

# **Z Tunes Documentation:**

## **Instantaneous Z Score Neurofeedback - 1 to 19 Channel of Surface EEG**

The majority of cortical pyramidal neurons are frequency “tuned” and behave like band-pass filters and discharge action potentials in specific phases of the back ground EEG waves. Examination of the frequency tuning characteristics of pyramidal neurons shows that they are approximately Gaussian shaped. The Neuroguide normative data values are also approximately Gaussian shaped and represent the summation of a large number of Gaussian “tuned” resonant oscillators or cortical pyramidal neurons and their associated synaptic and intrinsic inputs. Therefore, Z score biofeedback is a type of “tuning” whereby the EEG is reinforced to approximate  $Z = 0$  or the center of the various frequencies bands and scalp locations and in this way represents “Z Tuning”. We refer to the real-time Z score biofeedback as “Z Tunes” to provide a more intuitive understanding of the neurophysiological processes that underly this form of biofeedback.

Nineteen scalp electrodes distributed according to the 10/20 system measures the scalp electrical field generated by cortical pyramidal neurons rhythmically modulated by thalamo-cortical, cortico-thalamic and cortico-cortical connections. Therefore, the design of the Neuroguide Neurofeedback module (NF1) is to compute Z scores of the EEG 10/20 electrical field of 19 channels referenced to linked ears (mathematically linked and/or physically linked). In this way autospectral and cross-spectral measures such as absolute power, phase shift duration, phase lock duration, coherence, phase differences and amplitude asymmetry. In addition, with 19 channels there are approximately 8,000 EEG measures that can be computed. In order to reduce the number of variables to a logical and practical first "guess" of the most optimal variables Neuroguide uses a Hypothesis-Test process. The process is based on the goal to facilitate the user's ability to link symptoms and complaints to "Hubs" or "Functional Modules" by use of a symptom check list and QEEG Z scores. The symptom check list is used to create "hypotheses" as to the most likely scalp locations related to functional systems in the brain based on modern neuropsychological, neurological, electrophysiological and functional imaging neuroscience. The hypotheses are then tested by running a quantitative EEG analysis to match and mismatch the hypothesized scalp locations to the "observed" locations of deviant Z scores. Scalp locations of deviant EEG Z scores are divided into two categories: 1- Match to Symptom Locations and, 2- Mismatch to Symptom Locations. The match to symptom locations are considered to represent the "weak" systems related to the symptoms and complaints while the mismatch locations are considered to represent "compensatory" systems as part of the homeostatic balance of dynamically linked "Hubs" and "Functional Modules". Based on this logic a drastically reduced number of EEG variables (e.g., 20) are automatically selected as a Neurofeedback Protocol out of a universe of approximately 8,000 measures.

