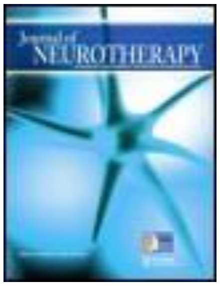

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Neurotherapy and the Heart: The Challenge of Energy Cardiology

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Editorial

Neurotherapy and the Heart: The Challenge of Energy Cardiology

by Gary E. Schwartz, Ph.D. and Linda G. Russek, Ph.D.

Science and society are facing a great challenge. On the one hand, we are facing tremendous dangers—to the health and well-being of our environment, our bodies and minds, our institutions, and our spirit. On the other hand, we have been given a tremendous opportunity—to re-envision health and well-being at all these levels so as to evolve into a responsible and caring species.

The birth and evolution of neurotherapy can be viewed as a prototype of how basic and applied science is attempting to address this challenge. Modern technology, designed and implemented with wisdom and compassion, is being used to help re-educate the brain to foster health and well-being. The Journal of Neurotherapy was created to foster the development of basic science and clinical knowledge in brain self-regulation and to communicate this knowledge to scientists and practitioners (and in the process, to policy makers and the public).

We believe that neurotherapy has the potential to become a prototype connecting conventional and alternative medicine. On the one hand, its concepts are based on generally accepted principles and knowledge in modern biophysics, neuroscience, and psychology. On the other hand, its applications involve intentionality, states of consciousness, and powers of mind that go beyond simple mechanistic, uni-directional, cause-effect models of how the brain and mind function. When modern concepts of energy and information are systematically integrated with traditional concepts and methods of neurotherapy, the potential for neurotherapy to serve as a prototype connecting conventional and alternative medicine is substantially increased.

The purpose of this Editorial is to consider a challenging development that we believe can have important implications for neurotherapy in the future. This development involves the integration of modern concepts of systems theory with modern concepts of energy and information. (Russek & Schwartz, 1994, 1996). Because of space limitations, the present discussion is necessarily abbreviated. However, as should become clear, the implications of this integration are far reaching, testable, and controversial.

Feedback, Systems Theory, and Energy

The foundation of neurotherapy is the concept of feedback. Feedback is a fundamental concept of systems theory. Systems theory, including general systems theory (von Bertalanffy, 1968) and general living systems theory (Miller, 1978), was developed as a conceptual tool to organize and integrate knowledge within and across disciplines, from the physical and biological sciences to the behavioral and social sciences (Schwartz, 1982, 1984, 1987, 1989).

The "heart" of systems theory, so to speak, is the notion of dynamic interaction. When two or more components are connected in a system, the components do not simply "act" upon each other, they "interact" with each other. Feedback loops therefore have complex, often non-linear, emergent effects. Complexity theory (e.g. Flood, 1988) and chaos theory (e.g. Cambel, 1993) are current examples reflecting the evolution of our understanding of this fundamental principle.

Paraphrasing Miller (1978), living systems can be defined as *dynamic organizations of intelligent information expressed in energy and matter* (Russek & Schwartz, 1996). Energy is defined as the capacity to do work. Organized energy is informational energy. Hence, when we speak of the heart generating electromagnetic energy, we are also speaking of information (generated by the heart and the brain) that is carried by the energy that affects matter.

Energy is one of the most mundane yet mysterious concepts in modern physics. Though the measurement of energy may be defined precisely, its interpretation is abstract and difficult to comprehend (even by seasoned physicists). Becker and Selden (1988) illustrate this point beautifully:

"Electromagnetism can be discussed in two ways—in terms of fields and in terms of radiation. A field is 'something' that exists in space around an object that produces it. We know there's a field around a permanent magnet because it can make an iron particle jump through space to the magnet. Obviously there's an invisible entity that exerts a force on the iron, but as to just what it consists of—don't ask! No one knows. A different but analogous something—an electric field—extends outward from electrically charged objects."

We believe that this difficulty of interpretation may be one reason why the concept of energy has yet to make its way into the mainstream of modern medicine and psychology. Systems theory reminds us that what we measure is the *functioning of systems*. Energy and force are *concepts* we invent to make sense of the *observation* that iron particles do, in fact, jump through space to a permanent magnet, and we use this observation to explain how, for example, the heart can be observed to contract when an electromagnet is placed near the chest (Ragan, Wang, & Eisenberg, 1995).

The Dynamical Energy Systems Approach and Energy Cardiology

We have recently derived five general hypotheses from systems theory, applied them to the concept of energy (termed the dynamical energy systems approach), and then specifically applied them to the heart as a prototypic energy generating system (termed energy cardiology) (Russek & Schwartz, 1996). Table 1 illustrates five dynamical energy systems hypotheses and their application to energy cardiology.

