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A Comparison of Cognitive/Neuropsychological Impairments of Nonretarded Autistic and Schizophrenic Children

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The performance of children meeting DSM-III criteria for schizophrenic disorder and infantile autism and of normal children (ages 7 years 10 months to 14 years 4 months) was compared on the Wisconsin Card Sorting Test, Rey's Tangled Line Test, Benton Judgment of Line Orientation, Digit Symbol Substitution Test, and Peabody Picture Vocabulary Test. The mean performance IQ of the schizophrenic and autistic children was equal and in the normal range. The normal children were of average intelligence as estimated by the PPVT. As compared to normal children, both autistic and schizophrenic children were impaired on the DSST and RTLT. The autistic children had significantly lower scores on the PPVT than schizophrenic and normal children. The schizophrenic children made significantly more perseverative responses on the WCST than did normal children. They significantly increased their nonperseverative errors on the second half of the WCST, after having been taught the correct sorting principles. It is argued that in schizophrenia a core deficit in momentary processing capaci-

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ty underlies the above performance pattern. In contrast, in autism the core cognitive deficit involves an inability to use language to regulate and control ongoing behavior.

Both infantile autism and childhood onset schizophrenia are characterized by cognitive impairments. While the relationship between these two childhood behavior disorders has been hotly debated (see e.g., Bender, 1974; Rutter, 1972), ironically, the nature of the cognitive impairment in these two disorders has not yet been directly compared. The absence of studies comparing these two disorders may be in part due to the methodological problems arising from the difference in general level of intellectual functioning between schizophrenic and autistic children. Schizophrenia is associated with mild, general intellectual deficits. The mean IQ of schizophrenics across many studies is within the normal range of intellectual functioning (Chapman & Chapman, 1973a). Autism, in contrast, is usually associated with mental retardation, although about one-fifth to one-fourth of autistic children are reported to have IQ scores in the normal range (Rutter, 1983). Many of the cognitive impairments found in retarded autistic children are not observed in nonretarded autistic children (Bartak & Rutter, 1976), underscoring the importance of studying nonretarded autistic children to separate the core deficits in autism from impairments associated with retardation (Prior, 1979). This investigation compared groups of nonretarded autistic and schizophrenic children equated in performance IQ. Both groups obtained performance IQs in the normal range.

While some of the cognitive deficits seen in autistic children may merely reflect retardation, there is abundant evidence that certain cognitive, as opposed to affective or conative, impairments in autism may be primary (Rutter, 1983). Language and language-related functioning, especially verbal mediation and abstraction, are markedly impaired in nonretarded autistic children (Hoffman & Prior, 1982). Autistic children are characterized by an inability to use language to encode experience and regulate behavior.

In contrast, schizophrenic children do not appear to suffer from problems in processing linguistic stimuli or in using language to mediate their experience. Schizophrenic children appear to have a core deficit in the ability to mobilize and control the deployment of information-processing capacity (Asarnow, Sherman, & Strandburg, 1986; Sherman & Asarnow, 1985), which is reflected in the impairments they show on tasks that make extensive demands on momentary processing capacity (Asarnow & Sherman, 1984). There is also evidence suggesting that schizophrenic individuals are impaired not only on tasks that tax momentary processing capacity by limiting processing time (through the tachistoscopic presentation of stimuli) but on tasks that make demands on temporally extended cognitive processing. For example, schizophrenic individuals show impairments on tasks that require such functions as maintaining categories (Larsen & Fromholt, 1976), utilizing informational feedback to modify performance (Spaulding, 1978), and generating, maintaining, and discarding hypotheses on problem-solving tasks (Pueschel, 1980).

The present study used the Wisconsin Card Sorting Test (WCST; Grant & Berg, 1981) and Rey's Tangled Line Test (RTLT; Rey, 1964) to attempt to tease apart the nature of schizophrenic and autistic cognitive impairment. The WCST is a cognitive/neuropsychological task that makes extensive demands both on verbal mediation and on the subject's ability to engage in temporally extended problem solving. Thus, the WCST taps into the hypothesized core deficits in both autism and schizophrenia. Autistic (Hoffman & Prior, 1982; Kumagai, 1984) and schizophrenic (Fey, 1951; Stuss *et al.*, 1983) individuals have shown deficits on the WCST or related tasks.

We therefore anticipated that autistic and schizophrenic children would have similar performance levels on the WCST, though the underlying cognitive impairments might differ. To differentiate the core cognitive impairments underlying autistic and schizophrenic performance on the WCST, both groups were explicitly taught the appropriate sorting principles halfway through the test. When schizophrenic individuals are provided with the appropriate strategy (Koh, 1978), their performance can be normalized on certain memory tasks. In contrast, if autistic children are unable to use language to symbolize their experience and regulate their behavior, teaching them a verbal strategy should have little effect on their sorting performance. Consequently, it is predicted that teaching schizophrenic children the correct sorting principles would improve WCST performance, while autistic children would not improve. Normal children in the age range of this study should be able to identify spontaneously and use the appropriate sorting principle. Explicitly teaching them the correct sorting principles should therefore have no effect on their WCST performance.

