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Neuropsychology

C.B. Dodrill

INTRODUCTION

As applied to the study of human beings, *neuropsychology* evaluates ability, personality, and behavioural correlates of brain lesions and other pathological conditions affecting the nervous system. It is a discipline arising from both neurology and psychology. From neurology, information is obtained about the central nervous system. From psychology, the techniques of precision in measurement are borrowed. Neuropsychology rests on the assumptions that the brain is systematically organised, that the behaviour of the organism is related to the condition of the brain, and that an index of the condition of the brain can be inferred by evaluating carefully the behaviour and abilities of the organism. It is also assumed that the neurological status of the brain will determine how far deficits may affect the organism's future activities. The two questions that neuropsychology asks for any patient are, 'What, if any, neurological dysfunction or impairment in brain functions exists?' and 'What impact will such a condition have upon performance in daily life?'

Neuropsychology is of immense importance in the total evaluation of the individual with epilepsy. By definition, an individual with a seizure disorder has a brain which is dysfunctional, at least intermittently. Furthermore it is known that in most cases one can detect the presence of a seizure disorder by means of multiple EEGs, all of which may be recorded interictally. When a patient is referred for an EEG it is not expected that a clinically obvious attack will be recorded, and such is not necessary to confirm the presence of a seizure disorder. This fact is well known to physicians but its significance with respect to neuropsychology is generally overlooked. It means that abnormal brain functioning persists between attacks in individuals with epilepsy. In addition, no one would dispute the contention that the brain is the seat of abilities. It is therefore reasonable to expect alteration in abilities not just during but also between attacks and it is also reasonable to assume that such alterations may affect a person's performance in daily life.

The purposes of this chapter are to describe the basics of neuropsychological assessment and to summarise some of the research which correlates important variables related to epilepsy with impairment in brain functions as identified by neuropsychological tests. The nature of neuropsychological evaluations will first be discussed, and will be followed by a partial review of the literature dealing with neuropsychological testing. Finally, a neuropsychological battery developed specifically for the evaluation of epilepsy will be presented and its use illustrated.

THE NATURE OF NEUROPSYCHOLOGICAL EVALUATION

The brain is an extremely complex organ which has many functions. Therefore it is readily apparent that one cannot evaluate fully the intactness of the brain without also evaluating many of these functions. It was on this basis that many years ago Halstead (1947) perceived that a full battery of tests was needed in order to make even reasonably adequate comments about brain functioning. Although this may seem elementary, it underlines that clinical neuropsychological evaluation can make a major contribution by a careful, detailed, and systematic evaluation of brain functions. There is no way, for example, that a professional can hope to obtain even a semi-adequate assessment of brain functions by having a patient draw a few figures. Furthermore, it is simply not possible to obtain an adequate index of recovery from a brain insult such as a severe head injury by merely talking to a patient and performing the simplest of memory, perceptual, and motor tests. Yet, these judgements are made every day on the basis of obviously inadequate observations. A valid systematic evaluation must be made of a broad range of functions including memory (both verbal and nonverbal), ability to attend to the task, motor skills, perceptual abilities (auditory, visual, tactile), cognition, visuo-spatial functions, and language-related abilities.

Although the evaluation of a broad range of abilities is important, more is required for a thorough neuropsychological evaluation. Such tests should provide information which can be used in complementary ways in order to relate neurological problems to those of adjustment. The majority of tests used by psychologists (such as tests of intelligence) provide only an indication of level of performance. This is important because it gives information about how a person compares with others and it is therefore used in neuropsychological testing. However, a person may perform poorly for a variety of reasons, only one of which may be because of brain injury or impairment in brain functions. One cannot, for example, say that an individual is necessarily brain damaged simply because of low intelligence although brain damage is found more often in those who are mentally deficient.

