NeuroRegulation

QEEG and 19-Channel Neurofeedback as a Clinical Evaluation Tool for Children with Attention, Learning and Emotional Problems

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Abstract

Attention, learning and emotional problems can have different causes that cannot be easily and clearly distinguished by clinical testing methods. But, QEEG and, even more so, live 19-channel Z-score training under different task conditions can both give very detailed insights about the specific functioning and dysregulations of an individual's brain. The clinical intake evaluation of the child is optimized by including a quantitative, neurometric analysis of an eyes open (EO) and eyes closed (EC) EEG acquisition combined with a real-time analysis of the child's (in vivo) brain functioning during a specific set of conditions, as described below. This method was developed and refined with more than 300 children who were tested between June 2012 and April 2014. The goal is to get as much information as possible in only one session lasting 45 to 60 minutes. The different parts of the evaluation consist of: eyes open (EO) and eyes closed (EC) collection of data, display of the actual brain waves, listing of the Z-score values (also presented as plots or instant brain maps with different task conditions), followed by games to play with a challenge condition. In addition, current source density (CSD) sLORETA of the different wave frequencies (usually delta, theta, alpha, beta, and gamma bands), distribution and velocity are shown as they change, as well as when the brain evaluates emotions. The session ends with a brief, individual 19-channel training with video feedback. Because of the usefulness of the information obtained from using this QEEG method, the author recommends that QEEG and an interactive neurofeedback session be included as a standard component in the diagnosis of and treatment planning for children with attention, learning and emotional problems.

Keywords: QEEG, 19-channel neurofeedback, z-score neurofeedback

Introduction

In the author's developmental clinic, the children and young adults display developmental delays in certain areas; they suffer from ADD and ADHD, processing disorders, and failures in school performance. Some display emotional problems as severe as Autism Spectrum Disorder (ASD), with coexisting family issues at times. In some cases, several disorders appear concurrently.

Clinical testing methods, including a thorough patient history, questionnaires, pediatric neurologic exam and neuropsychological testing, often do not clearly distinguish the different causes of these clinical conditions and are not precise enough in predicting which therapeutic approach will be the most promising in the individual child. In addition to a quantitative analysis of the EO and EC acquired EEG (QEEG), a 19-channel, interactive neurofeedback evaluation session has also proven a strong diagnostic tool and a guide for therapy. Through gathering this data, more criteria for choosing the most beneficial therapeutic options and predicting their outcome for the individual patient can be obtained.

The need for a more personalized treatment and the possibility to achieve this has already been expressed and studied by Martijn Arns et al. (2009, 2012). The suggested approach is also in concordance with a recently published Springer Brief titled, “ADHD As a Model of Brain-Behavior Relationship”. Herein, the need for the integration of tests to investigate the brain function into the evaluation process in ADD and ADHD is strongly recommended. There have been recent studies on QEEG for characterizing the autistic brain by Billeci et al. (2013).

The goal of this approach of intake evaluation, however, is less to characterize the patients according to QEEG findings in certain clusters, but to provide the most individualized therapeutic approach.

Methods

The clinically optimized approach adopted in the author’s clinic using 19-channel EEG data for quantitative analysis in combination with real-time evaluation of how the child’s brain responds to various challenge conditions is described below. It was developed and refined with more than 300 children tested between June 2012 and April 2014. The goal is to get as much information as possible in only one session of 45–60 minutes. The data was collected with the Brainmaster Discovery 24E, a 24-channel EEG and DC amplifier with BrainAvatar software and an EEG cap (Comby EEG caps, different sizes, Pamel), the real-time analysis of the data and the further evaluation is performed through comparing the patient’s obtained scores to an FDA 510K compliant normative database (Neuroguide, Brain DX).

This combined QEEG and 19-channel neurofeedback session is scheduled after a verbal patient history, questionnaires, pediatric neurologic exam and neuropsychological testing for most patients aged 3–21, usually with at least one parent present.

Step 1: Familiarizing the Patient with the Setting and their Brain Activity, Data Collection:

The evaluation starts with a brief explanation of what will be done, leading immediately into the practical process of putting on the EEG cap. The children are included in the process of checking the impedances, and most children/teenagers like to become active in turning the positions on an impedance testing meter. Some patients even get interested in the abbreviations displayed (Fz, P3, etc.), which can lead to an explanation of the different parts of the brain.