There are six steps that must be followed to use the symptom check list and

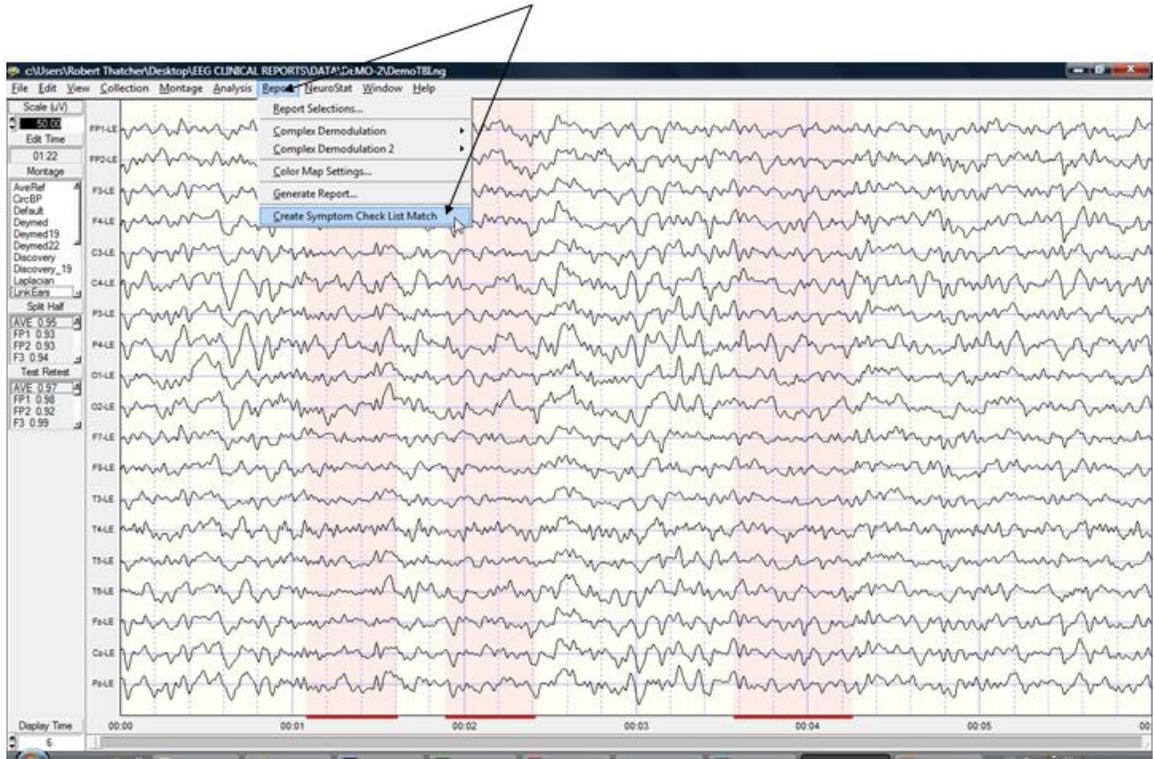
automatic Z score protocol generator:

- 1- Import an edited \*.ng EEG file by clicking File > Open
- 2- Click Report > Symptom Check List Match
- 3- Click Collection > Setup & Monitor > OK
- 4- Click Collection > Neurofeedback > Surface EEG
- 5- Click Symptom Check List in the Surface EEG Control Panel
- 6- Select the Symptom(s) that best represent the patient's symptoms and assign a severity from 1 to 10 for each symptom, then click OK.

There are three 10/20 scalp displays with the one labelled "Hypotheses" created by the Symptom Check List. The size of the green circle expands as a function of a relative severity index (average of the sum of channels x severity score and then scaled to the largest value). The top right 10/20 scalp display shows the symptom check list match to QEEG Z scores from steps 1 and 2 above. The size of the green circles is scaled according to the largest average Z score for a given scalp location and is considered as an estimate of the "weak" functional systems. The lower right 10/20 scalp display shows the mismatches and is considered an estimate of the "Compensatory" systems. The absolute Z score control can be varied from 0 to 10 standard deviations. As Z scores increase then the number of matches in the top right head display is reduced and vice versa. Default is  $Z = |Z|$  (absolute Z).

