14 The Energetic Heart
Biomagnetic Communication within and between People

*Rollin McCraty**

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INTRODUCTION

Biological Patterns Encode Information

Every cell in our body is bathed in an external and internal environment of fluctuating invisible magnetic forces.[1] It has become increasingly apparent that fluctuations in magnetic fields can affect virtually every circuit in biological systems to a greater or lesser degree, depending on the particular biological system and the properties of the magnetic fluctuations.[1,2] One of the primary ways that signals and messages are encoded and transmitted in physiological systems is in the language of patterns. In the nervous system it is well established that information is encoded in the time intervals between action potentials or patterns of electrical activity. This also applies to humoral communications. Several studies have revealed that biologically relevant information is encoded in the time interval between hormonal pulses.[3–5] As the heart secretes a number of different hormones with each contraction, there is a hormonal pulse pattern that correlates with heart rhythms. In addition to the encoding of information in the space between nerve impulses and in the intervals between hormonal pulses, it is likely that information is also encoded in the inter beat intervals of the *pressure* and *electromagnetic* waves produced by the heart. This supports Karl Pribram's proposal that low-frequency oscillations generated by the heart and body in the form of afferent neural, hormonal, and electrical patterns are the carriers of emotional information and that the higher frequency oscillations found

* Can be reached at Rollin.rollin@heartmath.org

in the electroencephalogram (EEG) reflect the conscious perception and labeling of feelings and emotions.[6] It is quite possible that these same rhythmic patterns can also transmit emotional information via the electromagnetic field into the environment, which can be detected by others and processed in the same manner as internally generated signals.

Detecting Bioelectromagnetic Patterns Using Signal Averaging

A useful technique for detecting synchronized activity between systems in biological systems and investigating a number of bioelectromagnetic phenomena is signal averaging. This is accomplished by superimposing any number of equal-length epochs, each of which contains a repeating periodic signal. This emphasizes and distinguishes any signal that is time-locked to the periodic signal while eliminating variations that are not time-locked to the periodic signal. This procedure is commonly used to detect and record cerebral cortical responses to sensory stimulation.[7] When signal averaging is used to detect activity in the EEG that is time-locked to the electrocardiogram (ECG), the resultant waveform is called the *heartbeat evoked potential* (Figure 14.1).

The Heartbeat Evoked Potential

In looking at heartbeat evoked potential data, it can be seen that the electromagnetic signal arrives at the brain instantaneously, while a host of different neural signals reach the brain starting about 8 ms later and continue arriving throughout the cardiac cycle. Although the precise timing varies with each cycle, the blood pressure wave arrives at the brain around 240 ms and acts to synchronize neural activity, especially the alpha rhythm. It is also possible that information is encoded in the shape (modulation) of the ECG wave itself. For example, if one examines consecutive ECG cycles, it can be seen that each wave is slightly varied in a complex manner (Figure 14.2).

The heart generates a pressure wave that travels rapidly throughout the arteries, much faster than the actual flow of blood that we feel as our pulse. These pressure waves force the blood cells through the capillaries to provide oxygen and nutrients to cells and expand the arteries, causing them to generate a relatively large electrical voltage. These pressure waves also apply pressure to the cells in a rhythmic fashion that can cause some of their proteins to generate an electrical current in response to this "squeeze." Experiments conducted in our laboratory have shown that a change in the brain's electrical activity can be seen when the blood pressure wave reaches the brain around 240 ms after systole.

There is a replicable and complex distribution of heartbeat evoked potentials across the scalp. Changes in these evoked potentials associated with the heart's afferent neurological input to the brain are detectable between 50 and 550 ms after the heartbeat.[8] Gary Schwartz and his colleagues at the University of Arizona believe the earlier components in this complex distribution cannot be explained by simple