Before the actual EEG collection starts, the patient’s brain activity is shown on a second screen with the different waveforms briefly explained. Then, artifact is demonstrated through eye opening and closure, teeth clenching and swallowing. During this process, the children also realize that the activity displayed on the screen is activity of both: their brain and muscles. This “experiment” is followed by the explanation about the difference between muscle and brain activity and that we are most interested in the brain activity during the EEG collection. The children also learn how to do diaphragmatic breathing when the situation gets stressful for them.

The following eyes open EEG collection lasts for 3–5 minutes. The eyes closed data collection follows immediately afterward. During this process, the children are informed every 30 seconds about the elapsed and remaining time.

Step 2: Neurofeedback Training: Different Challenge Conditions

The training is performed as a 19-channel Z-Score training (Z Scores are the normalized transformations of the various EEG measures taken on the patient compared in real time to a normative database). To begin, the patient screen shows a game with a moving object. There is no instruction provided except to watch how fast the object is moving. The training is adjusted in order to give plenty of success to the client. Some children get an idea of how to let the object move faster in this early investigational stage, but for most it is still not clear what this movement has to do with their brain activity.

The next step is a challenge condition. This application involves a race game. In the beginning, the threshold is set to let the child win. In a second step, they are asked to allow it to be harder on each race. During this exercise, the children usually get an idea of how they can get faster or work harder. Some children adjust easily to the more difficult condition, and some adjust only for a short period, but other children are easily irritated when only hearing that it might be harder and get discouraged.

The evaluator/physician gains insights into how the individual’s brain deals with increasing difficulty through observing the child’s behavior and through the wave pattern displayed; for example, more slow activity, more alpha activity or more fast activity, or less or more disconnection through the actual coherence values. These activation patterns in conjunction with the child’s experience are integrated in the instructions to the child: either to try harder or to just observe, in case of over-activation. Others need to learn to not be concerned about winning, and instead to let go and just allow the brain do the work.

When the child is not winning for the first time, then there is a chance to explore how the child deals with failure. The instruction is to give the brain a second chance at the same level of difficulty and often the brain has already accomplished the job and the race is won. Other children get very frustrated or unsure when losing and cannot adjust easily with the difficulty level. In this case, the feedback is adjusted in order for the child to accomplish the task and end with a win.

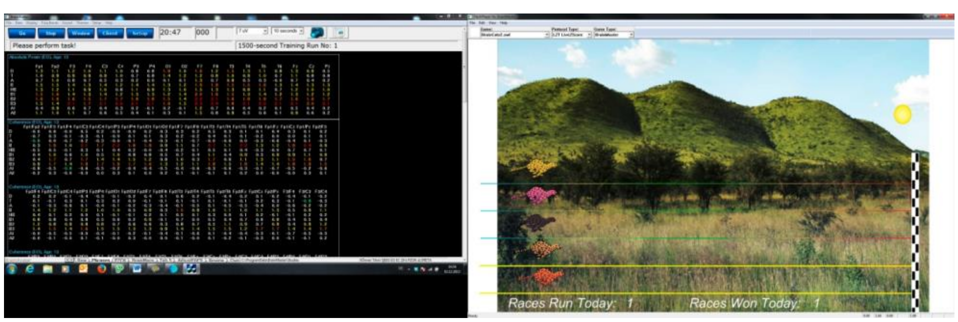


Figure 1. Z-Scores with challenge condition

Step 3: Overview of Brain Power, Coherence and Phase, and Evaluation of Stressors

The next step in the assessment is to look at the brainwaves again and then explain the transformation into Z-score values for power, coherence and phase, which are displayed as numbers or plots or instant maps. Here, there is another opportunity to bring the client in contact with the functioning of his brain.

The first evaluation step here is to ask the client to make their values/plots whiter (normal) if there is dysregulation. When this is instantly possible (in about half of the clients), then there can be challenges applied through the parents, who are usually observing the process. They can talk about what they consider stressful—school itself, reading, writing, math, other subjects, the teacher, or homework and topics which they would consider easy. Here, stress is usually shown by the values/plots becoming higher/more abnormal/less white/more reddish on certain topics. Before bringing up a new topic, however, it is important that the client normalizes the values/plots again.