The RTLT was also employed to differentiate between the cognitive impairments of schizophrenic and autistic children. The RTLT is a guided visual search task that, like the WCST, requires the deployment and regulation of attention for an extended period of time. Because of the extensive attentional demands of the RTLT, schizophrenic impairment on this task would be predicted. Past research has found that adults without a history of psychiatric disorder but with elevated scores on measures of psychosis-proneness show impairments on RTLT (Asarnow, Nuechterlein, & Marder, 1983).

Two alternate versions of RTLT were developed to differentially tap the respective core cognitive impairments of schizophrenic and autistic children. A longer version of RTLT was designed to tap the attentional impairments of schizophrenic children by making greater demands on deployment and regulation of attention than the original RTLT. Another version of RTLT was designed to tap the core cognitive impairments in autistic children by requiring subjects to form Gestalt closures over various discontinuities that were introduced into the lines. There is evidence that autistic children fail to perceive overall meaning in complex visual figures (Shah & Frith, 1983).

Subjects were also tested on the Benton Judgment of Line Orientation (BJLO; Benton, Varney, & Hamscher, 1978) to determine whether WCST and RTLT impairments reflect a more general cognitive deficit. The BJLO is a visual spatial/neuropsychological task that is thought to detect primarily right parietal lobe dysfunction in adults (Benton, Hannay, & Varney, 1975; Benton *et al.*, 1978). Lindgren and Benton (1980) suggest that the BJLO is a suitable test of visuospatial performance in children as young as 7 years old. Poor WCST and RTLT performance due primarily to attentional or verbal mediational impairment (frontal lobe dysfunction) should not be accompanied by poor BJLO performance. On the other hand, if subjects perform poorly on the BJLO, in addition to the WCST and RTLT, this would argue for the presence of a general cognitive deficit (or two specific cognitive deficits) not detected by IQ tests (since the groups were matched for performance IQs).

METHOD

Subjects

Eleven children who met DSM-III criteria for schizophrenic disorder, and 15 children meeting DSM-III criteria for infantile autism were studied.[4] The schizophrenic and autistic children were either living in residential treatment facilities or attending special programs for children with emotional and/or language disorders at the time of testing.

Case conference diagnoses of either schizophrenic disorder or infantile autism were used to screen children for inclusion in their respective target

[4]Our schizophrenic subjects were taken from a sample of schizophrenic children currently being studied at the Clinical Research Center for the Study of Childhood Psychosis at UCLA. Similar to our sample, the overall UCLA sample has a mean age of 11 years 8 months. Eighty percent of the children were found to have auditory hallucinations, and 46% suffered from formal thought disorder. These symptoms are consistent with other descriptions (Green *et al.*, 1984; Kolvin, Ounsted, Humphrey, & McNay, 1971) of the phenomenology of children meeting DSM-III criterion for schizophrenia.

groups. The children were then assigned a research diagnosis based on clinical interviews, using a semistructured interview modeled after the K-SADS. The data base collected on each subject also included (1) a developmental history as well as a history of the symptoms, derived in part from parental interviews; (2) an abstract of pertinent school records; (3) information from other professionals who previously treated the child, including records from previous hospitalizations. Children were considered to be schizophrenic or autistic only if two clinicians, either a psychiatrist and a clinical psychologist or two psychiatrists, agreed that the results of the parent/child interviews and the history indicated that a child met DSM-III criteria for either schizophrenic disorder or infantile autism.

Pediatric neurological screening and medical examination were used to ensure that none of the schizophrenic or autistic children included in the present study were found, either by history or by examination, to fit the diagnosis of organic brain syndrome. In addition, all target children achieved either a verbal or a performance IQ of 70 or above on the WISC-R.

A normal control group of 28 children, matched for mental and chronological age to both the schizophrenic and the autistic children, was also studied. These children were volunteers from Los Angeles area schools and service organizations. They were drawn from a wide range of socioeconomic backgrounds, comparable to those of the schizophrenic and autistic children. Parents of potential normal subjects were questioned about the medical/developmental history and school adjustment of their child to ensure that children with school, behavior, and/or neurological problems, as well as developmental delay or exposure to teratogens, would not be included in the normal control group.

Four of the schizophrenic children were receiving medication at the time of testing. Two were receiving antipsychotic medication (Mellaril or Stelazine). The schizophrenic child who was taking Stelazine was also taking Lithium Carbonate. One schizophrenic child (who was unable to complete any version of RTLT) was taking an antianxiety medication (Xanex), while another was taking Ritalin. Only one autistic child was taking medication: both an antidepressant (Elavil) and an antihypertensive (Inderal). Two normal subjects were taking medication for asthma.

