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1997 SSNR (Society for the Study of Neuronal Regulation) Presented Paper Abstracts

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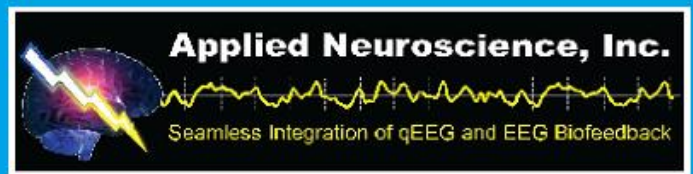
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1997 SSNR (Society for the Study of Neuronal Regulation) Presented Paper Abstracts

Quantitative EEG Profiles of Children with Attention and Learning Disorders and the Role of QEEG in Predicting Medication Response and Outcome.

Robert J. Chabot, Ph.D. New York University School of Medicine

This presentation will focus on two recently completed studies involving the role of Quantitative EEG in the diagnosis and treatment of children with attention and learning disorders.

The goal of the first study was to document patterns of neurophysiological abnormality in children with attention deficit disorders. To this end, QEEG was collected during an eyes-closed resting period, from 407 children with possible attention deficit and learning disorders. Clinical measures documenting IQ, reading achievement, memory problems, hyperactivity, inattention, and impulsivity were also obtained. The QEEGs from this sample were compared to a data base of 310 normal children. Discriminant analysis using a small subset of QEEG features resulted in a specificity of 88% and a sensitivity of 93.7% for distinguishing normal children from those with attention problems. As a group, children with attention disorders could be easily separated from normal children as 92.6% had abnormal QEEG evaluations. Two major neurophysiological subtypes were evident within the abnormal QEEG profiles encountered. The first was characterized by varying degrees of EEG slowing, especially in frontal regions, whereas, the second was

characterized by an increase in EEG activity, especially in frontal regions. These QEEG findings indicate deviation from normal development rather than maturational lag as the source of the neurophysiological abnormality in the majority of these children.

When taken in conjunction with recent MRI, PET, and regional cerebral blood flow studies, these results indicate neurophysiological dysfunction within the cortical and subcortical structures which serve the frontal/striatal system. Models suggesting both hypo- or hyper-arousal of these structures as possible causes of attention disorders are supported.

The goal of the second study was to use behavioral and QEEG indices to evaluate and predict treatment response to stimulant therapy in children with attention disorders. A sample of 132 children were evaluated. This sample included 65 children with attention deficit hyperactivity disorder (49.2%), 48 children with attention deficit disorder without hyperactivity (36.3%), and 19 children with minor attention and memory problems (14.5%). Paired associate learning tasks were used to evaluate a test trial of stimulant medication. Connor's, DSM III rating scales, and Neurometric QEEG was obtained before the stimulant trial and 6-14 months after treatment with the selected stimulant.

Significant QEEG differences were found between the normal control population (N=310) and the children with attention problems, with the degree of abnormality greatest in those children reaching criteria for attention deficit disorder with or without hyperactivity. QEEG abnormalities involved increased theta power greatest in frontal regions, frontal theta hypercoherence, and posterior interhemispheric power asymmetry and were similar to the abnormalities described above. QEEG abnormalities in short-term responders (increased paired associate learning) to dexamphetamine or methylphenidate differed, and a QEEG based discriminant function resulted in a sensitivity of 68.7% and a specificity of 67.5% for distinguishing the dexamphetamine and methylphenidate responders. Of greater

importance, was the finding that 20.4% of the children in this sample had previously exhibited an adverse reaction to either dexamphetamine or methylphenidate, with 83.9% of these children correctly classified by the QEEG discriminant function. Children who showed a favorable response to treatment had a greater likelihood of QEEG normalization, and those with an adverse behavioral response to treatment an increase in QEEG abnormality. Pre-treatment clinical and QEEG features could predict treatment response with a sensitivity of 87.1% and a specificity of 91.3%. We conclude that a combined behavioral and QEEG approach can be useful for following and predicting treatment response to stimulants in children with attention disorders.

