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Self-Reported Delinquency, Neuropsychological Deficit, and History of Attention Deficit Disorder

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This study was designed to evaluate the possibility that a pattern of cognitive deficit is associated with delinquent behavior, while avoiding some of the methodological problems of previous research. The Self-Report Early Delinquency instrument and a research battery of neuropsychological tests were administered blindly to an unselected cohort of 678 13-year-olds. Because the diagnosis of attention deficit disorder (ADD) was found at markedly elevated rates in the backgrounds of these delinquents, the possibility was examined that the neuropsychological deficits of delinquents might be limited to delinquents with histories of ADD. Although delinquents with past ADD were more cognitively impaired than non-ADD delinquents, both groups scored significantly below nondelinquents on verbal, visuospatial, and visual-motor integration skills. In addition, ADD delinquents scored poorly on memory abilities. Subjects with ADD who had not developed delinquent behavior were not as cognitively impaired as ADD delinquents, suggesting that it is the specific comorbidity of ADD and delinquency that bears neuropsychological study.

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There is a growing focus upon the role of central nervous system (CNS) factors in antisocial behavior, as evidenced by a number of recent books and reviews (Elliott, 1978; Lewis & Balla, 1976; Mednick & Moffitt, 1987; Mednick & Volavka, 1980; Moffitt & Mednick, 1988; Werry, 1986; Wilson & Herrnstein, 1985). This report focuses on juvenile delinquents' scores on neuropsychological tests as indicators of possible CNS dysfunction.

Twenty-five reports have been published of the neuropsychological test scores of juvenile delinquents (see Moffitt & Silva, 1988, for a complete citation listing). Across studies, the functions most consistently cited as impaired have been verbal and executive (abstraction, planning, inhibition of inappropriate responses, mental flexibility, sequencing, attention, and concentration). Though examined less often, memory abilities have also been found to be impaired. Visuospatial, sensory, and motor deficits have been found less consistently. Although these studies have used a wide variety of neuropsychological tests and have employed many different definitions of delinquency, the consistency of the reports has been impressive and suggests a robust effect. However, the findings must be viewed with caution because of several methodological shortcomings common to many of the studies.

The methodological problems of previous studies lie in the areas of subject selection, adequacy of controls, collection of neuropsychological data, and data analysis. In all of the studies reviewed, the subjects were a highly selected group: incarcerated volunteers, hospitalized violent adolescents, adjudicated recidivistic delinquents, or offenders referred for psychiatric evaluation. In addition, the subjects were well into their delinquent careers; in 19 of the 25 studies, the mean subject age was greater than 14 years. Samples of this type introduce several sources of bias. The subjects may have been involved in drug and alcohol abuse, fighting, or motor vehicle accidents (in which they may have sustained repetitive concussions). A history of truancy and/or institutionalization is also likely. Some of the studies reported that incarcerated subjects evidenced reactive depressive symptoms (Brickman, McManus, Grapentine, & Alessi, 1984), or were medicated with major tranquilizers (Krynicki, 1978; Yeudall, Fromm-Auch, & Davies, 1982). All of these factors may be expected to compromise performance on mental tests, suggesting that a delinquent life-style may result in neuropsychological deficit (Hare, 1984; Shanok & Lewis, 1981) rather than neuropsychological deficit predisposing to delinquency.

Nondelinquent comparison groups were used in only 11 studies and, when used, were usually nonrandomly recruited volunteers, higher in social class and education than the delinquents. The studies that failed to include nondelinquent controls compared delinquents' test scores to published norms or to standards of clinical judgment. It is far from clear that the published norms for most neuropsychological tests are adequate for benchmark com-

parison; their appropriateness for low social class, low education, and adolescent age groups is not well established.

