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published in
Autism
2006

DOI (link to publisher)
10.1177/1362361306063299

document version
Publisher's PDF, also known as Version of record

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Autism 2006 10: 266
DOI: 10.1177/1362361306063299

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SAGE Publications
and The National
Autistic Society
Vol 10(3) 266–287; 063299
1362-3613(200605)10:3

Can the Children's Communication Checklist differentiate autism spectrum subtypes?

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ABSTRACT The study explored whether children with high-functioning autism (HFA), Asperger syndrome (AS), and pervasive developmental disorder not otherwise specified (PDD-NOS) can be differentiated on the Children's Communication Checklist (CCC). The study also investigated whether empirically derived autistic subgroups can be identified with a cluster analytic method based on the Autism Diagnostic Interview–Revised. Fifty-seven children with HFA, 47 with AS, 31 with PDD-NOS, and a normal control group of 47 children between 6 and 13 years participated. Children with HFA, AS, and PDD-NOS showed pragmatic communication deficits in comparison to the controls. Little difference was found between the three subtypes with respect to their CCC profile. A three-cluster solution explained the data best. The HFA cluster showed most autism characteristics, followed by the combined HFA + AS cluster, and then the PDD-NOS cluster. The findings support the autism spectrum concept based on severity of symptom impairment rather than distinct categories.

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KEYWORDS *Asperger syndrome; Children's Communication Checklist; cluster analysis; high-functioning autism; pervasive developmental disorder not otherwise specified*

www.sagepublications.com
DOI: 10.1177/1362361306063299

Introduction

The validity of a distinction between various autism spectrum disorder (ASD) subtypes has often been questioned (Beglinger and Smith, 2001; Pomeroy, 1998). The *Diagnostic and Statistical Manual of Mental Disorders*, fourth edition text revision (DSM-IV-TR: American Psychiatric Association, 2000) includes several subtypes of ASD. Three subtypes may be associated with normal intelligence and intact formal language: Asperger syndrome (AS), the so-called high-functioning subgroup of autism (HFA), and pervasive developmental disorder not otherwise specified (PDD-NOS). HFA is characterized by a triad of symptoms: (1) qualitative impairment in social interactions, (2) qualitative impairment in communication, and (3) restricted, repetitive and stereotypic patterns of behaviours, interests and activities. Children with AS do not show clinically significant delay in cognitive and language development. Children with PDD-NOS fit within the spectrum, but do not meet full criteria for the three domains (Filipek et al., 1999).

While there are a growing number of studies comparing children with HFA and AS in their behavioural characteristics, symptom patterns, and cognitive profiles (see for reviews Gillberg and Ehlers, 1998; Klin and Volkmar, 1997), few studies have compared these subtypes with the PDD-NOS subtype (e.g. Mahoney et al., 1998; Mayes et al., 1993; Walker et al., 2004). The main aim of this study is to look at a subclassification of the three subtypes from a pragmatic communication perspective, using the Children's Communication Checklist (Bishop, 1998).

Inconsistent findings between studies may be due to the different and often vague or unspecified criteria used to differentiate between the disorders. Various diagnostic criteria have been suggested, but no consensus exists concerning their validity (Fombonne, 1998). Prior et al. (1998) argued that the better-functioning groups give rise to most of the diagnostic dilemmas, since the majority of low-functioning children with autism would not be considered for an AS diagnosis. Often, it is suggested that if strict DSM criteria are applied, a diagnosis of AS becomes unworkable (e.g. Ozonoff et al., 2000; Szatmari et al., 2003). Some have argued that it might be useful to distinguish between children in terms of their intelligence or language level (Beglinger and Smith, 2001; Fein et al., 1999) or in terms of their adaptive behaviour (Stone et al., 1999; Waterhouse et al., 1996). Most studies have used a categorical distinction between HFA and AS based on language development (e.g. Gilchrist et al., 2001; Howlin, 2003).

In the present study, following the majority of studies, children were assigned to the HFA group if they had social impairment, communication impairment, and restricted behaviour and interests, and showed definite

delays in language development (i.e. no single word speech by 24 months and/or no phrase speech by 36 months). Children were assigned to the AS group if they had social impairment, communication impairment, restricted behaviour and interests, and no delays in language development in the use of either words or phrases. Children were assigned to the PDD-NOS group if they attained criteria on only two of the three domains of autism (i.e. the social and/or the communication and/or the activities/interests domain). However, there is also some doubt regarding the use of early language delay as a differential criterion for AS and HFA (Mayes and Calhoun, 2001; Prior et al., 1998). Eisenmajer et al. (1998) argued that this criterion is only useful when the children are young (< 6 years).

A promising method to investigate whether there are empirically derived diagnostic differences between the subtypes is to use a cluster analytic approach. Boucher (1998) suggests that we should abandon attempts to identify diagnostically distinct subtypes and describe individual children in terms of multidimensional profiles of behaviour. Others argue that a dimensional view of the autism spectrum is more appropriate than a categorical one (Leekam et al., 2000; Waterhouse et al. 1996). Several cluster analytic studies have been conducted to define empirically derived ASD subgroups (e.g. Eaves et al., 1994; Sevin et al., 1995). Most studies failed to distinguish between high-functioning and low-functioning children with ASD. Hence, effects of mental retardation may interfere with the results in these studies. The Autism and Language Disorders Nosology Project (Fein et al., 1999; Rapin, 1996a) found two clusters that are to a large extent based on ability level, rather than on particular behaviours.