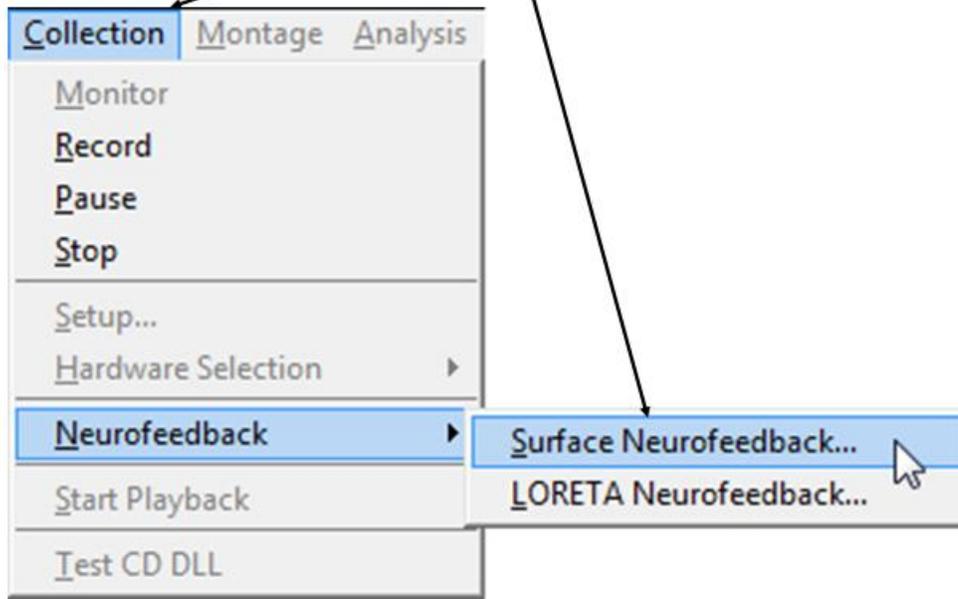
First Import the Patient's Edited EEG samples and click Report > Create Symptom Check List Match to generate temporary Z score files to be used in the Hypothesis testing and construction of a Neurofeedback Protocol

**To activate the Symptom Check List in the Neurofeedback Module, Import the Patient's edited EEG data, then Click Report > Create Symptom Check List Match**



Then Select the Acquisition Hardware and Setup and Monitor the Hardware in Preparation for Neurofeedback. Click OK in the setup and monitor screen to begin EEG collection. Then Click Collection > Neurofeedback > Surface Neurofeedback

**To activate 19 Channel Neurofeedback, first setup the Hardware and Setup & Monitor. Then Click Collection > Surface Neurofeedback**



19 channel Z score Neurofeedback includes Power, Power Ratios, Coherence, Phase and Amplitude Asymmetry as Well as Linked Ears, Average Reference and Laplacian Montages. Two different frequencies can be activated and 1 to 19 channels can be selected. The Z threshold determines Z scores that will be reinforced if they are equal to or less than the threshold value. The strategy is to reinforce Z scores that move the EEG toward  $Z = 0$ . For example, if a client has elevated Theta and reduced Beta then the goal is to suppress Theta (4 - 7 Hz) and simultaneously reinforce Beta (13-25 Hz). To achieve this goal select the two frequency bands (Theta & Beta) and set the Z score threshold at a value that is easy at first, e.g.,  $Z = 2.0$ . Set Percent Reward = 50% and the event integration interval = 250 msec and monitor how the client achieves a continually larger number of Green circles on the head display. The appearance of Green circles in the head display or the bell or chime means that the threshold of  $Z < 2.0$  was reached in 50% of the events that occurred in a 250 msec. interval. As the client becomes more skilled at achieving the threshold, then lower the Z score threshold to 1.5 standard deviations and again monitor the client's progress. The goal is to shape the client by making the initial feedback easy and then as the client learns to control his/her EEG then make the criteria more difficult to slowly shape the client toward a  $Z = 0$ . This procedure will simultaneously lower Theta and reinforce Beta as the EEG moves toward  $Z = 0$ .

Control of the difficulty of the threshold is by: 1- Lengthening the event interval,

2- and/or Lowering the Z score threshold, and/or 3- raising the Percent Correct.  
 To make neurofeedback easier, then shorten the event interval and/or raise the Z score threshold and/or lower the Percent Correct.