Table I presents information describing the characteristics of the three subject groups. Simple one-way (3 groups) analyses of variance indicated that while the groups did not differ in chronological age, the three groups differed significantly on the mental age, $F(2, 51) = 8.37, p < .001$, and standard score, $F(2, 51) = 12.88, p < .0001$, measures of the Peabody Picture Vocabulary Test (PPVT; Dunn & Dunn, 1981). Newman-Keuls analyses for differences between pairs of groups revealed that the normal and schizophrenic groups did not differ from each other on either the standard or mental age scores of the PPVT. The autistic children, however, had

Table I. Group Characteristics and Task Performance

Variables	Normal (N = 28)		Schizophrenic (N = 11)		Autistic (N = 15)	
Sex						
Male	22		8		14	
Female	6		3		1	
	Mean	*(SD)*	*Mean*	*(SD)*	*Mean*	*(SD)*
Age	11.00	(1.72)	11.13	(2.31)	10.71	(2.14)
WISC-R						
Full scale			92.00	(11.08)	85.73	(14.56)
Performance			92.55	(19.28)	93.67	(13.55)
Verbal			90.82	(16.38)	80.13	(19.77)
PPVT						
Mental age[e]	11.15	(2.20)	10.75	(2.69)	7.85	(3.13)
Standard score[e]	100.46	(14.65)	96.45	(12.66)	71.60	(25.85)
DSST						
First[f]	43.75	(8.99)	27.45	(8.41)	28.20	(11.43)
Second[f]	43.64	(9.21)	24.82	(9.56)	26.29	(8.88)[d]
BJLO	21.29	(4.40)	19.18	(7.17)	20.38	(6.40)[c]
WCST						
Correct (1)	43.00	(8.53)	40.45	(6.56)	42.46	(6.33)[c]
(2)	46.64	(9.99)	38.36	(12.59)	40.62	(7.94)[c]
Perseverative						
responses[g] (1)	12.82	(6.71)	18.18	(8.98)	14.77	(7.47)[c]
(2)	9.96	(6.01)	13.91	(7.57)	14.23	(6.34)[c]
Nonperseverative						
errors[h] (1)	10.29	(4.96)	8.55	(3.47)	9.54	(4.07)[c]
(2)	8.82	(6.32)	14.18	(10.65)	11.08	(5.09)[c]
Categories						
achieved (1)	2.68	(0.98)	2.55	(0.93)	2.38	(1.19)[c]
(2)	2.71	(1.88)	1.91	(1.45)	2.15	(1.07)[c]
Lost sets (1)	1.43	(1.07)	1.73	(1.10)	2.62	(2.53)[c]
(2)	2.29	(1.82)	2.45	(1.21)	2.15	(1.52)[c]
RTLT						
L-RTLT	55.43	(16.64)	43.30	(19.08)[b]	44.00	(19.12)[a]
O-RTLT[i]	56.64	(16.62)	45.30	(16.79)[b]	42.44	(15.50)[a]
D-RTLT	55.86	(16.05)	45.90	(22.24)[b]	45.44	(18.35)[a]

[a]$n = 9$.
[b]$n = 10$.
[c]$n = 13$.
[d]$n = 14$.
[e]Autistic children significantly less than normal and schizophrenic children, $p < .05$.
[f]Schizophrenic and autistic children significantly greater than normal children, $p < .05$.
[g]Schizophrenic children significantly less than normal children, $p < .05$.
[h]Schizophrenic children significantly increased over conditions, $p < .05$.
[i]Significant main effect of group $p < .05$, and schizophrenic and autistic children significantly less than normal children. $p < .10$.

significantly ($p < .05$) lower mental age and standard scores on the PPVT than did the schizophrenic and normal children.

Since the PPVT is heavily verbally loaded and autistic children are known to have impairments in verbal abilities, scores on the performance subtest of the Wechsler Intelligence Scales for Children-Revised (WISC-R; Wechsler, 1974) were used as an index of general intellectual functioning for the autistic and schizophrenic children.[5] Between-group *t* tests revealed no significant differences between the autistic and schizophrenic groups on either the WISC-R verbal or performance subtests. Inspection of the scores (see Table I) indicates that the autistic children tended to score lower on the verbal subtest, while they closely matched the schizophrenic children on the performance subtest.

Materials

Two parallel versions of the DSST from the WAIS (Lewis & Rennick, 1979) were administered to all subjects. One was presented at the beginning of the session. The other was presented at the end of the session to measure fatigue and habituation effects.

As indicated above, the PPVT was administered to all subjects. The PPVT yielded both a mental age and standard score. The WCST, the RTLT (the original version and two variants), and the BJLO were also administered.

The WCST requires a subject to sort cards containing figures that differ in number, form, and color into categories according to a single sorting principle that must be discovered by the subject. The principle will be either color, form, or number. The sorting rules are changed after a subject has sorted 10 consecutive cards correctly. The correct principle changes from color to form, and then to number. If more than three correct categories are achieved during the test, the order of correct principle is repeated.

