EDITORIAL

Computerized EEG and Evoked Potential Mapping of Brain Function (Brain Electrical Activity Mapping Beam)

By: A. Okasha

The attempt to derive information about brain function from the patterns of electrical activity detected on the cortical surface is venerable by brain imaging historical standards. Indeed, the computer enhancement of this field constitutes a second generation of this research approach. The field of electrophysiological approaches to psychiatric illnesses has already experienced a cycle of excitement and enthusiastic expectation followed by disappointment and disillusionment when this approach failed to delineate the underlying pathophysiology of mental disorders during the middle of this century. This has represented both an advantage and a disadvantage to this approach. The advantage has been a talented body of senior researchers who have, over decades, developed and refined our understanding of the electrophysiological aspects of human brain function. The disadvantages have been unrealistic expectations of increased information comparable to the PET scan and a related misunderstanding of the significant limits to this particular brain imaging approach. In this editorial, we will review some of the recent studies using computer imaging techniques to deal with the massive amounts of information derived from multiple lead recording of brain electrical activity.

A number of mapping strategies have been applied over the last three decades to assist in the examination of electrophysiologic data, *Duffy and colleagues (1979)* developed a system of EEG and evoked potential mapping called brain electrical activity mapping. This approach uses standard EEG amplifiers to record data from the skull surface which is then subjected to a Fast Fourier Transform analysis, which breaks the EEG data into this component frequencies (that is, delta, theta, alpha, and beta). This data is then topographically displayed in the form of color maps.

In the last three years this technique has been introduced into the investigation of schizophrenia. It has produced maps that have allowed a different presentation of summarized and condensed information as an aid in the analysis of this data. In this editorial, we will focus on two groups of findings:

A. Those that support an organizing theory of frontal lobe dysfunction.
B. Those that support an organizing theory of left hemispheric dysfunction.

FRONTAL LOBE DYSFUNCTION IN SCHIZOPHRENIA

The most striking finding of this study was increased delta activity over the entire cortical surface of schizophrenic patients as compared with controls. This abnormal delta activity was greatest over the frontal lobes and was seen in both the medicated and drug free patient groups. These findings are consistent with a recent spectral analytic investigation of schizophrenia that did not employ topographic mapping. In a 1980 study of schizophrenia, *Fenton (1980)* reported that his chronic schizophrenic patients demonstrated greater delta activity than controls. Thus, there is some supporting evidence from both topographic and non-mapping investigations of EEG in schizophrenia for abnormally increased delta activity in schizophrenia. Furthermore, this finding of increased delta activity that is greater in the frontal regions may be consistent with the work of *Ingvar and Franzen (1974)*. In this first study of the regional cerebral blood flow in schizophrenic patients compared to alcoholic controls, it was found that some patients with schizophrenia had a relative decrease in frontal blood flow. This was interpreted as indirect evidence that patients with schizophrenia have reduced neural metabolic activity in frontal regions.

Recently, a more direct measure of regional brain metabolism, positron emission tomography (PET), has been applied to schizophrenia research. This technique utilizes radioactive isotopes to investigate brain metabolism. Recent findings, using PET, report an abnormality of the antero-posterior gradient of metabolic activity in schizophrenia, that could be consistent with frontal findings. The second strategy was incorporated in a preliminary study of schizophrenia that employed both brain electrical activity mapping

and computed tomography (CT scan). Schizophrenic patients who fulfilled DSM-III and Research Diagnostic Criteria were divided according to whether they demonstrated marked frontal lobe atrophy or no apparent atrophy. These patients were then compared using brain electrical activity mapping methodology to determine whether the two groups differed across electrophysiological measures. When patients with and without evidence of frontal lobe atrophy were compared, only four regional differences were defined. In each case the electrophysiologic differences delineated involved regions that overlay the frontal lobes. Thus, this preliminary evidence suggests that in some patients with schizophrenia, functional differences in electrophysiology can be associated with gross structural abnormalities of the brain. In this manner, this combined anatomic and physiologic approach to the investigation of schizophrenia yields further evidence implicating the frontal lobes as a site of dysfunction that may be basic to the schizophrenic process.

