Journal of Autism and Developmental Disorders, Vol. 20, No. 4, 1990

Brief Report: Neuropsychological Testing of Autistic Children Through an Exploration with Frontal Lobe Tests[1]

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Despite major advances in symptom identification and description in childhood autism it appears that little is known about brain behavior relationships in the disorder. The last decade has seen an explosion of research attempting to find biological markers for autism but so far few reliable or distinctive findings have emerged (Prior, 1987). Neuropsychological investigations have been few in number, due in part to the inaccessibility of the children to psychometric testing but additionally because of the paucity of neurological theories applied to the disorder (but see Dawson, 1983; Hoffman & Prior, 1982; Rumsey & Hamburger, 1988).

Although frontal lobe deficiencies have been suggested (Damasio & Maurer, 1978; Schneider & Asarnow, 1987), no physiological or neuropsychological evidence appears to be available to evaluate the suggestion. Brain imaging studies (Campbell et al., 1982; Gillberg & Svendsen, 1983; Prior, Tress, Hoffmann, & Boldt, 1984) do not permit any conclusions concerning type, site, or even the likelihood of specific abnormalities. The Courchesne, Yeung-Courchesne, Press, Hesselink, and Jernigan (1988) data on autistic individuals via magnetic resonance imaging (MRI) indicated hypoplasia in neocerebellar vermal lobules but this has not been related to functional variables such as particular cognitive processes which might depend on intact

[1]This work was supported by a grant from the Apex Trust for Autism, Australia.
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0162-3257/90/1200-0581$06.00/0

cerebellar mechanisms. Horwitz, Rumsey, Grady, and Rapoport (1988) have suggested on the basis of PET investigation, abnormalities in frontal parietal interactions similar to proposals of Damasio and Maurer (1978). However the findings are also characteristic of Alzheimer's patients and therefore may be an indication of a general rather than an autism-specific pathology. It has been argued that any kind of brain damage at whatever level is likely to impinge on frontal lobe functioning since this represents the highest level of brain functioning in humans (Luria, 1973) and therefore it is to be expected that tests purporting to measure such functions would identify deficits in autistic persons (Prior, 1987).

In this investigation we selected three well-known neuropsychological tests which purport to assess frontal lobe functions including the ability to plan strategies, to profit from feedback, to categorize information in a flexible and adaptable way, and to organize the reproduction of a drawn figure in both copying and recall mode which also taps planning and conceptualization abilities (Walsh, 1985). We avoided frontal lobe tests that depend on verbal fluency because of the well-established problems of autistic children in this area (e.g., Schneider & Asarnow, 1987). Our expectations were that autistic subjects would not be able to profit from feedback or to alter their problem-solving strategies in a flexible way, that is, these frontal lobe tests would clearly differentiate between autistic and control children and provide qualitative data on problem-solving behavior.

METHOD

Subjects

Twelve children diagnosed as autistic, using the criteria of Rutter (1978) and functioning within the normal or borderline range of psychometric intelligence on the Leiter International Performance Scale (LIPS) were included. The age range of the 9 males and 3 females was 10 years 2 months to 17 years 3 months, mean 13 years 9 months. Mental age ranged between 8 years 7 months to 17 years with a mean of 11 years 4 months. The IQ range was 76–109, mean 88. No child had any known organic/medical problems in the history. Most subjects had been enrolled in a special school for autistic children at some time, but were currently mainstreamed for educational purposes. Verbal mental age (MA) of these children was not used in selection but was generally lower than their performance ability (Hoffmann & Prior, 1982).

The chronological age-matched (CA) control group of 3 girls and 9 boys ranged in CA between 10 years 3 months and 17 years with a mean of 13 years 9 months. MA was assumed to equal CA. LIPS IQ estimates for this group ranged between 85–112, mean 100. This was significantly superior to the mean of the autistic group, $t(22) = 2.63, p < .05$. The MA control group matched with the autistic group with respect to sex and MA (via the LIPS) ws significantly younger than the autistic group. As MAs were obtained for this group 2 years prior to the present study adjusted mental ages were used. Mean CA was 11 years 4 months (range 8 years 5 months to 16 years 10 months), mean MA, which did not differ significantly from that of the autistic children, was 9 years 8 months (range 6 years 3 months to 17 years). LIPS IQ ranged between 97–120; the mean of 107 was also significantly superior to the mean of the autistic group, $t(22) = 5.126, p < .001$. No control child had any known learning or behavior difficulties.