Prior to the first half of the WCST, subjects were given a deck of 64 cards and were told that they were to place each card beneath one of the four stimulus cards with which it might belong. They were also informed that they would not be told how to sort the cards but would be told after each sort whether they were right or wrong. They were to wait for feedback before sorting the next card. The WCST was administered following the

[5]WISC-R scores were available for all schizophrenic and autistic children as part of the screening conducted by the Clinical Research Center for the Study of Childhood Psychoses. Due to time limitations, WISC-Rs are not given as part of the screening of normal children. WISC-R scores were not available for our normal children.

procedure of Stuss *et al.* (1983). The three sorting principles were explained and demonstrated after the first half of the test. Instructions identical to those presented before the first half of the test were then repeated, and the subjects sorted the remaining 64 cards (second half). All scores were recorded separately for the first and second halves of the test.

The WCST yields a number of dependent measures, including the overall number of correct responses (number correct) and the number of runs of 10 consecutive correct responses made by a subject in completing a category (categories achieved). One measure of particular interest is the number of perseverative responses. Perseverative responses are sorts made according to either a principle that is no longer correct or a principle that consistently leads to an incorrect response. Errors made that are not perseverative were also measured (nonperseverative errors). Also of interest is a measure of inability to maintain set (Stuss *et al.*, 1983). This loss of set measure is recorded each time a subject sorts more than three consecutive cards correctly but loses this response set before the 10th consecutive card is correctly sorted.

The original RTLT (O-RTLT) requires subjects to visually track each of 16 lines from left to right, using no guides such as a finger or a pencil, through a changing course over which other lines are crossed. The subject responds by naming the numbered position (out of 24 possibilities) at which the line ends. The longer RTLT (L-RTLT) employs the same lines in the same complexity as the O-RTLT; however, the L-RTLT is 25% longer than the O-RTLT. The discontinuous RTLT (D-RTLT) is identical to the O-RTLT, except that at various points along each line, particularly where lines cross, gaps have been created.

Instructions to the subjects for the three RTLT tasks closely followed those suggested by Rey (1964). Subjects were instructed to follow each line across the page as quickly as possible without losing track of it, and then report the number at which it ended. Before each version of the RTLT, the instructions were repeated, along with a statement that the tasks might look familiar. For the D-RTLT, subjects were additionally instructed to follow the lines straight through the gaps. After each response on the three RTLT tasks, the stimulus was covered by a blank card so that subjects could follow lines only during the task, and not while the experimenter recorded their response. Each trial of all three RTLT tasks yielded an accuracy and a latency score. Latency was measured by a stopwatch accurate to two decimal places.

One score combining accuracy and latency was computed for each subject for each of the three versions of the RTLT task. Each of the 16 trials of a task was given a score scaled in accordance to the performance of a reference group of 40 normal subjects who were administered all three

RTLT tasks. The characteristics of the reference group, which included the 28 normal control subjects plus an additional 12 subjects were identical to those of the normal control group.[6]

Incorrect trials were given a scaled score of 1. Correct responses with the longest latencies (those falling in the longest 20% of the normal reference group's performance on that particular trial) were given a score of 2. Latencies falling in each successive quintile were assigned scores ranging from 2 through 6, from the longest to the shortest latencies. Scores were summed across the 16 trials for each RTLT task to arrive at one score that potentially ranged from 16, when all trials were wrong, to 96, when all trials were correct.

This scaling equated the three Rey tasks on range of scores and variance (see Chapman & Chapman, 1973b). The scaling of the three tasks essentially eliminates any differences among the three tasks within the normal group and equates the three tasks for level of difficulty. Any within-group differences then observed among the three tasks in the autistic and schizophrenic groups can then be attributed to the relative abilities of the groups to meet the differential demands made on cognitive processing by the three tests, not to differences in the difficulty levels of the three tests.

The BJLO consists of 30 successively presented pairs of lines. The lines in each pair are at varying angular orientations to each other, ranging (in 18-degree gradations) from 18 to 180 degrees. Subjects point to or name the two numbered lines that match the orientations of the two originally presented lines. Instructions were standard (Benton *et al.*, 1978). The dependent variable is the number of trials in which the subject selects the correct line pair.

Procedure

Children were tested individually in a well-lit room. They were seated at a table, in a comfortable chair. Upon arriving in the testing room, children were told that they would be participating in a study of how children use their different abilities to solve certain problems. Their verbal assent to participate was obtained before the sessions proceeded. Informed consent had been previously obtained from a parent or guardian.

Subjects were given the PPVT, and then form 1 of the repeatable version of the DSST. Subjects received the remaining tests in one of two

[6]The Normal Reference Group characteristics on the following variables in terms of means and standard deviations (in parentheses) were as follows: Chronological Age 11.14 (1.92); PPVT Mental Age 12.42 (3.93); PPVT Standard Score 104.82 (15.50).

counterbalanced orders. They received either the L-RTLT, BJLO, O-RTLT, WCST, and D-RTLT, or the reverse. Approximately half of the children in each group received each testing order. All subjects were then readministered a parellel form of the DSST.

The PPVT, DSST, and BJLO were administered using the procedures described above.

The entire testing session lasted less than 90 minutes, including brief rest periods.

