# Northern California Neurotherapy

# Functional Localization of Patient Symptoms in the Brain

by


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**Clinician's Note**: ***The purpose of this presentation is to educate the non-specialist in the use of brain mapping techniques, the interpretation of data derived from the analyses, and the conclusions regarding brain dysregulation and associated symptoms. Both Eyes-Open and Eyes-Closed recordings were done, but the data from the Eye-Closed recording is the only one used in this presentation.***

***The following presentation is a case study showing the functional deficits associated with a case of mild traumatic brain injury (mTBI). The identifying information about the patient, other than sex and approximate age, has been altered to protect confidentiality. It is an interesting study for the beginner, because this patient's brain underwent a self-healing process over a 2 month period of time. Therefore, one can easily see the evidence of mTBI in the brain maps that were generated 4 days after the TBI incident and compare those to a normal presentation of the same patient's brain 2 months after the incident. A detailed analysis of the patient's symptoms immediately following the mTBI is corroborated by the brain mapping analysis. Over the course of 2 months, the symptoms subsided, and the analysis of the brain maps clearly shows the return to normal. During this period of time, there was no neurofeedback intervention of any kind.***

***Electro-Imaging analyses were all generated using Neuroguide™ software developed by Robert Thatcher. The software analysis helps to "link symptoms and behavior to functional networks in the brain", thereby corroborating patient symptom reports (appliedneuroscience.com). The entire basis for the validity of the Electro-Imaging technique as used by Robert Thatcher in NeuroGuide clinical applications is that the patient's data may be reliably and robustly compared to normative data. Please see Robert Thatcher's paper entitled "After 25 Years the NeuroGuide Normative Databases are Accepted Science" by going to appliedneuroscience.com and downloading article number 58.***

# Introduction

**Electro-Imaging** uses sophisticated computer analysis of Electroencephalographic (EEG, or brain-wave) recordings from the scalp to determine functional deficits in the brain. The technique is non-invasive and provides a wealth of information about the localization of brain dysfunction or dysregulation. The patient's EEG data is compared to that of age- and sex-matched "neurotypical" controls (individuals with no symptoms or history of head trauma). Areas of the brain that are dysregulated show up clearly on "brain-maps" and the degree of statistical deviation from normal can be determined both for the surface of the brain and deeper into core brain structures. Localization of these dysregulated areas is correlated with patient symptoms that are well-established in the research literature by virtue of classical neurological/behavioral studies, functional Magnetic Resonance Imaging (fMRI), Diffusion Tensor Imaging (DTI) and Single Photon Emission Computed Tomography (SPECT-scan) results.

Figure 1 shows the standard electrode placements for the brain mapping procedures discussed in this paper.

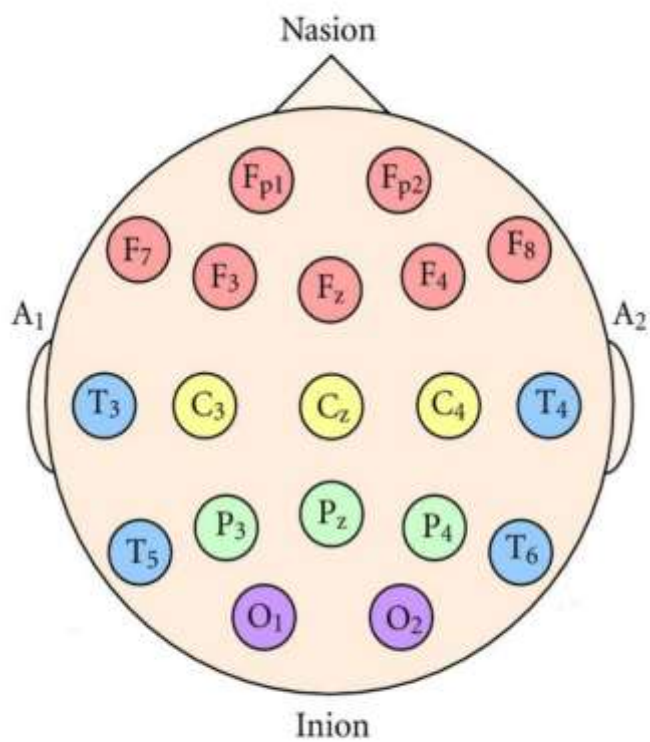



**Figure 1 - The 10/20 International System of Electrode Placement, showing the positions of 21 electrodes (19 on the head and two on the ear lobes) used to record a standard electroencephalogram or EEG. Note that this is a birds-eye view of the top of the head with the nose at the top of the diagram and the ears on either side.**

