ORIGINAL ARTICLE

Cognitive Impairments in Patients With Schizophrenia Displaying Preserved and Compromised Intellect

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Background: Although intellectual and neurocognitive deficits accompany schizophrenia, there are inconsistencies in the literature concerning issues of intellectual decline, premorbid deficits, a modal deficit pattern, and preserved abilities.

Methods: A battery of neuropsychological tests was administered once to 117 consecutively admitted patients with chronic schizophrenia and a group of 27 healthy control subjects to examine patterns of premorbid and current intellect (measured by means of reading scores and IQ, respectively) and the attendant cognitive profiles in schizophrenia using classification methods based on clinically derived (IQ levels) and atheoretical (cluster) techniques.

Results: Sixty patients (51%) with schizophrenia who displayed a general intellectual decline of 10 points or greater from estimated premorbid levels also exhibited deficits of executive function, memory, and attention. Twenty-eight patients (23%) with consistently low estimated premorbid intellect and current intellectual levels who displayed no evidence of IQ decline exhibited language and visual processing deficits in addition to deficits present in the intellectually declining group. The remaining 29 patients (25%) who displayed average estimated premorbid intellectual levels did not show IQ decline and exhibited a cognitive profile similar to normal, with the exception of executive function and attention impairment. Atheoretical analyses support the findings from clinically derived subgroups.

Conclusions: These results suggest that IQ decline, although modal in schizophrenia, is not universally characteristic and that executive function and attention deficits may be core features of schizophrenia, independent of IQ variations.

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SCHIZOPHRENIA HAS been characterized by executive function, attention, memory, and general intellectual deficits. Intellectual decline may occur subsequent to onset of schizophrenia.[1-3] In monozygotic twin pairs discordant for schizophrenia, Goldberg et al[4] demonstrated a 10-point IQ discrepancy in favor of the unaffected twin. Longitudinal studies support intellectual decline,[5,6] as do studies of first-episode patients.[1]

However, intellectual declines after the onset of schizophrenia are not universal.[7] Russell et al[8] suggested that any subsequent intellectual deficit is due to an early decline that predates onset of schizophrenia. In fact, the schizophrenia literature is replete with evidence of low premorbid function.[9] Numerous reports document low premorbid IQ in children who later develop schizophrenia.[3,10-15] Large birth cohorts have shown subtle but significantly lower premorbid levels of educational achievement, retardation in attainment of neuromotor developmental milestones, premorbid speech abnormalities, or intellectual diminution in individuals who later develop schizophrenia.[16,17] Other large population-based cohorts[18,19] reported that patients with schizophrenia displayed higher frequencies of low premorbid ability or IQ. Conversely, some studies have characterized high-functioning patients with schizophrenia who do not display intellectual decline.[20-22] For example, Palmer et al[23] reported that 27% of patients displayed a normal performance on a variety of cognitive measures, including IQ.

In the present study, we assessed a large sample of consecutively admitted patients with chronic schizophrenia. The cognitive domains of memory, attention, executive function, and visual perception were assessed. Premorbid intellect was inferred indirectly using the Wide Range Achievement Test–Revised (WRAT-R) Reading test. We addressed the following questions: (1) Is intellectual decline universally characteristic? (2) What other patterns of intellectual compromise or preservation might be present? and (3) What are the implications for other cognitive domains in patients whose premorbid and morbid intellect varies? Based on previous studies, we hypothesized that a group