In this part of the evaluation, stressors are identified, and an assessment of how fast the brain can normalize again is also accomplished. In some children, there are already strong hyper- or hypo-activations that cannot be regulated instantly or easily. This finding suggests that the dysregulation may be more longstanding and fixed or that the accompanying parent is a strong stressor himself/herself.

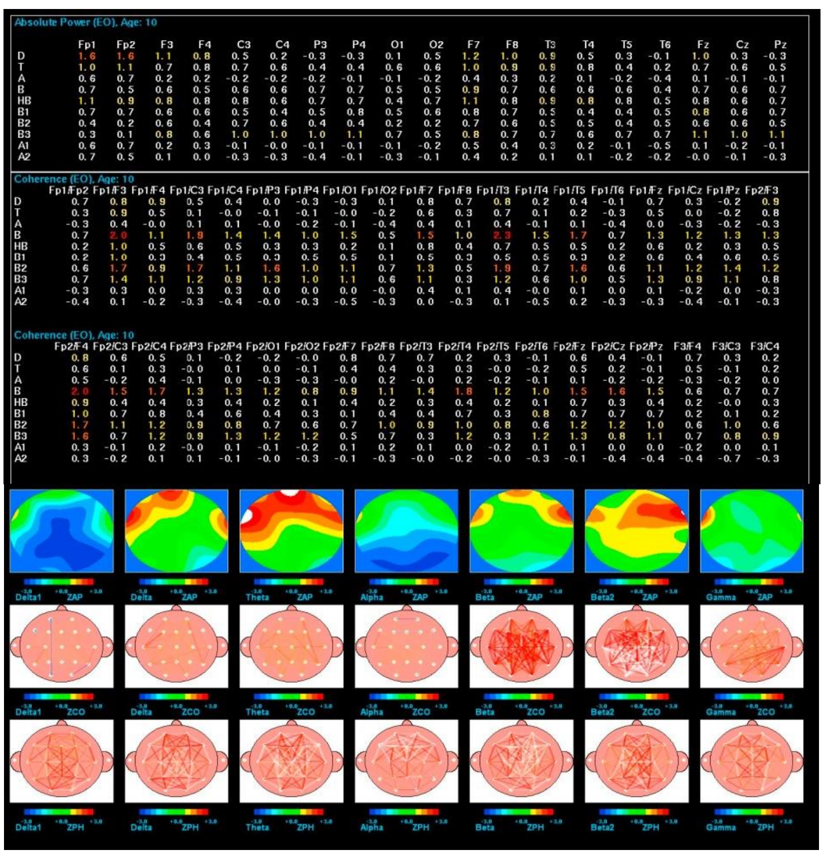
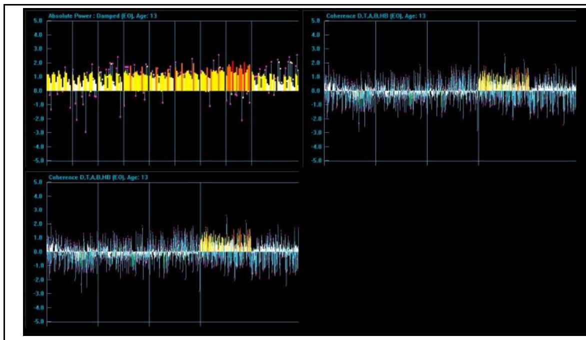
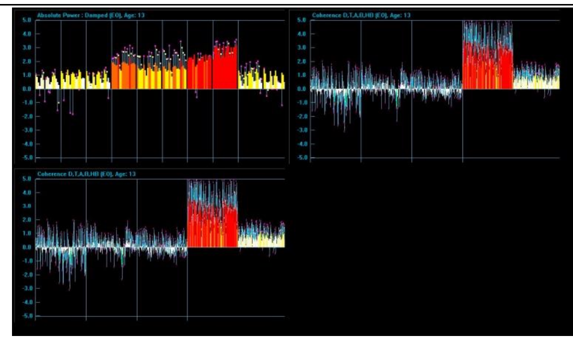


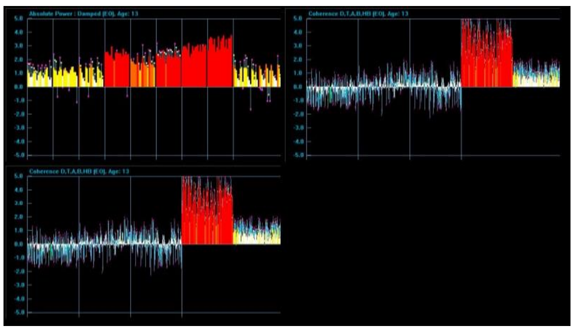
Figure 2. Z-score values displayed as instant brainmaps.