In all but three cases (Appellof & Augustine, 1985; Karniski, Levine, Clarke, Palfrey, & Meltzer, 1982; Skoff & Libon, 1987) the choice of neuropsychological measures was apparently determined post hoc, on the basis of scores collected during routine clinical evaluation. As a result, the tests employed often tapped a restricted range of primary cognitive functions, making the interpretation of patterns of relative strengths and weaknesses difficult. In only one study (Pontius & Ruttiger, 1976) was the examiner blind to the subjects' delinquent status. Few studies cited evidence for the reliability and validity of the tests used.

Statistical treatment of the data was less than rigorous in most of the studies. As many as 30 individual *t* tests were reported in one table, without regard for the likelihood of Type I error. In general, little attention was paid to possible confounding variables. For example, gender and social class are known to covary with delinquency and with many neuropsychological test scores, yet only two studies controlled statistically for social class (Karniski et al., 1982; Wolff, Waber, Bauermeister, Cohen, & Ferber, 1982) and only three studies tested for sex differences (Andrew, 1982; Brickman et al., 1984; Yeudall et al., 1982).

Finally, previous research has failed to address the issue of the specificity of the obtained neuropsychological deficits to antisocial behavior per se. Longitudinal follow-up studies of hyperactive/attention deficit disorder (ADD) children have shown them to be somewhat disproportionately represented among delinquents in adolescence (Loney, Whaley-Klahn, Kosier, & Conboy, 1983; Satterfield, 1987; Weiss, 1983). It has long been postulated that the ADD-hyperactivity syndrome results from central nervous system dysfunction (e.g., Wender, 1971), and indeed "minimal brain dysfunction" has been among the many diagnostic labels for the disorder (Clements & Peters, 1962). Although there is controversy regarding the causal ordering of the association between ADD and neuropsychological deficit, it is well established that ADD subjects score poorly on many tests of cognitive function (for reviews, see Campbell & Werry, 1986; Douglas, 1983). It is possible that much of the cognitive deficit associated with delinquency could be explained by the presence of a significant number of cases with histories of ADD among delinquent samples.

The present study offers certain advantages. Sampling bias was avoided by the use of a large unselected birth cohort. Delinquency was assessed by the self-report interview method, supplemented by parent and teacher reports. The procedure allowed for the designation of delinquent and nondelinquent comparison groups unconfounded by the likelihood of police detection or incarceration. A research battery of neuropsychological instruments

was selected in keeping with the goal of testing a broad range of cognitive and motor skills. The cohort was large enough to allow for calculation of its own norms. Tests were administered blind to delinquency status, in a standardized format, within 1 month of the subjects' 13th birthdays. Thus, it is unlikely that any deficits found are the result of a protracted criminal lifestyle. Prospective data were available concerning the subjects' histories of childhood behavior problems, including ADD.

This research addressed three questions: (1) Is there any relation between neuropsychological status and self-reported early delinquency in unselected populations? (2) Is the relation mediated by gender or socioeconomic factors? (3) Is neuropsychological deficit associated with predelinquent inattention problems rather than with antisocial behavior?

METHOD

Subjects

Subjects were adolescents involved in the Dunedin (New Zealand) Multidisciplinary Health and Development Study. The cohort's history has been described by McGee and Silva (1982). Briefly, the study is a longitudinal investigation of the health, development, and behavior of a complete cohort of consecutive births between April 1, 1972, and March 31, 1973, in Dunedin, New Zealand. Perinatal data were obtained, and when the children were traced for follow-up at 3 years of age, 1,139 children were deemed eligible for inclusion in the longitudinal study by residence in the province. Of these, 1,037 (91%) were assessed. Since then, follow-ups have been conducted every 2 years. In all, 850 subjects (82% of the 3-year-olds) were available for study at age 13. McGee (1985) has compared children who were lost to the study at each age with those remaining by age 11 and found no systematic differences in social class, IQ, or a variety of behavioral variables. When compared with the New Zealand general population, the cohort is slightly biased toward higher social class levels; on a six-level social class scale (Elley & Irving, 1972), 7% of New Zealand males but 11.7% of cohort fathers were rated in the highest level. It is predominantly of European ancestry (less than 2% Polynesian) and is therefore comparable with similar white samples from other English-speaking Western cultures.

