Brainwave Optimization (High-resolution, Relational, Resonance-based Electroencephalic Mirroring): A Non-invasive Technology for Neuro-oscillatory Calibration

Lee Gerdes
Founder and Chief Executive Officer, Brain State Technologies

Sung Lee, M.D., M.Sc.
Research Coordinator, Brain State Technologies

The purpose of this paper is to describe technical and theoretical aspects of Brainwave Optimization™, also known as High-resolution, Relational, Resonance-based Electroencephalic Mirroring™ (HIRREM™).

HIRREM is an innovative, non-invasive approach to facilitating greater self-regulatory capacity for, by and through the human brain. The approach may be conceived as a high-resolution electronic mirror that reflects the brain's activity back to itself in real-time. But rather than use *light* to reflect the brain's changing visual appearance, as with a conventional household mirror, the technology instead uses *sound* to reflect the brain's changing pattern of frequency-specific electrical activity.

Like any polished mirror, the technology is extremely precise, and also "non-judgmental." There is no imparting of normative information by the provider that would aim to explicitly reward, inhibit, entrain, instruct, re-program, or in any other way to overwrite the brain's existing pattern of activity.

This approach is fundamentally different from binaural beats, auditory or photic stimulation, synchronization and other brain-enhancement methodologies. For a detailed explanation of how it is both similar to and different from biofeedback (including electroencephalographic biofeedback or neurofeedback), see *Similarities and Differences Between Brainwave Optimization (HIRREM) and Electroencephalographic Biofeedback (pp. 13-17).*

Why is it important to have greater self-regulatory capacity for, by and through the human brain?

Understanding the Brain as 'Command Central'

Greater self-regulation *for* the human brain is necessary so the brain does not act out in destructive ways to achieve self-regulation. In many cases, substance abuse disorders can

The Leading System for Brainwave Optimization with RTS™
©2010 Brain State Technologies, LLC®

be better understood as attempts to self-medicate other underlying psychiatric disorders or brain imbalances. For instance a person with depression or anxiety may abuse substances in order to “treat” their depression or anxiety. We believe that the explanation of substance abuse as self-medication may be developed into a more general model. We propose that a wider range of human behaviors may be fundamentally motivated by the brain’s intention to regulate itself. Indeed, we believe that the brain’s impetus to self-regulate may eventually explain pathological behaviors more convincingly than can conventional psychological, sociological or genetic theories.

Greater self-regulation *by* the human brain is necessary because the brain is our central command center for our biology at a global level. The brain is the central control center for all human experience and functioning. So to improve any aspect of our well-being, we should ultimately aim to facilitate better functioning of the brain.

Peter Sterling’s model of allostasis (2004) provides a theoretical elaboration of the centrality of the brain for human self-regulation. In the past, the physiological and medical sciences have been based on the model of homeostasis, or stability through *constancy*. Homeostasis considers various systems in terms of their requirement to maintain various set points at constant values. Deviations from these set-points are treated as disease states. The cause of these deviations is understood to be dysfunctionality of local mechanisms in the system. That is to say, dysfunctional local mechanisms are seen to interfere with preservation of the set-points. The aim of medical therapy is to correct the local mechanisms which are associated with set-point deviations, e.g., disease.

In contrast, the allostasis model emphasizes that systems maintain stability through *change*. They shift their set-points based on the changing demands their environments present. The brain has a central role in shifting these set-points, based on the expected levels of demand on the system. Disease states are manifestations of set-points which have become deviated and then stuck because of a repeated exposure to a particular demand. Local mechanisms are not actually dysfunctional; they are simply responding to a different level of demand.

The concept of health and disease as manifestations of set-point dynamics is illustrated in Figure 1. Healthy systems are able to deviate their set-points dynamically, based on changing demand (A). If a system is repeatedly exposed to a particular level of demand, then its set-point may become “stuck” even after the demand eventually changes (B), and the system is diseased. Medications may help reduce disease symptoms by clamping the set-point at a pre-determined value, but such an approach will generally entail reducing the dynamic range of functionality of the system (C). The optimal solution is for the system to recalibrate itself appropriately for the actual level of demand, manifesting as the restoration of health (D).

BRAIN STATE TECHNOLOGIES®
The Leading System for Brainwave Optimization with RTS™