Because of the limitations in assessing only the level of performance, three other approaches to dealing with neuropsychological test information have been developed in detail by Reitan (1969) and are employed regularly. Briefly, the first of these compares the relative performances of the right and left sides of the body. This approach is borrowed from neurology where it is regularly employed. It has the important advantage of using the patient as his own control and may show up definitely pathological defects of performance. The second additional approach demonstrates specific signs of neurological deficit such as dysphasia or constructional dyspraxia which may have diagnostic value. The absence of such specific signs does not mean, of course, that mental function is necessarily normal. Finally, the information provided by a full neuropsychological battery allows for a pattern analysis from which may be inferred the nature, location and extent of the brain damage and the impact which it is likely to have upon functioning in life. The extent to which inferences about neurological problems can be made has been documented by Reitan (1964) who, using these complementary methods of neurological inference, was able to show a striking ability to define extent, location, and type of lesion based solely upon neuropsychological test findings and with no reference whatever to the history. The ability to make such inferences from neuropsychological test results is not widely known. However in my opinion this should not be the major function of neuropsychology, which should focus instead upon the impact of lesions upon performance in life. Nevertheless it is important to appreciate that accurate inferences about the nature of lesions can be made providing that one has sufficiently sensitive tests and that a sufficiently detailed evaluation is carried out.

In 1935, Halstead established the first full-time neuropsychological laboratory for the study of the effects of brain lesions upon human beings. In his work, he soon recognised the validity of the matters just discussed and set out to develop a comprehensive battery of neuropsychological tests, each of which would be sensitive to problems of brain function and which when taken together could provide a basis for making valid inferences about the condition of the brain. The many tests that he used are described in his monumental work, *Brain and Intelligence* (Halstead, 1947). Of these tests, five were finally adopted for use by Reitan and are perhaps among those test measures which are best validated and most widely used by neuropsychologists today.

Category Test. This is a complex test of problem solving ability. It uses a slide projecter which presents figures on the back of a milk-glass screen. In each of seven groups, the patient must determine what principle underlies correct responses and feedback is obtained about whether answers are right or wrong by a bell and a buzzer, respectively. The test evaluates a patient's ability to solve problems, to adapt to new and different situations, and to utilise effectively feedback given about the correctness of responses. The score is the number of items out of 208 which are incorrect.

Tactile Performance Test. This test employs a form of the Seguin-Goddard form board. The patient is blindfolded before the test begins and does not see the board at any time. The task is to put a series of blocks into the proper spaces on the board first using only the preferred hand, then only the non-preferred hand, then both hands taken together. The time required for each trial is recorded as well as the total for all three trials. After the task is over, the blocks and board are removed and the patient is required to draw a picture of the board putting in as many blocks as can be remembered and also trying to put them in the drawing where they were on the board. Both the number of blocks remembered (Memory Component) and the number correctly localised (Localisation Component) are indicators of 'incidental memory' since the patient is not forewarned that a picture of the board will be required at the end of the test. Like the Category Test, this test requires a substantial ability to solve problems and adapt to a novel situation with a strong emphasis upon tactile, kinaesthetic, motor, and visuo-spatial skills.

Seashore Rhythm Test. Thirty pairs of rhythmic beats are presented by a tape recorder and the subject must indicate whether the rhythms within each pair are the same or whether they are different. The test seems to require sustained attention to the task and ability to perceive and deal with non-verbal stimuli.

Speech-sounds Perception Test. Nonsense words are given over a tape recorder and the patient must select from four alternatives the word that is said. The words all have beginning and ending consonants with a central 'ee' vowel sound. This test evaluates auditory discrimination of verbal materials.

Finger Oscillation (Finger Tapping) Test. This test uses a manual tapper and the patient propels a key up and down as rapidly as possible. Several ten-second trials are averaged for the index finger of each hand. This test appears to be rather purely dependent upon motor speed.

