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CHAPTER 11

Neuropsychology of Epilepsy

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Epilepsy is one of the areas that has been most sadly neglected by psychologists. It is substantially underrepresented in the academic, research, and clinical programs of psychology (Mostofsky, 1978), a fact dramatically underscored by the incidence of this disorder. Very few psychologists are aware of the fact that epilepsy is probably more prevalent than are all psychotic disorders combined. The Professional Advisory Board of the Epilepsy Foundation of America, after detailed study of the literature, concluded that at least 2% of the population of the United States suffer from some form of epilepsy. This includes the commonly recognized forms of this disorder, plus many other epileptiform manifestations less well recognized (Epilepsy Foundation of America, 1975). Even if one were to use the more conservative figure of 1%, a staggering number of people are affected. Furthermore, the nature of epilepsy with the intermittent occurrence, the stigma, and the lifelong need to take intoxicating medications results in numerous psychological and social problems that could well use the services of the clinical psychologist and particularly the clinical neuropsychologist.

This chapter presents basic information about epilepsy and about the neuropsychology of seizure disorders, including the correlates of seizure history variables such as age at onset of seizure disorder, duration of disorder, the effects of anticonvulsant medications on performance, the neuropsychological correlates of the electroencephalogram, psychological phenomena associated with disorders of the temporal lobes, the effects of cortical resection surgery for epilepsy on performance, and the personal and social adjustment of the epileptic. Finally, specialized tools developed by me for the neuropsychological and psychosocial evaluation of persons with seizure disorders are presented.

NATURE OF EPILEPSY

Epilepsy may be defined simply as recurrent seizures. *Seizures* are paroxysmal events of cerebral origin that have a wide variety of manifestations. Because of the frequency with which seizure disorders are encountered, it is imperative that the neuropsychologist have a basic understanding concerning the seizure types that do exist.

The International Classification of Seizure Disorders (Gastaut, 1970) represents an effort to categorize the diversity of seizure types. While no scheme of seizure classification has achieved universal recognition, this method of classification is now in general use and makes several important contributions. It underscores the fact that the old terms "grand mal," "petit mal," and "psychomotor" are inadequate and that they are insufficiently specific to describe the numerous varieties of seizures that are now known to exist.

Furthermore, it emphasizes that an adequate seizure classification must use broadly based information, including clinical, anatomical, etiological, electroencephalographic, and biographical factors. In so doing, it provides a basis for the multiplicity of seizure types that are found. In this classification scheme, a basic differentiation is made between seizures of focal onset (partial seizures) and attacks that are bilaterally symmetrical and without focal onset (generalized seizures). Almost all attacks can be classified under one of these two headings. In the area of partial seizures, a distinction occurs between seizures having no impairment of consciousness (partial seizures with elementary symptomology) and seizures generally accompanied by such alterations (partial seizures with complex symptomology). In general, focal sensory and/or focal motor seizures fall under the former heading, while psychomotor attacks or episodes of temporal lobe origin fall under the latter classification. This last group may be especially complex in its manifestations, but attacks here are typically accompanied by an inability to respond to situations in a purposeful and meaningful fashion.

Generalized seizures, by definition, involve the entire brain, and regardless of their type, they tend to have a more striking impact on functioning. Classified under this major category are absence attacks, a certain subcategory of which has previously been known as petit mal. Myoclonic seizures, infantile spasms, clonic seizures, tonic attacks, tonic-clonic seizures (often referred to as grand mal epilepsy), atonic seizures, and akinetic attacks are the other principal types falling in this group. Absence attacks represent relatively brief episodes of a few seconds during which the patient is momentarily unresponsive to the environment. While motor components may exist, they represent only a very minor part of the episode; in no way do they represent behavior that is even semipurposeful in appearance. Also unlike complex partial attacks, the patient is unaware of environmental events during the episode and does not respond to them. Finally, while complex partial attacks are seen most frequently in adolescents and in adulthood, classical absence attacks are not usually seen after the age of twenty. Other types of generalized epilepsies include myoclonic attacks that often involve simultaneous and synchronous jerks of both sides of the body and atonic or akinetic attacks (drop seizures) in which the patient often suddenly loses total muscle tone and collapses to the floor.

All epileptic seizures have in common their relatively sudden onset and origin in the brain. However, the complex and multifaceted aspects of seizure disorders have led to a concept of "the epilepsies" rather than "epilepsy." While some epileptics have attacks that are easily recognized, at least some persons who have seizures are not even aware of this fact, even though on close questioning they will reveal that indeed they do have times when they cannot do what they are normally able to do or that they have experienced periods when they do strange things and do not know why. Naturally, psychiatric and emotional factors may be involved that may make differential diagnosis difficult.

The electroencephalogram (EEG) is very often crucial in establishing the diagnosis of seizure disorder. Abnormal electrical patterns termed "epileptiform discharges" are frequently seen in persons having seizure disorders. When they do appear in combination with a positive clinical history, a diagnosis of epilepsy can be confidently made. The difficulty is that the EEG evaluates only a relatively small segment of the behavior of the brain (usually thirty minutes or less) and that it is further handicapped by being able to detect electrical potentials only from a few millimeters of superficial cortex. Furthermore, these minute electrical variations are customarily recorded through the relatively thick insulating tissues of the head and distortions result. The result is that a number of individuals are known to have seizure disorders on the basis of their history who never

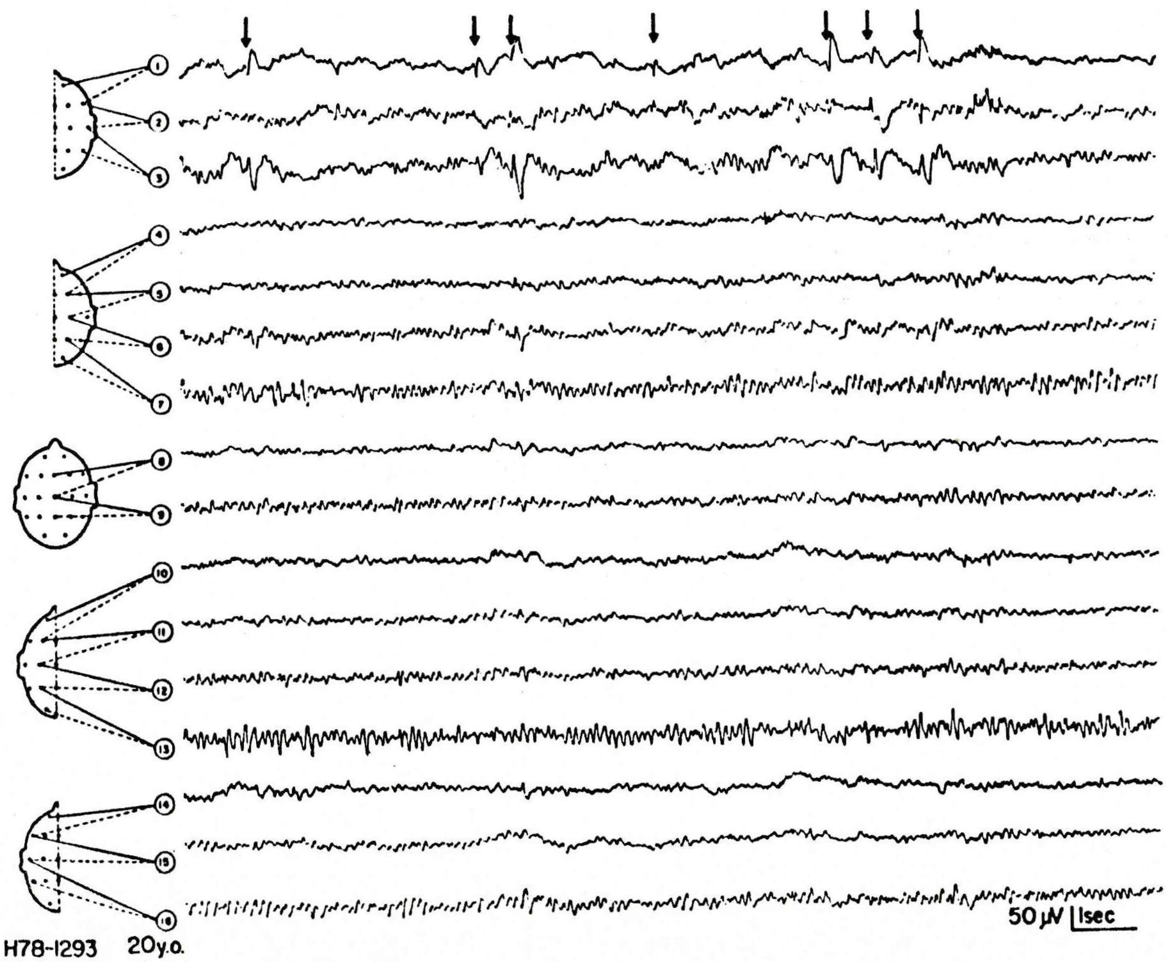

FIGURE 1. Focal discharges in a 20 year old patient with partial complex attacks. The arrows identify the discharges.

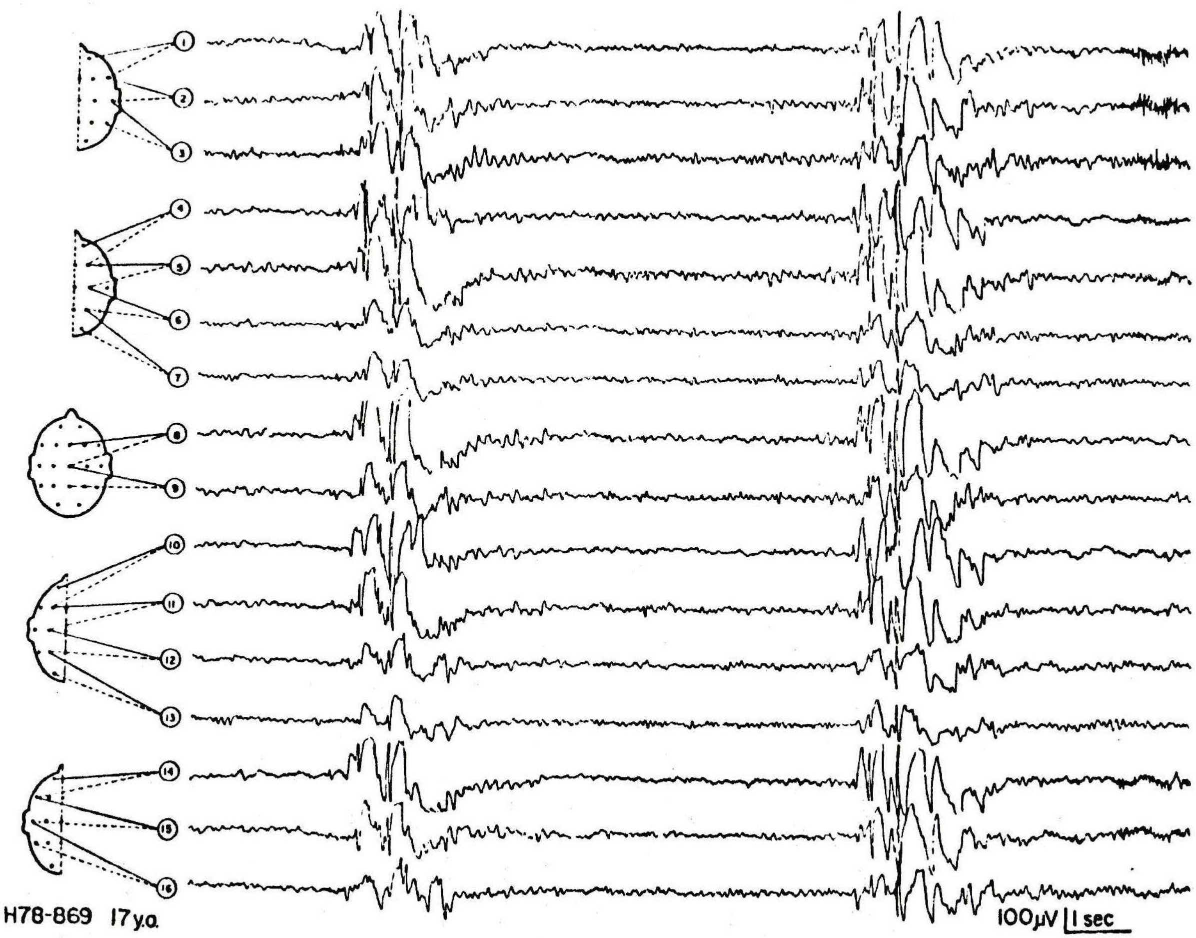

FIGURE 2. Generalized discharges in a 17 year old patient with a history of a single convulsion.

demonstrate even a single epileptiform pattern on their EEGs. EEGs recorded from implanted depth electrodes can be productive and can effectively complement the EEGs obtained from the scalp. There are instances in which, within a single tracing, distinct epileptiform discharges have been recorded by intracerebral, but not scalp, electrodes whereas exactly the opposite may be seen, even in the same tracing. It is fair to say that when positive findings appear in the EEG of a patient with a highly suggestive history, they are extremely helpful in making a positive diagnosis. When they are not found, they do not rule out the possibility of a seizure disorder.

