

Brain Mapping: A Short Guide to Interpretation, Philosophy and Future

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Introduction

Quantitative studies of EEG and evoked response, including spectral analysis and topographic mapping, are becoming increasingly popular in clinical practice. Recent studies have shown these techniques to be useful in cerebrovascular disease,^{1 2} epilepsy,^{3 4} headaches,⁵ mass lesions,⁶ and head injuries.⁷ Perhaps the most important application has been in documenting organicity in patients with psychiatric syndromes or learning disabilities.^{8 9}

Brain electrical activity mapping (BEAM), including computerized EEG and cortical evoked potentials, has demonstrated subtle neurological abnormalities in patients with schizophrenia,^{10 11 12} depression, Parkinson's, Alzheimer's,^{13 14} toxic exposures,^{15 16 17} and more. Brain mapping is also useful in analyzing and assessing the function of drugs given to patients.¹⁸ In many situations, the quantitative/topographic approach may be more sensitive than conventional test modalities, such as standard EEG, CT scanning, MRI, and neuropsychiatric testing.^{19 20 21} Moreover, brain mapping may also be useful in monitoring patients having undergone neurosurgery or cardiovascular surgery.^{22 23} Brain mapping is a great medical breakthrough which "medicalizes" psychiatry.²⁴

Components

The ideal brain map is a full spectrum BEAM, which can be obtained by applying the principles from the SPECTRUM invented by E. Roy Johns, Ph.D., at NYU, and the BEAM invented by Frank Duffy, M.D., at Harvard University. We utilize the BEAM with the full spectral components (Table 1) which were first developed as part of

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the SPECTRUM. Brain mapping consists of a computerized EEG (electroencephalograph), spectral computerized analysis of frequency bands, an auditory evoked potential (AER), and a visual evoked potential (VER), along with numerous spectral and accessory tests or components. (Table 1; tables follow references.)

The P300 is part of the auditory evoked potential, and at 300 milliseconds there is a peak. There are many other periods of time (latencies) which may be measured in terms of an evoked potential response. Hence, there are a variety of brain stress tests (reaction of the brain when exposed to light, sound, or cognitive stresses) that can be done on the full spectrum BEAM. For example, EEG with hyperventilation and strobed or different colored lights may reveal things about the brain's ability to process information. Measuring brain waves after such stressors can be helpful as heart stress tests reveal aspects of the heart. We hope to continue to improve upon the techniques used for measuring neurobio-chemical imbalances.

Identification of Diseases

On the quantified EEG much can be learned about both diagnosis and potential treatments. For example, it is well known that obsessive compulsive disorder individuals may have increased alpha waves. Drug abusers often have decreased alpha waves. There may be increased delta and theta waves in schizophrenics, although this is disputed, and decreased beta waves in Alzheimer's disease. Some researchers believe they can diagnose based on BEAM, but, more likely, each diagnosis is just a symptom of a heterogenous group of BEAM abnormalities. The effects of diseases on the spectral analysis is outlined in Table 2.

Commentary on Medications, Drugs, and Electrical Therapies

There has been a tremendous amount of research done on the interactions of medications and EEG's. It is to be noted that individual drugs can have very different effects on different individuals' brain waves, although there are some general patterns. For example, barbiturates produce slowing of EEG background activity. Barbiturate overdose, ischemia, cortical irritability, and attention deficit disorder can be marked by the appearance of widespread beta dominance. Barbiturates increase beta activity over the anterior head region. Drugs like Dilantin overdosage enhance slow waves, such as delta and theta. Tegretol can cause a diffuse slowing. In general, anticonvulsants stabilize brain waves by decreasing beta. The dominant effect of neuroleptics is to increase delta and theta, while decreasing beta and alpha activity. The dominant effect of antidepressants is to increase alpha activity and possibly all brain waves. The dominant effect of benzodiazepines is to decrease the slow waves such as slow alpha, delta, and theta, and increase the beta and alpha. The dominant effect of amphetamines, methylphenidate, and PCP is to tremendously decrease delta and theta.