In addition to these tests, Reitan added some additional measures and those usually used with adults include the following:

Aphasia Screening Test. This is Reitan's modification of the Halstead-Wepman Aphasia Screening test (Halstead & Wepman, 1949) which provides for the assessment of a number of types of aphasia and apraxia. The test requires the patient to name, spell, read, write, pronounce, calculate, and so on. The results are evaluated for specific signs of neurological deficit.

Trail Making Test. This test consists of two parts. In Part A, a person merely draws lines connecting circles numbered 1 to 25 in order. Part B requires the alternation of numbers and letters in an ordered fashion. This test appears to require the ability to keep more than one aspect of the stimulus situation in mind and to think flexibly in going from one type of stimuli to the next.

Lateral Dominance Examination. This test is used primarily to evaluate preference in handedness but it also includes a measure of grip strength with a hand dynamometer and an indicator of name writing speed. These two last test measures are obtained for both the preferred and non-preferred hands.

In addition to the above test measures, Reitan also included a general measure of intelligence and one of emotional functioning. For adults, these tests are the Wechsler-Bellevue Intelligence Scale (or Wechsler Adult Intelligence Scale) and the Minnesota Multiphasic Personality Inventory (MMPI). These are also regularly used in our evaluation of epileptic patients.

The above series of tests is used in many places around the world and is generally known as the Halstead-Reitan Neuropsychological Battery. Except for instances in which general measures of intelligence are used alone, this battery appears to have been applied more often to the evaluation of those with seizure disorders than any other. Representative studies which have used the battery will now be reviewed.

NEUROPSYCHOLOGICAL CORRELATES OF SEIZURE HISTORY VARIABLES

Most of these investigations reported in the literature have used measures of intelligence alone. However, such tests were never designed to evaluate the adequacy of brain functions and do not do so as well as the more specialised neuropsychological test measures. Since complete reviews of the performances of epileptic patients on tests of intelligence have already been published (Lennox & Lennox, 1960; Tarter, 1972) detailed findings of results already well known will not be given here.

Aetiology

The results of a long series of studies summarised by Tarter (1972) indicate that individuals with seizure disorders of known aetiology average approximately 5–10 fewer IQ points than those whose aetiology is unknown. In a more detailed study using the Halstead-Reitan approach, Kløve and Matthews (1966) found that individuals with epilepsy of known aetiology consistently performed more poorly than persons who had seizures of unknown aetiology but that in most cases the differences did not reach statistical significance. Of the tests described above, only the Trail Making Test, the Tactile Performance Test (Time Component) and the Halstead Impairment Index (a summary measure of performance on the Halstead tests) produced statistically significant differences. This study is perhaps the most carefully controlled one in the literature and it suggests that it is only with respect to motor and psychomotor problem-solving tasks that aetiology makes a consistent and reliable difference. One should recall in fact that the majority of tests of intelligence have a standard error of approximately five points so that this much fluctuation may be expected from one administration to the next without indicating any real differences between patient groups. This finding argues against overgeneralisation and over-interpretation of research findings.

Age at onset and duration of disorder

In general, studies have suggested that the earlier the age at onset and the longer duration, the lower the abilities. The differences demonstrated, however, are usually modest with some suggestion that they are greatest in cases with generalised tonic-clonic attacks (DeHaas & Magnus, 1958; Lennox & Lennox, 1960). Using the general Halstead-Reitan approach, Dikmen, Matthews, and Harley (1975) considered only individuals with major motor seizures and only the extreme groups of age at onset (age 0–5, age 17–50). Statistically reliable differences on 9 of 14 variables appeared between these groups which always favoured the group with the later age at onset. Even under these rather ideal circumstances for producing statistically significant differences, however, the differences were modest and it is not clear that many would have been found had the full range of individuals been evaluated including those with age at onset 6–16 years. Intellectual and psychomotor problem-solving tasks produced the greatest differences.