Examples of EEG epileptiform discharges are provided in Figures 1 and 2. In Figure 1, focal discharges are seen primarily in the right frontotemporal area in a twenty year old patient who has a history of partial complex attacks that have included focal features pertaining to the left side of the body. Here, the EEG was extremely helpful in confirming the presence of a seizure disorder and in suggesting its type. Note the appearance of the spikes as indicated by the arrows. Figure 2 was taken on a seventeen year old boy with a history of a single generalized convulsion. The epileptiform discharges seen on this tracing are compatible with a generalized seizure disorder. It is observed that the nature of the abnormal electrical findings is substantially different in Figure 2 than in Figure 1. In Figure 1 the discharges are rather specifically related to one area of the brain and are of a different overall form than those seen in Figure 2. As might well be suspected, these two figures are indicative of rather substantially different seizure disorders with markedly different behavioral manifestations.

The causes of seizure disorders have long been studied, but because of the complexity of the factors involved, definitive answers are frequently lacking. The most frequently mentioned causes of epilepsy prior to or immediately following birth include the following: toxemia and infectious processes during pregnancy, difficult birth with mechanical trauma or inadequate respirations, high fevers, congenital defects, and inherited problems such as metabolic errors. The full effect of any of these problems may not be manifested until later in life. In the school years, head injuries, high fevers, and infectious diseases are often believed to be causes of seizure disorders and in adulthood brain tumors and vascular problems appear as significant factors. Essentially, any condition that disrupts the normal functioning of the brain and provides the basis for abnormal electrical patterns can result in a seizure disorder. Furthermore, even though a very careful medical history is taken, in only about half the instances can even the probable cause of epilepsy be ascertained. Such individuals are said to be suffering from "symptomatic" epilepsy. In the remaining cases, a fraction have family members with confirmed disorders, but in the majority of cases in this group, no family history of epilepsy can be found. This last group is often said to be suffering from a form of epilepsy known as "cryptogenic," "idiopathic," or "essential." Regardless of the cause, there is a tendency for epilepsy to occur relatively early in life, with 30% of the persons who will ultimately have attacks demonstrating them prior to the school years, 64% by the end of elementary school, 77% by the end of adolescence, 93% through young adulthood, and 98% before old age and retirement (Epilepsy Foundation of America, 1975). With the age of onset being relatively early and the duration relatively long, the disorder has many opportunities to impact development, as well as lifelong adjustment.

As can be seen from this brief review, epilepsy actually represents a spectrum of disorders that are complex and multifaceted in their expression with etiologies which are equally varied. As can be suspected immediately, such a disorder is not likely to have any single form of behavioral or emotional consequence, and the full range of psychological impacts of seizure disorders are very complex indeed.

PSYCHOLOGICAL CORRELATES OF SEIZURE HISTORY VARIABLES

A large number of studies have been done that have related certain psychological correlates (especially intelligence) to certain variables pertaining to seizure history. Many of these have been previously reviewed (Lennox & Lennox, 1960; Tarter, 1972). Because of the large number of studies that have been done, the review provided here only summarizes the results of several representative studies for each variable evaluated. It should be noted that whereas statistically significant findings are often reported, the variance accounted for by any of these dimensions is fairly small and the predictability on a single case basis is essentially nil.

Etiology

Probably the most established general finding of the intellectual correlate of any of these variables is with respect to etiology. In a series of studies summarized by Tarter (1972), individuals who had seizure disorders of known etiology average approximately five to ten fewer IQ points than those whose etiology is unknown. A detailed examination of these studies, however, also reveals that on those demonstrating the largest differences, no effort was made to control the groups with respect to the amount of education received (Arieff & Yacorzynski, 1942; Collins, 1951; Lennox & Lennox, 1960; Sands & Price, 1947). At the same time, studies such as that performed by Kløve and Matthews (1966), which made more of an effort to control for education across groups, demonstrated smaller differences. Even here, however, education is not controlled for exactly; therefore, one wonders if the IQ difference of four or five points might not, in part, represent both differences in educational experience as well as differences in etiology.

To further examine correlates of known and unknown etiology, Kløve and Matthews (1966) administered the battery of neuropsychological tests originated by Halstead and developed by Reitan (Reitan & Davison, 1974). Epileptics with known etiology consistently performed more poorly than those with conditions of uncertain origin, although only in a portion of the comparisons did the differences achieve statistical significance. The differences were most prominent with patients having psychomotor attacks, but similar trends were observed with persons having generalized clonic-tonic seizures as well.

From these studies, it does appear that knowledge of causative factors in epilepsy is correlated with abilities and adequacy of brain functions, but only to a modest degree. It does seem likely that individuals who have suffered a sufficiently severe insult to establish a medical history of the same may also have suffered more impairment in brain functions than persons who have seizures, but no record of such incidents. In addition, of course, individuals who have more brain injury tend to be duller, and duller persons tend not to go as far through school. These are at least some of the factors involved here, but in individual cases there may be others as well.

Age at Onset and Duration of Disorder

In general, the literature suggests that the earlier the age at onset and the longer the duration, the lower the mental abilities. The studies with intelligence have typically produced only moderate differences across groups (typically 10 IQ score points or less).

De Haas and Magnus (1958) and Lennox and Lennox (1960) present data suggesting that the differences are most prominent when generalized tonic-clonic attacks are considered. In addition, a more detailed neuropsychological study has been conducted by Klove and Matthews (1969) and by Dikmen, Matthews, and Harley (1975). In each instance, some findings are reported that support the general thesis. One is impressed by their limited magnitude, however, even on sophisticated neuropsychological tests and even when only groups extreme on this variable are considered (Dikmen et al., 1975). The suggestion is that many factors are involved in the determination of ultimate performance level and that these variables are only 2 of many that are involved.

Seizure Type

The literature suggests that persons having primarily generalized tonic-clonic (grand mal) attacks demonstrate the most impairment, while other forms of seizures are associated with less impairment. Matthews and Kløve (1967), for example, demonstrated that generalized tonic-clonic seizures were associated with more impairment across many neuropsychological variables than were individuals suffering from complex partial (psychomotor) attacks. Furthermore, seizure type was more potent than etiology in correlation with performance, but an interplay between these factors was demonstrated since a maximal spread in scores was observed when they were simultaneously considered.

Turning to types of seizures, the interictal behavioral correlates of generalized absence (petit mal) attacks have in some cases been so minor that it has not been possible to differentiate persons with this form of epilepsy from individuals having no history of seizures. However, possible sequelae of generalized absence seizures cannot be completely dismissed (Rodin, 1976). To complicate the issue further, it is well known that there are substantial differences across individuals carrying the same seizure diagnosis with respect to the severity of the attacks. Clonic-tonic episodes in some individuals tend to be much longer than others, for example; and in some persons respiratory arrest occurs with regularity, whereas in others this is rare or nonexistent. Thus severity of attacks within each seizure classification is of marked interest to the neuropsychologist, but the variable is so elusive that it is virtually never included in studies, and the extent of its correlates with behavior is not known.

Seizure Frequency

In general, one might conclude that the more frequent the seizures, the greater the impairment. Conclusive findings for this are not evident from the literature, however. By restricting themselves to patients with generalized tonic-clonic attacks, Dikmen and Matthews (1977) were able to demonstrate an orderly decrease in abilities on neuropsychological tests with increasing seizure frequencies, but the differences found were quite limited in both scope and extent. Objective test results confirming even these findings are generally lacking in the literature, probably at least, in part, because most investigators considered a variety of seizure types. Thus unless one considers only the most severe forms of seizures, a relationship is not likely to be demonstrated, and even then it is not likely to be substantial. In addition, most studies evaluate seizure frequency only at one point in time and are unable to consider the lifelong history of attacks, which is likely to be more revealing. Although this is obviously difficult to do, preliminary work that I have done suggests that this variable may ultimately demonstrate substantial relationships with performance.

Deterioration in Performance

All the factors that complicate an assessment of the effects of seizures on performance, plus others, must be taken into consideration when a loss in abilities is evaluated. In particular, the possible effects of anticonvulsant medications must be considered, as well as the effects of aging. The former are covered in detail in the next section. Harris (1972) and Wasterlain and Duffy (1973) have shown that there is neuronal degeneration associated with repeated attacks in animals and also that seizures have an inhibitory effect on brain protein synthesis, brain growth, and eventually on behavioral development in infrahuman species. With these studies as a background, it is not surprising that several investigators do implicate a gradual deterioration of intellectual abilities (Arieff & Yacorzynski, 1942; De Haas & Magnus, 1958; Lennox & Lennox, 1960). In a study of 1 pair of identical epileptic twins, Dodrill and Troupin (1976) were able to report a lifelong major motor seizure count of 7 for 1 twin and 37 for the other. The difference in seizure frequency was associated with substantial differences in performances across a variety of areas and also with differences in emotional problems. Individuals working in the area, including myself, have seen several cases in which a substantial deterioration in performance has indeed occurred over time, particularly when numerous major motor attacks are involved and especially so when they come in rapid succession (status epilepticus). At the same time, many individuals (especially among those having partial seizures) demonstrate very little, if any, deterioration over several years of observation. This area is a particularly important one, since it appears that many persons working with epileptics are not cognizant of the deleterious effects that seizures can have and of the importance of reducing their frequency to the lowest possible level. It is furthermore the firm conviction of many workers in the area that seizures themselves increase the probability of more attacks with yet even more being therefore likely. The importance of bringing seizures to a complete halt is clear, and the recommendation of treatment facilities where advanced medical care is available can be one of the most important interventive services that the neuropsychologist can offer.

ANTICONVULSANTS AND PERFORMANCE

The assessment of the possible effects of medications taken for seizures on a person's ability to function has been of interest for many years. Certain methodological difficulties complicate investigation in the area and prominently include the following; (1) When changes in anticonvulsant regimens are made, there is often a change in seizure frequency so that the net effects of the drug are confounded. (2) The use of placebos in comparison with an active agent is not an effective technique for evaluating changes in performance, because the addition of *any* active agent to a preexisting drug regimen tends to decrease performance (any drug therefore appears detrimental if evaluated within this experimental paradigm). (3) Several studies in the area have used only normal control persons who undoubtedly metabolized the drugs differently than epileptics who have taken them for many years. And (4) the majority of studies that have been done in the area use a single test (or at most a few tests) which does not sample a sufficiently broad range of abilities that a pattern of drug impacts can be ascertained. Despite these limitations, some facts concerning the effects of anticonvulsants have come to light and the results of the best known studies are summarized next.