# Patient History

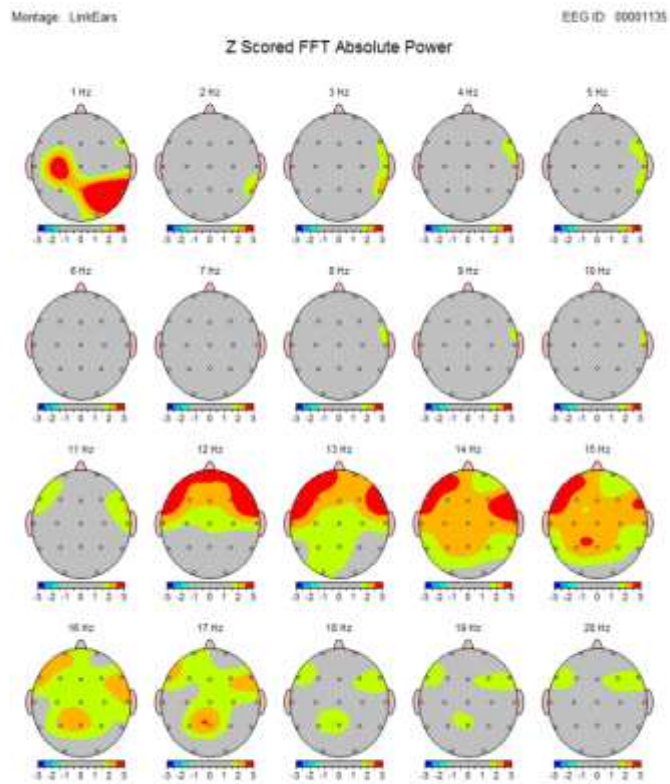
**My middle-aged female patient** was accosted by an unknown, younger man in broad daylight on a crowded street. She was struck in the face across the bridge of the nose with a closed fist. She did not lose consciousness. She was taken to the ER and released after an MRI showed no evidence of concussion. The following morning at about 4 am she had two grand mal seizures within a 30-min period of time.

The patient's post-assault symptoms were complicated by a whiplash injury due to the force of the blow to the forehead. She experienced pain and tension in the back of her neck for over a week. In addition she experienced difficulty sleeping, headaches, "brain fog" (cognitive confusion), inability to focus attention, "difficulty finding words," short-term memory loss, emotional lability, fatigue and dizziness. She reported "difficulty navigating" when she was being driven out of town by a family member 7 days later. These are classical post-concussive symptoms.

Prior to the assault, the patient had held the same job for many years as a high level manager in a government position. After the assault, she took an extended medical leave over a two-month period of time. During the period of medical leave, the symptoms slowly abated.

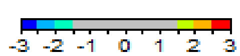
# Detailed Analysis of Electro-Imaging Results

**Figure 2- Electro-Image brain maps derived from surface EEG recordings 4-days post-assault, showing evidence of frontal mTBI in the 12-16 Hz frequency range and in the right temporal-occipital region at 1 Hz.**




The brain maps in Figure 2 show diagrams of 1 to 20 Hz (cycles/sec) brain frequencies in 1-hz bins. Each head-map is a birds-eye view of the top of the head, with the nose at the top of each diagram and the two ears pictured on the sides. The grey dots in each map are the 19 locations from which EEG data were recorded, referenced to linked-ears (electrically silent). The colored areas show the amount of power (similar to amplitude) in each frequency band as it varies from normal. Grey areas are not significantly different from normal.

## Z-Score Legend




The legends at the bottom of each brain map show the number of standard deviations (sd or z-scores) that each colored area varies from normal. Light Green signifies +1.5-2.0 sd higher power than normal, orange is +2.0-2.5 sd and red is +2.5-3.0 sd greater power than normal. Any variation that is +2 sd greater than normal is considered a statistically significant result (i.e. orange and red areas on the legend).

Note that this patient shows high amplitude activity that is +2 sd to +3 sd greater than normal in the 12-16 Hz range in the frontal lobes, the area of the brain that is responsible for executive functions, such as planning, judgment, sequencing, logical thinking, task orientation, focus, attention and emotional regulation. Normally, these areas of the brain would function well at 16-25 Hz, so the "slower" frequency activity would most likely hamper the executive functions of the brain. The frequency of brain activity that is +2.0-3.0 sd higher power than normal in the patient's brain maps indicate that this individual will have executive function deficits. Indeed, the patient complained of cognitive impairment ("brain fog"), short-term memory loss, problems with planning and organization, inability to focus attention, difficulty tracking a sequencing task, emotional lability, and fatigue.