Relevant references:

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Generational Association and Linkage Studies of Dopaminergic Genes in Attention-Deficit-Hyperactivity (ADHD) Probands and Multiple Family Members Up to Four Generations.

K. Blum¹, J. O. Lubar², J. F. Lubar³, J. G. Cull⁴, L. Bucci⁵, M. Sherman⁶, A. Eisenberg⁶, R. Wood⁷, and D. E. Comings⁸. University of North Texas, Denton, Tx¹, Southeastern Biofeedback and Neurobehavioral Institute², University of Tennessee, Knoxville, Tn³, Medical College of Virginia, Richmond, Va⁴, Weider Nutrition International, Salt Lake City, Ut⁵, University of North Texas Health Sciences Ctr., Ft. Worth, Tx⁶, University of Texas Health Science Center, San Antonio, Tx⁷, City of Hope National Medical Center, Duarte, Ca⁸.

Bouchard following an exhaustive review of the current twin and adoptive studies suggested that 30-60% of the variance in a number of personality traits were due to the addictive effect of multiple genes.¹ Polymorphisms of the dopamine D₂ receptor gene are associated with the "Reward Deficiency Syndrome" (RDS) or a number of related impulsive-compulsive addictive behaviors; the VNTR 10/10 genotype of the dopamine transporter gene (DAT1) associated with not only alcoholism but with ADHD and Tourette Syndrome (TS); and the B1 allele of dopamine-beta-hydroxylase gene (DBH) also associated with TS and a number of RDS behavioral subtraits. We genotyped 51 subjects up to four generations derived from two multiply affected families. The DNA was extracted from buccal swabs according to the PCR-based methods described by Blum et. al.² as modified by Sherman and Eisenberg. The two initial probands were carefully diagnosed by a number of standard instruments to have ADHD. Subsequently, the additional family members were also diagnosed for ADHD and other related RDS behaviors. All subjects were genotyped for the three dopaminergic genes (DRD2, DAT1, and DBH). Eighty percent of all subjects (40/50) carried the DRD2 TaqA1. When compared to "super" controls (1/30 or 3.3% carried the DRD2 A1 allele) a significant association was observed ($X^2=4.1$, $df=1$, $p=0.00000001$, Yates corrected) with an odds ratio of 116 [95% confidence limits 13.6 - 24.0]. While these findings seem over-inflated, we present this data to point out the importance for highly screened controls. A similar but less robust finding was obtained when we compared the data utilizing 714 non-alcoholic and non-drug abusing literature controls (185/714 or 26% carried the DRD2 A1 allele). A significant association was found ($X^2=63.2$, $df=1$, $p=0.00000001$, Yates corrected) with an odds ratio of 11.4 [95% confidence limits 2.56 - 3.72].

In 91 screened controls the prevalence of the DAT1 10/10 allele was 34/91 or 37.4%, as well as in 51 screened controls where the prevalence of the DBH B₁ allele was 27/51 or 53%. A significant association was found between

DAT1 (VNTR 10/10 genotype) in the ADHD-derived two-family members (30/50 or 60%) when compared to screened controls ($X^2=7.51$, $df=1$, $p=0.0061$) with an odds ratio of 2.64 [95% confidence limits 1.31 - 5.38]. In contrast, non-significance was found with carriers of the DBH B₁ (32/50 or 64%) compared to screened controls ($X^2=1.27$, $df=1$, $p=0.259$) with an odds ratio of 0.63 [95% confidence limits 0.28 - 1.4]. We believe that the high percent of the DRD2 in these subjects compared to 40-50% usually found with single addictive-impulsive-compulsive behavioral subtraits, is due to the multiple behavioral subtraits encompassing RDS. The nonparametric linkage program SIBPAL from the SAGE package was utilized with at least one RDS behavior present in a family member as a covariate. At the present time the linkage analysis is still incomplete. It is noteworthy that as the number of RDS behaviors increase in the subjects, the presence of the DRD2A1 allele also increases. At first glance it appears that the DRD2A1 allele relative to the other two dopaminergic genes, is more informative in predicting both ADHD and RDS behavior at least in this sample currently tested. The data is currently being processed and additional outcomes will be presented and discussed in terms of the impact these findings have on the biogenetics of impulsive-compulsive-addictive behaviors (RDS) as well as one important subtrait ADHD. These findings are consistent with the previous work of Comings et. al. which suggested the involvement of these same three dopaminergic genes in predicting clinical ADHD³.