The minimal nature of positive findings with these variables is further confirmed by work done in our own epilepsy centre with a diverse group of 305 adult epileptic patients. A statistically significant relationship was demonstrated between the age at onset and the Wechsler Adult Intelligence Scale Full Scale IQ with a correlation of 0.24 ($p < 0.001$) but no relationship was demonstrated with the Halstead Impairment Index (correlation of 0.00). The duration of the disorder was not significantly related to the WAIS Full Scale IQ (correlation of -0.07) but a significant relationship was found with the Halstead Impairment Index (correlation of 0.22 ($p < 0.001$). Although some of these findings are statistically reliable, it is apparent that they account for only a small fraction of the variation in performance scores (about 4 per cent). Thus, *when people with epilepsy are considered as a whole*, these relationships are clearly not potent ones.

Seizure type

Some studies have found no general relationship between seizure type and mental abilities whereas others have demonstrated decreased mental functions in those having primarily tonic-clonic attacks. Rarely has it been possible to show decreased intelligence in association with petit mal absences although difficulties with other types can usually be demonstrated (Lennox & Lennox, 1960). In the most complete neuropsychological evaluation that has been done, Matthews and Kløve (1967) simultaneously considered the question of aetiology and seizure type among adults having primarily complex partial seizures, primarily generalised tonic-clonic seizures, or both. In general, individuals with major attacks did more poorly than those with complex partial seizures, and those with known aetiology did worse than those with unknown aetiology. In this study, seizure type was more potent than aetiology in its correlation with performance but the two factors together showed the greatest differences in scores.

Seizure frequency

Although one might expect that decreased performance might be associated with increasing seizure frequency, the literature shows no such consistent trend. In the one detailed neuropsychological study which considered the question, Dikmen and Matthews (1977) used only patients with major motor attacks and demonstrated a small number of differences favouring persons with fewer attacks. It appears highly likely that had persons other than those with major motor seizures been included, no such relationships would have been demonstrated. In my own laboratory, I was able to determine reliably seizure incidence in 258 heterogeneous adult epileptic patients and found seizure incidence for the last 30 days to be correlated 0.10 ($p > 0.05$) with the Halstead Impairment Index and 0.00 with WAIS Full Scale IQ. Thus, there was no general relationship between seizure frequency and performance.

Research on the above variables is somewhat discouraging to review since only very modest relationships are found in the majority of instances. This underlines the complexity of measuring performance, and the need for caution in interpreting and explaining results.

PERFORMANCE AND ANTIEPILEPTIC DRUGS

Every physician dealing with epilepsy has received reports from patients on antiepileptic drugs which suggest that the medication may have some effect on their ability to think, remember, and perform in daily life. Many efforts have therefore been made to evaluate formally the effects of antiepileptic drugs upon performance. In examining these studies, one should be aware of four limiting factors. Firstly, the use of normals in antiepileptic drug studies produces results of limited general applicability since it is not clear that normals respond to the drugs as do individuals who have taken them chronically. Secondly, changes in drug regimens are often accompanied by changes in seizure frequencies and the net effects may be confounded. Thirdly, the use of a placebo in comparison with an active agent is not an effective technique for evaluating changes in performance even though it may be an effective approach for evaluating changes in seizure frequency. The reason for this is that such studies, by definition, compare an active agent with an inactive one and, since the addition of active agents in general tends to decrease performance, the outcome of the study with respect to tests of performance (not seizure frequency) is predictable to a considerable degree before the study is begun. Finally, the majority of studies that have been done evaluating the effects of antiepileptic drugs have used only one test as a measure of performance and so a pattern of deficits is not shown. This is particularly important since our own studies over a decade have demonstrated patterns of difficulties associated with each drug.

