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Predictors of outcome among high functioning children with autism and Asperger syndrome

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Background: The objective of this paper is to assess the extent to which measures of cognitive abilities taken in an inception cohort of young high functioning children with autism and Asperger syndrome predict outcome roughly two and six years later. **Method:** Children who received a diagnosis of autism or Asperger syndrome (AS) and who had a nonverbal IQ score in the 'non-retarded' range were included in the inception cohort. Measures of language and nonverbal skills were taken when the children were 4–6 years of age and outcome assessments were completed when the children were 6–8 and 10–13 years of age. The three outcome measures consisted of scales of adaptive behaviours in socialisation and communication and a composite measure of autistic symptoms (abnormal language, abnormal body and object use, difficulties relating to others, sensory issues and social and self-help difficulties). **Results:** The explanatory power of the predictor variables was greater for communication and social skills than for autistic symptoms. The power of prediction was stable over time but did differ by PDD subtype. In general, the association between language skills and outcome was stronger in the autism group than in the AS group. **Conclusions:** These results support the emphasis of early intervention programmes on language but more work needs to be done on understanding variables that influence outcome in social skills and autistic behaviours, particularly in those with AS. **Keywords:** Autism, Asperger syndrome, longitudinal studies, trajectory, outcome, prognosis. **Abbreviations:** PDD: pervasive developmental disorder.

The long-term outcome of autism is generally well known; the impairments appear to extend into adulthood although there are improvements in autistic behaviours and an increase in social and communication skills over time (Howlin & Goode, 1998; Nordin & Gillberg, 1998). The two variables consistently identified as early predictors of outcome are IQ and language (Lotter, 1974a, b; Gillberg & Steffenburg, 1987). Children with higher IQ and those who have developed functional, spontaneous, language prior to six years of age have a better outcome than children without these factors. A key methodologic issue with these studies is that most lack an inception cohort (i.e., the children with autism were not sampled at the same early stage of the disorder). Unless the group is assembled within a very short period after the onset of disorder, it is possible that those with rapid improvement or deterioration would not be included (Sackett, Richardson, Rosenberg, & Haynes, 1998). This systematic sample loss will bias outcome results, and will also influence the ability of predictor variables to explain variance in outcome. A second important issue is that, in many studies, the outcome assessments were not conducted blind to the assessment of prognostic variables; this could influence the association between the predictor and outcome variables either way, depending on the direction of bias.

Moreover, there are several important issues that have not been systematically evaluated in this literature. First, most studies were conducted with lower functioning children with autism so that the extent to which the results are generalisable to higher functioning children with autism or to those with other forms of Pervasive Developmental Disorder (PDD) is unknown. In particular, there are no data, that we are aware of, that report on the predictive ability of IQ and language in children with Asperger syndrome (AS; Wing, 1981) or Asperger disorder (APA, 1994). This type of PDD is characterised by impairments in social reciprocity, similar in kind but less severe than autism, fluent but pragmatically impaired communication, and unusual interests and preoccupations. The key distinguishing features that discriminate AS from autism are that in the former disorder there is an absence of 'clinically significant' cognitive and language delay, even though children with AS have many autistic symptoms (APA, 1994). We have shown that preschool children with AS have a better 2-year outcome than children with autism (Szatmari et al., 2000) but we do not know if language and IQ are important predictor variables for this group as well. Neither do we know whether the differences on outcome are maintained. In view of the better language abilities in AS, it is not clear that this variable would be as effective in predicting outcome as it is in autism. Without relevant data such as these, clinicians have been forced to rely on outcome and prognostic studies of lower functioning children with autism to

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provide information on children with AS. Second, it is not clear that language and IQ predict *several* outcome domains separately (such as autistic symptoms and social and communication skills). There is some evidence (Szatmari et al., in press, 2002) that adaptive behaviour (defined as the achievement of developmentally appropriate milestones in socialisation and communication skills and in activities of daily living) and autistic symptoms (lack of eye contact, echolalia, rituals, stereotypes etc.) represent two relatively independent dimensions in PDD. It is important to see if the hypothesised predictor variables explain a significant amount of variance in several different outcome domains, including attainment of skills independent of autistic symptoms. Third, it is unclear whether the predictive ability of language and IQ is stable over time (i.e., are these variables associated with outcome at several points in development or are they relevant only in the short term?). Fourth, it is not known whether language and IQ are *independent* predictors of outcome; children who are verbal also tend to have higher IQs so the prognostic ability of one variable may be entirely accounted for by variation in the other. Due to the overlap in measures, it is probably more relevant to ask whether verbal and nonverbal cognitive abilities (the two main components of IQ tests) independently predict outcome.

