

**This is a sample of a Functional Brain Mapping Report that describes the different tests in this battery, including EEG, Quantitative EEG (QEEG), and Evoked Potentials. The data provides a quantitative analysis of multiple aspects of brain dysfunction needed in diagnosing and assessing the nature and severity of brain disorders. This battery can help in checking the pace of recovery or clinical deterioration over time, assist in the better selection of psychotropic medications, and in setting more effective treatment protocols, particularly in brain activation training called EEG Operant Conditioning.**

Date: xx/xx/xxxx

## **BRAIN ELECTRO-NEUROPHYSIOLOGICAL** **TESTING BATTERY**

### **EEG, Neurometric Quantitative EEG and Evoked Potentials**

**Patient's Name:**

Patient's ID#:

DOT:

DOB:

DOA:

SS#:

Sex:

Technician:

Laterality:

**This patient suffered a closed head injury with loss of consciousness, and subsequently developed symptoms consistent with Post Concussion Syndrome as well as fears and avoidant anxiety that limit his ability to perform in his job.**

**The brain mapping battery of tests is done in order to establish the presence of brain damage and dysfunction that can be correlated to the Traumatic Brain Injury, and to assess and quantify the degree of the neuro-physiological dysfunction.**

#### **Introduction to the Brain Mapping Battery**

The following is a clinical diagnostic battery of neuro-physiological brain function tests that detects and measures brain dysfunction in neurological and neuropsychiatric disorders. It provides

information that assists in the differential diagnosis and in the selection of various medications and treatments for different conditions.

This battery was determined to be a valid clinical test by the criteria set by the American Academy of Neurology – see reference: "Conventional and Quantitative Electroencephalography in Psychiatry," John R. Hughes, M.D., Ph.D., E Roy John, Ph.D., J. Neuropsychiatry Clin. Neuroscience 11:2 Spring 1999.

The battery consists of the following tests: (1) Digital EEG, (2) Quantitative EEG using the Neuroguide and Neurometric databases which provide measurements that may have clinical and diagnostic implications, and (3) Several Multimodal Evoked Potentials including Brainstem EP, Visual EP and Brainstem-Somatosensory EP.

The different tests are evaluated in relation to each other, thus providing a three-dimensional assessment of brain dysfunction.

### **Different Database Analysis**

The Neurometric Database has a 510K clearance by the FDA (July 1998 #K974748), an indication that construction of the database has been scrutinized for good manufacturing practices (GMPs). It also signifies the legitimacy of marketing claims made concerning the database. It is based on 2,084 variables, and is based on measurements from some 782 normal individuals and 4,000 clinical cases.

The Neuroguide database was developed by Robert W. Thatcher in 1998. 943 variables are computed on each individual test. The construction and composition of the database are well documented.

### **The purpose of doing this battery of tests and its value to the treatment outcome of the patient are:**

1. to assess to what extent there is an organic basis for the patient's complaints, and to what degree of severity.
2. to locate areas of weakness and strength in the organization and neurophysiological status of the patient's brain so as to bring about a more efficient and optimal design of neurotherapy.
3. to establish a baseline of present level of brain dysfunction in order to be able to detect improvement and recovery, or lack off, in the future and assess the prognosis of the patient.
4. to assist in the selection of specific psychotropic medications based not only on clinical symptomatology, but on specific electrophysiological findings associated with them.

Current Medications: None

### **Test Performed**

- Digital EEG
- Quantitative EEG
- Topographic Brain Mapping

**Test Performed (cont.)**

- Brainstem Auditory Evoked Potential (BAEP)
- Pattern Reversal Visual Evoked Potential (PRVEP/LED)
- Brainstem Somatosensory Evoked Potential (BSEP/SSEP)

**Test Protocol**

This EEG evaluation involves 20 minutes of eyes closed, resting, baseline digital recording of EEG, with up to three minutes of standard hyperventilation, a period of post-hyperventilation and a period of photic stimulation.

Neurometric and Neuroguide Analysis of QEEG – Two to three minutes of artifact-free data were selected from the Digital EEG record. The selected data were subjected to spectral brainwave analysis and statistical analysis with the Neuroguide and Neurometric programs to detect abnormal deviations from corresponding measurements of normal individuals the same age. The analyses produced functional topographic brain maps and corresponding statistical tables that best summarize and display the analyzed data and the degree of their deviation from the norms.

Multimodal Evoked Potentials – Visual Evoked Potentials recorded separately in response to left and right eye pattern reversal stimulation; Brainstem Auditory Evoked Potentials recorded in response to monaural clicks; Somatosensory Brainstem Evoked Potentials recorded in response to left and then right median nerve stimulation.