The neuropsychological impacts of phenytoin (Dilantin) are of special interest because of the wide use of this drug. In one study, Matthews and Harley (1975) evaluated the effects of this drug in combination with those of primidone and phenobarbitone and classified patients as toxic or non-toxic based upon serum levels. Differences favouring the non-toxic group appeared on a few measures of attention and concentration, on indicators of motor coordination, and on static tremor. Dodrill (1975a) studied patients who were on phenytoin alone and compared those with high and low serum levels above and below 120 μmol/l (30 μg/ml) as well as those who were clinically classed as toxic or non-toxic. A series of results from this study pointed to decreased *motor* performance with increased serum levels and toxicity. However, no other functions were affected. This study is remarkable in that no other antiepileptic drugs were involved and also because the high serum level group had a very high average level of 172 μmol/l (43 μg/ml) which should have made it easier to demonstrate other mental deficits.

The other antiepileptic drug which has received the most attention is phenobarbitone. Somerfeld-Ziskind and Ziskind (1940) demonstrated no decreased mental ability when the administration of phenobarbitone was compared with a control epileptic group which essentially was untreated. In fact, mental age as evaluated by the Stanford-Binet Intelligence Scale actually increased in the group given phenobarbitone. However, the number of seizures experienced by that group was substantially less than that by the other. This study illustrates the pervasive finding that despite any adverse effects which may be associated with antiepileptic drugs, it is routinely better to administer these agents and stop the seizures than not to do so. In a well-executed study with normals, Hutt *et al.* (1968) found that increasing phenobarbitone serum levels was associated with decreased performances on tasks requiring sustained attention, psychomotor performance, and spontaneous speech. These findings are consistent with those of the study by Matthews and Harley (1975) and it is suggested that phenobarbitone has effects maximally evident on tasks requiring sustained attention, but that it may have effects on motor coordination as well.

Carbamazepine is another drug which has received some attention because of its presumed 'psychotropic' effects. Dalby (1975) reviewed approximately 40 studies and found evidence for such an effect in approximately half of these. Most commonly reported was improvement in mood and behaviour as well as reduced aggression and irritability and a possible decrease in depression. However, these conclusions were based on subjective observations rather than objective testing. Rodin, Rim, and Rennick (1974) used a double-blind placebo versus carbamazepine design and demonstrated some loss in ability with carbamazepine. Dodrill and Troupin (1977) used a battery of neuropsychological tests with a single agent double-blind cross-over design and compared carbamazepine with phenytoin. With seizure control about the same by either drug, some limited improvements in performance with carbamazepine were observed on mental tasks requiring problem solving and sustained attention. Emotional status and personality adjustment as evaluated by the MMPI also showed slight improvement. It was observed that duller persons and those with more extensive psychiatric problems improved the most with carbamazephine. The changes appeared to be due to starting cambamazepine rather than the stopping of phenytoin.

Studies related to other antiepileptic drugs may be mentioned briefly. One study of methoin (mephenytoin) demonstrated that there was slightly better attention to a task with methoin than with phenytoin (Troupin, Ojeman & Dodrill, 1976). Sodium valproate is only now coming under detailed scrutiny in the United States and therefore very little can be said about it at the present time in terms of performance correlates. Although some studies already exist in the current literature none have appeared which have used it as a sole antiepileptic drug, and studies which have contrasted it with a placebo cannot be used to support the contention that it is associated with decreased performance.

Over several years of working specifically with antiepileptic drugs and their effects, I have observed that when antiepileptic drug serum levels fall within therapeutic ranges and when there are no overt signs of toxicity, it is rarely possible to demonstrate performance deficits due to the medication. A review of all of the studies reveals only one (Dodrill, 1975b) in which there were truly striking differences in performance when two different groups of drugs were administered. This agent, sulthiame, is not used in the United States and apparently is used elsewhere only in combination with other drugs. In general, the effect on performance correlates with antiepileptic drugs is less than with the other variables discussed in this chapter. In certain cases, of course, there may be unusual protein binding or metabolic interactions of significance. However, unless there are at least slight clinical signs of toxicity, it is unlikely that drugs can be shown to cause performance difficulties.