The objective of this study is to assess the extent to which measures of nonverbal and language skills taken in an inception cohort of young high functioning children with autism and AS predict outcome two and six years later. We were interested in seeing whether the predictors were independently associated with multiple outcomes, whether predictive ability was stable over time, and whether AS and autism were associated with the same predictor variables. The study was designed using an inception cohort and the outcome variables were assessed blind to predictor variables.

Method

Subjects

Full details of subject recruitment are available in previous publications (Szatmari, Archer, Fisman, & Streiner, 1995; Szatmari et al., 2000). Briefly, all children, 4–6 years of age, either coming for assessment, or currently in treatment, at a 'PDD service' in six different centres that serve preschool children with developmental disabilities in southern Ontario were identified. This was done to ensure that subjects from non-university centres were also included. Children who received a diagnosis of autism or AS using data from the original Autism Diagnostic Interview (Le Couteur et al., 1989; ADI-1988 version), and who had either a Leiter IQ (Levine, 1986) above 68 or a Stanford–Binet (Thorndike, Hagn, & Sutton, 1985) IQ above 70 were included in the final sample and represent the inception cohort. During the enrolment phase, 164 children, 4–6 years of age, were screened at one of the centres. Of these, 80 children were excluded because either they did not have a PDD, non-compliance precluded valid psychometric testing, or previous testing revealed that they were functioning below the IQ criterion. The remaining 84 children with PDD underwent a full psychometric battery. A further 16 were excluded because their IQ on both the Leiter Scales and the revised Stanford–Binet was below the IQ cut-off for mental retardation (68 and 70, respectively). Thus, the size of the study group at enrolment was 68 higher-functioning preschool children with PDD.

Although this group was assembled well before DSM-IV was published, virtually the same differentiating criteria were used to distinguish AS and autism. Children with AS were identified on the basis of an absence of clinically significant language delay (the sampling frame stipulated that both groups would have an absence of clinically significant cognitive delay). The variable 'absence of language delay' was operationalised using data from the ADI to include spontaneous phrase speech by 36 months of age and an absence of marked or persistent delayed echolalia, pronoun reversal and neologisms (as coded as '2' or '3' on these items from the ADI). However, unlike DSM-IV, we decided that a diagnosis of AS could take precedence over a diagnosis of autism. DSM-IV states that a child with AS who also meets criteria for autism should be given a diagnosis of autism. (This is not true for ICD-10, however.) Applying the DSM-IV rule and using the ADI as a guide, 15 out of 21 children with a clinical diagnosis of AS met ADI criteria for autism (see also Eisenmajer et al., 1996; Ghaziuddin, Tsai, & Ghaziuddin, 1992; and Fecteau, Mottron, & Berthiaume, 1999 who report similar findings). To identify enough children with AS and to reflect actual clinical practice (Frid, 1998), it was necessary to reverse the hierarchy rule so that if a child met criteria for both autism and AS, he/she was given a diagnosis of AS.

In fact, the majority of children with AS had many examples of impairments in the three ADI domains; the mean score from the ADI was 12.5 ($SD = 3.5$) on the social domain (autism cut-off is 10), 11.8 ($SD = 2.9$) on the communication domain (autism cut-off is 8) and 6.0 ($SD = 2.5$) on the repetitive activities domain (autism cut-off is 4). The mean scores for the children with autism were 17.8 ($SD = 3.6$) on the social domain, 12.2 ($SD = 4.5$) on the communication domain, and 8.0 ($SD = 2.4$) on the repetitive activities domain. To summarise, the key features differentiating the groups were that the children with autism spoke after 36 months and had evidence of marked deviance in language development as defined above. The children with AS spoke before 36 months and did not show delayed echolalia, pronoun reversal or neologisms. Using these criteria, all 68 children could be classified; 47 met our criteria for autism and 21 for AS.

A full description of the characteristics of the groups at inception is given in a previous publication (Szatmari et al., 1995). The mean age at inception was 65.1 months ($SD = 11.7$ months, range of 48 to 87 months) for the children with autism, and 68.6 months ($SD = 9.1$ months, range of 52 to 80 months) for the children with AS. All but two children (1 with autism and 1 with AS) were assessed at the first follow-up.

