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“I have seen the critical need for a greater body of neurofeedback research during my time at the VA and, more recently, in private practice. Having research to back up what I know to be clinically beneficial helps us establish the legitimacy of the field. Research also helps my clients to commit to the number of sessions they need for effective results. However, we desperately need more, larger and better-designed research projects that answer clinicians’ questions and support our clinical experience.”

– Allen Novian, PhD, LMFT, LPC, Novian Counseling & Neuroeducation
Chief Clinical Advisor to Zukor Interactive

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Letter from ISNR President

When you receive your newsletter, the 20th Annual ISNR Conference will be either underway or starting very soon. If it hasn’t started and you haven’t decided to be there, I hope you will make your decision and get packed. This year’s conference promises to be the best yet, with the conference committee adding special events for your enjoyment. Another great slate of speakers is lined up, and the sessions and workshops are going to be excellent. The hotel accommodations are wonderful, making this an absolutely great 20th birthday celebration for ISNR.

As this issue goes out, I am finishing my year as president of ISNR, and it has definitely been an interesting year. It may have appeared to be a quiet year for ISNR but it was far from that for the ISNR Board. We have been incredibly busy rebuilding the infrastructure of the organization. This task was taken on to ensure that the organization is poised for the growth that is happening with both ISNR and the field. This restructuring also will allow ISNR to better serve its members and the field of neurotherapy.

A few months prior to the start of my term, Interim Executive Director Karen Forbes joined us through a consulting program of the Non-Profit Center at LaSalle College School of Business.

Karen worked as the Executive Director and consulted with the organization on nonprofit issues and best business practices. During this time we were able to structure our organization in the manner that a non-profit should be structured, as well as to streamline our operations. Karen also led our search for a new executive director. The Board determined that it wanted to go outside the field for its new ED and bring in a seasoned executive director who had a history of growing a professional organization. We accomplished this goal, and our present executive director, Cynthia Yablonski, MBA, joined the organization in May. Cindy is already seen as an excellent addition and will be an asset to ISNR for years to come. If you have not yet met her, please make it a point to do so at the conference.

The updating of our non-profit organization procedures allowed us to be current with governmental non-profit regulations and helped to better focus our business operations. Much of this was in the manner of best business practices for non-profits. We streamlined accounting processes and revised our policies and procedures. We literally reviewed almost every facet of our operational process, making changes where needed. This has been an exhausting process, but it should allow us to more efficiently meet anticipated future membership growth and services.

Another accomplishment this year was the clarification of roles and support between the ISNR Research Foundation and ISNR. This was accomplished through the creation of a Memo of Understanding by the two groups. The MOU should be in place by the time you are reading this report. This process turned out to be more work than it seemed it should, but both organizations learned a great deal about what they legally could and could not do in regards to grants/funding, roles, and service. It certainly helped both organizations align and determine direction for funding of research. Please donate to the Research Foundation. By doing so, you are investing in yourself and the field of neurofeedback.

There have been other projects along the way and one that hopefully will be announced at the conference, with positive results that could impact both the field and the membership. It has been difficult to take on many outside projects while focusing inward during the year. However, as president-elect Randy Lyle takes over the organization, ISNR should be poised to move forward with continued outreach and service to benefit the membership and the field in general.

I would like to take a moment to acknowledge and thank this year’s ISNR board. A special thanks to past-president Leslie Sherlin and president-elect Randy Lyle for the help and support that they have given me. This year’s Board members included Sarah Prinsloo, Anne Stevens, John Davis, Noland White, Rex Cannon, and Rob Coben. Thanks to all of them for their dedication and hard work.

Given that it is conference time, I want to especially thank the conference committee for their preparation of another outstanding conference. They have gone above and beyond to produce this annual event that everyone enjoys so much. Last, but certainly not least, great big thanks to conference coordinator and membership chair, Ann Marie Horvat, and executive director, Cindy Yablonski. These two are the very heart and soul of the organization, and I wouldn’t have made it through the year without them.

In closing, I would like to thank the membership of ISNR for the opportunity to be president this last year. It has been both rewarding and an opportunity for personal growth. ISNR has grown significantly in the past 20 years, and hopefully the work that has been done over the last two years will position ISNR to grow further and promote the field for many years to come.

I look forward to seeing you in Orlando!

Richard E. Davis, MS

Announcing NeuroConnections’ new online supplement!

Often our authors have to reduce the number of figures and tables and their information to fit the articles into the number of pages of NeuroConnections. In an effort to accommodate this shortcoming, we have decided to institute an online supplement that will be posted at http://isnr.org/neurofeedback-info/neoconcxnections-newsletters.cfm. Look for this symbol in articles to point toward information that will be available online.
François Mitterrand, former President of France, once said that for the United States to possess the world currency amounted to “an extraordinary privilege.” The banker always has an edge. For very different reasons, I feel the same way about our involvement over the years with neurofeedback. It is just an extraordinary privilege to be involved with neurofeedback at this singular moment in time when humanity discovers its ability to affect brain function directly, with profound implications for health, well-being, and mental competence.

We need to treasure the moment, because in retrospect it will not be seen as the major scientific revolution that it appears to be in prospect. In retrospect, people will simply marvel at the obtuseness of a prior age—the scientific dark ages when it comes to brain science. Of course the brain is trainable in broad generality. How else do we acquire our competences over the course of our lifetime? And, external feedback loops are as important to that process as internal ones. Further, external feedback loops that inform us of internal function are also part of the picture. So why would anybody ever have thought biofeedback to be controversial?

How can anyone have doubted that the quality of regulatory function in our central nervous system should be a key concern of the field of medicine? And of psychology? And yet, here we are, well launched into the 21st century, and still dealing with a medical system that is largely wired to structural models of functional failure. We are still stuck with an educational system that lives entirely in a pre-scientific frame of mind. And we are still stuck with a criminal justice system that cannot accommodate the insights from the brain sciences because they are outside of the paradigm of moral and legal discourse.

I have comforted myself over the years with the realization that this forced gradualism, where every little advance in our understanding has to be fought for in battles royal within our tiny field, is simply in the nature of scientific revolutions. All of us are fond of the system of ideas that we have gradually consolidated within ourselves, often at great effort and expense. And we love the comfort of a congenial professional community with shared beliefs, but something seems to be different in this go-round. We are aware in the culture at large of a general discrediting of the elites, ranging from politics in first instance, to law and justice, to finance and economics, to academia and corporate governance, and including finally also the titled (and entitled) health professions.

What the elites confront these days is a general acceleration of the rate of change within the disciplines that does not in any way connect with the pace of technological development. A fixed body of knowledge is not intrinsically adaptive, and is therefore unsuitable to come to terms with such a high rate of change. But that is not all. A second challenge is that societal problems are increasingly understood to be interdisciplinary, and so the solutions must be as well. The professions fail at the margins because they are all products of the silo model of education, with acolytes stove-piped through to the award of a degree in their chosen discipline.

Neurofeedback is a good exemplar of a cross-disciplinary development. It simply cannot be understood by—and encompassed within—the frame of any of the pre-existing professional categories. This is threatening to those who feel the sanctity of their professions being breached. It is almost funny to watch some of the chest-beating that is still going on as some individuals try to crowd certain ideas off the stage. In all such cases, the attempt is made to restrict the terms of debate to those
that prevail in one discipline. Yet the world moves on in spite of them. The elites are no longer in control. This is a fact, not a case of the wish being father to the thought.

Consider the pace of development in brain imaging. New imaging tools and new analytical methods are immediately deployed, and are leading to an exponential growth curve in publications. The caring professions are hardly in a position to keep up; already we have a number of studies on fMRI neurofeedback. What struck me about these studies is the matter-of-factness with which neurofeedback is accepted in this context. Unfortunately, the aura of these studies does not necessarily transfer to EEG feedback. It still has history to overcome, but that threshold of acceptance is surely not far off.

It is time for us to adopt the same attitude—the matter-of-factness of EEG neurofeedback. If we were not totally persuaded of the merits of our work, we would have no business offering neurofeedback to the public. And if we are so persuaded, then we ought to say so forthrightly. Neurofeedback does not yield to the placebo model. It never did. And if the placebo cannot be used to indict the field as a whole, then it also cannot be used to indict any particular approach within the field. It is time for us to show critics of neurofeedback and the naysayers our backsides. Their ignorance or their parochialism is not our burden. Rather, it deserves our contempt. EEG neurofeedback is a fact. Let’s move on to the real issues.

Our society is presently under extreme stresses that are largely beneath the notice of our media. At the same time, with the large-scale insertion of neurofeedback into pediatrics, the field of education, the criminal justice system, addictions treatment, and the care of the elderly, the effect on our society would be transformative. Neurofeedback is sufficient to bend the medical care cost curve all by itself, absent any other technological breakthrough. I know of nothing coming along in medicine—certainly not stem cells and not genomics—that offers a comparable near-term transformative potential. There is no technological or financial barrier standing in the way of a societal transformation mediated by the adoption of the self-regulation paradigm within health care and education. The only substantive barrier to such a shift is to be found among the elites, who are, by their nature, protective of their turf and tethered to the status quo. For evidence, look to the last forty years of our history.

“It is difficult to get a man to understand something, when his salary depends upon his not understanding it!”

—Upton Sinclair

Siegfried Othmer, PhD

Welcome to the fall edition of NeuroConnections.

This edition is devoted to showcasing new young researchers in the field of Neurofeedback. Nine Students are receiving their first publication in this newsletter and for some their first publication ever. Think back to your graduate school days and the excited anticipation of seeing your writings, thoughts, and images in print. Heady and terrifying, sometimes because your views were now “out there” and who knew what your next discovery would be. I just recently learned of a powerful new book, The Emotional Life of your Brain by Richard J. Davidson, PhD and Sharon Begley, which gives light to the possible reasons why some of these students will go on to further publications and some will not. Each and every one of these nine articles are worth your read and I hope you will find new ways of looking at clients from them.

Also in this edition, is the definitive setting forth of the practice approach of the Brownback work. Newbies and we “slightly older” clinicians and researchers will find added assistance in conducting our work from the reading and thinking through of this article.

Finally, we have created a tribute to Dr. Ernst Niedermeyer, whose passing creates a void in the science that will be hard to fill.

By the time you receive this edition the ISNR Conference will have taken place; I hope all of you attended and had a great time!

Merlyn Hurd, PhD, BCN Fellow

“What peculiar privilege has this little agitation of the brain which we call thought…” —David Hume

After attending one semester as a mathematics student with a view to becoming an astronomer, Hans Berger dropped out of Universität Jena in 1893 to enlist for a year of military service in the cavalry. During a training exercise, his horse suddenly reared and he was thrown into the path of a horse-drawn cannon. Fortunately for future generations of EEG researchers, the driver of the artillery battery was able to bring his team of horses to a timely halt, sparing the young Berger serious injury. At the very moment that these events were unfolding, Berger’s sister, although many miles away, had a feeling that he was in danger and insisted their father send him a telegram. This incident of spontaneous psychic connection made such an impression upon Berger that, upon completion of his military service, and obsessed by the question of how his mind could have carried a signal to his sister, Berger returned to University to study medicine with the goal of discovering the physiological basis of the correlation between objective neural activity and subjective mental experience.

In 1924, Berger succeeded in recording the first human electroencephalogram. When he published his technique for “recording the electrical activity of the human brain from the surface of the head” in 1929, and despite his publication of 14 subsequent papers, his findings were initially met with skepticism and incredulity by the German scientific establishment; it was not until his work was independently confirmed by British electrophysiologists Edgar Douglas Adrian and B. H. C. Matthews, that the importance of his discovery was officially acknowledged at an international forum in 1937. In belated recognition of his contributions as the “father of electroencephalography,” at the age of 65, Dr. Berger received appointment as Professor Emeritus in Psychology, in 1938, the same year in which he retired from his alma mater.

In an effort to learn from the lessons of the past, the NeuroConnections editorial team dedicates our current issue to the work of emerging student researchers (lest they, like Dr. Berger, might have to wait until retirement before the value of their work is appreciated!). In the present issue,
we are privileged to bring to you the work of a talented group of young people, mentored by some of the best and the brightest educators in our field. It is also fitting that, in an issue dedicated to research and education, we include a retrospective of Dr. Hans Niedermeyer, a man who has influenced the work of generations of students, researchers, and educators, and whose contributions to our field will long outlive his recent and untimely passing. We hope that you enjoy the current issue, and look forward to seeing each of you at the fall 2012 ISNR and spring 2013 AAPB meetings.

Roger Riss, PsyD


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**Letter from AAPB Executive Director**

**Choose Equipment Wisely**

There are a number of FDA-approved equipment options to consider for your biofeedback and neurofeedback practice, some good, and some, not so good. We are pleased to have participated in the IEEE project, piloted by Tom Collura, PhD, as a joint venture between AAPB and ISNR to establish a standard for evaluating the specifications of these devices. Be sure to read Dr. Collura’s article in this issue.