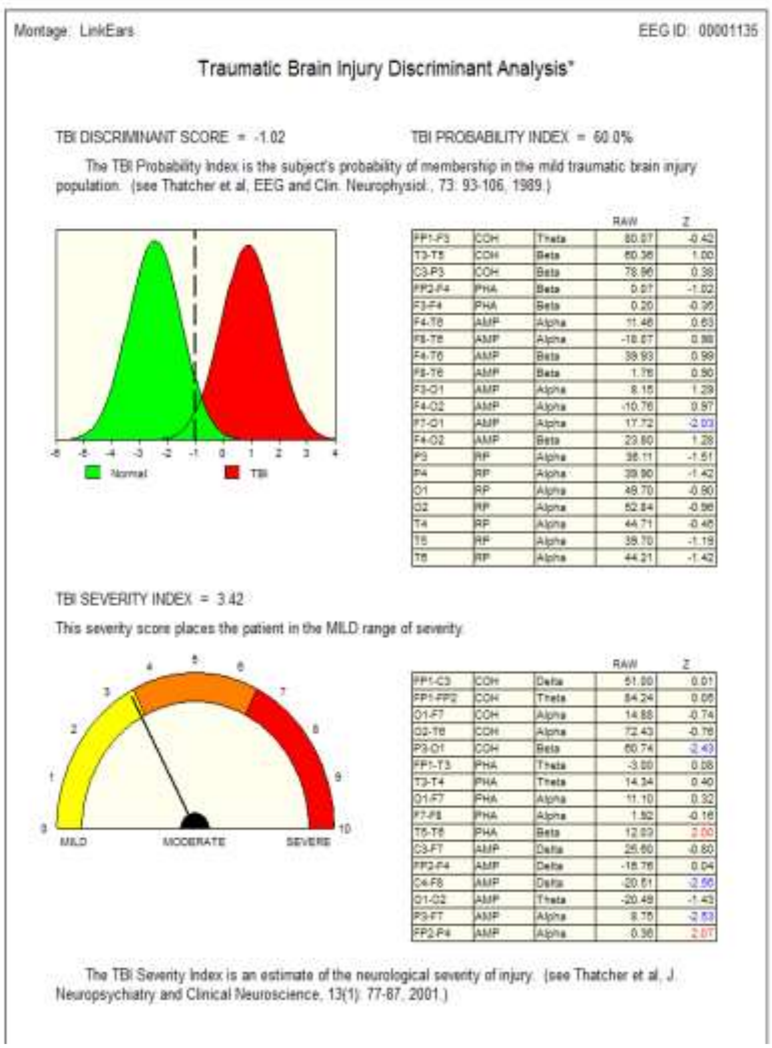
Also note the high amplitude activity in the 1 Hz bin in the lower right temporal and occipital region. The presence of high amplitude activity in this frequency range is more typical of a recent concussion. This may constitute a "contrecoup" impact, in which the brain contacts the inside of the skull opposite to the region that was struck, and the force of the blow causes the brain on the opposite side of the impact to be compromised. The patient reported a whiplash injury which supports the possibility of a contrecoup impact.

# Determining the Most Likely Symptoms Associated with Brain Injury

**There are a number of Electro-Imaging** analyses that can be done to substantiate suspected injury to the brain and corroborate patient symptoms. A few of these analyses are described in this section.

**1) TBI Index** - For example, Figure 3 shows the Traumatic Brain Injury or TBI Index for the patient described above. Note that the dysregulation in her brain places this client in the population of those with mild TBI with a 60% probability. The severity rating estimates that her brain injury is in the "mild severity of injury" category, but just short of moderate severity.

**Figure 3 - Traumatic Brain Injury Index (from NeuroGuide™ software)**



**2) Symptom Checklists** - Actual descriptions of symptoms that accompany brain trauma can be better clarified using the LPR Basic software created by Phil Jones, PhD (www.nftools.org). LPR helps consolidate and simplify the information generated by the NeuroGuide™ application. It places, in order of significance, the most likely set of functional deficits that are associated with statistically significant findings in the EEG analysis. The most likely symptoms get the most number of "hits" (see table below).