Some other common drug effects include temporary increase in alpha which occurs with many addictive drugs, including morphine, heroin, and marijuana. There can be delta bursts with PCP (phencyclidine), and it should be noted that THC (Tetrahydrocannabinol), the active ingredient in marijuana, will actually decrease beta frequency. Overall, drugs can significantly affect quantified EEG's²⁵ (Tables 3-6).

Estrogen may increase seizures. Tyrosine may increase estrogen and therefore promote seizures, while progesterone decreases seizures. Steroids increase both tryptophan and tyrosine and raise blood sugar and help encephalopathy. Testosterone levels decrease thyroid, and estrogen increases thyroid. To identify the meaning of abnormalities on brain mapping it is important to know approximately what each region of the brain does.

Physiological Abnormalities Associated with Anatomical Regions of Brain in

Correlation with Behavior on BEAM

Brain mapping can give clues in terms of treatment as well as to diagnosis of brain illnesses. Anyone with any type of serious behavioural disorder or deficit should have a brain map. In fact, brain mapping should probably be done on everyone as part of a total health check up. The brain is the most important part of the body and affects all diseases. A healthy brain is the first priority on the PATH® to wellness.

Generally speaking, left hemisphere dysfunctions will largely impact language processing areas. These findings are generally suggested by increased delta and theta activity on spectral analysis, as well as excessive reactivity during auditory and visual stimulation components of the BEAM. Mid-temporal and posterior temporal are more likely to impact specific language and language processing functions and may also be seen in individuals with central auditory processing disorders, which are further and more clearly defined with speech and language assessments. More anterior left hemisphere will likely impact language production (i.e., Broca's area involvement and aphasic disorders), as well as difficulty in learning and executing a sequence task.

Right hemisphere disturbances may be frequently associated with emotional modulation difficulty and impulse control disorders. Most characteristic is episodic dyscontrol, which may have a high correlation with physiologic disturbances in right anterior regions, specifically right anterior temporal and right frontal areas. These findings typically include increased theta activity on the spectral analysis and excessive reactivity in both auditory and visual stimulation components. Typically, the excessive reactivity occurs between a 150 and 350 milliseconds time frame and takes the form of excessive amplitude or aberrant wave forms in these regions. Right posterior physiologic dysfunctions may clinically be associated with visual-spatial analysis difficulties and the appreciation of social cues such as subtleties of individual facial expressions. Visual evoked responses showing excessive reactivity in these areas may therefore be correlated with these clinical findings.

EEG findings carry unusual implication of seizure disorders, but EEG's are frequently normal in the face of abnormal physiologic changes identified by spectral analysis and evoked potentials and are corroborated with neuropsychological and speech and language data.

Brain mapping reveals various effects of disease and drugs on brain mapping (Table 7). Tables 8-10 review regions of brain function which give clues to pathology.

Prescription Electricity

The most exciting development in the field of BEAM research is that amino acids and electrical methods can more naturally change brain waves. Amino acids (Phenylalanine, Tyrosine, and Tryptophane) affect alpha waves in particular. Other research is needed to help tailor nutrients to brain wave abnormalities. Also exciting is the concept of changing brain waves by cranial electrical stimulation (CES). The FDA has permitted the CES device for use in treating insomnia, anxiety, and depression. Our preliminary results show that, based on which device you use, we can demonstrate the ability to correct imbalances in delta, theta, and alpha waves. Furthermore, the electrical imbalances of substance abuse can be corrected. The age of prescription electricity for the brain seems to be dawning.^{26 27}