THE NEUROPSYCHOLOGICAL BATTERY FOR EPILEPSY

All of the neuropsychological tests discussed previously have been developed and standardised on groups of patients with a variety of neurological disorders and none was designed specifically for work with people with epilepsy. Thus, the effects of medication for seizures, seizures themselves, and the correlates of important EEG variables were not considered in the development of the tests. As a matter of fact, the majority of tests thus far described were developed before it was apparent that such variables would affect performance significantly. Further, no one has developed normal standards for people with epilepsy on even these tests, nor were sex differences taken into account. Existing neuropsychological batteries and even the Halstead-Reitan Neuropsychological Battery covered poorly the difficulties often complained of by patients, such as problems with memory or sustaining attention to a task.

These considerations led me to believe that the development of a Neuropsychological Battery for Epilepsy would be of assistance in dealing with patients having seizure disorders. The full development of this neuropsychological battery has been reported (Dodrill, 1978). Briefly, the deficits noted clinically with this group were catalogued together with the difficulties in performance documented from studies of the effects of seizures upon performance, of drugs, and of the correlates of important EEG variables. In pilot, principal, and cross-validation studies, approximately 100 prospective neuropsychological variables were reduced to 16 which had been tested for their ability to pin-point deficits associated with epilepsy, for a lack of overlap with one another, and for general applicability to normal and patient groups. These 16 test measures, known as discriminative measures because of their ability to differentiate those with, from those without epilepsy, include six from Halstead's Neuropsychological Battery, five from the tests that Reitan added, and the following additional tests.

Stroop Test. This is a test of reading rate and sustained attention to the task. A colour plate is used which has printed on it colour names (red, green, blue, orange) each of which is always printed in an incongruous colour. Thus, 'red' may be printed in green, blue, or orange, and 'green' may be printed in red, blue, or orange. In Part I of this test, the person reads through the words as quickly as possible, ignoring the colours in which they are printed. The time required is one of the discriminative measures. In Part II, the person must give the colour of the print while ignoring the word. This latter task proves to be extremely difficult for most people and for those with brain problems it is exceptionally hard. When the time required for Part I is subtracted from that for Part II, a measure of 'static' or interference is identified which appears to be an indicator of distractibility. This is also a discriminative measure.

Wechsler Memory Scale. The Logical Memory and Visual Reproduction portions of the Wechsler Memory Scale (Form I) are administered, since they have been previously used as indicators of verbal and non-verbal memory (Milner, 1975). In the verbal test, the person repeats as much as possible of two short stories which are given orally and the number of elements recalled is recorded. In the non-verbal (Visual Reproduction) portion, four drawings are reproduced after ten-second exposures and a single score is provided.

Seashore Tonal Memory Test. This test is somewhat like the Seashore Rhythm Test used by Halstead. A series of notes is played twice and in the second playing one note is changed. The patient must identify which note is changed in each of 30 trials. This is a harder test than the Seashore Rhythm Test and appears to evaluate sustained attention to the task.

Using all 16 test measures, norms were established for a highly diverse group of adult epileptic patients. For each of the 16 tests, a point was found in the performances of the control group below which approximately 25 per cent of these individuals scored. This was established as a 'cut-off' point and scores below this point were said to fall outside normal limits. In general, between 60 and 70 per cent of epileptic patients fall in this range. For an individual of average intelligence, the interpretation of the battery rests in some part upon the total number of tests falling outside normal limits and the following standards are used as general guidelines.

Within normal limits. 0–4 tests outside normal limits. Up to four tests may be expected to fall outside normal limits on the basis of chance alone and individuals with scores in this range usually show no impairment in brain functions whatever.

Borderline. 5–6 tests outside normal limits. Individuals here may or may not demonstrate some evidence of impairment in brain functions as for example in different performances of the right and left sides of the body. Even when such is demonstrated it is so minor that it has no detectable impact on ability to adjust to life.