©2010 Brain State Technologies, LLC®

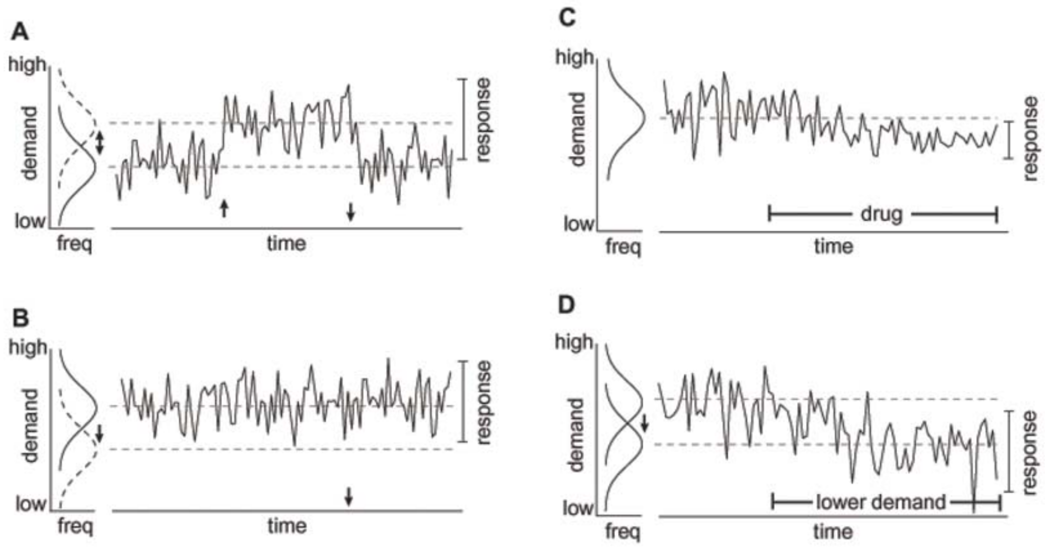


Figure 1. Set-point dynamics of an oscillating system under conditions of: A: Health; B: Disease; C: Drug therapy; and D: Restoration of health. Black arrows represent changing levels of demand on the system (up arrow = increasing demand; down arrow = decreasing demand). See text for further explanation. Reprinted from Sterling (2004).

The example of blood pressure regulation illustrates the difference between the homeostasis and allostasis models of physiological regulation. In Figure 2, the homeostasis model portrays blood pressure as a set-point managed by the variables of vascular resistance and cardiac output. Medical interventions aim to change dysfunctionality in the local mechanisms that influence vascular resistance and cardiac output.

BRAIN STATE TECHNOLOGIES®
The Leading System for Brainwave Optimization with RTS™
©2010 Brain State Technologies, LLC®

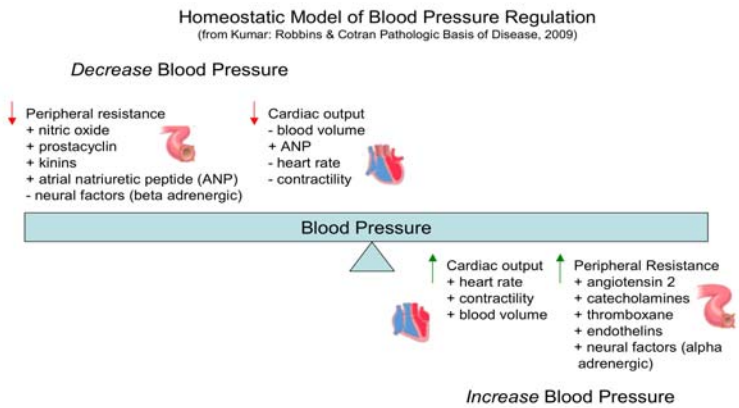


Figure 2. Homeostasis model of blood pressure regulation views blood pressure as being the net result of functioning of multiple different local effectors which modulate peripheral resistance and cardiac output. Effectors denoted by "+" increase activity whereas those denoted by "-"decrease activity. Medical interventions aim to modify the functioning of these effectors. Adapted from Kumar (2009).

In contrast, the allostasis model (Figure 3) portrays blood pressure as a set-point influenced by vascular resistance and cardiac output, among other factors, but ultimately managed by the brain. In the allostasis model, the ultimate way to change blood pressure is to encourage the brain to adopt a different set-point. Adoption of a new set-point necessitates higher-level interventions—that is to say, brain-based changes in thinking, perception, and lifestyle, as well as improved functionality of the brain itself.

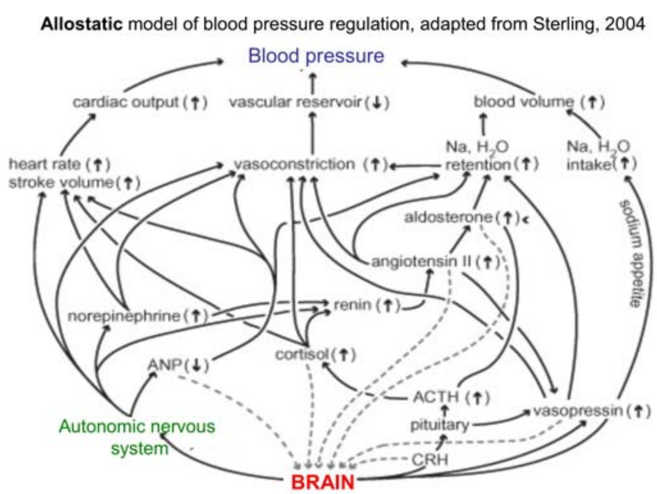


Figure 3. Allostasis model of blood pressure regulation emphasizes that the brain ultimately regulates the local effectors that influence blood pressure. Adapted from Sterling (2004).

