responsible for collecting the diagnostic information (e.g. ADI–R and ADOS–G), while the other tested the child on the cognitive measures. No data were shared between the research assistants and, therefore, both diagnostic assignment and cognitive assessment were conducted blind to potentially biasing information. Participants were paid $5.00 an hour for participating.

Results

Table 1 summarizes group performance on all dependent measures of the study.

Cognitive function

The following analyses of cognitive function compared all three groups (Asperger syndrome, high-functioning autism, control).

Intellectual function The three groups were matched on full scale IQ. Additionally, the Asperger and high-functioning autism groups did not differ statistically from either the control group or each other on verbal or performance IQ. There were, however, group differences in Wechsler subtest profiles. Both the high-functioning autism and Asperger syndrome groups performed significantly less well than the control group on the

Table 1 **Group differences on cognitive, behavioral and early history variables**

Measure	*Control (C)*	*High-functioning autism (HFA)*	*Asperger syndrome (AS)*	*Group differences*
Cognitive variables				
WISC–III VIQ	109.9 (11.0)	110.9 (16.6)	120.0 (17.8)	None
WISC–III PIQ	110.6 (13.1)	104.1 (15.1)	107.8 (20.7)	None
WISC–III FSIQ	111.0 (10.6)	108.9 (13.8)	115.6 (15.6)	None
VIQ–PIQ discrepancy	−0.7 (14.1)	6.8 (19.7)	12.2 (26.5)	AS>C
Picture completion	11.8 (2.5)	12.3 (2.8)	10.9 (3.5)	None
Information	11.9 (2.4)	13.1 (3.1)	14.6 (2.8)	AS>C
Coding	10.0 (3.1)	7.1 (3.3)	7.7 (3.2)	C>HFA=AS
Similarities	12.5 (2.9)	13.0 (2.5)	13.0 (3.7)	None
Picture arrangement	11.0 (2.5)	11.1 (3.5)	9.9 (3.6)	None
Arithmetic	10.8 (2.6)	10.9 (4.3)	12.9 (3.3)	None
Block design	12.6 (3.3)	11.9 (4.5)	13.3 (3.7)	None
Vocabulary	11.7 (1.9)	12.1 (3.8)	14.3 (4.8)	None
Object assembly	12.3 (3.3)	10.8 (3.1)	11.6 (5.0)	None
Comprehension	11.3 (2.7)	9.6 (3.8)	13.2 (3.5)	AS>HFA
Digit span	11.1 (2.6)	10.1 (3.3)	11.0 (2.2)	None
ID/ED stages reached	8.6 (0.8)	8.3 (0.9)	8.0 (1.0)	C>AS
ID/ED errors at ED shift	9.9 (9.3)	12.0 (11.5)	17.5 (13.1)	C>AS
ID/ED errors up to shift	7.9 (2.7)	7.6 (4.5)	8.8 (3.7)	None
Tower of London	7.2 (1.5)	7.5 (1.8)	7.7 (2.3)	None
CELF–III expressive	105.8 (10.5)	95.3 (15.2)	106.8 (11.2)	C=AS>HFA
CELF–III receptive	107.9 (11.2)	104.0 (19.1)	109.1 (17.3)	None
Current presentation variables				
ADI–R (current) social		10.3 (5.3)	9.7 (4.1)	None
ADI–R (current) communication		9.0 (4.0)	8.3 (4.6)	None
ADI–R (current) repetitive behaviors		4.6 (2.2)	3.8 (2.1)	None
ADOS–G social		7.8 (2.8)	6.3 (1.9)	None
ADOS–G communication		4.0 (1.4)	3.3 (1.4)	None
ADOS–G repetitive behaviors		2.2 (1.8)	1.3 (1.4)	None
ADOS–G imagination deficits		1.0 (0.7)	0.5 (0.5)	HFA>AS
Social Skills Rating System (SSRS)		78.0 (12.9)	85.2 (12.5)	None
Repetitive movements		5.1 (4.9)	3.4 (3.7)	None
Insistence on sameness		6.2 (4.3)	2.5 (4.2)	HFA>AS
Repetitive language		2.4 (1.8)	1.8 (2.4)	None
Circumscribed interests		1.1 (0.5)	2.8 (3.1)	AS>HFA
Historical variables				
ADI–R (age 4–5) social		19.9 (4.3)	13.7 (5.1)	HFA>AS
ADI–R (age 4–5) communication		16.7 (3.7)	11.4 (4.9)	HFA>AS
ADI–R (age 4–5) repetitive behavior		7.3 (2.2)	5.3 (3.0)	HFA>AS
ADI–R age at first single words		22.9 (12.6)	16.5 (5.4)	HFA>AS
ADI–R age at phrase speech		28.9 (15.8)	24.5 (7.1)	None
Number of DSM-IV symptoms		8.9 (1.7)	4.8 (0.5)	HFA>A
Years in special education		5.9 (4.2)	1.5 (1.5)	HFA>AS
Grade fully mainstreamed		6.9 (5.3)	3.3 (3.8)	HFA>AS