The five dynamical energy systems hypotheses can be applied to any organ system or combination of organ systems. In Russek and Schwartz (1996), the focus was the heart, which can be viewed as a generator of a broad spectra of types and frequencies of energies occurring over time. We could as well have focused on the brain, typically taken to be the prime generator of bodily processes. However, we wanted to show the new insights that can be derived from a dynamical energy systems approach to the body. For the purpose of this paper, we will focus our discussion on one component of cardiac energy—electromagnetic energy measured by the ECG.

When the biophysical consequences of organized energy are considered, far reaching implications for the role of the heart in health and healing emerge. For example, since the electromagnetic energy from the heart literally reaches every cell within the body, the heart (in concert with the brain) may be the major organizer and integrator of coordinated cellular functioning in the body. Moreover, since electromagnetic energy and information from the heart is not contained within the skin (it leaves the body roughly at the speed of light), cardiac energy patterns may interact *between* people (even at a distance). It is possible that cardiac energy patterns communicated

Table 1
Five Dynamical Energy Systems Hypotheses and Their Expression in Energy Cardiology

Dynamical Energy Systems Hypotheses	Energy Cardiology Hypotheses
1. Systems are expressions of organized energy and emit energy.	1. The heart is a dynamical energy generating system.
2. Energy activates and regulates systems interactively.	2. Energy from the heart may regulate organs and cells throughout the body interactively.
3. Different energies (types and frequencies) are emitted simultaneously, including at the quantum level.	3. The heart generates patterns of energy. The cardiac energy pattern includes electrical, magnetic, sound, pressure, temperature.
4. Energy is transmitted between systems dynamically and interactively.	4. Cardiac energy patterns may have interactive effects interpersonally and environmentally as well as intrapersonally.
5. Levels of consciousness may modulate patterns of energy in health and illness, and conversely, patterns of energy may modulate levels of consciousness.	5. Levels of consciousness may modulate cardiac energy patterns in health and illness, and conversely, cardiac energy may modulate levels of consciousness.

This table lists two parallel sets of hypotheses. The first set—the dynamical energy systems hypotheses—is drawn from general systems theory, and conceived in terms of energy. The second set—the energy cardiology hypotheses—applies the first set to biological systems, as illustrated by the heart and cardiovascular system. The hypotheses, necessarily abbreviated here for the sake of space, are organized from the least to the most controversial.

between people may be involved in both conventional and alternative therapies.

A central mystery in modern biology is how a system that contains literally trillions of highly specialized cells can ever function as an organized whole. The metaphor of a symphonic orchestra is useful here. If the body was thought to be an orchestra containing trillions of separate instruments, from "piccolos" (generating high frequency patterns) to "tubas" (generating low frequency patterns), how could these individual instruments ever play their unique melodies as a symphonic whole? The need for a "conductor" becomes self-evident. We believe that the heart may serve a fundamental synchronizing function since its energy and information reaches every cell within the body (including the brain). Using this metaphor, the heart becomes the "conductor," and the brain provides the "score."

The energy to do this need not be strong. Consider: very tiny electromagnetic signals have been shown to influence cellular functioning (reviewed in Becker, 1990, and in many articles in the journal, *Bioelectromagnetics*). Moreover, serious scientists are entertaining the possibility that biological cells can "rectify and signal average" weak electric fields through "stochastic resonance" (see Astumian, Weaver, & Adair, 1995). Though space precludes reviewing this research here, it is important to note that these new findings and models indicate that bioelectromagnetic effects often show an *inverted U-shaped function*—weak signals can produce resonance whereas strong signals may not.

Of course, all systems have boundaries that protect them from external matter and energy, and therefore information as well. As Miller (1978) writes, "an important function of boundary processes is fending off matter-energy excess stresses." Since the human body contains trillions of highly specialized cells designed to perform specific tasks, it makes sense that cells should not be excessively regulated by the heart (or any other organ or cell). It is conceivable that cells of the body (including the brain) have mechanisms that prevent them from being over-controlled by the heart (or any other energy generating system).

However, depending upon the state of the cell at a given moment, it may be more or less sensitive to the energy generated by the heart. A dynamical energy systems approach to heart-cell interactions requires that we consider each cell as a semi-independent unit (in effect, a sub-system) that responds dynamically and interactively with other semi-independent units, including the heart and, as we propose in Hypothesis 5, consciousness.