Undoubtedly, phenytoin (Dilantin) is the most widely used anticonvulsant in the world today. It is effective in dealing with a broad range of attacks, including generalized tonic-clonic seizures, most types of partial seizures, and some other less frequently observed seizure types as well. Some studies (Booker, Matthews, & Slaby, 1967; Idestrom, Schalling, Carlquist, & Sjoqvist, 1972; Stevens, Shaffer, & Brown, 1974) have evaluated the effects of this agent administered to normal persons, usually over relatively short periods of time and in fairly small doses. No consistent objective findings were produced from such studies, even though a variety of tests were used. Matthews and Harley (1975) assessed the effects of this agent in combination with those of primidone (Mysoline) and phenobarbital with chronic epileptics using a broad range of tests. Furthermore, they considered drug serum levels and classified patients as toxic or nontoxic based on those levels. The groups of patients examined were different in terms of serum levels, but in general, the toxic group had only moderately high levels. This group tended to perform more poorly than the nontoxic group, but the differences reached statistical significance on only a small number of variables. These pertain primarily to the functions of attention and concentration, to motor coordination, and to static tremor. I (Dodrill, 1975) evaluated the effects of phenytoin administered as sole anticonvulsant to chronic epileptics. In the first analysis, subjects were divided according to whether they had serum levels in excess of 30 μg/ml with high and low groups resulting. The high group had a very large amount of drug in their serum (average of 43 μg/ml). The groups were matched for age, education, and so on. In the second analysis, the patients were divided into toxic and nontoxic groups based on clinical examination. Evaluation of a broad range of abilities based on a series of tests revealed statistically significant findings only on tests with a strong motor component. The findings were most prominent in the analysis with subjects grouped according to serum levels. This study suggests that phenytoin has effects rather specifically relatable to motor performance. It is noteworthy that despite the extremely high serum levels reported, evidence could not be found that would suggest a general mental dulling. The findings of this study are consistent with those of Ghatak, Santeso, and McKinney (1976) and Rapport and Shaw (1977) that relate cerebellar degeneration to chronic phenytoin administration.

The other anticonvulsant repeatedly evaluated with psychological tests is phenobarbital. In an early study of this type (Somerfeld-Ziskind & Ziskind, 1940), one group of epileptics was administered phenobarbital, while another group was essentially untreated. No deleterious effects of phenobarbital were noted as assessed by the Stanford-Binet Intelligence Scale (1916 version) and, in fact, the mental age increased more for children on phenobarbital over a one year period than those children not being administered this agent. It was also observed that there were far fewer seizures when phenobarbital was administered than when it was not. This illustrates the fact that despite any negative effects which may be associated with anticonvulsant administration, it is routinely better to administer the drug and stop the seizures than not to do so. The study also illustrates a difficulty in interpreting investigations of this type—namely, that drug changes are frequently accompanied by changes in seizure frequency.

In a short, but revealing, study, Hutt, Jackson, Belsham, and Higgins (1968) administered phenobarbital to normal subjects with serum level control. They found decreases in abilities with phenobarbital administration that in many instances were related to phenobarbital blood serum levels. These effects were seen most prominently on tasks requiring sustained attention, psychomotor performance, and spontaneous speech. The drug effects became more prominent as the tasks became more difficult and more lengthy and as the degree of external constraint (having the examiner in the room) was decreased. These findings emphasized some of those reported by Matthews and Harley (1975), which is not surprising, since both primidone and phenobarbital result in phenobarbital in the blood serum. It is concluded that phenobarbital has effects maximally evident on tasks requiring attention and concentration, but that it may have effects on motor coordination as well.

Another anticonvulsant that has received special attention because of its presumed "psychotropic" effects is carbamazepine (Tegretol). In a major review of the literature (Dalby, 1975) that cited nearly 40 studies, about half of the studies reported a beneficial psychologic effect. Typically, an improvement in mood and behavior has been noted as manifested by greater cooperativeness, reduced aggression and irritability, and a possible decrease in depression, but these conclusions were based on subjective observations rather than objective testing. Rodin, Rim, and Rennick (1974) attempted to validate these results with epileptics by contrasting the effects of carbamazepine with a placebo when either was added on to a preexisting drug regimen. They were unable to demonstrate any clear psychotropic effect of this medication and, in fact, noted slightly decreased performances, particularly with respect to tasks requiring attention and concentration. This, of course, is the expected finding when a sedating drug is contrasted with an inactive substance.

Dodrill and Troupin (1977) used a single agent, double-blind, crossover design and compared performance and psychological well-being with carbamazepine (Tegretol) administration to that assessed under phenytoin administration. With seizure control about the same under each agent, some modest improvements in performance were noted on mental tasks requiring attention and problem solving with carbamazepine administration. In addition, emotional status as evaluated by the Minnesota Multiphasic Personality Inventory (MMPI) also showed slight improvement. Duller persons and persons with more extensive psychiatric difficulties appeared to improve the most. However, one cannot be certain that the change is entirely due to the institution of carbamazepine administration or whether it is due to the discontinuance of phenytoin. It does appear likely that this drug is less sedating with increased performance specifically in higher-level mental skills. It is of some interest to note that this is the case despite the fact that EEGs taken under carbamazepine administration actually looked somewhat worse than under phenytoin administration (Wilkus, Dodrill, & Troupin, 1978).

Studies with other anticonvulsants may be briefly mentioned. Mephenytoin is a potent agent that appears to permit better attention to the task than phenytoin (Troupin, Ojemann, & Dodrill, 1976), but which can have serious side effects and is therefore infrequently used. A relatively new agent used in the United States is valproate sodium or valproic acid (Depakene), which at the time of this writing has not received adequate evaluation with respect to psychological correlates. Studies of valproic acid such as that reported by Sommerbeck, Theilgaard, Rasmussen, Lohren, Gram, and Wulff (1977) which are based on an active agent versus a placebo cannot be used to indicate that valproic acid is associated with decreased performance. In reality, the neurologist is forced to decide which drug will be used, not whether a drug will be used. Furthermore, studies of such agents must take into account the fact that each new medication tends to be applied to the worst patients so that if no improvement is seen, this does not necessarily indicate that it is any less effective than any of the agents already in common use.

After having spent several years working specifically in the area of anticonvulsants and their effects on behavior, I cannot help concluding this section with two observations. First, when anticonvulsant serum levels fall within therapeutic ranges and when there are no overt signs of toxicity, the chances are that any deleterious effects are only minimal if detectable at all. A review of all the studies mentioned thus far fails to identify even one investigation in which striking and far-reaching effects were noted. In general, the magnitude of psychological correlates are significantly less than those of the other variables discussed in this chapter. Furthermore, the effects are decidedly offset by decreased seizure frequency, which has known effects on the deterioration of mental functions; and it is far more preferable to have modest drug side effects than seizures.

The second general observation is that studies that add on active agents to preexisting drug regimens and contrast them with inactive placebos may routinely be expected to result in decreased performance with the addition of the active toxic agent. These studies therefore provide little information for the neuropsychologist, although they may be of greater interest to the neurologist, who must often decide if another drug is to be added to an existing drug regimen.

In concluding this section, one should note that the assessment of anticonvulsant side effects is undoubtedly one of the most challenging tasks of the neuropsychologist working with seizure patients. One should be aware that the foregoing statements are generalizations and that unusual reactions in individual patients can by no means be ruled out. Furthermore, it is possible, if not probable, that the full range of anticonvulsant effects are not assessed by existing test measures. Facts such as these underscore the need for additional information in this area and the desirability of caution in drawing conclusions with respect to particular cases encountered in clinical work.

ELECTROENCEPHALOGRAPHIC VARIABLES

Electrical changes of cortical origin represent the heart of the epileptic attack. Even in instances when such changes cannot be demonstrated by the EEG using scalp electrodes, such changes are assumed to exist within the brain at a level not within the rage of the standard EEG. As is well known, the presence of epilepsy can frequently be documented between attacks by the appearance of interictal epileptiform discharges as were illustrated in Figures 1 and 2. These patterns, characteristic of epilepsy, have attracted a special interest when they appear as the three-per-second spike-and-wave discharges often seen in generalized absence attacks. In a series of papers, Mirsky and associates (Mirsky, Primac, Ajmone Marsan, Rosvold, & Stevens, 1960; Mirsky & Van Buren, 1965) have demonstrated that such paroxysms are accompanied by substantially decreased performances at the point where they occur. Kooi and Hovey (1957) found that certain "nonanswer" responses judged inappropriate relative to a patient's usual performance occurred during generalized or focal clinical or subclinical discharges.

Wilkus and Dodrill (1976) evaluated epileptics who on a single EEG demonstrated generalized discharges, focal discharges, or no signs of discharges. A broad battery of neuropsychological tests were used, including those originated by Halstead and developed by Reitan. A very striking ordering of the groups was observed with respect to performance with the generalized discharge group having the greatest impairment, the focal discharge group having intermediate impairment, and the group with no evidence of discharges on a single tracing having the least impairment. In the same study, average rate of occurrence of discharges was also examined with respect to neuropsychological correlates, with the group demonstrating no discharges performing best, the group with discharges of less than one per minute being generally intermediate, and the group with discharges of more than one per minute being the worst. It was possible to demonstrate that individuals with generalized discharges greater than one per minute had the worst performances of all. Thus increasing involvement of the brain with epileptiform discharges is systematically and lawfully related to decreased performance. Furthermore, the decreased performances associated with this condition are conspicuously widespread and involve many different kinds of functions. One may raise the question about whether the decreased performance is a product of the immediate effects of the discharges or whether the discharges and the decreased performance are in the typical instance both symptoms of underlying brain pathology. Putting generalized absence attacks aside, the latter alternative appears most likely to me.

The EEGs of epileptics have also been studied with respect to rhythm frequency. In the general literature, probably the greatest amount of attention has been paid to the dominant posterior rhythm (Giannitrapani, 1969; Lennox & Lennox, 1960; Vislie & Henriksen, 1958). Generally, decreased abilities were demonstrated with slower rhythm frequencies. It is unfortunate that many studies in this area have limited the scope of the rhythms examined to the traditional alpha range (8 to 13 Hz) and also that the psychological test variables have almost always pertained only to the area of intelligence. In an effort to remedy the situation, Dodrill and Wilkus (1976) studied the performance of a large group of epileptic patients on a broad range of neuropsychological tests. In general, performance was not substantially decreased until the dominant posterior rhythm frequency dropped below 8.0 Hz when performance rather substantially diminished. Furthermore, patients with such rhythms in the range of 5 to 6 Hz routinely showed very substantially decreased performance. Although decreased performances were seen to some degree across a range of skills, those particularly requiring simultaneous attention and complex mental manipulations showed the greatest losses. The magnitude of the differences seen was less than that pertaining to epileptiform discharges, however (Wilkus & Dodrill, 1976).

