NEUROPSYCHOLOGICAL ASSESSMENT OF COGNITIVE DISORDERS WITH THE LURIA-NEBRASKA BATTERY.

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Summary: This study estimates the influence of schizophrenic formal thought disorders on cognitive functioning as revealed by the Luria-Nebraska (LN) neuropsychological assessment. Forty chronic schizophrenic patients were selected according to DSMIV. Twenty patients with severe formal thought disorders (+FTDs) were matched for age, sex, education, WAIS-IQ, chronicity, dosage, and hospital care with twenty schizophrenics chosen for absence or mild formal thought disorders (-FTDs). All subjects were administered the LN neuropsychological battery. Twelve out of 14 scales of the LN were sensitive to FTDs while most LN scales were not sensitive to severity of non-FTDs symptoms as measured by Andreasen's index. Discriminant function analysis of the LN results, correctly classified 95% of patients from normals, and 85% of -FTD and +FTD patients from the schizophrenic sample. The +FTD patients were significantly poorer on measures of sensori-motor and fronto-temporal functioning. The -FTD patients scored poorly on measures of fronto-basal functioning. Almost identical results were obtained when possible confounding effects of severity of other psychotic symptoms were removed through covariate procedures. Results support the association of FTD with neuropsychological deficits independently of severity of other psychotic symptoms.

Key words: Schizophrenia, Thought disorders, Neuropsychology, Luria-Nebraska, Language

INTRODUCTION

Schizophrenic formal thought disorders (FTD) involve problems with derailment of thinking, loose associations, overinclusion, deficits of abstraction (Spitzer RL, Endicott J, Robins E. 1975). There is a recent renewal of interest in the identification of a biological basis for cognitive abnormalities in schizophrenia as distinct from its psychotic pathology (Buschbaum MS. 1990; Crow TJ. 1990; Robins TW. 1990; Gur RE, Gur RC, Saykin AJ. 1990; Hardy-Bayle MC. 1994). Formal thought disorders or disorders of the thinking process are no longer considered to be secondary consequences of psychotic interference. Many authors considered them to be primary schizophrenia-specific symptoms, in contrast to content thought disorders (manifested in the bizarreness or low probability of word content) which are reliably shown to be secondary to psychotic processes and possibly to anxiety (Broen WE. 1968; Carr V, Wale J. 1986; Cattel RB. 1961; Schneider SJ. 1976). Neuropsychological assessment techniques can be used to reveal the structure and content aspects of schizophrenic thinking.

Golden et al. (1980), Moses et al. (1983), Lewis et al. (1979) identified cognitive differences among subgroups of chronic schizophrenics, according to their performance on the Luria-Nebraska Neuropsychological Battery (LN). The LN is a well established standardized reliable battery of the most ecologically relevant cognitive functions. They found that one schizophrenic subgroup was characterized by cognitive functioning that was clearly within normal limits. Another subgroup however showed significant abnormal cognitive functioning. One pervasive question in this field addresses the following issue: do sub-categories of the schizophrenics differ qualitatively in terms of symptomatology or only in terms of degree of severity of symptoms ? or both ? Our hypothesis is that a certain cluster of deficits (formal thought disorders) must be present at a significant degree, to produce a qualitatively distinct symptomatology, distinct from other categories. Severity of other aspects (content thought disorders, affective symptoms, psychomotor disorders) might not be as crucial in differentiating sub-groups of schizophrenics, but we propose along with other researchers that formal thought disorganization is essential.

Formal thought disorder may also be also involved with attentional dysfunctions (Bleuler E. 1991). Baribeau & Laurent (Baribeau J, Laurent J-P. 1986; 1991) showed that schizophrenics can be differentiated according to at least two patterns of attentional and cognitive disorders. Such attentional dysfunctions were reliably indexed by cognitive cerebral