SUBJECTS AND METHODS

SUBJECTS

One hundred seventeen patients, 84 males and 33 females, with a diagnosis of schizophrenia who were consecutively admitted to the National Institute of Mental Health Neuroscience Center at St Elizabeths, Washington, DC, participated in this study. The number of patients contributing to the analysis of any particular test outlined herein varied slightly because of patient compliance. A board-certified psychiatrist made the diagnosis by the Structured Clinical Interview for *DSM-III-R* using *DSM-III-R* criteria without knowledge of the neuropsychological evaluations. Patients who received concurrent Axis I psychiatric diagnoses or those who had a history of current substance abuse, head injuries with concomitant loss of consciousness, seizures, central nervous system infection, diabetes, or hypertension were excluded. Patients were classified into undifferentiated (63.3%), paranoid (25.6%), disorganized (9.4%), and residual (1.7%) subtypes. In addition to patients with schizophrenia, 27 healthy control subjects, recruited through the National Institutes of Health Normal Volunteer Office, participated in this study. Healthy control subjects with a history of psychiatric disorders, current substance abuse, head injuries with concomitant loss of consciousness, seizures, central nervous system infection, diabetes, or hypertension were excluded. All subjects provided informed written consent before participation in this study. The institutional review board of the National Institute of Mental Health reviewed and approved this study.

NEUROPSYCHOLOGICAL TESTS

Neuropsychological tests assessing several cognitive domains were administered to all subjects for 1 to 3 sessions by a practicing psychologist or psychometrician (T.W.W., T.E.G., J.M.G.) trained in administration and scoring of all tests. Scoring followed standardized procedures. Logical Memory I and II and Visual Reproduction I and II of the Wechsler Memory Scale–Revised (WMS-R)[24] and the California Verbal Learning Test (CVLT)[25] were administered as tests of declarative memory. The Boston Naming Test (BNT)[26] and Word Fluency[27] were administered as tests of verbal retrieval and lexical integrity. The vigilance and distractibility versions of the Gordon Continuous Performance Test (CPT)[28] were administered as tests of attention processes. A 128-card version of the Wisconsin Card Sorting Test (WCST)[29] was administered as a test of executive function and set shifting. The Benton Line Orientation Test[30] was administered as a test of visuospatial perceptual abilities. Forms A and B of the Trail-Making Test[31] were administered as tests of psychomotor speed. The Finger Tapping Test[32] was administered as a test of motor speed.

Current FSIQ Estimate

All subjects were administered a 4-subtest version of the WAIS-R,[33] consisting of the Arithmetic, Digit Symbol Substitution, Picture Completion, and Similarities subtests, to obtain an estimate of their current FSIQ.[34,35]

Premorbid IQ Based on WRAT-R Reading Scores

All subjects received the Reading subtest of the WRAT-R[36] to obtain an estimate of premorbid intellectual levels. The Reading subtest of the WRAT-R is thought to reflect preserved abilities, since it is a test of decoding skills that are routinely acquired before the onset of disease and appear to remain unaffected by the disease process in analogous fashion to the hold subtests (those tests that are insensitive to deterioration associated with normal aging and certain types of brain damage[37]) of the WAIS-R.[3,38,39] In monozygotic twin pairs discordant for schizophrenia, the unaffected twin scored on average 10 points higher than the affected twin with respect to IQ, whereas WRAT-R Reading scores were equivalent.[4] Furthermore, previous

of intellectually declining patients would display executive function, attention, and memory deficits; a nondeclining, high-functioning group would display a milder and more restricted range of deficits; and a group with both premorbid and morbid IQ deficits would display a broader spectrum of cognitive impairment. Healthy control subjects were included as a comparison group to determine the degree to which patients with schizophrenia deviate from normal on different cognitive measures and as a means of providing a form of validity for the use of Reading scores as a premorbid intellectual measure.

To validate our patient grouping strategy, atheoretical cluster analyses were performed using Wechsler Adult Intelligence Scale–Revised (WAIS-R) Full-Scale Intelligence Quotient (FSIQ) and WRAT-R Reading scores. Cluster weights and between-cluster analyses of variance (ANOVAs) provided indices of internal homogeneity and external validity. Canonical analyses comparing IQ and FSIQ–WRAT-R Reading difference scores with all other cognitive measures were performed to determine the extent to which IQ and difference scores account for unique, nonredundant variance.