**First and foremost, know what you are getting into when you purchase your biofeedback/neurofeedback devices.**

Before you leap into the purchase of any device, we advise some careful analysis. Here are a few resources that can help:

- The IEEE project—overview provided in this issue of NeuroConnections

Many people are uncomfortable approaching vendors because they may not know the language or the questions to ask. To help in addressing these concerns, we recommend the following resources:

- AAPB’s Home Study Modules: These home study courses are available to provide the basic didactic education needed to understand the basics of biofeedback and neuro-
feedback, including such important topics as terminology and the disorders that can be effectively managed with these modalities. These modules are available on the AAPB website.

- There are always great continuing education courses offered by both AAPB and ISNR at their respective annual conferences. Webinars are also a good source of this type of information, most of which offer continuing education credits.

- Additional great resources are the AAPB and ISNR exhibit programs, where you have the opportunity to meet directly with the vendors and test drive their equipment. This offers a firsthand opportunity to understand the specifications of various devices, how they are used, the efficacy of their use for a variety of disorders and/or optimal functioning, and to contrast and compare.


- The AAPB website also includes a link to a Biofeedback Glossary from its home page.

First and foremost, know what you are getting into when you purchase your biofeedback/neurofeedback devices. Happy, but careful, hunting!

David L. Stumph, IOM, CAE

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Letter from ISNR Executive Director

Dear Friends,

I am delighted to join ISNR as its Executive Director.

It is an honor to be associated with an organization that for 20 years has done so much to promote education and excellence in the field of neurofeedback training and neurotherapy from various professional disciplines throughout the world. With an outstanding board of directors firmly committed to our mission, a highly professional and dedicated team, well-attended annual conferences, along with the resources of our professional journal and newsletter, ISNR is well positioned to face the challenges ahead.

The environment for all ISNR members is undergoing change, driven by domestic as well as global influences. While the pace and scope of these changes may vary among countries, there are many common goals: promoting increased member knowledge through conferences, publications, and educational materials and programs; improving the levels of communications among the growing multidisciplinary community of dedicated neuroscientists, neuroscience practitioners and clinicians; supporting advances from neuroscience into clinical practice, and strengthening the public’s knowledge of neurofeedback.

ISNR’s mission is to promote excellence in clinical practice, educational applications, and research in applied neuroscience in order to better understand and enhance brain function. Our efforts are focused on improving lives through neurofeedback and other brain regulation modalities; encouraging understanding of brain physiology and its impact on behavior; as well as establishing clinical and ethical guidelines for the practice of applied neuroscience. In the past, much of our activity has been dedicated to providing information resources for the public and professionals and to promoting scientific research and our peer-reviewed publications with impressive results. The large number of professionals who have participated in programs administered by ISNR since 1995 have made enormous contributions to society.

Looking ahead, ISNR will retain its traditional focus on clinical practice, educational applications, and research, but will also seek to collaborate with other like-minded organizations. Special attention will be paid to strengthening training and to promoting leadership capacity, innovation, networking opportunities, and research. To accomplish this end, we will look to establish new partnerships with professional and academic organizations, foundations, and individuals who share our vision.

The recent publication of the IEEE Recommended Practice for Neurofeedback Systems on June 29, 2012 is just one example of a successful partnership with IEEE and AAPB. ISNR would like to acknowledge Tom Collura (BrainMaster Technologies, Inc.) as Chair of the IEEE Committee, for leading this important initiative, and a special thank you to Nancy Wigton for her representation of ISNR in the process. You can learn more about the standard on the IEEE website: http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=6228483&contentType=Standards.

I am very excited to be associated with ISNR. The challenges ahead are substantial but opportunities abound.

I look forward to working with friends and colleagues of ISNR and strongly value your ideas and suggestions. Please feel free to contact me directly. My e-mail is cyablonski@isnr.org.

With best wishes,

Cindy A. Yablonski, MBA, Executive Director
State-Dependent Neurophysiology: Depression
Kelley Callaway

The DSM-IV proposes that patients suffering from Major Depressive Disorder (MDD) will display state-dependent irregularities when examined by electroencephalogram (EEG) and other experiment methods. Essentially, the neurological changes associated with depression can be seen in EEG records only when a patient diagnosed with MDD has been exposed to a stimulus capable of evoking a depressive response. People without an MDD diagnosis, however, will show no such changes.

To determine if the theory of state dependence is, in fact, an accurate characterization of MDD, we designed an experiment utilizing several experimental methods. Topographical EEG and connectivity measures were analyzed for each subject. Low Resolution Brain Electromagnetic Tomography (LORETA) current source density (CSD) in the alpha frequency domain was also computed. LORETA software provides an inverse solution that is able to identify brain structures that are responsible for measured EEG activity. Pre and post task cortisol analyses were a final measure used to quantify subject stress response. It was hypothesized that each of these methods would reveal observable differences between groups in brain regions that have been correlated with MDD.

The study was conducted with twenty-three university students, thirteen of whom had previously received an MDD diagnosis. Five of these subjects had been prescribed anti-depressant medications, but only three of these were currently taking their prescriptions. Depressed subjects were administered a structured clinical interview (SCID-R) to reaffirm their previous diagnoses. The experiment began by obtaining a baseline cortisol sample from each subject. We then examined each subject using EEG. Baseline measurements were taken for four minutes with eyes closed (ECB) and eyes open (EOB) prior to administration of the Beck Depression Inventory (BDI). The BDI is a questionnaire that is commonly used to diagnose depression and is capable of producing a depressed response in subjects with an MDD diagnosis. EEG was recorded continuously as potential effects in other brain regions that may be visible in other frequency domains. Asymmetry was observed between groups during the BDI with depressed subjects showing increased alpha activity in the right hemisphere, particularly the right prefrontal cortex (PFC). This is an incredibly important feature of depression, as this asymmetrical activity in the alpha range has been connected with symptoms of depression including negative affect and has been well documented in many previous studies. Essentially, we were able to show that not only did depressed subjects have resting brain activity that differed from controls, but they also showed a measurable change in right prefrontal asymmetry that occurred during the BDI, suggesting that there were state-dependent changes taking place when the depressed subjects were exposed to a depressive stimulus.

The cortisol analysis yielded interesting and unexpected results. We had hypothesized that depressed subjects would show a stressed response due to the content of the questions in the BDI, which would result in an increase in cortisol. Further, increased PFC activity has been linked to higher cortisol concentrations as well, so the asymmetry that was observed in the PFC further implied that cortisol concentration would increase in depressed subjects.

LORETA CSD

Cortisol analysis showed that depressed subjects had significantly higher resting cortisol concentration, a characteristic that has been verified in many previous studies. Interestingly, all subjects, including controls, showed a decrease in salivary cortisol (significant in depressed subjects) after task completion. This, however, is not without similar findings in other studies. This decrease may be attributable to the emotional task that was used as a stimulus for the subjects. Cortisol studies are typically conducted with cognitive tasks such as arithmetic or public speaking, and the emotional nature of the BDI may have caused a different reaction. Perhaps the most likely explanation is that depressed subjects experienced a sense of validation when completing the BDI and that this caused a relaxation effect that resulted in a decrease in cortisol rather than an increase.

In conclusion, the results of this study show that depressed individuals do, in fact, show state-dependent significant differences in EEG CSD and asymmetry while completing the BDI. Our findings also suggest that state-dependent neurophysiology may be a potential method to evaluate psychological syndromes and to monitor effects of their respective treatments. The current method may be capable of providing potential biomarkers for a more accurate diagnosis of MDD as well as an effective treatment outcome measure for future cases.

About the author: Kelley Callaway, a recent graduate of the University of Tennessee in Knoxville, completed an undergraduate thesis in the university’s biopsychosocial laboratory under the guidance of Dr. Deborah Baldwin and Dr. Rex Cannon. The thesis, titled State-Dependent Neurophysiology: Depression, investigates depression and its classification as a state-dependent psychopathology.

Depressed > Control BDI measures show extensive asymmetries concerning the right prefrontal and its relation to the rest of the cortex. The red in the image depicts cortical sites operating outside the network that is processing the BDI. The blue depicts those sites that operate within this network during the BDI task. Specific to the alpha frequency, the asymmetries appear between right fronto-temporal regions and midline contralateral regions. This type of asymmetry has been shown to be connected with symptoms of MDD including negative affect.
Jonathan E. Walker, M.D.

- Board Certified Neurologist
- Board Certified Electroencephalographer
- President of the Neurofeedback Division of AAPB
- President of the American Board of QEEG Technology
- Pioneer in the field of neurotherapy research and treatment, he has used neurofeedback in his medical practice for over 20 years

EEG / QEEG interpretations, analyses and reports with protocols using the modular activation / coherence approach to allow practitioners to achieve superior results

Dr. Walker personally reads each QEEG Service includes phone consultation with Dr. Walker

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We have developed a technique of analyzing the single-trial errors in a segmented electroencephalography (EEG) recording by using the low-frequency components of the recording isolated through a wavelet transform. This method of examining errors in EEG recordings offers several advantages over others, such as the more traditional generation of event-related potential (ERP) waveforms. To study this novel method, it was applied to posttraumatic stress disorder (PTSD) subjects and control subjects in an attempt to discover differences in error processing between the two.

**Limitations of Traditional ERPs**

One of the most common methods of examining error processing and corrective action is the ERP waveform. Briefly, many trials of a particular task are repeated multiple times by a participant. These instances, or epochs, are averaged together based on a particular event, such as a certain type of stimulus or response. This procedure eliminates the underlying EEG activity that generally obscures the presence of an ERP component (Picton, Lins and Scherg 1995). The waveform produced from this averaging procedure is known as an ERP waveform, referred to here as the traditional ERP waveform. However, there are additional consequences that must be considered in using this analysis method.

The most significant impact that the averaging procedure has on the underlying signal is the destruction of the amplitude and latency information that was present in the original single-trial epochs. In general, the time, size, and shape of the ERP component between different subjects and between the individual trials of the same subject can be quite variable. This unpredictability and variability means that information from the single-trial ERP components is lost when the averaging procedure is performed.

It is also a characteristic of traditional ERP waveform generation by averaging, that a sufficient number of epochs are needed to remove the underlying EEG “noise” from the signal. If there are not enough epochs available, the final traditional ERP waveform will be less resolved. Therefore, it is necessary that the subject completes an adequate number of trials from which the appropriate epochs can be extracted. If the epochs of interest are rare occurrences or events, such as errors, it may become even more difficult to collect a satisfactory number for evaluation.

Traditional ERP waveforms are not suitable for use in applications that require real-time information. Even if a small number of epochs were used, the time it would take to complete the averaging would approach several seconds. In a neurofeedback or brain-computer interface application, this delay would be unacceptable (Bensch, Karim, Mellinger, Hinterberger, Tangermann, Bogdan, Rosenstiel and Birbaumer 2007; Hamilton, Glover, Hsu, Johnson and Gotlib 2011).

**Single-Trial Time-Frequency Domain Method**

To overcome the limitations of the traditional ERP waveform, we used a new single-trial method of examining the ERP components of EEG recordings. Briefly, participants with PTSD as diagnosed using the DSM-IV-TR were recruited from the Anxiety Program at the University of Louisville. Controls were recruited through advertisements in the local media. Both groups underwent the Eriksen’s flanker test, a test that is known to produce a relatively large number of errors, while EEG recordings from the medial fronto-central region were taken. The collected EEG
recordings were segmented into epochs based on the subject responding incorrectly to the stimulus. These individual epochs were input into a custom program that applied a wavelet transform to the epochs.

The wavelet transform is a type of time-frequency transform similar to the Fourier transform, with the exception that the wavelet transform is not only able to resolve the frequency components of a signal, but is also able to locate where in time the particular frequencies occur. When applied to our method, we used the wavelet transform to isolate the theta (4-8 Hz) frequency range, based on previous studies (Cavanagh, Cohen and Allen 2009), of the epochs input into the program. From this isolated range, deflections that most closely matched two ERP components related to error processing, the traditional error-related negativity (ERN) ERP component and error-related positivity (Pe) ERP component, were selected. The amplitude and latency of these selections were named the single-trial time-frequency ERN and Pe. A depiction of the method described is shown in Figure 1.

When we compared the single-trial time-frequency ERN and Pe between the PTSD and control subjects using a one-way analysis of variance (ANOVA), it was found that the PTSD patients showed a significantly reduced response to errors as indicated by the amplitudes of the single-trial time-frequency ERN and Pe. This same phenomenon was not seen when the traditional ERP analysis was used. The reduced responses in the PTSD subjects discovered by this novel analysis method can be supported by existing literature that indicates that particular medial fronto-central structures associated with error processing and corrective action are deficient in PTSD (Lanius, Williamson, Hopper, Densmore, Boksman, Gupta, Neufeld, Gati and Menon 2003).