evoked potentials (Hansen JC, Hillyard SA. 1980; Baribeau J. et al.,983). Schizophrenics with major formal thought disorders (+FTD) manifested hypovigilance with narrowed attention, slow, variable, uncertain signal detection regardless of channel filtering. On the other hand, schizophrenics with minor formal thought disorders (-FTD) manifested hypervigilance with labile attention and distraction between sensory channels. These group differences were independent of chronicity and of drug effects. The largest amplitude difference in the auditory evoked potentials appears over frontal regions of the scalp. Such attentional-related evoked potential differences have been replicated in many laboratories (Pritchard W. 1986; Hiramatsu et al. 1984) and in the same patients over 5-years period (Laurent J-P, Baribeau J. 1992). There is also limited psychometric evidence that suggests language functions may be affected by formal thought disorders (Harvey PD et al. 1992; Landre J. et al. 1992; Maher BA, Manschreck TC, Rucklos ME. 1981; Passerieux C. et al. 1995). Thus we propose that it is the severity of "formal thought disorders" which best differentiates between the two varieties of patients described above on neuropsychological batteries. The purpose of the present study is to determine the influence of formal thought disorders on the neuropsychological functioning of chronic schizophrenics. Formal thought disorder is also related to severity of schizophrenia. Consequently, covariate analysis will be used to control for severity of symptoms.

METHOD

Subjects

Fifty schizophrenic right-handed patients, as determined by the Harris test of lateral dominance, were diagnosed according to DSMIV criteria and the SADS (Schedule for Affective Disorders and Schizophrenia). All were chronic schizophrenics and has been institutionalized for at least 5 years with an average of approximately 10.5 years. Individuals with seizures, neurological disorders, EEG abnormalities (slow waves, spikes), and drug abuse were excluded.

Out of the original fifty, forty schizophrenic patients were selected based on extreme scores on the Bannister-Fransella Grid Test for Formal Thought disorders. Twenty patients (+FTD) scored above 1200 on this scale while 20 others (-FTD) scored below 700. High intensity score reflects minimal conceptual disorganization while a low score reflects pathological disorganization. The 2 samples were matched for age, education, IQ on abbreviated WAIS (Vocabulary and Block Design), chronicity, hospital care, duration of institutionalization, neuroleptic dosage, and anxiety scores on the Cattell State Anxiety Test (see table 1). There were

----------insert Table 1 here----------

no significant differences between the two groups on any of these variables. As predicted by previous studies showing a high correlation between the BFGTD and the SADS (Baribeau J. ; Laurent J-P., 1986; 1991), we found that the all 20 Ss high on the BFGTD were classified as high according to SADS' criteria for formal thought disorders (FTD) and all the 20 Ss low on the BFGTD were classified low on SADS.

Spitzer et al's SADS criteria for formal thought disorders (SADS-FTD) were obtained by adding frequency scores for all SADS-FTD items for each subject (S). Schizophrenics with SADS-FTD scores totalling 10 or higher put in the +FTD group. While those with scores lower than 10 were put in the -FTD group. The overall range was 3-24. The means (and SDs) were 7.1 (2.3) and 15.4 (4.7) for the -FTD and +FTD groups respectively. It should be noted that most patients scored consistently on the different SADS-FTD items. No patients, for example, received a rating of 6 on one item and a low rating on another. The final two samples of twenty patients were obtained by selecting only those patients who could be paired with patients of similar age, sex, chronicity and drug dosage in the other group.

T-tests confirmed sampling pre-selection with significant difference between groups on the intensity ($p<.0001$) and consistency ($p<.02$) scales. There was more variability (inconsistency) and weakness of formal thought processes in the +FTD patients. Both groups showed evidence of some content thought disorders (such as delusions, ideas of reference, thought broadcasting, thought insertion, etc.) as opposed to formal disorders per se.

To assess severity of non-FTD symptoms, Andreasen's checklists for positive (SAPS) and negative symptoms (SANS) were used. Table 1 shows that when schizophrenics are subdivided according to FTD, the 2 sub-samples also differ in terms of severity of symptoms on Andreasen's global scores of the positive and negative scales. To control for severity of schizophrenic symptoms other than FTD, scores for non-FTD pathology on Andreasen' scales were re-calculated separately. The "non-FTD" Andreasen score was obtained by subtracting FTD items (such as alogia) from the global weighted score. In other words this "Andreasen" covariate is a weighted mean of the positive and negative items which measure overall severity of schizophrenic non-FTD symptoms. This "Andreasen" score was used as a covariate in order to subtract the effect of severity of symptoms in Column B of Table 3.