Here, we were interested in the question whether it is possible to make a distinction between subgroups of *high-functioning* children with ASD. The present study also reports an empirical clustering method of symptoms and behaviours of children with ASD. Only one study has focused on this high-functioning group (Prior et al., 1998). This study reported a three-cluster solution, which bore some relationship to the clinical differentiation of HFA, AS, and PDD-NOS. The nature of the differences between the clusters was strongly related to degrees of social and cognitive impairments. The present study differs from most previous cluster analytic studies in using a large sample with higher ability levels. In addition, the influence of age and intelligence on the identified patterns was evaluated. In this way we were able to analyse if subgroups could be validated through measures other than their defining symptoms. An important difference between this study and that of Prior et al. (1998) is that we adopted the Autism Diagnostic Interview–Revised (ADI–R: Lord et al., 1994) as a basis to identify subgroups. The ADI–R is a well-standardized structured interview considered as the 'gold standard' diagnostic parental interview for ASD (Filipek et al., 1999).

An important issue for further investigation is the domain of *pragmatic communication*. Pragmatic communication is the appropriate use and interpretation of verbal and non-verbal language in relation to social situations (Rapin, 1996b). Often, children with ASD are poorly distinguished from children with developmental language disorders, because both conditions are characterized by pragmatic communication problems (e.g. Bishop and Norbury, 2002; Gagnon et al., 1997). Semantic and pragmatic aspects of communication are impaired in ASD (e.g. receptive difficulties in conversation, inadequate conversational skills, use of stereotyped language), while expressive language may be fluent, and phonology and syntax intact (Minshew et al., 1995; Tager-Flusberg, 1997). However, the content may be bizarre (Dodd and Crosbie, 2002). Rather than simply noting that children with ASD have pragmatic communication difficulties, an interesting question is whether different ASD subtypes can be distinguished in the severity of these difficulties. Individuals with HFA often have higher rates of speech delay and deviant language (i.e. delayed echolalia, pronoun reversal, unusual intonation, and use of neologisms) than individuals with AS (Gilchrist et al., 2001; Twachtman-Cullen, 1998) or individuals with PDD-NOS (Luteijn et al., 2000; Mayes et al., 1993). Subjects with AS have a more pedantic style of speech (i.e. marked verbosity or incessant monologues) than subjects with HFA (Ghaziuddin and Gerstein, 1996; Kugler, 1998). Ramberg et al. (1996) found that children with HFA and AS exhibit comparable evidence of pragmatic difficulties.

The Children's Communication Checklist (CCC) can be used to assess language impairment, especially pragmatic difficulties, and is useful for children with ASD (Bishop, 1998). The CCC was developed in response to the difficulty of obtaining a reliable, formal measure of pragmatic language skills in everyday situations (Nathan, 2002). This 70-item questionnaire, rated by parents or teachers, contains nine scales: two scales assess aspects of formal language (fluency of speech output and complexity of syntax); five scales are combined to assess pragmatic language use (inappropriate initiation, coherence, stereotyped conversation, use of context, and conversational rapport); and two scales assess non-language domains (social relationships and unusual or restricted interests).

Of interest for present purposes was the finding that children with pragmatic problems and autistic features had lower CCC ratings (indicating more profound deficits) than children with pure semantic–pragmatic disorder and specific language impairment (Bishop, 1998; Botting and Conti-Ramsden, 1999). Furthermore, Bishop and Baird (2001) found that children with a diagnosis of autism had more pragmatic problems on the CCC than children with AS or PDD-NOS. Bishop and Baird (2001) argued that the CCC is a suitable instrument for professionals (teachers or speech

and language therapists) as well as for parents to delineate autism characteristics. No studies to date have analysed whether cluster analytic identified subgroups may be distinguished by social pragmatic skills. In this way, an additional check is made as to whether subgroups can be externally validated.

The first goal of this study was to explore whether children with HFA, AS, and PDD-NOS (according to clinical diagnosis based on modified DSM criteria and established with stringent selection criteria) can be differentiated in terms of their CCC profile. It was hypothesized that children with HFA would have more problems on the formal language scales (i.e. speech output and syntax) than children with AS, PDD-NOS and normal control children (Ghaziuddin et al., 2000; Szatmari, 1998; Twachtman-Cullen, 1998). It was predicted that children with PDD-NOS would have scores falling between those of children with HFA and AS and those of normal controls on all the other subscales of the CCC. Because of inconsistencies in the literature, we did not have specific hypotheses concerning the comparison of children with HFA and AS with respect to their pragmatic difficulties. The second goal was to investigate whether we could identify empirically derived ASD subgroups on the basis of autism characteristics and developmental history with a cluster analytic method, and to explore whether the results for the clinical children on the CCC differed when ASD subgroups were based on a cluster analysis instead of a clinical diagnosis following modified DSM criteria.