RESULTS

DEMOGRAPHIC AND CLINICAL CHARACTERISTICS

Table 2 lists sex ratios, mean age, duration of illness, age of first symptom onset, and age of first hospitalization. Duration of illness was measured from the time of each patient's first hospitalization.

At the time of testing, most patients (87%) were receiving typical neuroleptic medications, usually haloperidol, fluphenazine hydrochloride, molindone hydrochloride, or thioridazine hydrochloride. The remaining patients (13%) were receiving atypical neuroleptic medications, either clozapine or risperidone. Eighty-six percent of the preserved group, 83% of the compromised group, and 92% of the deteriorated group were receiving typical neuroleptic medication. No cognitive differences on the basis of medication status were discerned among the groups.

CLINICALLY BASED SUBGROUPING ANALYSES

Intellectual decline of at least 10 points from premorbid levels as measured by WRAT-R Reading occurred in ap-

studies have consistently demonstrated reading scores to be viable measures of premorbid intellect.[38-42]

Support for the validity of using WRAT-R Reading standard scores as measures of general intellect in the normal population can be found in **Table 1**, which demonstrates nearly identical means for WRAT-R Reading standard scores and the 4-subtest version of the WAIS-R FSIQ in the healthy control group. Consistent with other healthy samples,[43] the WAIS-R FSIQ and WRAT-R Reading standard scores in our healthy group were significantly correlated ($r = 0.74$, $P < .001$). The SD of the FSIQ–WRAT-R Reading difference scores was 11.5 in the total sample.

CLASSIFICATION OF PATIENTS

Clinically Derived Groups

Based on previous findings that demonstrated high-functioning, deteriorated, and compromised patients with schizophrenia,[1,4,8,23,44,45] patients were classified into 1 of 3 intellectual groups: (1) those displaying a meaningful decline in IQ (≥10 points) as evidenced by the difference between current IQ (based on a 4-subtest version of the WAIS-R FSIQ) and premorbid IQ (based on WRAT-R Reading standard score), hereafter referred to as *intellectually deteriorated*; (2) those displaying premorbid IQ based on WRAT-R Reading scores that were below 90, hereafter referred to as *intellectually compromised*, which is consistent with the work of David et al[18] and with conventional usage (less than the 16th percentile)[33]; and (3) those whose premorbid IQs based on WRAT-R Reading scores were above 90 and who demonstrated less than a 10-point difference between their premorbid IQ based on WRAT-R Reading and their current IQ, hereafter referred to as *intellectually preserved*. Existence of a 10-point IQ decline took precedence to either of the cutoff strategies described.

Empirically Derived Groups

Atheoretical canonical and cluster analyses were applied to the data to determine the validity of our clinically derived patient grouping strategy. We performed a cluster analysis on FSIQ and WRAT-R Reading scores using complete linkage and Squared Euclidean Distances to determine the number of clusters that might be present in the patient sample. Examination of the resulting dendrogram, a tree diagram that displays how individual observations are grouped, suggested a 4-cluster solution would be appropriate. Next we entered the data into a k-means cluster analysis, with the number of clusters equal to 4. Uniformly high classification accuracy across clusters (77.8% for cluster 1, 100% for cluster 2, 93.8% for cluster 3, and 100% for cluster 4) demonstrates excellent separation of the clusters. It is important to emphasize that the algorithm defining these groups was based entirely on FSIQ and WRAT-R Reading scores.

STATISTICAL ANALYSES

A χ^2 analysis was used to evaluate the dichotomous variable of diagnostic subtype in relation to intellectual subgroup. A χ^2 partitioning procedure was used to determine which of the diagnostic subtypes were represented among the intellectual subgroups beyond expected values. The χ^2 partitioning procedure allows more detailed analysis of a contingency table for which a significant χ^2 value has been obtained.[46]