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attention-deficit/hyperactivity, conduct and oppositional defiant disorder: the addictive and subtractive effect of the three dopaminergic genes-DRD2, DBH, DAT1. *Am J. Med. Genet. (Neuropsychiat Genet)* 67: 264-288.

Experiments on Brainwave Therapy for Alcoholism.

Paul J. Kulkosky, Ph.D.

In 1989, E.G. Peniston and P.J. Kulkosky published an innovative therapy for the treatment of alcoholism and prevention of its relapse. This therapy combined systematic desensitization, temperature biofeedback, guided imagery, constructed visualizations, rhythmic breathing, autogenic training, alpha theta brainwave biofeedback, and booster sessions to treat chronic alcoholism in male inpatients. This Peniston & Kulkosky Brainwave Neurofeedback Therapy increased alpha and theta brainwave production; normalized personality measures, prevented a rise in beta endorphin-levels; and produced a prolonged prevention of relapse, in comparison with traditionally treated and nonalcoholic controls. Subsequent internal replications demonstrated this therapy's effectiveness in treatment of inpatients symptoms of PTSD in association with alcohol abuse. Although there have been several external case studies supportive of this novel therapeutic approach, there have been few controlled experiments published. To convince a skeptical general scientific and clinical audience to accept this alternative therapy, a large scale, external, direct replication must be published in a mainstream journal. Deviation from original procedures of Peniston and Kulkosky may preclude similar results. However, future research designs could also address the following: 1) the external, systematic replicability of the method results in diverse populations with traditionally treated matched control groups; 2) the essential components and durations in this multiple stage therapy required for therapeutic advantage; 3) extension via conceptual replication beyond

alcoholism and PTSD to the treatment of other psychopathology and 4) the physiological and psychological processes of the therapeutic effects. For example, extensive research confirms that endogenous neuropeptides are physiological stimuli for the initiation and termination of alcohol ingestion. newly approved pharmacological therapy for alcoholism is based on the neuropeptide control of alcohol intake. Future research on brainwave therapy for alcoholism can address how regulatory neuropeptides are affected by the procedures of biofeedback. Only carefully controlled experimentation can advance wide acceptance of brainwave therapy for alcoholism and related-disorders.

Visual Evoked Potentials and Explosive Behaviors: a Brain Signature Response.

Donald R. Bars, Ph.D.; F. LaMarr Heyrend, MD; Dene Simpson, Ph.D.

Since 1990 our clinic has conducted over 1200 computerized electro-encephalogram (CEEG) and cortical evoked potential (EP) studies of children and adolescents exhibiting a variety of psychiatric disorders. Across the years, clinical observations suggested that when the occipital lobe showed a high amplitude response during pattern reversal visual evoked potential (PREP) patients typically had histories of major difficulty in controlling emotional responses. This paper presents the results of a study conducted to determine if the amplitude of the P100 wave form predicts explosive behavior in children and adolescents.

CEEG and visual and auditory EP studies of all patients, age 6 to 18 years, seen during 1966 (N=177) were compared based upon the presence or absence of explosive behaviors. (Analysis of other data is under way and will be addressed in future papers.) Logistic regression was used to evaluate the relationship of the amplitude of the P100 wave form recorded from occipital electrodes (O1/O2).