Very mild impairment. 7–8 tests outside normal limits. Individuals falling in this range typically demonstrate convincing evidence of impairment in brain functions but it is so slight that it has only a limited impact on adjustment.

Mild impairment. 9–11 tests outside normal limits. Persons whose performances fall in this range almost always demonstrate both definite evidence of neurological problems and also of at least some impact upon ability to function.

Moderate impairment. 12–14 tests outside normal limits. Patients with performances falling in this range are easily identified as impaired and a portion of this group is able neither to live independently nor to function in normal employment.

Severe impairment. 15–16 tests outside normal limits. Individuals here routinely show striking neurological impairment which has a marked impact on abilities in every or nearly every area. They will need assistance in sheltered or semi-sheltered employment and living conditions.

Case material

D.D. was a 20 year old caucasian male referred for a neuropsychological evaluation as part of his presurgical work-up at our epilepsy centre. He was diagnosed as having complex partial seizures with occasional secondary generalisation and a large number of these partial attacks had occurred in the month prior to the evaluation. There was no family history of seizures. Sudden noises and emotional upsets appeared to precipitate some of the attacks. Repeated EEGs demonstrated focal epileptiform discharges over the right frontotemporal area as well as moderate diffuse abnormalities. An intra-carotid sodium amytal test ('Wada' test) showed that speech was clearly related to the left cerebral hemisphere. At the time of the evaluation, this 84 kg man was taking 1500 mg of carbamazepine, 1000 mg of primidone, and 38 mg of clorazepate per day.

The results of the neuropsychological evaluation are presented in Table 7.1. The results from the 16 specialised neuropsychological tests are given in the middle of the page and the general indicators of intelligence, personality, and preference in handedness are given at the bottom of the page.

A review of the discriminative measures provides information of interest. First of all, some 9 of 16 (56 per cent) of the specialised neuropsychological tests were performed in a range designated as outside normal limits (mild impairment). Examination of the scores does not point to any one area where the deficiencies are striking but rather shows limited difficulty with a number of tests. Probably the greatest of these pertain to his inability to attend to the task under distracting conditions and it was observed that his performances on both Seashore tests and on the Stroop Test were deficient. Other poor results included a relatively poor visuo-spatial memory (Wechsler Memory Scale), language-related problems (Aphasia Screening Test), decreased motor speed (name writing), and deficient problem solving (Category Test). Thus, difficulties were noted in a variety of tests and although none of these were overwhelming, they would almost certainly make him less able to function in life.

The 16 discriminative measures were also examined for laterality and a series of performances were found which implicated the right cerebral hemisphere. The relatively poor memory for non-verbal materials has already been mentioned and is in some contrast to his good memory for verbal material. On the Tactile Performance Test there was scarcely any improvement at all on the second trial when the left hand was used and because of memory factors, we would have expected an improvement of perhaps 30–35 per cent. In addition, it was observed that his left hand was slow on the Finger Tapping Test and we would expect the left hand to perform about 90 per cent as well as the right hand even in this strongly right-handed person. Finally, it was observed that the left hand was relatively slow on the name writing procedure. In terms of letters per second executed, we would expect the left hand to take approximately three times as long as the right but a considerably longer period was required. Furthermore, there were four perceptual errors made on the left side of the body but only one made on the right. The left cerebral hemisphere was implicated only by seven errors made on the Aphasia Screening Test.

It is concluded from the specialised neuropsychological measures that there is evidence for organic involvement of both cerebral hemispheres but that the right cerebral hemisphere is definitely involved more than the left. Thus, it appeared that the EEG focus and whatever caused that focus had very definite behavioural correlates, which included certain aspects of functioning traditionally related especially to the right temporal lobe but also the posterior inferior frontal lobe and, to some degree, to the parietal lobe as well.