Brain State Technologies®
The Leading System for Brainwave Optimization with RTS™
©2010 Brain State Technologies, LLC®

Greater self-regulation *through* the human brain is important because methodologies that don't directly and precisely engage the human brain are likely to be more haphazard and time-consuming.

Medical and psychological interventions for facilitating well-being, such as counseling and psychoactive medications, tend to be highly operator-dependent (especially counseling) and/or limited in their specificity of action (especially medications). Thus, there is a pressing need for interventions that act through the brain with high degree of precision and efficacy, with only minor or non-existent side effects.

Achieving Right-Left Hemispheric Balance

Where in the brain does HIRREM focus? It focuses on training the left and right hemispheres of the brain simultaneously, so that optimal balance can be more easily facilitated between the two hemispheres.

HIRREM couples the core function of mirroring to a postulation that the two hemispheres of the brain perform optimally when they are in balance. Balance of the two hemispheres is understood not in terms of popular culture notions of logic versus creativity, and so forth, but rather in terms of specific patterns of EEG activation in homologous regions of the brain with critical functional neuro-anatomical significance.

The Brain's Connection to the Autonomic Nervous System

Most importantly, we have found that EEG asymmetries in the temporal lobes (i.e., at T3 and T4 in the 10-20 EEG system) correspond to characteristic imbalances of autonomic nervous system functioning. Relative dominance of EEG amplitudes at T4 over T3 (right temporal lobe over left temporal lobe) is typically associated with dominance of the sympathetic (fight-flight) nervous system, which may correspond to anxiety, cardiovascular overdrive, hyper-vigilance and other manifestations of hyper-arousal.

Relative dominance of EEG amplitudes at T3 over T4 (left temporal lobe over right temporal lobe) is typically associated with dominance of the parasympathetic (rest-digest-freeze) nervous system, which may correspond to emotional numbness, cardiovascular under-activity, gastrointestinal dysfunction, or other manifestations of under-arousal (i.e., associated with a freeze state).

Our model of T3/T4 EEG balance as a way to assess autonomic nervous system functioning is convergent with data from several other fields of inquiry. Numerous studies in cognitive neuroscience and clinical neurology have concluded that the right hemisphere mediates activation of the sympathetic nervous system (SNS), and that the left hemisphere mediates activation of the parasympathetic nervous system (PNS). Evidence includes findings from studies of hemispheric inactivation (through intracarotid amobarbital), studies of patients with cerebrovascular accident or unilateral migraine, and studies of lateralized image presentation (Avnon et al 2004; Hilz et al 2001; Yoon 1997;

Brain State Technologies
The Leading System for Brainwave Optimization with RTS
©2010 Brain State Technologies, LLC®

Wittling 1997; Wittling et al 1998).

Also, Rabe *et al* (2006) have shown that survivors of motor vehicle accidents with a diagnosis of post-traumatic stress disorder (PTSD) have asymmetric activation of the EEG (right hemisphere greater than left). Additionally, Craig (2005) has described a likely anatomical basis for autonomic nervous system lateralization. The right anterior insula (located deep to T4) receives ascending projections originating from afferent nerves that mediate sympathetic nervous system functions, whereas the left anterior insula (located deep to T3) receives projections from afferent nerves that mediate parasympathetic nervous system functions.

When the HIRREM process is provided at the bilateral temporal lobes (T3 and T4), characteristic syndromes of autonomic imbalance or dysregulation tend to mitigate, in subtle or sometimes dramatic ways. For example, there may be a reduction of cardiovascular hyper-arousal, reduction in anxiety, improved sensory awareness, improvement of gastrointestinal functioning and so forth.

Trauma's Imprint on the Brain

In terms of behavioral or emotional history, significant dominance of either the right or left temporal lobe EEG over the other side suggests a likely history of traumatic stress. The paradigmatic condition associated with T4 (right temporal) dominance is hyper-arousal, in which a tendency for sympathetic drive is established due to a traumatic infringement. On the opposite end, the paradigmatic condition of T3 dominance is a tendency for emotional disengagement or numbness, in which a parasympathetic (freeze mode) tendency is established due to an experience of total loss of control in an overwhelmingly stressful circumstance, for example emotional isolation, abandonment, or other form of overwhelm.

The characterization of freeze-mode phenomenology—emotional numbness, metabolic shutdown—as a reflection of parasympathetic activity is highly consistent with the poly-vagal theory of hierarchical staging in emotional expression and engagement (Porges 2007). Porges has proposed that freeze-mode phenomenology is a last-resort stage of autonomic functioning, mediated by an ancient division of the parasympathetic nervous system that predominates only in the circumstance of overwhelm, when sympathetic (fight-flight) behaviors are inadequate.

In practice, most individuals with traumatic life histories or post-traumatic stress disorder will have variable degrees of dominance of T4 over T3 or vice-versa, across the EEG frequency bands, due to the common compounding of different types of traumas in the course of a life; that is to say, both trauma that infringes and trauma that overwhelms.