The two schizophrenic groups were compared to a control group of ten volunteers who did not report history of psychotic disorder on any measure. They were also

matched based on similar gender, mean age, education level, and anxiety scores. The controls were selected from the staff at the same hospital. Due to the French educational system, it was difficult to find normals with less than 11 years of education. The controls were somewhat younger than the patients (24.9 vs 31.2 vs 30.0 years, $p < .05$) (see Table 1).

Treatment

All schizophrenic Ss were in-patients, followed-up by the same psychiatrist, with consistent prescription criteria and nursing care over five years, at the Clinique de Chailles (except for 5 patients who came from another hospital 3-4 years earlier). The neuroleptic drugs used in standard combinations or sequences were Haloperidol (butyrophenone), Levomepromazine (phenothiazine), Cyamemazine (phenothiazine), Modecate (fluphenazine decaonate), Pipotiazine, with doses ranging from 25 mg to 400 mg/day, with a mean/mode of 250 mg/day. Other drugs prescribed were benzodiazepines (Lorazepam, Flunitrazepam) with dosages varying around the "Diazepam equivalent" of 15 mg/day. They were prescribed under routine clinical standard criteria developed at the Clinique de Chailles by the same team of 3 resident psychiatrists who composed the treating team in charge over the last 5 years.

Dosage was categorized by this team on a scale of 1 to 4, ranking from clinically defined "mild to heavy" dosage. These values from 1 to 4 were subtracted as covariates in multivariate covariate analyses. Psychiatrists were blind to the experimental grouping of the patients and to the research goals and hypotheses.

Procedure

After a first screening session, the Luria-Nebraska Neuropsychological Battery (LN) was administered according to the standardized procedures (Golden et al., 1980) by a trained psychologist. The tests were given in counterbalanced order with minimal interference between memory tasks. Testing was interrupted with 10-15 minutes breaks as needed, with the same average session duration of 3-4 hours for the 2 groups. All testing, recording and scoring was done with blind procedures.

The LN consists of series of sub-scales. Items on the MOTOR scale reflect manual speed, dexterity, bilateral coordination, pantomime, gesticulation by verbal command, reproduction of simple geometric directions, fine control of fingers, oro-buccal and facial muscles. RHYTHM items reflected tonal and rhythm discrimination, to repetition and imitation of patterns of rhythms or simple sounds. TACTILE tasks are done while Ss are blindfolded, to evaluate intensity, form or movement of tactile stimuli on each of the superior limbs, and to identify

numbers, letters traced by the examiner, to recognize visual objects by touch alone. The VISUAL scale involves directional discrimination, analyses of tridimensional figures, dimensional rotations, time representation on clocks. VERBAL RECEPTION involves repeating phonemes, complex phrases, spontaneous speech, structuring and completion of phrases. WRITING and READING reflect letter, phoneme, word and phrase discrimination. ARITHMETIC assesses reading and reproduction of numbers and basic operations. MEMORY assesses short- and long-term memory, recall of words, phrases, stories, figures, rhythm, with or without interference. INTELLIGENCE involves tasks similar to those on the WAIS, in addition to categorization, reasoning and comprehension of opposites. Composite scales were also employed. ORGANIC included items discriminating neurological patients and control groups in terms of severity and intensity of neurological signs. The LEFT HEMISPHERE scale included items from the motor and tactile scales assessing right limbs, versus the RIGHT HEMISPHERE scale which assesses the left limbs.

RESULTS

To contrast the specificity of the FTD categorization (SADS) against the categorization based on severity of non-FTD symptoms (Andreasen), analyses were done in parallel for two types of sample sub-grouping. Table 2a presents the means and standard deviations for each LN scale for the two schizophrenic sub-groups selected according to SADS criteria for formal thought disorders (FTD). Table 2b presents means and SDs for the two sub-groups defined as high(+) or low(-) according to Andreasen's non-FTD severity index. Only the -

----------Insert Table 2a & 2b here----------intelligence and organic scales significantly differentiated the two groups. A further analysis of these data was carried out to determine the influence of positive and negative symptoms. The schizophrenic patients were therefore divided into two groups, those having high or low positive and those having high or low negative symptoms. The presence or absence of these symptoms had little influence on the results. The only difference was that the organic scale was no longer significant.