Intelligence was evaluated by means of the Wechsler Adult Intelligence Scale and Table 7.1 demonstrates that he scores in the lower ranges of normal or average performance. In the emotional area, the MMPI suggested that he may be seen as peculiar or odd by others. He may also tend to keep a social distance from people and to have limited social skills. Immaturity, dependency, and passivity were also indicated and the possibility was raised that at least some of his physical complaints may have a functional basis.

Two months after his neuropsychological evaluation, he

Table 7.1 Summary of neuropsychological tests on patient D.D., a 20-year-old male with complex partial seizures and a focus in the right temporal area.

NEUROPSYCHOLOGICAL REPORT -- EPILEPSY CENTRE

Name D.D.		Hospital No.	Date 5/5/77	No. 709
Age 20	Education 12	Handedness R	Race C	Occupation Unemployed

NEUROPSYCHOLOGICAL BATTERY FOR EPILEPSY

Discriminative Measures

Stroop Test	Part I		216(6)*
Part II 320(13)	II–I		194*
Wechsler Memory Scale (Form I)			
Verbal (Stories)			21
Visual-Spatial (Drawings)			8*
Perceptual Examination	R	L	
Misperceptions	0	0	
Suppressions	0	0	
Finger Agnosia	0	0	
Agraphagnosia	1	4	
Astereognosis	0	0	
Total Errors	1	4	5
Astereo. Time	11	9	
Name Writing (Let/Sec)			
Pref. 1.23	Nonpref. 0.24		0.40*

Category Test		88*
Tactile Performance Test		
Preferred 4.5	Total time	9.9
Nonpreferred 4.2	Memory	8
Both Hands 1.3	Localization	5
Seashore Rhythm Test		23*
Seashore Tonal Memory Test		19*
Finger Tapping		
Preferred 55	Nonpreferred 46	101
Trail Making Test		
Part A 57	Part B	146*
Aphasia Screening Test		
Expressive 4	Receptive 1	7*
Constructional Dyspraxia		Ques.
Total tests outside normal limits:		9/16(56%)

*Performance falls outside normal limits.

General Measures

Wechsler Adult Intelligence Scale

VIQ	88	Info	8	Dig Sym	7
PIQ	95	Comp	7	Pic Com	11
FSIQ	90	Arith	11	Bl Des	11
VSS	47	Simil	7	Pic Arr	10
PSS	47	Dig Sp	7	Obj Ass	8
TSS	94	Vocab	7		

Minnesota Multiphasic Personality Inventory

?	50	Pd	69	Es	31
L	66	Mf	65	Ep	31
F	76	Pa	65	A	18
K	46	Pt	69	R	24
Hs	77	Sc	88	Man Anx	22
D	72	Ma	63	Cr. In.	11
Hy	73	Si	67		

Lateral Dominance Examination

	R	L
Hand	7	0
Eye	2	0
Foot	2	0
Dyna.	53.5	49.5

was taken to surgery and a low grade glioma was excised from the right temporal lobe. Follow-up one year later demonstrated a substantial decrease in seizure frequency although occasional attacks persisted. In general, slight improvement on the neuropsychological tests was demonstrated at that time and this is often seen with individuals for whom the surgical procedure has been substantially or fully effective. Emotional status also showed some improvement although he continued to remain somewhat withdrawn socially.

CONCLUSIONS

We have found that a neuropsychological evaluation complements other forms of neurological assessment and that it provides an objective assessment of epilepsy and its impact upon behaviour. At approximately twice the cost of a standard EEG and six to eight hours of patient time, this entirely non-invasive procedure may be used which approaches the brain from the viewpoint of functioning rather than having the goal of establishing structural or electrical problems. In addition, the procedure provides a good index of what can be expected of a person with respect to performance in daily life and information is thereby provided which is not available through other methods of assessment. Because of these assets, neuropsychological evaluation is very frequently used at our Epilepsy Centre in order to provide a more complete assessment of the problems and prospects for our epileptic patients.

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