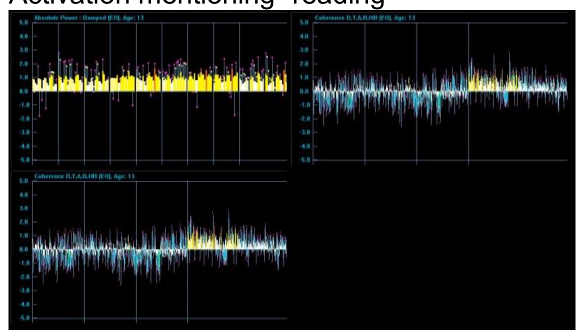
Actual activation



Activation mentioning “reading”



Activation mentioning “reading with mom”.



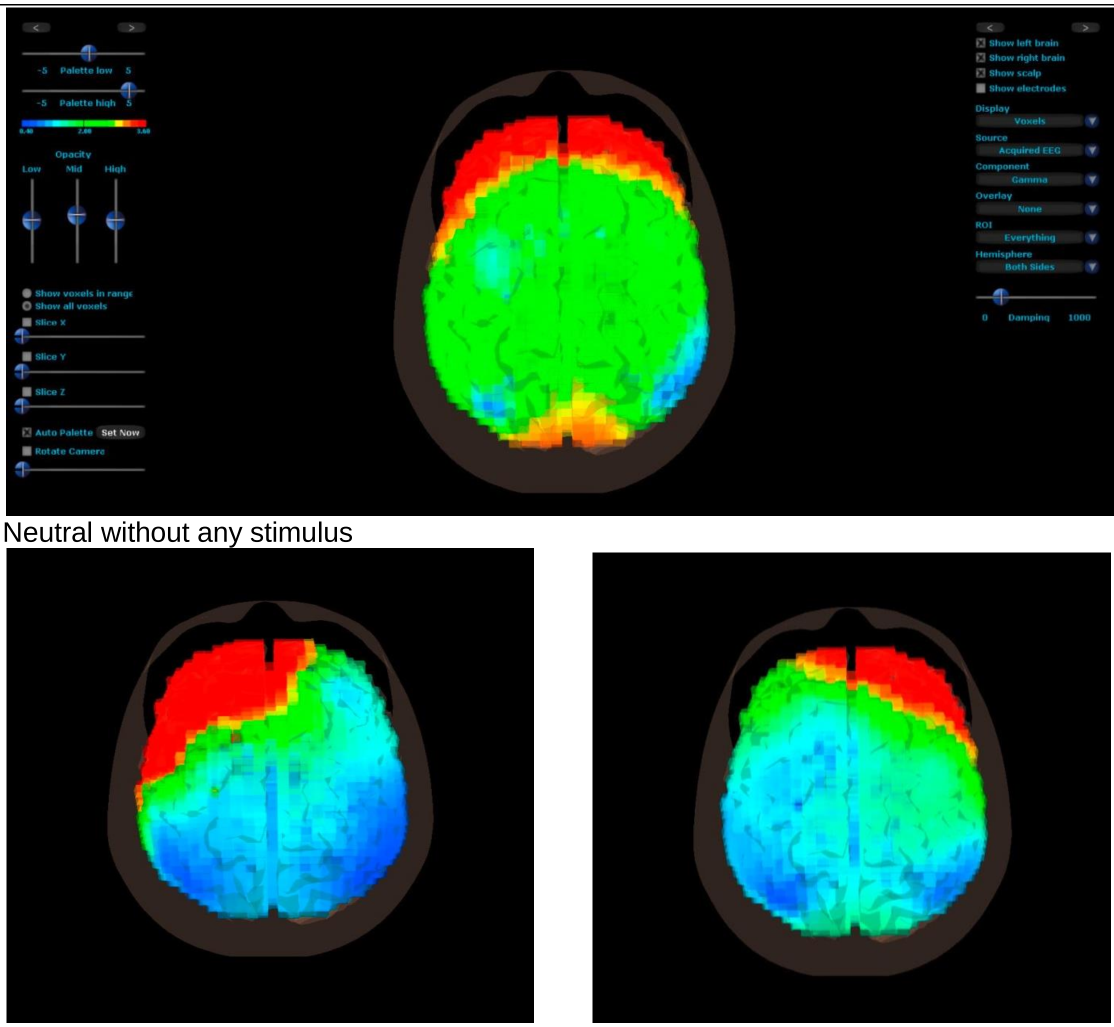
Activation “let the brain make it as white as possible”.

