Quantitative EEG Analyses

PATIENT INFORMATION
Name: [Redacted]
Exam#: 07172002
Age: 11.55 years
Sex: Male
Handedness: Right

Medication: Prozac, Concerta, Abilify and DDAVP.

RECORDING
Date: February 4, 2014
Ref. By: Dr. Jan Mustin
Test Site:
Analysis Length: 2:00 Minutes
Ave. EEG Reliability: 0.99 (SH)
Ave. EEG Reliability: 0.98 (TRT)

HISTORY: suicidal verbalizations and/or behaviors; severe impulsivity or explosive expression of anger; severe defiant, disruptive or destructive behavior; dangerous, self-injurious or unsafe behaviors; severe deterioration of functioning (family, school, community); serious lack of development of age-appropriate functioning; serious depressive symptoms; possible cognitive processing disturbance interfering with social adaptation and learning; aggressiveness or assaultiveness; recurrent thoughts, impulses or images; and irritable or labile mood - Posttraumatic Stress Disorder, Attention-Deficit/Hyperactivity Disorder, Oppositional Defiant Disorder, History of Reactive Attachment Disorder, History of possible Physical and Sexual Abuse of Child (Victim), Rule-Out Mood Disorder, Rule-Out Learning Disorder, and Rule-Out Intermittent Explosive Disorder - Rule-Out Complex-Partial Seizure Disorder.

SUMMARY OF EEG ANALYSES:
The power spectral analyses were deviant from normal with reduced power in bilateral occipital regions and especially right occipital and in left frontal region from 8 – 10 Hz and excessive power in bilateral frontal regions and especially right frontal from 18 Hz and higher. LORETA 3-dimensional source analyses were consistent with the surface EEG and showed reduced current sources in the limbic lobes of the posterior cingulate gyrus with a minimum at 9 Hz (Brodmann areas 23, 29 & 30). Reduced LORETA current sources were present in the left superior temporal and supramarginal gyri with minimum at 10 Hz.
(Brodmann areas 22, 39 & 40). Elevated LORETA current sources were also present in right middle and superior frontal and anterior cingulate gyri with a maximum at 19 Hz (Brodmann areas 10, 11 & 32). EEG amplitude asymmetry, EEG coherence and EEG phase were abnormal, especially in bilateral frontal and occipital relations. Reduced coherence was present in the bilateral frontal regions and especially right frontal which indicates reduced functional connectivity. Elevated coherence was present in bilateral occipital regions and especially right occipital which indicates reduced functional differentiation. Both conditions are often related to reduced speed and efficiency of information processing. The learning disability discriminant function did not detect a pattern in the EEG that is commonly present in individuals with a history of general academic problems. The brain performance index (BPI) predicted an average capacity to efficiently allocate neural resources with a balanced prediction for performance I.Q. and verbal I.Q. The BPI was not designed to replace neuropsychological testing but rather is a measure of the general health of the brain and the degree to which neural resources are efficiently allocated. In summary, the qEEG analyses were deviant from normal and showed de-regulation of the bilateral occipital lobes and especially right occipital, the bilateral frontal lobess and especially right frontal of the middle and superior frontal gyri, the limbic lobes of the anterior and posterior cingulate gyri, and the left superior temporal and supramarginal gyri. The occipital lobes are involved in the visual processing center for the visual cortex of visual perception and spatial processing. The frontal regions are involved in mood control, executive functioning, abstract thinking and social skills. The limbic lobes are involved in motivation, emotion, learning, and memory. The posterior cingulate gyrus is involved in short-term memory and attention control by regulation of limbic emotional and memory input to the cortex. The anterior cingulate is involved in rational cognitive functions, such as reward anticipation, decision-making, empathy, impulse control, and emotion. The temporal lobes are involved in auditory information processing, short-term memory, receptive language on the left and face recognition on the right. The supramarginal gyrus is involved in language perception and processing. To the extent there is deviation from normal electrical patterns in these structures, then sub-optimal functioning is expected.