RESULTS

The mean and standard deviations of correct responses on the DSST for each group on both administrations are presented in Table I. To explore the possibility of habituation or fatigue effects, within-group t tests were conducted to determine differences in performance between the first and second DSST administrations in each of the three groups. Only the schizophrenic group showed a significant, $t(10) = -2.65, p < .05$, performance decrement on the DSST second administration relative to the first. Though the 11 schizophrenic children may have become fatigued, fatigue effects were equally distributed across tasks through counterbalancing.

Table I presents the means and standard deviations of the three groups on five dependent variables (correct responses, perseverative responses, nonperseverative errors, categories achieved, and lost sets) for both halves of the WCST[7]. These variables were analyzed by five separate 3(groups – between) by 2(conditions – first vs. second half, within) mixed-model analyzes of variance, which used Least Square Mean approximations to correct for unequal sample sizes. These analyses revealed no significant effects for the number correct, categories achieved, and lost sets variables.

For the perseverative response measure, there was a significant effect of group, $F(2, 49) = 3.57, p < .05$. Simple effects were analyzed using a Newman-Keuls procedure, which revealed that the schizophrenic children had significantly ($p < .05$) more perseverative responses than the normal children. The autistic children were intermediate in their performance between the schizophrenics and normals and not significantly different from either group. Inspection of Table I suggests that there is a nonsignificant

[7]The performance of four autistic children on the WCST were not included in these analyses because they perseverated throughout the entirety of the task. Since two of these four children did not complete any other tasks, they were eliminated from all analyses and are thereby not included among the subject characteristics for autistic children studied.

tendency for normal and schizophrenic children to decrease the number of perseverative responses during the second half of the WCST relative to the first half, while autistic chidlren do not change as much. The main effect of condition approaches significance ($p < .06$) accordingly.

For the nonperseverative error measure, there was a significant group by condition interaction, $F(2, 49) = 4.03, p < .05$. The interaction was further explored by multiple t tests, which used Least Square Means estimations. To ensure an alpha level of $p < .05$, only preplanned comparisons (within-group) were explored. Only the schizophrenic children made significantly ($p < .05$) more nonperseverative errors during the second half of the WCST relative to the first half.

The scaled scores on the three RTLT tasks are presented in Table I.[8] Examination of the scores clearly indicates an absence of differences among the three tasks within each group. A 3(group—between) by 3(tasks—within) mixed-model analysis of variance using least square means approximations to correct the unequal sample sizes revealed a main effect of group that approached significance, $F(2, 44) = 3.04, p < .058$. There was no significant effect of task, nor was the group by task interaction significant.

There were no within-group differences across tasks. In addition, in all three groups there were highly significant correlations among the three RTLT tasks, ranging from $r = .64$ to $r = .97$ across the three groups for the nine correlations. Since the three tasks, contrary to our intentions, seemed to be highly equivalent, analyses focused on the O-RTLT. A simple one-way (between) group analysis of variance revealed that the O-RTLT significantly differentiated the three subject groups, $F(2, 44) = 3.44, p < .05$. A Newman-Keuls analysis, however, did not detect any significant differences between pairs of groups. Inspection of Table I indicates that the normal children tended to perform better than either the autistic or the schizophrenic children by at least 10 points. Autistic and schizophrenic performance was similar on the O-RTLT.

Information in Table I suggests that the three groups did not differ in their performance on the BJLO.[9] A one-way, between-group analysis of variance of the number of correct responses on the BJLO confirmed that

[8]Six autistic children and one schizophrenic child were unable to complete the RTLTs. Subject characteristics of the nine autistic children who did complete the RTLTs were identical to those of the complete sample of autistic children studied. The autistic children who completed the Rey's tasks obtained the following means and standard deviations (in parentheses) on the subject characteristics listed: Chronological Age 10.94 (1.90); PPVT Mental Age 8.18 (2.67); PPVT Standard Score 74.44 (24.14);WISC-R, Verbal 78.56 (18.87); WISC-R, Performance 91.0 (12.84).

[9]One autistic subject was unable to complete the BJLO.

the three groups of children did not significantly differ in their performance on this task.

Inspection of Table I also suggests that schizophrenic and autistic children made fewer correct responses on both forms of the DSST[10] than did the normal children. One-way, between-group analyses of variance on both the DSST, Administration 1 and DSST, Administration 2 revealed significant differences between groups, $F(2, 51) = 18.36, p < .0001$, and $F(2, 50) = 25.38, p < .0001$, respectively. Further analyses conducted using the Newman-Keuls test confirmed that, on both DSST 1 and 2, normal children made significantly ($p < .05$) more correct responses than did schizophrenic or autistic children, who did not differ from each other.

Intercorrelations between the neuropsychological tests (BJLO, DSST, RTLT, and WCST) and IQ measures were explored to determine the degree to which the neuropsychological task performance was independent of general intellectual functioning.