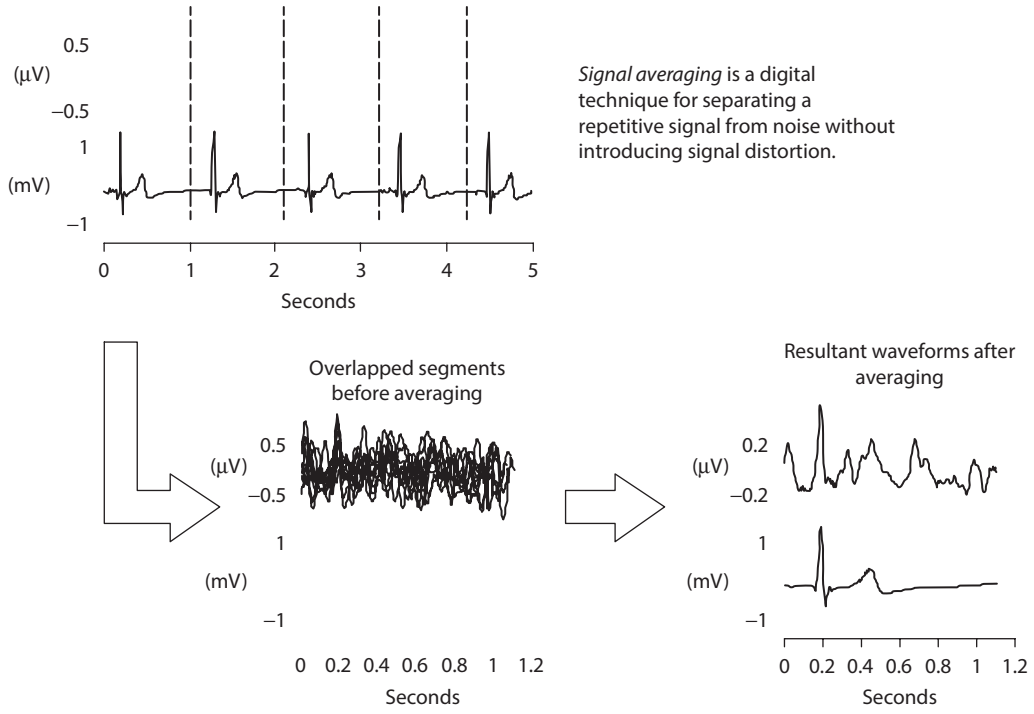

FIGURE 14.1 Signal averaging. The sequence of the signal averaging procedure is shown above. First, the signals recorded from the EEG and ECG are digitized and stored in a computer. The R-wave (peak) of the ECG is used as the time reference for cutting the EEG and ECG signals into individual segments. The individual segments are then averaged together to produce the resultant waveforms. Only signals that are repeatedly synchronous with the ECG are present in the resulting waveform. Signals not related to the signal source (ECG) are eliminated through this process.

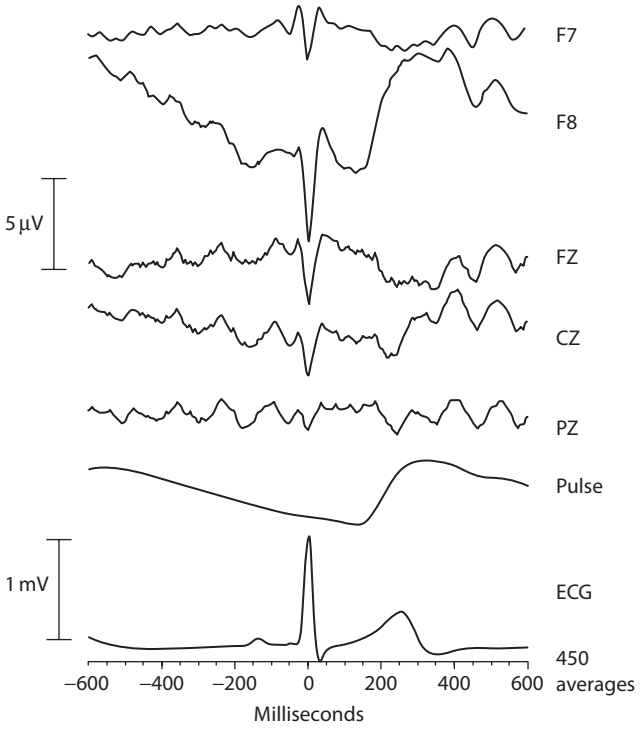

FIGURE 14.2 Heartbeat evoked potentials. This figure shows an example of typical heartbeat evoked potentials. In this example, 450 averages were used. The pulse wave is also shown, indicating the timing relationship of the blood pressure wave reaching the brain. In this example, there is less synchronized alpha activity immediately after the R-wave. The time range between 10 and 250 ms is when afferent signals from the heart are impinging upon the brain, and the alpha desynchronization indicates the processing of this information. Increased alpha activity can be clearly seen later in the waveforms, starting at around the time the blood pressure wave reaches the brain.

physiological mechanisms alone and suggest that an energetic interaction between the heart and brain also occurs.[9] They have confirmed our findings that heart-focused attention is associated with increased heart-brain synchrony, providing further support for energetic heart-brain communications.[2] Schwartz and his colleagues also demonstrated that when subjects focused their attention on the perception of their heartbeat, the synchrony in the preventricular region of the heartbeat evoked potential increased. From this they concluded that preventricular synchrony may reflect an energetic mechanism of heart-brain communication, while postventricular synchrony most likely reflects direct physiological mechanisms.