Psychological correlates of generalized nonepileptiform EEG abnormalities have also been evaluated. Vislie and Henriksen (1958) found lowered intelligence and clinical signs of dementia among individuals exhibiting "diffuse dysrhythmia." Lennox and Lennox (1960) produced similar findings with various measures of intelligence and concluded, "Slow waves often match slow wits" (p. 673). Jenkins (1962) studied a variety of neurological patients and demonstrated a relationship between slowing and performance on the Wechsler Adult Intelligence Scale (WAIS) that was consistent across both the Verbal and Performance scales, but which reached statistically significant proportions only on the Performance Scale. Increased slowing was accompanied by decreased performance. In an effort to shed further light on the area and using only epileptics, Dodrill and Wilkus (1978) used a broad range of neuropsychological tests with patients grouped by specific criteria according to whether they showed mild abnormalities, moderate abnormalities, or marked abnormalities. With patients grouped in this fashion, very striking differences were noted across a full series of neuropsychological test variables; the magnitude of these differences exceeded that found with both epileptiform discharges (Wilkus & Dodrill, 1976) and the dominant posterior rhythm frequency (Dodrill & Wilkus, 1976).

The foregoing findings are remarkable and require comment on several points. First, although undoubtedly generalized nonepileptiform EEG abnormalities demonstrate the most potent relationships with performance, they have clearly been the least investigated and apparently do not have the appeal to the investigator that the other variables seem to present. Second, as has been recently shown by Wilkus and Dodrill (1978), simultaneous consideration of several of these EEG variables is likely to result in the greatest correlations with performance. Third, the area of simultaneous EEG and neuropsychological testing has only begun to be tapped, and most of the studies just mentioned did not collect data by simultaneous psychological testing and EEG recording. This is an important area for research, particularly since epileptiform patterns may disrupt activities even when no seizure occurs. Finally, one should observe that the order of magnitude of differences in performance noted on many of these EEG studies exceeds that of most of the foregoing studies, including that of anticonvulsants and seizure history variables. Even considering limitations of the standard EEG, it is apparent that there are many prospects for continued work in this area.

EMOTIONAL ADJUSTMENT AND TEMPORAL LOBE PHENOMENA

As one of America's foremost epileptologists has said, "There is practically no epileptic patient who is not confronted with some type of psychosocial problem . . ." (Rodin, 1977, p. 74). For centuries, epileptics have been observed and it has been believed that some form of behavioral pattern generally characterizes them. An early statement of this was made by Aretaeus (Temkin, 1945): "They become languid, spiritless, stupid, inhuman, unsociable, not disposed to hold intercourse, not sociable at any period of life; sleepless, subject to many horrid dreams, without appetite and with bad digestion, pale, of leaden colour, slow to learn from the torpidity of understanding and of the senses." We understand today that the nature of the disorder and the multiplicity of its manifestations are such that this type of sweeping generalization could hardly be true. However, it is disturbing to see how such stereotypes hold to the present time and that they even appear in some of the most recent literature (Bear & Fedio, 1977; Flor-Henry, 1972). The use of such terms can only do disservice to patients suffering from seizure disorders, and they cloud the issues at hand more than they clarify them.

While investigators have given up attempting to find a universal "epileptic personality," they have instead sought out particular personality patterns to be associated with particular seizure types. Undoubtedly, the most common of these pertains to the type said to be assocaited with psychomotor epilepsy or complex partial seizures arising predominantly from the temporal areas. Unquestionably, the most prolific investigator in this area has been Flor-Henry, who, in a sizable series of papers, has investigated the question of psychosis as related to temporal lobe seizure disorders. The most important papers in this series are cited here (Flor-Henry, 1969, 1972, 1974, 1976). In particular, Flor-Henry directs himself to the question of psychosis versus epilepsy. Beginning with a psychiatric population and evaluating epileptics within that population, he concludes that schizophrenia among epileptics is associated with EEG epileptiform discharges arising from the left temporal area, whereas affective psychoses are associated with epileptiform discharges arising from the right temporal area (Flor-Henry, 1969). In a summary statement, he concludes, ". . . in schizophrenic and manic-depressive psychoses associated with temporal lobe epilepsy, the schizophrenic syndrome is very significantly related to dominant, and the manic-depressive syndrome to non-dominant, temporal-limbic dysfunction . . ." (Flor-Henry, 1974, p. 146). In the briefest of forms, he also presents neuropsychological test information comparing these groups and used a series of tests, including portions of the Halstead-Reitan Neuropsychological Test Battery, as well as other measures. With blind evaluations of such findings, he reports extremely high associations of frontotemporal dysfunction of the right cerebral hemisphere with affective disorders and the left cerebral hemisphere with schizophrenic disorders. In fact, 82 out of 100 psychotic individuals with temporal lobe epilepsy were correctly classified as having primarily right or left temporal lobe dysfunction on the basis of the neuropsychological tests (Flor-Henry, 1976).

Occasional support for Flor-Henry's position has been found (see, for example, Bear & Fedio, 1977a; Gur, 1978). In the majority of instances, however, investigations in this area have not supported Flor-Henry's conclusions; if they have been generally supportive, they have not provided the explicit support required to document the clear-cut conclusions given by Flor-Henry. The question about whether complex partial attacks are to be associated with increased psychiatric disturbance has been raised and a series of studies have found no support for this contention (Rodin, 1973; Stevens, 1966; Stevens, Milstein, & Goldstein, 1972). Where psychiatric problems have often been related to the temporal lobes, they have often taken the form of difficulties other than psychosis, such as aggressiveness (Serafetinides, 1965), or they have only been found when various seizure types have simultaneously coexisted (Rodin, Katz, & Lennox, 1976). In this last study, numerous epileptics were extensively evaluated and support for Flor-Henry's lateralization hypothesis was not found.

Several factors appear to be relevant to the discrepancies among these findings. First, the samples evaluated vary dramatically from one to the next. Flor-Henry's work (and that of most other investigators providing at least partial support for his findings) start with clear-cut psychiatric populations rather than epileptic groups. The importance of this single point cannot be overestimated. If one begins with a psychotic group that also has epilepsy and finds certain modest associations between the type of psychosis and the origin of the epileptic foci, one cannot at all conclude that if one has epileptic foci in these locations, one must therefore be psychotic. A second problem in this area pertains to the common equivalent usage of the terms "psychomotor" and "temporal lobe" epilepsy. About one-fifth of patients with a temporal lobe focus never have a psychomotor seizure and another one-fifth of patients with psychomotor or complex partial attacks never demonstrate a temporal lobe electroencephalographic focus (Stevens, 1966). Thus particularly when the American versus European studies are contrasted, it is not clear that the same patients are being compared. A third problem is the tendency to misinterpret the fact that about three-fifths of persons with epilepsy and psychoses have complex partial attacks. One cannot therefore necessarily conclude that these two phenomena are related. As Stevens (1966) has pointed out, about three-fifths of all epileptics have psychomotor attacks! A fourth problem is the apparent failure of some investigators to take into account the fact that most epileptics and particularly psychotic epileptics do not have highly focal disorders with all other parts of the EEG falling absolutely and entirely within normal limits. When Flor-Henry (1969) takes the possibility of bilateral involvement into account, he actually finds higher rates of psychosis of almost any type associated with such bilateral foci than with unilateral foci. It is not clear that this finding from his own data agrees with his basic hypothesis.

A fifth problem preventing a full acceptance of Flor-Henry's conclusions is that personality inventories and neuropsychological tests routinely have failed to support his hypothesis. Even in the examination of the most relevant study (Flor-Henry, 1976), one finds that he has classified such tests as the Trail Making Test and Seashore Rhythm Test as specifically implicating 1 hemisphere and 1 hemisphere only. Furthermore, some of the data he reports on lateralized motor measures implicate the *right* cerebral hemisphere for schizophrenia rather than the left hemisphere. Thus schizophrenics made more errors on the finger localization task with *both* the right and left hands than persons with affective disorders. An examination of Flor-Henry's data, in fact, reveals that the schizophrenics performed more poorly on *every one* of the 11 test variables reported. The general deficit associated with schizophrenia is completely ignored in Flor-Henry's report. Other findings not consistent with his hypotheses are also ignored. For example, the schizophrenics are never reported as having significantly lower Verbal IQ scores than patients with affective disorders or the reverse for the Performance IQs.

A sixth, and final, point is that the schizophrenics classically reported may not be the same as those who appear with epilepsy. This viewpoint is presented in detail by Slater and Beard (1963) and is one hypothesis that must be entertained by any serious student in this area.

What can we then conclude about social and emotional problems in epilepsy, as well as personality characteristics associated with this disorder? Unquestionably, many social and emotional problems are found with epileptics that are far in excess of the base rate of the population. The etiology of these problems is more obscure, however, undoubtedly stemming in part from (1) seizures themselves, with their disruption of experience and activity, (2) decreased adaptive abilities stemming from impairment in brain functions, and (3) social stigma and factors affecting the interaction with others. With the presence of these and other etiological factors and with the complex manifestations of this disorder, it seems likely that few if any one-to-one relationships can be drawn between the types of seizure disorders and emotional status. With respect to temporal lobe disorders, whereas, in fact, some of Flor-Henry's findings may be accurate in part, these relationships are more likely to be found when one begins with a severely disturbed population. In no way is it expected that Flor-Henry's observations will be confirmed when one begins with a general epileptic group, because the incidence of psychotic or psychoticlike reactions in this group is simply too low. Even when one begins with severely disturbed individuals who also have epilepsy, it appears that the relationships found by Flor-Henry are not nearly as clear-cut as he presents them.

The area of emotional adjustment and temporal lobe phenomena is one with a strong appeal to investigators, and it is also one of major clinical importance. Because of this, it is believed that there will be a great deal of activity here in the future. As in the past, it is suspected that there will be a tendency to arrive at premature conclusions through oversimplification of the problems at hand. Caution in this regard is strongly urged.

CORTICAL RESECTION SURGERY FOR EPILEPSY

In the 1920s at the Montreal Neurological Institute, Wilder Penfield developed the technique of cortical resection surgery for epilepsy; and despite the addition of more recent technological advances, in many respects, the same procedures are used today. In general, scalp EEGs identify an area that appears to be the origin of persistent epileptiform abnormalities in patients with poor response to anticonvulsant medications. Under local anesthesia, a bone flap is turned and the cortical surface is exposed on the area surrounding that previously identified by the EEG as associated with the discharges. In the majority of instances, EEG electrodes are placed directly on the brain and the exact location of the spike source is identified. Assuming that this is an area not directly identified with vital functions (including speech and motor abilities), the portion of the brain associated with the discharges is then removed.

This section of the chapter is primarily concerned with the success of the procedure and the possible contribution that neuropsychology may make to improvement in success rates. In terms of success, this procedure can be generally said to lead to a significant reduction or arrest of seizures in about 70% of the patients (Feindel, 1975). The largest series of surgery patients is that done in the Montreal Neurological Institute, where more than 2000 patients have now been operated on for relief of seizures. Feindel (1975) briefly summarized their results on 1230 patients by indicating that 21% were seizure-free since discharge, 18% became seizure-free after some early attacks, 9% had rare or occasional attacks 3 or more years following surgery, 19% experienced a marked reduction of seizure frequency but not complete control, and 33% had a moderate to no reduction of seizure frequency. Thus while in a sizable portion of patients distinct improvement can be expected, there is also about a third of the patients in which little or no improvement is realized. This has, of course, led to a number of studies in an effort to better predict surgery outcome from a medical viewpoint; these studies have been summarized and several variables examined (Bengzon, Rasmussen, Gloor, Dussault, & Stephens, 1968; Feindel, 1975). From a medical perspective, some variables of interest have been identified such as discreteness of focus, unresponsiveness to standard anticonvulsant regimens, localization of the focus in a "dispensable" area, and so on. Nevertheless, a sizable failure rate persists; as a consequence, neuropsychologists have raised the possibility that study of the brain from a neuropsychological perspective might be of assistance in predicting outcome of surgery.