We conclude that this single-trial time-frequency domain method of studying errors in PTSD offers several advantages over the traditional method. It offers an alternative in situations where traditional ERP waveforms are not suitable or cannot be generated.

References


About the authors: Zachary Clemans, BS is a graduate student at the Department of Biomechanical Engineering, Speed School of Engineering, University of Louisville, Kentucky. He is pursuing a Master’s Degree in Bioengineering and plans to enroll into a PhD program. His mentors are Ayman El-Baz, PhD, Associate Professor of Bioengineering, University of Louisville, and Tato Sokhadze, PhD, Associate Professor of Psychiatry & Behavioral Sciences, School of Medicine, University of Louisville, Kentucky.

Figure 1: The general procedure used for the time-frequency domain wavelet analysis. First the wavelet transform on the individual epochs is performed. Next the low-frequency components are isolated and the final time-frequency waveform is generated. Finally the single-trial time-frequency ERN and Pe are identified.

Resonance Frequency Measurements Are Reliable

Jordan Fuller

Introduction

Heart rate variability (HRV) biofeedback is a growing area in the biofeedback field, and has shown to be efficacious in the treatment of many disorders, including asthma, hypertension, depression, fibromyalgia, and PTSD (Yucha & Montgomery, 2008). Lehrer (2007) posited that low HRV indicates vulnerability to stressors and disease.

Lehrer et al. (2004) proposed that each person has a breathing rate, known as the resonance frequency, that will maximize HRV measures. Paced breathing at the resonance frequency has become a standard practice to stressors and disease.

Method

Nineteen undergraduates, 19 to 22 years old, participated in the study. A Thought Technology ProComp Infiniti™ system measured several HRV indices using an Infiniti EKG™ sensor and respiration rate using a strain gauge placed over the navel. Subjects sat upright in a straight-backed chair with eyes open throughout this study. Following a 5-minute resting baseline without feedback, subjects were instructed to follow an animated pacing display designed to guide their breathing from 7 ½ to 4 ½ breaths per minute in seven descending ½-breath-per-minute steps. They breathed at each target rate for 5 minutes followed by a 1-minute buffer period. Subjects were retested using the same procedure 2 weeks later to assess the reliability of these measurements. They received no HRV training or breathing practice during this intervening period.

Results

Resonance frequency for this study was defined as the breathing rate to the nearest ½-breath-per-minute that increased the most HRV measures, including pNN50, or the percentage of adjacent NN intervals that differ in length by more than 50 milliseconds; SDNN, or the standard deviation of NN intervals; and HR Max-Min, or the average of the differences between maximum and minimum heart rates during each breathing cycle.

A Pearson Product-Moment Correlation Coefficient showed that breathing rates selected as the resonance frequency were reliable r(17)=0.73, p =.000. The time domain indices pNN50, r(17) =.65, p =.002; and SDNN, r(17) =.59, p =.008, were also reliable, but HR Max–HR Min was not reliable, r(17)=0.30, p=.212.

Discussion

Training clients or patients to breathe at their resonance frequency is an effective way to...
increase their heart rate variability for the treatment of many disorders. This study demonstrated that the resonance frequency is sufficiently reliable to guide heart rate variability training for individuals like our healthy undergraduates.

About the author: Jordan Fuller has been involved in applied psychophysiology and biofeedback research for three years at Truman State University in Kirksville, Missouri. During his tenure on Dr. Fred Shaffer’s research team, he has researched diverse topics, including the effects of ujjayi breathing on HRV, the reliability of the resonance frequency; the issue of handedness in measuring skin conductance; and the effects of heartfelt emotion on heart rate variability. During the 2011–2012 school year, Jordan served as the lab manager for Dr. Shaffer’s 40-member undergraduate research team. Jordan has presented biofeedback research at Truman State research conferences as well as at the annual meetings of the Association for Applied Psychophysiology and Biofeedback (AAPB). He is now pursuing his PhD in clinical psychology at the Illinois Institute of Technology in Chicago, Illinois.

References

Table 1. Physiological Measures.

<table>
<thead>
<tr>
<th>Measure</th>
<th>N</th>
<th>Week 1 Mean (SE)</th>
<th>Week 3 Mean (SE)</th>
<th>Test-Retest Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resonance Frequency</td>
<td>19</td>
<td>5.94 (0.96)</td>
<td>5.58 (0.92)</td>
<td>0.73 (.00)</td>
</tr>
<tr>
<td>HR Max – HR Min</td>
<td>19</td>
<td>25.33 (8.59)</td>
<td>27.12 (5.85)</td>
<td>0.30 (.214)</td>
</tr>
<tr>
<td>pNN50</td>
<td>19</td>
<td>0.11 (0.09)</td>
<td>0.14 (0.10)</td>
<td>0.65 (.002)</td>
</tr>
<tr>
<td>SDNN</td>
<td>19</td>
<td>93.3 (54.26)</td>
<td>110.03 (28.99)</td>
<td>0.59 (.008)</td>
</tr>
<tr>
<td>VLF</td>
<td>19</td>
<td>4.97 (5.44)</td>
<td>4.28 (2.65)</td>
<td>0.33 (.170)</td>
</tr>
<tr>
<td>LF</td>
<td>19</td>
<td>84.31 (9.37)</td>
<td>84.54 (6.53)</td>
<td>0.18 (.104)</td>
</tr>
<tr>
<td>HF</td>
<td>19</td>
<td>14.72 (0.79)</td>
<td>14.18 (0.61)</td>
<td>0.21 (.009)</td>
</tr>
<tr>
<td>LFHF</td>
<td>19</td>
<td>12.41 (7.76)</td>
<td>11.54 (8.17)</td>
<td>0.58 (.009)</td>
</tr>
</tbody>
</table>

Event-Related Potential (ERP) Study of Facial Negative Emotional Expression Recognition in Autism

Ashley P. Hinchen, BS, and Guela E. Sokhadze, BS

Background
Autism spectrum disorder (ASD) is a range of neurodevelopment disorders, which presents with impairments in communication, social skills, and stereotyped, repetitive patterns of behavior. Difficulty in effectively communicating and engaging with others can cause detriment to the social interactions of these individuals. One element that is essential to successful communication is being able to apply so called “Theory of Mind” (Baron-Cohen, 1991), or correctly deduce another individual’s mental state. In contrast to others, this skill is underdeveloped in autistic individuals (Brune & Brune-Cohrs, 2006). Not being able to read a mental state from a face and in turn attribute an emotion to the facial expression, relates to a hindrance in social skills (Baron-Cohen, 1995). Attention deficits contribute to a viable explanation for the impairment of “Theory of Mind” in autistic individuals. Various attention deficits exist, including having an expanded focus for attention, resulting in being overly stimulated (Burack 1994). If an autistic individual is hypersensitive to their surrounding environment, they may find difficulty in focusing on other pertinent higher processed information, such as facial cues (Herrmann & Knight 2001). The hypersensitivity to stimuli and impairment in cognitive processing is thought to be related to over-processing of sensory information at modality-specific cortical areas, in addition to an abnormal connection between these sensory areas and the higher level integrative cortical processing areas (Belmonte et al., 2004; Casanova, 2006; Minshew et al., 1997; Rubinstien & Merzenich, 2003; Welchew et al., 2005).

Our study aimed to take a more in-depth investigation into the attention patterns of autistic subjects when processing emotions in human faces. Examining event-related potentials (ERPs), a measure of attention taken from EEG readings, was proposed as a viable technique to provide more insight into how complex affective stimuli (i.e., facial emotional expressions) are processed in autism. The ERPs of the autistic subjects were evaluated according to their amplitude, latency, and topography and subsequently compared to those of age and gender matched control subjects. We anticipated finding a significant difference in the earlier potentials (~170 ms post-stimulus at parieto-occipital sites), which represent pre-attentive sensory neural responses to facial stimuli (Coles, 1995). In addition, we also expected a variance in the later potentials which correspond to the higher level cognitive processing of stimuli at the centro-parietal and parietal regions of interest (Verleger, 1988). In particular, we used an experimental design where the test focused on an easy task of recognition of the gender of face (male vs. female) and more difficult task where subjects were requested to differentiate emotional facial expressions.

Method
This study used ERP measures of facial emotional expression recognition to test cognitive functions and emotional responsiveness in autism and typical controls. In a forced-choice ERP test, subjects were instructed in two blocks (60 trials each) to differentiate gender of faces with neutral and emotional expressions (male vs. female), and then in the following 2 blocks differentiate facial emotional expressions (e.g., fear vs. sadness; anger vs. disgust). ERPs were recorded using a 128-channel EGI Net Station system. ERP responses at frontal, temporal, central, centro-parietal, parietal, parieto-occipital, and occipital sites of EEG recording were analyzed and compared across two groups (autism N=18, typical controls N=21).

Results and Discussion
Our results concur with the predicted outcomes. The earlier ERP measurement of N170 in the parieto-occipital and occipital areas represents visual stimuli being detected without further cognitive processing. Identifying gender, a simpler task, revealed a prolonged latency and a larger amplitude in autistic subjects when compared to control subjects.

In particular, the autistic group, as compared to controls, showed more negative N170 component (Fig. 1) in the emotion differentiation task (-3.97 vs. -1.37 µV, p<0.023), but not in the gender recognition task (p=0.11,

Student Research
n.s.). Latency of the parieto-occipital N170 was significantly prolonged in the autism group, especially at the right hemisphere in emotional differentiation condition (e.g., at P4, 211 vs. 158 ms in controls, p=0.01). The magnitude of this ERP component may result from the over-processing facial stimuli, which may in turn serve as a distraction and delay of higher level processing. In centro-parietal P3b component, a later ERP which correlates with cognitive processing in the central and parietal areas, a shorter latency (257 vs. 295 ms, p=0.013) and larger amplitude (4.01 vs. 2.44 µV in controls, p=0.031) was recorded in autistic subjects, when identifying emotions only (Fig. 2). The shorter latency may be explained by emotions having relatively less of an influence on autistic individuals. However, the larger amplitude implies that being able to attribute an emotion to a facial expression, or use “Theory of Mind,” requires more effort. Identifying attention patterns in autism by examining specific ERPs may offer a further explanation of the social and communication deficits that these individuals encounter.

About the authors: Ashley Hinchen completed her undergraduate degree in Psychology at Xavier University of Louisiana. She is currently a rising second-year medical student at the University of Louisville School of Medicine. In the future, she plans on pursuing a career as a child and adolescent psychiatrist. Ashley participated in the project as a medical student researcher at the Cognitive Neuroscience Laboratory at the Department of Psychiatry and Behavioral Sciences. Guela Sokhadze completed her undergraduate degree in Psychology at the Department of Psychological and Brain Sciences at the University of Louisville. Currently, he is enrolled in a pre-doctoral program in Anatomical Sciences and Neurobiology at the University of Louisville School of Medicine. His interests are focused on qEEG studies of neurodevelopmental disorders including autism and ADHD. His poster presentation at the AAPB 2011 meeting in New Orleans was selected as a best student paper.

References:

Interdisciplinary Approach to Research on Neuro-Optometric Rehabilitation

Caitlin M. Hudac

As a young scientist, it’s exciting to be trained using interdisciplinary methods. My undergraduate focus in Human Development at the University of Chicago primed me for exploring the relationship between psychology, biology, sociology, and anthropology. My research is also heavily informed and motivated by my work as a milieu therapist after college. Each child faced unique challenges, but overall impairments often compounded issues across multiple domains. I found the best interventions were dynamic and addressed psychiatric and socio-emotional issues as they arose during daily living.

These experiences invigorated my interest in brain and behavior relationships. Cognitive neuroscience provides a way to better specify early developmental issues. My work with Dr. Kevin Pelphey explored neuroendophenotypes to bridge the gap between the state of having autism and the vulnerability for developing autism (Kaiser et al., 2010). We proposed that these neural signatures may identify children at risk for developmental disorders during infancy, allowing for subsequent intervention. Initiated by this research, my long-term goal is to improve methods for prevention, diagnosis, and treatment of developmental and learning disorders, brain injury, and other mental health problems.