In the normal and schizophrenic children, verbal IQ was most strongly associated with performance on the second half of the WCST. This was true to a greater degree for the normal than for the schizophrenic subjects. In the normal subjects, out of the five performance measures on the second half of the WCST, three showed correlations with the PPVT standard score that were, or approached, significance of an alpha level of $p < .05$: nonperseverative errors ($r = -.36$), categories achieved ($r = .38$), and lost sets ($r = -.42$). In the schizophrenic subjects there were no significant correlations between the PPVT standard score and the second half WCST measures, but there was a significant ($p < .01$) correlation ($r = .73$) between the WISC-R, Verbal subtest and the lost sets measure on the second half of the WCST.

In autistic subjects, in contrast to the normal and schizophrenic subjects, verbal intelligence was most closely associated with performance on the first half of the WCST. PPVT standard score correlated significantly ($p < .05$) with correct responses ($r = .61$) and nonperseverative errors ($r = -.65$) on the WCST, first half, and the correlation between the WICS-R Verbal subtest and the WCST, first half, nonperseverative error measure $r = -.54$) approached significance at an alpha level of $p < .05$.

Measures of Performance IQ (available only for the autistic and schizophrenic subjects) were found to be associated most strongly with the BJLO. For autistic children BJLO scores were significantly ($p < .05$) correlated with the WISC-R Performance subtest ($r = .60$); for schizophrenic children this correlation ($r = .56$) approached significance ($p < .07$). In addition, the WISC-R Performance subtest was significantly ($p < .05$) cor-

[10]One autistic child was unable to complete the DSST, Administration 2.

related (r = .62) with the lost sets measure on the first half of the WCST in the schizophrenic children.

DISCUSSION

Consistent with predictions based on previous research, schizophrenic and autistic children were not impaired on the BJLO compared to normal children. The psychotic children, then, do not seen to have gross impairment of the visuospatial functions measured by the BJLO. One problem in making this assertion is that the BJLO was validated on adults with gross right parietal lobe pathology, and as such it is a measure of visuospatial *dysfunction,* as opposed to relative visuospatial *function.* The BJLO may be insensitive to individual differences in the normal range of functioning.

Autistic children showed impairments relative to schizophrenic and normal children in verbal functioning, as measured by the PPVT, which is sensitive to individual differences in the normal range of functioning. This was observed even though the autistic and schizophrenic children were matched on the WISC-R, Performance IQ.

Both the autistic and schizophrenic children performed less well than the normal children on the DSST tasks. The DSST is more sensitive to brain damage than other WAIS subtests and makes broad demands on cerebral functioning, including motor persistence, sustained attention, response speed, and visual-motor coordination (Lezak, 1983). Impaired performance of the autistic and schizophrenic children on the DSST might reflect dysfunction in any one or more of the multiple systems tapped by this test.

On the original RTLT the schizophrenic and autistic children tended to perform less well than the normal children. The original RTLT makes heavy demands on visual-motor coordination and sustained attention, both of which are normally associated with frontal lobe functioning (Crowne, 1983; Teuber, 1972).

The schizophrenic children had significantly more perseverative responses on the WCST than normal children. This finding is consistent with past studies of schizophrenic individuals (Fey, 1951; Stuss *et al.,* 1983). Autistic children's performance was intermediate to, but not significantly different from, that of schizophrenic and normal children on the perseverative response measure. The perseverative response measure is sensitive to frontal lobe damage (e.g., Drewe, 1974; Milner, 1963).

There is some evidence suggesting that this trend toward greater preservative responses in the autistic children may be tied to language development. Four autistic children who were tested, but whose results on the WCST were not reported, perseverated throughout almost the entirety of the WCST. These subjects stayed with one category regardless of verbal feedback. The four perseverating autistic children scored somewhat lower than the other autistic children on the performance subscales of the WISC-R. The four perseverators scored significantly lower on the verbal scale of the WISC-R, $t(15) = 2.34, p < .05$, than the other autistic children. Verbal ability may be related to perseverative responding for the autistic children.

As predicted, the provision of explicit instructions as to what the WCST sorting principles were did not affect the performance of autistic and normal children. It is likely that the normal children were well aware of the sorting principles before the manipulation. The same may be true of the autistic children, or they might have had trouble utilizing the verbal information provided by the manipulation. Verbal instructions did not have any effect on the performance of the four autistic children who perseverated throughout the second half of the WCST.

Contrary to our hypothesis and to the findings of Koh (1978), providing the schizophrenic children with a sorting strategy did not improve their performance. Rather, their performance significantly deteriorated after they were taught the relevant sorting principles. Stuss *et al.* (1983) also found that a similar manipulation had a deleterious effect on the WCST performance of chronic schizophrenics with prefrontal leucotomies. In addition, Pueschel (1980) found that schizophrenic individuals provided with verbal directions tended to decline in their performance on a hypothesis testing task. These findings are also similar to the findings of Rodnick and Shakow (1940) and Steffy (1978), who found, in their crossover studies, that added information (even task-relevant) sometimes impaired performance in schizophrenic individuals.