Patients who exhibited explosive, out-of-

control behaviors were significantly more likely to have high amplitude P100s ($p < .0001$). Grouping individuals as high amplitude or not, based upon our clinical guidelines (high amplitude = greater-than-or-equal-to 11 uV) still showed a significant relationship with explosive behavior ($p < .005$).

These findings indicate that the use of PREP studies allows the identification of one subset of individuals who have organically based explosive behavior tendencies. It strongly suggests that much explosive behavior is biological and not the result of "bad" parenting skills. The information provided by this study allows more appropriate intervention and treatment strategies to be implemented, while providing a better therapeutic relationship with the patients and parents.

Biophysical Integration of MRI, EEG & Cognition in Traumatic Brain Injury

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Departments of Neurology and Radiology, University of South Florida College of Medicine, the Bay Pines Foundation and the Walter Reed Army Medical Center, Washington, D.C.

Nuclear magnetic resonance (NMR) of brain water proton (^1H) T2 relaxation times, measures of cognitive function and measures of absolute amplitude of EEG and EEG Coherence were obtained from 19 closed head injured (CHI) patients. Statistically significant relations between ^1H NMR, EEG and cognitive function were conjointly observed. The relationship between QEEG and ^1H NMR differed as a function of EEG frequency and neocortical gray matter versus white matter in which lengthened white matter T2 relaxation time was positively correlated with increased EEG amplitude in the delta frequency band (0.5 - 3.5 hz). In contrast, lengthened gray matter T2 relaxation time was most strongly correlated with decreased EEG amplitude in

the alpha and beta frequency bands (7-22 hz). These findings are consistent with clinical EEG studies in which white matter lesions are related to increased EEG delta amplitude and gray matter lesions are related to decreased EEG amplitude in the alpha and beta frequency bands. Decreased EEG coherence in short distance connections of the frontal and temporal lobes was also correlated with increased T2 relaxation time. Estimates of the severity of injury were obtained by neuropsychological measurements, in which lengthened T2 relaxation times in both the neocortical gray and white matter were correlated with diminished cognitive function. The findings imply a measurable biophysical link between the state of protein lipid structures of the brain, the scalp recorded EEG and cognitive function.

Results of similar research in Alzheimer's Disease will also be presented. Finally, the beginning of an improved and more generalized suite of QEEG and QMRI discriminant functions will be discussed.

Binocular Vision and Mild Traumatic Brain Injury

John K. Nash, Ph.D.

The primary cue to depth is binocular disparity. The images from the eyes must be precisely overlapped quickly and automatically; this is called fusion. The brain must then create the appearance of a depth field from the range of fused objects of varying binocular disparities. This is called stereopsis. Stereopsis is the visual equivalent of stereophonic sound.

Patients with mild traumatic brain injury routinely show severely impaired fusion and stereopsis. They may also experience accommodative disorders, meaning that one or both eyes fail to adjust rapidly to different viewing distances. Patients experience a range of symptoms from "eye socket" headaches and impaired ability to judge distances to frank diplopia - double vision - while reading or looking at nearby objects. The most common

symptom is that the world loses its beauty and appears flat, one thing "stuck" on the next, much the way a stereo system sounds if switched to "mono."

Data will be presented on MTBI patients with these impairments and on their subsequent recovery of binocular visual function with a combination of orthoptic visual therapy and neurotherapy. Visual therapy is supervised by a developmental optometrist. Patients receive guided practice with a variety of binocular visual stimuli, gradually extending their ability to create normal fusion and stereopsis. Accommodative disorders can be treated through a combination of proper lenses and training procedures.

The recovery of visual function is often rapid (10-20 sessions) when visual therapy is coupled with neurotherapy. Improving binocular vision is separate but complementary to improving memory, concentration and multi-tasking abilities. The improvement in vision causes a positive effect on a wide range of symptoms, including affect and attention. Patients report improved mood, confidence in spatial judgments and a great sense of relief and amazement that they can see in "3-D."