All boys in each group had been used in a previous study (Hoffmann & Prior, 1982) of left and right hemisphere functioning via neuropsychological tests. The three autistic girls included in this study had also been assessed on the battery reported in that study and displayed the same neuropsychological profile, that is, a pattern of normal level functioning on right hemisphere tests along with severe difficulties with left hemisphere tests.

Measures

Milner Maze (Milner, 1965). The subject's task is to discover and remember the one correct path leading from the lower left-hand corner to the upper right-hand corner of the array. The rules are few; the child must go back to the previous correct response when an error is made, he must not retrace portions of the correct path, and must not move diagonally. The maze is electronic and gives immediate feedback for errors made. The test was modified for use with children in that only 15 trials were allowed. Testing continued until the criterion of 3 successive errorless runs were made or 15 trials were completed. Time scores were unobtrusively recorded. It was expected that autistic children would make more errors than control children and would perseverate in their responses.

Wisconsin Card Sorting Test (Modified Version; Nelson, 1976). The Modified Version has the same set of four unique stimulus cards as the Wisconsin Card Sorting Test (WCST) (Grant & Berg, 1948). However any card which showed more than one attribute (e.g., same shape and color) was removed from the test leaving a set of 24 cards, each of which shared one and only one attribute with each of the stimulus cards. The children were instructed to sort response cards under the stimulus cards according to certain rules which they had to discover. Unlike the WCST, after six correct responses in a row the children were told, "The rules have now changed; I want you to find another rule." The test was discontinued following completion of the six categories or when the two sets of 24 cards were exhausted. Responses were scored according to number of categories and for perseverative or nonperseverative errors. It was expected that autistic children would perseverate more and not complete as many categories as control children.

Rey-Osterrieth Complex Figure Design Copying Test (Rey, 1959). This test was designed to investigate both perceptual organizational and visual memory abilities. Test material consists of Rey's complex figure, 2 blank sheets of paper, and colored pencils. The task is to copy the complex figure by using different colored pencils for 1-min each, until the copy is completed. The order of the colors used is noted and time taken to copy recorded. After a delay interval of 3 min, in which the examiner talks to the child about topics of personal interest unrelated to the study, the child is given a second sheet of paper and asked to draw the design from memory. The designs are scored for the number of parts of the design present, number of errors, style, and organizational integrity.

Each child was tested in a familiar environment, at home or at school with the Modified WCST, the Figure of Rey, and finally the Milner Maze. Testing was usually completed in less than 1 hr.

RESULTS AND DISCUSSION

Group mean scores are shown in Table I. Since these data did not meet conditions for parametric statistics (e.g., assumption of a normal distribution) a series of one-way nonparametric analyses of variance (Hotellings T^2 tests) was carried out, comparing the three groups on each of the test scores (Table I).

The only measures on which the autistic group did not differ significantly from comparison groups were on frequency of nonperseverative errors in the WCST, the time taken to make a copy of the Rey Figure, the accuracy score on this copy, and time taken for the recalled copy production. On the Milner Maze, autistic subjects took twice as long to complete as nonautistic children and made three times as many errors. Furthermore, when attainment of criterion for successful solving of the maze is considered (defined as three consecutive error-free trials) only 1 autistic child achieved this goal compared with 6 CA controls and 8 MA controls. Of 24 normal children tested, 14 reached criterion for solution, and all but 2 of these were older than 12 years.

On the WCST, autistic children made three times as many errors in sorting. Although all of the nonautistic children could name all categories used in sorting, among the autistic children, 8 could name color, 6 could

Table I. Scores on All Measures

Measure	Autistic		MA control		CA control			
	M	*SD*	*M*	*SD*	*M*	*SD*	*F*	*p*
WCST								
Total errors[a]	15.3	13.1	5.7	5.0	3.2	5.0	6.66	.003
No. correct[a]	30.2	10.9	36.7	2.1	36.7	2.5	3.8	.03
Perseverative errors[a]	8.3	11.6	1.6	1.8	1.1	1.9	4.18	.02
Nonperseverative errors	7.0	9.4	4.2	3.5	2.1	3.3	1.97	ns
Milner Maze								
Errors[a]	180.2	119.5	65.9	29.5	63.2	40.6	9.56	.000
Time (min)[a]	19.1	12.1	8.9	1.8	7.8	2.1	9.18	.000
Rey Figure								
Copy time	4.1	2.0	4.0	1.1	3.0	0.9	2.24	ns
Copy score	27.2	7.5	29.8	6.9	32.4	2.6	2.23	ns
Recall time (min)	3.6	2.0	2.7	1.1	2.3	0.9	2.72	ns
Recall score[a]	11.5	6.3	18.8	7.7	19.4	7.3	4.49	.02