Note:
HFA = high-functioning autism group.
AS = Asperger syndrome group.
C = control group.

coding subtest (high-functioning autism, $t(47) = -3.17$, $p < 0.01$; Asperger syndrome, $t(35) = -2.01$, $p < 0.05$); the performance of the two PDD groups did not differ from each other. The Asperger group significantly outperformed the autistic group on the comprehension subtest ($t(32) = 2.62$, $p < 0.05$) and the control group on the information subtest ($t(35) = 2.98$, $p < 0.01$). As has been previously reported, block design was a relative strength for both the autism and Asperger groups; contrary to popular lore and some empirical work (Dennis et al., 1999; Lincoln et al., 1995), it was not, however, the strongest performance for either group. As can be seen in Table 1, performance on the information subtest was, on the average, higher than that on block design for both the high-functioning autistic and Asperger groups. Only 5 of 23 high-functioning autism participants (22 percent) and 3 of 12 Asperger syndrome participants (25 percent) demonstrated block design as their highest score. Comprehension was a relative weakness for the high-functioning autism group, but again did not fit the typical pattern reported in the literature as the lowest in the profile (Lincoln et al., 1995), coding performance being even worse. Only 5 of 23 high-functioning autistic individuals (22 percent) demonstrated their poorest performance on the comprehension subtest and none of the Asperger group evidenced this pattern. As can be seen in Table 1, the autism group's mean score on the comprehension subtest still falls well within the normal range. Those with Asperger syndrome evidenced little difficulty on the comprehension subtest and in fact demonstrated one of their strongest performances on this subscale.

The difference between verbal and performance IQ was also examined in the three groups. A significant discrepancy was defined as 12 points or more between VIQ and PIQ (Sattler, 1992). Twenty-six percent of controls, 35 percent of the high-functioning autism group, and 50 percent of the Asperger syndrome group demonstrated significantly higher VIQ than PIQ scores, while 30, 17, and 8 percent, respectively, displayed the opposite pattern (PIQ > VIQ). The group differences in proportions evidencing each profile were not statistically significant. The Asperger group demonstrated a significantly larger VIQ–PIQ discrepancy than the control group ($t(37) = 1.97$, $p < 0.05$). The size of the verbal–performance discrepancy did not differ statistically in the autism and Asperger samples.

Executive function Asperger participants demonstrated significant deficits relative to controls in both number of ID/ED stages completed ($t(37) = -2.08$, $p < 0.05$) and number of errors committed at the ED shift ($t(37) = -2.07$, $p < 0.05$). The high-functioning autism group's performance fell between that of the Asperger syndrome group and the control group. There were no significant differences between the Asperger

syndrome and high-functioning autism groups, or between the high-functioning autism and control groups, on any executive function variable.

In contrast to the impairment that individuals with Asperger syndrome demonstrated on the flexibility variables, relative to normally developing individuals, there was no group difference on the ID/ED 'control' variable not considered to measure flexibility, the number of errors committed prior to the ED shift. Similarly, there was no significant difference in the performance of the high-functioning autism, Asperger syndrome or typically developing control groups on the CANTAB Tower of London task.

Language A significant group difference on the expressive language scale of the CELF–III was evident ($F(2, 63) = 5.49, p < 0.01$). Contrasts exploring the source of this effect found it due to poorer performance by the high-functioning autism group, relative to both the Asperger syndrome group ($t(33) = -2.31, p < 0.05$) and the control group ($t(50) = -2.93, p < 0.01$). There were no group differences on the receptive language scale of the CELF–III.

Current behavior and clinical presentation

The following analyses of current symptomatology and behavioral difficulties were conducted on the Asperger syndrome and high-functioning autism groups only, as the variables were largely irrelevant to the control group. See Table 1 for group scores on the following measures.

Diagnostic symptoms The high-functioning autism and Asperger syndrome groups did not differ on any ADI–R algorithm summary variable (reciprocal social interaction, communication or repetitive behaviors/stereotyped patterns) rated based on the parent's report of the participant's *current* behavior. Similarly, there were no significant differences between the high-functioning autism and Asperger groups on the ADOS–G reciprocal social interaction, communication or stereotyped behavior summary scores. The Asperger syndrome group did demonstrate significantly fewer deficits on the ADOS–G imagination/creativity scale than the high-functioning autism group ($t(33) = 2.35, p < 0.05$).