EEG Biofeedback Treatment for Vietnam Veterans Suffering from Post Traumatic Stress Disorder

Ken Graap, M.Ed. 1, David J. Ready, Ph.D. 2, David Freides, Ph.D. 1, Bob Danials, Ph.D. 2, David Baltzell, M.D. 1

Acknowledgments:

Rachel Dupre 1, Carol Drummond 2, Ph.D., Elizabeth Henkit 1, Tim Sheehan 1
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2 VA Medical Center, Decatur, GA

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Peniston and Kulkosky (1991) reported outstanding results in relieving symptoms of PTSD with an EEG biofeedback based treatment. This study was undertaken in an attempt to replicate Peniston and Kulkosky findings in an outpatient setting. To this end, outpatient veterans who sought treatment for PTSD at the Atlanta, VA were screened for participation in a two group cross over design study. Ultimately, nineteen of the veterans participated in some part of the study and thirteen of them completed the EEG biofeedback training. Dependent measures including the Beck Depression Inventory (BDI), Minnesota Multi-phasic Personality Inventory (MMPI), Millon Clinical Multi-Axial Inventory (MCMI), Clinician Administered Posttraumatic Stress Scale (CAPS), Mississippi Scale for Post Traumatic Stress (Miss) and 19 channel EEG recordings were collected on three separate occasions. Half of the sample was treated at Emory using the Lexicor Biolex system and half were seen at the VA using a Focus Technology system. All participants were also enrolled in therapy groups with their cohort. BDI and Mississippi Scale scores declined across the study interval while other variables did not systematically change.

Overall, the results indicated that applying the treatment described by Peniston and Kulkosky (1991) to the outpatient population did not lead to the same dramatic results as they reported. A discussion of the past research, the present study and the factors which may have lead to the failure to replicate is presented.

The Case for Alpha-Theta: A dynamic Hemispheric Asymmetry Model
Tom Budzinski, Ph.D.

The Dynamic Hemispheric Assymetry model (DHA) postulates a differential functional cortical arousal level range wherein the dominant hemisphere, with its critical screening capability, is diminished in this capacity at high and low arousal levels, however, the nondominant hemisphere is still

able to function at these extreme levels. At the low end of the arousal continuum, images and/or verbal suggestions are processed without the full effect of the critical screening, and therefore, are more likely to be accepted and acted upon. Conversely, early memories, especially those traumatic in nature, tend to be brought to the surface during this low arousal condition which has been labeled the twilight state. Neurofeedback, in the form of alpha-theta training, provides the means to access and maintain this state.

The Effects of Single Session and Multi-Session Audio-Visual Stimulation (AVS) at Dominant Alpha Frequency and Two Times Dominant Alpha Frequency on Cortical EEG

Joel F. Lubar, Ph.D., University of Tennessee, Knoxville

AVS at fixed frequencies has been shown to synchronize brain activity towards those frequencies. We have conducted two studies employing 19 channel EEG recordings to determine if a single 20 minute session of AVS stimulation had significant and lasting effects over baseline on the cortical EEG measured in the 19 standard 10-20 electrode locations. We then examined the effects of dominant and twice dominant frequency stimulation over 20 sessions assessing the EEG every 5 sessions and also 2 weeks after the termination of all stimulation. Measurements were compared with initial baseline measurements which were taken in eyes closed situation and also we evaluated the effects on an eyes open post baseline measurement compared with a pre-eyes open measure before any stimulation had been employed. All of the measurements were obtained on normal college students. They were ten individuals in each AVS group. In addition, another study was carried out over 20 sessions to evaluate the effects of stimulation at one half the dominant frequency (theta activity) on cortical EEG. In addition to the AVS-EEG measurements, we obtained an assessment of possible behavioral effects as measured by the Categories Test of

the Halstead-Reitan battery, the NEO - a personality assessment measurement, the Woodcock Johnson Psychoeducational Evaluation and a measurement of hypnotic susceptibility.