With respect to the parametric data collected from the various neuropsychological tests, a series of ANOVAs were performed to determine which variables differed significantly among the different intellectual subgroups and healthy controls. For each of the ANOVAs, results were considered to be significant after consistently and uniformly applying a Bonferroni correction for multiple comparisons using $P \leq .002$, unless otherwise noted. Predetermined post hoc contrasts using least significant difference (LSD) analyses (with α set at .05) were performed on the basis of hypothesized differences among groups. All statistical analyses were based on 2-tailed tests of significance.

proximately half (51.3%) of the patients (the intellectually deteriorated group). Nearly a quarter of the patients (23.9%) showed low premorbid intellect based on WRAT-R Reading scores, combined with low average current IQ (the intellectually compromised group). The remaining 24.8% of the patients were intellectually preserved with both current and premorbid IQ based on WRAT-R Reading scores within normal limits. Table 1 provides the mean IQ and WRAT-R Reading standard scores for patients and controls.

NEUROPSYCHOLOGICAL DEFICITS

There were significant differences among groups on immediate and delayed visual reproduction from the WMS-R, the number of items recalled correctly from list A (trials 1-5) and the number of items recalled correctly during free recall after short and long delays from the CVLT, the number of items correctly named on the BNT, the number of items correctly identified on the Benton Line Orientation Test, a composite of the number of correct responses obtained during both the vigilance and distractibility portions of the CPT, the percentage of perseverative errors and the number of categories attained on the WCST, and the mean time to complete forms A and B of the Trail-Making Test (**Table 3**). After applying a Bonferroni correction, immediate and delayed logical memory of the WMS-R displayed near-significant differences among groups (Table 3). There were no significant differences among groups with respect to word fluency and finger tapping (Table 3). Post hoc LSD testing showed that the compromised group differed significantly from the preserved and healthy control groups on immediate and delayed visual reproduction of the WMS-R, all the measures of the CVLT, the BNT, the Benton Line Orientation Test, the CPT, the WCST, and Trails A and B (Table 3). Further LSD follow-up analyses revealed that the deteriorated group differed significantly from the preserved and healthy control groups on immediate and delayed visual reproduction of the WMS-R, all the measures of the CVLT, the WCST, and Trails A and B (Table 3). Additionally, the deteriorated group differed significantly from the healthy control group on the CPT and from the preserved group on line orientation (Table 3). Additional post hoc LSD analy-

Table 1. Mean (SD) Scores on Tests of Intellectual Abilities for Patients With Schizophrenia and Healthy Controls*

	Healthy Controls (n = 21-26)	Patients With Schizophrenia			F	*df*	*P*	Post Hoc Analysis†
		Preserved (n = 29)	Deteriorated (n = 56-60)	Compromised (n = 28)				
Wechsler Adult Intelligence Scale–Revised								
Arithmetic	10.27 (3.07)	10.52 (2.80)	7.22 (2.53)	5.93 (1.72)	23.89	139	<.001	a
Similarities	10.72 (2.54)	11.90 (2.35)	9.18 (2.88)	8.18 (1.54)	13.03	138	<.001	a
Picture Completion	9.77 (3.29)	9.93 (2.12)	8.21 (2.19)	7.75 (2.19)	6.44	139	<.001	a
Digital Symbol Substitution	9.52 (3.04)	8.21 (2.38)	6.29 (1.91)	6.12 (1.93)	15.19	133	<.001	b
Full-scale IQ	101.32 (13.58)	101.97 (11.50)	87.77 (10.13)	80.86 (5.11)	29.64	138	<.001	a
Wide Range Achievement Test–Revised								
Reading standard score	101.39 (16.20)	100.62 (11.62)	104.87 (10.51)	81.29 (9.47)	27.08	136	<.001	c

**Sample size varied with patient compliance and ability.*
†*a indicates healthy controls significantly different from preserved and deteriorated patients; b, healthy controls significantly different from all patient groups; and c, healthy controls significantly different from compromised patients.*