Currently, I am a graduate student at the University of Nebraska-Lincoln working with Dr. Dennis Molfese, the Director of the Center for Brain, Biology, and Behavior. This interdisciplinary facility provides an opportunity to apply and extend cutting-edge research strategies. As part of this community, I am involved in diverse research questions and encouraged to integrate techniques and concepts across disciplines. In one such collaboration, a surprising case study motivated a recent study exploring rehabilitation following a traumatic brain injury (Hudac, Kota, Nedrow, & Molfese, 2012).
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Neuro-Optometric Rehabilitation: Case Study Using VERP

A 44-year-old female patient suffered a traumatic brain injury (TBI) after a fall in the shower. An undetermined period of unconsciousness and paralysis immediately followed, after which the patient was able to stand and walk with some hesitancy that improved over a brief time. Urgent care diagnosed her with a closed head injury. Continued symptoms left her unable to return to work. These included migraines, dizziness, short-term memory loss, frequent falls due to poor balance and depth perception, word-recognition trouble, severe stutter, and nausea. Magnetic resonance imaging and computed tomography scans were reported as unremarkable. The patient was referred to my colleague, Dr. James Nedrow, a local neuro-optimist, due to her continued vision dysfunction, which is a common TBI symptom (Hellerstein et al., 1995). Her visual problems consisted of phonophobia, blurred vision, sensitivity to bright light (photophobia), visual memory problems, and occasional episodes of diplopia. Dr. Nedrow diagnosed the patient with primary Post-Trauma Vision Syndrome (Padula et al., 1994) and secondary Visual Midline Shift Syndrome (Padula et al., 2000).

Prismatic intervention is a neuro-optimistic rehabilitation strategy designed to relocate the visual field (Khan, Leung, & Jay, 2008). The patient was using yoked prisms (left eye: 3 diopters up and in 45°; right eye: 3 diopters up and out 45°) with midpupil bi-nasal occlusion. In addition to improving visual performance, the prisms produced drastic improvements in other domains. The patient was able to read and walk unassisted. Her migraines were also greatly diminished. Importantly, the patient’s stutter disappeared almost instantly with use of prisms. One of the mysteries of this case study is why stuttering occurred and how neuro-optimistic rehabilitation supported these improvements. Our research sought to explore the mechanisms by which rehabilitation impacts the systems underlying and related to vision.

The patient participated in visual event-related potential (VERP) experiments using high-density electroencephalography under two conditions: (1) with normal lenses (no prisms condition), and (2) with corrective prisms. During a simple pattern-reversal task, the patient watched a checkerboard reversing its pattern every 1 s. VERPs were time-locked to the onset of the pattern change during No Prism and With Prism conditions. The grand-average of all VERPs produced a strong P148 component (see Figure 1) for both conditions. A dynamic channel selection strategy determined that these conditions were classified with high accuracy (87% overall accuracy). This indicated that neural mechanisms are reliably distinct between conditions. In other words, her brain process was different with the addition of the prisms.

Using a temporal principal components analysis (PCA), nine factors or temporal regions of the VERP accounted for 92% of the overall variance in the waveform. These principal components were submitted to an analysis of variance (ANOVA) to determine which temporal factors were associated with the prism intervention. The ANOVA design included repeated measures for condition (2: No Prisms, With Prisms) and scalp electrode regions. Two factors characterized variance near the late portion of the P148 component (168-256 ms). These scalp topographies are illustrated in Figure 2 at intervals that correspond to the beginning, peak, and end of each factor. The black arrows highlight latency differences in voltage at different time points for the 2 factors. Negative peaks appear reliably 30-45 ms early with the prisms. This indicates that without prisms, processing speed was slower, suggesting a less efficient visual system that is corrected by using prisms.

One of the unique contributions of this work using high-density EEG involved the ability to estimate sources within the brain that generated the brain waves recorded at the scalp. Our analysis strategy used backwards modeling to estimate the most likely neural sources responsible for generating the scalp-recorded VERPs that varied between conditions. Results implicated two separate neural systems engaged with and without neuro-optimistic rehabilitation during the P148 component. Without prisms, neural sources engaged within somatosensory, language, and executive brain regions engage. These language and sensory areas are not optimal for vision processing and potentially overloaded the ability of the visual system to engage in the simple task of passive viewing. In other words, without prisms the visual system is inefficient and additional areas are recruited to compensate for the reduced visual involvement. This resulted in the behavioral presentation of stuttering, poor word recollection, and communication issues. When prisms were introduced, the system was normalized to primary visual cortices, the parahippocampal cortex, and the cingulate cortex, regions typically implicated in vision processing.

Implications for Future Research

This research presents a novel interdisciplinary approach to exploring neuro-optimistic rehabilitation. Gains in the targeted visual system and associated neural networks (e.g., language, proprioception) are measureable and meaning-ful. The evidence suggests that prismatic intervention heavily influences the engagement of other sensory and cognitive systems. However, the full extent to which domains (e.g., cognition and vision) interact over time is not clear. Longitudinal studies should be conducted to assess performance stability across domains while rehabilitation strategies evolve. Further research should explore how neuroimaging fa-
cilitates the ability to evaluate treatment decisions (e.g., prescription adjustment for corrective lenses and prisms). As a student interested in exploring treatment options, it is exciting to consider these implications for TBI, as well as developmental disorders. I am continually impressed with the sensitivity of neuroimaging (e.g., VERP) to identify underlying processes in the brain. The possible implementation of these tools for diagnosis, prognosis, and treatment is alluring. Nonetheless, rehabilitation and treatment are likely best addressed using multiple strategies, including measures of behavior and clinical acumen. Interdisciplinary approaches address complex phenomena by sharing expertise across fields. I am eager to continue interdisciplinary collaborations with other experts, such as clinicians, cognitive neuroscientists, and psychologists. Together, it will be possible to combine tools and knowledge to facilitate early and optimal treatment for patients.

References

Long-Term Effectiveness of Neurofeedback combined with Metacognitive Training for Children with ADHD: A Pilot Study
Wence Leung, MA

Introduction
Several studies have shown that neurobiofeedback is effective in improving attention, academic performance, IQ, and social behavior in children with ADHD while avoiding the side effects of medication. Researchers have suggested that by combining metacognitive training with neurobiofeedback, the positive effects are best generalized to daily function. Recently, Gani and colleagues have shown that students are able to practice the more mature brainwave patterns that they learned in the neurofeedback training even after they have completed training sessions, suggesting potential for long-term maintenance. However, whether the improvement seen with neurofeedback training can be maintained over time is still under investigation. This study evaluated the short-term and long-term impact of a 40-sessions neurofeedback training program combined with metacognitive strategies training. The goals of this study were: (1) to determine whether the number of ADHD symptoms rated by caregivers changed from pre-training to post-training; and (2) to determine whether the perceived gain made by the children with ADHD after 40 sessions of NFB training is sustained.

Methods
This study comprised two parts. In the first part, short-term effects of the program were examined by completing secondary data analysis on existing questionnaire and computerized assessment data from the ADD Centre (Mississauga), at the pretreatment and the immediate post-treatment points. The sample size was 318, and the inclusion criteria were: (a) a diagnosis of ADHD/ADD (b) completion of 40 sessions of neurofeedback training, (c) age six to seventeen years at the time of training. The questionnaire data, collected for all participants, was completed by caregivers and included the (1) Conner’s Global Index: Parent Version, (2) DSM symptom list, and (3) ADD-Q. For a subset of 110 participants, computerized assessment data was also collected: (1) Test of Variables of Attention (TOVA) and (2) IVA+Plus – Integrated Visual & Auditory Continuous Performance Test (CPT).

In the second part, the long-term effectiveness of this program was investigated. Twenty-two participants were recruited from part one of the study. Caregivers completed the same set of questionnaires (Conner’s Global Index: Parent Version, DSM symptom list, ADD-Q). After the data was collected, the scores on the questionnaires were then compared to the participant’s pre training and post training to determine whether the gains have been sustained for at least one year post training.

Results
In the first part of the study, decreases in both hyperactive and inattentive symptoms were reported in the questionnaire from pre to post training as shown in Figure 1. Repeated-measure MANOVA was used to further support that significant behavior improvement in both ADHD symptoms. In the second part of the study, both hyperactive and inattentive symptoms continued to decrease as shown in Fig-

Figure 1. Mean Score of ADHD symptoms reported on the questionnaires from pre and post training.

Figure 2. Mean Score of ADHD symptoms reported on the questionnaires from post training to follow-up point.


Conclusions

The results of this study provide evidence supporting the use of neurofeedback combined with metacognitive training as an effective intervention for ADHD. In addition, this study demonstrates that the decreases in ADHD symptoms seen after training last for at least one year following training.

About the author: Wence Leung is currently a doctoral Clinical School Psychology student at the University of Alberta. Upon completion of her undergraduate degree at the University of Waterloo (2005), she started working in the ADD Centre as a neurofeedback trainer. With the inspiration from Drs. Michael and Lynda Thompson, Wence pursued her first Master’s degree in Educational Psychology at the Chinese University of Hong Kong in 2006 and her second Master’s degree in Clinical School Psychology at the University of Alberta in 2009. With the support from her wonderful supervisor (Dr. Jacqueline Pei), her inspiring mentors (Drs. Thompson), and the supportive staff from the ADD Centre, she successfully completed her thesis, which focused on evaluating the long-term impact of the combination of neurofeedback and metacognitive training on children with ADHD. In her doctoral years, she decided to extend on her Master’s thesis to further investigate the impact of neurofeedback with the ADHD population.

References


University of Tennessee Clinical Neuroscience and Biological Psychology Lab

The clinical neuroscience and biological psychology lab at the University of Tennessee exists as an interdisciplinary approach to unite various disciplines into its research objectives under the direction of Dr. Rex Cannon and Dr. Debora Baldwin. The lab serves to investigate a spectrum of foci including connectivity and reliability of quantitative EEG (qEEG) phase, coherence, and current source density. Spatial specific LORETA Neurofeedback is also a prominent research goal, which has been administered in many clinical subjects with comparisons (of neurological features) assessed among normal populations as well. We have conducted studies involving negative schema and self-perception, qEEG reliability, neurofeedback in clinical populations, physical properties of depression, and physical properties of the implementation of an ATP protocol treatment (cortisol and neuronal activity). We are also interested in the HPA axis and stress response as measured by salivary cortisol. Furthermore, the lab works in adjunct with a neuroscience component of the University of Tennessee Medical Center; much of this research relates to neurocognitive testing among various clinical populations.

Dominic DiLoreto

I have been active in research at the University of Tennessee for quite some time. Much of my research pertains to the morphology of working memory, which was presented at the International Society for Neurofeedback and Research (ISNR) conference in 2011, and I am currently working on the manuscript for the Journal of Neurotherapy. This involves seven regions of maximum change, correlated to change working memory scores due to neurofeedback. The seven regions were correlated based on each frequency band, task, and the region itself. This work demonstrates the importance and role of networks within the brain and brain plasticity.

I have also recently presented the effects of self-regulation on anxiety in the Comparative and Experimental Medicine for Public Health (CEMPH) symposium at the University of Tennessee with plans to present on a similar topic at the ISNR conference in 2012. This is a portion of a more in-depth neurofeedback study of self-regulation and its effects on psychopathology. This neurofeedback training for self-regulation has been applied to many different clinically diagnosed disorders (addictive disorders, ADHD, BD, BPD, GAD, MDD, Asperger’s syndrome), as well as normal populations. We have seen vast improvements in most individuals (including the normal group) in executive function. This training also results in a reduction in several subscale PAI scores.


More recently, I have been focusing many of my studies and master’s thesis on anxiety, mainly involving research on the neural correlates of anxiety. My thesis aims to further distinguish anxiety from fear by focusing on essential forms of anxiety in a normal population, while also comparing this with stress response as measured by salivary cortisol. The purpose of this is to determine typical levels of anxiety, which will serve to compare a normal individual’s anxiety with pathological anxiety and other forms of stress such as fear or a startle response, which we will examine in the future.

Sherman M. Phillips III

My research foci involve the integration of the concept of “self” with biological psychology, neuroscience methods, and neurophysiology to examine the capability and capacity of biofeedback (physical and psychological). My variables of interest include EEG LORETA and heart rate variability as measures of self-regulation in response to stress and other physical and psychological impairments as well as direct and indirect effects of biofeedback (physical and psychological) on the brain and body systems to identify cross-system (brain-body) relationships as a result of localized biofeedback treatment.

Previously, we assessed quantitative EEG and LORETA source localization, using a repeated measures design to analyze the underlying relationship between cortical activity and functional connectivity associated with logic and deductive reasoning. Presently, we are utilizing qEEG and LORETA source localization, alongside hypothalamic-pituitary-adrenal (HPA) axis activity to facilitate real-time inquiry into active, cortical regions of interest (ROI) and stress reactivity associated with logic and deductive reason. Plausible interpretation of the data may denote the importance of low frequency bands and/or stress in information retrieval and network integration of syntax, semantics, and other executive processes as a function of deductive inference decision-making in the AC, PFC, and PCC.

Additionally, we are also investigating state dependent MDD utilizing a novel multimodal line of inquiry into self (self-
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perceptual and self-referential processing), self-regulation (cognitive, affective and behavioral) and human psychopathology (state dependent MDD). The objective of this study is to investigate the functional connectivity and modulation of ANS-CNS systems and self-referential processing in relation to state dependent MDD. More specifically, this study will describe and compare sympathetic and parasympathetic activity (vagal tone), along with hypothalamic-pituitary-adrenal (HPA) axis (cortisol) and cortical activity in clinically diagnosed depressed participants (clinical group) and non-clinical (normal) controls.