Undoubtedly, the study most specifically directed toward this issue is that done by Wannamaker and Matthews (1976). Using a small group of patients ($N = 14$) they intensively evaluated them both before and after surgery and discovered that individuals who had the least neuropsychological impairment preoperatively tended to have the best seizure control following surgery. With patients divided into groups according to whether they (1) were seizure-free, (2) had experienced definite improvement, but were not seizure-free, and (3) had experienced no significant improvement, successively higher levels of impairment were demonstrated. In addition, some evidence indicated that patients who were most impaired preoperatively were inclined to develop the greatest neuropsychological impairment postoperatively.

One cannot complete a section discussing neuropsychology and cortical resection surgery for epilepsy without making reference to the detailed work of Brenda Milner at the Montreal Neurological Institute. In a long series of papers, she and her colleagues studied many aspects of memory in epilepsy and the alteration of this by surgery (Milner, 1964; Milner, Corkin, & Teuber, 1968; Penfield & Milner, 1958). Although these studies involved evaluation of functions related primarily to the temporal lobes, she has done additional studies pertaining to the frontal lobes and associated functions (Milner, 1963; Milner, 1969). The findings from these papers and many others are not reviewed here, but reference is specifically made to one study arising from the group of investigators at Montreal (Bengzon, Rasmussen, Gloor, Dussault, & Stephens, 1968) with relevance to the question of prognosis concerning the alleviation of seizures. This study demonstrated that if cerebral dysfunction as evaluated by the neuropsychologist was localized to the temporal areas (the area of surgery), there was a much more favorable outcome than if problems were detected elsewhere as well. This finding certainly agrees with those of Wannamaker and Matthews (1976) and raises the possibility that if the brain is essentially normal (except for a highly localized area of dysfunction) and if the abnormality can be removed from that area, the overall condition of the organism may actually be improved. The prognostic possibilities of neuropsychological tests in this context deserve further exploration.

While not reviewed in detail here, the reader may find of interest a series of papers detailing various psychological changes following surgery. In the intellectual and neuropsychological areas, several findings have been summarized by Meyer and Yates (1955) and by Milner (1975). A series of studies have been done evaluating surgery's effects on psychosocial functioning, including Falconer (1973), Horowitz and Cohen (1968), Savard and Walker (1965), Serafetinides (1975), Serafetinides and Cherlow (1976). In general while some specific neuropsychological deficits can be found, psychosocial adjustment is often improved following surgery for epilepsy provided that the surgery is at least in part successful in permitting greater control of the seizures.

NEUROPSYCHOLOGICAL EVALUATION IN EPILEPSY

Having now completed a review of the major variables of interest to neuropsychologists that pertain to epilepsy, we now come to the question of the formal neuropsychological evaluation of epileptics. This section summarizes the work I have done in this area.

As is well known, the brain is a complex organ; as such, an evaluative approach that recognizes this complexity is required. In particular, in line with the work of Halstead (1947) and Reitan (1955a), a series of measures must be used rather than a single test to obtain a suitable index of brain functioning. One simply cannot adequately evaluate brain functions by having the patient draw a few figures, for example. Furthermore, although there has been a strong tendency to evaluate epileptics only with tests of intelligence, we know that such tests were originally designed to predict how well children would do in a school situation and they were not constructed with neurological assessment in mind. Any test used with neurological groups should, of course, have specifically demonstrated sensitivity to impairment in brain functions with adequate validational studies.

These factors led me to believe that to evaluate neuropsychological deficits in epileptics, a comprehensive battery of measures was needed that would meet the forementioned criteria. More than this, the battery of tests to be used should be selected specifically for its relevance to epilepsy and epileptic-related phenomena. The tests must include measures sensitive to the side effects of anticonvulsants, the influences of seizures on abilities, and the correlates of important EEG findings such as epileptiform discharges. Furthermore, such a battery must be responsive to the complaints often made by professionals dealing with epileptics and by the epileptics themselves to maintain sustained attention to the task. While the Halstead-Reitan Neuropsychological Battery appeared to meet some of these demands, it was not designed specifically for epileptics or to meet the requirements arising with respect to that disorder. At the time this battery was developed, of course, few anticonvulsants existed, very little was known about the relationship of EEG epileptiform discharges to performance, and the effects of seizures themselves on abilities were very poorly described indeed. Since that time, many studies have been done documenting that

these factors and others are related to abilities, with several of these studies having been summarized in the preceding sections of this chapter. Furthermore, despite the fact that the Halstead-Reitan Neuropsychological Battery has demonstrated usefulness in many contexts (Reitan & Davison, 1974), not all the tests in that battery have been standardized and none on an epileptic population. Halstead did much of his original work on tumor and head injury cases, and the substantial alterations in brain tissue frequently seen in those cases would probably not be found in the typical epileptic today. Other factors such as sex differences in performance were also not considered at that time, although they have at least some significance (Dodrill, 1979). Finally, the normal or control samples used in previous studies have routinely been drawn from selective groups not representative of the general population (Halstead, 1947; Reitan, 1955a; Vega & Parsons, 1967).
Parsons, 1967).

All these factors led me to believe that it would be desirable if not essential to develop a battery of neuropsychological tests specifically to deal with the problems frequently seen with epileptics and standardized on that group. The battery of neuropsychological tests (the Neuropsychological Battery for Epilepsy) that was ultimately developed specifically for the neuropsychological evaluation of adult epileptics is briefly described next. A detailed description is provided elsewhere (Dodrill, 1978).

Method

In selecting subjects for the study, it was desired that they be representative of epileptics referred for neuropsychological evaluations. All patients referred during a period of 6 years were therefore examined with respect to the variables of sex, age, education, occupational status, and race. A total of 75 epileptics, (50 for the main study, 25 for the cross-validational study) were selected who had characteristics highly similar to the overall group. Control subjects were individuals with no histories of neurological disease or other events that may have affected the nervous system. They were selected in various ways from the general community and not from any patient population. Every control person was individually matched with an epileptic for the variables in question. The final group was about 60% male and 40% female. They averaged 27 years of age and typically had high school educations. Approximately 98% were Caucasian. Some 20% were students, 30% were employed persons, 40% were unemployed, and 10% were housewives. Concerning primary seizure type, about 60% had complex partial attacks, 12% had elementary partial seizures, 25% had some form of generalized seizure, and the remainder had several seizure types given as primary diagnoses. Age at onset of seizure disorder had typically been by early adolescence.

Previous experience and research with respect to the question of test selection suggested that two types of tests should be included in the battery. First, certain General Measures appeared to be necessary to provide basic information concerning the individuals evaluated in the areas of intelligence, emotional adjustment, and preference in handedness. On the basis of clinical experience, the measures selected for these areas were the WAIS, the MMPI, and the Lateral Dominance Examination (Reitan, 1966). No further evaluation of these measures was made; attention instead was turned to the second series of tests that consisted of specialized neuropsychological measures designed to assess the particular brain-related difficulties in performance often seen in epilepsy. These specialized tests, ultimately labeled as Discriminative Measures, combined with the General Measures and constituted the Neuropsychological Battery for Epilepsy.

The tests selected for evaluation in this study as possible Discriminative Measures included the well-established neuropsychological tests of the Halstead-Reitan Neuropsychological Battery. Material produced from the Aphasia Screening Test was evaluated on the basis of a manual developed for this purpose, a procedure that has been used previously (Dodrill & Troupin, 1977). In addition to these well-established tests, others were added for this specific patient population, including the Wechsler Memory Scale (WMS) (Form I), a modification of the Stroop Color-Word Test (Stroop, 1935), the Seashore Tonal Memory Test (Seashore, Lewis, & Saeteveit, 1960), and the Wonderlic Personnel Test (Wonderlic, 1973). These tests were included because of demonstrated sensitivity to the effects of anticonvulsant medication, because previous work by other investigators had shown them to be useful in epilepsy, or because they appeared to address the complaints that patients were frequently reporting. An informal content analysis of the entire constellation of tests was done to assure that simple and complex motor, cognitive, and perceptual functions were represented. Although the final selection of tests to be evaluated was somewhat arbitrary and other tests might have been included, the procedures used at least insured the inclusion of tests representing the areas perceived to be important in evaluating the neuropsychological correlates of epilepsy.

After this set of tests had been established, a pilot study with 33 control-epileptic pairs was completed to initially assess the effectiveness of all measures and also to evaluate the use of various new scores and combinations of scores devised by me that I thought possibly to be of use. For example, since the performances of both hands are routinely added together for the Tactual Performance Test (TPT), an effort was made to do this for other tests as well, such as for the Tapping Test. A total of approximately 100 neuropsychological test variables were evaluated in this fashion, but many of these appeared to contribute little or nothing to the commonly used scores and were therefore discarded. In particular, the Coin Recognition portion of the Reitan-Kløve perceptual examination was discarded as were all parts of the WMS, except for Logical Memory and Visual Reproduction. In sum, the pilot study resulted in the reduction of variables to be considered from approximately 100 to 35. Data on these 35 variables were then collected using the 75 control-epileptic pairs described earlier. The selection of the final set of Discriminative Measures was then begun and a three step successive sieve approach was used.

First, the criterion of *discrimination* was applied following the work of previous investigators in the area (Halstead, 1947; Reitan, 1955a; Vega & Parsons, 1967). It was believed that unless the measures showed a consistent ability to discriminate between normal and epileptic persons, they were not likely to be sensitive to the brain-related problems associated with seizure disorders. With extraneous factors such as age and education held constant, epileptics must consistently perform more poorly than their matched controls on a given test before that test can be presumed to evaluate a deficit relatable to the seizure disorder. It was therefore a priori decided that any test measure that did not statistically differentiate normal control individuals from epileptics at the .01 level or better would be discarded. Application of this technique resulted in the elimination of two variables, including the Speech-sounds Perception Test and the Time Component of the Tactile Form Recognition Test.

Second, the criterion of *test overlap* was applied in an effort to reduce the number of redundant test measures. In consideration of both the principal control (N = 50) and epileptic (N = 50) groups, a test was eliminated when it correlated with another test more than any 2 of Halstead's tests correlated with each other. Thus no test could correlate more than .66 with any other test. In the elimination of duplicative measures, the pervasiveness of the overlap of the tests with others was primarily considered, but some attention was also paid to the extent of discriminability of the measures. Application of this criterion resulted in the elimination of 17 of the 33 remaining test measures.

Finally, each of the 16 variables meeting the first 2 criteria was subjected to the criterion of *cross-validation* by differentiating between normals and epileptics in a final study. This cross-validational effort included 25 new control-epileptic pairs. On this occasion, the .05 level of discriminability was used as criterion, and all 16 measures met this criterion and were considered to be cross-validated. A listing of these 16 test measures are given in Table 1 and is based on all 75 control-epileptic pairs.