Table 3 presents ANOVAs and ANCOVAs performed separately according to two grouping criteria on 14 LN scales. Thus four types of results are presented two for each grouping factor. On the two first columns (A and B) Ss were grouped according to FTD as measured by SADS. On the final two columns (C-D) Ss were sub-grouped according to their non-FTD Andreasen index. ANOVAs are presented on columns A & C and ANCOVAs on columns B and D.

----------Insert Table 3 here----------

As expected, schizophrenics (pooled as one group) scored significantly worse than controls on most scales. The INTELLIGENCE, MEMORY, MOTOR and VISUAL scales were particularly affected. A stepwise discriminant analyses was then performed on the data. Ninety-five per cent of subjects were correctly classified ($p < .01$). The INTELLIGENCE, MEMORY, MOTOR and VISUAL scales proved to be best able to discriminate the groups. When the 2 schizophrenic sub-samples were separated according to FTD, 10 scales discriminated the 3 groups. +FTD Ss generally showed more pathological scores than -FTD Ss. -FTD patients showed scores that were intermediate between controls and +FTD patients on 7 scales: MOTOR, VERBAL COMPREHENSION, MEMORY, INTELLIGENCE, ORGANIC, LEFT-RIGHT HEMISPHERE SCALES. -FTD schizophrenics performed below organic cut-off values on these scales while +FTD patients scored above organic pathognomonic level. -FTD patients were significantly worse than normals on these scales and in addition READING and ARITHMETIC.

They were several of scales in which -FTD patients and controls did not differ: WRITING, VERBAL EXPRESSION, TACTILE, and VISUAL scales. Analyses of covariance (ANCOVA) were done to control for dosage variance these scales. The results remained in the same direction with +FTD patients being poorer than -FTD patients, and the -FTD poorer than controls (with the same exceptions as above).

In Table 3-column A, ANOVAs were performed on patients who scored high (FTD+) versus low (FTD-) on the FTD-SADS criteria (n=20 each). All but two LN scales significantly differentiated the groups. READING and ARITHMETIC did not differ among the two groups. This is probably because these academic skills are correlated to the WAIS sub-scales used to match the SADS sub-groups.

When schizophrenics were sub-divided according to Andreasen's global score (Table 2b) no differences on the LN sub-scales were found. Two general scales, INTELLIGENCE and ORGANIC, did reveal significant differences with + Andreasen patients scoring lower than - Andreasen patients (table 3, col. C).

In Table 3-column B, the ANCOVA (n=40) is performed on the FTD-SADS sub-grouping, but using the non-FTD Andreasen score as a covariate to subtract the effect of severity. After covariate subtraction, most scales that were significant in Column A remained significant often with smaller p values. Only 3 scales (VISUAL, WRITING, INTELLIGENCE) failed to remain significant although the general tread remained constant.

In Table 3-Column D the ANCOVA (n=40) is carried out on the two Andreasen sub-groups using the FTD-SADS score as a covariate. This ANCOVA did not alter the differences that were obtained with the ANOVA (col C.). Only the ORGANICITY scale showed a significant group difference between the two Andreasen groups.

No significant correlation was found between individual LN scales and Andreasen's global score. Correlational analyses between the LN scales and the other clinical scales (Cattell and abbreviated WAIS) were not significant except for the Bannister-BFGTD scale. The BFGTD was however significantly correlated with the frontal (INTELLIGENCE, LANGUAGE) and temporal lobe (MEMORY, RHYTHM) scales of the LN (with Pearson r values larger than .8, $p<.01$).

A principal component analysis (PCA) was also performed on the LN scales pooling all patients. Factors were selected using eigenvalue > 1. Table 4 presents the 3 significant factors obtained following a varimax rotation. The first factor (49.9%o the variance:

F1) reflects largely to sensori-motor functions especially those that are lateralized (see RIGHT HEMISPHERE and LEFT HEMISPHERE scales) and also a "temporal" cluster defined by Golden et al.[11] This cluster reflects a pattern of performance similar to that of brain-injured patients with temporal lesions for whom the largest deficits are on the MEMORY and RHYTHM scales.

----------Insert Table 4 here----------

The second factor (11.1% of the variance) showed the largest weights in the verbal abilities such as WRITING, READING and VERBAL EXPRESSION. These were the scales that showed the least degree of difference with the patients. The third factor (8.5% of the variance) was similar to Golden et al.'s frontal cluster found in patients with pre-frontal lesions. It reflects higher cognitive functions such as abstraction (see INTELLIGENCE), gnostic functions (as in the VISUAL imagery items) and VERBAL RECEPTION (comprehension).