Table 2. Demographic Characteristics*

Characteristic	Healthy Controls (n = 27)	Patients With Schizophrenia		
		Preserved (n = 29)	Deteriorated (n = 60)	Compromised (n = 28)
Age, mean (SD), y	26.7 (9.9)	34.9 (6.8)	33.7 (9.1)	32.1 (8.1)
M/F	15/12	21/8	44/16	19/9
Duration of illness, mean (SD), y	. . .	11.9 (7.3)	12.4 (7.8)	9.4 (8.7)
Age of symptom onset, mean (SD), y	. . .	20.5 (4.8)	18.5 (4.9)	19.3 (4.6)
Age of first hospitalization, mean (SD), y	. . .	23.8 (5.9)	22.0 (6.1)	22.3 (5.4)
Diagnostic subtype, No. (%)				
Undifferentiated	. . .	18 (15.7)	34 (29.6)	22 (19.1)
Paranoid	. . .	10 (8.7)	14 (12.2)	6 (5.2)
Disorganized	. . .	1 (0.9)	10 (8.7)†	0 (0.0)

**The residual subtype was omitted because of the low incidence of patients in that category; therefore, the total number of patients with schizophrenia in this analysis equals 115.*
†*Significant deviation from expected frequency based on a* χ^2 *partitioning procedure where* $P<.01$.

ses demonstrated that the compromised group was significantly different from the deteriorated group on the basis of the BNT, Benton Line Orientation Test, and the number of categories attained on the WCST (Table 3). Finally, post hoc LSD analyses revealed that the preserved group differed significantly from the healthy control group on the basis of the CPT and number of categories attained on the WCST (Table 3).

OTHER RELEVANT VARIABLES

Based on a series of 1-way ANOVAs, there were no significant differences among any of the patient groups with respect to the duration of illness, age of first symptom onset, or age of first hospitalization (Table 2). The difference between the age of first symptom onset and the age of first hospitalization ranged from 3.0 to 3.5 years for each of the 3 groups.

INTELLECTUAL SUBGROUP AND DIAGNOSTIC SUBTYPE

On the basis of a χ^2 analysis, diagnosis was found to be significantly associated with the intellectual subgroups ($n=115$, $\chi^2_4=9.69$, $P=.05$). Disorganization was more likely to occur in the intellectually deteriorated group ($n=85$, $\chi^2_1,=7.75$, $P=.01$) (Table 2). There were no other deviations from expected frequencies with respect to the occurrence of a specific diagnostic subtype of schizophrenia in any of the neuropsychological subgroups.

EMPIRICALLY BASED SUBGROUP ANALYSES

Canonical Correlation Analyses

A separate canonical correlation procedure applied to the total sample of patients with schizophrenia revealed that root 1, on which FSIQ loaded primarily (–1.00) and the WAIS-R minus WRAT-R Reading difference score loading minimally (0.05), accounted for 0.20 variance ($n=117$, $\chi^2_{42},=168.28$, $P<.001$). Root 2, on which the difference score loaded (1.00) (FSIQ loaded minimally, 0.007), accounted for 0.06 variance ($n=117$, $\chi^2_{20}=38.91$, $P=.007$). These results indicate that both FSIQ and the FSIQ-WRAT-R Reading difference scores make independent contributions to the variance in other cognitive domains.

Table 3. Mean (SD) Scores on Neuropsychological Tests for Patients With Schizophrenia and Healthy Controls*