Only subjects with present data for every neuropsychological measure and the delinquency measure were included in the analyses. Of the 850 subjects who participated at age 13, 108 lived too far away to come into the research unit for neuropsychology and delinquency assessment. Of those who were available for testing, a small number had missing data for varied rea-

sons (e.g., 3 subjects' severe comprehension deficits precluded their understanding the self-report delinquency task, 1 subject's test anxiety prevented her from completing the neuropsychological tests, 1 institutionalized subject was psychotic and untestable, 1 subject had a broken wrist and could not perform the manual tasks). A total of 678 subjects had 100% present data. The 172 subjects not included in the analyses did not differ from the remaining subjects on WISC-R Full Scale IQ ($t(827) = .43, p = .66$) or parental report of subject's antisocial behvior (from the Socialized Aggression (SA) subscale of the Quay and Peterson (1987) Revised Behavior Problem Checklist (RBPC) ($t(828) = .53, p = .59$).

Variables

Delinquency. The Self-Reported Early Delinquency instrument (SRED, described fully in Moffitt & Silva, 1987) was administered to subjects by an examiner who was blind to their neuropsychological test scores. Briefly, this 58-item measure was designed specifically for use in New Zealand; it includes validity checks between card-sort and interview protocols, as well as screening and assistance for poor readers. It also provides a score weighted for item seriousness. One-month test-retest reliability ($r = .85$), internal consistency (Kuder-Richardson Formula 20 $r = .90$), and concurrent validity (with parental rating of RBPC SA, $r = .43, p < .001$) were assessed and found to be adequate. Thefts (especially shoplifting) accounted for 41.2% of acts reported by the subjects, minor assault for 24.7%, and vandalism and substance abuse for 10.7% and 9.9%, respectively.

A group of subjects most heavily involved in delinquent activities was identified by exploiting the possibility for agreement among four available sources of information about antisocial behavior. The advantages of this approach have been described by Loeber and Dishion (1983). Subjects could report themselves delinquent by scoring above the 85th percentile on the SRED. (Use of the 85th percentile cutoff was suggested by an observed discountinuity in the skew at this point in the distribution.) Parents could report their children delinquent by providing scores above the 85th percentile on the SA scale of the RBPC, which was completed at the time of the age 13 assessment. Teachers could report a child delinquent by giving him/her antisocial subscale scores beyond the 85th percentile on the Rutter Child Scale B (RCSB; Rutter, Tizard, & Whitmore, 1970), also completed when the subjects were 13 years old. All percentile ranks were calculated separately for boys and girls, so that group membership reflects serious delinquency *relative to same-sex peers.* A subject was assigned to the delinquent group if at least two reports met the above criteria, *or* if a file was found for him/her in the police district office. Thus, subjects could not name themselves delin-

quent without the consensus of at least one adult reporter. This reduced the chance of erroneous group assignment resulting from overzealous self-report. Likewise, a subject who underreported delinquent acts could nevertheless be designated delinquent by agreement between adult reporters. Seventy-one boys and 53 girls met these conservative criteria. Mean scores for the SRED were as follows: delinquent girls, 10.69; nondelinquent girls, 2.19; delinquent boys, 15.73; nondelinquent boys, 5.70. Eighteen of the delinquent group members were eventually excluded from the analyses reported here because they were among those without complete neuropsychological test data. The 18 did not differ from the 106 delinquents studied on either SRED score, $p = .55$, or WISC-R Full Scale IQ, $p = .17$.

Neuropsychological Measures. A 50-minute neuropsychological assessment and the WISC-R were administered in counterbalanced order by trained psychometrists who were blind to subjects' delinquency status. The tests administered, and selected citations regarding their reliability and validity, are presented in Table I. The criteria that guided instrument selection were that each test (1) be widely used and commonly known, (2) have published positive evaluations of reliability and validity, and (3) be brief and intrinsically interesting, in order to accommodate adolescent attention spans and maximize motivation. The WISC-R was administered according to standard protocol, with two exceptions: Two subtests were omitted because of time constraints, and certain Information subtest items have been modified for local relevance in the New Zealand version of the WISC-R. The other tests were administered in standardized fashion. Short forms of the Wisconsin Card Sort (three categories), Rey Auditory Verbal Learning Test (four learning trials), and Verbal Fluency (two trials) were used because pilot work showed that many adolescents became bored and frustrated by the longer versions.