These families had moved out of the area, making participation difficult. The mean age at the first follow-up was 90.8 months in the autism group and 93.4 in the AS group. At the second follow-up there was a further loss of 2 individuals, and the mean age at this assessment was 159.0 months in the AS group and 159.7 in the autism group.

Procedure

The assessment conducted at inception included tests of verbal and nonverbal cognitive abilities, and a diagnostic interview (Le Couteur et al., 1989; Autism Diagnostic Interview-1988 version). Families were contacted roughly two years after their date of enrolment in the study (mean 26 months, range 21–30 months). The assessment conducted at this outcome included a parent-completed questionnaire of autistic behaviours (the Autism Behavior Checklist, ABC; Krug, Arik, & Almond, 1980) and two measures of adaptive behaviour in socialisation and communication from the Vineland Adaptive Behavior Scales (VABS; Sparrow, Balla, & Cicchetti, 1984). All follow-up assessments were administered by a different research assistant than the one who did the original assessments, thus ensuring blindness. The children were then contacted roughly six years after the inception cohort was assembled (mean = 78 months, range 71–86 months) and the outcome measures from the ABC and VABS were again re-administered blind to the assessments at inception.

Instruments

Outcome variables

a) **Autism Behaviour Checklist (ABC):** This self-administered checklist, filled out by parents, measures a wide range of autistic symptoms (Krug et al., 1980). Inter-rater, test-retest and validity data for total scores are excellent (inter-rater reliability is .85; Krug et al., 1980; sensitivity is .80, and specificity is .70; Volkmar et al., 1988). This measure was chosen as a primary outcome because it represents a clinically important aspect of outcome and is independent of the way the groups were originally defined. The checklist consists of five scales that measure a variety of autistic symptoms and are highly correlated with each other; sensory ('seems not to hear, covers ears, stares into space', etc.), relating ('is stiff and hard to hold, often frightened or very anxious', etc.), body and object use ('walks on toes, twirls, spins and bangs objects, gets involved in complicated rituals such as lining things up', etc.), language ('pronoun reversal, speech is atonal, repeats sounds or words over and over' etc.) and social and self-help ('forgets quickly, has special abilities, has temper tantrums, does not dress self without frequent help' etc.).

b) **Vineland Adaptive Behaviour Scales (VABS):** The VABS, a semi-structured interview, is designed to assess adaptive behaviour in socialisation, communication, motor, and daily living skills (Sparrow et al., 1984). These represent typical developmental accomplishments that are anchored to specific ages. We only used the first two measures for this analysis since the 'activities of daily living' scale is more responsive to environmental influences and opportunities. Scores derived have a mean of 100 and a standard deviation of 15. The scale has demonstrated excellent reliability and validity (Sparrow et al., 1984) and is sensitive to severity of impairment in autism (Carter et al., 1998). This measure was also chosen as a primary outcome measure because it is clinically important and independent of the way the groups were originally defined.

Predictor variable

c) **Autism Diagnostic Interview (ADI):** This semi-structured interview (LeCouteur et al., 1989), administered to parents, was designed to make a diagnosis of autism according to both draft ICD-10 and DSM-III-R criteria. Data from the interview were used to differentiate children with autism from those with AS at inception.

d) **Arthur Adaptation of the Leiter Performance Scales (Levine, 1986):** This is a standardized measure of nonverbal problem solving. The Leiter is widely used with PDD and other language impaired children. While the cognitive abilities of the children assessed in this study are relatively comparable, significant variability in verbal abilities exist that can influence comprehension of instructions. The Leiter is especially appropriate to the population under study because it does not require verbal instructions for administration, and correlates highly with WISC-R IQs (Levine 1986).

e) **The Beery Visual–Motor Integration Test (VMI)** is an untimed, geometric design-copying task that measures visual–motor integration (Beery, 1987). A standard score, based on a mean of 10 with a standard deviation of 3, was obtained for each child.

f) **Stanford–Binet Intelligence Scale, Fourth Edition (Thorndike et al., 1985):** The Stanford–Binet measures overall cognitive development as well as four different cognitive domains – verbal reasoning, quantitative reasoning, abstract/visual reasoning, and short-term memory skills (mean = 100, $SD = 15$). These four domain scores were used as the predictor variables in this study.