NEUROFEEDBACK RECOMMENDATIONS:
The following implications for neurotherapy are offered based upon the clinical evaluation of the patient as well as the reference data base results. These suggestions for neurotherapy should be evaluated with caution and should only be considered as possible strategies that the clinician may considered in his/her evaluation. If the patient is depressed, then the clinician should consider treating this condition first through alpha frequency enhancement or some other biofeedback protocol that may reduce depression. If depression or poor mood and/or motivation is not a problem then the clinician may consider using one or more strategies with the priority of treatment in the order presented below.

1- Suppress frequency activity 8 - 10 Hz at O2.

2- Suppress frequency activity 9 - 10 Hz at F3.

3- Reinforce EEG coherence at 8 – 12 and/or 15 - 18 Hz between FP2 and F8.

Robert W. Thatcher, Ph.D., QEEG-D, BCIA, ECNS
Electrical NeuroImaging

Linking a patient’s symptoms and complaints to functional systems in the brain is important in evaluating the health and efficiency of cognitive and perceptual functions. The electrical rhythms in the EEG arise from many sources but approximately 50% of the power arises directly beneath each recording electrode. Electrical NeuroImaging uses a mathematical method called an “Inverse Solution” to accurately estimate the sources of the scalp EEG (Pascual-Marqui et al, 1994; Pascual-Marqui, 1999). Below is a Brodmann map of anatomical brain regions that lie near to each 10/20 scalp electrode with associated functions as evidenced by fMRI, EEG/MEG and PET NeuroImaging methods.
Conventional EEG Samples and Quantitative EEG Analyses

Fig. 1 - Example of EEG and Absolute Power Z scores – Linked Ears eyes closed condition

Fig. 2 - Example of Laplacian Absolute Power – eyes closed condition
Fig. 3 – Example of LORETA Z Scores at 9 Hz. (Brodmann Area: 23, 29 & 30)
Fig. 4 – Example of LORETA Z Scores at 10 Hz. (Brodmann Area: 22, 39 & 40)
Fig. 5 – Example of LORETA Z Scores at 19 Hz. (Brodmann Area: 10, 11 & 32)
NETWORK zSCOREs
(Circles = zSCOREs, Radial Lines = Brodmann Areas)

Pain

Attention Ventral

Attention Dorsal

Mood

Default Mode

Pleasure

Working Memory

Addiction

Anxiety

Brodmann Area Maps

Significant zBrodmann Areas (z >= 1.96)
Recommendations for LORETA NeuroFeedback

Circles = z-Scores, Radial Lines = Brodmann Areas

- Pain
- Attention Dorsal
- Default Mode
- Mood
- Attention Ventral
- Pleasure
- Working Memory
- Addiction
- Anxiety

Brodmann Area Maps

Significant z-Brodmann Areas (z ≥ 1.96)
Z Scored FFT Absolute Power

Montage: LinkEars

EEG ID: 07172002
Z Scored FFT Absolute Power

Montage: LinkEars

EEG ID: 07172002

Frequency Bands:
- 21 Hz
- 22 Hz
- 23 Hz
- 24 Hz
- 25 Hz
- 26 Hz
- 27 Hz
- 28 Hz
- 29 Hz
- 30 Hz
Z Scored FFT Amplitude Asymmetry

Montage: LinkEars

EEG ID: 07172002

Delta (1.0 - 4.0 Hz)
Theta (4.0 - 6.0 Hz)
Alpha (8.0 - 12.0 Hz)
Beta (12.0 - 25.0 Hz)
High Beta (25.0 - 30.0 Hz)
Beta 1 (12.0 - 15.0 Hz)
Beta 2 (15.0 - 18.0 Hz)
Beta 3 (18.0 - 25.0 Hz)