Figure 3. Z-Score values displayed as plots

Step 4: Brainwave Distributions and Emotional Evaluation

The next step is to show the client where the different brainwaves originate and how they spread. This is done by an sLORETA current source density display through BrainAvatar. The voxels can be seen as small cubes; the colors show the amount of activity, with red being the most and blue the least. To begin, the client views the distribution and movement of their delta waves. This is followed by the theta waves and the alpha waves. If there is not very much alpha in the posterior area of the brain, the patients are asked to try to let more of those waves happen by allowing the posterior area of the head display to become red. Often clients can do this instantly. Then they are asked to do this for a short period and they usually describe the feeling that comes with it as relaxing. Regarding beta activity, we look for symmetry especially in the frontal areas. When much beta activity shows up in the back of the brain, then there may be muscle tension in the neck that needs to be reduced.

In order to evaluate the emotional life of the brain, the gamma waves are displayed. There is usually a frontal spreading going from right to left and vice versa, being symmetrical most of the time. To introduce how the brain evaluates emotions, a description is provided of the study that showed that a baby’s brain produces more gamma on the left when they taste something pleasant (sugar), but they show more gamma on the right when they taste something aversive (lemon; see Davidson, *The Emotional Life of Your Brain*, page 38). Then the children can evaluate how certain things like food, situations, or people feel more or less pleasant/comfortable to their brain. The parents also usually like to try out certain subjects. Normally, there is a very brief response, then the brain normalizes again. In some children there is a pronounced lateralized difference, usually more activation on the right side. These are the children who often also display a more negatively focused view.



Neutral without any stimulus

Thinking about favorite dish

Thinking about boy in class who is bullying him.

Figure 4. BrainAvatar voxels with symmetrical gamma activation, and right and left dominant activation

Step 5: Neurofeedback Training

The last step is to let the child/teenager experience neurofeedback while watching a movie for 5–10 minutes so they can try another part of real training and learn that it can be fun to do so. The training reflects the individual's dysregulation/pathology, if present, usually as 19-channel surface Z-Score training of power, coherence and phase measures move above the normal thresholds set by the evaluator. As a result, the movie becomes dark or the picture becomes smaller when they don't meet feedback criteria. As it is the first session, the reward is usually on the higher end (70–100% of the time) depending on their personal ability to deal with difficulty. During this period, the investigator can observe the Z-score values and/or sLORETA display again to see how the child deals with more or less feedback or observe how emotional scenes in the movie impact activation.