We are utilizing continuous qEEG and HRV modules along with stress hormone cortisol and psychometric self-report (SPESA, DASS and PANAS-X) serving to inquire and reflect internal and external state dependent MDD abnormalities across three domains: cognition, affect (emotion) and behavior to examine brain-body mechanisms underlying subjective stress reactivity and self-referential processing in clinically depressed participants and non-clinical controls. This study is also investigating the relationship between self-referential processing and self-affect regulatory dysfunction, along with assessing self-relevant central-peripheral or CNS-ANS (i.e., brain activity, vagal tone and salivary cortisol) responses as biomarkers of state dependent MDD.

**Tiffany Shaw:**
I have rather broad research objectives that will ultimately allow me to merge neuroscience with direct educational and clinical applications. I am interested in a spectrum of criteria in hopes to engage in research that will offer to promote more beneficial outcomes for individuals struggling with psychological disorders, educational delays, and disorders of the brain and nervous system.

My current project includes a comparison study, which attempts to distinguish between the effects of a recently developed α-protocol designed for improvements in self-regulation and LORETA neurofeedback training of the α-frequency in the precuneus with the same function. This study assesses both clinical and research applications. Concentration of both protocols lie in the left parieto-occipital cortex. The study consists of both children and adults (in both groups) with ADHD. The initial group received 20 sessions of the alpha protocol two to three times per week; this was contrasted with participants who underwent the LNFB protocol over 15–20 consecutive weekdays. Results reveal similarities and differences specific to each protocol, with LNFB appearing to influence specific networks more finitely. Considering that neurofeedback, in general, operates under the auspices of neuroplasticity and a neural-efficiency model, we have found that differences between topographical and LORETA neurofeedback exist and should be investigated further, which will serve as a post-investigation within the lab.

A second research objective that I am working on amalgamates neuropsychology directly with clinical practices. This work extends from research at Cole Neuropsychology Center. Here, I direct neurocognitive testing in the Multiple Sclerosis (MS) clinic. This mainly involves the evaluation of patients’ performance on cognitive tasks as well as depression indices. Finding significant correlations between cognition and depression, I assessed lesions in the anterior and posterior cingulate through ranking of MRI scans as lesion positive or lesion negative. This research reveals connections between neurocognition, depression, and lesion sites in MS patients.

Considering the prior study served as an exploratory screening of potential lesions sites to focus on for volumetric studies associated with depression and neuropsychological functions, future goals are to draw volumetric correlates of cingulate lesions and diffusion network...
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Attention dysfunction in autism has been a subject of extensive study since it was first noted in the original descriptions by Leo Kanner (1943). Deficits in multiple types of attention functions have been demonstrated in the autistic population, including selective attention, sustained attention, and shifting attention (Allen & Courchesne, 2001). We evaluated visuo-spatial attention in autistic children and age matched control subjects using a variation of the Posner cued spatial attention task. The aim of the study was to investigate differences in behavioral response measures (such as reaction time and error rates), as well as frontal and centro-parietal ERPs between the two groups.

Methods

Children with ASD were recruited from Weisskopf Child Evaluation Center at the University of Louisville. Twenty-one autistic subjects were able to comply with the EEG recording procedure and completed the task. A group of 20 age-matched typically developing children also completed the same task. In the Posner cued spatial attention task, the subjects responded by indicating the position of the stimulus “X” (Figure 1). Before the stimulus appeared, the subjects were “cued” by a red box, which directed the subject’s attention to that side of the screen. In congruent trials, the cue appeared on the same side of the screen as the subsequent target (80% of the trials), while in incongruent trials, the target appeared on the opposite side (20% of the trials). This task required the subjects to disengage attention from one point, shift attention to a new spot, and reengage attention at the new location (Posner, Cohen, & Rafal, 1982). The analysis of EEG data concentrated on ERPs of interest including early (N100, P200) and late (N200, P300) components at the frontal and centro-parietal areas, which are thought to reflect spatial attention processes. Behavioral data analysis included comparison of reaction time and number of errors between groups.

Results

Reaction time and errors were analyzed for each condition. The horizontal and diagonal conditions did not show significant differences within groups and were therefore combined for analysis of behavioral data. In both the congruent and incongruent conditions, the ASD group had higher RTs (367 vs. 403 ms in congruent, 409 vs. 501 ms for incongruent), though the result did not reach significance. The number of errors was significantly higher in the ASD group in congruent condition (1.1 vs. 11.7 t = 2.33, p < .05), but not in incongruent condition (0.7 vs. 5.0 t = 2.05, p = .06). Analysis of ERPs revealed higher amplitude of the frontal N100 component in the autism group in the diagonal condition in the right hemisphere (-0.82 vs. -2.70 μV F = 3.88, p = .40). In addition, the amplitude of the posterior N2b component was higher in the autism group in the horizontal
congruent condition (F=4.52, p = .041) in both hemispheres. The P3b component showed differences between ASD and CNT groups at the midline (F=5.38, p=0.026) and at the left hemisphere (F=4.80, p=0.035) in invalidly cued diagonal target condition and was significantly prolonged in the ASD group.

**Discussion**

The ERP differences observed at the frontal sites indicated possible fronto-executive deficits in the autistic group. The ERP data corroborated with behavioral response measures showing prolonged latencies of evoked responses in autism. Though spatial attention dysfunction is not considered a core symptom of autism, it has important implications for autism since abnormal attention can prevent autistic individuals from properly engaging with the outside world, and puts them at a disadvantage for learning higher-level cognitive skills including language, social cognition, and other behaviors. Quantitative EEG measures including ERPs are an informative tool for analysis of neural deficits resulting in attention impairments in developmental disorders such as ASD and ADHD. In the future we plan to include ADHD as a contrast group to understand the differences underlying the neural deficits between Autism and ADHD.

**References**


**About the author:** I have been interested in psychology for as long as I can remember; and in the last four years I have been able to become an active participant in research. Throughout my undergraduate studies, I have worked in labs of diverse interests, including infant psychology lab, bio-imaging lab, and cognitive neuroscience lab. My main interest has been studying developmental disorders, specifically attention processes and emotional reactivity in children with autism and children with ADHD. Through my experiences, I have learned much about designing experiments, implementing and analyzing EEG recordings, and psychophysiology. Last year, I was able to share the results of our lab’s studies at the ISNR conference, and as a student, I am grateful for the support of ISNR and its members. This fall I will begin the doctoral program at the University of Louisville, and plan on continuing my research as I work towards a PhD degree in the Department of Anatomical Sciences and Neurobiology. Drs. Casanova and Edelson were mentoring me in this study.

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**Student Research at the Institute of Medical Psychology and Behavioral Neurobiology**

**Sarah Wyckoff**

Since 1993, Prof. Dr. Niels Birbaumer has been the director of both the Institute of Medical Psychology and Behavioral Neurobiology and the Magnetoencephalography (MEG) Center at the University of Tübingen. The Institute has focused on the investigation of restorative and assistive applications of neurofeedback therapy and brain-computer-interfaces (BCI) for the last two decades. The early research of Birbaumer and colleagues at the University of Tübingen focused on the operant conditioning of EEG brainwaves (Lutzenberger, Birbaumer, & Steinmetz, 1976) and slow cortical potential (SCP) activity (Birbaumer, Roberts, Lutzenberger, Rockstroh, & Elbert, 1992; Elbert, Rockstroh, Lutzenberger, & Birbaumer, 1980). The discovery that SCPs and other brainwave components could be classified, conditioned, and retrained led to the investigation of therapeutic applications for symptom reduction in patients with treatment resistant epilepsy (Kotchoubey et al., 2001) and attention-deficit/hyperactivity disorder (ADHD; Leins et al., 2007; Strehl, Leins, Goth, Klinger, & Birbaumer, 2006), as well as for thought translation and enhanced communication through BCI in patients with amyotrophic lateral sclerosis (ALS; Kübler et al., 2001). Current projects under investigation at the institute have extended the early research findings and have expanded to include collaborations with Hertie Institute for Clinical Brain Research, Centre for Integrative Neuroscience, and the Max Planck Institute.

Doctoral researchers working at the institute come from a variety of educational backgrounds including psychology, medicine, neuroscience, computer science, engineering, biology, and physics. Current projects focus on the investigation of EEG, SCP, near-infrared spectroscopy (NIRS), and real-time functional MRI (rtfMRI) neurofeedback, as well as BCI applications for clinical populations and peak-performance training through EEG neurofeedback and transcranial direct current stimulation (tDCS). To summarize the methods under investigation, neurofeedback is the practice of providing sensory feedback in an operant conditioning paradigm to modify or enhance the activity of the central nervous system, including EEG, event related potentials, SCP, and blood oxygenation level-dependent (BOLD) signal. EEG neurofeedback provides feedback of traditional frequency bands such as delta, theta, alpha, SMR, and beta, while SCP neurofeedback focuses on the conditioning of negative and positive polarizations in EEG activity of around 0.01 Hz. SCP shifts are hypothesized to play a critical role in the preparatory distribution of sensory, motor, and attentional resources and to reflect the regulatory mechanisms of cortical activation and inhibition. NIRS and rtfMRI applications focus on the operant conditioning of the hemodynamic response and cerebral blood flow. For neurofeedback applications, individuals are provided information related to changes in cerebral blood flow, specifically concentrations of oxyhemoglobin and deoxyhemoglobin of BOLD signal. The tDCS neurostimulation technique involves passing a constant, low current signal of 1 mA between a pair of water-soaked sponge electrodes fixed to the head. The applied current increases or decreases the neuronal excitability in the specific area being stimulated based on the type of stimulation being used, either anodal or cathodal, respectively.

Several neurofeedback studies in progress focus on the treatment of ADHD and psychopathology of violent offenders. Under the supervision of Ute Strehl, Sonja Keller and her team are contributing to a multi-center investigation of the efficacy of SCP neurofeedback compared to EMG training for the reduction of ADHD symptoms in children aged 7-9 years old. Starting in 2009, the workgroups in Tübingen, Mannheim, Göttingen, and Frankfurt began training 144 patients with 25 sessions of SCP or EMG sham feedback. For a review of the study protocol, see Figure 1. Anna-Maria Werner is also investigating the efficacy of NIRS feedback for the reduction of ADHD symptoms in this age group. Since 2010, Kerstin Mayer and I have been investigating the application of theta-beta feedback and SCP training for the treatment of adults with ADHD. In a pilot study, 12 adults with ADHD completed 30 sessions of theta-beta neurofeedback, and in the most current investigation, 20 adults with ADHD are participating in 30 sessions of SCP neurofeedback. Both studies are near completion and will report on pre-post neurophysiological changes in resting state EEG, P300, and CNV tasks, as well as behavioral changes in core ADHD symptoms. Following 15 sessions of SCP training, a preliminary investigation indicated a significant improvement in self-ratings of ADHD symptoms and a trend of increased CNV mean amplitude (Mayer, Wyckoff, Schulz, & Strehl, 2012).
of physiotherapy and BCI training rewarding the desynchronization of SMR activity with contingent online grasping movements of a hand orthosis will be investigated. The data acquisition and training for these projects has concluded and the analysis and manuscript preparation are currently in progress.

Colleen Dockery examined the enhancement of planning abilities through the application of tDCS to the left dorsolateral prefrontal cortex during the Tower of London task. Investigation of performance during and after anodal, cathodal (1 mA, 15 min), and sham tDCS in 24 healthy volunteers was analyzed. The findings indicated anodal tDCS enhanced performance when applied in sessions following cathodal tDCS, whereas improved performance with cathodal tDCS applied during acquisition and early consolidation was observed when preceding anodal tDCS, but not in the later training session (Dockery, Hueckel-Weng, Birbaumer, & Plewnia, 2009).

Researchers Giulia Liberati and Linda van der Heiden focused their research on semantic classical conditioning and classification of emotional states for communication with patients with ALS and Alzheimer’s disease using fMRI BCI. Liberati et al. (2012) discussed research findings suggesting that involuntary brain signals, e.g., those related to emotional states, may provide useful information about the user, allowing for the development of “affective BCIs.” In their position paper, they propose a paradigm shift from instrumental learning to classical conditioning, with the aim of discriminating “yes” and “no” thoughts after associating them to positive and negative emotional stimuli respectively. This hypothesis has been tested in a group of healthy adults and the analysis and manuscript preparation is currently in progress.