An examination of the test measures listed in Table 1 is of interest in its own right. Of the 16 test variables, the first 6 originate from the work of Halstead, the next 5 primarily from the work of Reitan, and the last 5 come from additional sources. With respect to the test measures from Halstead, the original scores are used except for the elimination of the Speech-sounds Perception Test and for alterations in the Finger Tapping Test. In the latter, the sum total of the performances by both hands was a more reliable indicator than the preferred hand alone. Furthermore, sex differences have now been documented on this test (Dodrill, 1979) that are in substantial part due to differences in hand size. Therefore, the performances for males and females are considered separately. With respect to the measures contributed by Reitan, the scoring system for the Aphasia Screening Test permitted an objective evaluation of the number of language-related errors and also for the extent of constructional dyspraxia (0 = None; 1 = Questionable; 2 = Mild; 3 = Moderate; 4 = Severe). With respect to the remaining test measures, it should be observed that Part I of the Stroop Test represents the easy part of reading the words printed in

Table 1. Comparison of Means across Control (N = 75) and Epileptic (N = 75) Samples for the Final Group of Discriminative Measures

	Control group		*Epileptic group*		
Test variable	*M*	*SD*	*M*	*SD*	*t*
Category	38.60	24.34	58.52	30.44	5.38[c]
TPT, Total Time	13.63	8.17	26.86	15.42	7.92[c]
TPT, Memory	8.09	1.24	6.87	1.77	5.63[c]
TPT, Localization	5.47	2.25	3.52	2.21	6.99[c]
Seashore Rhythm	26.36	2.93	23.77	4.75	4.27[b]
Tapping, Total (males)	107.47	9.83	89.33	15.14	8.89[c]
Tapping, Total (females)	97.66	8.70	78.91	14.63	7.23[c]
Trail Making, Part B	74.51	45.99	119.17	76.62	5.34[c]
Aphasia Screening, Errors	1.76	2.46	3.88	4.10	5.99[c]
Constructional Dyspraxia	0.67	0.83	1.45	1.21	4.69[b]
Perceptual Examination, Errors	4.47	5.58	12.57	14.27	5.26[c]
Name Writing, Total (letter/sec)	1.03	0.34	0.74	0.28	6.66[c]
Seashore Tonal Memory	23.63	5.52	18.64	7.34	4.85[c]
Stroop, Part I	87.33	18.37	112.93	41.99	5.49[c]
Stroop, Part II—Part I	132.47	46.53	195.44	85.60	6.94[c]
Memory Scale, Logical Memory	22.87	7.51	17.95	7.06	3.99[a]
Memory Scale, Visual Reproduction	11.10	3.06	8.21	3.09	5.67[c]
Summary: Number of tests outside normal limits	3.60	3.73	9.71	4.08	12.01[c]

Note: All t statistics were calculated on the basis of data in T-score form.
[a] $p < .001$.
[b] $p < .0001$.
[c] $p < .00001$.

various colors of ink, while Part II requires sustained attention in order to read the colors of ink while ignoring the words giving incongruous color names. When the former is subtracted from the latter (Stroop, Part II minus Part I), a measure of interference or distractability is obtained.

It can also be observed that the Name Writing procedure used in the Lateral Dominance examination is now evaluated by calculating the number of letters executed per second with the preferred hand, the nonpreferred hand, and then with both of these performances simultaneously considered. This was necessary because the length of names varies rather markedly. Finally, on the WMS, while the Visual Reproduction score is identical to that used by Wechsler, the Logical Memory score represents the total number of memories for the 2 passages on the WMS, Form I, without division by 2.

Table 1 also presents the basic data on group differences for all Discriminative Measures when the total group of 75 control-epileptic pairs are considered. If one uses the size of the t statistics as an index of discriminability, it is obvious that all tests discriminate between groups at high levels of statistical confidence. Furthermore, many of the tests, which are relatively new in this context, do as well as some of the better-known measures.

The ability of the tests to discriminate between control and epileptic persons was also evaluated on a subject-by-subject basis. To do this, a uniform cutoff system was established and after some experimentation with the original subject groups of 50 controls and 50 epileptics, it was determined that cutoff scores are most effectively established for both controls and epileptics when 20 to 30% (about 25% overall) of the controls are misclassified on each test measure. The establishment of a new set of cutoff scores had the advantage of uniformity. It seemed necessary since the use of the cutoff scores established by Halstead (1947) and Reitan (1955b) resulted in the misclassification of from 6 to 40% of the controls and from 5 to 66% of the epileptics, depending on the particular test variable examined. As can be seen from Table 2, the present cutoff scores are much more consistent from one to the next and in general it can be said that there is approximately a 25% chance of an individual with no history of neurological problems falling outside normal limits on any of the test measures.

In examining the test scores presented in Table 2, it can be observed that where critical scores have been established previously, the present cutoff values tend to vary only moderately from the previous ones, but with some differences noted, particularly on the drawings associated with the TPT. With respect to the classification of individual subjects overall, it is of interest to observe that the Category Test is the poorest measure out of the 16, while in Reitan's study (Reitan, 1955a) it was the best. Furthermore, some of the best discriminators have strong motor components, with the best single measure of all being the Finger Tapping Test. These are not findings that would be expected in a general neurological population. The possibility has been raised that differences in the patient groups between the present subjects and those evaluated by Reitan (1955a) may be partially responsible. For example, it is likely that the majority of Reitan's patients has grossly identifiable brain lesions, whereas with the present group of epileptics (whose problem is essentially electrical in nature), it is likely that not nearly as many structural lesions could be documented. It is possible that such measures as the Category Test are more sensitive to such structural lesions than to electrical abnormalities and that differences across groups are rarely found when such groups were developed on the basis of EEG variables (Dodrill & Wilkus, 1976, 1978; Wilkus & Dodrill, 1976). Furthermore, some of the anticonvulsants such as Dilantin have very strong motor components (Dodrill, 1975) and are certainly, at least in part, responsible for the unusually great differences

Table 2. Cutoff Scores and Percentages of Correct Classification of Subjects for All Discriminant Measures

Test variable	Cutoff (inside/outside)	Percent correct classification	
		Controls	Epileptics
Category	53/54 errors	76	49
TPT, Total Time	16.2/16.3 min	79	69
TPT, Memory	8/7 blocks remembered	76	57
TPT, Localization	4/3 blocks localized	77	52
Seashore Rhythm	26/25 correct	73	59
Tapping, Total (males)	101/100 taps (average)	80	88
Tapping, Total (females)	92/91 taps (average)	76	85
Trail Making, Part B	81/82 sec	79	64
Aphasia Screening	2/3 errors	79	53
Constructional Dyspraxia	questionable/mild	80	49
Perceptual Examination	6/7 errors	79	51
Name Writing, Total	.85/.84 letters/sec	72	72
Seashore Tonal Memory	22/21 correct	73	60
Stroop, Part I	93/94 sec	75	61
Stroop, Part II—Part I	150/151 sec	77	63
Memory Scale, Logical Memory	19/18 total memories	76	59
Memory Scale, Visual Reproduction	11/10 total points	77	78
Summary: Total tests	6/7 outside normal limits	83	79

between groups on the Finger Tapping Test. Since such drugs must be continually ingested, their side effects become part of the patient's disability that must be evaluated. It is concluded that whereas there are commonalities between epileptics and other neurological groups, there are also important differences.

The foregoing has briefly summarized the development of a neuropsychological battery specifically tailored for this neurological disorder. To my knowledge, this is the first such specialized neuropsychological battery that has been developed as a comprehensive tool to deal with this specific neurological group. It is observed that the summary measure from this battery is more effective in discriminating epileptics from normal control persons than is the Halstead Impairment Index, and we have found the former to be considerably more stable in making overall estimates of functioning disabilities. Furthermore, the battery incorporates some features (such as the objective scheme for scoring the aphasia examination) that would appear to be useful with any neurological group. Research is underway at our Epilepsy Center to determine the full effectiveness of the battery with patients having seizure disorders.

ASSESSMENT OF PSYCHOSOCIAL FUNCTIONING

As has already been documented previously, the majority of individuals with epilepsy suffer from psychological and/or social problems. It has been the impression of many of us working with these patients that such problems more often than not outweigh in importance the seizures themselves. In the Vocational Unit of our Epilepsy Center, for example, a survey was recently undertaken by following up the placement of approximately 100 epileptics in job situations. Of these, approximately 20% had lost their jobs within a year, but in only 1 instance could seizures be documented as being relevant to the job loss. In that instance, low pay was also a significant factor in job discontinuance. In all other instances, social, psychological, emotional, and other factors represented the primary reasons for job loss. This does not, of course, deny the possibility that seizures may be contributing to social and psychological problems, but we have become convinced that such psychological and social difficulties represent the leading reason for ineffectiveness in functioning rather than factors related to seizure control. Despite the importance of such psychosocial factors, however, we were unable to find a single test or inventory specifically designed to objectively assess these problems in the epileptic.

The factors just mentioned led us to believe that it would be useful to develop an inventory specifically designed to evaluate the important psychosocial problem areas often seen with persons suffering from seizure disorders. With the help of a grant obtained from the Epilepsy Foundation of America, a major project was initiated at our Epilepsy Center involving neuropsychology, social service, and biostatistics. The product of the project was the Washington Psychosocial Seizure Inventory, the development and use of which is briefly described next, but which is reported in detail elsewhere (Dodrill, Batzel, Queisser, & Temkin, 1980).

Initially, it was determined that seven areas of psychosocial problems were of interest: (1) family background, (2) emotional adjustment, (3) interpersonal skills and adjustment, (4) vocational adjustment, (5) financial status, (6) acceptance of seizures, and (7) the patient's evaluation of medical treatment received. In addition, an overall indicator of psychosocial functioning was deemed desirable. Furthermore, to serve as checks on validity, a lie scale, a scale of rarely endorsed items (such as the F scale on the MMPI), and an indicator of the number of items left blank were included. On the basis of 2 complete pilot studies and the administration of preliminary forms of the inventory, 132 yes-no items were selected that constituted the final form of the Inventory, and the principal validation study was begun.

In all, 127 adult epileptics, representing an unbiased sample of patients coming through our Outpatient Clinic, were the subjects used in this study. They were typically in their late twenties and had high school diplomas. The majority had partial seizures; in particular, complex partial attacks were very well represented. The majority had had their seizures for several years, with the beginning of such attacks usually by early adolescence. Each participant was approached at the time of the clinic visit and paid for their participation. Participation consisted of a psychosocial interview by a social worker or a psychologist and the completion of the Inventory. After the interviews, professionals rated each patient on each of the psychosocial areas of interest, and each area ultimately became a scale on the Inventory. By conducting 10 joint interviews, interrater reliability was established for each of the scales (except for the validity scales) and ranged from .80 to .95.

The Inventory scales were developed in much the same fashion as was the MMPI. Each of the 132 items was correlated with professional ratings of psychosocial adjustment in each area of interest, with the use of the point-biserial correlation coefficient. An item was considered for inclusion in an Inventory scale if it had a statistically significant correlation with professional ratings of that psychosocial area, regardless of the content of the item. A significance level of .01 was used for individual scales and .001 for Overall Psychosocial Functioning. When an item correlated to this extent with more than 1 basic psychosocial area, it was included only in the area with which it correlated highest. In this fashion, each scale was composed on a purely statistical and predictive basis, but no item appeared in more than 1 of the basic clinical scales (Background, Emotional, Interpersonal, Vocational, Financial, Adjustment to Seizures, and Medicine and Medical Management). The number of items in each of the single clinical scales ranged from 7 to 34, but there were 57 items in the Overall Psychosocial Functioning Scale. Finally, the Lie Scale had 10 items and the Rare Items Scale had 17 items.

The reliability and validity of the clinical scales were then assessed. Thirty-day test-retest reliability and internal consistency evaluated by split-half technique with application of the Spearman-Brown Prophecy Formula are presented in Table 3. While these coefficients were generally considered to be adequate, they were somewhat lower on the shorter scales. Validity was evaluated by correlating the scales of the Inventory with the judgements by professionals. These coefficients are also presented in Table 3 and represent the final product of original and cross-validational efforts described in detail elsewhere (Dodrill et al., 1980). The coefficients suggest that the inventory, to a considerable degree, reproduces the professional judgments that would be made about the adequacy of functioning in patients had those patients been evaluated individually by social workers or psychologists.