Furthermore, we suggest that not only may the relative balance of the EEG at T3 and T4 reflect past emotional traumas and physical health symptoms related to the autonomic

Brain State Technologies®
The Leading System for Brainwave Optimization with RTS™

©2010 Brain State Technologies, LLC®

nervous system, but also that T3/T4 imbalances may be a driving force behind some social behaviors, whereby the brain drives a behavior in an attempt to self-correct an imbalance.

Data from the criminology literature appear to provide preliminary corroboration of this hypothesis. Ortiz and Raine (2004) concluded from a meta-analysis of 45 studies, that "low resting heart rate appears to be the best-replicated biological correlate to-date of anti-social behavior in children and adolescents." One possible explanation for this phenomenon was that low resting heart rate may be due to dysfunctioning of the right hemisphere (which normally manages heart rate through SNS activation). Compensatory activation of the left hemisphere would entail lowering of the heart rate (through the parasympathetic system).

Developmentally, the right hemisphere of the human brain—including its competency to manage the emotions through regulation of the SNS—undergoes critical maturational processes in early infancy, through strong parental-infant bonding (Schore 2009). Inadequacy of early bonding may thus lead to inability of the individual to competently activate and manage their SNS, putting the individual at higher risk for emotional disturbance. Because of the inadequacy of SNS regulation, PNS compensation (and eventually dominance) may ensue.

Dominance of the PNS (managed by the left hemisphere), due to inadequacy of the right hemisphere, thus mediates production of a freeze response. Again, a key physiological characteristic of the freeze response is *low arousal*, which for instance may manifest as low resting heart rate. Low arousal is closely related to the emotional numbing or disengagement that characterizes antisocial behavior. This PNS-dominant, low-arousal state may then become a driver for the acting out of antisocial behavior. *Inappropriate stimulus-seeking (including substance abuse, violent tendencies, or anti-sociality) may be a manifestation of the brain's attempt to self-correct an excessively low-arousal state.*

Testing our Hypothesis with Inmates

We have produced corroborative evidence for the PNS-dominant anti-sociality hypothesis, in the course of a pilot study to investigate whether HIRREM could facilitate improved self-regulation of subjects incarcerated in a medium-security correctional facility (Gerdes *et al,* 2007). Five subjects underwent this procedure. All five had initial assessments that showed marked dominance (more than 250 percent difference in amplitude) of the left temporal lobe over the right, suggesting PNS dominance.

After approximately 25 sessions each, these five subjects experienced major shifts in their behavior and well-being. They became dramatically more cooperative and less hostile. There were stark improvements in the degree of T3/T4 EEG balance (reduced to approximately 10 percent difference in amplitude). The quality of the improvements in the subjects' behavior, as observed by the correctional facility staff and administrators,

The Leading System for Brainwave Optimization
©2010 Brain State Technologies, LLC®

was considered to be well beyond that achieved with other interventions encountered during an extensive career in corrections administration (Skolnik, personal communication).

HIRREM thus includes a model of balance between EEG activity at the right and left temporal lobes (T3 and T4). This balance is postulated to reflect the degree of balance in the autonomic nervous system and theoretically can explain emotional and cognitive tendencies, physical health traits, and possibly even behavioral tendencies, especially for individuals who have experienced trauma that infringes or overwhelms.

Working with the Brain in Totality

Finally, although balance at the temporal lobes is crucial, nonetheless this technology *approaches the brain in a global, non-reductionistic manner*. Mirroring takes place throughout major regions of the cortex.

Reductionistic models of neural functioning have been extremely helpful for identifying local mechanisms and dysfunctions across a range of neural and human phenomena. Yet, our understanding of various discrete mechanisms doesn't necessarily translate to facilitating betterment for the individual's condition as a whole.

"Rather than a problem in a single brain region, scientists increasingly believe that psychiatric diseases are a result of dysfunctional circuits spread over multiple regions leaving them unable to properly communicate and work together. That disrupts, for example, the balance between impulsivity and self-control that plays a crucial role in addiction. These networks of circuits overlap, explaining why so many mental disorders share common symptoms, such as mood problems. It is also a reason that addictions—to nicotine, alcohol or various types of legal or illegal drugs—often go hand-in-hand with post-traumatic stress disorders, depression, schizophrenia and other mental illnesses.

"Think of it as if the brain were an orchestra, its circuits being the violins and the piano, and the brass section, all smoothly starting and stopping their parts on cue. That orchestration is disrupted in psychiatric illness. There is not a psychiatric disease that owns one particular circuit." (Nora Volkow, Director of NIH NIDA, keynote address to American Psychiatric Association, May 24, 2010)

HIRREM sessions typically involve training five to eight regions of the brain per session (generally 90 minutes per session). Training of multiple lobes and regions of the brain aims to facilitate greater global functional integration and therefore more robust improvements.

BRAIN STATE TECHNOLOGIES®
The Leading System for Brainwave Optimization with RTS™

©2010 Brain State Technologies, LLC®

Who Can Brainwave Optimization Help?

Who should undergo Brainwave Optimization, and for what reasons?

Greater self-regulatory capacity for, by, and through the human brain may theoretically benefit any human being in any given condition.