g) **Language measures:** Several measures of expressive and receptive language were given to all the children at inception:

- *The Test of Language Development – 2* (TOLD-2; Newcomer & Hammill, 1988). The Grammatic Completion, Grammatic Understanding and Picture Vocabulary subtests of the TOLD-2 were used to measure grammatical comprehension and usage. Standard scores (mean = 10, $SD = 3$) were calculated for each child.
- The Verbal Comprehension Scale A of the *Reynell Developmental Language Scales* (Reynell & Huntley, 1987) measures comprehension of single words, abstract verbal concepts and increasingly complex grammatical structures. Age-equivalent scores were calculated for each child in our study.
- *McCarthy Oral Vocabulary Test*: In the Word Knowledge, Part 2 of the oral vocabulary section of the McCarthy Scales of Children's Abilities (McCarthy, 1972), the child is asked to define 10 words and a total score is calculated from all 10 items. The test assesses the child's ability in expressive language. Raw scores were employed because we used an abbreviated form of the subtest.

If the child was mute or was unable to reach a basal level on the language tests, he or she was given an imputed score equal to one below the lowest score obtained by a child who was able to complete the test. This was done to ensure that missing data were kept to a minimum and provided a reasonably valid, if conservative, estimate of abilities. On the TOLD-2 Picture Vocabulary test, 13 children with autism and 1 child with AS were given imputed scores. Twenty-two (22) children with autism and 1 child with AS were given imputed scores on Grammatical Understanding and Grammatical Completion. On the Reynell Developmental Language Scales, 2 children with autism were given imputed scores, while 25 children with autism and 2 children with AS had imputed scores on the McCarthy Oral Vocabulary Test.

Analysis

There were three outcome measures chosen for analysis: parental assessments of social and communication skills as measured by the Vineland Adaptive Behaviour Scales (VABS), and a composite measure of autistic symptoms as measured by the Autism Behaviour Checklist (ABC). Raw scores were used from the VABS to be more sensitive to developmental changes.

A large battery of verbal and nonverbal cognitive measures were taken at inception to predict outcome. We had no *a priori* hypothesis as to which tests to use as each had its own set of conceptual and psychometric strengths and weaknesses. Instead, composite measures of language and nonverbal skills were needed that would combine information from all tests. Factor analysis is a way of reducing a set of predictor variables and of seeing whether several different measures are associated with a more general, but latent, set of dimensions or factors. A factor analysis was done using varimax rotation on all 11 tests of verbal and nonverbal skills. The quantitative reasoning score from the Stanford–Binet test did not load on any factor and so was dropped. We then standardised the remaining scores (so that variation in scale did not influence the loadings), redid the factor analysis and saved the factor scores for each child.

The factor analysis of the standardised scores is shown in Table 1. Two factors were obtained with eigenvalues over 1.0; these explained 73.4% of the variance in the scores. There was a large drop in eigenvalue to the next component (1.30 to .65), suggesting that a third factor explained little of the remaining variation in the data. Table 1 shows the rotated loadings of each test with the two factors. The seven language tests (McCarthy Oral Vocabulary, the Reynell Receptive Language, the TOLD grammatic completion, grammatic understanding and picture vocabulary and the Stanford–Binet verbal reasoning and sentence memory scores) loaded heavily on the language factor and the three nonverbal tests (the Leiter, the Stanford–Binet abstract-visual reasoning and the VMI) loaded heavily on the second, nonverbal, factor. Factor scores were then calculated for each child based on these orthogonal loadings. These became two of the predictor variables for the regressions described below.

Table 1 Rotated factor analysis of cognitive tests

Test	Factor 1	Factor 2
Oral vocab	.81	.16
Reynell	.87	.30
SB-Verbal	.80	.39
GC	.87	.00
GU	.81	.32
PV	.83	.22
SB memory	.70	.33
Leiter	.24	.83
SB-abstract-visual	.43	.72
VM1	.10	.84
Eigenvalve	6.04	1.30
Cumulative variance	60.36%	73.40%

GC – grammatic completion; GU – grammatic understanding; PV – picture vocabulary.