Method

Participants

Four groups of children participated in this study: 57 children with HFA, 47 children with AS, 31 children with PDD-NOS, and 47 normal control (NC) children. All children were aged 6 to 13 years. A stringent selection procedure was used. Only children with a clinical ASD diagnosis based on a multidisciplinary assessment participated in the study. Diagnoses of the children were validated using the ADI–R (Lord et al., 1994). Children were excluded if (1) parents reported a history of epileptic seizures, (2) they used medication that could not be discontinued, and (3) their IQ estimate was below 80. Intellectual functioning was assessed with four subtests (vocabulary, arithmetic, picture arrangement and block design) of the Wechsler Intelligence Scale for Children–Revised (WISC–R: Van Haasen et al., 1986). The IQ estimated on the basis of these subtests correlates strongly ($r = 0.93$ to $r = 0.95$) with full-scale IQ (FSIQ: Groth-Marnat, 1997).

Normal controls Parents of 63 children from three mainstream schools approved their assignment to the study. Children were excluded from the study if the parent or the teacher stated that the child had ever had a clinical diagnosis or used medication that could not be discontinued or their FSIQ estimate was below 80. Forty-seven children fulfilled the inclusion criteria for this group.

ASD One hundred and sixty children with a clinical diagnosis of ASD were recruited for participation through psychologists and psychiatrists of rehabilitation centres, special school services, and other agencies specialized in the care of children with autism and related disorders. Two children were excluded because of a history of epileptic seizures. Eleven children were excluded because of the use of medication that could not be discontinued. Twelve children with an FSIQ estimate below 80 were also excluded. Based on the selection criteria, 57 of the children were assigned to the HFA group, 47 were assigned to the AS group and 31 were assigned to the PDD-NOS group. In line with expectations, the HFA and AS groups showed significantly more ASD characteristics than the PDD-NOS group on all domains of the ADI–R. The HFA group was rated as having more social problems than the AS group (see Table 1).

The mean age of the children was 8.8 years (SD = 1.8) in the HFA group, 8.9 (SD = 2.2) in the AS group, 8.8 (SD = 1.6) in the PDD-NOS group, and 9.4 (SD = 1.6) in the NC group. Groups did not differ with respect to age ($F(3, 178) = 1.05$, n.s., $\eta^2 = 0.02$). The mean FSIQ estimate of the children was 98.9 (SD = 17.6) in the HFA group, 105.7 (SD = 16.3) in the AS group, 98.0 (SD = 14.7) in the PDD-NOS group, and 112.1 (SD = 9.7) in the NC group. Groups differed with respect to FSIQ estimate ($F(3, 178) = 10.78$, $p < 0.001$, $\eta^2 = 0.15$). The three clinical groups had a lower FSIQ estimate than the NC group. The gender composition (male/female) was 53/4 in the HFA group, 43/4 in the AS group, 26/5 in the PDD-NOS group, and 40/7 in the NC group. Groups did not differ with respect to gender composition ($\chi^2(3, n = 182) = 2.78$, n.s.).

Material

The CCC (Bishop, 1998; translation Hartman et al., 1998) contains 70 items grouped in nine scales: (a) speech output, (b) syntax, (c) inappropriate initiation, (d) coherence, (e) stereotyped conversation, (f) use of conversational context, (g) conversational rapport, (h) social relationships, and (i) interests. The pragmatic composite score consists of the sum of the scores on scales (c) to (g). Items are scored on a three-point scale (does not apply = 0, applies somewhat = 1, and definitely applies = 2). Lower scores indicate greater impairment. Adequate psychometric properties of

Table 1 **Clinical diagnosis based group means and standard deviations for the ADI–R scores[a]**

Measure	*NC (n = 47)*		*HFA (n = 57)*		*AS (n = 47)*		*PDD-NOS (n = 31)*		*Bonferroni (α = 0.05)[b]*
ADI–R:[c]			Mean	SD	Mean	SD	Mean	SD	
Social interaction	–	–	18.4	5.0	16.1	3.8	12.2	4.0	PDD-NOS < HFA, AS; AS < HFA
Communication	–	–	15.2	3.4	15.0	3.7	10.5	3.8	PDD-NOS < HFA, AS
Repetitive/stereotyped	–	–	7.2	2.2	6.3	2.4	3.5	2.7	PDD-NOS < HFA, AS

[a] The number of participants differs for the dependent variables due to missing data.
[b] All *F*-values were significant at 0.001.
[c] ADI–R = Autism Diagnostic Interview–Revised.

the CCC have been reported (Bishop, 1998; Bishop and Baird, 2001). For this study, the CCC was translated into Dutch using a two-way translation procedure, the inter-rater reliability r for the scales ranged from 0.39 to 0.59, and the internal consistency ranged from 0.68 to 0.90 for parents and from 0.63 to 0.90 for teachers. The internal consistency for the pragmatic composite score was 0.91 for parents and 0.84 for teachers.

Procedure

Parents received a full description and were informed of the aims of the study. When written consent was obtained, families were contacted by phone and appointments for the diagnostic interviews were made. The questionnaires for parents and teachers were sent by mail.

Statistical analyses

First, ANOVAs were performed to determine group differences on the CCC scales with group (four levels) as the between factor. To investigate the nature of the group main effects, *post hoc* tests were conducted with alpha levels adjusted for multiple tests (Bonferroni correction). For all analyses alpha was set at 0.05. Because age and IQ might influence CCC performance, the analyses were also conducted by covarying for effects of age and FSIQ estimate.