Energy and Heart-Brain Relationships

Of all the organs within the body, the heart is preeminent in terms of the centrality of its location, the richness of its connections to all the cells within the body, and particularly relevant here, the intensity of its energy transmission. This energy aspect of the heart does not receive much attention. But just as the heart not only pumps patterns of biochemical nutrients to every cell within the body through the circulation, it also "pumps" patterns of energy and information to every cell within the body through the circulation as well.

For example, it is well known that the electrical potential generated by the heart, identified by the electrocardiogram, can be recorded from *any site on the body* because of "volume conduction," a mechanism that is well known in physics and biology, and is not, in and of itself, controversial (Malmivuo & Plonsey, 1995).

A natural example of volume conduction is the simultaneous recording of fetus and mother cardiac electrical fields (potentials) *from the same pair of ECG electrodes* placed on the abdomen (Wakai, Wang, & Martin, 1994). For the first nine months of gestation, the developing fetus is literally "bathed" in cardiac energy generated by the mother, and the mother, in turn, is similarly bathed in the emerging cardiac energy of the developing fetus. Historically, the mother's electrocardiogram has been considered to be an annoying recording "artifact" that seriously confounds the measurement of the fetus' electrocardiogram rather than reflecting the actual "sharing" of cardiac energy and information that may have, heretofore, unrecognized yet important biophysical consequences for the fetus, the mother, and the mother-fetus relationship.

It turns out that of all the internal organs, the heart is by far the largest generator of magnetic energy. Superconducting quantum interference devices that measure magnetic fields outside the body have shown that the heart generates over 50,000 femtoteslas (a measure of intensity of magnetic field), compared to less than 10 femtoteslas recorded from the brain (Clarke, 1994), which makes the heart's magnetic field 5,000 times greater than the brain's. For this reason, when researchers try to record the magnetic field of the brain (the magnetoencephalogram) they discover that it is "contaminated" by the magnetic field of the heart (the magnetocardiogram). The magnetic field of the heart travels through the brain and mixes with the brain's magnetic field.

As is well known in radio and television transmission, information can be transmitted on top of waves of energy (i.e. carrier waves) that also have specific timing functions. Further, different radio or television stations—each a different frequency band—carry different kinds of information. It is conceivable that each of the various energies in the pattern of cardiac energy may contain different information.

For example, frequency patterns in addition to the patterns comprising the electromagnetic activity of the heart can be carried and observed in the electrocardiogram, ranging from the very low frequencies (.01 to 30 Hertz) to high frequencies (thousands of Hertz)—"noise" that is "riding" on top of the electrocardiogram. In traditional cardiologic measurement, however, these additional patterns are deliberately "removed" and disregarded.

Additional energy and information is routinely removed, for example, by careful electrode placement. If electrodes are placed on the chest across the heart (with an appropriate ground), the primary signal *observed* is the electrical activity arising from the heart. With this electrocardiogram electrode placement, the electrical activity of the brain, for example, which is also volume conducted throughout the cardiovascular system, is very small (because much of the EEG is subtracted using ECG leads) and is typically treated as "noise" to be ignored.

Conversely, if electrodes are placed on the scalp across the brain (for example, scalp to linked ears), the primary signal *observed* is the electrical activity arising from the brain. With this electroencephalogram electrode placement, the electrical activity of the heart is relatively small (because much of the ECG is subtracted using EEG leads referenced to linked ears) and is typically treated as "noise" to be ignored.

However, if one electrode is placed on the scalp, and the other electrode is placed below the heart on the chest, what will be observed is the *electrocardiogram combined with the electroencephalogram*—one will literally see brain waves riding, so to speak, on top of cardiac waves. With this scalp-chest (brain-heart) electrode placement, the true mixing of brain and cardiac electrical signals becomes self-evident.

Just as the blood contains a *mixture* of both molecules (for example, hormones) and cells (for example, red and white blood cells), it also contains a *mixture* of types (for example, electrical and thermal) and frequencies of energies. The dynamical energy systems approach encourages us to attempt to measure the holistic (mixed) nature of multiple types and frequencies of energies within and between organs such as the heart and the brain.