Uncontrolled data from nearly 30,000 individuals world-wide suggests that the training may have a role for relief of symptoms related to post-traumatic stress, insomnia, substance abuse, mood disorders, anxiety, attention-deficit disorders, traumatic brain injury, movement disorders including Parkinson's and Tourette's, learning disabilities, cardiovascular disease, endocrine disorders, chronic pain, gastrointestinal disease and other conditions. Improvements have also been reported for a client with trisomy 21 and a client with chromosome 8p inversion.

The training has also been found to have a superior role for performance enhancement among musicians, visual artists, athletes, and executives.

An individual may undergo training sessions at virtually any time in their life. Individuals who have undergone this procedure range in age from one-and-a half to 100-and-a-half.

Given the extraordinarily non-invasive character of the technology, the question may be raised as to how such a subtle methodology might promote improvements in brain functioning. We theorize that at the level of fundamental physics, the training facilitates auto-calibration of oscillating neural networks through resonance-based dissipation or accretion of neural energy.

Listening to the 'Music' of the Brain

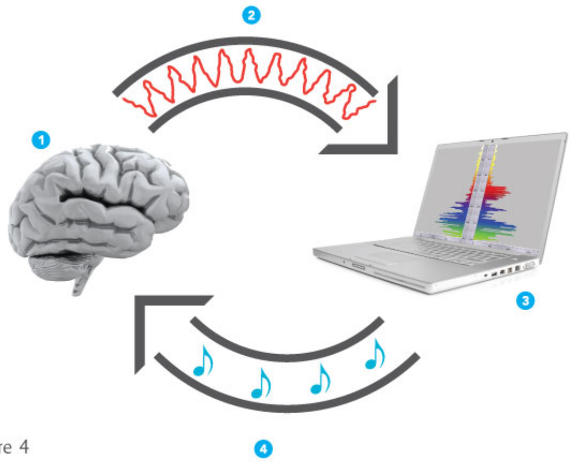
As described earlier, the mirror provided by HIRREM does not use light to reflect a visual image. Rather, it uses sound to reflect a pattern of electrical activity or brain energy. The choice of the sound to be reflected back to the user is made through a mathematical algorithm that identifies the dominant frequency of the individual's EEG spectrum in a floating middle range at a given instant of time. The dominant EEG frequency is translated to a musical note whose frequency corresponds to the dominant EEG frequency. The musical note is played back to the individual through earphones (Figures 4 through 6).

Brain State Technologies®
The Leading System for Brainwave Optimization with RTS™

©2010 Brain State Technologies, LLC®

Converting brainwaves into sound

Brainwave Optimization (HIRREM)

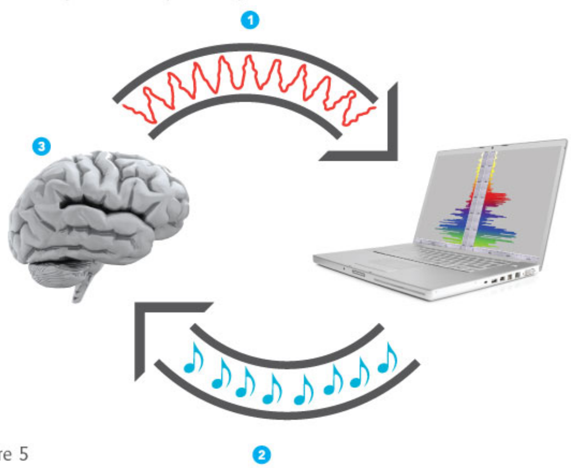


1. Brainwaves are electrical rhythms produced by neurons.
2. Sensors placed on the head transmit energy to the computer.
3. Computer converts brainwave energy to sound in the form of musical notes.
4. Brain "hears" its own brainwaves in the form of musical notes.

Figure 4

Creating a 'mirror effect' that produces neural-musical resonance

Brainwave Optimization (HIRREM)



1. As a result of trauma, brain sounds may be out of balance and harmony.
2. Brainwave activity begins to auto-calibrate, recovering balance and harmony.
3. Neural networks begin to change.