Finally, Sergio Ruiz and colleagues investigated the application of rtfMRI neurofeedback to train patients with schizophrenia to achieve volitional control of the bilateral anterior insula cortex during a face emotion recognition task. Following a two-week training period, nine patients with schizophrenia showed a learning effect for the self-regulation of the bilateral anterior insula and recognized disgust faces more accurately and happy faces less accurately (Ruiz et al., 2011). The level of self-activation of the right insula correlated with improvements in disgust recognition and rtfMRI training led to an increase in the number of effective connections to the anterior insula.

This article summarizes several of the doctoral research projects currently under investigation at the Institute of Medical Psychology and Behavioral Neurobiology. This is only a snapshot and brief introduction to the work of my colleagues and fellow researchers. Several of the projects discussed have been funded through grants from the Deutsche Forschungsgemeinschaft (DFG) and Bundesministerium für Bildung und Forschung (BMBF). To contact the researchers highlighted, please refer to the publications when provided or feel free to contact me for additional information at wyckoffsarah@yahoo.com.

References


Integrating Norms-Based Neurofeedback into Psychophysiological Interventions

Linda Walker

As norms-based neurofeedback becomes increasingly accessible as a treatment tool, incorporating it into a full psychophysiological program makes a great deal of sense from the perspective of whole-person optimization. In other words, if norms-based neurofeedback—also known as Z-score neurofeedback—optimizes the brain, it would follow that the client will stand to benefit even more if other underlying physiological systems are also optimized.

Combining neurofeedback and biofeedback interventions is certainly nothing new. What makes the discussion relevant to Z-score neurofeedback, with its potential to train 248 metrics simultaneously over four 10-20 sites, is helping the client integrate feedback in a way that is helpful, and not overwhelming.

Z-Score neurofeedback is still in its infancy as a training tool, but preliminary case studies indicate adding this tool may help the brain stabilize and re-organize on a more complex level than achieved with simple amplitude training.

A Little Background

For those new to the training tool, Z-Score neurofeedback is the process of comparing and feeding back in real time a client’s EEG functioning with age-matched individuals who have a relatively “normal” history of neurologic function.

For the client, Z-score training unfolds much like standard neurofeedback training. Typically, individuals receive a positive sound, animation, and/or tactile sensation when their EEG functioning is within a desired range. With Z-score training, clinicians have more options for establishing thresholds according to the client’s symptoms and complaints, learning style, and treatment needs.

A basic training screen like the one below, using an advance version of Thought Technology’s Biograph 6.0, can be complex or simple, depending on the treatment and learning needs of the client, as well as the preferences of the clinician. In this case, the client views a very simple screen, but the clinician screen contains more data relevant to tracking progress.

Clinicians can train up to four 10-20 sites at a time in measurements (or metrics) of absolute power, relative power, ratio, coherence, asymmetry and phase. For four sites, that’s 248 metrics over eight standard bandwidths.

In the example above, feedback is given when the trainee meets two parameters—functioning within 1.5 standard deviations of all 248 metrics 90 percent of the time, and when a group of specific metrics identified by the therapist also shows movement toward zero standard deviations. For example, clinicians may choose to target specific metrics, such as absolute power theta or high beta, based on an assessment that shows these areas far outside the norm and contributing to an individual’s symptoms.

There is presently one database—the Normative Lifespan Database—that provides for real-time training. Clinicians can purchase this from Applied Neuroscience to add the functionality of Z-score training to their existing biofeedback platform. For a more detailed discussion of the database and how it is used to create real-time feedback, the following article by Dr. Robert Thatcher provides the technical foundations and can be accessed on the Applied Neuroscience website: http://www.appliedneuroscience.com/Z%20Score%20Biofeedback.pdf.

While Z-Score neurofeedback is a powerful intervention in itself, enhancing it with the addition of breath work, EMG training, heart rate variability, or other biofeedback interventions may be just what’s needed to help treatment proceed effectively. Clients particularly benefit from learning mindful awareness through psychophysiological training as a way to help facilitate norms-based neurofeedback more fully.

Creating the Intervention

How clinicians decide to integrate Z-Score neurofeedback with other physiological modalities—or even traditional EEG training—always begins with a thorough assessment of each individual’s symptoms, complaints, treatment needs, and learning style. In my own practice, that assessment process typically includes quantitative EEG, psychophysiological stress assessment, self report, clinical profile, and continuous performance assessment. Clients with chronic pain may receive pain inventories and EMG assessments. Referrals to help clients optimize nutrition, exercise, and supplementation are also key.

For purposes of Z-Score intervention, I want to understand the EEG functions common to most pre-neurofeedback assessment—where the EEG is dysregulated, what compensatory processes may be present, and how the EEG presentation fits with the pattern of symptoms and complaints.

While a Z-Score assessment doesn’t replace a comprehensive qEEG, clinicians who do not have access to equipment may find that in some cases a four-electrode assessment provides an economical adjunct that offers rich information to more traditional non-normed measures like absolute power. Additionally, for clients who cannot tolerate a 19-electrode measurement, a four-electrode assessment might be a helpful alternative.

As an example, one recent client whom we will call Michelle, a college-aged young woman who struggled with ADHD, lifelong learning difficulties, anxiety, and tension headaches, had a qEEG assessment that showed excess theta frontally in the eyes closed condition. Unfortunately, her eyes-open record was so challenged with muscle

Figures 1 & 2

An example of a general Z-score training screen; clinicians can train multiple parameters, yet keep feedback direct for the client.

A Z-score training screen showing the menu system used to quickly target and train Z-scores. Clinicians can choose specific metrics or a combination of metrics to create a customized training protocol.
tension it was not usable.

In this case, Michelle had much less difficulty with four electrode placements, and the four-channel assessment helped confirm the findings. Following is an example of Michelle’s eyes open functioning using Z-Score assessment, which was instrumental in confirming the presence of theta in the eyes open condition.

Real-time Z-Scores are not quantified in the same way as in qEEG, so values that are significant can appear much smaller. In this case, theta that is 1.5 standard deviations outside the norm in Z-score assessment could appear to be up to 3 S.D. outside the norm in a standard qEEG map.

Note that metrics outside of the defined range (in this case +/- one standard deviation) are displayed in red. Raw microvolt means for each site is displayed, as well as an index percentage that allows a clinician to isolate and target which measures (absolute power, relative power, power ratio, coherence, asymmetry, or phase) may contain areas of weakness.

In addition to measuring dysregulation in the EEG, psychophysiological assessment isolates areas in which stress response may contribute to a client’s complaints and can illuminate how a client may respond to the neurofeedback process as they encounter barriers to success. Michelle’s assessment below confirmed excess muscle tension in response to stressful tasks in addition to ragged, irregular breathing patterns.

For Michelle, the EMG artifact I encountered in the qEEG alone presented a strong case to build an integrated psychophysiological approach. She needed to address a spectrum of learning and attention issues and isolate specific functional difficulties in the EEG. Training in frontal areas prone to muscle artifact would be critical. To be successful, she also needed to become aware of and reduce the muscle tension in her forehead and to develop a strategy to deal with stress before it fed her anxiety.

I’ve seen clients like Michelle often in the office. They learn about mindful, relaxed observation and yet in the spite of the coaching, I watch them observing the neurofeedback screen with their shoulders scrunched, brow furled and holding their breath as they try to make the animation move!

In addition to psychotherapy, EMG, and heart rate variability training, Michelle’s neurofeedback intervention included monitoring for raw EMG on the frontalis.

Below is an example of a Biograph Infiniti 6.0 Z-Score training screen combined with EMG. In addition, automatic artifacting can be added to stop feedback any time the EEG functioning is outside parameters specified by the clinician. Feedback resumes when the EEG is within specified parameters for both high and low amplitude (muscle tension and eye blink) artifacts. These interventions can make training at frontal and temporal sites more practical.

For Rita, who was working to recover from a head injury, chronic pain, and post traumatic stress, breath work became a key element to integrate with norms-based training. For most clients, optimal, consistent breathing creates an ideal co-intervention.

The direct impact of respiration and heart rate variability training on z-score neurofeedback has not yet been elucidated through research, yet a good deal of compelling literature suggests optimal breathing may contribute to better attention and cognitive function, regulate anxiety, and promote homeostasis by providing a steady supply of oxygen to the brain for metabolism of glucose and maintenance of pH balance in the blood (Gevirtz & Schwartz, 2003; McCraty, Atkinson, & Tiller, 1995; Moss & Schaffer, 2006; Reiner, 2008; Stein & Kleiger, 1999; Thayer & Friedman, 2002; Zucker, Samuelson, Muench, Greenberg, & Gevirtz, 2009).

For breath work, spending several biofeedback sessions shaping the breath and focusing on slow, consistent diaphragmatic breathing prior to initiating neurofeedback helps trainees learn the skill and sets the stage for a favorable neurofeedback experience. When a trainee learns he can control heart function by adjusting the way he breathes, changing brain function doesn’t seem like such a foreign concept.

In addition to pre-treating with biofeedback, having direct physiological evidence present on the screen during neurofeedback may help the client understand the impact of breathing on the brain at the moment training unfolds.

The critical task for the clinician is to facilitate physiological feedback in a way that does not interrupt z-score neurofeedback or overwhelm the client. While the brain appears quite able to meet 248 metrics in real time, having too many other instruments or tasks simultaneously may seem too taxing to the client psychologically.

For Rita, quieting the breath became her strategy for becoming more successful with Z-Score neurofeedback. When she became stuck, a gentle prompt to temporarily direct her attention to the on-screen pacer and remember her breath helped Z-score feedback resume with greater success. In these scenarios, the trainee is instructed to observe the Z-score feedback, but if they find they are struggling to maintain presence with the training, they may wish to temporarily direct their attention to the physiological feedback.

For individuals with attention problems, the need to limit instruments on the training screen may mean bringing out physiological feedback in limited periods. In these cases, the clinician may decide to display a physiological instrument for a short period of training to help the client become initially centered. Then physiological feedback can be absent as z-score training unfolds, or it can be brought back out as a prompt.

Finally, shifting the session to physiological feedback that occurs between three to...
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<td><strong>Fall 2012 Webinar Series</strong></td>
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<td>Elena Labkovsky, PhD, Joel Lubar, PhD, Don Cooper, PhD</td>
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- 1b: LORETA Theory |
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<th>Joel Lubar, PhD</th>
<th>Barry Sterman, PhD</th>
<th>Jay Gunkelman, QEEGD</th>
<th>Don Cooper, PhD</th>
<th>David Hagedorn, PhD</th>
<th>James Thompson, PhD</th>
<th>Michael Lindon, PhD</th>
<th>Cynthia Kerson, PhD</th>
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five minute Z-score training periods can help trainees rest and renew their inner resources.

Only in rare cases—as in working with Michelle’s EMG—have I found combining a reward for physiological and z-score performance into a single animation or sound reward to be useful. The EEG of individuals included in the Normative Lifespan Database was originally recorded in a relaxed state and not under task. Clinicians will want to use care to avoid placing a trainee under task by a particular physiological feedback intervention.

Following are examples of Z-score training integrated with breath work. For Rita, a pacer was helpful even after she completed a course of HRV training. Some clients periodically benefit from seeing the inter-beat interval of their heart and respiration along with training, as long as the information does not distract from Z-Score training or overwhelm the trainee.

In the screen above, the inter-beat interval of the heart in red and respiration in blue are shown in the same instrument. They are not connected to a feedback reward, but they serve to inform the trainee about their functioning.

Above, the Z-score feedback displayed along with the pacer allows down-training of specific problem metrics while also requiring that a global index of norms fall within a specific range. In a case like Rita’s, in which excess low alpha and theta predominated in the occipital and parietal areas, having more than one Z-Score training parameter made sense. Rewarding any occurrence in which the slowing decreased also helped shape the EEG more effectively.

Since Rita had a habit of holding her breath when she was looking intently at neurofeedback screens, both a pacer and music designed to help trainees follow a consistent respiration pattern cued her to breathe and created less interruption that my verbal prompts.

In both cases, the psychophysiological assessment and training enhanced the treatment process and helped it proceed more efficiently. Both clients reported more instances of self awareness in ways they would not have experienced without the combination of Z-score neurofeedback and integrated psycho-physiological intervention.

As Z-score neurofeedback continues to mature as a treatment tool, more research will be helpful for therapists hoping to effectively direct combined Z-score neurofeedback and biofeedback interventions. The potential is to give trainees a highly-tailored intervention to promote self regulation.

Linda Walker, MHR, LPC, BCB, BCN, is a doctoral student in the psychophysiology program through University of Natural Medicine and has a small private practice in Traverse City Michigan. She also teaches and consults in the areas neuroscience and biofeedback.

References


In Memoriam: Dr. Ernst Niedermeyer, 1920–2012

Faye Mc Nall, R.EEG T, M.Ed.

