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## The role of quantitative EEG topographic mapping or 'neurometrics' in the diagnosis of psychiatric and neurological disorders: the pros

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A vast literature, based upon qualitative visual evaluations, suggests that a substantial proportion of psychiatric patients display EEG abnormalities. With the advent of computerized analysis of EEG data, these earlier impressions were substantiated by quantitative methods. An extensive review by Shagass (1975) not only confirms the existence of differences between normal subjects and patients with psychiatric disorders but provides replicated reports of abnormal profiles distinctive for each disorder.

Reviewing more than 50 recent papers on the electrophysiology of schizophrenia, Grebb et al. (1986) concluded that it was now 'well-established' that there was a high incidence of abnormal findings among schizophrenic patients. Among the consistently replicated findings were increased delta and theta but decreased alpha activity, and bilateral asymmetries. Summarizing a somewhat different selection of over 50 papers, Small (1983) concluded that schizophrenics were consistently reported to have increased delta and beta but decreased alpha activity, as well as marked bilateral asymmetries. Ford et al. (1986) concurred that frequency abnormalities, especially increased beta activity, were commonly encountered among schizophrenics but also emphasized the prevalence of increased interhemispheric coherence, in agreement with Merrin et al. (1989) who cite 3 other reports with similar findings.

A very different picture emerges from studies of affective disorders. Summarizing over 100 articles on depression, Perris (1980) concluded that interhemispheric asymmetry, mean integrated amplitude and its variance are the most consistently confirmed abnormal EEG measures in depressed patients.

Goodin and Aminoff (1986), Giannitrapani and Collins (1988), Giaquinto and Nofle (1988), and Soininen and Partanen (1988) agree that a high proportion of patients with senile dementia display an abnormal electrophysiological profile, but one which is very different from that seen in schizophrenia or depression. Reviewing well over 100 papers, these workers agree that dementia patients are characterized by generalized increased delta and theta activity together with decreased alpha and beta activity.

In view of this abundant evidence that patients with different psychiatric disorders display abnormal electrophysiological profiles which are distinctively different from each other, it is not surprising that such patients can be differentially classified utilizing electrophysiological variables. Discrimination has been accomplished between dementia and normals by Giaquinto and Nofle (1988), between Alzheimer's and non-Alzheimer's dementia and normals by Goodin and Aminoff (1986) and Giannitrapani and Collins (1988), and between Alzheimer's and multi-infarct dementia and normals by Leuchter et al. (1987). Discrimination of dementia from depressed from normals has been accomplished successfully by Brenner et al. (1986) and of Alzheimer's from vascular dementia

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from depressed by O'Connor et al. (1979). Abrams and Taylor (1979) described differential EEG profiles which discriminate between affective disorders, schizophrenics and normals, as have Shagass et al. (1984) using EEG factor scores, Merrin et al. (1989) using coherence variables, and Ford et al. (1986), who separated schizophrenic from depressed from dementia patients, also finding coherence variables to contribute most to the discrimination. These latter authors cited 17 papers which reported successful discrimination between schizophrenics and normals and 13 reporting discrimination between depressed patients and normals. Flor-Henry et al. (1983) performed principal components analysis of frequency and coherence variables in depressed, manic and schizophrenic patients and normal controls, finding that overall coherence contributed most to the discrimination.

Recently, our laboratory has reported marked electrophysiological differences between patients with a variety of psychiatric disorders and normal subjects, showing that patients with different disorders could be reliably discriminated from one another (John et al. 1988) and that different subtypes of depressed patients could be identified (Prichep 1987). We computed most of the measures used by any of the workers cited above, considered data from the whole 10/20 system, performed age regression, complied with the theoretical assumptions of our statistical procedures, constructed composite variables, and enhanced the ratio of pathognomonic 'signal' to background activity 'noise' by Z transformation relative to a normative data base ('neurometrics'). We analyzed many groups simultaneously and used large samples to enable independent replications of our discriminant functions. For these reasons, our results were unusually robust but otherwise compatible with the evidence cited above. We found that comparable discrimination can be achieved using different subsets of features. This reflects substantial redundancy in the EEG measure set and reconciles the different measure subsets found to be discriminating in the studies cited. Numerous aspects of the EEG are disturbed distinctively by these disorders.

The technology which we used is now incorporated into a commercial functional imaging de-

vice, under license from New York University<sup>1</sup>. A number of other such devices are also now available. Since these devices appeared, there have been many expressions of concern in professional journals and society meetings that this heralds a premature incorporation of a procedure still 'experimental' into clinical practice. At the same time, numerous societies here as well as abroad are formulating criteria for certification in quantitative EEG and topographic mapping. If the concern is that this method is only an experimental tool, why discuss certification? If the concern is that some of those using this method for clinical purposes will not be qualified to use it properly, will use by a certified person change an experimental tool into a clinical method? If the concern is that this method will yield high false positives due to artifacts and normal deviants, Neurometric methods use on-line artifact identification and are calibrated to ensure that false positives are at the chance level. Specificity of quantitative EEG is at least as good and reliability far better than conventional EEG, known to have 10% or more false positives, and only 60–70% inter-rater concordance and 70% test-retest reliability among skilled practitioners.

Most important, what about sensitivity? Quantitative EEG is far superior to conventional EEG in its detection of true positives and in its ability to discriminate among psychiatric disorders. Why are the critics not equally concerned about the continuing use of conventional EEG with psychiatric patients, in spite of its high incidence of false negatives and generally conceded inability to discriminate among psychiatric patients?

By industry estimates, about 400 topographic mapping quantitative EEG machines are now in routine use in this country. Conservatively, about 50,000 patients a year are currently being examined by these devices. Many users of these instruments were recently contacted by me in an informal survey. Two-thirds of those who replied were neurologists; half were certified in EEG. The remainder were primarily psychiatrists and psychologists. Most reported regularly repeated re-

<sup>1</sup> Spectrum 32, Cadwell Laboratories, Kennewick, WA 99336, U.S.A.

referrals as a major source of patients for mapping, indicating that the results were useful to the physicians making these referrals. Ninety percent considered quantitative EEG as a valuable adjunct to routine clinical practice.

How do we decide when an experimental tool is ready to become a clinical method? The mountain of evidence cited above<sup>2</sup>, built over the past decade, seems sufficient. Psychiatry needs better tools, it needs objective diagnostic instruments such as these. What justification, other than territoriality, exists for opposing their use?

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<sup>2</sup> This commentary is restricted to the present status of quantitative EEG analysis and topographic mapping for clinical applications in psychiatry. Less controversial applications in neurology and the vast volume of relevant event-related potential research were not considered.