Prior to the present study, the 14 neuropsychological test scores and the 8 WISC-R subtest scores had been submitted to a principal components analysis, with varimax rotation using a randomly selected half of the sample. This analysis is described in detail in Moffitt and Heimer (1988). Briefly, its purposes were to reduce the large number of cognitive variables to a smaller set of composite scores having greater reliability and to overcome problems for interpretation of results caused by intercorrelation between the measures. Five components were extracted that together accounted for 62% of the total variance in test scores. The interpretive labels assigned to the components were Verbal, Visual-Motor Integration, Visuospatial, Verbal Memory, and Mental Flexibility. Table II presents the results of this analysis. The principal components solution was successfully replicated using the remaining half of the sample. Scales were constructed as the mean of the standardized (Z) scores for the measures that loaded on

Table I. Research Neuropsychological Test Battery

WISC-R (8 subtests; Wechsler, 1974)
Grooved Pegboard (Bornstein, 1986; Klove, 1963; Knights & Moule, 1968)
Mazes (optional WISC-R subtest; Milner, 1965; Wechsler, 1974)
Rey Auditory Verbal Learning Test[a] (Rey, 1941; Ryan, Geisser, Randall, & Georgemiller, 1986; Taylor, 1959).
Rey-Osterreith Complex Figure (Osterreith, 1944; Waber & Homes, 1985)
Trail-Making Test, Forms A and B (Lewinsohn, 1973; Reitan, 1958)
Verbal Fluency[a] (Benton & Hamsher, 1976; Lezak, 1983)
Wisconsin Card Sort[a] (Berg, 1948; Heaton, 1981; Milner, 1963)

[a]Abbreviated version administered.

each component. This practice ensured that each measure would be given the same variance weight in the composite scale, regardless of its original metric. It also allowed reporting of group mean scores in a *Z* format, reflecting group deviation from the sample norms. The five component measures served as the dependent measures in the present study

Family Adversity. A measure of social-class-related factors was calculated on the basis of the model of Rutter's adversity index (Rutter, 1978). The index combined low parental education, low parental income, single-

Table II. Component Loadings, Percentages of Variance, and Interpretive Labels for Five-Component Principal Components Analysis with Varimax Rotation for Sample A

	Components				
Neuropsychological measure	Verbal	Motor integration	Visual-spatial	Verbal memory	Flexibility
Information	.86	.00	.12	.15	.03
Vocabulary	.85	.06	.11	.08	.04
Similarities	.80	.14	.09	.11	.18
Arithmetic	.69	.25	.19	.20	.03
Trails A time	.02	.79	.11	.10	.04
Coding	.19	.68	.10	.15	.04
Trails B time	.26	.59	.22	.24	.05
G. P. total time	.05	.55	.33	.00	.19
Rey O. recall	.10	.06	.80	.18	.14
Rey. O. copy	.19	.16	.77	.01	.15
Object assembly	.36	.27	.48	.05	.13
Mazes	.05	.00	.44	.13	.31
RAVLT delayed recall	.09	.20	.19	.81	.03
RAVLT last trial	.11	.29	.12	.76	.01
RAVLT first trial	.23	.04	.03	.72	.19
WCST % perseverative errors	.08	.04	.20	.06	.72
WCST responses to 1st category	.08	.07	.03	.01	.72
Percentage of total item variance	29.3	10.2	8.9	6.9	6.9

parent status, large family size, poor maternal mental health, and a relatively poor score on a measure of family social environment (Moos, 1974). Higher scores indicated greater adversity in the family environment.