It is a great honor to be asked by the editors of NeuroConnections to contribute an article about the life and contributions of Dr. Ernst Niedermeyer. It was a privilege to know him and to call him a friend. He was an ardent supporter of neurodiagnostic technologists and ASET: The Neurodiagnostic Society. What many people don’t know about him was that he was an accomplished pianist and avid mountain-climber. He climbed over 144 mountains during his lifetime, and since he spent his youth in Austria, many of these were in the Alps.

I first met Dr. Niedermeyer at an ASET meeting, many years past. He often agreed to travel at his own expense to give a lecture for a course or present an abstract at the ASET annual conference. He was always very approachable and willing to talk to technologists, so it was quite easy to meet him and strike up a conversation.

I recall the ASET meeting in Norfolk, Virginia in 1999, when I attended the ASET president’s reception one evening in a hotel suite. Dr. Niedermeyer was also an invited guest. There was a grand piano in the suite, and Ernst sat down and began to play classical music like a professional pianist. He was so talented and the life of the party!

When I became director of education for ASET in 2004, I had the opportunity to work with him professionally, as I planned content for our meetings. He never used e-mail for communication. I have saved and filed all of the letters he wrote to me regarding the lectures we were planning, and the hand-written thank you notes for every post-meeting faculty letter that I sent to him. We also often spoke on the phone, and he insisted that I call him by his first name, and when I slipped up, he would correct me, saying, “Please call me Ernst!”

Technologists flocked to Dr. Niedermeyer at meetings, and there are many pictures out there of Ernst surrounded by a bevy of smiling attendees. He always had time to speak to each person who approached him, asking their names, listening carefully, responding to questions. He was a brilliant physician and a well-read man with diverse interests, a charming conversationist with a personal history that was as fascinating as a novel. He could tell very interesting stories of his past, with details that he never forgot, and never dwelt on the negative aspects of the challenges he faced.

When I told Dr. Niedermeyer that I wanted to present an abstract about his life and contributions to the field of neurology, at the 2010 Congress of OSET: The International Organisation of Societies for Electrophysiological Technology, in Bielefeld, Germany, he laboriously typed up a thirty-page manuscript with his autobiography and a list of all of his publications, totalling 243! He mailed these materials to me, along with his original historic photographs, some of his parents and grandparents, and his early years. I was astounded that he entrusted these personal treasures to me, so that I could make slides of all of them.

I will now share the story of his life with you and try to highlight his many contributions to neurology and neurophysiology.

Ernst Niedermeyer was born in 1920, in Schoenborg, Germany, which was in the province of Silesia, once part of Prussia, and now part of Poland. His mother was born in Breslau, now Wroclaw, Poland, and his father was born in Vienna, Austria. His father was a brilliant scholar, holding three doctoral degrees in science, medicine and jurisprudence. His parents were married in 1916, and his father first worked as a country doctor and then an obstetrician. He had special interest in social hygiene and medical ethics. Ernst did not enjoy the benefits of a loving paternal relationship with his father, and as a child, he found his father’s frequent violent outbursts of temper to be frightening. However, he did wish to follow in his father’s footsteps and become a physician. The Nazis came to power in Germany in 1933. His father relocated to Austria soon after this event, because he disagreed with the new racial laws and forced sterilization of the disabled. In March of 1938, the Nazis invaded Austria, and his father was sent to a concentration camp, from which he was eventually released. As a teenager, Ernst also found out that his father’s mother was brought to a concentration camp, from which he was eventually released. As a teenager, Ernst also found out that his father’s mother was brought up in Budapest and was Jewish, but he had no contact with this branch of the family until he was fifteen. He met his cousin, who was a few years older than Ernst, when he visited them in Budapest. He was so impressed with his cousin that he chose him as a role model, and since his cousin was gifted with musicality, Ernst followed him in his love of music, especially the works of Chopin.

In 1938, Ernst finished prep school while his father was still in captivity. As a German citizen, he was conscripted to serve a two-year term in the military. In 1939, at the start of World War II, while he was still in the German military, he was sent to Vienna to study medicine because they desperately needed physicians. However, in 1943, his education ended abruptly, when he was removed from the program, deemed racially tainted and politically unreliable, due to his family history. He was then sent to the Soviet-Ukrai-
understand instrumentation theory. A quote from his notes reads: “A self-taught EEGer! Shamefully, I remember those reports of mine!” But he prevailed and determined to become a skilled interpreter of EEGs.

In 1960, Dr. Rex Ingram, an internationally recognized neuroanatomist from the University of Iowa visited Innsbruck. Dr. Ingram had been working with Dr. John Knott, and they were in desperate need of a junior faculty electroencephalographer. Dr. Niedermeyer was offered the job. The Niedermeyers had four children by then, and the family moved to Iowa to start a new life. A fifth child was born later, in America.

Dr. Niedermeyer learned much from working with John Knott, but found him to be a “difficult superior to work for.” He also met another famous EEGer, Dr. Charles E. Henry, who was a lifelong friend of Dr. Knott. It was Dr. Henry who suggested that Dr. Niedermeyer take on the role of Director of EEG at Johns Hopkins Hospital in Baltimore in 1965. He remained at Johns Hopkins until he retired in 1997.

Over the years, Dr. Niedermeyer was a prolific writer of articles for various journals, mostly Clinical Electroencephalography and the American Journal of Electroencephalographic Technology. He also wrote books on the epilepsies. In 1978, he was invited to edit a comprehensive textbook of EEG, Electroencephalography: Basic Principles, Clinical Applications, and Related Fields. He invited Dr. Fernando Lopes da Silva, a famous neuroscientist from Portugal to be co-editor. There were many authors contributing, but Dr. Niedermeyer wrote a third of the original book. This book did very well, and is now in its sixth edition. As he became internationally recognized, he was elected president of the American EEG Society in 1990. He also served as medical editor of the American Journal of Electroencephalographic Technology from 1983–1991.

He became interested in ultra-fast EEG frequencies after digital EEG made it possible to record these frequencies. He investigated the range of 80 to 1000 Hz. signals and their significance in epileptogenesis and neurocognitive functions.

He was very honored when, after his retirement, a symposium in his honor was held at Johns Hopkins. He presented a paper entitled A Concept of Consciousness. In the years following retirement, he remained active, editing the 2005 edition of his textbook, Electroencephalography. The sixth edition of this book was published in 2011. In 2006, he presented a new concept in the cause and treatment of Alzheimer dementia, related to the cerebral blood flow, improved by a simple, head lower than body positioning on a daily basis. He practiced this himself, and he certainly kept an agile mind as he aged. When I last saw him, four months before his passing, he was witty, charming, reflective and very interested in current events.

Dr. Niedermeyer was a pioneer and an adventurer, and he contributed so much to so many! It was a pleasure to know him, and to have the opportunity to share his life story with readers.

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Using a Comprehensive Neurodiagnostic Evaluation to Develop an Individualized Treatment Plan for a Client with Multiple Diagnoses: A Case Study

Part II of IV—See the Spring 2011 issue for Part I

Linda Brownback, MA

Introduction

Neurotherapy professionals determine what training program to utilize with clients in a variety of ways. Underlying those decisions are paradigms that are the foundation of the decision tree. This case study demonstrates a decision flow based on a paradigm that asserts that customizing the training program to the individual through the information gained in a comprehensive neurodiagnostic evaluation is ideal, especially if the client has multiple diagnoses.

Background

Andrew was an eight-year-old boy whose parents brought him to us for several reasons: firstly, they preferred a non-drug treatment approach; secondly, even if they were open to medication as a solution, they suspected that a number of his problems were not amenable to medication; and thirdly, given the multiplicity of his problems they preferred an approach that could potentially treat all of his problems in a comprehensive manner, rather than seeking help from a number of professionals for varied treatments.

When potential clients call to learn more about our neurofeedback services, knowing that they are likely to be doing Internet searches, I educate them on the various approaches to training. I explain that one model is based on the paradigm that there is a single underlying mechanism in the brain that, if rewarded through neurofeedback, can result in varying degrees of remediation and/or amelioration of dysregulation and/or unwanted behaviors. Another approach to treatment planning seeks to identify various disorders by their specific neurodiagnostic characteristics, and to match that disorder with a specific neurofeedback training program. A third paradigm, which we support, asserts that the most powerful treatment is based on a comprehensive analysis of the individual’s brain function that systematically examines each person’s presenting symptoms, medical history, and quantitative brain activity, within a systematic neurophysiological framework, resulting in a fully-customized training program. Given the complexity of Andrew’s difficulties, his parents appreciated our paradigm and chose to bring him to our office for neurofeedback.

Our comprehensive neurodiagnostic evaluation process consists of four parts. The quantitative Electroencephalogram (qEEG), or brain map, is part one. Part two involves completing the online Comprehensive Neurodiagnostic Checklist (CNC-1020), filling out an intake, and having a consultation to review the intake and to discuss any significant discrepancies between the various raters on the CNC-1020. Part three is completing a battery of standardized psychoeducational tests. Incorporating components one, two and three allows for the most in-depth, comprehensive and accurate neurodiagnostic evaluation possible, enabling us to match problematic cognitions, emotions, and behaviors with dysregulation in brain function. This information then allows us to create a very fine-tuned, highly personalized neurotherapeutic intervention. When all of this information is integrated and analyzed, the fourth part is a review session with client and support persons (or, if the child is too young, just the parents) to explain the findings and to make treatment recommendations.

Intake Interview

The intake form asks a breadth of questions on familial/genetic medical history, client’s medical history, client’s prenatal and neonatal development, and a series of rule-out questions on diagnoses, such as scotopic sensitivity syndrome or sensory processing disorder. On the intake form and in the intake consultation, Andrew’s parents shared a picture of a young boy who was engaged in more off-task behaviors. Another major concern was that he was easily distracted and had difficulty sitting still.

Academically, Andrew had received remedial services since kindergarten for speech and reading; despite these efforts, now in third grade, he was still not performing at grade level. Teachers consistently reported that Andrew needed more one-on-one supervision and attention than the average student. They noted that he engaged in more off-task motor behavior than the average student. In addition, they reported “social skills issues,” including “problems with self-control in tattling,” looking for the teacher to help in problem-solving conflicts with other peers, and utilizing his teacher to “facilitate and initiate interaction with his peers.”

CNC-1020 Summary

The CNC-1020 is an online, 300-item symptom checklist that is completed by the client (if age-appropriate) and any support persons—parents, spouse, siblings, caregivers, etc., who would have relevant information regarding the client’s behavior. The raters use a 9-point scale with symptom severity scores.
In reviewing Andrew’s data, we found the history provided by his parents on the written intake form and their responses on the CNC-1020 questionnaire were largely in agreement. Nonetheless, their CNC-1020 responses did highlight several critical needs, which they hadn’t shared on the intake history form, and we were able to explore these further during our subsequent consultation interview with them.

When informed that their symptom report on the CNC-1020 indicated a problem with neurosensory integration, the parents said, “Oh, yes—he can’t throw and catch a ball well yet!” Additionally, it was only after we fed back to them their rating of Andrew as having speech difficulties that we were informed that he had been receiving speech therapy since kindergarten. Similarly, it was only after we highlighted Andrew’s elevated CNC-1020 score on the social skills scale that his parents remembered to share with us teachers’ observations about his difficulties in relationships with his peers. Closer examination revealed that among the items that his family strongly reported were “lack of eye-contact, excessive preoccupation with a particular interest, repetitive motor movements, focus on parts of an object, little interest in communicating with people other than expressing needs, and repeating special phrases.”

### Psychoeducational Testing

As a component of the neurodiagnostic process, Andrew completed a standardized psychoeducational test battery assessing a wide range of cognitive abilities and behaviors; the results are displayed on a series of International 10-20 System Placement diagrams, three of which are displayed in Figures 4, 5, and 6. On these diagrams, the higher the score, the more the particular neuropathology interferes with healthy functioning. Also, our battery of tests does not cover all of the neuropathologies: the dashes reflect that this particular neuropathology was not assessed.

The psychoeducational battery* Andrew took was:

- The Kaufman Brief Intelligence Test (K-BIT) (Kaufmann & Kaufman, 1990)
- The TONI-3, Test of Nonverbal Intelligence (3rd Edition)
- The TAPS-3: Test of Auditory Processing Skills (Third Edition)
- The TVMS-R: Test of Visual-Motor Skills (Revised)
- WRAT-3 Wide Range Achievement Test (3rd Edition)
- The Integrated Visual and Auditory Continuous Performance Test (IVA +Plus)

*For more information on the instruments and/or Andrew’s scores, please contact the author.