Second, a cluster analysis was performed to classify the *clinical children* into subgroups on the basis of ASD characteristics derived from the scores on the 12 subscales of the ADI–R. These subscales match the different symptoms of the DSM-IV-TR. Furthermore, the score for abnormality of development evident at or before 36 months was included. An agglomerative hierarchical clustering method was applied to find the best hierarchically nested set of subgroups in the data (Everitt, 1996). Raw scores were transformed into z-scores (Kaufman and Rousseeuw, 1990). Fusions were made with Ward's (1963) method, which is considered one of the most effective clustering algorithms for recovering underlying structure (Lorr, 1983). The number of clusters was determined *ad hoc* by using the following criteria: (1) clinical usefulness (i.e. interpretability in clinical terms), and (2) external validation (i.e. statistical differentiation on external criteria). After the clusters were obtained, *post hoc* comparisons of the cluster means on the ADI–R subscale scores were performed with one-way ANOVAs (Bonferroni correction). Kruskal–Wallis tests for simple pairwise comparisons were conducted on all ADI–R items to determine the difference between the clusters in detail. This test is a K-independent samples ranking procedure and is a non-parametric equivalent to one-way ANOVA (Sheskin, 2000).

Third, ANOVAs and ANCOVAs (covarying for age and FSIQ estimate) were performed to determine group differences on the CCC scales with the

three clusters as between factor in order to have an external validation of the cluster solution. *Post hoc* tests with Bonferroni correction were conducted for these analyses.

Missing data

For a number of CCC questionnaires, some items were not completed. If 10 percent or less of the items were missing on a particular scale for a particular child, missing data were replaced by the mean of the scores on the remaining items of that scale. If more than 10 percent of the items were not completed, the data for that scale were not included in the analyses. In scales with a small number of items (e.g. syntax), one missing item was still admissible. The distribution of missing data for the groups was: (1) zero to one missing cases per scale for the NC group, (2) zero to eight missing cases per scale for the HFA group, (3) zero to five missing cases per scale for the AS group, and (4) zero to four missing cases per scale for the PDD-NOS group. It should be noted that the interests scale had a large number of missing items: more than 10 percent missing items for seven children on the parent CCC and 15 children on the teacher CCC. This implies that results for the interest scale should be interpreted cautiously. Bishop and Baird (2001) also found a large number of missing items for this scale, suggesting a need for further improvement.

Results

Group comparisons parent CCC

The results for the four groups on the parent and teacher CCC are presented in Table 2. As can be inferred from Table 2, the main effects of group were significant for all subscales, for both parent and teacher ratings. Below, only the significant group comparisons will be described.

As expected, for speech output and syntax, more problems were reported in the HFA group compared to the NC and the AS groups. Contrary to expectations, children with PDD-NOS demonstrated more problems than the NC group on both scales. The three clinical groups scored lower than the NC group for all other scales (i.e. inappropriate initiation, coherence, stereotyped conversation, use of conversational context, conversational rapport, social relationships, interests, and pragmatic composite score). When the three clinical groups were compared to each other, the HFA group had more problems of coherence than the AS and PDD-NOS groups. The HFA group had lower conversational rapport scores than the PDD-NOS group. The PDD-NOS group had fewer restricted interests than the HFA and AS groups. The HFA group had a lower average pragmatic composite score

Table 2 Parental and teacher CCC ratings in relationship to clinical diagnosis based groups[a]

Measure	NC (n = 47)		HFA (n = 57)		AS (n = 47)		PPD-NOS (n = 31)		Bonferroni ($\alpha = 0.05$)[b]
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
(a) Speech output									
Parent	35.3	1.7	31.4	4.3	33.5	3.4	33.1	3.6	NC > HFA, PDD-NOS; AS > HFA
Teacher	35.1	1.9	31.8	4.6	33.9	3.7	33.3	3.6	NC, AS > HFA
(b) Syntax									
Parent	31.8	0.6	30.0	2.2	31.3	1.0	30.8	1.4	NC > HFA, PDD-NOS; AS > HFA
Teacher	31.6	0.7	30.6	1.9	31.4	1.1	30.8	1.7	NC, AS > HFA
(c) Inappropriate initiation									
Parent	28.2	1.8	23.4	3.1	24.1	3.5	23.7	2.6	NC > HFA, AS, PDD-NOS
Teacher	28.1	1.6	25.6	3.1	26.7	3.3	26.6	2.7	NC > HFA
(d) Coherence									
Parent	35.2	1.3	26.8	3.8	28.6	3.4	29.6	4.5	NC > HFA, AS, PDD-NOS; AS, PDD-NOS > HFA
Teacher	34.7	1.8	28.5	4.2	30.9	3.8	30.1	4.8	NC > HFA, AS, PDD-NOS; AS > HFA
(e) Stereotyped conversation									
Parent	28.5	1.9	21.7	4.1	22.0	4.1	22.8	3.2	NC > HFA, AS, PDD-NOS
Teacher	28.7	1.5	24.7	3.5	25.5	3.7	26.4	3.1	NC > HFA, AS, PDD-NOS
(f) Use of conversational context									
Parent	30.3	1.6	21.9	3.4	23.1	3.6	23.4	3.3	NC > HFA, AS, PDD-NOS
Teacher	30.7	1.5	24.9	2.9	25.1	3.6	26.2	3.5	NC > HFA, AS, PDD-NOS
(g) Conversational rapport									
Parent	33.0	1.7	25.3	3.3	25.6	3.0	27.1	3.9	NC > HFA, AS, PDD-NOS; PDD-NOS > HFA
Teacher	32.1	2.6	26.8	3.7	26.9	3.8	27.3	3.9	NC > HFA, AS, PDD-NOS
(h) Social relationships									
Parent	33.4	1.1	24.9	3.6	25.5	3.7	26.2	3.8	NC > HFA, AS, PDD-NOS
Teacher	32.6	1.7	27.5	4.1	27.7	3.6	27.8	3.5	NC > HFA, AS, PDD-NOS
(i) Interests									
Parent	31.8	1.8	26.9	2.4	27.6	2.8	29.3	2.7	NC > HFA, AS, PDD-NOS; PDD-NOS > HFA
Teacher	31.4	2.1	28.6	2.5	27.8	2.8	29.7	2.7	NC > HFA, AS, PDD-NOS; PDD-NOS > AS
Pragmatic composite (c)–(g)									
Parent	155.3	5.6	119.0	12.6	123.1	12.9	126.6	13.4	NC > HFA, AS, PDD-NOS; PDD-NOS > HFA
Teacher	154.3	6.3	130.6	12.0	134.7	13.3	136.6	12.4	NC > HFA, AS, PDD-NOS