History of Attention Deficit Disorder. Diagnoses of ADD (described in detail by Anderson, Williams, McGee, and Silva, 1987) were made at age 11 using the following criteria to ensure pervasiveness of the symptoms (Schachar, Rutter, & Smith, 1981): (1) The child reported symptoms meeting DSM-III criteria for ADD during an interview with a child psychiatrist who used the Diagnostic Interview Schedule for Children-Child Version (DISC-C; Costello, Edelbrock, Kalas, Kessler, & Klaric, 1982), and (2) either parent or teacher ratings on the inattention and motor hyperactivity subscales of the Rutter Child Scales A (for parents) or B (for teachers) (Rutter et al., 1970) provided independent consensus report of DSM-III criterion symptoms. The parent and teacher instruments did not tap enough symptoms to meet DSM-III diagnostic criteria, and so neither could be used to make the diagnosis independently. However, if a child failed to self-report all requisite symptoms, but parent or teacher reports filled in the remaining symptoms, the diagnosis of ADD was made. Data concerning problem behavior collected from parents and teachers when the children were 5 and 7 years old confirmed onset of the disorder before age 7. At age 11 the sex ratio for ADD so diagnosed was 5.1 boys to 1 girl, and 85% of the cases had more than two symptoms of hyperactivity in addition to their attentional problems.

RESULTS

A previous childhood diagnosis of ADD was found for 18% (2 girls and 17 boys) of the delinquent group, contrasted with a 2% prevalence of childhood ADD among the nondelinquents ($\chi^2 = 46.2$, $p < .001$). Indeed, of 33 cases of childhood ADD in the portion of the cohort studied here, 58% were found in the delinquent group at age 13. (The Pearson product-moment correlation between DISC-C inattention scale score and SRED score was .24, $p < .001$.)

Each of the five neuropsychological component measures was entered into a 4 × 2 analysis of covariance. Independent variables were group (nondelinquents, delinquents with histories of ADD, delinquents without histories of ADD, and nondelinquents with histories of ADD) and gender. In order to control for social class, the effects of the independent variables were assessed after the effects of the Family Adversity measure were partialed out. The Bonferroni inequality (Grove & Andreasen, 1982) was used to correct for the possibility of Type 1 error inherent in presenting multiple effect tests. Overall alpha was held to .01 by requiring p for the five individual F tests

of the main effect for delinquency group to reach .01/5 = .002. Planned contrasts (using the *t* statistic) tested between-group differences in neuropsychological scores. Cell numbers were as follows: 278 nondelinquent boys, 280 nondelinqent girls, 17 ADD delinquent boys, 2 ADD delinquent girls, 44 non-ADD delinquent boys, 43 non-ADD/delinquent girls, 12 ADD/nondelinquent boys, 2 ADD/nondelinquent girls.

Although main effects for gender were obtained with the Verbal, Visuospatial, and Verbal Memory measures ($p < .01$, uncorrected), there were no significant ($p < .01$, uncorrected) interactions between delinquency group and gender for any measure. Small numbers of girls in the two ADD groups did not allow examination of girls separately, but this low rate of ADD among girls reflects the population prevalence, and therefore the results are likely to be generalizable (Mednick, 1978). After controlling for Family Adversity, significant main effects for group ($p < .002$) were found for Verbal, Visuospatial, Verbal Memory, and Visual-Motor integration measures. Group means and standard deviations, collapsed across gender, are presented in Table III.

Correction for Type 1 error was also applied to each family of contrasts, at $p = .05/5 = .01$. Because gender by group interactions were absent, groups

Table III. Means and Standard Deviations of Standardized (*Z*) Neuropsychological Test Component Measures for Nondelinquents and Delinquents, With and Without Histories of Attention Deficit Disorder[a]