Multiple regression models were used to identify predictors of outcome at Times 2 and 3. Four key issues were addressed: first, what was the total amount of variance explained; second, was the amount of variance explained stable over time; third, what were the independent and separate contributions of the clinical diagnosis (high functioning autism versus AS) and the verbal and nonverbal factors; and fourth, were the interaction terms (clinical diagnosis by predictor) significant? The three main effects (the two factors and clinical diagnosis) were entered into the regression equation along with the two interaction terms – diagnostic group by each factor score. If the interaction term was significant, we can conclude that the relationship between the predictor and outcome variable differed by whether the child had autism or AS. The five predictor variables (three main effects and two interactions) were entered together and tested for overall significance. The unique variance of each variable (controlling for the effect of other variables) was calculated from the part correlation of each variable. The amount of variance common to all predictor variables (main effects and interactions) was obtained by subtracting the sum of unique variances from the total variance (the R^2). The stability of the predictor variables was assessed by seeing the extent to which the factors also predicted a similar amount of variance at the second follow-up (i.e., at Time 3).

Results

Mean scores of predictor and outcome variables

Table 2 provides a summary of the mean scores, standard deviation and range of scores for the outcome and predictor variables. It is clear that there is substantial variation in all outcomes and the low raw scores on the VABS (the SOC and COMM subscales) and the high score on the ABC composite total score and each of its subscales are consistent with the kinds of impairments and range of symptoms seen in children with high functioning PDD. In general, the children with AS had higher predictor and outcome scores in socialisation and communication and lower scores on autistic symptoms (the ABC). It is important to note that there was no difference in the variance of scores. In particular, the variance in language scores was not truncated in the AS group.

Table 2 Summary statistics

	Autism			Asperger's disorder		
	Mean (SD)	Range	*N*	Mean (SD)	Range	*N*
Predictor variables						
Language						
Reynell	32.13 (12.17)	13–57	47	53.38 (16.07)	29–84	21
Told GC	4.51 (2.18)	3–13	47	7.05 (3.02)	3–12	21
McArthur Oral Vocab	0.94 (1.82)	0–7	47	5.19 (4.57)	0–14	21
SB – Verbal	66.64 (16.18)	43–117	47	87.95 (16.66)	63–130	21
Told GU	2.98 (2.30)	1–9	45	6.43 (3.99)	1–14	21
Told PV	4.47 (3.08)	1–11	47	7.71 (3.69)	1–17	21
SB – Memory	71.49 (16.26)	51–108	47	85.19 (13.40)	66–121	21
Nonverbal						
Leiter	86.60 (17.92)	42–130	47	99.33 (16.59)	73–131	21
SB – Abstract Visual	75.51 (18.09)	51–123	47	85.10 (15.55)	59–117	21
VMI	4.91 (3.06)	0–14	47	6.29 (3.68)	1–12	21
Outcome variables						
Outcome 1						
ABC Total	58.78 (25.84)	9–113	45	36.95 (20.29)	8–85	21
ensory	7.42 (5.32)	0–23	45	4.19 (4.71)	0–13	21
Relating	11.73 (8.92)	0–36	45	9.52 (7.81)	0–24	21
Body & Object Use	12.29 (7.34)	0–28	45	8.48 (5.64)	0–26	21
Language	12.49 (6.85)	0–25	45	4.76 (5.18)	0–15	21
Social & Self-help	14.84 (5.16)	0–24	45	9.52 (4.76)	0–17	21
VABS SOC	61.78 (13.56)	29–95	45	75.55 (15.73)	56–114	20
COMM	66.11 (25.54)	25–120	45	87.75 (22.03)	52–124	20
Outcome 2						
ABC Total	60.33 (23.77)	7–106	45	35.53 (25.80)	2–78	19
Sensory	7.36 (4.48)	0–17	45	3.53 (5.64)	0–22	19
Relating	15.33 (9.00)	0–36	45	9.84 (8.71)	0–28	19
Body & Object Use	12.16 (7.68)	0–30	45	7.05 (5.45)	0–16	19
Language	4.76 (5.18)	0–15	45	5.32 (5.68)	0–17	19
Social & Self-help	14.44 (5.10)	4–24	45	9.79 (5.59)	0–19	19
VABS SOC	51.98 (18.70)	19–96	44	67.21 (18.34)	42–124	19
COMM	63.23 (26.39)	19–123	44	84.37 (15.58)	64–111	19

GC – grammatical completion; SB – Stanford–Binet; GU – grammatical understanding; PV – picture vocabulary; MI – visual motor integration; ABC – Autism Behaviour Checklist; VABS SOC – Socialization subscale from the Vineland Adaptive Behaviour Scales; VABS COMM – Communication subscale from the Vineland Adaptive Behaviour Scales.