[a] The number of participants differs for the dependent variables due to missing data.
[b] Bonferroni tests were conducted for parent and teacher ratings separately. All *F*-values are significant at 0.001 and a lower CCC score indicates greater impairment.

than the PDD-NOS group. The main effect of group for each of the scales did not alter after taking account of age and FSIQ estimate. The same pairwise comparisons as in the analyses without covariates were significant.

Group comparisons teacher CCC

The findings on the parent CCC were to a large extent replicated in the teacher questionnaires. With respect to the teacher CCC, only those results are discussed that differed from the results of the parent ratings. First, for speech output and syntax, the PDD-NOS group did not differ from the normal controls. For inappropriate initiation, the AS and PDD-NOS groups could not be differentiated from the NC group. The HFA and PDD-NOS groups did not differ for coherence, for conversational rapport, for interests, and for the pragmatic composite score. All the other significant differences on the parent questionnaires were replicated for the teacher questionnaires. After controlling for age and FSIQ estimate, the overall group effect remained significant for all scales, with the same pairwise comparisons reaching significance.

Cluster analysis: cluster solution

The cluster dendogram suggested that the entire study sample could be split into two clusters of 89 and 46 subjects. The larger cluster was then further subdivided into two clusters of 26 and 63 subjects, respectively. Hence, cluster A contained 26 children; cluster B 46 children; and cluster C 63 children. This solution was chosen because it best explained the data, i.e. it provides the best statistical validation. A MANCOVA with the 13 subscales of the ADI–R as dependent variables, the three clusters and gender as independent variables, and age and FSIQ estimate as covariates still revealed a significant main effect of the three clusters ($F(26, 230) = 4.08$, $p < 0.001$). Furthermore, a three-cluster solution is clearly interpretable, because it is clinically the most useful, i.e. it provides the best representation of current nomenclature. Cluster A was predominantly (22/26) composed of children with a clinical diagnosis of HFA (38.6%). The other four children had a clinical diagnosis of AS (8.5%). Most children with a clinical diagnosis of PDD-NOS were found in cluster B (87.1%). Cluster B also contained children with a clinical diagnosis of HFA (15.8%) and AS (21.3%). Most children with a clinical diagnosis of AS were grouped in cluster C (70.2%). Cluster C also contained almost half of the children with HFA (45.6%). The other children had a clinical diagnosis of PDD-NOS (12.9%). For this reason, we named cluster A the HFA cluster, cluster B the PDD-NOS cluster, and cluster C the combined HFA + AS cluster. To determine the degree to which the clusters are related to the autism spectrum subtypes, we calculated the Hubert–Arabie Adjusted Rand Index, i.e. a

measure between 0 and 1, with 1 as index of perfect agreement (see Steinley, 2004). This index was 0.18, indicating a weak relationship.

Cluster analysis: group differences

Demographic variables ANOVAs were conducted with age and FSIQ estimate as dependent variables. The three empirically derived clusters were treated as independent variables. A χ^2 test was performed for gender. The mean age was 8.3 years (SD = 1.9) in the HFA cluster, 8.7 (SD = 1.7) in the PDD-NOS cluster, and 9.3 (SD = 2.0) in the combined HFA + AS cluster. The clusters did not differ with respect to age ($F(2, 132) = 2.94$, n.s., $\eta^2 = 0.04$). The mean FSIQ estimate of the children was 98.6 (SD = 17.4) in the HFA cluster, 99.5 (SD = 15.2) in the PDD-NOS cluster, and 103.2 (SD = 17.5) in the combined HFA + AS cluster. The clusters did not differ with respect to FSIQ estimate ($F(2, 132) = 1.01$, n.s., $\eta^2 = 0.02$). The gender composition (male/female) was 25/1 in the HFA cluster, 38/8 in the PDD-NOS cluster, and 59/4 in the HFA + AS cluster ($\chi^2(2, n = 135) = 4.96$, n.s.).

Diagnostic variables ANOVAs were conducted with the domain and subscale scores from the ADI–R as dependent variables and the three clusters as the independent variable (see Table 3). We examined the most significantly differentiating item scores that were used to compose the different subscales using Kruskal–Wallis comparisons (detailed results from these analyses can be obtained from the first author).