**Figure 4 - LPR Basic™ Symptom Checklist (SCL)Matching Results**

| Hits | Percent | SCL Match Description | Hits | Percent | Networks Match Description |
|---|---|---|---|---|---|
| 5 | 50.00 | Dyscalcula - Problems Calculating | 6 | 30.00 | Executive Function |
| 5 | 35.71 | Amnestic Disorder Anterotrograde | 6 | 25.00 | Isocortex Hippocampocentric |
| 5 | 50.00 | Aphasia Posterior Transcortical Sensory | 5 | 35.71 | Attention - Dorsal |
| 5 | 62.50 | Aphasia Posterior Word Deafness | 5 | 22.73 | Default Mode |
| 5 | 41.67 | Loss of Visual Imagery Space | 5 | 35.71 | DTI - Local Parietal |
| 4 | 25.00 | Slow Reader | 5 | 25.00 | Isocortex Olfactocentric |
| 4 | 66.67 | Agnosia Social Emotional | 4 | 28.57 | Attention - Ventral |
| 4 | 80.00 | Apraxia Visual Topographic | 4 | 25.00 | Attention - Emotional |
| 4 | 100.00 | Attentional Disturbances Balints Syndrome | 4 | 21.05 | Hagmann Module 4 (Auditory Language Mem... |
| 4 | 100.00 | Attentional Disturbances Neglect | 3 | 21.43 | Anxiety |
| 3 | 60.00 | Anosognosia - Denial of a Problem | 3 | 15.00 | DTI - Frontal Occipital |
| 3 | 60.00 | Insensitive to Others Emotional Expressions | 3 | 12.50 | DTI - Frontal Parietal |
| 3 | 25.00 | Insensitive to Others Feelings | 3 | 37.50 | DTI - Local Occipital |
| 3 | 30.00 | Symptoms of Fibromyalgia | 3 | 21.43 | DTI - Local Temporal |
| 3 | 37.50 | Agnosia Auditory Space | 2 | 10.00 | Working Memory |
| 3 | 75.00 | Agnosia Visual Topographic | 2 | 7.14 | DTI - Frontal Temporal |
| 3 | 60.00 | Agnosia Visual Acronomatopsia | 2 | 33.33 | Hagmann Module 1 (Vision) |
| 3 | 75.00 | Apraxia Motor Constructional | 2 | 12.50 | Mesulam - Executive Function |
| 3 | 75.00 | Apraxia Motor Dressing | 2 | 40.00 | Mesulam - Spatial Attention |
| 3 | 75.00 | Disturbances Visual-Spatial Disorientation | 2 | 25.00 | ICN 7 (Middle Frontal Gyri Prefrontal & Pari... |
| 3 | 50.00 | Disturbances Visual-Spatial Topographic A... | 2 | 50.00 | ICN 9 (Superior & Posterior Parietal Lobule) |
| 3 | 30.00 | Loss of Visual Imagery Objects | 2 | 50.00 | ICN 10 (Middle and Inferior temporal Gyri) |
| 2 | 11.11 | Attention Deficits - Easily Distractible | 2 | 33.33 | ICN 1112 (Lateral nad Medial Posterior Occ... |

Note in the "Networks Match Description" in Fig 4, the top 3 symptoms that are associated with the patient's mTBI involve executive function, memory problems, and attention, all of which match the patient's description of her post-assault cognitive state. In addition, the "SCL Match Description" category on the left shows "dyscalcula" or problems calculating numbers (which cannot be corroborated as the patient did not attempt mathematical calculations in the post-assault period). Amnestic (memory) disorder, typical of post-concussive state, was also confirmed by patient reports .

**More on Symptom Checklists** : The Symptom checklists that accompany the NeuroGuide software analysis of the brain are derived from the following areas of clinical research:

1) Common symptoms and complaints from individuals with brain trauma, emotional/psychological problems;
2) The Intrinsic Connectivity Network (ICN) symptoms;
3) Conventional Neural Network symptoms (e.g. attention, salience, pain, executive function, Diffusion Tensor Imaging, Hagmann Modules, Mesulam networks);
4) Neuropsychological Symptoms;
5) DoD/VA (Department of Defense, VA Hospital) TBI symptoms;
6) NeuroLink symptoms and complaints

For example, the list of common symptoms and complaints which can be corroborated by medical doctor, psychologist or neurologist exams, includes the following:

- Anosognosia - Denial of a Problem
- Anxiety
- Attention Deficits - Easily Distractible
- Auditory Sequencing Problems
- Balance Problems
- Blurred Vision
- Chronic Pain
- Compulsive Behaviors and/or Thoughts
- Concentration Problems
- Decreased Tactile or Skin Sensitivity
- Delusional
- Depression (Sad & Blue)
- Difficulty Comprehending Social Cues
- Dyscalcula - Problems Calculating
- Dyslexia - Letter Reversal
- Executive Function Problems
- Face Recognition Problems
- Failure to Initiate Actions
- Hyperactive and/or Agitation
- Impulsive Behaviors
- Insensitive to Others Emotional Expressions
- Insensitive to Other's Feelings
- Low Motivation
- Low Threshold for Anger & Loss of Control
- Migraine Headaches
- Mood Swings
- Multi-Tasking Problems
- Obsessive Thoughts about Self
- Obsessive Thoughts and/or Hyper Focused
- Oppositional Defiant Conduct
- Orientation in Space Problems
- Perception of Letters Problems
- Poor Judgment
- Poor Skilled Motor Movements
- Poor Social Skills

- Receptive Language Problems
- Recognizing Objects by Touch Problems
- Self-Esteem Problems
- Sequential Planning Problems
- Short-Term Memory Problems
- Slow Reader
- Slowness of Thought - Easily Confused
- Spatial Perception Problems
- Speech Articulation Problems
- Symptoms of Fibromyalgia
- Word Finding Problems

The list of Neuropsychological Symptoms, which can be correlated with and verified by Neuropsychological testing include:

- Agnosia of Action Apperceptive
- Agnosia of Action Associative
- Agnosia Auditory Apperceptive
- Agnosia Auditory Associative
- Agnosia Auditory Space
- Agnosia Prosopagnosia (Face)
- Agnosia Social Emotional
- Agnosia Social of Action - Theory of Mind
- Agnosia Somatosensory Autotopagnosia
- Agnosia Somatosensory Finger
- Agnosia Somatosensory Anasognosia of Aphasia
- Agnosia Somatosensory Pain
- Agnosia Somatosensory Blindness
- Agnosia Somatosensory Left Hemiplegia
- Agnosia Somatosensory Right Hemiplegia
- Agnosia Somatosensory Mental Illness
- Agnosia Tactile Apperceptive
- Agnosia Tactile Associative
- Agnosia Visual Topographic
- Agnosia Visual Acronomatopsia
- Agnosia Visual Anomia Color
- Amnestic Disorder Anterotrograde
- Amnestic Disorder Working Memory
- Amnestic Disorder Transient Global amnesia (TGA)
- Amnestic Disorder Reduplicative Paramnesia
- Aphasia Anterior Broca's
- Aphasia Anterior Transcortical Motor
- Aphasia Anterior Articulation
- Aphasia Posterior Wernicke's 11
- Aphasia Posterior Transcortical Sensory
- Aphasia Posterior Conduction
- Aphasia Posterior Word Deafness
- Apraxia Motor Constructional
- Apraxia Motor Dressing
- Apraxia Motor Gate, Trunk
- Apraxia Motor Ideational

- Apraxia Motor Ideomotor
- Apraxia Motor Limbkinetic
- Apraxia Motor Oral
- Apraxia Social Disorganization of social actions
- Apraxia Visual Topographic
- Aspontaneity Abulia and/or Apathy
- Aspontaneity Akinetic Mutism
- Aspontaneity Catonia
- Attentional Disturbances Balint's Syndrome
- Attentional Disturbances Neglect
- Attentional Disturbances Excessive Shifting of Attention
- Delusions Capgras Syndrome
- Delusions Grandiose
- Delusions Guilt
- Delusions Persecutory
- Disturbances of Self-Image Depersonalization
- Disturbances of Self-Image Derealization & Self Awareness
- Disturbances Visual-Spatial Disorientation
- Disturbances Visual-Spatial Topograhpic Agnosia
- Disturbances Visual-Spatial Topograhpic Apraxia
- Hallucinations Auditory Elementary
- Hallucinations Auditory Complex
- Hallucinations Visual Elementary
- Hallucinations Visual Complex
- Mood Disturbances Aggression, Rage
- Mood Disturbances Mania
- Mood Disturbances Panic
- Mood Disturbances Obsessive Compulsive
- Mood Disturbances Secondary Depression
- Loss of Visual Imagery Objects
- Loss of Visual Imagery Space

**3) Connectivity Analysis** - Injury to the brain tends to interrupt the natural rhythms and coordination of brain functions. Network communications between different brain areas can become inefficient and compromised. The NeuroGuide™ software allows us to interpret these breeches in communication network status as a result of brain injury. For this discussion we will explore the use of the Coherence measure only.

**Figure 5 - Coherence Analysis is a measure of network communication efficiency in the brain. The dark red and blue lines show activity that is statistically different from normal for the patient presented. The data is from 4 days post-assault analysis.**