Figure 5

The Leading System for Brainwave Optimization

©2010 Brain State Technologies, LLC®

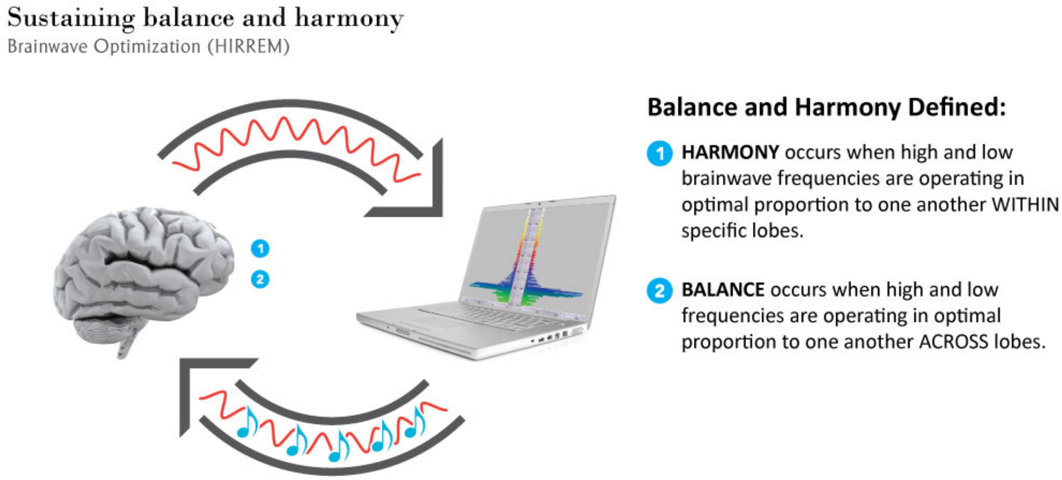


Figure 6

Because of the identification between the dominant EEG frequency and the musical note frequency, the phenomenon of resonance occurs between the individual's brain and the musical note. *We theorize that resonance between the individual's dominant EEG frequencies and the musical notes played back in response creates an opportunity for the brain to either dissipate or accrete neural energy.* Neural-musical resonance may be a mechanism for auto-calibration of neural networks.

We thus propose the following general model for HIRREM:

Neural oscillations, which manifest macroscopically as brainwaves, are a primary-process feature of neural networks. Like any oscillating system, neural networks have set points that can be subject to perturbation with ensuing disequilibrium. In the case of human brains, perturbations will commonly present as traumas, either physical or emotional. Disequilibria may manifest as different types of acute mental, emotional, and/or physical health disturbances.

If perturbations are of a sufficient degree or frequency, new set points may develop, establishing disequilibria more firmly and manifesting as clinical disease syndromes.

Once perturbed, a neural network may be able to regain its original equilibrium; in other words, health is restored. The possibility of such an outcome suggests that neural networks likely have innate programs or templates for their oscillatory parameters, toward which they have a natural tendency to gravitate. Such parameters, if identified, would represent canonical energetic relationships within and between populations of neurons.

Brain State Technologies®
The Leading System for Brainwave Optimization with RTB™
©2010 Brain State Technologies, LLC®

The technology aims to de-establish the dis-equilibrious set points of neural oscillatory networks, and facilitate recovery of canonical energetic relationships within and between populations of neurons.

This approach respects the subtlety of neural oscillatory dynamics and aims to simply provide a resonance-based mirror for the networks. Through shifting sequences of resonance, the networks receive information in a rapidly recursive manner about the patterns of their own functioning. As this process iterates, the networks dissipate or accrete energy in specific frequency bands, in accordance with speculated canonical energetic relationships.

If the neural network is viewed as a form of instrumentation, the HIRREM process can be likened to a technique for auto-calibration. Auto-calibration allows restoration of the set points of original equilibrium.

As yet, the preceding model is hypothetical only. We are currently in the process of attracting appropriately qualified investigators from relevant disciplines to help confirm, refute, or extend the model, so the HIRREM methodology can be advanced and improved.

03.07.11

©2010 Brain State Technologies, LLC®

Similarities and Differences Between Brainwave Optimization (HIRREM) and Electroencephalographic Biofeedback

Lee Gerdes
Founder and Chief Executive Officer, Brain State Technologies

Sung Lee, M.D., M.Sc.
Research Coordinator, Brain State Technologies

In terms of technological lineage, Brainwave Optimization™ (more formally known as High-resolution, Relational, Resonance-based Electroencephalic Mirroring or HIRREM) can be considered as an advance on the methodology of electroencephalographic biofeedback (also known as "EEG biofeedback" or "neurofeedback.") For purposes of this discussion, we will generally refer to it as "EEG biofeedback."

In order to clarify the similarities between HIRREM and EEG biofeedback, it may be helpful to present the following joint statement regarding the definition of biofeedback, agreed on by two professional societies, the International Society for Neurofeedback Research (ISNR) and the Association for Applied Psychophysiology and Biofeedback (AAPB):

> Biofeedback is a process that enables an individual to learn how to change physiological activity for the purposes of improving health and performance. Precise instruments measure physiological activity such as brainwaves, heart function, breathing, muscle activity, and skin temperature. These instruments rapidly and accurately "feed back" information to the user. The presentation of this information—often in conjunction with changes in thinking, emotions, and behavior—supports desired physiological changes. Over time, these changes can endure without continued use of an instrument. (www.aapb.org, accessed Aug. 31, 2010.)

The International Society for Neurofeedback Research further explains that neurofeedback is based on the following premise:

> Resulting information [about brainwave activity] is fed back to the trainee virtually instantaneously with the conceptual understanding that changes in the feedback signal indicate whether or not the trainee's brain activity is *within the designated range* [italics added]. (www.isnr.org, accessed Aug. 31, 2010.)

BRAIN STATE TECHNOLOGIES®
The Leading System for Brainwave Optimization with RTS™

©2010 Brain State Technologies, LLC®

In broad principle, the joint AAPB/ISNR definition of biofeedback and neurofeedback highlights two core similarities between HIRREM and neurofeedback.