Social skills There were no differences between the Asperger and autism groups on parent SSRS ratings of current social skills.

Repetitive behavior The two PDD groups differed significantly in the type and severity of repetitive behaviors they displayed. The Asperger syndrome group demonstrated significantly more circumscribed interests than the high-functioning autism group ($t(31) = 2.48, p < 0.05$). The high-functioning autism group demonstrated significantly more sameness behav-

ior than the Asperger sample ($t(31) = 2.38, p < 0.05$). Asperger and autistic participants did not differ on the two other subscales of the Repetitive Behaviors Questionnaire, repetitive movements and repetitive language.

Early history and course

Analyses of historical information and lifetime symptomatology were again conducted on the Asperger syndrome and high-functioning autism groups only, as the variables were not relevant to the controls. See Table 1 for group scores.

Diagnostic symptoms The PDD groups differed significantly on most early history variables. The Asperger syndrome group demonstrated significantly lower scores than the high-functioning autism group on the ADI–R algorithm summary scores (rated at the 4–5 year period) for reciprocal social interaction ($t(33) = 3.78, p < 0.01$), communication ($t(33) = 3.59, p < 0.01$), and repetitive behaviors/stereotyped patterns ($t(33) = 2.17, p < 0.05$). In addition, they developed the use of single-word speech at a significantly younger age than the high-functioning autism group ($t(33) = 2.46, p < 0.05$). There was no significant difference in the age at which phrase speech was acquired, however (see Table 1).

The Asperger syndrome group also demonstrated significantly fewer DSM-IV symptoms than the high-functioning autism group ($t(33) = 8.13, p < 0.001$). Chi-square analyses indicated that the high-functioning autism group was significantly more likely than the Asperger group to display the following DSM-IV symptoms: delay in the development of spoken language (2a: $\chi^2(1, 35) = 5.41, p < 0.05$), impaired reciprocal conversation (2b: $\chi^2(1, 35) = 6.29, p < 0.05$), stereotyped, repetitive or idiosyncratic language (2c: $\chi^2(1, 35) = 13.44, p < 0.001$), limited make-believe or social imitative play (2d: $\chi^2(1, 35) = 16.03, p < 0.001$), non-functional routines and rituals (3b: $\chi^2(1, 35) = 15.54, p < 0.001$), and persistent preoccupation with parts of objects (3d: $\chi^2(1, 35) = 12.17, p < 0.001$).

Educational history The autism and Asperger groups were well matched on both chronological age and number of years in school. Therefore, they could be compared directly on the number of years receiving special education assistance in school. The high-functioning autism group spent significantly more years in special education than the Asperger syndrome group ($t(29) = 3.27, p < 0.01$). The grade in which the child was fully mainstreamed and received no further special education services of any kind was also significantly higher in the autistic than the Asperger group ($t(29) = 2.01, p < 0.05$). Finally, the proportion of the autistic group who had always received special education assistance and had never been main-

streamed was significantly higher than in the Asperger syndrome group (χ^2 (1, 35) = 5.11, $p < 0.05$).

Discussion

This study examined three possible sources of difference between Asperger syndrome and high-functioning autism: cognitive function, current symptomatology and early history. We found few group differences in current presentation and cognitive function, but many early history differences, a pattern very similar to that recently obtained by Eisenmajer and colleagues (1998). The only two cognitive tests differentiating the groups, the comprehension subtest of the WISC–III and the expressive scale of the CELF–III, were language-based and were in favor of the Asperger sample. Both of these differences may be secondary to the original group definition process. One of the critical variables used in group assignment was the child's early development of language, with a normal course (defined as single-word use by 24 months and phrase speech by 36 months) necessary for a diagnosis of Asperger syndrome. Since the groups were defined at least partially on the basis of language skills, it is not surprising that statistically significant differences emerged on tests of language function. What is perhaps more noteworthy is the lack of group differences on all other measures of current language function. There were no Asperger–autism differences evident on the CELF receptive scale, nor were there any on five of six Wechsler verbal scale subtests. Thus, most Asperger–autism language differences apparent in the preschool years had disappeared by the time of the study, when the participants were, on average, in their early to mid teens.