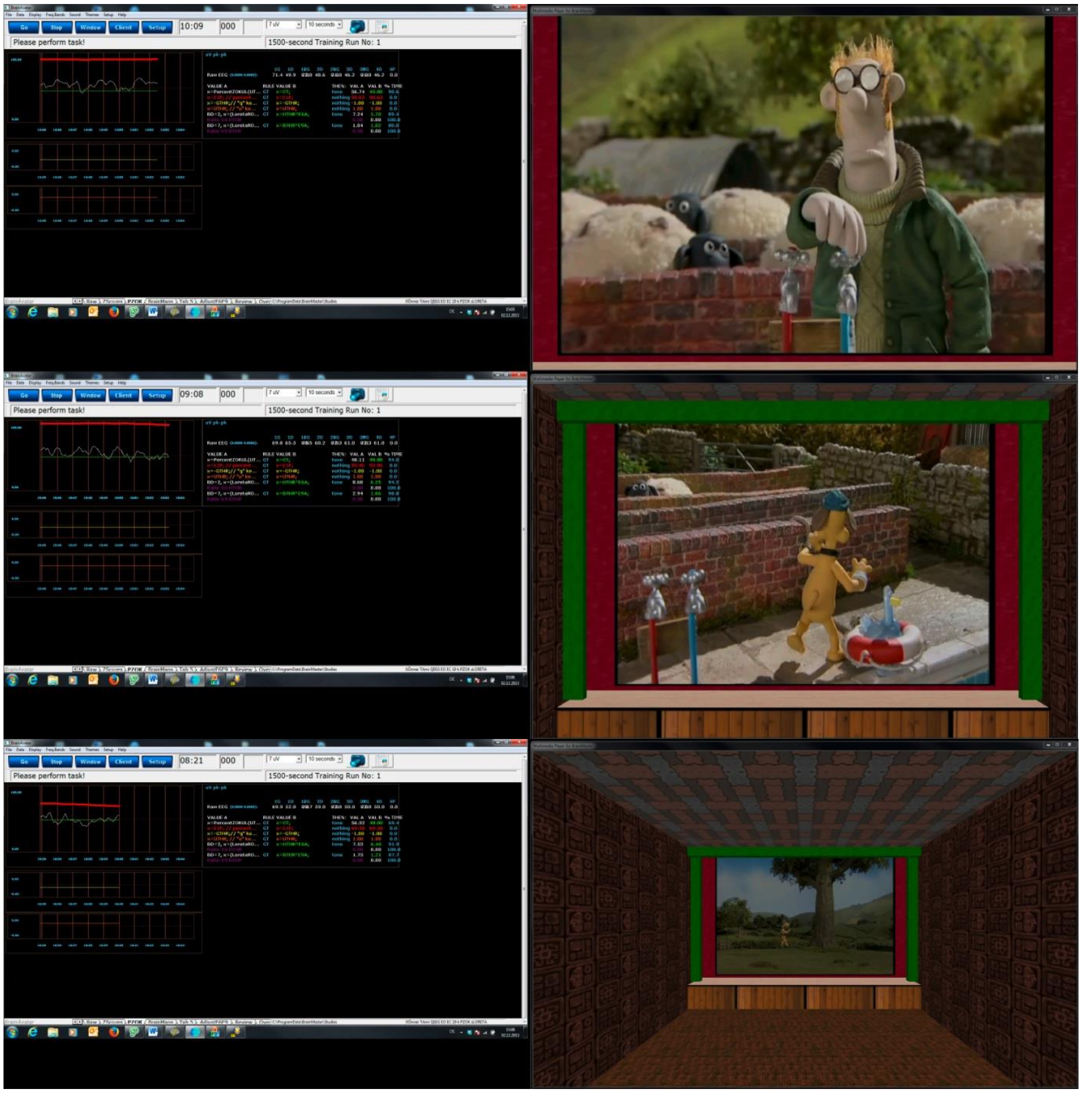


Figure 5. Z-Scores and movie

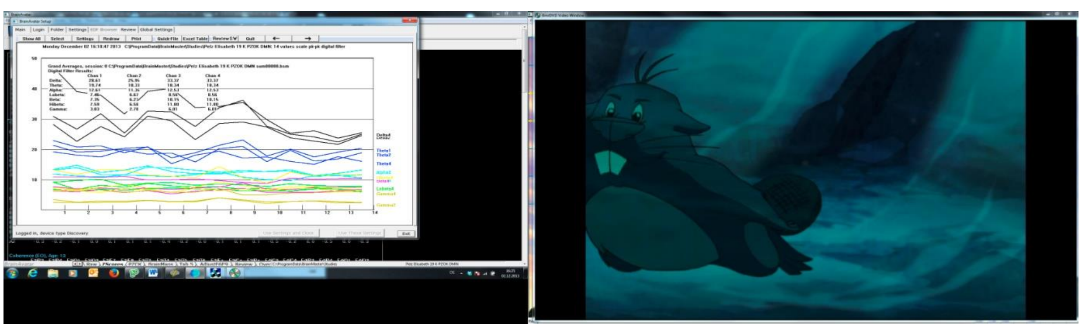


Figure 6. Session trend

Aftermath

After the diagnostic and therapeutic session ends, the parents and the patients are encouraged to watch for reactions and effects and to communicate those to the evaluator/physician through an email the next day. They learn that there can be some tiredness (often), but that there can also be small, short-lasting effects such as homework or learning becoming easier or some event being viewed more positively. Sometimes, strong effects are reported after this single session, like a teenager cleaning up his messy room and starting to organize his learning utensils all by himself. Or the teacher may report very positively about the student the next day, or the child begins to read by himself for the first time. It is important to ask for the email the next day to elicit these effects.