Predicting outcome from the combined models

Table 3 provides a summary of the results of the regression equations and the total amount of variance explained at each time for each outcome. The total score from the parent report of autistic symptoms (the ABC) was the first outcome variable analysed. In the Time 2 model, the overall prediction was significant ($F = 3.26$, $df = 5,58$; $p = .012$), but only a small amount of the variance (15%) was explained. At Time 3, the total amount of variance explained went up (29%) and the overall model was again significant ($F = 5.93$, $df = 5,56$; $p < .001$). At both points in time, virtually none of the total variance explained (0–.01) was common to two or more variables.

The second set of prediction models looked at the VABS socialisation scores. For Time 2, the combined

Table 3 Unique, common and total variance of main effects and interactions

	ABC-T_2	ABC-T_3	SOC-T_2	SOC-T_3	COMM- T_2	COMM-T_3
Diagnosis	.04	.03	.06*	.06*	.01	.02
Language	.01	.02	0	0	.03*	0
Non-verbal	.05	.15*	.02	.02	.01	.01
Dx by language	0	.02	.10*	.05*	.08*	.11*
Dx by NV	.04	.07*	0	0	.02*	.02
Common variance	.01	0	.28	.22	.49	.40
Total variance	.15	.29	.46	.35	.64	.56
F (df)[1]	3.26 (5,58)	5.93 (5,56)	11.29 (5,56)	7.34 (5,55)	22.32 (5,56)	16.37 (5,55)

[1] $p < .05$ for ABC-T_2; $p < .001$ for the rest for full models.
* $p < .05$ for independent effects.
Dx – diagnosis; NV – nonverbal; ABC – Autism Behaviour Checklist, SOC – socialisation score from VABS; Com – communication score from VABS; T_{2-} Time 2; T_{3-} Time 3.

set of 5 predictor variables was significantly associated with outcome ($F = 11.29$, $df = 5,56$; $p < .001$) and explained 46% of the variance. Of that, 28% was common variance attributed to two or more of the variables in the model. At Time 3, the total set of variables was again significantly associated with the outcome ($F = 7.34$, $df = p < .001$) but predicted a slightly smaller amount of variance (35%) than at Time 2. Again, most of the variance was common to several variables.

The third outcomes analysed were the parental reports of communicative competence on the VABS. At the Time 2 assessment, the combined set of predictor variables was very strongly associated with the outcome ($F = 22.32$, $df = 5,56$, $p < .001$) and explained 64% of the variance. At Time 3, the total amount of variance explained by the set of predictor variables was 56% ($F = 16.37$, $df = 5,55$, $p < .001$). Again in both circumstances, most of the variance explained was shared by two or more of the variables in the model.

From these data there is certainly little evidence for a dramatic fall-off in explanatory power of the predictor variables over time. It was also true that predictive ability was strongest for the communication outcome and weakest for autistic symptoms.

Predictive ability and unique variance of main effects of clinical diagnosis, language and nonverbal skills

Table 3 also provides the unique variance associated with the main effects and interaction terms (calculated from the part correlations). Focusing first on the main effects, none of the three main effects (clinical diagnosis, language and nonverbal factor) was independently associated with the autistic symptom score at Time 2. At Time 3, however, the nonverbal factor was significantly associated with the ABC scores ($p = .001$) and the standardised beta coefficient was –.71; in other words, the higher the nonverbal factor, the lower the ABC score (i.e., fewer symptoms) at Time 3. Of the total variance explained by all variables in the model (29%), 15% could be attributed to the unique effects of this variable alone, controlling for all other effects.

The clinical diagnosis was the only main effect to make a separate and independent contribution to predicting the socialisation outcome at both Time 2 and Time 3 (partial $t = 2.52$, $p < .015$; for Time 2; partial $t = 2.31$, $p = .02$, at Time 3). In other words, children with AS had a higher score (i.e., did better) on this outcome at both times than children with autism. Six per cent of the variance could be uniquely attributed to clinical diagnosis at both these points; however, neither of the cognitive factor scores were associated with the socialisation outcome (controlling for other variables in the model) at either of these outcome assessments.