LEFT HEMISPHERIC DYSFUNCTION IN SCHIZOPHRENIA

The schizophrenic subject demonstrated an anterior and right-sided displacement of the P300 maximum and a left temporal deficit in brain electrical activity through auditory evoked potential. When the statistical technique of significance probability mapping was applied to these topographic findings, the left-middle and posterior temporal regions were delineated as this finding was shown to have the potential to discriminate between schizophrenic patients and control subjects. Although neither the psychological concomitants of the P300 nor the nature of its neural generators are clearly defined, these findings do appear to support the hypothesis of the left hemispheric dysfunction in schizophrenia. Furthermore, these findings of increased fast beta activity are theoretically consistent with the work of *Ingvar and Franzen (1974)* who found relatively increased blood flow in post-central regions. In addition, a recent PET study by *Delisi et al. (1986)* has reported increased temporal lobe glucose utilization in schizophrenic patients that is consistent with these findings. These findings are also consistent with the work of *Gur (1984)* who found evidence of left hemispheric overactivation in schizophrenic patients with the use of regional cerebral blood flow. However, her work also emphasizes the important effects of medication, gender and specific cognitive activation tasks. Further

research is needed to delineate the effects of these factors on the findings of the various studies described here.

Common to the use of all computer assisted techniques in neuropsychiatry is a balance between the strengths and limitations of each of these approaches. Two major limitations of computerized topographic approaches are basic to electrophysiological research. First, the electrical activity of the brain is usually measured at the cortical surface and this limits the ability of this technique to resolve different neural generators and to detect electrical phenomena that do not occur close to the surface of the brain. In most cases, as a result, little can be determined concerning electrical activity deep within the brain parenchyma and a conservative interpretation of the topographic focus of electrical activity is warranted. Second, electroencephalography is sensitive to muscle artifact, eye movements and drug effects. For this reason these potential sources of artifact must be carefully controlled in all research applications. A special limitation that is inherent in computer brain imaging approaches is that the data may be biased both in its analysis and presentation by assumptions and rules incorporated into the computer software. This requires circumspect and conservative interpretation of computer maps of brain electrical activity.

A major advantage of computerized topographic EEG approaches is that it is non-invasive and does not involve radiation exposure. Moreover, it may therefore be repeated more easily and safely than other brain imaging techniques. Finally, these computer-assisted electrophysiological approaches have much greater chronologic resolution than other methods of investigating brain function. For example, these techniques can examine electrical events that occur in small fractions of a second and are therefore particularly well suited for the investigation of transient cognitive phenomena.

In our team work, we are collecting data in a massive pilot study on brain mapping of affective disorders, cerebro-vascular incidents, neoplasms, paranoid and non-paranoid schizophrenics, obsessional disorders, epilepsy, migraine, etc... Our research team is focusing on different presentations of BEAM in schizophrenia and affective disorders, personality disorders with substance abuse associated with organic neurophysiology. Results will be revealed once a large group is examined to be statistically evaluated.

REFERENCES

1. Buchsbaum, M.S., Ingvar, D.H., Kesseler, R et al. (1982): Cerebral glucography with positron tomography: Use in normal subjects and in patients with schizophrenia. Arch. Gen. Psychiatry, 39: 251.

2. Delisi, L.E., Buchsbaum, M.S., Holcomb, H. et al.. (1986): Increased temporal lobe glucose utilization in chronic schizophrenic patients. Biol. Psychiatry, in press.

3. Duffy, F.H., Burchfiel, J.L., Lombroso, C.T. (1979): Brain electrical activity mapping (BEAM): A method for extending the clinical utility of EEG and evoked potential data. Ann. Neurol., 5: 309.

4. Duffy, F.H. (1986): Topographic mapping of brain electrical activity. Butterworths.

5. Fenton, G.W., Fenwic P.B.C. Doll re, J. et al. (1980): EEG spectral analysis in schizophren Brit. Psychiatry, 136: 445.

6. Gur, R.E. (1984): Regional cerebral blood flow in psychiatry: The resting and activated brains of schizophrenic patients. In: Morihisa, J.M. (ed.). Brain Imaging in Psychiatry, pp. 65-76. American Psychiatric Press, Washington, DC.

7. Ingvar, D.H., Franzen, G. (1974): Abnormalities of cerebral blood flow distribution in patients with chronic schizophrenia. Acta Psychiatrica. Scand., 50: 425.

8. Morstyn, R., Duffy, F.H., McCarley, R.W. (1983): Altered P300 topography in schizophrenia. Arch. Gen. Psychiatry, 40: 729.

9. Wolkin, A., Jaeger, J., Brodie, J. et al. (1985): Persistence of cerebral metabolic abnormalities in chronic schizophrenia as determined by positron emission tomography. Am. J. Psychiatry, 142, 564.