	Group[b]			
Neuropsychological component measure	Nondelinquent non-ADD	ADD non-delinquent	Non-ADD delinquent	ADD delinquent
Verbal[c]				
M	0.07	−0.17	−0.25	−0.89
SD	0.76	0.96	0.87	0.66
Visual-motor integration[c]				
M	0.08	−0.25	−0.10	−0.56
SD	0.55	0.60	0.57	0.95
Visuospatial[c]				
M	0.09	−0.24	−0.15	−0.47
SD	0.61	0.87	0.79	0.81
Verbal memory[c]				
M	0.08	−0.42	−0.08	−0.82
SD	0.79	0.61	0.76	0.80
Mental flexibility				
M	0.05	−0.18	−0.14	−0.02
SD	0.71	0.74	0.96	0.44

[a]Group *N*'s were as follows: nondelinquents, 558; ADD nondelinquents, 14; Non-ADD delinquents, 87; ADD delinquents, 19.
[b]Main effects for group were tested after the effect of Family Adversity was partialed out.
[c]Individual *F*'s, $p < .002$, corrected overall $p < .01$. Lower scores indicate greater neuropsychological deficit.

were collapsed across gender for the contrast analyses. Both the ADD and non-ADD delinquent groups differed significantly from the nondelinquents on the Verbal, Visual-Motor Integration, and Visuospatial measures. Although both delinquent groups differed from nondelinquents on these dependent measures, their neuropsychological deficits were not equivalent. ADD delinquents scored significantly below non-ADD delinquents on the Verbal and Visual-Motor Integration measures. The delinquents with histories of ADD differed significantly from both the nondelinquents and the non-ADD delinquents on Verbal Memory. Interestingly, subjects with a history of ADD who had not become delinquent did not differ significantly from any of the other three groups on any neuropsychological measure except one; the ADD nondelinquents scored significantly *better* on the Verbal measure than ADD delinquents. (Although significance testing indicated no difference between the ADD nondelinquents and controls, Table III shows that group means for this group were actually more distant from controls' means than were the means for the delinquent/non-ADD group on three dependent measures. Lack of statistical significance for these apparent group differences may be ascribed to low power from the small number of subjects in the ADD nondelinquent group.)

The results of the contrasts described above suggested the post hoc hypothesis that subjects evidencing both ADD and delinquency were distinct in certain ways from subjects with only ADD or only delinquency. Table IV presents comparisons of the 19 ADD delinquent subjects with the other three groups on parent and teacher ratings of their ADDH-related behavior problems at age 11 (inattention, motor hyperactivity, and aggressiveness), scores on a reading achievement test, "family adversity" scores, and SRED scores. Three planned contrasts compared the ADD delinquent group with each of the other three groups on each measure, with $p = .01/3 = .003$. (A more strict significance criterion was used for these families of contrasts because of the post hoc exploratory nature of the analyses.) The contrasts revealed that the two groups of ADD subjects could not have been distinguished by their parents' and teachers' ratings of their inattention or motor hyperactivity problems at age 11. However, both parents and teachers viewed ADD children who were later to become delinquent as significantly more aggressive at 11 than ADD children who did not become delinquent ($t(657) = 7.72, p < .001$). ADD delinquents had significantly poorer reading achievement than controls and non-ADD delinquents, but were not *significantly* ($p = .18$) poorer than the other ADD children on reading (although their mean reading score was lower). The ADD delinquents had come from homes characterized by greater family adversity than the other groups. Their SRED scores showed that they had engaged in significantly more delinquent behavior than even the other delinquent subjects ($t(677) = 3.1, p < .001$). These significant group differences were large; the ADD delinquent group's

Table IV. Means and Standard Deviations of Standardized (*Z*) Scores for Parent and Teacher Ratings of Behavior Problems, and Measures of Family Adversity, Reading Achievement, and Self-Reported Delinquency for Nondelinquents and Delinquents, With and Without Histories of Attention Deficit Disorder[a]