The most surprising findings of this research is that the effects of AVS are counter intuitive and far from simple. For example, simulation at the dominant alpha frequency has relatively minor effects on alpha production and has much more profound effects on either theta and/or beta activity. Beta stimulation also has relatively little effect on alpha but effects slow activity as well as fast activity. The distribution of these effects in terms of cortical regions is also very complex. For example, there are far fewer effects in occipital regions and in temporal regions than there are in frontal regions.

The basic findings from this initial research will be presented as well as the implications of these findings for combining AVS stimulation with neurofeedback in order to enhance neurofeedback effects. Because the results are counter intuitive and very complex, clinicians should be extremely careful in the employment of this modality until they have a clear picture of which regions and which frequencies are effected by theta, alpha and beta auditory and visual stimulation. Various models of how the AVS might be combined with neurofeedback will be presented and should lead to some open dialogue as to the best paradigms.

Theta: Don't Tread on Me

Marvin Sams Ph.D., R.EEG T, QEEGT, L. Ac.

Theta activity is defined by international Federation of Electrophysiology and Clinical Neurophysiology as a frequency band of 4-8 mHz. As is well recognized, however, various subsets exist in all EEG frequency bands; Theta is noexception.

Subset 1: Frontal Midline Theta (Fm Theta) is a specific EEG frequency seen in

those subjects actively engaged in cognitive activity, such as solving math problems and playing Tetris™, a Nintendo™ game. the peak frequency is between 6.2 and 6.7 Hz and maximally present at Fz, but with a wide fronto-central distribution.

Subset 2: According to Cavanaugh (1972), 4 Hz Theta is associated with object naming, an important aspect of memory.

Fm Theta is associated clinically with the ability to sustain attention over a time, an extroverted personality, low anxiety and low neuroticism..

Of importance, the administration of diazepam (Valium™) and the ingestion of alcohol increases Fm Theta. In a study of those with marked extroversion, Fm Theta was found, along with lowered platelet MAO activity.

Due to the favorable characteristics of Fm Theta and 4 Hz Theta, Theta should not be inhibited or decreased in Neurofeedback training. The one exception is statistically elevated Theta activity on a QEEG reference database.

Fm Theta is easy to train with Neurofeedback, with positive clinical outcome. Specific protocols will be discussed.

Poster Abstracts:

Reflexology and It's Effect on the EEG

John A. Putman and Merle Sunde, EEG
Spectrum Encino, CA

Reflexology is an ancient holistic healing technique that has been practiced as far back as the Egyptian Era and is currently used throughout the world. It's basic premise is that specific reflex points on the hands and feet correspond to different glands and organs in the body. When stimulated, the body's own healing abilities are engaged resulting in improved health and feelings of well being. The

purpose of this project was to examine how these positive changes, resulting from a single reflexology session, would manifest in the EEG of 14 volunteers (adults ranging in age from 23 to 63).

We used an 8 channel multi-modality biofeedback system in which 2 channels were dedicated to the EEG measurement. Electrode placement was at C3 and C4 where sensory input is registered. Other measures used were temperature, skin conductance and heart rate. The EEG measures taken were amplitude, power, % power and % synchrony. Bandwidths examined were theta (3.5- 7.4 Hz), alpha (7.4-12.1 Hz) and beta (12.2 -42 Hz) with subsequent bandwidth redefinition in order to check for trends in narrower bands.

All but 2 of the subjects found reflexology to be a very pleasant experience. Of the 14 subjects, 11 had useable data. (Combining EEG with "hands on" treatment techniques brings with it a particular set of liabilities with respect to artifacts), Of these 11 persons, 10 showed significant increases, over the course of the session, in one or more of the following measures: alpha amplitude, theta amplitude, % alpha synchrony and % theta synchrony. All increases in amplitude were bilateral. Only one person showed no increases. Additionally, and perhaps more importantly, there was a substantial drop in these measures immediately following the baseline period when the hands on portion of the session began. This may have important implications with respect to the role of healing touch in cortical stimulation.