	Healthy Controls (n = 19-24)	Patients With Schizophrenia						
		Preserved (n = 20-29)	Deteriorated (n = 45-60)	Compromised (n = 21-28)	F	*df*	*P*	Post Hoc Analysis†
Wisconsin Card Sorting Test								
Categories	8.00 (2.50)	5.84 (2.48)	4.23 (3.31)	2.78 (2.24)	15.84	3, 116	<.001	f
Perseverative errors, %	11.34 (6.89)	16.05 (9.94)	22.36 (15.42)	26.65 (13.60)	6.40	3, 112	<.001	a
Gordon Continuous Performance Test								
Vigilance and distractibility total correct	56.84 (4.40)	51.04 (11.28)	47.62 (8.96)	45.57 (8.99)	6.61	3, 111	<.001	c, e
Benton Line Orientation Test	24.24 (4.49)	26.72 (2.95)	23.60 (5.15)	21.04 (5.52)	6.80	3, 131	<.001	d, e, g
Trail-Making Test								
Form A	25.50 (8.10)	36.14 (10.37)	49.31 (25.04)	46.57 (19.80)	9.32	3, 134	<.001	a
Form B	59.73 (18.80)	75.21 (27.24)	135.54 (78.04)	136.64 (75.66)	12.41	3, 134	<.001	a
Finger Tapping Test								
Dominant hand	48.42 (6.03)	48.92 (7.13)	45.47 (7.44)	45.23 (10.32)	1.70	3, 123	.17	h
Nondominant hand	45.42 (5.57)	44.26 (6.56)	41.00 (6.62)	42.74 (14.36)	1.63	3, 124	.18	h
California Verbal Learning Test								
List A trials 1-5	54.35 (11.52)	49.77 (8.34)	37.64 (13.61)	38.62 (11.25)	13.29	3, 107	<.001	a
Short-delay free recall	10.78 (3.40)	10.45 (2.48)	7.51 (3.52)	7.38 (3.34)	8.02	3, 105	<.001	a
Long-delay free recall	11.57 (2.83)	10.75 (2.63)	7.73 (3.73)	7.67 (3.07)	10.16	3, 105	<.001	a
Word Fluency	43.70 (10.58)	38.66 (11.91)	36.63 (10.86)	34.52 (9.32)	3.43	3, 135	.009	h
Boston Naming Test	51.52 (6.52)	53.41 (3.75)	50.69 (7.11)	45.85 (6.50)	7.13	3, 131	<.001	e
Wechsler Memory Scale–Revised								
Logical Memory I	26.88 (6.71)	23.24 (6.93)	18.68 (9.31)	17.86 (7.27)	4.50	3, 120	.005	h
Logical Memory II	23.63 (6.93)	19.07 (7.17)	13.93 (9.84)	14.07 (8.44)	4.67	3, 119	.004	h
Visual Reproduction I	35.37 (3.22)	33.34 (5.81)	27.56 (9.74)	27.86 (7.37)	7.28	3, 131	<.001	a
Visual Reproduction II	29.68 (8.51)	28.97 (7.83)	21.33 (12.00)	20.50 (7.79)	7.02	3, 130	<.001	a

*Sample size varied with patient compliance and ability.

†*a indicates healthy controls and preserved patients significantly different from compromised and deteriorated patients; c, healthy controls significantly different from all patient groups; d, preserved patients significantly different from compromised and deteriorated patients; e, compromised patients significantly different from all other groups; f, all groups significantly different from each other; g, deteriorated patients significantly different from all other patient groups; and h, no significant differences among groups.*

Cluster Analyses

Cluster 1 was composed of 9 patients displaying high FSIQ and WRAT-R Reading scores. This atheoretically derived group was similar in nature to our previously defined preserved group. Cluster 2 was composed of 52 patients displaying a mean 8.9-point intellectual decline based on WRAT-R Reading score. Cluster 3 was composed of 32 patients displaying a mean 14.9-point intellectual decline based on WRAT-R Reading score. Taken together, these 2 declining clusters are analogous to our deteriorated group. In the fourth cluster, consisting of 24 patients, both FSIQ and WRAT-R Reading scores were well below average, consistent with our previously described compromised group.

We next used a series of ANOVAs to examine between-cluster differences on all non-FSIQ and WRAT-R Reading cognitive variables to assess within-cluster homogeneity and between-cluster heterogeneity (data available on request). The patterns of cognitive impairment among the atheoretical clusters were analogous to the patterns obtained on the basis of clinically driven cutoff scores. Thus, cluster 4 differed from all other groups on the WCST, CPT, memory tests, and, importantly (analogous to our previously described results in Table 3), tests of language and visual processing (line orientation and naming). In contrast, the 2 declining clusters exhibited impairments on CPT, memory, and WCST vis-à-vis healthy controls but no deficits on naming or line orientation. The preserved cluster did not differ from the healthy control group on any of the cognitive variables assessed.

