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# Research Support for Using QEEG As a Diagnostic Aid for ADHD

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## Introducing a New Service for Analyzing EEG Data

Quantitative EEG (QEEG) is a variant of EEG that employs the computerized acquisition of EEG data, refined signal processing, mathematical transformations of EEG data, and large data bases of well defined normative cut-offs so that EEG patterns associated with particular psychiatric disorders can be identified. Recently, as a result of these technologic advances, Lexicor introduced the NeuroLex<sup>SM</sup> Indicator Report to aid analyzing EEG data to assist you in the assessment process. Extensive research supports the use of QEEG as an assessment aid for patients presenting with attention problems.

In a recent *Child and Adolescent Psychiatric Clinics of North America* article, Chabot, di Michele, and Prichep (2005) reviewed the research support on the use of EEG as an assessment aid for ADHD and concluded:

*"...these findings justify the clinical use of QEEG in the initial screening and treatment evaluation stages of children with ADD, ADHD, and LD.... A QEEG can aid in the detection of organicity as the cause of brain dysfunction in children who present with learning and attention problems...A QEEG can play a role in optimizing pharmacologic, remediation, or psychological intervention."*

## Background and Research Strategy

The premise underlying Quantitative EEG (QEEG) is that different neurocognitive disorders can be identified and characterized by distinctive patterns of brain electrical activity and that the identification of these patterns can provide a reliable biological marker of different disorders. As discussed below, the EEG pattern reliably present in individuals with ADHD involves reduced electrical activity in the prefrontal cortex. Specifically, individuals with ADHD typically show an abnormally high amount of slow frequency theta waves (3.5-7.5 HZ) relative to higher frequency beta waves (12.5-25 HZ), i.e., they show an elevated theta/beta ratio.

When used as an assessment aid for ADHD, QEEG data for an individual patient are evaluated mathematically to determine whether the patient's brain activity is more similar to either the brain activity of the normal population or to individuals who have been diagnosed with ADHD in accordance with the full DSM-IV criteria. In the latter circumstance, the patient is said to be positive for the biological marker of ADHD.

As you consider the QEEG research findings summarized below, be mindful of the studies' basic method. Like all psychiatric disorders, ADHD is diagnosed using the criteria outlined in the DSM-IV. These include a number of specific behavioral symptoms, as well as the requirements that the symptoms create significant impairment, are evident relatively early in life, and are not better explained by another psychiatric condition. In studies examining the utility of QEEG as an assessment aid for ADHD, QEEG findings for meticulously diagnosed ADHD patients are compared with findings obtained from normal controls to determine whether QEEG data – specifically the theta/beta ratio noted above – is distinctly different between these groups. Finding such a distinct difference would provide evidence of a specific and unique EEG pattern in people meeting DSM-IV diagnostic criteria for ADHD.

For QEEG data to be of value to clinicians evaluating clients for ADHD, it is important to go beyond documenting that average group differences exist in the theta/beta ratio of individuals with and without ADHD. This is because even though average group differences exist, there may still be too much overlap between individuals with and without ADHD for the EEG marker to be useful in individual evaluation decisions. Instead, it must be shown that when individuals are classified as having ADHD or not based on a rigorous DSM-IV based evaluation, QEEG data can be used to accurately classify individuals into these groups.

If QEEG results provided a perfectly reliable indicator of ADHD, then 100% of individuals meeting DSM-IV criteria for ADHD would screen positive for the EEG marker and everyone not meeting the criteria would screen negative. Such a measure would be said to have 100% sensitivity – everyone with ADHD shows the marker – as well as 100% specificity – no one without ADHD shows the marker. In medicine, assessment tools with 80% sensitivity and 80% specificity are generally considered valuable for routine use within clinical practice. Some widely used tests have sensitivity and specificity rates that are even stronger. For example, mammograms have a reported sensitivity and specificity of 93% and 97% respectively (Eltahir, et al, 1999). As you shall see, the data supporting the use of QEEG to assist in the evaluation of ADHD is comparable to this mainstream medical procedure.