Of the three main effects, only the language factor was a significant independent predictor of communication outcome at Time 2 (partial $t = 2.20$, $p = .032$); those PDD children with higher language scores at Time 1 had higher communicative competence at Time 2. Only 3% of the total variance was due to the effects of this variable alone, controlling for the effects of the other variables. No main effects were significant at Time 3.

The predictive ability of the interaction term

In comparison to the paucity of significant main effects, several interaction terms were significant, although the amount of unique variance explained was limited and in no case greater than 11%. The clinical diagnosis by language interaction term made a significant and independent contribution to predicting outcome for both the socialisation and communication scores at both times. The clinical diagnosis by nonverbal interaction term was associated with the ABC scores at Time 3 and with the communication scores at Time 2.

To illustrate the meaning of the significant interaction terms, it is useful to think of clinical diagnosis as an effect modifier; it *modifies* the association between the factor scores and the outcome. The strength of language scores at 4–6 years of age in predicting socialisation at the outcome is *stronger* in the autism group than in the AS group. There is little or no association between language scores and socialisation among the children with AS. A similar pattern holds for the interaction term at Time 3; the strength of prediction of the language factor for socialisation was significantly higher in the autism than in the AS group. For the communication outcomes, both interaction terms were associated with outcome controlling for the main effects at Time 2. Both the nonverbal (for Time 2) and language factors (for Times 2 and 3) show a stronger relationship with communication outcome among the children with autism than among the children with AS. Neither factor appears to have much explanatory power among those with AS. In contrast, for the ABC at Time 3, the explanatory power of the nonverbal factor was stronger in the AS group than in the children with autism. We looked at the predictive ability of the nonverbal factor for the 5 separate components of the ABC in the AS group. The factor was significantly and independently associated ($p = .017$ to $.001$) with 4 of the 5 subscales (all except the 'sensory' scale; $p = .30$).

Discussion

In general, the results of this study support findings from other studies of children with autism that early language and nonverbal skills are important predictors of outcome in adaptive behaviour in

communication and in socialisation and to a lesser extent in autistic symptoms (Lotter, 1974a; Rutter, Greenfield, & Lockyer, 1967; Ventner, Lord, & Schopler, 1992). In addition, predictive ability is stable over time for these outcomes, at least until the pre-adolescent years. The average amount of variance explained was 60% for the VABS communication scores compared to an average of 40% for socialisation scores and 22% for autistic symptoms. The amount of variance explained for communication was substantial. Although this may not be surprising, it is important to note that adaptive behaviour in this domain measures *communicative performance in the real world* (i.e., the use of language) whereas the early language measures focus on linguistic knowledge (notably vocabulary and grammar) and were taken under the highly structured setting of psychometric testing. Although there is overlap, these are not identical constructs, thus providing some confidence that these findings are valid and not due to measurement redundancy.

There are, however, several important qualifying statements that need to be made, which may, in fact, be more clinically relevant than the main results. First, the unique variance associated with the main effects for communication and socialisation was dwarfed by the variance common to all variables. The amount of common variance is a function of the overlap among predictor variables and the extent to which they are related to the dependent variables. These predictor variables have much in common in terms of their explanatory power, and one should not make too much of their independent influence on development. Second, these prospective data show that among children with PDD, outcome is not a unitary construct. The explanatory power of the models is much higher for communication and social skills and than it is for autistic symptoms. Indeed, while we can predict outcome fairly well in terms of communication skills, our ability to do so with respect to social skills is weaker and for autistic symptoms it is very poor indeed.

Third, the strength of prediction differed among the children with autism and those with AS for all three outcomes on at least one occasion. The language factor was a better predictor of outcome for children with autism than it was for children with AS at both Times 2 and 3. This could not be accounted for by a truncated distribution of language scores in the AS group. The nonverbal factor score was a better predictor of autistic symptoms among children with AS at Time 3 but was a better predictor of communication competence among children with autism at Time 2. The important point is that the determinants of outcome in children with autism are different than in the children with AS.

An important clinical implication of these data is that the distinction between autism and AS may be useful in terms of suggesting that working on language skills may improve outcome more dramatically in children with autism than in children with AS. However, it is possible that language is a marker for another, more fundamental, variable that would have a stronger influence on outcome. The true impact of treating language skills on outcome in autism and AS would need to be tested in a proper randomised trial. There is certainly an urgent need to more fully understand variables associated with the outcome of AS since these data indicate that it is inappropriate to extrapolate from children with autism alone.