Brain Rejuvenation

Brain rejuvenation may sound like a faddish term, but in some ways it is a truism of advanced medical science. As the human brain ages or gets diseased, it has reductions in neurotransmitters and functional neurons. Through neurotransmitter manipulation, amino acids, and nutrients, we are able to rejuvenate the memory in various individuals and improve their mental functioning. Virtually all aging is associated with some memory loss and neurological deterioration. Alzheimer's (senile dementia) has been increasing in our society, and we expect even more organic brain diseases to become prevalent due to the prevalence of toxins such as lead, mercury, pesticides, organics, etc., as well as drug abuse. Brain rejuvenation techniques may be augmented by bioelec-trical devices, amino acid

supplementation, and neurotransmitter augmenting medications. The neurotransmitter systems can be built up and rejuvenated by nutrients in a number of ways. Nutrients rejuvenate the brain and increase the levels that age, stress, and drug abuse have depleted, as well as balance an individual's neurotransmitters that have been deficient since birth.²⁸ Rejuvenation of the brain after drug abuse is another prime and critical example of the technique of reversing brain disease.²⁹ Tables 11 and 12 describe the relationship between drugs, nutrients, and brain chemistry, i.e., neurotransmitters.

Philosophy of Brain Mapping: An Analysis of Consciousness

One can speculate that brain electrical-mapping device or BEAM is a measurement of consciousness. Normally, beta and alpha waves are indicative of conscious processes, and theta and delta waves are indicative of unconscious processes. Abnormalities in brain waves are indicative of problems of consciousness. Consciousness raising in some ways is the proper balance of all levels of consciousness so that it can be raised mutually and jointly. We now know that in certain conditions medications that relieve anxiety or depression can raise beta waves while antipsychotics decrease them. A person who has an excess of beta waves might be said to have a lack of tranquility. Unreality, irritability, hyperactivity, anesthesia, and ischemia produce increases in beta waves. We also know that an absence of alpha waves (alpha waves can be increased by certain techniques that relax the brain) can symbolize a lack of creativity, imagination, etc. An excess of alpha waves can occur in an overly compulsive person and that overly-compulsive activity may likely be antidoted by anxiety reduction techniques. Individuals with spikes in their consciousness or irregular overconcentrated consciousness might be thought to need to defocus their attention or antidote this with an anticonvulsant. Antianxiety medicines also widen out consciousness by decreasing delta and theta and increasing alpha and beta. Deficiencies in theta and delta waves may also indicate a lack of tranquility as an excess of those waves can symbolize a lack of arousal.

Both antipsychotic and antidepressants increase delta and theta waves. Excess delta and theta waves without a drug source might symbolize a person who has too much involvement with his or her unconscious. Brain waves symbolize various dimensions of our consciousness, and with knowledge and treatment of these we may get closer to our own balanced brain waves or happiness. Prescription electrical devices with amino acids may be the best natural way to "raise consciousness" or "heal consciousness" by changing brain waves.

Summary

Brain mapping is a new technique which measures the electrical waves of the brain. It is able to diagnose and predict future prognosis of brain biochemical imbalances and provide clues to treatment of learning disabilities, Alzheimer's, schizophrenia, epilepsy, drug abuse, depression, anxiety, Parkinson's multiple sclerosis, etc. All brain diseases are both chemical and electrophysiological in their makeup. The brain's chemistry and electrophysiology affect the immune system, appetite control, and virtually every illness interacts in the chemistry and biology of the brain. The brain is the chief organ of the body: chief endocrine gland, cardiovascular regulator, and immunodefense. Therefore, the most important part of the health of every individual is the brain's balance. *Brain imbalances are a factor in virtually all diseases.*

A full spectrum BEAM is the best path to brain analysis because it sheds light on brain function and helps reveal the tendency for drug abuse and many other important aspects of brain health. Brain electrical wave abnormalities are identified and this information is combined with blood testing for biochemical abnormalities to provide a complete understanding of the brain's function. A dynamic integrative treatment can then be implemented, using a nutritional, electrical, and/or drug approach. If the patient is not interested in the bioelectrical or nutritional approach, one can use a heavier biochemical treatment which can overcome the biochemical and even some of the electrical imbalances. We try to stay away from the current electrical

treatments in psychiatry such as electroconvulsive shock therapy. Sledge hammer approaches with drugs (i.e., polypharmacy, overmedicating) or shock therapy can often be replaced by more subtle treatments. The ideal treatment of all brain disease is both electrical and biochemical (bioelectrical) because the brain is electrical and biochemical. Eventually we hope to develop a collection site which will go into the various physicians' offices where individuals will be able to have brief brain wave checks as a measure of their brain health.