THE HEART'S ROLE IN EMOTION

Throughout the 1990s, the view that the brain and body work in conjunction in order for perceptions, thoughts, and emotions to emerge, gained momentum and is now widely accepted. The brain is an analog processor that relates whole concepts (patterns) to one another and looks for similarities, differences, or relationships between them, in contrast to a digital computer that assembles thoughts and feelings from bits of data. While some have suggested that emotions originated only in the brain, we now recognize that emotions can be more accurately described as a product of the brain and body acting in concert. Moreover, evidence suggests that of the bodily organs, the heart may play a particularly important role in emotional experience. Research in the relatively new discipline of neurocardiology has confirmed that the heart is a sensory organ and acts as a sophisticated information encoding and processing center that enables it to learn, remember and make independent functional decisions that do not involve the cerebral cortex.[10] Additionally, numerous experiments have demonstrated that patterns of cardiac afferent neurological input to the brain not only affect autonomic regulatory centers, but also influence higher brain centers involved in perception and emotional processing.[11–14]

Heart Rate Variability Patterns

Heart rate variability (HRV), derived from the ECG, is a measure of the naturally occurring beat-to-beat changes in heart rate that has proven to be invaluable in studying the physiology of emotions. The analysis of HRV, or *heart rhythms*, provides a powerful, noninvasive measure of neurocardiac function that reflects heart-brain interactions and autonomic nervous system dynamics, which are particularly sensitive to changes in emotional states.[2,15] Our research, along with that of others, suggests that there is an important link between emotions and changes in the patterns of both efferent (descending) and afferent (ascending) autonomic activity.[12,15–17] These changes in autonomic activity are associated with dramatic changes in the *pattern* of the heart's rhythm that often occur without any change in the *amount* of heart rate variability. Specifically, we have found that during the experience of negative emotions such as anger, frustration or anxiety, heart rhythms become more erratic and disordered, indicating less synchronization in the reciprocal action that ensues between the parasympathetic and sympathetic branches of the autonomic nervous system (ANS).[17] In contrast, sustained positive emotions, such as appreciation, love or compassion, are associated with highly ordered or *coherent* patterns in the heart rhythms, reflecting greater synchronization between the two branches of the ANS and a shift in autonomic balance toward increased parasympathetic activity[15–19] (Figure 14.3).

COHERENCE

The various concepts and measurements embraced under the term coherence have become central to fields as diverse as quantum physics, cosmology, physiology, and brain and consciousness research. Coherence has several related definitions, all of which are applicable to the study of human physiology, social interactions, and global affairs.

Physiological Coherence

We introduced the term *physiological coherence* to describe a number of related physiological phenomena associated

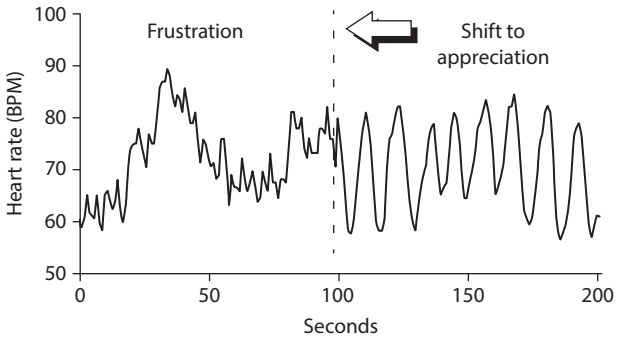

FIGURE 14.3 Emotions are reflected in heart rhythm patterns. Heart rate variability (heart rhythm) pattern of an individual making an intentional shift from a state of frustration to a genuine feeling of appreciation by using a positive emotion refocusing exercise known as the Freeze-Frame technique. It is of note that when the recording is analyzed statistically, the *amount* of heart rate variability is found to remain virtually the same during the two different emotional states; however, the *pattern* of the heart rhythm changes distinctly. Note the immediate shift from an erratic, disordered heart rhythm pattern associated with frustration to a smooth, harmonious, sine wave-like (coherent) pattern.

with more ordered and harmonious interactions among the body's systems.[20] The term *coherence* has several related definitions. A common definition of the term is "the quality of being logically integrated, consistent, and intelligible," as in a coherent argument. In this context, thoughts and emotional states can be considered "coherent" or "incoherent" as different emotions are clearly associated with different degrees of coherence in the oscillatory rhythms generated by the body's various systems. Thus, we use the term *physiological coherence* to describe the degree of order, harmony, and stability in the various rhythmic activities within living systems over any given time period. This harmonious order signifies a coherent system whose efficient or optimal function is directly related to the ease and flow in life processes. By contrast, an erratic, discordant pattern of activity denotes an incoherent system whose function reflects stress and inefficient utilization of energy in life processes.