EEG Coherence Training Based on QEEG Abnormalities in Patients with Closed Head Injury.

J.E. Walker, M.D.

Anecdotal reports indicate that EEG biofeedback to correct coherence abnormalities on QEEG may remediate memory loss and cognitive problems in patients with mild closed head injury. We report our successes and

failures in remediating the symptoms of mild closed head injury in our first twenty-three patients using this approach. In each case a QEEG was obtained . The most highly significant intrahemispheric or inter-hemispheric coherence abnormality was addressed with ten sessions of EEG biofeedback. If mild or no improvement was noted, the next most significant coherence abnormality was addressed with biofeedback training. If little or no improvement was again obtained, the 3rd most significant coherence abnormality was addressed. Overall, using only coherence training, 19 of the 23 patients experienced at least a 50% improvement in their symptoms. 5-30 sessions were required. Training to increase beta coherence seemed particularly effective and produced more rapid improvement than central beta power training (Walker 1966). Frontal and central placements seemed particularly effective. Milder benefit was noted with training to theta and beta coherence in the majority of patients, as well as with training to increase alpha coherence. A minority of patients improved with training to increase theta coherence. Adverse effects were noted in a few patients, and these will be reviewed. Whether coherence training with these placements would have similar results if no QEEG were done or if no abnormalities were present in these areas is not known.

Audio-visual Stimulation in Childhood Autism

Patricia Woodbury, Ph.D.

The purpose of the study was to investigate the effectiveness of light/sound technology to promote sensory integration which facilitates the learning capacity of children with autism by reducing their high state of arousal, increasing time on task and decreasing acting-out behaviors. This research extended the work of A. Jean Ayres and Lorna King who theorized that the autistic individual's brain does not register, modulate or integrate sensations that most people notice; auditory and visual inputs are ignored more than other types of sensory

stimuli. This study utilized light/sound technology to stimulate and desensitize these sensory channels to facilitate processing of incoming stimuli. The technology was furnished by Dr. Harold Russell and was programmed with a microchip to control the frequency patterns. Twelve subjects were selected to participate in this eight week study; only five subjects completed. They represented schools in the Tidewater region of Virginia and Illinois. Inattention, Impulsivity, and Hyperactivity were assessed with The Attention Deficit Disorder Evaluation-Home and School Versions. Comparison of the results of these measures and qualitative data were incorporated into case studies. There was improvement noted in social skills, attention and on-task behavior. The results are supportive of research conducted with learning disabled and AD/HD students conducted by Drs. Carter and Russell.

QEEG Findings Among Violent Offenders.

Jim Evans, Ph.D.

Quantitative EEG data were obtained from 32 men convicted of murder or rape. Lexicor Neurosearch 24 equipment was used to gather data during an eyes closed, resting condition. Data were analyzed using the NREP system of Hudspeth in conjunction with the

Thatcher Life Span Reference Database. QEEG abnormalities were found in all a cases, and more than the number expected by chance were found in 27 cases. The modal finding was of a preponderance of abnormalities involving frontal and/or right hemisphere sites. This was true for 19 of the 27 subjects having significant numbers of QEEG abnormalities, as well as for three of the five with less than the number expected by chance. In the cases were frontal or right sided abnormalities were not predominant, two had been diagnosed schizophrenic, and several had significant numbers of posterior left side abnormalities and/or the high Theta to Beta ratio characteristic of adults with ADHD. In two cases inspection of raw EEG tracings revealed periodic abnormal Delta waves and/or spiking at right frontal or right anterior temporal sites. The data suggest several dysfunction patterns which singly, or in combination, may contribute to violent behavior: (1) impulse control problems (frontal); (2) impaired perception and/or expression of emotion (right hemisphere); (3) impaired verbal learning, with school failure (left posterior hemisphere); (4) attention disorder (high Theta to Beta ratio); (5) periodic abnormalities of consciousness (transient frontal/temporal EEG abnormality; and (6) psychosis.