[a]Autistic children significantly poorer than control groups by post hoc tests.

name function, and 5 named number. This was clearly deficient performance in the ability to identify categories.

The very high standard deviation scores for the autistic group on many of the tests is an indication of the great variability in performance in this group and suggests the need to look carefully at individual rather than group performance in assessing abilities. The oldest autistic girl in fact performed perfectly normally on the WCST but very poorly on the Milner Maze. The most able autistic boy, on the other hand, performed normally on the Milner Maze but poorly on the WCST. The variation in perseverative errors was notable, with four subjects making 0 or 1 such error and one boy making 42 such errors. The two groups of normal children did not differ significantly from each other on any of the measures, despite their age differences.

A discriminant function analysis was carried out to ascertain whether test performance could discriminate between the three groups. Seventy-eight percent correct discrimination was achieved. Ten autistic children were correctly classified, with 2 children misclassified as MA controls. Within the CA group, 3 subjects were misclassified as autistic. Two MA controls were misclassified as CA controls and 1 as autistic. The discriminant function was based on all but the Rey figure copy scores, with the Milner Maze data and WCST errors being the variables most highly correlated with the function

Table II. Discriminant Function Analysis: Correlations of Variables with Function

Milner Maze total errors	.66
WCST total errors	.51
Milner Maze time	.49
WCST correct responses	.43
WCST perseverative errors	.38
Rey Figure recall time	.35
WCST Nonperseverative errors	.28

(Table II), that is, the most discriminating tests. Figure of Rey copy scores were entered into the analysis but did not emerge as significant discriminators.

Ideally, a factor analysis should have been done on these data. However, the small *n*s precluded this. Correlations between performance on the various tests for each of the groups separately (Table III) show some coherence in the data with an apparent perseveration factor, a Rey Figure factor, and a Maze plus Rey Figure factor emerging.

Thus autistic children do show frontal lobe type processing problems when compared with children of similar mental or chronological age. However, it would be simplistic to conclude from this study that frontal lobe deficits are a strong candidate for an explanation of autistic disabilities. Not only do we lack any neurophysiological evidence to corroborate our findings but it is highly likely that deficits at lower levels of cortical or subcortical functioning would lead to difficulties with the higher order processing, planning, and organizational skills which are required for successful performance on the tests we have used (Couchesne et al., 1988). Moreover the relationship between the tests selected and particular lesion sites is not an inevitable one. The adult neuropsychological literature shows that the reliability and validity of neuropsychological testing of adult populations is far from ideal; these problems may be magnified when child populations are studied (Rourke, Bakker, Fisk, & Strang, 1983). Comparisons with previous studies with children using the tests selected here are difficult because of variations in subject samples, and varying versions of the tests (e.g., Chelune & Baer, 1986, for WCST). Rumsey and Hamburger (1988) found deficient performance in the WCST in a comparison of older autistic men and controls, but Schneider and Asarnow (1987) did not find more perseverative errors in autistic subjects of comparable MA and IQ to those in our sample, by comparison with normal controls.

It appears that the copying of a complex figure does not present problems for autistic children at least in this ability range. They are able to plan and organize as rapidly and as effectively as normal children. However, they do significantly less well in producing the figure from memory indicat-

