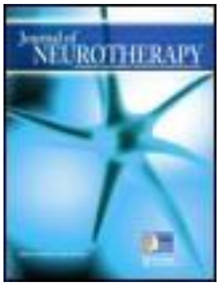


Journal of Neurotherapy: Investigations in Neuromodulation, Neurofeedback and Applied Neuroscience

# Psychological EEG Analysis

David A. Kaiser Senior Editor PhD

Published online: 30 Nov 2009.

**To cite this article:** David A. Kaiser Senior Editor PhD (2009) Psychological EEG Analysis, Journal of Neurotherapy: Investigations in Neuromodulation, Neurofeedback and Applied Neuroscience, 13:4, 193-195, DOI: 10.1080/10874200903338570

**To link to this article:** http://dx.doi.org/10.1080/10874200903338570

*Journal of Neurotherapy*, 13:193–195, 2009

ISSN: 1087-4208 print/1530-017X online
DOI: 10.1080/10874200903338570

## *EDITORIAL*

# Psychological EEG Analysis

Recently a colleague of mine used quantitative EEG to help him determine whether a man convicted of felony murder deserved the death penalty. The question was whether this young man had sufficient mental capability to control himself. My friend, a psychologist, used a number of psychological instruments, but the QEEG results were by far the clearest, revealing significant functional immaturity missed by conventional neuropsych testing. Anyone trained in psychological EEG analysis would come to the same conclusion as my colleague, that the convict's frontal lobes were significantly functionally underconnected, in nearly every index of EEG connectivity, that his brain activity resembled that of a teenager more than that of an adult in his early 30s. I was flown in to testify, to support the application of EEG analysis for this purpose.

The practice of law is the practice of science, an ideal slowly actualized through iteration. In both realms progress is slowed by ambition and error, but such is to be expected of any human endeavor. It is also clear to me that law must incorporate scientific understanding of human behavior if it is to survive, and functional neuroimaging in particular poses a unique challenge to its existence. Law and science both rely on precedents, though we have an advantage over law in that we are able to repeat an experiment as many times as necessary to understand human behavior and they must judge a single instance. We can replicate an action and change participants, setting, lighting, anything of interest, but law is given a single outcome and force to play the cards it was dealt.

In my testimony I explained to the judge and trial lawyers how individuals trained in Psychology interpret neuroelectromagnetism differently from those trained in Neurology, that EEG is a tool shared by both fields and one group may use it for X and another for Y and either may be valid in their use and interpretation. Of course I didn't use algebra to make my point but analogies, as a verbal reasoner, the judge, was the audience I hoped to convince. EEG is a tool, and like any tool it may be used in different ways by different people. A judge uses a hammer to maintain order and a carpenter uses it to build a house, but we wouldn't force all hammers to be round at both ends, or require a metal claw to protrude from a gavel, would we? Hammers come in all shapes and sizes, and like EEG they can be wielded in different ways. Same tool, different purposes.

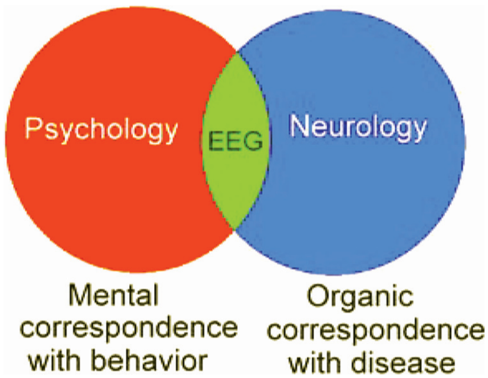
The opposing view, expressed by the DA, was the neurologist's view of this tool, that EEG can be used only to identify structural problems in the brain, a stance so misguided and limited that it should evoke pity in the reader. The study of neuroelectromagnetism is closer to cosmology than medicine in the way we are doing it. We are investigating how human thought creates light, currents of electromagnetism, the generation of orderly energy, and how that regulated energy controls and manipulates matter, the body. In fact Hans Berger created the first EEG equipment in the 1920s to study thought processes (mostly in his son) and only later did he adapt his technology to study epilepsy and other brain disorders.

The defense team phoned me a few days after my testimony and asked me to help undermine the credibility of the opposing expert, a well-known neurologist and friend of a friend. I told them to ask the witness questions relevant to psychological investigations of EEG. For instance, what would we expect to see in an EEG record of an individual during a lexical decision task, with or without lateralized presentations . . . that's easy enough. And what happens at posterior electrode sites when a gambler playing blackjack considers himself ahead or beating the house? Most of my undergraduates can answer these questions, and these are just two of the many psychological applications associated with EEG analysis. More than 42,000 quantitative EEG papers have been published since 1965, and a survey of last year's publications revealed three times more EEG research on issues under the umbrella of Psychology—attention, sleep, unconsciousness, animal behavior—than under the smaller parasol of Neurology. In other words, identifying and studying organic disorders with EEG has been a minority application of this technology for my entire lifetime.