The classification value of the above predictors was then verified. A global discriminant function analysis (DFA-direct method, SPSS-1989) confirmed the 95% correct classification of the 40 patients and the 10 controls. In Table 5 (top), a second discriminant analysis was done to confirm FTD sub-grouping within the schizophrenic sample (n=40). All 14 LN variables were entered simultaneously with the direct method. The results showed overall correct classification of 85.4% of patients between the +FTD and -FTD samples. The stepwise method also showed that the MEMORY scale itself correctly classified 71% of schizophrenics, (75% of -FTD and 67% of +FTD patients). When the INTELLIGENCE scale was also included 81% of schizophrenics were correctly classified. Table 5 (top, stepwise) provides the other discriminant factors (VERBAL EXPRESSION, VISUAL AND READING) which resulted in an 85.4% classification.

----------Insert Table 5 here----------

The bottom of Table 5 shows that the DFA was less successful in classifying patients according to the Andreasen criterion. Only 75.6% of the subjects could be correctly classified, with the inclusion of the INTELLIGENCE and READING factors

DISCUSSION

Schizophrenic patients, pooled as a single group, performed worse than controls on all scales. This was the case on higher cognitive functions such as complex intellectual processes, memory, directed attention, and abstraction. Patients' best scores were for verbal

academic skills, such as reading, writing and verbal expression, This trend was more apparent for -FTD patients. The +FTD patients still performed well below the mean.

Formal thought disorder differentiates schizophrenic sub-groups on neuropsychological functioning. Neither the removal of possible non-FTD severity confound by the ANCOVA, nor the sub-grouping according to severity on Andreasen's scale, altered these results. It would appear there for that it is the importance of FTD per se that distinguishes schizophrenics on neuropsychological tests.

When non-FTD severity effects were removed from the LN data during the ANCOVA, +FTD schizophrenics still showed significantly more pathology than -FTD patients on most scales. The finding, the FTD may affect other functions, is consistent with Golden & Moses notion that the very severe pathology of one group of patients (corresponding here to our FTD patients) involves distinct additional features (we suggest FTD) not found in patients with milder neuropsychological deficits. +FTD patients presented many pathological scores suggesting pervasive cerebral abnormalities in fronto-temporal and visual functional lobe. -FTD schizophrenics performed poorly in a somewhat more focused fashion, usually involving frontal functions. Their scores were nevertheless often below organic cut-off values. Neither CT nor MRI scan had been carried out in the patients, there is thus no supporting evidence of structural damage.

The memory scale emerged best able to discriminate the two groups. Other scales did not greatly increase classification accuracy probably because they were highly correlated with it. By contrast, when patients are classified according to Andreasen scales, intelligence and reading emerge as the best discriminators.

The MEMORY scale was highly correlated to most non-linguistic scales, while academic skills clustered on Factor 2, and general intelligence, abstraction and verbal comprehension cluster in Factor 3.

The first and third factors are similar to the "sensori-motor/temporal" and "frontal" clusters reported by Moses and Golden in schizophrenic populations. Two measures from the frontal cluster (Factor 3- INTELLIGENCE AND VISUAL), provide the least significance (Table 3, column B) when variation on Andreasen's severity index is controlled. This indicates that these "frontal" processes are related to severity of non-FTD symptoms. On the other hand, the "sensori-motor/temporal" cluster appears the most significant and remains or gains in significance after covariate subtraction. Thus the sensori-motor and temporal measures correlate

with FTD symptoms independently of other symptoms. This may suggest that sensori-motor and temporal deficits are more FTD or schizophrenia-specific than the others. The other measures seem sensitive to severity aspects of the illness, possibly in co-variance with the psychotic process rather than the schizophrenia-specific formal thought disorders.