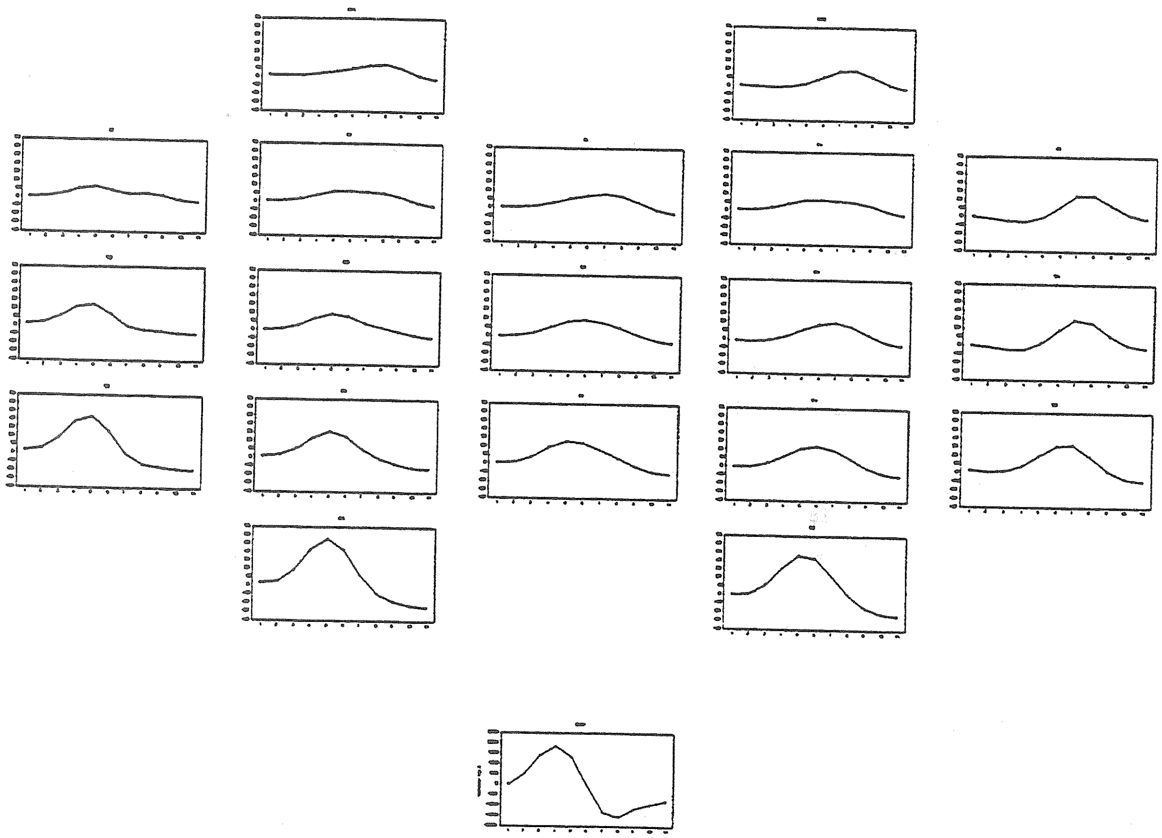
Why is this worth doing? To discover what the "noise" is conveying. For example, the electromagnetic signal coming from the heart may be a carrier wave for additional information that is not only diagnostic of cardiac function and disease, but also indicative of the functioning of other biological systems.

Simply stated, the ECG and the EEG mix with each other and travel to every organ and cell within the body (and by extension, beyond the body). When the heart is used as a "trigger," and the EEG is averaged using event related potential procedures, the R spike of the ECG can be clearly observed in the EEG. Moreover, there is a clear topographic pattern of the ECG observed in the EEG.

To demonstrate this effect, Figure 1 (from Russek & Schwartz, 1994), displays averaged cardiac synchronized energy patterns (CSEPs) recorded from 20 male subjects during a 2-minute eyes-closed resting baseline. The data were collected as part of a 42-year follow-up to the Harvard Mastery of Stress Study (Funkenstein, King, & Drolette, 1957; Russek, L., King, Russek, S., & Russek, H., 1990). Nineteen channels of EEG (referenced to linked ears) and the ECG (arm to arm placement) were recorded at 128 Hz using a Lexicor Neurosearch 24 system.

Figure 1 displays the temporal window surrounding the R spike per se. Four samples preceding the peak and six samples after the peak are displayed. At 128 Hz, this represents an 85.94 millisecond window of time. One microvolt equals 13.21 units (obtained from the raw data files) as displayed in the figure. The average number of heartbeats in the 2-minute baseline for the sample was 122.7 (SD=21.2).

Figure 1



Averaged EEG and ECG waveforms synchronized with the subject's (n=20) ECG R spikes. The top two waveforms are FP1 and FP2, the next to the bottom two waveforms are O1 and O2, the bottom waveform is the subject's averaged ECG. The scale for the EEG waveforms is +70 to -40, the ECG waveform is +2500 to -2000. One microvolt equals 13.21 units.