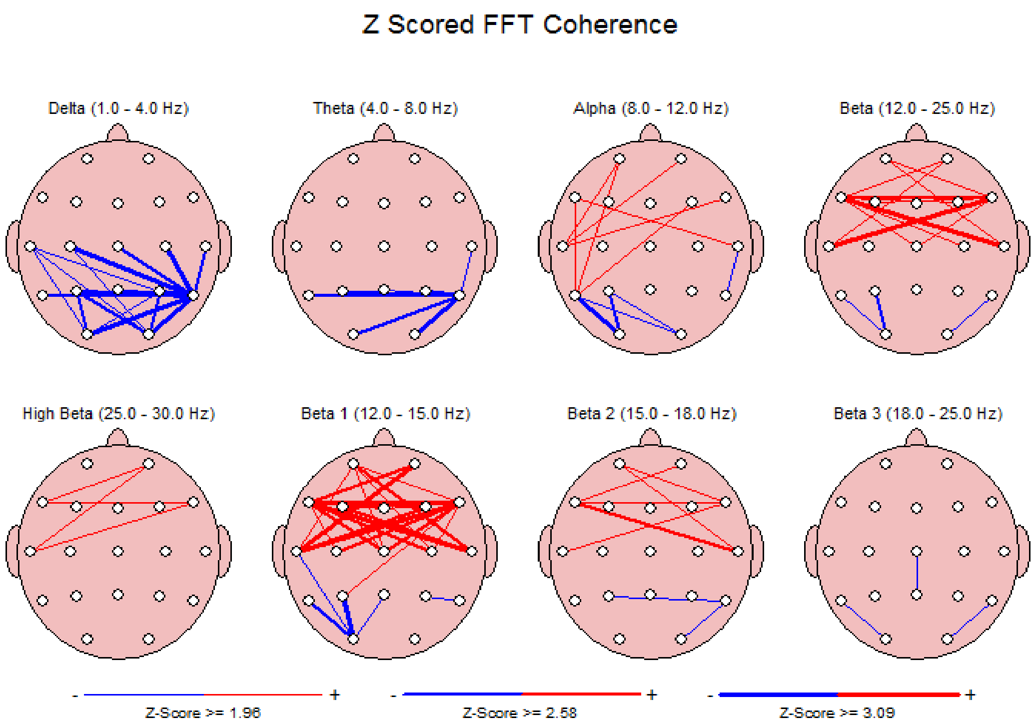


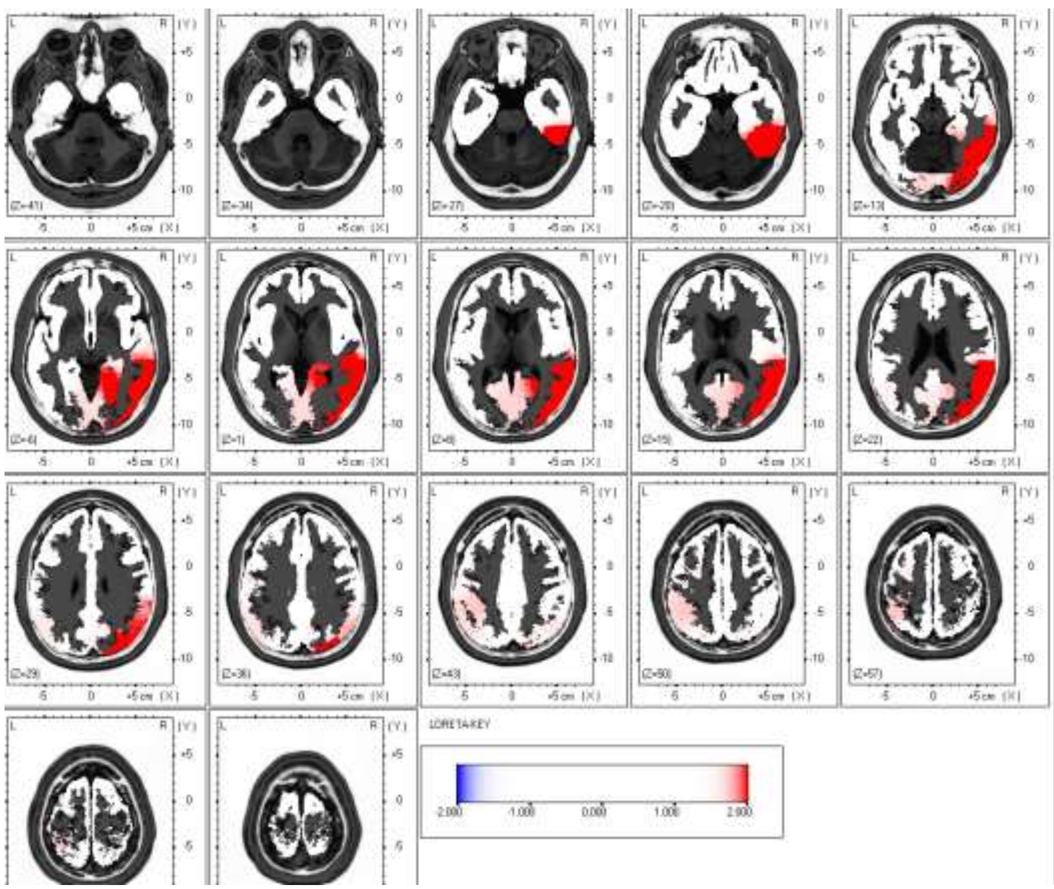

Fig 5 is a topographic representation of Coherence, or the ability of the brain to do "functional differentiation." Each hub, represented y the 19 dots on the brain maps, processes information of various types and sends that information to other brain areas for further integration and coordination. For example, under normal circumstances, the frontal lobes coordinate executive decision making, judgment, sequencing, planning etc, and send that information to other brain areas that may result in a verbal response, or recalling a memory, or a perceptual impression, or a highly integrated motor function. When executive function is compromised as a result of frontal lobe injury, the ability of the brain to coordinate its tasks becomes inefficient and these functions become impaired.

Note the areas of high coherence (dark red lines) in the Beta (12-25 Hz) and the Beta1 (12-15 Hz) in Fig 5. These results suggest that the normal executive functions of the frontal lobes are "over-connected" or "stuck" and cannot perform normal functional differentiation between the involved hubs, as well as with the rest of the brain. Remember that the functional brain injury for our patient affected these same frequency bands precisely in this frontal region of the brain (recall Fig 1). Also note the presence of very low coherence (dark blue lines) in the occipital, parietal and right temporal areas in the Delta (1-3 hz) and Theta (4-8 Hz) frequency ranges. Low coherence suggests that the regions involved are "offline" or not communicating at all with other brain regions. The low coherence is possibly associated with the contrecoup injury that we saw in the first head-maps (Fig 1) in the right occipital and temporal regions.