Performance of the two groups in the executive function domain is perhaps most informative to the questions addressed by this study, since it is the most clearly distinct from the original diagnostic process. We found no Asperger–autism differences on two measures of flexibility and planning, replicating earlier studies (Ozonoff et al., 1991; Szatmari et al., 1990) and failing to support the case for external validity. It was somewhat surprising that the autism group also showed no executive deficits relative to typically developing controls, given the robust previous literature on executive function impairment in autism (see Pennington and Ozonoff, 1996, for a review). One potential explanation for this failure to replicate earlier research is the computerized format in which the executive function tasks used in this study were administered. It has been suggested that computer administration attenuates or eliminates deficits that would ordinarily be apparent on cognitive tests in people with autism (Ozonoff, in press). Empirical support for this 'computer facilitation' hypothesis has

been demonstrated with the Wisconsin Card Sorting Test; when it was administered in the standard fashion, by humans, group differences were robust, but when it was administered by computer, group differences were much reduced (Ozonoff, 1995). Similar patterns were found by Pascualvaca and colleagues (1998) using the traditional (human-administered) Wisconsin Card Sort and a computerized matching task devised by the authors. One other study has also failed to find differences between high-functioning autistic individuals and normal controls on the ID/ED task (Turner, 1997).

In the analyses of current behavior and presentation, a few additional differences between the Asperger and high-functioning autism groups emerged. Those with Asperger syndrome demonstrated better imaginative play and creative abilities than those with high-functioning autism. The Repetitive Behavior Questionnaire (Turner, 1997) permitted a more differentiated analysis of the domain of stereotyped behavior than previously possible with other measures; a more fine-grained analysis of this domain pointed out two additional differences between the PDD subgroups. By parent report, the Asperger syndrome sample displayed more circumscribed interests than those with high-functioning autism, who for their part demonstrated greater insistence on sameness than the Asperger participants. In general, however, the current presentation domain was remarkable for its limited ability to differentiate Asperger syndrome from high-functioning autism. The groups did not differ on multiple other parent-report and observer-rated measures of communication, social skills or repetitive behavior.

Clear differences between Asperger and high-functioning autistic participants emerged on historical variables, however. Parent reports of early language development, behavior in the preschool years, DSM-IV lifetime symptomatology, and use of special education services all demonstrated more impairment in the high-functioning autism than the Asperger group. Thus, there is some evidence that the developmental course of the two conditions differs, with high-functioning autism starting off more severe. What is not quite as clear is whether this difference provides any source of external validation for the Asperger syndrome diagnosis. One critical qualification for assignment to the Asperger syndrome group is that the diagnostic criteria for Autistic disorder not be met. There are two primary ways in which a PDD child can fail to meet autism criteria, yet still qualify for Asperger criteria: he or she can demonstrate a subthreshold number of symptoms (e.g. fewer than six) or can have onset of symptoms after age 3. In this study, all Asperger participants failed to meet autism criteria because they demonstrated fewer than six DSM-IV symptoms. Thus, it is expected that the number of DSM-IV symptoms displayed by the Asperger group

should be lower than that displayed by the high-functioning autistic group; for the same reason, it is also not surprising that ADI–R algorithm scores were higher in the autistic group. The differences in the use of special education are less clearly secondary to the initial group definition process, however, and thus may provide some valid differentiation of the two PDD subtypes. In fact, one important method of external validation of a syndrome is demonstrating that it requires different interventions or benefits differentially from the same intervention than other syndromes; this may be the case for Asperger syndrome.

The group differences we found in current language function, repetitive behavior, imagination and special education utilization suggest that the prognosis for Asperger syndrome may be better than that for high-functioning autism. Conversely, the fact that clear preschool-age differences between the two groups had largely disappeared by adolescence indicate that the high-functioning autistic group has actually caught up rather well and may have a better prognosis than earlier studies indicated (Gillberg, 1991; Szatmari et al., 1989a).

It remains to be seen whether the magnitude and type of group differences found in the current study are sufficient to provide external validation for the Asperger syndrome label. Our findings of very similar cognitive profiles and current behavioral presentations suggest that Asperger syndrome is on the same spectrum as other autistic syndromes and differs primarily in degree of impairment (see also Prior et al., 1998). If so, separate labels for the conditions may be confusing to policymakers, treatment providers and parents alike (Schopler, 1996). Future research should continue to explore and clarify syndromic differences, however, focusing particularly on dimensions independent of the diagnostic definition process. The group differences in imagination and repetitive behavior found in this study merit further exploration and may perhaps provide some evidence of external validity for the Asperger syndrome label in the future, if replicated. It is just as dangerous, and just as poor science, to prematurely discard the Asperger syndrome label as it is to unequivocally endorse it before all the data are in.

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