Table III. Significant Correlations Between Test Performance

Group		r	p	
Autistic	WCST perseverative errors + Milner Maze total errors	.70	.006	) Perseverative
	WCST perseverative errors + Milner Maze time taken	.83	.000	) factor
	Milner Maze errors & Rey Figure copy score	−.55	.03	) Maze & Rey
	Milner Maze errors & Rey Figure recall score	−.54	.03	) Figure factors
	Rey Figure copy time & recall score	.75	.003	) Rey Figure
	Rey Figure copy score & recall score	.57	.03	) consistency in
				) copy & recall
MA control	WCST total errors & Rey recall time	.60	.02	
	WCST total correct & Milner Maze time	−.54	.03	
	WCST perseverative errors & Rey copy time	.54	.03	
	WCST perseverative errors & Rey recall time	.58	.03	
	Milner Maze errors + Rey copy score	−.67	.008	) Maze &
	Milner maze errors + Rey recall time	−.61	.02	) Rey Figure
	Milner Maze errors + Rey recall score	−.53	.04	) factor
	Rey Figure copy time & recall score	.51	.05	) Rey Figure
	Figure copy score & recall score	.75	.002	) consistency
CA control	WCST perseverative errors & Rey Figure copy time	−.58	.02	
	Milner Maze time & Rey Figure recall score	−.7	.006	Maze & Rey Figure factor
	Rey Figure copy time errors & Rey Figure recall score	.73	.003	Rey Figure consistency

ing problems with storing of material in a coherent way. This is the area that is claimed to be most sensitive to frontal lobe impairment (Lhermitte, Derouesne, & Signoret, 1972). Perseveration of lines was a common feature in their reproductions and there was a tendency to recall details of the figure, rather than the outline. The copying of the Rey Figure of course taps into an area of strength for many autistic children, visuospatial processing (Hoffmann & Prior, 1982; Shah & Frith, 1983), so it is likely that these abilities minimize any presumed deficit in frontal lobe-mediated processing. Nevertheless the approach to copying was often disorganized and the autistic children often selected minor aspects of the model to copy first rather than the overall figure.

The Milner Maze perhaps brought out the most characteristic problems of autistic children. For the most part they were not able to learn effectively by their mistakes, they perseverated with maladaptive strategies, making the same mistakes repeatedly, and seeming unable to conceive of a strategy to overcome their difficulties. Many of them needed the rules explained repeatedly during testing. Some appeared unable to retain information about corrent portions of the path and verbalized the fact that they were "lost." It was as if each trial was a new experience for them. Younger children showed impulsive responding. Emotional reactions to the difficulties varied from apparent indifference and disinterest, to annoyance and frustration. From a normative perspective, it appears that the Milner Maze test is appropriate for children of 12 and above in that their performance approximates that of normal adults; however its length may need to be modified for younger children. Many control children worked on a counting strategy in order to complete the maze.

One obvious difficulty for the autistic children was sorting into categories (i.e., formation of concepts). This had been noted also in our earlier study using the Weigl Colour Form Sorting Test (Hoffmann & Prior, 1982). Even when aware of making errors, autistic subjects were unable to change their behavior to achieve correct responses, and many perseverated in strategies. For those who were able to obtain categories, the verbalization of abstractions such as color, shape, or number seemed beyond their capacities.

Task performance relationships (see Table III) indicated that only the autistic group produced what might be called a perseveration factor—common to the WCST and the Maze. The Rey Figure appeared to produce a relatively independent factor as well as being related to maze performance for all three groups. These results suggest some commonality of underlying processes which in the conventional neuropsychological literature might be termed frontal lobe functioning. If this is accepted, then autistic children undoubtedly showed frontal lobe deficits except when good visuospatial abilities compensated for lack of planning and organizational ability, as in the Rey Figure.

The group discrimination accuracy of 78% shown in the discriminant function analysis, while far from perfect, does support the specificity of autism-related deficits in a design involving close matching on developmental factors. The variables having most weight in subject classification were those involving planning and response to feedback, clearly implicating frontal lobe functions. Control subjects misclassified in the discriminant function analysis tended to be those who had particular difficulty with the maze task. Since the autistic children in this study were deficient in verbal skills by comparison with controls, it must be acknowledged that verbal handicaps could have influenced their performance in a significant way. However, it is not immediately obvious why such deficits should not have had similar effects across all tests. Perhaps verbal rehearsal assisted nonautistic children with the Milner Maze and the WCST, but was not so relevant with the Rey Figure. However autistic children did talk to themselves at least during the Maze task albeit in a nonadaptive way.

Further research and theory which draws links between neurological and neuropsychological functioning and the kinds of cognitive disabilities typical of autistic children (i.e., the brain behavior relationships) is necessary before real advances are possible in our understanding of the disorder. However, the search for frontal lobe dysfunction appears a basic focus for future research and one that has implications for strategic remedial education for these children.

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