## **Testing Results**

### ***Raw EEG Findings***

The patient was alert and cooperative. EMG activity was seen in T3 and T4 (anterior-temporal regions) reflecting tension of his jaw muscle, more in the left.

The record is poorly organized, showing a predominant frequency of 9-10 Hz, which is abnormally spread towards the anterior regions.

There is a poor production of alpha in the occipital regions, with power asymmetry in the occipital areas, with more power in the right.

The parietal alpha is more synchronous with the anterior alpha, than with the low powered occipital alpha, and more robust than in the occipital regions. It suggests an occipital dysfunction and functional disconnection between the occipital regions and adjacent areas (parietal and posterior temporal regions).

The waveforms are well formed, moderately sustained with medium voltage.

The patient had a good photic drive response.

No epileptic activity, sharp waves or spikes were elicited.

There was a normal response to hyperventilation and photic stimulation.

### ***Quantitative EEG: This is an Abnormal Record***

#### **Clinical Discriminant Scores**

This measurement functions as a diagnostic aid by calculating the probability of fitting an individual QEEG profile to profiles established for certain clinical groups.

#### **Neuroguide Database Clinical Discriminant Score**

- TBI Probability index – 90.0%
- TBI Severity Index – 5.69, reflecting a moderate range of severity. It is an estimate of the neurological severity of injury.

#### **LORETA Analysis**

The LORETA detects deep sources of abnormal EEG activities in the parieto-occipital midline area, extending laterally and to the mid parietal region.

Mild abnormality is seen along the midline regions, extending to the mid prefrontal regions.

## *Neuroguide Database EEG Spectral Analysis*

### **Phase Lag Measurements**

This measurement reflects a conduction delay between two points that are engaged in similar activity.

- Left hemisphere – Delay in the alpha waveband: P3-O1: -3.24 s.d.
- Left hemisphere – Delay in the alpha waveband: P3-T5: -3.92 s.d.
- Right Hemisphere – Delay in the alpha waveband: P4-O2: -2.63 s.d.

### **Coherence Measurements**

Coherence measures the similarity of simultaneous EEG wave activity between two points, or two regions. The measurements of the level of coherence or synchrony range from 0 for no synchrony at all and 1 for full synchrony of wave activities. Normal range is optimally around 0.65. Any higher score is defined as hypercoherent, and when lower as hypo-coherent. It is indicative of changes in connectivity between regions in the brain, and may reflect brain dysfunction, changes in optimal communication, coordination, synchrony and alignment of integrated brain activity.

### **Interhemispheric Coherence Measurements**

There is a hypo-coherence in the parietal, posterior-temporal and occipital regions across all wavebands, indicative of poor connectivity.

**There is significant hypo-coherence across all wavebands, between the left and right occipital regions reaching an average of 4 s.d.. This finding is the most significant and most deviant measurement in this QEEG.**

The Central region also manifests significant hypo-coherence measurements in its relationship with the occipital regions, and hypercoherence in its work with the prefrontal and frontal regions.

There is hypercoherence between the hemispheres in the frontal and prefrontal regions as well as the central and parietal ones in the theta, alpha and beta wavebands (see tables).

### **Absolute Power Measurements**

There is significant delta power excess in the occipital regions and left posterior-temporal region, peaking in the right occipital.

Overall, both relative and absolute power show a significant global elevation of theta power, indicative of a diffuse brain dysfunction. This is most probably causally related to a diffuse axonal brain injury.

There is a less significant elevation of beta activity in the right occipital region.

The alpha activity in the occipital is elevated from the norm in the absolute power measurements.

**Relative Power Measurements**

There is (1) a significant theta elevation in the mid-anterior region, including the prefrontal regions, peaking in the mid-frontal area, (2) a theta elevation in the occipital regions, more in the left occipital, and (3) an alpha elevation in the left prefrontal region and right frontal region.

One-hertz bitmaps show a theta focus in Fz, mid-frontal region, peaking in 6HZ.

**Power Asymmetry**

There is more power in the right hemisphere across all wavebands, than in the left one, suggesting a relative left hemisphere dysfunction.

The power asymmetry reaches its peak in the occipital regions.

There is a theta relative power surge focus in the left occipital, which suggests damage and dysfunction there.

## **Q-EEG Scores Summary**

This is a relatively low powered record, in which there is a global predominance of theta power, peaking in the right occipital and left posterior temporal, while generally showing lower power in the left hemisphere. That suggests a diffuse weakness of the left hemisphere.

There is a globally low interhemispheric coherence (abnormally low synchronicity) that reaches significance in the occipital regions across all band waves. That shows a poor connection between the hemisphere, and possible damage to the Corpus Callosum or the interhemispheric axonal connection.