The conclusion of the Coherence analysis for our patient is that her normal ability to do high functioning, executive decision making in her daily managerial job, and in her life in general, had become compromised as a result of the assault.

**4. LORETA (LOw Resolution Electromagnetic Tomography)** - LORETA analysis expands the power of Electro-Imaging from a consideration of cortical activity at the surface of the brain to localization of functional deficits deep in the core of the brain. The scans from LORETA analysis are derived from the same EEG recordings that produced the previous head-maps. *LORETA maps look very similar to MRI data, but instead of describing anatomical abnormalities in the brain, they point to localization of functional deficits that can be identified symptomatically as well as statistically compared to normal brain activity*. In Fig 6 below, we see a LORETA scan from the same patient, 4-days post-assault. This LORETA scan is at 2 Hz (a frequency implicated in the right temporal-occipital region where the contra-coup occurred). Each consecutive Electro-Image is a depiction of a slice of the brain from the base of the brain to the top of the head. The red areas show +2sd greater activity in the right temporal-occipital area.

**Figure 6 - LORETA Electro-Imaging analysis at 2 Hz, 4 days post-assault.**



# Follow-up Electro-Imaging Analysis

**It is interesting to see** how the brain can heal itself and regulate back to normal functioning following a mild TBI. The next two figures show head-maps at 2.5 weeks post-assault and then 2 months post-assault. Compare these with Fig 1, which showed the functional deficits 4 days post-assault. The patient did not undergo any treatment for the brain dysregulation at any time within the 2 month period following the assault.

**Figure 7 - Electro-Image brain maps 2.5 weeks post assault**

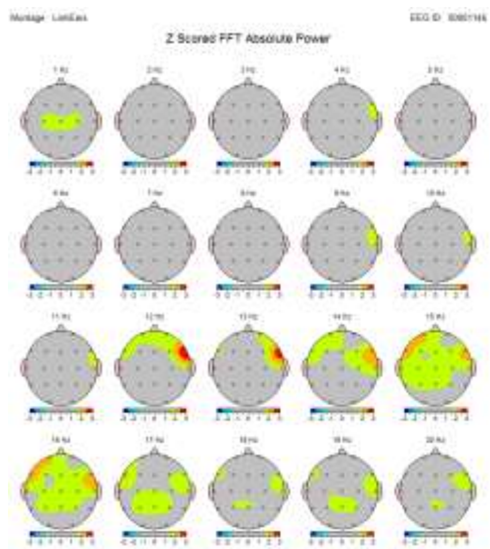
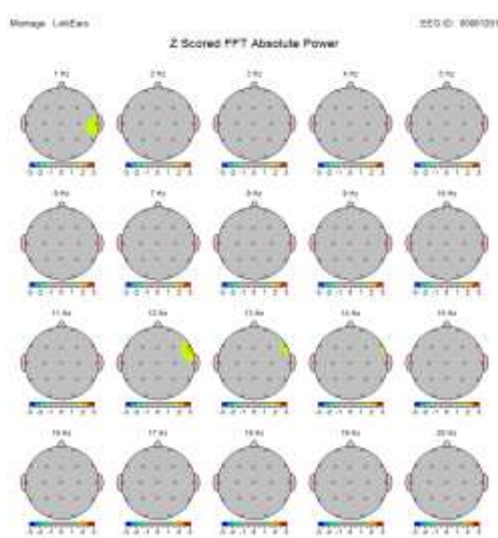



**Figure 8 - Electro-Image brain maps 2 months post-assault**



Notice how the brain has healed itself within a 2 month period of time. Further evidence of self-healing appears below in Figs 9 and 10. Compare each to the comparable 4-days post-assault data.