References

1. Ahn SS, Jordan SE, Nuwer MR: Computerized EEG topographic brain mapping. Moore W., (ed.). *Surgery for Cerebrovascular Disease*. New York, Churchill Livingstone, 1987, 275-280.
2. Nuwer MR, Jordan SE, Ahn SS: Evaluation of stroke using EEG frequency analysis and topographic mapping. *Neurology*, 37:1153-1159, 1987.
3. Kowell AP, Reveler MJ, Nuwer MR: Topographic mapping of EEG and evoked potentials in epileptic patients. *Jrnl Clin Neuro-physiol*, 4:233-234, 1987.
4. Nuwer MR: Frequency analysis and topographic mapping of EEG and evoked potentials in epilepsy. *Electroenceph Clin Neuro-physiol*, 68:2, 1988.
5. Braverman ER: Remission of forty years of headaches with divalproex sodium. *Brain Dysfunct*, 2:55, 1989.
6. Nagata K, Gross C, Kindt G, Geier J, Adey G: Topographic electroencephalographic study with power ratio index mapping in patients with malignant brain tumors. *Neurosurg*, 17:613-619, 1985.
7. Houshmand W, Director K, Beckner E, Radfar F: Topographic brain mapping in head injuries. *Jrnl Clin Neurophysiol*, 4:228-229, 1987.
8. Duffy FH: The BEAM method for neurophysiological diagnosis. *Ann NY Acad Sci*, 457:19-34, 1985.
9. Duffy FH: *Brain Electrical Activity Mapping: Issues and Answers*. Topographic Mapping of Brain Electrical Activity. Duffy F.H. (ed.). Boston, Butterworth, 401-418, 1986a.
10. Daniels EK, et al: Patterns of thought disorder associated with right cortical damage, schizophrenia, and mania. *Amer Jrnl of Psychiatry*, 145:944-948, 1988.
11. Stoudemire A, et al: Interictal schizophrenia-like

- psychoses in temporal lobe epilepsy. *Psychosoma*, 24:331-338, 1983.
12. Braverman ER: Brain electrical activity mapping in treatment resistant schizophrenics. *Jrnl Orthomole Med*, 5(1):46-48, 1990.
 13. Morstyn R, et al: Altered P300 topography in schizophrenia. *Arch Gen Psychiatry*, 40:729-734, 1983.
 14. Karson CN, et al: Computed electroencephalographic activity mapping in schizophrenia. *Arch Gen Psychiatry*, 44:514-517, 1987.
 15. Duffy|FH, et al: Brain electrical activity in patients with presenile and senile dementia of the Alzheimer type. *Annals of Neurology*, 16:439-448, 1984.
 16. Bernad PG: Review: EEG and pesticides. *Clin Electroenceph* 20: ix-x, 1989.
 17. Knoll O, et al: EEG indicates aluminum load in long term hemodialysis patients. *Trace Elements in Med*, 1:54-58, 1984.
 18. Saletu B, et al: Topographic brain mapping of EEG in neuropsychopharmacology - Part II. Clinical applications (Pharmac EEG imaging). *Meth and Find Expt Clin Pharm*, 9:385-408, 1987.
 19. Lombroso CT, Duffy FH: Brain electrical activity mapping as an adjunct to CT scanning. *Advances in Epileptology*, XIth Epilepsy International Symposium. Cangor R., Angeheri F., Penry J.K. (eds.). New York, Raven Press, 1982, 83-88.
 20. Fisch BJ, Pedley TA, Keller DL: A topographic background symmetry display for comparison with routine EEG. *Electroenceph Clin Neurophysiology*, 69:491-494, 1988.
 21. Nuwer MR: Frequency analysis and topographic mapping of EEG and evoked potentials in epilepsy. *Electroenceph Clin Neuro-physiol*, 69:118-126, 1988.
 22. John ER, et al: Monitoring brain-function during cardiovascular surgery: Hypoperfusion vs Microembolism as the major cause of neurological damage during cardiopulmonary bypass. *Heart & Brain*, 405-421, 1989.
 23. John ER, et al: Real-time intraoperative monitoring during neurosurgical and neuroradiological procedures. / *Clin Neuro-physio*, 125-158, 1989.
 24. Garber HJ, Weilburg JB, Duffy FH, Manschreck TC: Clinical use of topographic brain electrical activity mapping in psychiatry. / *Clin Psychiatr*, 50:205-211, 1989.
 25. Herman WM, Itil TM: *Biological Psychiatry Today*. Obiols et al (ed.). Elsevier, North Holland: Medical Press, 1317-1327, 1979.
 26. Braverman ER, Blum K, Smayda S.J.-A. commentary on brain mapping in sixty substance abusers: Can the potential for drug abuse be predicted and prevented by treatment? *Curr Ther Res*, October 1990.
 27. Braverman ER, Smith RB, Smayda RJ, Blum K: Modifications of P300 amplitude and other electrophysiological parameters of drug abuse by cranial electrical stimulation (CES). *Curr Ther Res*, October 1990.
 28. Braverman ER, Pfeiffer CC: *The Healing Nutrients Within*. New Canaan, CT: Keats Publishing, 1987.
 29. Blum K: A commentary on neurotransmitter restoration as a common mode of treatment for alcohol, cocaine and opiate abuse. *Integr Psychiatry*, 6:199-204, 1989.