Evaluation Process and Therapeutic Consequences

The more in-depth evaluation of the collected data takes place after the initial assessment session. The first step is to search for paroxysmal activity, followed by surface and connectivity maps, peak frequencies, and sLORETA, as well as TBI and learning disability indices when such problems have been noted in the obtained verbal history.

These results, in combination with the findings from the live Z-Score training with the challenge condition, the information about how the child deals with failure, and the identification of stressors and the emotional situation all lead to suggestions about the most promising therapeutic approach. There is much information now available to take into account in developing the individual child's treatment plan.

The following are only rough guides that provide some examples of how this data can affect the therapeutic approach:

- The recommendation of medication is more likely to be given when immediate change is needed or when there is slowing in the frontal areas, a typical QEEG pattern of ADD, and little endurance in the task condition displayed.

- Family therapy is more likely to benefit the child when there are no typical ADD patterns and they show good adaption to challenges, but signs of stress, even provoked through the parent, are present at the investigation.

- A psychiatric referral, along with neurofeedback training, is considered when there are signs of depression (activation asymmetries) in the brainmaps or, for instance, when there is pronounced fixed gamma activity at the right frontal area in the sLORETA display.

- In a lot of cases, there are findings that warrant the suggestion of neurofeedback therapy, usually performed as 19-channel surface and/or Region of Interest (ROI) LORETA training as a standalone procedure or in combination with other therapies. The most prominent examples of findings that would lead to this recommendation are pronounced power elevations in theta or other bands, power elevations that are even higher under task conditions, disconnections displayed as low coherences in the dorsal attention network, alpha abnormalities, hyperactivation and hyperconnectivity, to name just a few.

- Disconnections are also often found in the author's patients during puberty, especially when there were many failures in school, or they have had many personal disappointments. These usually display as general low coherences in the delta and theta (and alpha) bands, in combination with a negative outlook. Here, often only a few neurofeedback sessions with coherence training and the experience that their brain is still graciously working can lead to huge improvements.

- Examination anxiety also responds well to neurofeedback training by learning to relax/normalize the values/plots while imagining the exam situation.

- Important information for parents, teachers and the therapist on how distressed the individual brain is can be indicated by elevations in the beta and high beta bands, in combination with hypercoherences, the tendency to quickly give up in the challenge/failure situation, and/or low endurance.

- Longer standing stress is usually accompanied by a similar activation pattern in the eyes closed condition and no instant ability to change the pattern through the display of Z-Score values or plots. In this case, it is most important to identify and reduce the stressors and to provide the child with the ability to relax through neurofeedback or biofeedback training.

- Sensitive children often have similar activation patterns to stressed children, but usually the patterns are less fixed or the pattern occurs only when looking at a movie like Tom and Jerry. In such cases, the recommendation is limit the child's exposure to conditions/movies/situations that are too emotionally challenging.

The last step in the assessment process is to review the findings with the parents and clients at a second meeting. At this time, they are informed about possible therapeutic options, the rationale for the recommendations that are given, and ways to follow through with these recommendations.

Discussion and Outlook

Here, only an approximation of all the invaluable information gained through this investigational process can be demonstrated. The value of this process is that a more personalized treatment plan can be chosen and applied. According to the experience of the author, this leads to faster and more pronounced results of therapy.

As this has been developed as a clinical approach, it can be utilized in part or in full by clinicians immediately. When there is 19-channel neurofeedback equipment available, it is only a short step to use it also in an investigational way. To make it a standard procedure in the diagnosis of attention, learning and emotional disorders, however, there should be a systematic evaluation process in order to find the most powerful diagnostic procedures and integrate them into a general evaluation process.

Children, teenagers and parents often express that this is a unique event for them, and they understand more about how their brains function and start to admire their brain's abilities at the end of only one diagnostic and investigational session that last only about 45 minutes. This can be an excellent starting point for any neurological treatment.

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The author declares that the investigation was conducted in the absence of any commercial or financial relationship that could be construed as a potential conflict of interest.

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