With the Inventory thus developed, we searched for a method by which the results could efficiently and meaningfully be presented to all individuals working with epileptics. Because the Inventory consisted of items directed specifically toward individuals with seizures, it was not possible to collect Inventory data on a normal control group and to use such data as a reference in developing scale scores. Furthermore, we observed that our patient population had substantially different amounts of difficulty in the various areas in question. For example, the majority of our patients have definite emotional difficulties, but few of them express any dislike for their physicians and the medical treatment they are

Table 3. Reliability and Validity Coefficients of the WPSI Scales

WPSI scales	*Reliability test-retest ($n = 21$)*	*Coefficients split-half ($n = 127$)*	*Validity coefficients ($n = 127$)*
Clinical Scales			
1—Background	.83	.69	.72
2—Emotional	.84	.92	.71
3—Interpersonal	.80	.88	.70
4—Vocational	.73	.82	.75
5—Financial	.87	.88	.70
6—Adjustment to Seizures	.70	.88	.66
7—Medicine and Medical Management	.66	.68	.58
8—Overall Psychosocial Functioning	.85	.95	.73
Validity Scales			
A—No. Blank	.28	—	—
B—Lie	.58	.75	—
C—Rare Items	.58	.37	—

receiving. Thus the use of scores such as percentiles would have greatly different meanings depending on the particular area in question. After much consideration, it was finally decided to develop a clinical profile based directly on the professional ratings. Figure 3 presents the profile that we use. The raw scores are plotted in the various columns, and they are found to correspond to the professional ratings as indicated on the far left. Here, the higher the numbers, the more indicators of psychosocial difficulties. Because we lacked standard scores to use as guidelines for interpretative purposes, we eventually developed a series of 4 profile areas that are identified on the right side of the profile and have clinically been found to have approximately the following meanings: Area 1—scores here are suggestive of no significant difficulties; Area 2—scores in this area suggest the presence of possible problems, but any problems here are not usually far-reaching and do not have substantial adjustmental significance; Area 3—scores here indicate distinct and definite difficulties having unquestionable adjustmental significance; Area 4—scores falling in this area routinely point to very striking problems with marked adjustmental signifi-

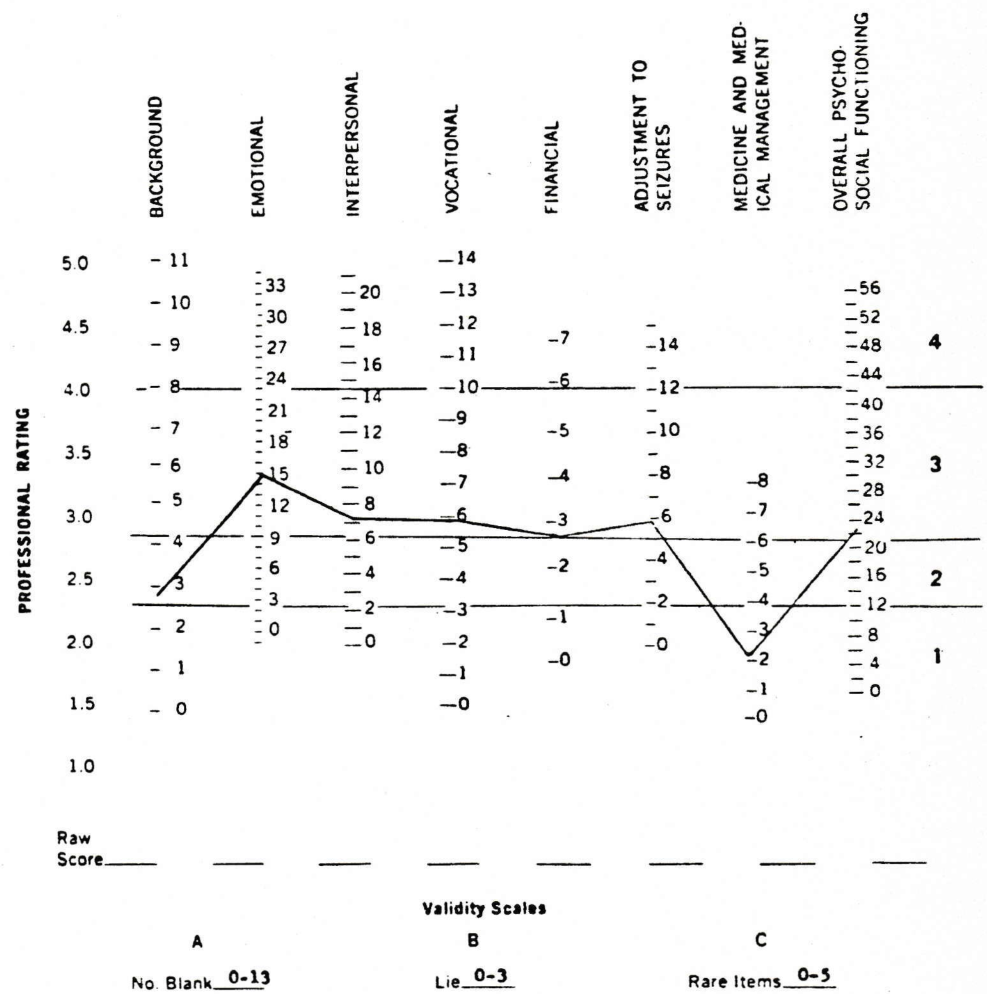

FIGURE 3. Profile form for the Washington Psychosocial Seizure Inventory.

cance. By drawing a profile for each patient and by using these standards as general guidelines, it is possible to identify for each patient which area or areas represent those where the greatest adjustmental problems are likely to be found.

To illustrate the general use of the profile and to describe our patient population more thoroughly, the average score for the 127 persons involved in this study is plotted on the profile presented in Figure 3. This profile presents what we believe to be true about our patients based on our clinical work—namely, that on the average they have emotional problems at the foremost. The patients also have significant interpersonal, vocational, and financial concerns, as well as difficulties in adjusting to their seizure problems. This is consistent with the fact that we deal primarily with long-standing seizure disorders.

Beyond clinical experience, we have thus far completed 1 unpublished study with this Inventory to evaluate its usefulness. The study was designed to more specifically validate the Vocational Scale. Fifty-eight adult epileptics were divided into employed ($N = 20$), underemployed ($N = 8$), and unemployed ($N = 30$) groups. Slight differences across various scales of the Inventory were found with higher profile elevations being systematically associated with decreased employment. On the Vocational Scale, however, a highly statistically significant difference was found ($F = 8.78, p < .005$), and the groups were ordered according to extent of employment. In the same study, it was possible to compare the ability of this scale to differentiate between the various groups with that of standard MMPI scales, a summary measure of neuropsychological impairment (the number of the Discriminative Measures outside normal limits of the Neuropsychological Battery for Epilepsy), formal education, and intelligence. The WPSI Vocational Scale differentiated between these groups more effectively than did any of the other variables. Furthermore, when the discriminant function was applied, the Vocational Scale and the indicator of neuropsychological impairment were the most important dimensions, and they were, in fact, the only 2 variables to make statistically significant contributions to the predictive process.

At the present time, we are continuing both clinical work and research investigations with the WPSI. Although we believe it to be a promising Inventory, its full usefulness is yet to be demonstrated. We have noted that by giving the Inventory in advance of formal clinical assessment, one can quickly screen for difficulties in several areas and can have a much more directed interview. Our clinical work has suggested that the WPSI may be sensitive to changes in psychosocial functioning, and we are therefore incorporating it into studies where behavioral changes may be observed. These include evaluating effects of treatment at our specialized facility, evaluating cortical resection surgery for epilepsy, and assessing the effects of certain anticonvulsant medications. In time, information concerning the WPSI's usefulness in these contexts will be available.

CONCLUSIONS

In this chapter it is concluded that epilepsy is one of those areas about which clinical psychologists and even neuropsychologists know entirely too little, especially in view of this disorder's prevalence. Furthermore, several variables complicate the adjustment of persons with epilepsy, including the effects of seizures themselves, epileptiform discharges without clinical signs, psychosocial and emotional problems, and the sporadic and often unpredictable appearance of the disorder. The stress that the disorder places on the person is often sadly compounded by social stigma, and the final product may be a decrease in functioning that far exceeds the momentary effects of the seizures themselves. The prevalence is so high, the disabilities are often so great, and the human suffering is so substantial that this is certainly one of the areas that deserves our attention the most in the years to come.

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REFERENCES

Arieff, A. J., & Yacorzynski, G. K. Deterioration of patients with organic epilepsy. *Journal of Nervous and Mental Disease,* 1942, **96,** 49–55.

Bear, D. M., & Fedio, P. Quantitative analysis of interictal behavior in temporal lobe epilepsy. *Archives of Neurology,* 1977, **34,** 454–467.

Bengzon, A. R. A., Rasmussen, T., Gloor, P., Dussault, J., & Stephens, M. Prognostic factors in the surgical treatment of temporal lobe epileptics. *Neurology,* 1968, **18,** 117–131.

Booker, H. E., Matthews, C. G., & Slaby, A. Effects of diphenylhydantoin on selected physiological and psychological measures in normal adults. *Neurology,* 1967, **17,** 949–951.

Collins, A. L. Epileptic intelligence. *Journal of Consulting Psychology,* 1951, **15,** 392–399.

Dalby, M. A. Behavioral effects of carbamazepine. In J. K. Penry & D. D. Daly (Eds.), *Advances in Neurology,* Vol. 11. New York: Raven Press, 1975.

De Haas, A., & Magnus, O. In A. De Haas (Ed.), *Lectures on Epilepsy.* New York: Elsevier, 1958.

Dikmen, S., & Matthews, C. G. Effect of major motor seizure frequency upon cognitive-intellectual functions in adults. *Epilepsia,* 1977, **18,** 21–39.

Dikmen, S., Matthews, C. G., & Harley, J. P. The effect of early versus late onset of major motor epilepsy upon cognitive-intellectual performance. *Epilepsia,* 1975, **16,** 73–81.

Dodrill, C. B. Diphenylhydantoin serum levels, toxicity, and neuropsychological performance in patients with epilepsy. *Epilepsia,* 1975, **16,** 593–600.

Dodrill, C. B. A neuropsychological battery for epilepsy. *Epilepsia,* 1978, **19,** 611–623.

Dodrill, C. B. Sex differences on the Halstead–Reitan Neuropsychological Battery and on other neuropsychological measures. *Journal of Clinical Psychology,* 1979, **35,** 236–241.

Dodrill, C. B., Batzel, L. W., Queisser, H. R., & Temkin, N. R. An objective method for the assessment of psychological and social difficulties among epileptics. *Epilepsia,* 1980, **21,** 123–135.

Dodrill, C. B., & Troupin, A. S. Seizures and adaptive abilities: A case of identical twins. *Archives of Neurology,* 1976, **33,** 604–607.

Dodrill, C. B., & Troupin, A. S. Psychotropic effects of carbamazepine in epilepsy: A double-blind comparison with phenytoin. *Neurology,* 1977, **27,** 1023–1028.

Dodrill, C. B., & Wilkus, R. J. Neuropsychological correlates of the electroencephalogram in epileptics: II. The waking posterior rhythm and its interaction with epileptiform activity. *Epilepsia,* 1976, **17,** 101–109.

Dodrill, C. B., & Wilkus, R. J. Neuropsychological correlates of the electroencephalogram in epileptics. III. Generalized non-epileptiform abnormalities. *Epilepsia*, 1978, **19**, 453–462.

Epilepsy Foundation of America, *Basic Statistics on the Epilepsies*. Philadelphia: F. A. Davis, 1975.

Falconer, M. A. Reversibility by temporal lobe resection of the behavioral abnormalities of temporal-lobe epilepsy. *New England Journal of Medicine*, 1973, **289**, 451–455.