Table 1

BEAM Components

EEG	P300 (Oddball Paradigm)
Spectral Analysis	Statistical Tests
AER	(comparing one BEAM to another)
VER	

Full Spectral Components

Total Frequency, Power and Percent Power
 Coefficient of Variation and % Coefficient of Variation
 Asymmetry and % Asymmetry
 Coherence and Phase Coherence

Components

Hyperventilation	Brain Stem Evoked Potentials P200,
Coloured Lights	N100, N450, etc.
Supplemental	

Table 2
Clinical Diseases and QEEG

Alzheimer's Hyperactivity Parkinson's Drug Abuse Schizophrenia Depression Hepatic Coma

Beta	▼	▲				▼	▼
Alpha	▼		▼	▼		▼	▼
Theta	▼▲				▲	▼	▲
Delta	▼▲				▲	▼	▲

Table 3
The Effects of Drugs on QEEG

	30 mg. Chlorprothixene	75 mg. Imipramine	10 mg. Diazepam	250 mg. Caffeine	600 mg. Pyritinol
Beta1	▼		▲		
Beta2	▼	▲	▲	▼	▲
Beta3	▼	▲	▲		▲
Alpha-Fast	▼				▲
Alpha-Slow		▲		▼	▲
Theta	▲	▲	▼		▲
Delta	▲	▲	▼		▲

Table 4
The Effects of Drugs on QEEG

	L-Dopa	L-Phenylalanine	Anticonvulsants	Estrogen	Progesterone
Beta					
Alpha-Fast	▲	▲	▼	▲	▼
Alpha-Slow			▲	▼	▲
Theta					
Delta					

Table 5
The Effects of Drugs on QEEG

	Inderal	Aspirin	Chlortrimeton	Oxiractam	Prednisone
Beta1					▲
Beta2					
Beta3		▼			
Alpha-Fast	▲			▲	
Alpha-Slow		▼		▲	
Theta		▲	▲	▼	
Delta	▼		▲	▼	

Table 6
The Effects of Drugs on QEEG

	Elavil	Antimotion Scopolamine	Lithium	Prozac	Cocaine	Amphetamines
Beta	▲		▼		▲	▲
Alpha	▼	▼▼	▼		▲	▲
Theta	▲	?▼	▲?			
Delta	▲	?▼	▲			