How HIRREM and EEG Biofeedback are Similar

First, this technology and biofeedback are similar in that both use *precision instruments to measure physiological activity*, and *present this information back to individuals* in such a way that *desired physiological changes are supported*.

Second, both this technology and biofeedback aim to facilitate *changes that eventually can endure without continued use of an instrument*.

Sharing this goal, both HIRREM and EEG biofeedback can be considered as methodologies that aim to enhance the human being's capacity for *self-regulation*. Both HIRREM and EEG biofeedback share a basic belief in the power of human physiology to improve its own functioning through innate mechanisms, together with a belief that such mechanisms can be catalyzed through technologically advanced, but non-invasive means.

Both HIRREM and EEG biofeedback share an orientation that neural oscillatory dynamics are primary processes, and that patterns of neurotransmitter activity at the synaptic junction are secondary.

How HIRREM and EEG Biofeedback Differ

The definitions of EEG biofeedback and neurofeedback also highlight two concepts which distinguish HIRREM from both.

First, the ISNR definition explains neurofeedback as a form of operant conditioning. The approach of the neurofeedback provider is to begin by designating a desired range of intensity (typically, the average amplitude of a frequency band, as measured in micro-volts) for the client's brainwave activity. This range is deemed to be a normative value, based on population averages. Then, a feedback signal is (or is not) provided to the client depending on whether the client's brain is generating activity within that range of amplitudes. The client is taught to try to generate certain ranges of amplitudes, and is rewarded by watching a video play or hearing a pleasant tone whenever they produce the pre-specified amplitude ranges. Or, certain brainwave amplitudes are inhibited, generally by removal of the positive feedback signal. Within a given training session, typically only one or two different types of feedback are given.

In contrast, HIRREM *provides feedback signals that are dynamically modified, in near real-time, so as to reflect activity of those frequencies of the EEG that are dominant within a floating middle range of the EEG frequency spectrum.*

Provision of the feedback signal is *not* contingent on whether the client has generated brainwave amplitudes that meet a pre-determined threshold. Providers of this technology do *not* designate ranges of EEG amplitudes as being normative or desirable. The

©2010 Brain State Technologies, LLC®

approach is thus *not* a form of operant conditioning and there are no reward or inhibit parameters to inform the client training process.

In a real sense, the technology is essentially "non-judgmental" toward the brain's functioning. It recognizes aberrance, but does not aim to overwrite it. In contrast, EEG biofeedback technology is essentially "judgmental" in that the machinery aims to control or overwrite the client's brainwave amplitudes through the conditioning influences of rewarding or inhibiting stimuli.

Second, the AAPB and ISNR definitions explain that biofeedback and neurofeedback are educational processes, in the sense that clients are encouraged to have a conceptual understanding of the feedback being given, and therefore to consciously learn to change their physiological activity. In contrast, HIRREM *focuses little or no attention on conscious learning and does not encourage clients to develop conscious control over their physiology*.

EEG Biofeedback Asks the Person to Train Their Brain;
HIRREM Asks the Person to 'Step Aside'

Sessions utilizing HIRREM are largely and explicitly devoid of extended conceptual engagement or educational dialogue between providers and clients. Rather, clients are encouraged to gently release any explicit intentions for control over their physiology.

Although precise estimations are difficult or perhaps currently impossible, there is little doubt that our normal waking consciousness can manage only an infinitesimal fraction of the information-processing power of our nervous system as a whole (Norretranders 1998). For example, consider the maximum speed (postulated to be between 12 to 40 bits per second) at which our conscious mind can receive and comprehend the contents of written words. In contrast, other elements of our nervous system—including divisions that manage sensory, motor and internal self-regulatory functions—process vastly larger amounts of information (postulated to be hundreds of millions of bits per second or more).

By providing precision information to clients without relying on the slower processing speeds associated with conscious learning, HIRREM aims to recruit and engage the larger-scale information processing power of neural systems not typically associated with conscious awareness or learning.

These two principles—mirroring and a focus on the high-capacity information-processing power of the nervous system—represent the two features of this technology that most significantly differentiate it from biofeedback and neurofeedback.

©2010 Brain State Technologies, LLC®

Precision Data Collection Allows Brain to Evolve, Change in Real-Time

A third general difference between HIRREM and EEG biofeedback concerns the amount of data granularity. The technology *observes electroencephalographic activity at increasingly high resolutions.*

Greater resolution or granularity of data collection and processing occurs in the dimensions of both time and the EEG frequency spectrum. With respect to temporal resolution, HIRREM provides auditory feedback to the client within 25 milliseconds after the EEG signal has been generated. In comparison, most EEG biofeedback systems provide feedback to the client within up to 2.5 seconds, if given through visual graphics. With respect to frequency spectrum resolution, HIRREM can discriminate and provide feedback for EEG information that originates with windows that are as narrow as 0.1 hertz. In comparison most EEG biofeedback systems provide feedback over broad ranges of the frequency spectrum, for example over 4-8 hertz or 16-24 hertz.