Traditional validations of neuropsychological tests usually interpret quantitative differences in test scores beyond cut-off points as qualitative differences related to structural brain pathologies. Moses et al. (1980) and Golden et al. (1978) suggested that the LN could predict the presence of fronto-temporal ventricular enlargement, sulcal widening and sub-cortical abnormalities (basal ganglia) as detected by computerized tomographic scanning of the brain in schizophrenics. Frontal cognitive dysfunctions often appear with basal ganglia degeneration in certain brain pathologies(Robins T.W., 1990; McHugh P., 1989). These data support the frontal\basal ganglia model of attention that refers to the directional or controlling aspect of attention frequently impaired in both pathologies.

Interestingly the PCA shows that the "academic" factor (factor 2) is orthogonal with the language and intelligence measures in Factor 3. This supports the importance of matching schizophrenics for educational level, even if they show marked cognitive deterioration. The DFA applied to High+ and Low- groups on Andreasen`s measures (Table 5, bottom) showed INTELLIGENCE and READING as the only 2 relevant factors. This supports Moses` argument (1983) on the role of education level in identifying the psychotics most likely to show problem-solving deficits. But one must remember that if one takes FTD into consideration (Top of Table 5), reading takes the least discriminant rank.

On the LN, -FTD schizophrenics were in an intermediate position between controls and +FTDs. These results would confirm those of Lewis et al. (1979) who found evidence for subgroups of schizophrenics who performed in a manner clearly similar to brain-damaged Ss and others who performed within normal range on the LN. This intermediate position however is often taken to mean that there are only differences of severity between sub-groups of schizophrenics. According to one argument, -FTDs would have a similar but less severe deficit than +FTD patients. However, both the discriminant function analyses on FTD and Andreasen's criteria and both covariate analyses showed that the presence of FTD is the single classification criterion, irrespective of severity of non-cognitive symptoms. There is additional evidence of qualitative differences between +FTD and -FTD patients. First, sensori-motor and academic skills are not impaired in -FTD patients compared to controls, in contrast to +FTDs (see Table 2). The

latter show more deficits in RHYTHM, VERBAL COMPREHENSION and MEMORY. All three scales involve items testing conceptual organization and categorization, skills that are also pervasive in the definition of formal thought processes in Spitzer et al's cognitive criteria. RHYTHM items involve organizing series of tones to structure them into rhythms. This may be similar to memory test that require the organization of information and structuring them into categories. Similarly, the organization of verbal comprehension requires organizing words into logical phrases. Thus +FTD patients may be unable to organize and structure information into a meaningful whole across a variety of tasks.

CONCLUSION

Evidence from electrophysiological data, presented elsewhere (Baribeau J., Laurent J-P., 1991), has also demonstrated that +FTD and -FTD patients show different deficit during selective attention tasks. The converging pattern of neurophysiological and behavioral results showed that chronic schizophrenia involved at least two sub-groups. One (+FTD) was characterized by more severe and many formal thought disorders, more severe positive and negative symptoms (Andreasen scale), by a general electrophysiological "flatness", by a deficient attentional modulation of frontal evoked potentials and by a slowing of stimulus classification time. The -FTD patients were typified by less severe psychotic signs, by evoked potential indices of intrusion (large frontal N100 and P300 amplitude to ignored stimuli), by cognitive perseveration, and hyperarousal,

In summary, the differences between FTD-SADS groups are striking on most LN scales even after covariate subtraction of severity of Andreasen's non-cognitive symptoms. These group differences are not confounded by medication. All patients participating in the present study were undergoing a stabilized and standard course of chemotherapy implemented for a sufficient duration to ensure stability of effects.

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TABLE 1

Description of samples.

		CONTROL	-FTD	+FTD
Age in years	**M**	**24.9***	**31.2***	**30.0**
	SD	**5.7**	**6.4**	**4.8**
School years	**M**	**13.2***	**11.5**	**10.7***
	SD	**1.8**	**1.7**	**1.6**
Anxiety	**M**	**4.3***	**7.6***	**6.9**
(Cattell)	**SD**	**2.2**	**2.1**	**2.3**
Dosage	**M**	**-**	**2.6**	**2.6**
(Score,1-4)	**SD**	**-**	**0.8**	**1.0**
Hospitalisation	**M**	**-**	**10.5**	**10.5**
(Years)	**SD**	**-**	**5.5**	**4.0**
SADS	**M**	**-**	**7.1***	**15.4***
	SD	**-**	**2.3**	**4.8**
Bannister				
Intensity	**M**	**-**	**129.5***	**68.6***
(/10)	**SD**	**-**	**24.8**	**17.6**
Consistency	**M**	**-**	**0.7**	**0.1**
	SD	**-**	**0.2**	**0.5**
Andreasen				
Positive	**M**	**-**	**32.1***	**61.9***
	SD	**-**	**18.1**	**18.9**
Negative	**M**	**-**	**28.2***	**45.3***
	SD	**-**	**12.3**	**13.1**