Table 7
The Effects of Disease on Brain Regions

	Depression	Schizophrenia	Cocaine	Marijuana	Alcohol	Lead	Dyslexia
Frontal		X		X	XX		
Temporal	X	X	X		X	X	X
Parietal	X	X	X		X		
Occipital	X		X				

Table 8
Frontal Lobe — Behavioural Effects

Aphasia	Aggression
Auditory Hallucination and Illusion	Rage Reaction
Psychotic Behaviour	Apathy
	Placidity

Table 9
Temporal Lobe — Behavioural Effects

Difficulties in Adapting	Labile Mood
Loss of Initiative	Rigidity of Thinking
Lack of Tact	Lack of Ability to Sit Still
Bland Affect	Lack of Problem Solving Ability

Table 10
Parietal Lobe — Behavioural Effects

Disorders of Language	Loss of Logic
Memory Loss	Loss of Emotional Well-Being
Emotional Ability	

Table 11

Neurotransmitter/ central action	Drug of abuse that affects neurotransmitter action	Central location
Gamma Aminobutyric acid (GABA) General inhibition of other neurotransmitters	Alcohol Barbiturates Benzodiazepines Chloral hydrate Ethchlorvynol Meprobamate Methaqualone (?) Phencyclidine	Throughout brain
Acetylcholine Counterbalances Dopamine Maintains memory Initiates short-term memory	Phencyclidine	Caudate nucleus Lentiform nucleus Cerebral cortex Nucleus basalis of Meynert Nigrostriatal tract Reticular activating Substance
Norepinephrine Modulates mood Maintains sleeping state	Amphetamines Cocaine Opiates Phencyclidine	Nucleus locus Ceruleus Pontine and medullary cell groups
Dopamine Counterbalances Acetylcholine Stimulates pleasure center Modulates mood Affects intellectual Processes Inhibits prolactin release	Amphetamines Cocaine Phencyclidine	Caudate nucleus Lentiform nucleus Nucleus accumbens Basal Ganglia Tuberoinfundibular Pathway Pathway
Serotonin Modulates mood Initiates sleep Involved in REM sleep	Psychedelic agents Phencyclidine Alcohol	Pontine raphe nuclei
Beta-Endorphin Modulates mood Modulates pain perception Inhibits Norepinephrine release	Opiates Phencyclidine Nucleus locus ceruleus	Thalamus Arcuate and premamillary nuclei Hippocampus Nucleus solitarius Substantia gelatinosa

Table 12

Neurotransmitter/ central action	Nutrients that affect that action	Drugs that affect that action
Gamma Aminobutyric acid (GABA) General inhibition of other neurotransmitters	Taurine, manganese, B6, gamma-amino butyric acid, glutamine, glutamic acid	Anticonvulsants, benzodiazepines, Lioresal, Valium
Acetylcholine Counterbalances dopamine Maintains memory Initiates short-term Memory	Choline, manganese, B6, lysine, threonine, niacin	Prostigmin, tetrahydroacridine Neostigmin
Norepinephrine Modulates mood Maintains sleeping State	L-dopa, tyrosine, phenylalanine, folic acid, thiamine, copper	Desipramine, Pamelor
Dopamine Counterbalances acetylcholine Stimulates pleasure center Modulates mood Affects intellectual processes Inhibits prolactin release	L-dopa, tyrosine, phenylalanine, folic acid, thiamine, copper	Desipramine, Pamelor, Parlodel, Parsidol, Symmetrel, Sinemet, Artane
Serotonin Modulates mood Initiates sleep Involved in REM sleep	Tryptophan, Zinc, B6, Niacin	Prozac, Fenfluramine, Desyrel, Alcohol
Beta -Endorphin Modulates mood Initiates sleep Involved in REM sleep	d, 1-phenylalanine, branched-chain amino acids, enkephalins	Trexan heroin, alcohol
Histamine Modulates mood, appetite, sleep, immune system, cognition	Histidine, methionine, niacin, calcium, magnesium, zinc, copper, vitamin C	Periactin, Benedryl, Haldol, Elevel, ephedrine, adrenalin, terfenadine, astemizole