Overall, the HFA cluster showed the most problems for the social domain, followed by the combined HFA + AS cluster, which contained children with more social problems than the PDD-NOS cluster. Children in the HFA and combined HFA + AS clusters exhibited more problems for the communication domain than children in the PDD-NOS cluster. Overall, the HFA and combined HFA + AS clusters could not be differentiated from one another. Children in the HFA cluster showed the most severe symptoms in the domain of repetitive, restricted, and stereotyped behaviours, followed by the children in the combined HFA + AS cluster, which contained children with more restrictions than the PDD-NOS cluster. Information regarding the analyses on subscale levels can be found in Table 3. With respect to abnormality of development evident at or before 36 months, it was found that children in the HFA cluster more frequently had a history of deficits than children in the other two clusters.

Cluster comparisons parent CCC We performed CCC comparisons in order to have an external validation of the cluster solution. Analyses were

Table 3 **Ratings of autism characteristics (ADI–R total and subscale scores) in relationship to cluster analysis based groups[a, b]**

Measure	*Cluster A (n = 26)*		*Cluster B (n = 46)*		*Cluster C (n = 63)*		*Bonferroni (α = 0.05)*[c]
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	
Social interaction	22.4	2.9	11.7	3.0	16.9	3.5	PDD-NOS < HFA + AS < HFA
Non-verbal behaviours	4.8	1.3	2.7	1.5	3.8	1.3	PDD-NOS < HFA + AS < HFA
Peer relationships	6.6	1.1	3.8	1.3	5.4	1.3	PDD-NOS < HFA + AS < HFA
Shared enjoyment	4.5	1.3	2.2	1.2	3.3	1.4	PDD-NOS < HFA + AS < HFA
Socio-emotional reciprocity	6.5	1.2	3.0	1.3	4.3	1.7	PDD-NOS < HFA + AS < HFA
Communication	16.3	3.3	10.8	3.3	15.4	3.3	PDD-NOS < HFA + AS = HFA
Language delay and gestures	4.4	2.5	3.4	2.3	5.2	2.2	PDD-NOS < HFA + AS
Make-belief play and imitation	4.6	1.3	3.0	1.4	4.7	1.0	PDD-NOS < HFA + AS = HFA
Conversational interchange	3.0	1.2	1.7	1.2	2.9	1.0	PDD-NOS < HFA + AS = HFA
Stereotyped speech	4.3	1.5	2.7	1.7	2.6	1.6	PDD-NOS = HFA + AS < HFA
Repetitive/stereotyped behaviour	8.9	1.2	4.4	2.6	6.1	2.4	PDD-NOS < HFA + AS < HFA
Preoccupations/interests	2.9	0.9	1.4	1.0	2.1	1.1	PDD-NOS < HFA + AS < HFA
Routines/rituals	2.8	0.9	1.4	1.3	1.6	1.2	PDD-NOS = HFA + AS < HFA
Motor mannerisms	1.5	0.6	0.8	0.9	1.0	0.8	PDD-NOS = HFA + AS < HFA
Preoccupations part of objects	1.7	0.5	0.8	0.6	1.4	0.6	PDD-NOS < HFA + AS = HFA
Abnormality before 36 months	4.5	0.9	2.4	1.4	2.4	1.2	PDD-NOS = HFA + AS < HFA

[a] The number of participants differs for the dependent variables due to missing data and exclusion of extreme scores.
[b] Cluster A = HFA cluster; cluster B = PDD-NOS cluster; cluster C = combined HFA + AS cluster.
[c] All *F*-values are significant at 0.01 (< = better score).

Table 4 **Parental and teacher CCC[a] ratings in relationship to cluster analysis based groups[b,c]**

Measure	*Cluster A (n = 26)*		*Cluster B (n = 46)*		*Cluster C (n = 63)*		*F-values*
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	
(a) Speech output							
Parent	30.0	4.9	33.2	3.6	33.1	3.4	PDD-NOS = HFA + AS > HFA
Teacher	31.5	5.1	33.5	3.5	33.0	4.1	n.s.
(b) Syntax							
Parent	29.8	2.2	30.9	1.5	30.7	1.7	PDD-NOS = HFA + AS > HFA
Teacher	30.3	2.3	31.1	1.3	31.1	1.6	n.s.
(c) Inappropriate initiation							
Parent	22.7	3.6	23.1	2.6	24.6	3.1	HFA + AS > HFA = PDD-NOS
Teacher	26.1	2.4	25.9	3.1	26.4	3.4	n.s.
(d) Coherence							
Parent	26.1	3.4	28.5	4.1	28.6	3.9	PDD-NOS = HFA + AS > HFA
Teacher	28.6	4.5	30.2	4.1	29.7	4.3	n.s.
(e) Stereotyped conversation							
Parent	20.9	4.2	21.9	3.5	22.6	4.0	n.s.
Teacher	25.7	2.9	25.3	3.7	25.3	3.7	n.s.
(f) Use of conversational context							
Parent	21.2	3.4	22.7	3.2	23.2	3.5	HFA + AS > HFA
Teacher	25.3	2.9	25.5	3.6	25.1	3.3	n.s.
(g) Conversational rapport							
Parent	25.1	3.1	26.5	3.9	25.6	3.0	n.s.
Teacher	27.2	3.9	28.1	3.5	26.0	3.7	PDD-NOS > HFA + AS
(h) Social relationships							
Parent	25.1	3.6	25.8	3.6	25.3	3.8	n.s.
Teacher	28.3	3.8	28.1	4.0	27.0	3.7	n.s.
(i) Interests							
Parent	26.5	2.2	28.7	2.8	27.5	2.7	PDD-NOS > HFA = HFA + AS
Teacher	29.2	2.0	29.1	2.9	27.9	2.7	PDD-NOS > HFA = HFA + AS
Pragmatic composite (c)–(g)							
Parent	116.1	12.9	122.5	13.5	124.7	12.4	HFA + AS > HFA
Teacher	132.9	12.1	135.2	13.3	132.2	12.6	n.s.