M= mean, SD= standard deviation, * P <.02

TABLE 2a
Means (M) and standard deviations (SD) for the Luria-Nebraska scales for the 2 schizophrenic groups (+FTD, -FTD) and the controls.

		CONTROL	-FTD	+FTD
MOTOR	**M**	**0.03****	**0.20****	**0.32***
	SD	**0.03**	**0.13**	**0.19**
RHYTHM	**M**	**0.14**	**0.23***	**0.50***
	SD	**0.16**	**0.25**	**0.38**
TACTILE	**M**	**0.16**	**0.24***	**0.37***
	SD	**0.08**	**0.17**	**0.13**
VISUAL	**M**	**0.29****	**0.62****	**0.76**
	SD	**0.18**	**0.25**	**0.20**
VERB. REC.	**M**	**0.03****	**0.13****	**0.22***
	SD	**0.04**	**0.10**	**0.13**
VERB. EXP.	**M**	**0.09**	**0.10****	**0.19****
	SD	**0.05**	**0.05**	**0.12**
WRITING	**M**	**0.12**	**0.12***	**0.31***
	SD	**0.13**	**0.13**	**0.32**
READING	**M**	**0.02***	**0.09***	**0.12**
	SD	**0.05**	**0.09**	**0.14**
ARITHMETIC	**M**	**0.04***	**0.17***	**0.27**
	SD	**0.07**	**0.13**	**0.25**
MEMORY	**M**	**0.17****	**0.43****	**0.74****
	SD	**0.17**	**0.22**	**0.32**
INTELLIGENCE	**M**	**0.31***	**0.58****	**0.82****
	SD	**0.15**	**0.24**	**0.19**
ORGANIC	**M**	**0.17***	**0.26***	**0.36***
	SD	**0.07**	**0.12**	**0.11**
RIGHT HEMIS.	**M**	**0.11**	**0.20***	**0.37***
	SD	**0.06**	**0.14**	**0.22**
LEFT HEMIS.	**M**	**0.07****	**0.21****	**0.34****
	SD	**0.05**	**0.13**	**0.15**

M= mean, SD= standard deviation, * P <.02 ** P < .005

TABLE 2b

Means (M) ans standard deviation on the Luria-Nebraska scales for the 2 schizophrenic groups (LOW-ANDREASEN, HIGH +ANDREASEN) and the control group.

		LOW-ANDREASEN	HIGH+ANDREASEN
MOTOR	**M**	**0.24**	**0.28**
	SD	**0.20**	**0.14**
RHYTHM	**M**	**0.34**	**0.39**
	SD	**0.34**	**0.36**
TACTILE	**M**	**0.27**	**0.34**
	SD	**0.19**	**0.13**
VISUAL	**M**	**0.63**	**0.75**
	SD	**0.25**	**0.20**
VERB. REC.	**M**	**0.16**	**0.18**
	SD	**0.14**	**0.10**
VERB. EXP.	**M**	**0.12**	**0.16**
	SD	**0.08**	**0.11**
WRITING	**M**	**0.17**	**0.26**
	SD	**0.30**	**0.22**
READING	**M**	**0.11**	**0.10**
	SD	**0.13**	**0.11**
ARITHMETIC	**M**	**0.18**	**0.25**
	SD	**0.14**	**0.25**
MEMORY	**M**	**0.51**	**0.67**
	SD	**0.31**	**0.31**
INTELLIGENCE	**M**	**0.60***	**0.80***
	SD	**0.26**	**0.18**
ORGANIC	**M**	**0.27***	**0.35***
	SD	**0.14**	**0.10**
RIGHT HEMIS.	**M**	**0.25**	**0.33**
	SD	**0.21**	**0.20**
LEFT HEMIS.	**M**	**0.25**	**0.31**
	SD	**0.18**	**0.12**

M= mean, SD= standard deviation, * P < .05

TABLE 3.
F and p values for ANOVAs performed on the Luria-Nebraska global scores for 2 groups N= 40.