Bipolar measurements show a significant inter hemispheric parieto occipital asymmetry, (s.d. 3.16) with more power to the right, which is significantly hypo coherent. The regional score for abnormality is 4.34 s.d. units.

The fronto-temporal regions show a significant hypo coherence in most wave bands. The regional score of abnormality is 2.03 s.d. units.

### ***Interpretation of Evoked Potential Findings***

#### **Brainstem Auditory EP: Normal.**

There are no conduction delays in either the left or right auditory stimulation, there is no evidence of eighth nerve or brainstem damage bilaterally, and there is no delay in interpeak latency 1-3 and 3-5 or 1-5.

#### **Pattern Reversal Visual EP: Abnormal.**

Left eye stimulation bilateral occipital evoked responses were delayed, 110.55 and 109.77 msec. in left and right occipital measurement points.

Right eye stimulation bilateral occipital evoked responses were delayed, 114.84 and 113.67 msec. in left and right occipital measurement points.

#### **Brainstem Somatosensory EP: Normal.**

No conduction delays are detected in the brainstem and thalamic level of the somatosensory tracts bilaterally.

## **Summary of Findings and Conclusions**

This is an abnormal record with findings strongly supporting the diagnosis of a Traumatic Brain Injury in more than one test.

The findings show a global dysfunction manifested in the significant elevation of theta power globally.

A LORETA mapping of deeper sources of abnormal EEG activity show area of dysfunction in the occipital and parietal mid line regions.

A regional damage and dysfunction is shown in the occipital region, and its poor connectivity with associated and adjacent areas, as well as the central region.

The central region EEG activity is recruited into high synchrony with the anterior regions, and not with the posterior regions.

The delays in the optic pathways conduction from both eyes to the occipital regions is significant bilaterally, indicative of an axonal damage in the white matter.

The clinical discriminant for Traumatic Brain Injury is positive for Traumatic Brain Injury and the neurological symptomatology is assessed statistically to be of a moderate degree based on his testing score.

The Conner's Continuous Performance Test shows mild impulsivity and fast reaction time, usually typical to a frontal lobe dysfunction. Being considered a highly intelligent person, he may have lost a significant range of attention without hitting the abnormal score.

The BDI score indicates a moderate level of depression, with checked symptoms which are shared with those of Post Concussion Syndrome, i.e. impaired concentration, irritability, tiredness, agitation, sleep and indecisiveness.

The causal relationship between the patient's cognitive dysfunction, his depression and his minor Traumatic Brain Injury is established with a high degree of medical certainty.

In addition to his Post Concussion Syndrome, the patient suffers from anxiety, agoraphobia and acrophobia, as well as from avoidant behavior, which relate to a Post Traumatic Stress Disorder.

Considering the fact that the patient was able to function well prior to the above mentioned injury, it is correct to assume that the damage due to the Traumatic Brain Injury as well as his lingering Post Traumatic Stress Disorder are the causes of the patient's current neuropsychiatric disabilities.

The patient is determined to be totally disabled as far as being able to work in the profession he engaged in prior to his injury.

He is determined to be partially disabled as far as being able to function on his currently less demanding and lower paying job.

The patient's diffuse axonal damage manifests in irritability, depression, impaired attention, concentration and short-term memory deficit. Also, the patient reports having difficulty in organization and executive functions, and has to rely on notes and lists.

The patient is vulnerable to social and environmental stresses and is prone to clinical setback.

It is important to note that any additional brain concussion in the future may cause the patient a major neurological and mental deterioration due to a diminished neuronal reserve.

Also, studies show that the chances for an early onset of dementia are higher in such patients due to their diminished neuronal reserve.

### **Recommendations**

The patient should be engaged in an active neuropsychiatric rehabilitation program to address his lingering depression and impaired attention and cognition.

It should include psychotherapy and medications – antidepressant and as well as stimulants as needed.

His psychotherapy should address his phobias, anxiety and depression, and PTSD symptomatology.

The patient should be engaged in attention and cognitive enhancement training. EEG biofeedback, or EEG Operant Conditioning is strongly recommended, and he will need about 60 sessions (plus/minus 20) to assure optimal results.

### **Prognosis**

The patient's brain dysfunction is now in a chronic phase, and the patient is expected to have residual disability for the rest of his life. His disability is associated with compromised brain function, reduced adaptability and capacity to learn, recall and solve problems and is compounded by his Post Traumatic Stress Disorder and phobic symptoms.

He may improve to a degree with cognitive training, and should try to do so, for every increment of improved performance will add meaningfully to the quality of his life.

The assessed moderate degree of the patient's neurological symptomatology, as seen in his brain mapping battery of tests, suggests that the patient is facing a limitation in his vocational choices and ability to advance in his career to a higher executive level of function and responsibility.

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