[a] CCC = Children's Communication Checklist.
[b] The number of participants differs for the dependent variables due to missing data. Bonferroni tests were conducted for parent and teacher ratings separately.
[c] Cluster A = HFA cluster; cluster B = PDD-NOS cluster; cluster C = combined HFA + AS cluster (a lower CCC score indicates greater impairment).

performed using the parent and teacher CCC ratings as the dependent variables (see Table 4).

Children in the HFA cluster exhibited more problems than those in one or both of the other two clusters for speech output, syntax, the pragmatic composite score, inappropriate initiation, coherence, and use of conversational context. Furthermore, the PDD-NOS cluster had more problems in inappropriate initiation than the combined HFA + AS cluster. Children in the PDD-NOS cluster had less restricted interests than the HFA and combined HFA + AS clusters. The main effect of cluster for each of the scales did not alter, after taking account of FSIQ estimate. However, the significance of the pairwise comparison between the HFA and combined HFA + AS clusters disappeared for the interests scale. When age was covaried, the main effect of cluster disappeared for use of conversational context. The same pairwise comparisons as in the analyses without covariates were significant for the other scales.

Cluster comparisons teacher CCC For the teacher ratings, the three clusters could be distinguished only for conversational rapport and for interests. The combined HFA + AS cluster had a lower score than the PDD-NOS cluster for conversational rapport. The PDD-NOS cluster had less restricted interests than the HFA and combined HFA + AS clusters. These differences remained significant after controlling for age and FSIQ estimate, with the same pairwise comparisons reaching significance.

Discussion

The major goal of the present study was to investigate whether children with different ASD subtypes (HFA, AS, and PDD-NOS) could be differentiated in terms of their communication deficits (based on their CCC profile), compared to a normal control group and compared to each other. According to Rapin (1996a), there are two fundamental approaches to define groups within a population. The first is a clinically derived or categorical approach that adopts pre-existing theoretical notions concerning the existence of subgroups (e.g. DSM-IV-TR). The second approach begins with a set of observations, and lets an empirically driven algorithm attempt to find naturally occurring groups; this is the statistical or dimensional approach (e.g. cluster analysis). The two approaches were compared here.

The clinically derived approach indicated that for parent ratings, the three clinical groups had lower scores (indicating more difficulties) than the NC group for most CCC scales. These findings were to a large extent replicated using the teacher questionnaires. When the three ASD subtypes were compared with each other, differences in the CCC profiles were very

modest. As expected, for many subscales, children with PDD-NOS had scores falling between those of children with HFA and AS on the one hand and those of normal controls on the other. Contrary to expectations, children with PDD-NOS could barely be *significantly* differentiated from the children with HFA and AS. The three ASD subtypes were found to be even less distinguishable with respect to teacher ratings. In contrast to the suggestion by Bishop (1998), profiles of language impairment did not vary with age here. The impairment profiles of the clinical groups did not alter, after taking into account FSIQ estimate.

Bishop (1998; see also Bishop and Baird, 2001) suggested that a cutoff score of 132 would discriminate best between children with and without pragmatic language deficits. Inspection of the results here indicated that, according to parents, 0 percent of the normal control children, 72 percent of the children with HFA, 70 percent of the children with AS, and 55 percent of the children with PDD-NOS had pragmatic problems. Teachers rated 0 percent of the normal control children, 56 percent of the children with HFA, 38 percent of the children with AS, and 29 percent of the children with PDD-NOS as having pragmatic difficulties. On the basis of these results, we conclude that the CCC is a useful instrument for the identification of pragmatic problems in children with ASD. Overall, parents and teachers are consistent in the kind of information they provide. However, a noteworthy finding was that parents rated the children as having more problems than the teachers (see also Oosterlaan et al., 2000). A possible explanation for this is that teachers observe the child in a limited variety of contexts compared with parents.