	A		B		C		D	
	FTD ANOVA F ratio	p	FTD ANCOVA F ratio	p	ANDR.ANOVA F ratio	p	ANDR.ANCOVA F ratio	p
MOTOR	5.97	0.019	7.82	**0.008**	0.75	0.391	0.12	0.730
RHYTHM	6.82	0.013	11.83	**0.001**	2.34	0.631	0.20	0.654
TACTILE	6.96	0.012	7.44	**0.010**	1.86	0.181	0.95	0.335
VISUAL	3.91	0.055	1.74	0.195	2.77	0.104	1.58	0.216
VERB. REC.	6.03	0.019	7.65	**0.009**	0.45	0.508	0.00	0.994
VERB. EXP.	9.97	**0.003**	5.92	0.020	1.27	0.268	0.32	0.573
WRITING	6.23	**0.017**	3.56	0.067	1.36	0.250	0.44	0.509
READING	0.94	0.339	0.40	0.531	0.05	0.815	0.24	0.628
ARITHMETIC	2.61	0.115	1.05	0.311	1.24	0.273	1.09	0.304
MEMORY	13.04	**0.001**	8.29	0.007	2.51	0.121	1.33	0.718
INTELLIGENCE	11.82	**0.001**	3.42	0.072	8.55	0.006	2.18	0.148
ORGANIC	6.61	0.014	8.20	**0.007**	4.50	0.040	4.33	0.044
RIGHT HEMIS.	8.51	0.006	9.89	**0.003**	1.91	0.175	0.78	0.384
LEFT HEMIS.	9.09	**0.004**	3.83	0.034	0.98	0.329	0.12	0.729

TABLES 4

Three factors (F1-F3) obtained by principal component analysis after varimax rotation, between each Luria-Nebraska scale.

	F1	F2	F3
RIGHT HEMIS.	**0.923**	**0.229**	**-0.012**
LEFT HEMIS.	**0.795**	**0.314**	**0.257**
MOTOR	**0.779**	**0.363**	**0.073**
TACTILE	**0.779**	**-0.032**	**0.385**
ORGANIC	**0.615**	**0.345**	**0.435**
MEMORY	**0.608**	**0.049**	**0.280**
RHYTHM	**0.549**	**0.433**	**0.260**
WRITING	**0.441**	**0.799**	**0.180**
READING	**0.090**	**0.765**	**0.253**
VERB. EXP.	**0.322**	**0.711**	**0.022**
ARITHMETIC	**-0.013**	**0.629**	**0.421**
INTELLIGENCE	**0.203**	**0.221**	**0.847**
VISUAL	**0.494**	**0.098**	**0.710**
VERB. REC.	**0.157**	**0.333**	**0.650**

TABLE 5
Discriminant Function Analysis, Coefficients and Classification Rates

Step	LNNB Variables	Wilks' lambda	x^2	p
1	MEMORY	.749		.001
2	INTELLIGENCE	.650		.000
3	VERB. EXP.	.588		.000
4	VISUAL	.561		.000
5	READING	.540		.000

Classification hit rates (%)

	-FTD	+FTD	OVERALL
LNNB variables L1 through L14 (all)	85.0	85.7	85.4
Stepwise			
1: MEMORY	75.0	66.7	70.7
2: INTELLIGENCE	80.0	81.0	80.5
3: VERB. EXP.	85.0	76.2	80.5
4: VISUAL	80.0	85.7	82.9
5: READING	85.0	85.7	85.4

Step	LNNB Variables	Wilks' lambda	x^2	p
1	INTELLIGENCE	.790		.003
2	READING	.716		.002
3	WRITING	.687		.003

Classification hit rates (%)

	-ANDREASEN	+ANDREASEN	OVERALL
LNNB variables L1 through L14 (all)	75.0	76.2	75.6
Stepwise			
1: INTELLIGENCE	65.0	76.0	70.7
2: READING	75.0	76.2	75.6
3: WRITING	75.0	66.7	70.7

We will refer to them as "formal thought disordered" with the label +FTD. To refer to them we will use the terms "minimal formal thought disorders", or the label -FTD.