### qEEG Results

Due to Andrew’s inability to control eye movement, there was an inordinate amount of EMG artifact in the frontal EEG sites, which was manually removed as completely as possible. The edited eyes open and eyes closed data were analyzed using linked ear and Laplacian montages and compared to the following databases: NeuroGuide Lifespan Normative Database, the LORETA current density normative database from Applied Neuroscience, and the NxLink database. The progression of our analysis is: raw brainwave, absolute Laplacian and linked ears, relative Laplacian and linked ears and LORETA. We consider anything that is + or - 1.5 Z-scores above the norm to be significant. Due to space limitations, all of these data cannot be presented in this article; however, the full map is available at [http://isnr.org/neurofeedback-info/neuroconnections-newsletters.cfm](http://isnr.org/neurofeedback-info/neuroconnections-newsletters.cfm). Figure 7 is representative of qEEG results that correlated with Andrew’s problems.

### Training

From all the information generated by the neurodiagnostic process, we create a training protocol customized to the individual client. We begin with a problem that has significance to the client and support persons, one that is evident in the eyes open data, and one that involves downtraining, and, in a case like Andrew’s, a site that involves more than one presenting pathology. We begin with an eyes open condition to allow the client to connect with what is happening on the screen and his/
her own subjective experience of the training. (We utilize “Trend” for magnitude and Z-score training on the BrainMaster Atlantis 4X4 system (BrainMaster, Ohio, USA). We don’t use games, videos, etc.; we want clients to understand the connection between what is happening in their brain and what is happening on the screen.) We begin with down training because, in our experience, most clients find this task easier to perform. Therefore, Andrew’s first program was percent Z ok (PZOK the BrainMaster Z-score normalization training program) at Fz with eyes open, since Fz is a placement that has been implicated in distractibility, hyperactivity, and OCD.

Over the course of his first 15 sessions Andrew did the following programs, as well:
- T5,P3,Pz,O1, eyes open, PZOK for reading and listening comprehension.
- F3,Fz,C3,Cz, eyes closed, percent z ok for hyperactivity and OCD.
- Pz uptraining for 8–12 Hz for calming.
- Pz, eyes open, PZOK for OCD, reading perception.

While beyond the scope of this article, it should be noted that our training approach includes paying attention to basic healthy behaviors, including nutrition, exercise and diaphragmatic breathing.

### Results

Andrew began neurotherapy about one month after completing the neurodiagnostic process in July 2010. His father was in a serious accident in late September, so Andrew missed approximately three weeks of training in the early fall. We normally remap after every 20 sessions, but, for this article, Andrew had a remap done on December 28, 2010 after completing 15 sessions. Andrew’s eyes-open data in the beta frequencies is contaminated by significant temporomandibular tension. Of the qEEG data that could be compared pre and post training, there were 33 abnormalities that could be evaluated: overall, 91% of the abnormalities improved and 9% (3 abnormalities) remained unchanged. During the 15 training sessions, six of Andrew’s neuropathologies were targeted. For Distractibility, six abnormalities could be compared: four normalized, one improved by 2.5 sd and one improved by 1.5 sd. For Language/Listening, four abnormalities could be compared: two normalized, one improved by 2.5 sd and one remained unchanged. For Language/Reading, all four improved by 2.0 sd. For Comprehending Social Cues, all three improved by 2.0 sd. For Hyperactivity, four abnormalities could be compared: three improved by 1.5 sd and one improved by 1.0 sd. For Obsessive-Compulsive Disorder, of the twelve abnormalities that could be compared, 8...
five normalized, one improved by 2.0 sd., three improved by 1.5, one improved 1.0 sd and two remained unchanged.

Our typical remap also includes a retake of the IVA. There was a decline in performance on the visual Global Response Control Scale (and therefore on the Full Scale, as well, which we cannot explain). However, as Figure 8 demonstrates, there was significant improvement (15 quotient score points of change = 1 sd) on the Global Attention Scales, the Sustained Attention Scales and the Auditory and Visual Attention Subscales of Vigilance and Speed. In addition, Andrew’s pre-test score on the Visual Sensory/Motor Scale was so slow that he scored in the “Extreme Outer Limits” (59 quotient score), his quotient score was now 114, placing him “Within Normal Limits.”

Before actually beginning training, the client (if old enough) and the support persons who completed the CNC-1020 at the beginning of the neurodiagnostic process now receive the CNC-1020, Level 2. Level 2 consists of additional items for each of the highest six neuropathologies. The ratings from the CNC-1020 and now the CNC-1020, Level 2 are combined to create a customized checklist for each rater of the highest scoring items from the top 6 neuropathologies and any additional items that the rater scored high until a total of 50-60 items is reached, creating the Customized Tracking Checklist (CTC-1020). An email reminder to complete the online CTC-1020 is automatically sent to each rater weekly so we can track the client’s progress across raters.

Andrew’s mother and aunt (who is a teacher) participated in completing the CTC-1020. Table 2 shows the improvement in ratings for the top six neuropathologies from each rater for the “Other” category (all the additional highest scoring items) and for the total score. Also, Andrew’s mother emailed me at Christmas time about the differences people saw in him over the holiday. She stated, “Sarah (another aunt of Andrew’s) said that she saw a difference in Andrew, and both Andrew’s father and I noticed marked changes in him today at the party. His father remarked how he saw changes in Andrew’s behavior after being “reminded” by watching Joey, a very hyperactive child in Andrew’s class and social circle. A year ago, their behaviors were very similar.

We have typically seen this level of improvement for someone with multiple difficulties in only 15 sessions in our office. We believe strongly that this is due to not only our approach of creating customized protocols based on the neurodiagnostic process, but also because of our use of the CTC-1020. Before using the CTC-1020, we would learn of...
improvement when there were major changes or when a subtle change was so remarkable that the client or support person(s) felt compelled to share. We have also found that the client and support person(s) quickly forget previous life experience; as they change, life becomes easier, so often it doesn’t occur to them to comment. The CTC-1020 encourages people to note small changes, which, in turn, determines if we are headed in the right direction. Because of the power of customized protocols, clients often report changes after even the first session, and certainly by session three. Therefore, Mother reporting a 40% reduction (and Aunt, a 35% reduction) in Andrew’s OCD behaviors and a corresponding 27% and 22% overall improvement after 15 sessions is a typical outcome.

While there is more work to be done, we believe that this amount of improvement in such a relatively short period of time for a child with multiple problems demonstrates well the value of using a comprehensive neurodiagnostic process to formulate neurofeedback training strategies.

**Addendum**

Since this article was written, Andrew has completed the training. His mother emailed our office a follow-up note of appreciation that included the following: “Even though Andrew’s grades were never the reason we came, I wanted you to know that his grades have improved from B’s and A’s to A’s and A+’s. What matters to me is that he can do the work on his own. We used to spend three or four hours EVERY night together, struggling through his homework. You can’t imagine how freeing it has been to not have to do any more than most parents do in supervising their children’s homework (and to have his grades improve on top of that)! As I write this to you, I have tears in my eyes because it has made home life so much better to not have all of the tension and strife over spending hours to do the work, AND because Andrew wrote for an assignment in which he had to evaluate himself as a student: ‘I am proud of getting good grades. And I would give myself the grade of 95/100 on focus—I focus well!’ (Even the exclamation point is his! How do I say thank you for what you have done for him—for us?)”

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**Table 2**

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How can purchasers and users of neurofeedback equipment be sure what they are getting? Do they know the working principles, design elements, and performance details of their equipment? Is there a uniform standard that can be used to ensure uniformity of expectations and outcomes? Dr. John Nash, while president of the ISNR in 2009, asked these questions, and came up with an unfortunate “no.” In response to this need, he chartered a group to look toward establishing an industry standard that could pave the way to create uniform standards and recommendations for neurofeedback systems design, documentation, and training. The result of this effort has now been approved by the Institute for Electrical and Electronics Engineers (IEEE) in the form of a draft standard. In much the same way that standards ensure that your television or cable device works correctly, or that an MRI machine meets relevant requirements, this standard sets out criteria and recommendations for neurofeedback systems. It is intended for systems that comply with this standard to meet a minimum level of performance and understandability and that this will help to ensure uniform clinical experiences and outcomes.

A working group of the Institute for Electrical and Electronics Engineers (IEEE) has drafted a Recommended Practice Standard for Neurofeedback Systems, published in June of 2012. The standard was created based upon the initial efforts of John Nash, while president of the ISNR. John saw the need for a standard that could guide neurofeedback systems developers, as well as users, in ensuring the validity, quality, and understandability of neurofeedback devices and software, amid an ever-changing world of technology and methods. The committee was formed in 2010, and consisted of Chair Tom Collura representing BrainMaster Technologies Inc., Vice-Chair Howard Lightstone representing EEG Software, Marc Saab representing Thought Technology, Cynthia Kerson and Nancy Wighton representing the ISNR, Alan Pope from NASA representing the AABP, Klaus Schellhorn from neuroConn, and Sara Aguel and Michael Hoffman representing the US FDA. This standard was developed following the IEEE’s established procedures, and has been approved by the IEEE Standards Association as a recommended practice. The majority of the drafting work was done by Howard Lightstone and Marc Saab, but all group members contributed their time and expertise.

This standard includes nine sections describing recommended design, testing, and documentation. The major areas covered are general (regulatory, training, and marketing), system components, electrodes and sensors, data acquisition, software, computers, and user documentation. The standard includes a detailed conformance statement that providers can fill out, to describe and document their compliance with the standard. A provider who follows this standard will be providing equipment, software, and documentation that meet industry-wide expectations for how the system is designed and functions, so that it meets the needs of the neurofeedback community. Providers will have to be clear about how they are processing data, presenting feedback, and how the performance of the system can be traced to the system design and specifications. This standard is not intended to limit or shackles any developers or manufacturers; rather, by providing a standard of clarity and documentation, it will help providers ensure that users understand and use their equipment to best advantage. It will also help to ensure the repeatability and consistency of neurofeedback results, based upon objective standards.

This standard does not dictate exactly how systems are designed. It defines the four major components and delineates how they should be described and documented, to ensure that users know what they are using. The electrode/sensor component should use standard nomenclature, and should define the usage and lifetime expectations of the sensors. Stability and related factors should also be stated. This is increasingly significant as neurofeedback moves from the traditional 1–30 Hz operation into low-frequency work below 1 Hz, and into high-frequency work, including Gamma at 40 Hz, 60 Hz, or beyond. One provision of the standard is that frequency response including corner frequencies, rolloff, attenuation, and other parameters be clearly stated, and supported by testing. Of particular importance is the issue referred to as “shaping,” which includes how artifacts and/or key EEG values are detected and rewarded, how controls such as sustained reward conditions or refractory periods are used, and how baseline or historical data are used in the system processing algorithms.

With regard to software, the standard states that transformations such as digital filtering, characterization and shaping of EEG data, and response characteristics be described and validated. This will help to ensure that practitioners have confidence that their equipment and software are performing as expected, and that all performance claims are supported by proper evidence and data.

Critical user-interface issues are also addressed, such as the uniform use of color, the ability to change colors if required, the availability of impedance and signal quality data, and information support displays. Systems should have adequate flexibility for selecting and viewing information in real time, and selecting which bands or components are to be displayed or used for feedback. Also, times and dates, as well as changes in settings, should be stored along with data, to facilitate quality evaluation and ensuring that parameters can be verified in conjunction with data or statistical reviews. Data formats, and HIPAA conformance are also addressed. While the details of an implementation are not dictated, systems should be able to package data in suitable portable formats, and it should be possible to operate a system in a HIPAA-compliant manner, even if the system does not specifically support HIPAA-related features. Playback, analysis, review, and user documentation are also described, with minimum requirements specified for a basic system.

An important issue raised by this new standard is how it will be validated, and by whom, for each provider. Providers can complete the Implementation Conformance Statement that is built into this standard, but some type of third-party verification will likely be desired. We anticipate that a competent evaluating body, such as are now used for compliance with other specifications, can be brought into this effort to provide auditing and certification services. The IEEE has a Conformity Assessment Program (ICAP) that is working with this group to establish the procedures and guidelines. It is possible, although not certain, that the FDA or other regulatory bodies may look for compliance with this standard as part of achieving certification to 510(K), exempt status, or other approvals.
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Engaging yet contingent multimedia feedback
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*Combine biofeedback with audio entertainment*

A new Binaural Beat Pacer Instrument provides 2 modes of entertainment:

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- Adaptive Mode automatically determines starting frequency from the dominant EEG frequency and leads the client towards the desired frequency

*New Z-Score tool gives you full control*

- A new screen instrument allows you to visualize all NeuroGuide Z-Score metrics, for 2 or 4 channels, on a single screen.
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Strict adherence to the IEEE Recommendations for Neurofeedback Systems

Thought Technology, in collaboration with other leading equipment manufacturers, the ISNR and the IEEE, helped create and closely adheres to equipment and software guidelines for manufacturers of Neurofeedback equipment.
The Infinite Evolution
1975-2012

Continuing to invent the future

For over 37 years we have pursued the dream of helping people help themselves through Biofeedback and Neurofeedback

Thank you for making the dream a reality