In the second part of this study, the statistical approach was adopted. We implemented the golden standard parental ADI–R; this has a clear algorithm and hence consensus exists regarding which items are to be included. A three-cluster solution explained the data adequately. The first cluster was almost totally composed of children with a clinical diagnosis of HFA. Most children with a clinical diagnosis of PDD-NOS were found in the second cluster. In contrast to Mahoney et al. (1998, p. 284), we could differentiate the PDD-NOS group from the other subgroups. The third cluster was composed of a mixture of children with AS and HFA. The nature of the differences between the three clusters was strongly related to the degree of social impairment and repetitive, restricted, and stereotyped behaviour. Communicative abilities differentiated the first and third cluster from the second cluster, but did not distinguish the first from the third cluster. In contrast to Prior et al. (1998), a history of early language delay differentiated the first cluster as opposed to the second and third cluster. Problem behaviour before 36 months (i.e. early language delay or first concerns of parents) validated the clusters here. However, it was found that

45.6 percent of the children with early language delay (HFA children in the first part of the study) belonged to the third cluster, which was largely composed of children with AS. Hence, it seems that the early language delay criterion *alone* is insufficient to validate the distinction between HFA and AS. Szatmari (1998) has noted that children with AS have adequate expressive language by 3 years of age, which places them on a certain developmental trajectory. Some children with HFA reach this developmental milestone of expressive language, but at a later age. It is possible that these children become more like AS children when they grow older. Children with HFA who do not develop this level of expressive language abilities remain on the original developmental pathway, and hence show more impairment. This may explain why the third cluster here is composed of children with both HFA and AS. The present study highlights that the early language delay criterion only has *some* predictive value for a differentiation in pragmatic communication problems of 6- to 13-year-old children.

Prior et al. (1998) found that there was considerable diagnostic overlap in their clustered groups. Hence, severity of symptoms rather than distinctive symptom patterns was an underlying factor in their clustering. The results presented here may be interpreted similarly. One can argue that the results support the autism spectrum concept based on severity of symptom impairment, rather than clearly distinct categories. Together, it seems that members of the HFA cluster exhibited most autism characteristics, followed by the combined HFA + AS cluster, and then the PDD-NOS cluster.

In the second part of the study, we also explored whether the results on the CCC differed when ASD subgroups were based on a cluster analysis instead of a clinical diagnosis according to modified DSM criteria. The usefulness of a dimensional classification based on ADI–R symptoms was demonstrated for parent ratings. Overall, parents rated children in the HFA cluster as having the most pragmatic problems (80%), then the PDD-NOS cluster (69%), and finally the combined HFA + AS cluster (60%), based on Bishop's (1998) cutoff score ($\chi^2(2) = 3.65$, n.s., indicating a weak overlap between the clusters and pragmatic problems). The clusters did not differ for the social relationships subscale. This was surprising, because differences between the three clusters based on the ADI–R were most strongly related to degrees of social impairment. The correlation between this subscale and the ADI–R social domain was low ($r = 0.16$ for parents and $r = 0.17$ for teachers). Possibly, different aspects of social relationships are measured in the CCC as opposed to the ADI–R. Little external validation for a dimensional classification was found for teacher ratings. According to teachers, pragmatic deficits were equally divided across the autism spectrum. Pragmatic problems were reported for 46 percent of children in the HFA cluster, 30 percent of children in the PDD-NOS cluster, and 52

percent of children in the combined HFA + AS cluster ($\chi^2(2) = 5.28$, n.s., indicating a weak overlap between the clusters and pragmatic problems).

The present study has some diagnostic implications for clinical practice and future research in children with ASD. The findings are in favour of an autism spectrum. There is a growing consensus among professionals working with children with ASD that the distinctions between HFA and AS are not useful in terms of either intervention or prognosis (Howlin, 2003). The present study seems to confirm this view. Furthermore, the PDD-NOS group showed fewer symptoms of ASD than the HFA and AS groups, although as a group they also reached the cutoff criteria on all three domains of the ADI–R. Hence, high-functioning subgroups are better described in terms of degree of impairment rather than on the basis of categorical cutoff scores. Children with PDD-NOS show problems that are more subtle but still substantial and, hence, deserve special attention. In our view, a categorical diagnosis is useful only for distinguishing low-functioning and high-functioning subgroups with ASD. However, on the basis of the present study, it remains difficult to argue whether a categorical or dimensional view is a better representation of this reality. The results offer too little external validation for both approaches to justify a choice between them. A systematic developmental follow-up study concerning variation in course, outcome, and treatment response for children with ASD would be of interest, because we may then be able to judge to what degree the ASD subtypes have distinctive symptom patterns (e.g. Beglinger and Smith, 2001; Kugler, 1998).

The present study confirms that children with ASD, irrespective of subgroup, show at least some pragmatic communication problems. Hence, it is important for intervention and education programmes to focus on language skills, especially pragmatic communication, and not simply formal language skills (Mawhood et al., 2000). Szatmari et al. (2003) argued that this would improve communication in general. Lord and Paul (1997) stated that interventions that emphasize functional communication could remediate or prevent in part the secondary effects of limited communicative experience on the development of children with ASD. However, the present results suggest that the same kind of intervention can be used for all high-functioning subtypes of the autism spectrum.

One may wonder if the CCC can be used as a screening instrument for subjects with ASD. In our view, children with ASD can be adequately differentiated from normal control children in terms of their language deficits, based on the CCC. The present results show that parents and teachers agree reasonably well in the kind of information they give. There was a very low false positive rate, but a relatively high false negative rate. Hence, the CCC is a useful instrument to obtain a global inventory of deficits in the domain of language and to assess language deficits in ASD, but a number of children

with ASD would not be detected if the CCC was used as a diagnostic instrument. Furthermore, the CCC is less useful for differentiation between subtypes within the autism spectrum, possibly because these subtypes are not valid or reliable.

Acknowledgements

We gratefully acknowledge Dorothy Bishop for giving permission to use the Children's Communication Checklist in the present study and her help with the translation of the questionnaire. We want to thank the children and parents without whose participation this research would not have been possible.

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