Parenthetically, however, we note that the mean FSIQ score was higher in cluster 1 (mean, 116.11) than in the healthy control group (mean, 101.32). Therefore, a subsequent ANOVA was performed in which the patients with schizophrenia from cluster 1 (FSIQ: mean, 116.11; SD, 11.13) were matched on the basis of WAIS-R FSIQ score with subjects from the healthy control group (FSIQ: mean, 112.44; SD, 7.20). The patients with schizophrenia from cluster 1 differed significantly from this matched healthy control group on the number of categories obtained in the WCST (patients from cluster 1: mean number of categories, 6.78; SD, 2.77; matched controls: mean number of categories, 9.44; SD, 0.88; $F_{1,16}=7.55$, $P<.01$). This result is consistent with the result obtained via the clinically driven cutoff scores. An ANOVA on the IQ-matched groups for CPT distractibility correct scores was not significant (cluster 1: mean number correct, 28.44; SD, 2.13; matched controls: mean number correct, 28.71; SD, 2.36).

COMMENT

In a large sample of patients consecutively admitted to a tertiary referral center, we found evidence for distinct patterns of cognitive dysfunction in schizophrenia. The results support previous findings of intellectual decline based on WRAT-R Reading scores in schizophrenia with associated deficits of attention, memory, executive function,

and oculomotor speed, although this diminution was obtained in only half of the inpatients with chronic schizophrenia in this sample. The remaining 50% did not appear to experience a significant intellectual decline. Of these nondeclining patients, approximately half (ie, 25% of the total sample) appear to be compromised on the basis of displaying mildly impaired premorbid IQs based on WRAT-R Reading scores and impairment in a wide variety of cognitive domains. The remaining patients evince a neuropsychological profile that resembles normal, with the selective exception of specific executive function and possibly attention deficits. The argument may be made that the delineation of IQ patterns creates a tautology, since all patients necessarily had to meet criteria for one category or another. However, there was no a priori reason to believe that the distribution would be as it was or that the preserved or compromised groups would display the pattern of deficits observed.

To validate our clinically driven subgroup strategy, we applied cluster and canonical correlation analyses to the patient data set. Cluster analytical results were consistent with the clinically driven cutoff score results. The clusters differed significantly from one another and from healthy controls in a manner that was broadly and strikingly similar to the patterns observed using clinically driven subgroups, thus providing a measure of external validity. Canonical correlation analysis demonstrated that IQ and IQ minus WRAT-R Reading score independently predicted other cognitive measures, providing weight to the fulcrum of our study. Although previous work[22,47] has demonstrated heterogeneity in the cognitive deficits displayed in schizophrenia, the present findings extend their results by demonstrating preservation and impairment for a wide variety of cognitive domains that follow in a principled way from patterns of preserved and compromised intellect.

The pattern of memory, visuospatial perception, attention, executive function, language, and psychomotor deficits in the compromised group was similar to the finding of Russell et al,[8] who found low premorbid IQ (mean IQ, 84.1) in a sample of children who had early contact with child guidance clinics. These findings implicate widespread cortex dysfunction in the compromised group. The modal deteriorated patient group in our sample displayed an intellectual decline based on the use of WRAT-R Reading as a measure of premorbid intellect.[4-6,38,39,44,48,49] We recognize that this intellectual decline does not affect all cognitive domains equally. Intellectual decline observed in the deteriorated patient group was accompanied by memory, executive function, attention, psychomotor speed, and oculomotor scanning impairments and implicates frontotemporal dysfunction.[50] The pattern of cognitive deficits in deteriorated patients does not preclude a neurodevelopmental mechanism in the etiology of cognitive deficits in schizophrenia, since subtle neurodevelopmental changes may precede and set the stage for later cognitive impairment and psychiatric disturbance.[51] Furthermore, previous studies have demonstrated that this intellectual decline is limited to the period around symptom onset rather than being progressive throughout the illness.[52,53]