In sum, the schizophrenic children performed in the normal range on the PPVT and the WISC-R. Relative to normal children, they showed a higher number of perseverative responses across both halves of the WCST, a higher number of nonperseverative errors on the second half of the WCST, poor performance on the DSST and RTLT, and normal performance on the BJLO. The WCST, RTLT, and DSST all make extensive demands on processing capacity. The second half of the WCST makes even greater demands on processing capacity than the first half because of the demand to integrate a verbal instruction. Schizophrenic children, however, showed no impairment on tasks such as the PPVT and BJLO, which require more automatic processing of highly ordered or overlearned material.

The autistic and schizophrenic children obtained comparable scores on the performace subtest of the WISC-R. In comparison to the normal and schizophrenic children, however, the autistic children tended to have lower scores on the WISC-R Verbal subtest and significantly lower scores on the PPVT. The autistic children's level of perseverative responses on the WCST was intermediate to that of schizophrenic and normal children. Similar to the schizophrenic children, the autistic children performed well on the BJLO and performed poorly on both the DSST and the RTLT relative to normal children. The low scores obtained by the autistic children on two verbal IQ measures (PPVT and WISC-R, Verbal) suggest an impairment in language functions. It is possible that their difficulty in utilizing language to encode and regulate behavior may have resulted in their impaired performance on tasks like the DSST and WCST, which involve verbal mediation.

Few tasks significantly differentiated between the schizophrenic and the autistic children. The performance of the autistic children was significantly lower than the schizophrenic children's on the PPVT. Schizophrenic children increased the number of nonperseverative errors from the first to the second half of the WCST. Autistic children, however, showed no such change. The fact that so few measures differentiated between the schizophrenic and autistic children underscores the importance of matching the two groups on some index of general intelligence to eliminate differences between the two groups that merely reflect global IQ differences.

The impaired performance of the autistic children on the PPVT suggests that even in nonretarded autistic children there are impairments in language abilities. This impairment may be specific to language functions but may have pervasive effects on a wide variety of higher cognitive functions that require or are facilitated by verbal mediation. In contrast, schizophrenic children are not significantly impaired relative to normal children in verbal abilities. They, however, show impairments across a variety of tasks that make extensive demands on processing capacity by requiring the momentary integration of information from a variety of sources to direct an ongoing action. The provision of task-relevant information to the schizophrenic individual whose momentary processing capacity may already be overburdened results in the paradoxical effect of further impairment in performance.

Future research is needed to replicate the current findings. The many similarities found between autistic and schizophrenic children in the current study make our interpretations of the processes underlying the differences tentative. A number of interesting questions are raised by this study. Are autistic children specifically impaired in their use of language to mediate problem solving? If autistic children show a specific impairment in the use of verbal mediators, provision of nonlinguistic mediators should improve their performace. Does the performance of schizophrenic children depend more on the degree to which mediators tax momentary processing capacity than on whether they are linguistic or nonlinguistic mediators? The results of the present study suggest that highly overlearned or automatically processed mediators are most likely to improve the performance of schizophrenic children.

In this study we attempted to define the nature of the cognitive impairments of schizophrenic and autistic children by looking for disassociations between tasks. This was accomplished by comparing the relative properties of tasks on which each group showed deficits to those of tasks on which each group performed adequately in comparison to the normal control group. In future studies it will be important to ensure that observed disassociations between tasks reflect the relative cognitive adequacies and impairments in a subject group, rather than the relative psychometric adequacies of the tasks to detect individual differences. This can be accomplished by equating tasks in their psychometric properties (Chapman & Chapman, 1973b; Strauss & Allred, in press).

REFERENCES

Asarnow, R. F., Nuechterlein, K. H., & Marder, S. R. (1983). Span of apprehension performance, neuropsychological functioning and indices of psychosis proneness. *Journal of Nervous and Mental Disease, 171,* 662-669.

Asarnow, R. F., & Sherman, T. (1984). Studies of visual information processing in schizophrenic children. *Child Development, 55,* 249-261.

Asarnow, R. F., Sherman, T., & Strandburg, R. J. (1986). The search for the psychobiological substrate of childhood onset schizophrenia. *Journal of the American Academy of Child Psychiatry, 26,* 601-614.

Bartak, L., & Rutter, M. (1976). Differences between mentally retarded and normally intelligent autistic children. *Journal of Autism and Childhood Schizophrenia, 6,* 109-120.

Bender, L. (1974). Childhood schizophrenia. *American Journal of Orthopsychiatry, 17,* 40-56.

Benton, A. L., Hannay, H. J., & Varney, N. R. (1975). Visual perception of line direction in patients with unilateral brain disease. *Neurology, 25,* 907-910.

Benton, A. L., Varney, N. R., & Hamscher, K. deS. (1978). Visuo-spatial judgement. A clinical test. *Archives of Neurology, 35,* 364-367.

Chapman, L. J., & Chapman, J. P. (1973a). *Disordered thought in schizophrenia.* New York: Appleton-Century-Crofts.

Chapman, L. J., & Chapman, J. P. (1973b). Problems in the measurement of cognitive deficits. *Psychological Bulletin, 79,* 380-385.

Crowne, D. P. (1983). The frontal eye fields and attention. *Psychological Bulletin, 93,* 232-260.