Feindel, W. Factors contributing to the success or failure of surgical intervention for epilepsy. In D. P. Purpura, J. K. Penry, & R. D. Walter (Eds.), *Advances in Neurology*, Vol. 8. New York: Raven Press, 1975.

Flor-Henry, P. Psychosis and temporal lobe epilepsy: A controlled investigation. *Epilepsia*, 1969, **10**, 363–395.

Flor-Henry, P. Ictal and interictal psychiatric manifestations in epilepsy: Specific or non-specific? A critical review of some of the evidence. *Epilepsia*, 1972, **13**, 767–772.

Flor-Henry, P. Psychosis, neurosis and epilepsy. *British Journal of Psychiatry*, 1974, **124**, 144–150.

Flor-Henry, P. Lateralized temporal-limbic dysfunction and psychopathology. *Annals of the New York Academy of Sciences*, 1976, **280**, 777–797.

Gastaut, H. Clinical and electroencephalographical classification of epileptic seizures. *Epilepsia*, 1970, **11**, 102–113.

Ghatak, N. R., Santoso, R. A., & McKinney, W. M. Cerebellar degeneration following long-term phenytoin therapy. *Neurology*, 1976, **26**, 818–820.

Giannitrapani, D. EEG average frequency and intelligence. *Electroencephalography and Clinical Neurophysiology*, 1969, **27**, 480–486.

Gur, R. E. Left hemisphere dysfunction and left hemisphere overactivation in schizophrenia. *Journal of Abnormal Psychology*, 1978, **87**, 226–238.

Halstead, W. C. *Brain and Intelligence: A Quantitative Study of the Frontal Lobes*. Chicago: University of Chicago Press, 1947.

Harris, A. B. Degeneration in experimental epileptic foci. *Archives of Neurology*, 1972, **26**, 434–449.

Horowitz, M. J., & Cohen, F. M. Temporal lobe epilepsy: Effect of lobectomy on psychosocial functioning. *Epilepsia*, 1968, **9**, 23–41.

Hutt, S. J., Jackson, P. M., Belsham, A., & Higgins, G. Perceptual-motor behaviour in relation to blood phenobarbitone level: A preliminary report. *Developmental Medicine and Childhood Neurology*, 1968, **10**, 626–632.

Idestrom, C-M., Schalling, D., Carlquist, U., & Sjoqvist, F. Acute effects of diphenylhydantoin in relation to plasma levels: Behavioral and psychophysiological studies. *Psychological Medicine*, 1972, **2**, 111–120.

Jenkins, C. D. The relation of EEG slowing to selected indices of intellective impairment. *Journal of Nervous and Mental Disease*, 1962, **135**, 162–170.

Klove, H., & Matthews, C. G. Psychometric and adaptive abilities in epilepsy with differential etiology. *Epilepsia*, 1966, **7**, 330–338.

Kløve, H., & Matthews, C. G. Neuropsychological evaluation of the epileptic patient. *Wisconsin Medical Journal*, 1969, **68**, 296–301.

Kooi, K. A., & Hovey, H. B. Alterations in mental function and paroxysmal cerebral activity. *Archives of Neurology and Psychiatry*, 1957, **78**, 264–271.

Lennox, W. G., & Lennox, M. A. *Epilepsy and Related Disorders*, 2 vols. Boston: Little, Brown, 1960.

Matthews, C. G., & Harley, J. P. Cognitive and motor-sensory performances in toxic and nontoxic epileptic subjects. *Neurology*, 1975, **25**, 184–188.

Matthews, C. G., & Kløve, H. Differential psychological performances in major motor, psychomotor, and mixed seizure classifications of known and unknown etiology. *Epilepsia,* 1967, **8**, 117–128.

Meyer, V., & Yates, A. J. Intellectual changes following temporal lobectomy for psychomotor epilepsy. *Journal of Neurology, Neurosurgery and Psychiatry,* 1955, **18**, 44–52.

Milner, B. Effects of different brain lesions on card sorting: The role of the frontal lobes. *Archives of Neurology,* 1963, **9**, 90–100.

Milner, B. Some effects of frontal lobectomy in man. In J. M. Warren & K. Akert (Eds.), *The Frontal Granular Cortex and Behavior.* New York: McGraw-Hill, 1964.

Milner, B. Residual intellectual and memory deficits after head injury. In A. E. Walker, W. F. Caveness, & Critchley (Eds.), *The Late Effects of Head Injury.* Springfield, Illinois: Charles C. Thomas, 1969.

Milner, B. Residual intellectual and memory deficits after head injury. In A. E. Walker, W. F. Caveness, & M. Critchley (Eds.), *The Late Effects of Head Injury.* Springfield, Illinois: Charles C. Thomas, 1969.

Milner, B., Corkin, S., & Teuber, H. L. Further analysis of the hippocampal amnesic syndrome: Fourteen year follow-up study of H. M. *Neuropsychologia,* 1968, **6**, 215–234.

Mirsky, A. F., Primac, D. W., Ajmone Marsan, C., Rosvold, H. E., & Stevens, J. R. A comparison of the psychological test performance of patients with focal and nonfocal epilepsy. *Experimental Neurology,* 1960, **2**, 75–89.

Mirsky, A. F., & Van Buren, J. M. On the nature of the "absence" in centrencephalic epilepsy: A study of some behavioral, electroencephalographic and autonomic factors. *Electroencephalography and Clinical Neurophysiology,* 1965, **18**, 334–348.

Mostofsky, D. I. Epilepsy: Returning the ghost to psychology. *Professional Psychology,* 1978, **9**, 87–92.

Penfield, W., & Milner, B. Memory deficit produced by bilateral lesions in the hippocampal zone. *Archives of Neurology and Psychiatry,* 1958, **79**, 475–497.

Rapport, R. L., & Shaw, C-M. Phenytoin-related cerebellar degeneration without seizures. *Annals of Neurology,* 1977, **2**, 437–439.

Reitan, R. M. An investigation of the validity of Halstead's measures of biological intelligence. *Archives of Neurology and Psychiatry,* 1955a, **53**, 28–35.

Reitan, R. M. The relation of the Trail Making Test to organic brain damage. *Journal of Consulting Psychology,* 1955b, **19**, 393–394.

Reitan, R. M. A research program on the psychological effects of brain lesions in human beings. In N. R. Ellis (Ed.), *International Review of Research in Mental Retardation, Vol. I.* New York: Academic Press, 1966.

Reitan, R. M., & Davison, L. A. (Eds.) *Clinical Neuropsychology: Current Status and Applications.* Washington, D. C.: V. H. Winston, 1974.

Rodin, E. A. *The Prognosis of Patients with Epilepsy.* Springfield, Illinois: Charles C. Thomas, 1968.

Rodin, E. A. Psychomotor epilepsy and aggressive behavior. *Archives of General Psychiatry,* 1973, **28**, 210–213.

Rodin, E. A. Petit mal seizures are not necessarily harmless. *Epilepsy Center of Michigan News,* 1976, **18**, 3.

Rodin, E. A. Psychosocial management of patients with seizure disorders. *McLean Hospital Journal,* 1977, 74–84.

Rodin, E. A., Katz, M., & Lennox, K. Differences between patients with temporal lobe seizures and those with other forms of epileptic attacks. *Epilepsia,* 1976, **17**, 313–320.

Rodin, E. A., Rim, C. S., & Rennick, P. M. The effects of carbamazepine on patients with psychomotor epilepsy. Results of a double-blind study. *Epilepsia,* 1974, **15**, 547–551.

Sands, H., & Price, J. A pattern analysis of the Wechsler-Bellevue Adult Intelligence Scale in epilepsy. *Research Publications of the Association for Research in Nervous and Mental Disease*, 1947, **26**, 604–615.

Savard, R. J., & Walker, E. Changes in social functioning after surgical treatment for temporal lobe epilepsy. *Social Work*, 1965, **10**, 87–95.

Seashore, C. E., Lewis, D., & Saetveit, J. G. *Seashore Measures of Musical Talents (Manual)*. New York: Psychological Corporation, 1960 (Rev. ed.).

Serafetinides, E. A. Aggressiveness in temporal lobe epileptics and its relation to cerebral dysfunction and environmental factors. *Epilepsia*. 1965, **6**, 33–42.

Serafetinides, E. A. Psychosocial aspects of neurosurgical management of epilepsy. In D. P. Purpura, J. K. Penry, & R. D. Walter (Eds.), *Advances in Neurology, Vol. 8*. New York: Raven Press, 1975.

Serafetinides, E. A., Cherlow, D. G. Psychiatric test assessment of patients with psychomotor epilepsy. *American Journal of Psychiatry*, 1976, **133**, 844–847.

Slater, E., & Beard, A. W. The schizophrenia-like psychoses of epilepsy. I. Psychiatric aspects. *British Journal of Psychiatry*, 1963, **109**, 95–150.

Somerfeld-Ziskind, E., & Ziskind, E. Effect of phenobarbital on the mentality of epileptic patients. *Archives of Neurology and Psychiatry*, 1940, **40**, 70–79.

Sommerbeck, K. W., Theilgaard, A., Rasmussen, K. E., Lohren, V., Gram, L., & Wulff, K. Valproate sodium: Evaluation of so-called psychotropic effect. A controlled study. *Epilepsia*, 1977, **18**, 159–167.

Stevens, J. R. Psychiatric implications of psychomotor epilepsy. *Archives of General Psychiatry*, 1966, **14**, 461–471.

Stevens, J. R., Milstein, V., & Goldstein, S. Psychometric test performance in relation to the psychopathology of epilepsy. *Archives of General Psychiatry*, 1972, **26**, 532–538.

Stephens, J. H., Shaffer, J. W., & Brown, C. C. A controlled comparison of the effects of diphenylhydantoin and placebo on mood and psychomotor functioning in normal volunteers. *Journal of Clinical Pharmacology*, 1974, **14**, 543–551.

Stroop, J. R. Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, 1935, **18**, 643–662.

Tarter, R. E. Intellectual and adaptive functioning in epilepsy: A review of fifty years of research. *Diseases of the Nervous System*, 1972, **33**, 763–770.

Temkin, O. *The Falling Sickness*. Baltimore: Johns Hopkins University Press, 1945.

Troupin, A. S., Ojemann, L. M., & Dodrill, C. B. Mephenytoin: A reappraisal. *Epilepsia*, 1976, **17**, 403–414.

Vega, Jr., A., & Parsons, O. A. Cross-validation of the Halstead-Reitan tests for brain damage. *Journal of Consulting Psychology*, 1967, **31**, 619–625.

Vislie, H., & Henriksen, G. F. Psychic disturbance in epileptics. In A. M. Lorentz De Haas (Ed.), *Lectures on Epilepsy*. Amsterdam, Elsevier, 1958.

Wannamaker, B. B., & Matthews, C. G. Prognostic implications of neuropsychological test performance for surgical treatment of epilepsy. *Journal of Nervous and Mental Disease*. 1976, **163**, 29–34.

Wasterlain, C. G., & Duffy, I. E. Status epilepticus in immature rats. *Archives of Neurology*, 1976, **33**, 821–827.

Wilkus, R. J., Dodrill, C. B., & Troupin, A. S. Carbamazepine and the electroencephalogram of epileptics: A double-blind study in comparison to phenytoin. *Epilepsia*, 1978, **19**, 283–291.

Wilkus, R. J., & Dodrill, C. B. Neuropsychological correlates of the electroencephalogram in epileptics. I. Topographic distribution and average rate of epileptiform activity. *Epilepsia*, 1976, **17**, 89–100.

Wonderlic, E. F. *Wonderlic Personnel Test (Manual)*. Los Angeles: Western Psychological Services, 1973.