Measure	Group			
	Nondelinquent non-ADD	ADD non-delinquent	Non-ADD delinquent	ADD delinquent
Parents' behavior problem ratings, age 11[b]				
Motor hyperactivity[e]				
M	−0.08	1.25	0.15	1.02
SD	0.91	1.20	1.12	1.50
Inattention[e]				
M	−0.13	1.41	0.29	1.61
SD	0.88	1.39	1.00	1.33
Aggression[e]				
M	−0.11	0.21	0.34	1.64
SD	0.91	1.04	1.09	1.34
Teachers' behavior problem ratings, age 11[c]				
Motor hyperactivity[e]				
M	−0.12	1.80	0.06	1.98
SD	0.81	1.62	0.96	1.84
Inattention[e]				
M	−0.16	2.30	0.17	2.32
SD	0.81	0.98	0.92	1.15
Aggression[e]				
M	−0.13	1.41	0.13	2.38
SD	0.76	1.55	1.07	1.95
Additional measures				
Reading achievement[d,e]				
M	0.08	−0.69	−0.22	−1.13
SD	0.93	1.03	0.94	1.03
Family adversity[e]				
M	−0.01	−0.08	0.43	1.40
SD	0.95	0.98	1.18	1.35
Self-report delinquency[e]				
M	−0.14	−0.08	1.00	1.76
SD	0.78	0.72	1.48	2.07

[a]Group *N*'s were as follows: nondelinquents, 558; ADD nondelinquents, 14; Non-ADD delinquents, 87; ADD delinquents, 19.

[b]Parents completed the Rutter Child Scales A (Rutter, Tizard, & Whitmore, 1970), which had been supplemented with items tapping DSM-III symptoms of ADDH (McGee, Williams, & Silva, 1985). For all parent and teacher measures in this table, higher scores indicate more problems.

[c]Teachers completed the Rutter Child Scales B (Rutter, Tizard, & Whitmore, 1970).

[d]The Burt Word Reading Test at age 11 (Scottish Council for Research in Education, 1976). Higher reading *Z* scores indicate better reading achievement; higher Family Adversity and SRED scores indicate greater adversity and more delinquent activity.

[e]Individual *F*'s, $p < .001$, corrected overall $p < .01$.

mean problem scores were between 0.75 and 2 standard deviations greater than those of the comparison groups. (Because the non-ADD delinquent group contained proportionately more girls (50%) than the ADD delinquent group (10%), the girls' relatively lower SRED scores may have contributed spuriously to the group difference in SRED score. The analysis was repeated using only boys, and neither the direction nor the significance of the finding was altered.)

DISCUSSION

Several studies have reported neuropsychological deficits in juvenile delinquents. The nature of the methodological problems characterizing these studies (e.g., highly selected samples, inadequate controls, absence of blind assessment) cast doubt on the likelihood of replicating previously reported findings. Nevertheless, group differences in neuropsychological function were found in this controlled study of unselected subjects. In addition, this study is the first demonstration that mild neuropsychological deficits can be found among delinquents who have not had a history of attention deficit disorder.

The finding of neuropsychological differences was perhaps especially striking in light of the youth of the subjects and the mildness of their delinquent behaviors relative to the offense histories described for many of the subjects in American and British studies (murder, rape, multiple assaults). However, given the low crime rate of New Zealand, extent of perceived *deviance* of the behaviors relative to age and culture norms may not be dissimilar across research samples. Also, it is the case that early onset of delinquent activity is an excellent predictor of later serious recidivism (Farrington, 1983; Moffitt, Mednick, & Gabrielli, in press; Robins, 1966; Wolfgang, Figlio, & Sellin, 1972). Longitudinal studies of delinquency have invariably revealed that subjects who were the most deviant were also the most likely to retain their relative positions in the deviance continuum over time (for a review, see Loeber & Stouthamer-Loeber, 1987). Consequently, many of the members of the delinquent group in this study can be expected to develop more serious delinquency as they grow older. The ultimate test of the usefulness of neuropsychological variables in delinquency research will be whether they can prospectively predict later recidivistic offending. The subjects of this study are being reassessed for delinquency at age 15 with this test in mind.