Increasing EEG data resolution, without a predetermined end point, is a core objective of the HIRREM developer team. As knowledge and opportunity grow, technology software and hardware are being upgraded regularly.

Selected References:

Avnon Y. et al. Autonomic asymmetry in migraine: augmented parasympathetic activation in left unilateral migraineurs. Brain. 2004; 127(9): 2099-2108.

Craig B. Forebrain emotional asymmetry: a neuroanatomical basis? Trends in Cognitive Sciences Vol. 9 No.12 December 2005.

Gerdes et al. Demonstration Summary of Brain State Technologies Training for Inmates in the Nevada Department of Corrections, 2007.

Hilz M. et al. Hemispheric influence on autonomic modulation and baroreflex sensitivity. Annals of Neurology. 1 May 2001; 49 (5): 575-84.

Kumar V., Ed. Robbins and Cotran's Pathologic Basis of Disease, 8th Ed. Elsevier, 2009.

Norretranders T. The User Illusion. New York: Viking Penguin, 1998.

Ortiz J. and Raine A. Heart rate level and anti-social behavior in children and adolescents: a meta-analysis. Journal of the American Academy of Child and Adolescent Psychology. 2004, 43(2): 154-162.

Porges S. The poly-vagal perspective. Biological Psychology 74 (2007) 116–143.

Rabe et al. Regional brain activity in posttraumatic stress disorder after motor vehicle accident. Journal of Abnormal Psychology. 2006; 115 (4) 687-98.

Rabe et al. Changes in brain electrical activity after cognitive behavioral therapy for posttraumatic stress disorder in patients injured in motor vehicle accidents. Psychosomatic Med. 2008; 70: 13-19.

Schore A. Right brain affect regulation: an essential mechanism of development, trauma, dissociation, and psychotherapy, in Fosha D, Siegel D, and Solomon M, Eds., The Healing Power of Emotion. New York: WW Norton, 2009.

Sterling P. Principles of allostasis: optimal design, predictive regulation, pathophysiology, and rational therapeutics, in Schulkin J, Ed., Allostasis,

BRAIN STATE TECHNOLOGIES®
The Leading System for Brainwave Optimization with RTB™

©2010 Brain State Technologies, LLC®

Homeostasis, and the Costs of Physiological Adaptation. New York: Cambridge University Press, 2004.

Wittling W. The right hemisphere and the human stress response. Acta Physiologica. 1997; (640) 55-9.

Wittling W. et al. Hemisphere asymmetry in parasympathetic control of the heart. Neuropsychologia. 1998 May 1; 36 (5): 461-68.

Yoon BW. Cerebral hemispheric lateralization in cardiac autonomic control. Archives of Neurology. 1997; Jun, 54 (6) 741-4.

About Lee Gerdes

Lee Gerdes is Founder and CEO of Brain State Technologies®. He is the creator of Brainwave Optimization with Real-Time Balancing™. Today, Brain State Technologies has the largest interrelational and functional database of brainwave patterns, having served and assessed more than 30,000 client's brains. The network includes about 140 affiliates offices, located in 15 countries and growing.

Lee is the author of Limitless You: The Infinite Possibilities of a Balanced Brain, published in 2009 by Namaste Publishing. His work emanates from a combination of his interests in how the brain works and how it affects mind, body. He has been a systems analyst, pastoral counselor, management consultant, and vice president of solutions for NetPerceptions where he pioneered the discovery of algorithms for predicting consumer purchase behavior ("If you bought this, you'll like this.")

Lee's education includes Doane College in Crete, Nebraska; Columbia University in New York; John F. Kennedy University in Orinda, California and Wartburg Seminary in Dubuque, Iowa.

About Sung Lee, M.D.

Dr. Sung Lee is research coordinator for Brain State Technologies. He works with Brain State Technologies founder Lee Gerdes to help discover, test and expand current and new applications for optimizing brainwaves, and hence, human potential. Trained in internal medicine, mind-body health and clinical research methods, Dr. Lee operates a practice that provides Brainwave Optimization™ in Sedona, Arizona.

Dr. Lee graduated with honors from Brown University and studied at the University of Cambridge in Cambridge, England. He completed his medical training at the University of California at San Francisco, Yale-New Haven Hospital, and the New York Presbyterian Hospital. He led studies to test the efficacy of mind-body health practices to improve quality of life and to reduce fatigue in patients with breast cancer and Parkinson's disease at the Weill Medical College of Cornell University. From Cornell, he holds a Master's of Science in Clinical Epidemiology and Health Services Research. He is a member of the Advisory Board of the International Brain Education Association and a scientific advisor to *Brain World* magazine.

This material is protected by U.S. copyright law and may not be reproduced, distributed, transmitted, displayed, published or broadcast without the prior written permission of Brain State Technologies. You may not alter or remove any trademark, copyright or other notice from copies of the content. 12.6.2010

©2010 Brain State Technologies, LLC®

The Leading System for Brainwave Optimization with RTB™

©2010 Brain State Technologies, LLC®