The DA asked me whether I knew the neurology standard for sampling rates was 200 Hz, and I laughed when he told me the number, disbelief to the point of mockery. Why would any EEG science rely on a base-10 number? I asked aloud. The defense loved my response and I continued to explain to the unhappy DA how such a standard was archaic, 40 years out of date, a relic from the hey-day of Grass and Gibbs in the late 1930s, perhaps, or established by Molly Brazier and her crew in the 1950s. A base-10 sampling rate was like using horse-and-buggy rules to control highway traffic. The Fast Fourier transform (FFT) was invented in 1965, and no serious scientific group would rely on a base-10 value after its occurrence, as it would sacrifice accuracy, speed, and communication, the trifecta of scientific investigation. We have been the power of 2 since 1965, with rates set to 128, 256, 512 samples per second for a reason. The FFT is a clever and highly efficient algorithm for quantifying frequency information within a time series, light years ahead of any spectral estimation technique in vogue prior to 1965. The discrete fourier transform (DFT), available since the 19th century, for instance, requires endless iterations of trigonometry and floating-point operations, a dicey and memory-intensive operation 40 years ago, whereas the FFT is an N log N algorithm, which is geek speak for "Hello, gorgeous!" It was superior in every way, a major algorithmic breakthrough when it hit the world in the late 1960s, and all serious sciences that employed frequency analysis—seismology, acoustics, physical oceanography—responded to this change . . . except neurology, apparently.

During most of my examination and cross-examination the computer screen behind me showed a Vend diagram of Psychology and Neurology, the study of mental functions and behavior and the study of disorders of the nervous system, respectively, with their intersection being "EEG" (see Figure 1). The assistant DA asked me time and again about the use of the EEG in diagnosing organic disorders, and time and again I responded that we were using EEG to study mental operations and abilities. My testimony was being evaluated under the Daubert decision (1994), which produced guidelines for evaluating scientific evidence and testimony in court trials. A technique or theory must be accepted by the relevant scientific community and governed by explicit rules to be viewed as credible evidence in a court of law. Aware of this decision, I explained how science, like law, is not homogeneous or uniform but an assemblage of independent disparate groups, each its own school of thought, largely inert to the successes and failure of adjacent fields. Each science makes its own rules, and only rarely do rules of one field extend or cascade into another. Unlike law, science has remarkably few rules shared across disciplines, but they are the following: a measurement must be repeatable, a theory falsifiable, an inference logical, all tools are considered imperfect, and communication between practitioners or to the public must be honest and transparent. Those are our

FIGURE 1. Use of EEG technology shared by disciplines.




standards, by the way. Unfortunately the other day I noticed one of our "practitioners" breaking Rule 4, using the phrase "zero error" on his Web site to describe his analysis. We should remind ourselves that making a claim of zero error is not science but propaganda.

My take-home message from this experience was that the International Society for Neurofeedback and Research (ISNR) needs its own standards, which it is working on, and the recognition that neurofeedback instruments are likely misclassified by the Food and Drug Administration as neurological therapeutic devices (§ 882.5050). The Food and Drug Administration does not regulate psychological tools such as the Minnesota Multiphasic Personality Inventory, Beck Depression Inventory, or Test of Variables of Attention, nor does it classify video games as food or drug, so how does computer-interface technology that encourages mental exercise and psychological change fall under the aegis of a government agency dedicated to drug safety? And if it does, why aren't World of Warcraft and other addictive video games similarly regulated? I think ISNR needs to establish its own system of evaluating the claims, safety, and efficacy of neurofeedback equipment.

In this issue of the journal David Vernon and colleagues weigh in on the general principles of neurotherapy, and Mark Jensen and his colleagues discuss opportunities for neurotherapy in pain management. Also included in this issue are the proceedings from our recent conference in Indiana, which was like a Roman marketplace of new ideas and new technologies in the service of mental health. Along with ISNR's proceedings, abstracts from the Society for the Advancement of Brain Analysis (SABA), a daughter group of ISNR, are also included. Finally the Perspectives section reappears, a section for clinical narratives. Storytelling is an important part of scientific investigation as stories are often the best teachers. There are many who prefer examples to abstract principles, and in fact behavioral neurology owes its existence to case studies, that is, singular examples of brain dysfunction, beginning with Phineas Gage in 1848 and Paul Broca's observations of Tan in 1861 to the "split-brain" callosotomy patients first described at Caltech in 1962 to the uniquely brain-injured patients known only by initials, such as the late H.M. We hope the inclusion of clinical narratives in this journal provides further insights into the use of neurotherapy.

*David A. Kaiser, PhD*
*Senior Editor*