## **Research Findings**

Since 1997 there have been 13 studies in which EEG data of individuals diagnosed with ADHD via comprehensive DSM-IV evaluation procedures were compared to normal controls (Bresnahan et al., 1999; Clarke et al., 1998, 2001a, 2001b, 2001c, 2001d, 2002a, 2002b; El-Sayed et al., 2002; Lazzaro et al., 1998; Lazzaro et al., 1999; Monastra et al., 1999; Monastra et al., 2001). These studies were completed by 5 different research groups with no affiliation to Lexicor and included a total of 2642 subjects. Results from these studies have indicated that individuals with ADHD can be reliably distinguished from asymptomatic individuals by EEG scan of cortical areas.

One way to evaluate the clinical utility of QEEG findings is to examine the extent to which individuals with and without ADHD are correctly classified using QEEG data. There have been 2 studies published that provide data relevant to this approach (Monastra et al., 1999; Monastra, Lubar, & Linden, 2001.) The first study included 482 participants ages 6-30 who were classified

as ADHD, Inattentive Type (n=176), ADHD, Combined Type (n=221), or normal controls (n=85) based on a comprehensive DSM-IV based evaluation. The researchers examined the accuracy of an elevated theta/beta ratio – the cut off they used was 1.5 standard deviations above the normal population mean - for correctly identifying whether or not each participant met diagnostic criteria for ADHD. Results indicated that 86% of individuals with ADHD showed this elevated theta/beta ratio, i.e., the sensitivity was 86%. In contrast, the theta/beta ratio was below this level in 98% of normal controls, i.e., the specificity was 98%.

In a second study published by this research group that included 469 participants between the ages of 6 and 20, the sensitivity and specificity figures obtained were 90% and 94% respectively. Thus, as with the prior study, QEEG findings were able to discriminate between youth with and without ADHD at a high level of accuracy. Additional findings presented in this paper indicated that individuals' results on the QEEG assessment were highly stable over a 30-day period, suggesting that aberrant findings on this measure are likely to reflect a stable pattern of EEG functioning.

In a final study by Monastera's group that was presented at the 2000 Annual Meeting of the American Psychological Association, data on the ability of QEEG findings to differentiate between individuals with ADHD and those with other psychiatric disorders was presented. Participants in the study were 209 individuals ranging in age from 6 to 30. Of the 209 participants, 177 had been diagnosed with ADHD, 16 with Oppositional Defiant Disorder (ODD), and 17 with a mood or anxiety disorder. The authors indicate that these were pure diagnostic groups, meaning that although members of each group may have displayed symptoms found in other psychiatric disorders, none met full diagnostic criteria for any disorder other than their primary diagnosis.

Seventy-eight percent of individuals meeting DSM-IV criteria for ADHD were found to show the EEG marker for the disorder. In contrast, of the 33 youth diagnosed with one of the other disorders, only 1 showed the EEG marker characteristic of ADHD. This highlights the fact that abnormal theta/beta ratios are largely restricted to individuals with ADHD and are rarely found in those with other psychiatric disorders.

These findings point to the strong research support for incorporating QEEG into a comprehensive DSM-IV based evaluation for ADHD. While no test – including QEEG – should ever be used in isolation to make diagnostic decisions for any individual, the objective, independent, and biologically based information provided by QEEG results can be an important complement to traditional interview and rating scale methods.