## Z Score Neurofeedback Panel

Select Frequency Bands & 1 to 19 Channels & Combinations of Channels for Cross-Spectra

The screenshot shows the 'Surface Neurofeedback Selections' window with the following sections and annotations:

- Metric:** Radio buttons for Absolute Power (selected), Relative Power, Power Ratio, Amplitude Asymmetry, Coherence, and Absolute Phase. Annotation: **Select Power or Coherence, Phase Amp. Asym**
- Montage Reference:** Radio buttons for Linked Ears (selected), Average Reference, and Laplacian. Annotation: **Select Montage Laplacian, Ave. Ref & Linked Ears**
- Frequency Band:** Radio buttons for Delta (selected), Theta, Alpha, Beta, High Beta, Alpha 1, Alpha 2, Beta 1, Beta 2, Beta 3, D/T, D/A, D/B, D/HB, T/A, T/B, T/HB, A/B, A/HB, and B/HB. Annotation: **Select Frequency Bands & 1 to 19 Channels & Combinations of Channels for Cross-Spectra**
- Auto Spectral Channels:** A list of channels from FP1 to Pz. Annotation: **Select Frequency Bands & 1 to 19 Channels & Combinations of Channels for Cross-Spectra**
- Cross Spectral Combinations:** A list of channel combinations from FP1 to Pz. Annotation: **Select Frequency Bands & 1 to 19 Channels & Combinations of Channels for Cross-Spectra**
- Upper Z:** A slider set to 2.00. Annotation: **Z Score Threshold Reward if Less Than Or greater than**
- Lower Z:** A slider set to -2.00. Annotation: **Z Score Threshold Reward if Less Than Or greater than**
- Metrics Selected:** A field showing '0'. Annotation: **Z Score Threshold Reward if Less Than Or greater than**
- Window:** A field showing '0.25 sec'. Annotation: **Event Integration Interval (Variability)**
- Display:** A dropdown menu showing '10/20 Head'. Annotation: **Sound on/off & Visual Displays & DVD/Flash**
- Sound:** A dropdown menu showing 'Off'. Annotation: **Sound on/off & Visual Displays & DVD/Flash**
- Buttons:** Symptom Check List, Save, Load, OK, and Cancel. Annotations: **Symptom Check List**, **Save, Load & Cancel**

The event integration interval is a time window that varies from 250 msec to 1 sec. In order to receive reinforcement then 100% of the time events within a window must reach the Z score criteria. By lengthening the window time then one will simultaneously reinforce reduced variability. Thus, the time window provides a variability feedback method. Click sound on for the eyes closed condition and/or use both visual and auditory feedback with eyes open.

Once one has selected the channels, frequencies, EEG features and montage then click OK to activate the 10/20 Reward display. If dual monitors are used then enable the monitor in the control panel > Display Settings and depress the left mouse button over the 10/20 reward display and move it to the 2nd monitor. If criteria is met for all time points in a window (e.g.,  $Z < 2.0$ ) then a reward is the color green in the 10/20 locations selected in the Z score neurofeedback panel. The goal is to make the 10/20 head display show green as often as possible. Start with an easy reward criteria, e.g.,  $Z < 2.0$  and then adjust the reward criteria to lower Z values (e.g.,  $Z < 1.0$ ) in order to shape the client/patient EEG features toward  $Z = 0$ .

## **Symptom Check List Hypotheses and QEEG Z Score Tests**

Identify the symptom(s) exhibited by the patient/client and double click the severity score to activate the symptom. Enter a severity score from 1 to 10. This will create red circle on the 10/20 scalp display and the size of the circle increases as a function of the severity value. As more symptoms are selected then Neuroguide automatically weights the symptom locations and scales the size of the green circles to represent "hypotheses" of "weak systems" or "loss of function" systems (Luria, 1973).

The top right 10/20 scalp display will change depending on the symptom check list and the match of the QEEG Z scores to the hypothesized locations. The location of green circles in the "Match" 10/20 display represents a match between hypothesized scalp locations and observed QEEG Z Scores. The radius of a green circle is produced by scaling with respect to the maximum average Z score greater than the threshold for a given scalp location. The larger the average Z score then the larger the radius of the circle. After the user finds an optimal link to hypothesized locations, then click OK to automatically generate a Neurofeedback Protocol. The automatic protocol is produced by the cross-product of the symptom severity and the average Z score in a given location or  $(\sum S \times Z)/N$  where S = sum of the severity index from the symptom check list for that location and Z = average Z scores in that location where the absolute Z or  $|Z|$  is greater than the threshold as determined by the user (Default is  $|Z| = 2$ ). The user can veto or modify the automatically produced protocol by clicking metrics, frequencies, auto-spectrum and cross-spectrum selections in the Surface EEG panel.