Z-Score ≥ 1.96
Z-Score ≥ 2.58
Z-Score ≥ 3.09
Montage: LinkEars

Z Scored FFT Coherence

Delta (1.0 - 4.0 Hz)
Theta (4.0 - 8.0 Hz)
Alpha (8.0 - 12.0 Hz)
Beta (12.0 - 25.0 Hz)
High Beta (25.0 - 30.0 Hz)
Beta 1 (12.0 - 15.0 Hz)
Beta 2 (15.0 - 18.0 Hz)
Beta 3 (18.0 - 25.0 Hz)

Z-Score >= 1.96
Z-Score >= 2.68
Z-Score >= 3.09
Learning Disability Discriminant Analysis

LD DISCRIMINANT SCORE = -3.00
LD PROBABILITY INDEX = Not Significant

The Learning Disability Probability Index is the subject's probability of membership in the Learning Disability (LD) population.

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*Statement of Indications of Use:
The Discriminant Analysis and Severity Index are to be used by experienced and qualified professionals for the post-hoc statistical evaluation of the human electroencephalogram (EEG). The Discriminant Analysis and Severity Index are to be viewed as an adjunct to the evaluation of the patient, and they do not serve as a primary basis for a diagnosis. Warning: Inclusion criteria of no history of traumatic brain injury and age between 6 years and adulthood must be adhered to.
### Technical Information

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| Sampling Rate:    | 128              |
| Collection Hardware: | Daymed          |
An Addendum to Neuroguide QEEG Report

Important disclaimer - QEEG tests are ancillary tests that are not intended to provide a diagnosis by themselves, but are used to evaluate the nature and severity of deregulation in the brain such as in mild traumatic brain injury. The QEEG tests provide a quantitative assessment of areas of brain dysfunction and information on impaired conduction and connectivity between different regional neural networks in the brain. The assessment of impaired connectivity is based on abnormal measurements of Coherence and Phase.

The TBI Discriminant does not provide a diagnosis for MTBI but only information on the presence of a pattern in the EEG that is often found in patients with a history of mild traumatic brain injury. The TBI discriminant also provides information about connectivity and excitability of brain regions.

The TBI discriminant is to be used only on patients with a clinical history and symptoms of a Traumatic Brain Injury and Post Concussion syndrome.

The diagnosis of MTBI is a clinical one and is not based on any one test. A diagnosis is performed by the clinician, who integrates the medical history, clinical symptoms, neurocognitive tests with the above mentioned brain function tests as well as other information to render a diagnosis.

The information on impaired brain connectivity is derived primarily from abnormal measurements of Coherence and Phase. Assessments of regional abnormality rely also on abnormal amplitude (power) distribution across the spectrum of EEG frequencies as compared to the normative database.

Description of the Neuroguide Normative Database:

The NeuroGuide normative database in versions 1.0 to 2.4.6 included a total of 625 carefully screened individual subjects ranging in age from 2 months to 82 years. NG 2.5.1 (6/12/2008) involved the addition of 53 adult subjects ranging in age from 18.3 years to 72.6 years resulting in a normative database of 678 subjects. The inclusion/exclusion criteria, demographics, neuropsychological tests, Gaussian distribution tests and cross-validation tests are described in several peer reviewed publications (Thatcher et al, 1983; 1987; 2003). Two year means were computed using a sliding average with 6 month overlap of subjects. This produced a stable and higher age resolution normative database with a total of 21 different age groups. The 21 age groups and age ranges and number of subjects per age group is shown in the bar graph in Appendix F figure 2 in the NeuroGuide Manual (click Help > NeuroGuide Help).

The individuals used to create the normative database met specific clinical standards of no history of neurological disorders, no history of behavioral disorders, performed at grade level in school, etc. Most of the subjects in the normative database were given extensive neuropsychological tests. Details of the normative database are published at: Thatcher, R.W., Walker, R.A. and Guidice, S. Human cerebral hemispheres develop at different rates and ages. Science, 236: 1110-1113, 1987 and Thatcher R.W., Biver, C.L., North, D., Curtin, R. and Walker, R.W. Quantitative EEG Normative Databases: Validation and Clinical Correlation. Journal of Neurotherapy, 2003, 7(3/4): 87-121. You can download a description of the normative database by going to www.appliedneuroscience.com and clicking on the webpage Articles & Links > Articles > Article #5.