One of the goals of this study was to illuminate any pattern of deficit found to discriminate delinquents from nondelinquents. Tests on which delinquents showed impairment fell into conceptually interpreted groupings reflecting verbal skills, visuospatial skills, and visual-motor integration. The finding

of verbal deficits replicated previous studies and is consistent with the theories of Hirschi and Hindelang (1977) and Buikhuisen (1987) wherein verbal learning deficits produce antisocial behavior through the medium of school failure. One important indicator of school failure, low reading achievement, was differentially characteristic of the subgroup of delinquents with past ADD in this cohort. Other writers have suggested the alternate hypothesis that verbal deficits prohibit children from developing internal verbally based means of inhibiting antisocial impulses (Savitsky & Czyzewski, 1978; Tarter, Hegedus, Winsten, & Alterman, 1984; Yeudall, 1980). Visuospatial and motor integration abilities were also found to be impaired in the present study, although less impaired than verbal functions. Few authors have emphasized interpretation of visuospatial or motor deficit, but Robbins, Beck, Pries, Jacobs, and Smith (1983) suggested that problems in visual processing and motor skills may serve to limit a child's opportunities to achieve outside of academics. That is, if poor verbal skills handicap school achievement, and other neuropsychological deficits preclude success in the arts or athletics, the resulting absence of prosocial sources of self-esteem increases the risk of antisocial behavior. To the extent that verbal and visuospatial functions are subserved by opposite hemispheres of the brain (but see Moscovitch, 1979), the presence of deficits in both functional areas failed to provide support for Flor-Henry's (1978) theory of specific left hemisphere cerebral dysfunction in antisocial behavior.

Delinquents with and without histories of ADD were examined separately in order to determine if delinquency-related cognitive deficits were limited to delinquents with childhood ADD. The cognitive deficits of ADD delinquents were notably greater than those of non-ADD delinquents, especially in verbal and verbal memory functions. Nevertheless, the performance of non-ADD delinquents was significantly poorer than that of controls on three of five neuropsychological measures. Surprisingly, the performance of ADD subjects who had not become delinquent was much less impaired than the performance of ADD delinquents. In fact, nondelinquent ADD subjects' tested verbal skills were significantly *better* than the verbal skills of delinquent ADD subjects. Parent and teacher ratings of inattention and hyperactivity could not have prospectively differentiated the two ADD groups. This finding suggests that attention deficit cannot be viewed as a univariate explanation for poor neuropsychological test performance. Rather, future research is needed to elucidate the relation between neuropsychological impairment and the comorbidity of aggressive behavior and ADD. In one study of this comorbidity, Satterfield and Schell (1984) reported prospective group differences in amplitudes of the N2 component of the auditory event-related potential, suggesting that more optimal cortical arousal may have characterized ADDH boys who did not become delinquent relative to those who did.

In a review of longitudinal studies of predictors of later recidivistic serious (FBI index) criminal offending, comorbidity of ADD and antisocial behavior has been found to be a better predictor than early self-reported delinquency alone (Loeber & Stouthamer-Loeber, 1987). Farrington, Loeber, and van Kammen (1987) found a strong interactive predictive effect of ADDH symptoms and childhood conduct disorder on adult chronic criminal offending. Findings presented here suggest that it is a subgroup of ADD children distinguished by neuropsychological dysfunction, aggressive behavior, and adverse family circumstances who are at special risk for delinquent offending. (In another report—Moffitt & Silva, 1988—we have demonstrated that a linear combination of neuropsychological variables can explain variance in delinquency beyond that accounted for by family adversity.) Results of the present research suggest that the neuropsychological functions of delinquents with histories of ADD deserve an especially close look for construction of developmental theories of criminal offending.

It is important to point out that neuropsychological measures are of little utility in identifying unknown delinquents in the general population. Nevertheless, knowledge of delinquency-related patterns of cognitive dysfunction may (1) increase our understanding of the etiology of delinquency, (2) enable us to identify specific delinquency-related patterns of deficit that can be targeted for preventive intervention, (3) add to the growing list of warning signs for the early identification of children at risk for developing seriously delinquent life-styles, and (4) provide information in support of theory construction.

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