An unexpectedly large minority of patients (about 25%) were intellectually intact. This group may be informative in several respects. First, they confirm that antipsychotic drug therapy does not necessarily compromise performance on numerous cognitive tests. Second, they demonstrate that chronic schizophrenia can exist in the context of preserved intellect and cognition. This group may also speak to the ongoing controversies about whether there is a core cognitive deficit associated with schizophrenia. These patients displayed mild impairment only in the cognitive domain of executive function and, possibly, attention and encoding.

The preserved group was generally similar to those intellectually preserved groups previously described.[20-23,45,54] However, these cognitively intact patients appeared to be subtly impaired on the WCST relative to controls displaying equivalent overall ability, consistent with the results of Elliott et al,[45] who observed impaired performance on an analogue of the WCST in patients who displayed otherwise intact intellect.

There are several limitations to the present study. First, the design of this study was not longitudinal, and we did not directly obtain premorbid IQ scores. Clearly, using actual premorbid IQ estimates would make the strongest argument for intellectual decline with the onset of schizophrenia, and our results would suggest that such a study is warranted. A second limitation refers to the representativeness of our sample. Although we routinely admit patients with chronic disease, we believe that our sample is representative since we observed high-functioning patients, our total patient mean FSIQ of about 90 is similar to others, and our sex ratios are consistent with others.[55-57] Although an imperfect overlap between our atheoretical clusters and clinically driven subgroups constitutes a third limitation, we were struck by the fact that the atheoretical procedure would generate homogeneous groups, approximating real-world phenomena.

It is also possible that our results might be driven by general intelligence. Results of a principal components analysis of our patient data militate against this possibility. Briefly, 3 factors were extracted. The first might be considered a prefrontal executive or attention factor (with WCST loading), the second can be considered a verbal memory factor (with WMS-R logical memory loading), and the third can be considered to reflect IQ (with WAIS-R, WRAT-R Reading, language, and visual spatial processing loading). (Results are available on request.) Thus, IQ does not fully predict other cognitive impairments.

Cognitive deficits associated with schizophrenia, including those in intelligence, may emerge along several hypothetical developmental trajectories. One course may be characterized by profound and widespread cognitive impairment manifest from early development prior to psychotic symptom onset. A second course may be characterized by a circumscribed deficit pattern that includes intellectual decline and encompasses the domains of executive function, attention, and episodic memory, and may approximately coincide with psychotic symptom onset. Finally, a third group of patients have subtle cognitive deficits, apparently restricted to the domain of executive function. It is unclear whether these deficits precede or coincide with the onset of clinical symptoms.

It would appear that deficits associated with the function of the prefrontal cortex, ie, executive function defi-

cits (as indexed by the number of categories attained on the WCST), constitute a necessary type of cognitive impairment in schizophrenia, given their presence in the intellectually compromised and preserved groups, and are in keeping with the findings of Shallice et al,[58] who also found consistent evidence for executive impairment. Results from this study also appear to synthesize the schizophrenia neuropsychological literature with respect to (1) intellectual decline based on WRAT-R Reading score, (2) the presence of premorbid deficits based on WRAT-R Reading score, (3) a modal cognitive deficit pattern, and (4) preserved cognitive abilities. Previous studies have generally tended to focus on only 1 of the 3 cognitive groups of patients with schizophrenia.

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Correction

Error in Table Footnote. In the original article by Weickert et al titled "Cognitive Impairments in Patients With Schizophrenia Displaying Preserved and Compromised Intellect," published in the September 2000 issue (2000;57:907-913), Table 1 on page 910, the first part of the second footnote should have read "a indicates healthy controls significantly different from deteriorated and compromised patients; . . . "