Cardiac synchronized energy patterns were obtained using special purpose software written to calculate averaged waveforms per trial per subject per site. Using the raw EEG and ECG data files, the program calculates averaged ECG and EEG waveforms synchronized either with the subject's own ECG (*intra*personal CSEPs—shown in Figure 1) or another person's ECG (*inter*personal CSEPs). The program:

1. Detects the peak of each R spike (the largest peak that accompanies each ventricular depolarization). Various peak detection procedures and amplitudes can be used.

2. Selects a given number of samples (e.g. 30) preceding each R spike and a given number of samples (e.g. 90) following each R spike.

3. Calculates averaged waveforms (and standard deviation waveforms) over the samples (e.g. 120) for a given trial. The program can select any number of R spikes, every other R spike, or create "pseudo" R spikes (to obtain control averages not synchronized with the ECG).

It can be clearly seen that the R spike was largest in posterior sites (e.g. 01 and 02), was smaller in midline (PZ) compared with left and right sites (e.g. T5 and T6), and was larger on the right side (e.g. F8) in anterior sites. There were individual differences in the amplitudes of the ECG observed in the EEG, and there was some variation in the topographic pattern between individuals.

Space precludes presenting and discussing the CSEPs obtained when a second person's heart was used as the trigger (see Russek & Schwartz, 1994). Though the magnitude of the effect was much smaller, the data suggest that interpersonal heart-brain registration is possible.

Some Implications of Energy Cardiology and the Dynamical Energy Systems Approach for Neurotherapy

Traditionally, it has been assumed that the ECG is minimally present in the EEG. Moreover, it has been assumed that the ECG plays no role in the functioning of the brain and mind. However, when the concept of energy is considered from a systems framework (the dynamical energy systems approach), and when predictions are applied to the heart (energy cardiology) and the brain (what might be termed energy neurology), novel ideas suggest themselves that are open to empirical investigation.

From a strictly "artifact" point of view, it may turn out that removing more of the ECG from the EEG (for example, by simultaneously measuring the ECG and developing on-line signal removal procedures) may improve the direct association between neurofeedback and underlying CNS functioning. However, this "simple" approach presumes that the ECG and the EEG do not interact energetically. If these energies are not "independent," but instead are "interdependent," then EEG feedback is to some extent ECG feedback, not only for "artifact" reasons, but for dynamical energy systems reasons as well!

The idea that the brain itself functions as a dynamical energy system is consistent with the work of Becker and colleagues. Becker and colleagues have proposed that the nervous system carries direct (dc) electrical currents in addition to neural impulses (reviewed in Becker & Selden, 1988; Becker, 1990). This research has led Becker to propose what he calls the "dual nervous system," where direct currents travel in perineural cells parallel to the electrochemical responding of the neuron. He further proposes that the earth's magnetic field, via the magnetic organ of the pineal gland, influences both neural firing and direct electrical currents, which in turn regulate the senses and muscle movements (nerve impulses) and injury and repair (direct electrical currents).

The "heart" of neurotherapy is feedback—the "heart" of feedback is dynamic interaction. Modern advances in software using Window's based systems and protocols that can be standardized in multiple sites now makes it possible to collect ECG data along with the traditional EEG data. User friendly software systems can be written to make it possible to routinely measure (and give feedback for) cardiac and CNS synchronized energy patterns if future data warrants the development of this technology.

Is it possible that individual differences in the clinical efficacy of neurofeedback for attention deficit disorder, drug addiction, or depression, for example, may be related to individual differences in heart-brain synchrony (assessed through future EEG/ECG CSEP procedures)? Also, is it possible that a social psychophysiological analysis of the trainer/patient relationship may reveal interpersonal cardiac energy interactions that may facilitate learning and growth? Does the ECG of the trainer contribute to the EEG of the patient in some complex and potentially meaningful ways?

An energy cardiology approach encourages us to entertain the possibility that future neurotherapy which combines EEG measurement with ECG measurement and trains patterns of brain-heart relationships may improve clinical efficacy in neurologic, cardiologic, and other conditions. EEG/ECG pattern training may find future applications in the treatment of dissociative and other psychiatric and psychosomatic conditions where the split between cognition and emotion is a salient clinical symptom.

Potential energetic interactions within and between individuals will never be discovered unless we entertain the possibility of energy hypotheses and we collect the kinds of data needed to evaluate these hypotheses. A dynamical energy systems approach to neurotherapy, integrating the brain and the heart, though inherently complex and controversial, could facilitate the integration of conventional and alternative approaches to health and wellness.

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Erata: Due to a technical error, the version of Dr. Michael Linden's article that appeared in Volume 1, Issue 3 of the *Journal of Neurotherapy* was not the final version. To correct this error, the final version of Dr. Linden's article is printed in this issue. The Journal of Neurotherapy apologizes for this error and any inconvenience it may have caused.

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