Surprisingly, nonverbal skills do predict outcome in autistic symptoms among PDD children in general, and among those with AS in particular. There does not appear to be any specificity as to which types of autistic symptoms (as assessed by the ABC) are influenced by nonverbal abilities. Even though language and nonverbal skills are highly correlated, this predictive ability was independent of the variance shared by each factor. The mechanism for the predictive ability of nonverbal skills is unclear and deserves to be further studied. One possibility is that early nonverbal skills may show homology with executive function abilities at a later age; in fact, the correlation between this factor at inception and the Wisconsin Card Sorting Test (Heaton, 1981) taken at Time 3 is surprisingly high ($r = .34$, $p = .02$). Another possibility is that nonverbal skills are a proxy measure of relatively better attention skills, some, but not all, of which are strictly executive. Perhaps children with high scores on this factor fare better because they have better attentional skills than other children with PDD that allow them to benefit more fully from early intervention attempts.

This study has several strengths that ensure the validity of the results. First, an inception cohort of children with PDD was assembled within a year or two of that diagnosis being given. A large sample size was collected and there was very little attrition over time. Predictor variables were assessed blind to outcome variables, and we were able to use multiple outcome and predictor variables in order to explore relationships over three points in time. The study also has some limitations that should be kept in mind. Most of the children with AS met the ADI diagnostic algorithm for autism. It is important to remember that the ADI was not intended to distinguish AS from autism so this overlap is not surprising. Our definition of AS is consistent with, though not identical to, the ICD-10 (1992) and DSM-IV (1994) criteria, which appeared only after initial data collection was completed. Several authors (Miller & Ozonoff, 1997; Fecteau et al., 1999; Eisenmajer et al., 1996) have reported that the DSM-IV criteria are overly stringent and essentially unworkable; even the cases described by Asperger himself would not have met the DSM-IV criteria for that disorder because they also meet criteria for autism. We too have reported that the ADI algorithm is not able to differentiate 4–6-year-old children with autism from

those with AS (Szatmari et al., 1995). We and others now believe that the DSM-IV criteria will need to be modified but the results reported here must take into account this discrepancy with the official criteria. It is also true that the number of children with AS was relatively small so that the estimates associated with the interaction terms may be imprecise. Replication is obviously needed for these particular findings.

The clinical implication of these findings is that clinicians can reassure parents of higher functioning PDD children that early language and nonverbal skills are important predictors of outcome in communicative and social competence domains. This certainly supports the emphasis of early intervention programmes on language skills and on improving communication in a general sense. But focusing on language alone may not have a significant impact on social skills, on autistic symptoms or on the outcome of children with AS. It is important for parents to think of outcome along multiple domains and that steady improvement in one domain does not guarantee a similar amount of improvement in another. There is some justification from these data for programmes that target nonverbal abilities, but a clearer understanding of mechanisms is needed before a heavy emphasis is placed on focusing on these skills in isolation.

Another important implication from these data is that the clinical differentiation of autism from AS is useful in terms of predicting outcome. These two groups do have a different outcome, to be sure (Szatmari et al., 2000), but the predictors of outcome are both similar and different in the two groups. This does not mean that these two PDD subtypes are 'different', nor does it necessarily mean they lie on the 'same spectrum'. The whole notion that AS is a 'mild' form of autism is overly simplistic, as demonstrated by the greater significance of the interactive terms relative to main effect of diagnosis in these analyses. The design employed here cannot address the issue of 'same' or 'different'. Rather it does support our model that AS and autism represent different, but potentially overlapping, developmental trajectories that are influenced by similar (though not identical) prognostic factors (Szatmari, 2000). According to this model, children with PDD appear undifferentiated in infancy, but those who develop fluent language by 3 years of age (and so receive a 'diagnosis' of AS) start off on a different developmental pathway than those children who are still nonverbal at that age. As a result, the predictive ability of language in the AS group is limited compared to the autism group. There is an opportunity for children with autism to join the developmental pathway of the AS children once they too develop fluent language, but the longer it takes them to do so, the less likely that is to occur. Children who do not develop fluent language fall farther and farther behind their cohort of PDD children, even if they are higher functioning and have good nonverbal skills at inception. The aim of early intervention studies will be to identify the mechanisms for moving children from one pathway to the other, and perhaps even off the PDD pathway altogether. A careful analysis of predictors of outcome may be helpful in designing those studies.

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