*Note - Lexicor has recently completed two clinical validation studies that specifically examine the accuracy of the theta/beta ratio in differentiating individuals with ADHD from those with other psychiatric disorders. This is extremely important, because determining when attention problems reflect ADHD as opposed to a variety of other conditions that can produce similar symptoms is a challenge that clinicians routinely face. We are encouraged by the results of our study and have submitted them for publication and as part of various regulatory filings. We share these results, upon request, on a limited basis, under non-disclosure.*

## **Comparison of QEEG data to other tests used in the evaluation of ADHD**

The QEEG findings summarized above are even more impressive when considered in relation to other procedures that are frequently used to assist in the evaluation of ADHD. A paper published recently in *Neuropsychology* (Frazier, Demaree, & Youngstrom, 2004) reports data on a wide range of neuropsychological tests that are often used for this purpose. The tests examined in this paper included IQ tests, computerized tests of attention (i.e., Continuous Performance Tests), and a number of neuropsychological measures of executive functioning (e.g., the Wisconsin Card Sorting Test, the Stop Signal Task, the Trail Making Test). Although many of these measures showed significant average differences between individuals with and without ADHD, these differences were all smaller than what has been reported for QEEG data. Thus, in comparison to the results discussed above for QEEG, other widely used assessments are likely to be less accurate in differentiating between individuals with and without ADHD.

What about the value of the standardized behavior rating scales that clinicians frequently use as part of their comprehensive ADHD evaluations? Because these scales are used to obtain ratings of specific ADHD symptoms, it is reasonable to presume that they would be highly accurate in distinguishing between individuals with ADHD and normal controls. However, the sensitivity and specificity data for such measures is not as robust as one might expect.

In a recent paper reviewing the use of behavior rating scales used to assess ADHD (Collett, Ohan, & Myers, 2003) the sensitivity and specificity data reported for the most widely used rating scales ranged from 49-84%, substantially lower than what has been found for QEEG. The only rating scale with sensitivity and specificity data comparable to what has been found for QEEG were the Conners' Rating Scales. Lexicor researchers have published a critique of the rating scales questioning reported accuracy of the scales due to limitations in the study designs used to validate the scales (Snyder, Drozd, & Xenakis, 2004).

These data suggest that QEEG findings are more likely to match the results of a comprehensive psychiatric evaluation for ADHD than are behavioral rating scale data. These findings do not minimize the value of rating scales as part of a comprehensive ADHD evaluation, as such measures can play a very important role. However, such findings offer strong evidence that incorporating QEEG results into a comprehensive diagnostic evaluation will provide an important source of independent information that can be extremely helpful in your diagnostic decisions. As discussed in the clinical benefits section of this packet, the objective data provided by NeuroLex<sup>SM</sup> can also be helpful in increasing parents' willingness to accept the diagnosis- when it is warranted - and comply with your treatment recommendations. This result was recently demonstrated by Dr. Monastra where EEG as part of comprehensive evaluation led to patients being more satisfied with the process and compliant with the treatment up to two years post diagnosis (Monestra, 2005).

## Summary

As discussed above, there is substantial research support for the use of QEEG as an assessment aid for ADHD. Professionals who begin using NeuroLex<sup>SM</sup> as an EEG analysis service can thus be confident that they are introducing a clinical procedure that has extensive scientific support, and that is also practical enough to be used in the clinical setting. According to Dr. Patricia Quinn, Director of the National Center for Gender Issues and ADHD and a member of the Professional Advisory Board of CHADD, QEEG:

*"...is the only procedure that comes out of the laboratory setting and is practical enough for use in the clinician's office. By providing an objective measure, it aids the clinician in dealing with several problem areas often encountered in the diagnostic process. QEEG solves problems in identification including: differences in parent vs. teacher reports on rating scales; documentation of the inattentive type of the disorder which characteristically has been more difficult to diagnose; and the identification of females which DSM criteria and symptom checklists have characteristically overlooked. In addition, this technology and resulting pattern analysis allows for more accurate diagnosis when the symptoms of coexisting conditions cloud the diagnostic picture."*

Although no single assessment aid, no matter how accurate, should ever be used in isolation to make diagnostic decisions about any individual, as part of a comprehensive evaluation, QEEG findings can play an important role. In fact, as this research overview indicates, the data supporting the use of QEEG as a diagnostic aid in clinical practice is actually stronger than the data for any of the other widely used tests and behavior rating scales.

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