**Figure 9 - Coherence Analysis 2 months post-assault**

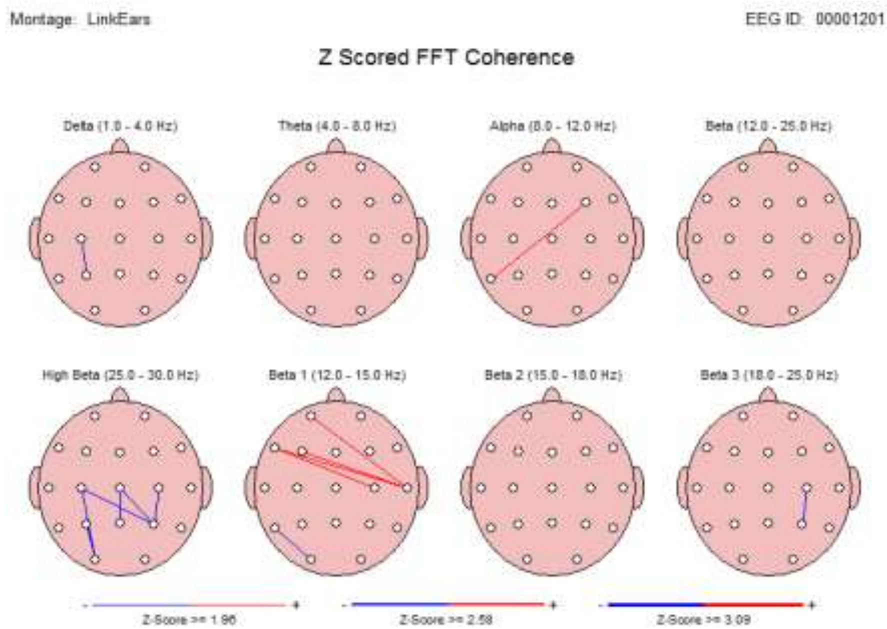
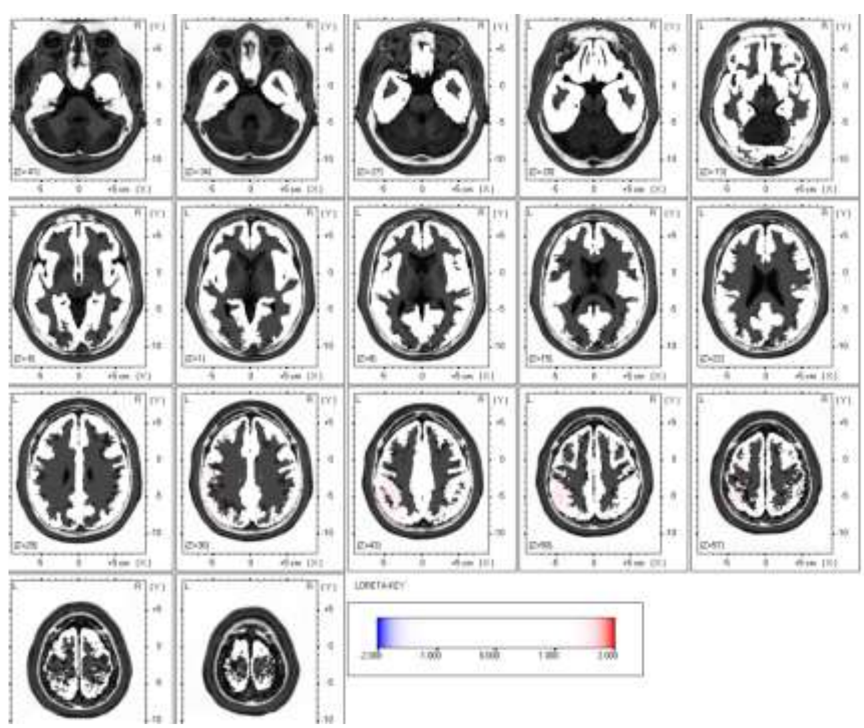



**Figure 10 - LORETA Electro-Imaging analysis at 2 Hz, 2 months post-assault.**



# Post-Script

**The purpose** of this presentation was to educate and inform about the value of Electro-Imaging in determining the functional deficits in cognitive and behavioral systems. The applications of Electro-Imaging vary from research and clinical diagnosis to substantiation of symptoms and functional deficits associated with brain injury in legal and workers compensation cases. The Electro-Imaging results may be corroborated with findings from neurological exams, neuropsychological testing and primary care doctors assessments of disability.

Although the presented case was not typical of serious brain trauma that would result in disability for a long period of time, it is a clear, uncomplicated, and useful case to elucidate the power and value of Electro-Imaging in assessing functional deficits in the brain that may substantiate patient's reports of symptoms.

The case study that was examined demonstrated the failure of an MRI in an emergency room setting to show any evidence of a concussion, and yet, clearly, the patient rapidly developed typical concussion symptoms that were corroborated by the Electro-Imaging Analysis. One of the powerful aspects of Electro-Imaging is its ability to clearly define functional deficits that other, more sophisticated and expensive medical technologies, cannot identify. The patient's symptoms subsided over time, which also correlated with the follow-up Electro-Imaging analysis, demonstrating a return to normality within 2 months post-assault.

For further information regarding the literature that is the foundation of these techniques and applications, please see the International Society for Neurofeedback & Research (ISNR.org), EEGInfo.com, and Robert Thatcher's NeuroGuide software website (appliedneuroscience.com).

In particular, please see Robert Thatcher's paper entitled "***After 25 Years the NeuroGuide Normative Databases are Accepted Science***" by going to appliedneuroscience.com and downloading article number 58. The entire basis for validity of the Electro-Imaging technique as used by Robert Thatcher in the NeuroGuide application is that patient's data may be reliably compared to normative data.