**Double click the Severity of a Symptom and Grade Severity 1 to 10.**

**Set the Z score threshold from the QEEG Analyses**

**Match to Symptoms & QEEG Z Scores**

Symptom Check List

Symptom / Complaint	Severity
Problems with Perception of Letters	0
Slow Reader	0
Dyslexia - Letter Reversal	0
Problems with Spatial Perception	0
Orientation in Space Problems	0
Receptive Language Problems	0
Insensitive to Others Emotional Expressions	0
Blurred Vision	0
Obsessive Thoughts about Self	0
Migrane Headaches	0
Symptoms of Fibromyalgia	0
Auditory Sequencing Problems	0
Short-Term Memory Problems	0
Face Recognition Problems	0

Z Score: 2.00

Hypothesis

Match

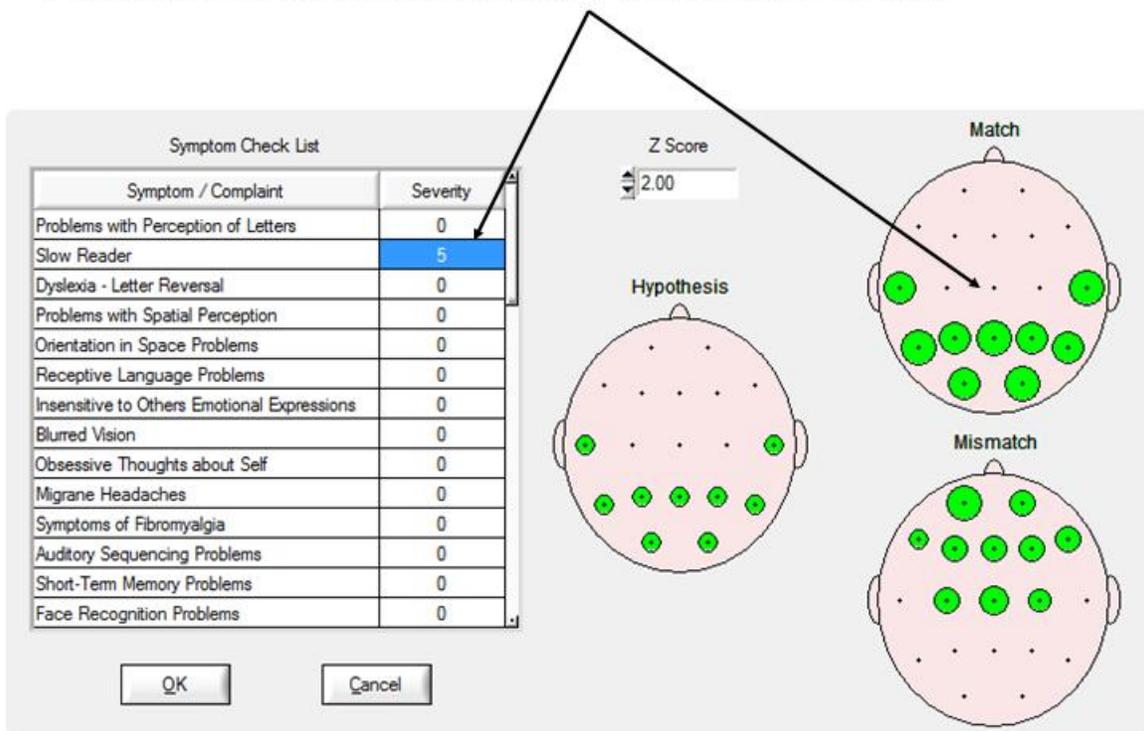
Mismatch

OK Cancel

**Symptom Check List Hypotheses**

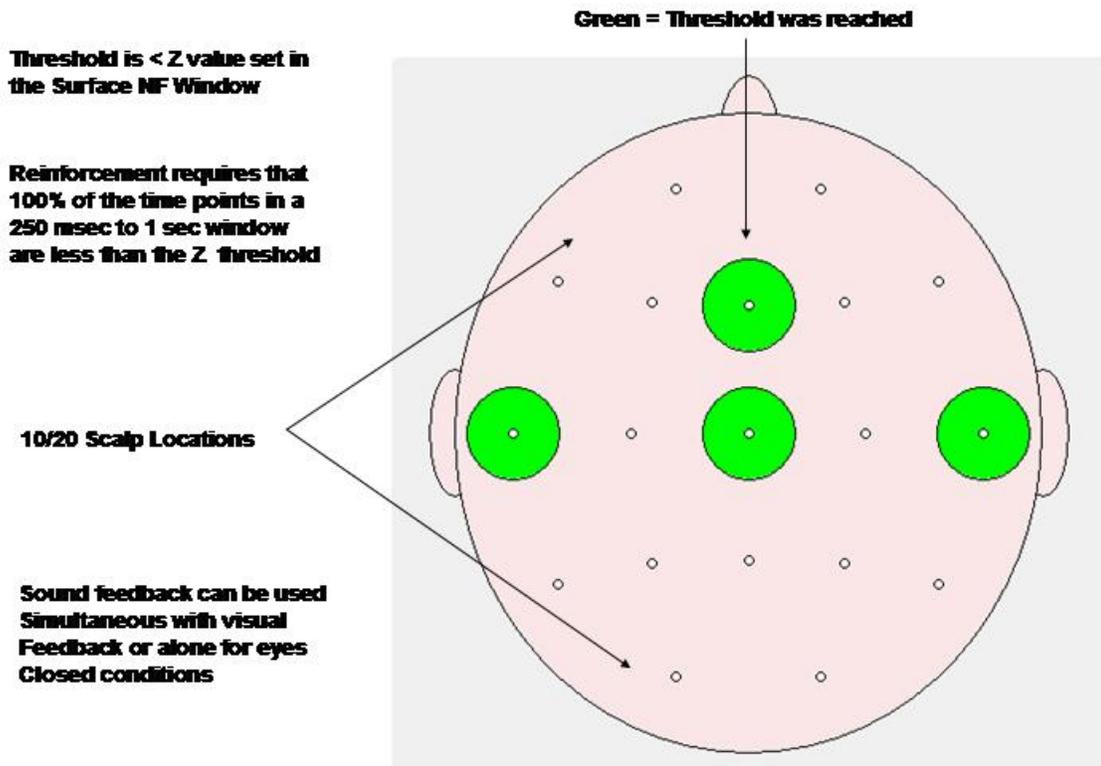
**Mismatch of Symptoms & QEEG Z Scores**

**Example of a Slow Reader Symptom Check List Hypotheses and the Test Of the Hypothesis using QEEG Z Scores. Note how the mismatch items Move to the match 10/20 head display as Symptoms are matched**



Click OK in the Symptom Check List Panel to Return to the Surface Neurofeedback Panel and View the Automatic Selections based on the Symptom Check List as Hypotheses and QEEG Z Scores as Tests of the Hypotheses. Click OK if satisfied or modify by selecting or deselecting variables or click Clear to start over. Then click OK in the surface EEG Neurofeedback panel to activate the Neurofeedback reinforcement display

## Neurofeedback Reinforcement Window – Can Be Moved to a 2<sup>nd</sup> Monitor



View the progress of Neurofeedback by clicking OK in the surface EEG Neurofeedback Panel. Change the time scale from 1 second to 30 seconds and view the progress of the client. Change reinforcement thresholds so that the subject receives rewards at about 70% of the time.

## Progress Charts to be Monitored by the Clinician During Neurofeedback