Is there a normative database for different montages including bipolar montages?

Yes. The raw digital data from the same group of normal subjects is analyzed using different montages such as Average Reference, Laplacian current source density, a common reference based on all
19 channels of the 10/20 system and standard clinical bipolar montages (e.g., longitudinal, circular, transverse). Users can create any montage that they wish and there will be a normative reference database comparison available for both eyes closed and eyes open conditions.

**Age range of the LORETA current density and Source Correlation normative databases**

The LORETA current density and source correlation norms use the same subjects as are used for the surface EEG norms and the age range is 2 months to 82 years. The computational details of the LORETA current density norms are published at: Thatcher, R.W., North, D., Biver, C. EEG inverse solutions and parametric vs. non-parametric statistics of Low Resolution Electromagnetic Tomography (LORETA). Clin. EEG and Neuroscience, Clin. EEG and Neuroscience, 36(1), 1 – 9, 2005 and Thatcher, R.W., North, D., Biver, C. Evaluation and Validity of a LORETA normative EEG database. Clin. EEG and Neuroscience, 2005, 36(2): 116-122. Copies of these publications are available to download from [www.appliedneuroscience.com](http://www.appliedneuroscience.com) by clicking Articles & Links > Articles > Numbers 11 and 12. The computational details of the LORETA source correlation norms are in the Neuroguide manual, click Help > NeuroGuide help > Appendix-G.

**Implementation of LORETA measurement in Neuroguide**

The Key Institute's LORETA equations and the LORETA viewer (Pascual-Marqui et al, 1994; Pascual-Marqui, 1999) can be launched by a single mouse click in the Neuroguide window. NeuroGuide Deluxe exports frequency domain and time domain edits of 19 channel x 256 point digital EEG in microvolts (or uV^2) in the Lexicor electrode order as the standard input to the Key Institute T-Matrix. Rows are 256 microvolt time points and the columns are 19 channels at a sample rate of 128 thus producing 0.5 Hz resolution from 1 to 30 Hz. 1 Hz increments in the LORETA viewer are computed as the sum of adjacent 0.5 Hz bins and thus the ‘Time Frame’ control in the LORETA Viewer is frequency from 1 to 30 Hz. (see Pascual-Marqui RD, Michel CM, Lehmann D., 1994. Low resolution electromagnetic tomography: a new method for localizing electrical activity in the brain. International Journal of Psychophysiology 18:49-65. For computational details see: Pascual-Marqui. R.D., 1999. Review of Methods for Solving the EEG Inverse Problem. International Journal of Bioelectromagnetism, Volume 1, Number 1, pp:75-86. Pascual-Margui, R.D., 2004. Free software and documentation from the Key Institute that was downloaded from [http://www.unizh.ch/keyinst/NewLORETA/Software/Software.htm](http://www.unizh.ch/keyinst/NewLORETA/Software/Software.htm).

There is a need to match different amplifiers to the amplifier on which the Neuroguide amplifier that acquired the original database information.

This stems from the fact that amplifiers have different frequency gain characteristics. The matching of amplifiers to the Neuroguide database amplifier was done by injecting microvolt calibration signals of different amplitudes and frequencies into the input of the respective EEG machines and then computing correction curves to exactly match the amplifier characteristics of the norms and discriminant functions. The units of comparison are in microvolts and a match within 3% is generally achieved. The Neuroguide research team double checked the amplifier match by computing FFT and digital spectral analyses on calibration signals used to acquire the norms with the calibration signals used to evaluate a given manufacturers amplifiers.

**History of the Scientific Standards of QEEG Normative Databases**


**QEEG Normative Database Publications and Validations:**