Drewe, E. A. (1974). The effect of type and area of brain lesion on Wisconsin Card Sorting Test Performance. *Cortex, 10,* 159-170.

Dunn, L. M., & Dunn, L. M. (1981). *Peabody Picture Vocabulary Test-Revised.* Circle Pines, Minnesota: American Guidance Service.

Fey, E. T. (1951). The performance of young schizophrenics and young normals on the Wisconsin Card Sorting Test. *Journal of Consulting Psychology, 15,* 311-319.

Grant, D. A., & Berg, E. A. (1981). *Wisconsin Card Sorting Test.* Odessa, Florida: Psychological Assessment Resources.

Green, W. H., Campbell, M., Hardesty, A. S., Grega, D. M., Padron-Gayol, M., Shell, J., & Erlenmeyer-Kimling, L. (1984). A comparison of schizophrenic and autistic children. *Journal of the American Academy of Child Psychiatry, 23,* 399-409.

Hoffman, W. L., & Prior, M. R. (1982). Neuropsychological dimensions of autism in children: A test of the hemisphere dysfunction hypothesis. *Journal of Clinical Neurology, 4,* 513-531.

Koh, S. D. (1978). Remembering of verbal materials by schizophrenic young adults. In S. Schwartz (Ed.), *Language and cognition in schizophrenia* (pp. 55-99). Hillsdale, New Jersey: Erlbaum.

Kolvin, I., Ounsted, C., Humphrey, M., & McNay, A. (1971). The phenomenology of childhood psychoses. *British Journal of Psychiatry, 118,* 385-395.

Kumagai, T. (1984). Card sorting responses in autistic children: The frontal dysfunction hypothesis. *Japanese Journal of Special Education, 21,* 17-23. (From *Psychological Abstracts,* 1984, *71,* Abstract No. 28849)

Larsen, S. F., & Fromholt, P. (1976). Mnemonic organization and free recall in schizophrenia. *Journal of Abnormal Psychology, 85,* 61-65.

Lewis, R. F., & Rennick, P. M. (1979). *Manual for the Repeatable Cognitive-Perceptual-Motor Battery.* Gross Pointe, Michigan: Axon.

Lezak, M. D. (1983). *Neuropsychological assessment.* New York: Basic Books.

Lindgren, S. D., & Benton, A. L. (1980). Developmental patterns of visuospatial judgement. *Journal of Pediatric Psychology, 5,* 217-225.

Milner, B. (1963). Effects of different brain lesions on card sorting. *Archives of Neurology, 9,* 90-100.

Pueschel, K. M. (1980). *Neuropsychological assessment and "hypothesis testing" in schizophrenic and brain damaged patients.* Unpublished manuscript.

Prior, M. R. (1979). Cognitive abilities and disabilities in infantile autism. *Journal of Abnormal Child Psychology, 7,* 357-380.

Rey, A. (1964). *L'Examen clinique en psycologie [The clinical exam in psychology].* Paris: Presses Universitaires de France.

Rodnick, E. H., & Shakow, D. (1940). Set in the schizophrenic as measured by a composite reaction time index. *American Journal of Psychology, 97,* 214-225.

Rutter, M. (1972). Childhood schizophrenia reconsidered. *Journal of Autism and Childhood Schizophrenia, 2,* 315-337.

Rutter, M. (1983). Cognitive deficits in the pathogenesis of autism. *Journal of Child Psychology and Psychiatry, 24,* 27-41.

Shah, A., & Frith, U. (1983). An islet of ability in autistic children: A research note. *Journal of Child Psychology and Psychiatry, 24,* 613-620.

Sherman, T., & Asarnow, R. F. (1985). The cognitive disabilities of schizophrenic children. In M. Sigman (Ed.), *Children with emotional disorders and developmental disabilities* (pp. 153-170). Orlando, Florida: Grune & Stratton.

Spaulding, W. (1978). The relationship of some information processing factors to severely disturbed behavior. *Journal of Nervous and Mental Disease, 166,* 417-428.

Steffy, R. A. (1978). An early cue sometimes impairs process schizophrenic performance. In L. C. Wynne, R. L. Cromwell, & S. Matthysse (Eds.), In *The nature of schizophrenia: Approaches to research and treatment* (pp. 225-232). New York: Wiley.

Strauss, M. E., & Allred, L. J. (in press). Measurement of differential cognitive deficits after head injury. In H. S. Levin, H. M. Eisenberg, & J. Grafman (Eds.), *Neurobehavioral recovery from head injury.* New York: Oxford University Press.

Stuss, D. T., Benson, D. F., Kaplan, E. F., Weir, W. S., Naesser, M.A., Lieberman, I., & Ferrill, D. (1983). The involvement of orbitofrontal cerebrum in cognitive tasks. *Neuropsychologia, 21,* 235-248.

Teuber, H. L. (1972). Unity and diversity of frontal lobe functions. *Acta Neurobiologiae Experimentalis, 32,* 615-656.

Wechsler, D. (1974). *WISC-R Manual. Wechsler Intelligence Scale for Children-Revised.* New York: Psychological Corporation.