The term "coherence" is used in physics to describe the ordered or constructive distribution of power within a waveform. The more stable the frequency and shape of the waveform, the higher the coherence. An example of a coherent wave is the sine wave. The term *autocoherence* is used to denote this kind of coherence. In physiological systems, this type of coherence describes the degree of order and stability in the rhythmic activity generated by a single oscillatory system. Methodology for computing coherence has been published elsewhere.[15]

Coherence is also used to describe the coupling and degree of synchronization between different oscillating systems. In some cases, where two or more oscillatory systems operate at the same basic frequency, they can become either phase or frequency-locked as occurs between the photons in a laser. This type of coherence is called cross-coherence and is the type of coherence that most scientists think of when they use the term. In physiology, cross-coherence occurs when two or more of the body's oscillatory systems, such as respiration, heart rhythms and blood pressure rhythms, become entrained and operate at the same frequency.

Global Coherence

There are also many examples in physiology where synchronized activity occurs across different time scales, which is characteristic of a globally coherent system. The brain rhythms operate over a wide range of frequencies, yet most of these exhibit various degrees of synchronized activity with the heart, which has much slower rhythms than the brain. Global coherence does not mean that all the parts are doing the same thing simultaneously. In complex globally coherent systems, such as human beings, there is an incredible amount of activity at every level of magnification or scale that spans more than two thirds of the 73 known octaves of the electromagnetic spectrum. It can appear at one level of scale that a given system is operating autonomously, yet it is perfectly coordinated within the whole. If this were not the case, it would be a free-for-all among the body's independent systems, rather than a coordinated federation of interdependent systems and functions. Biologist Mae-Won Ho has suggested that coherence is the defining quality of living systems and accounts for their most characteristic properties, such as long range order and coordination, rapid and efficient energy transfer, and extreme sensitivity to specific signals.[21]

All the above definitions apply to the study of bioelectromagnetism's role in physiology, energetic level interconnectivity in social settings and between people and the earth's electromagnetic field environment. We have found that positive emotions are associated with a higher degree of coherence *within* the heart's rhythmic activity (autocoherence) as well as increased coherence *between* different oscillatory systems (cross-coherence/entrainment).[2,15] Typically, entrainment is observed between heart rhythms, respiratory rhythms, and blood pressure oscillations. However, other biological oscillators, including very low frequency brain rhythms, craniosacral rhythms, electrical potentials measured across the skin, and, most likely, rhythms in the digestive system, can also become entrained.[2]

We have also demonstrated that physiological coherence is associated with increased synchronization between the heartbeat (ECG) and alpha rhythms in the EEG. In experiments measuring heartbeat evoked potentials, we found that the brain's alpha activity (8–12 Hertz frequency range) is naturally synchronized to the cardiac cycle. However, when subjects used a positive emotion refocusing technique to consciously self-generate feelings of appreciation, their heart rhythm coherence significantly increased as did the ratio of the alpha rhythm that was synchronized to the heart.[2,22]

Resonance

Another related phenomenon associated with physiological coherence is *resonance*. In physics, resonance refers to

a phenomenon whereby an unusually large vibration is produced in a system in response to a stimulus whose frequency is identical or nearly identical to the natural vibratory frequency of the system. The frequency of the vibration produced in such a state is said to be the *resonant frequency* of the system. When the human system is operating in the coherent mode, increased synchronization occurs between the sympathetic and parasympathetic branches of the ANS, and entrainment between the heart rhythms, respiration and blood pressure oscillations is observed. This occurs because these oscillatory subsystems are all vibrating at the resonant frequency of the system. Most models show that the resonant frequency of the human cardiovascular system is determined by the feedback loops between the heart and brain.[23,24]

Heart rhythm coherence and resonance are reflected in the HRV power spectrum as a large increase in power in the low frequency (LF) band (typically around 0.1 Hz, which is equivalent to a 10 s rhythm) and a decrease in power in the very low frequency (VLF) and high frequency (HF) bands. A coherent heart rhythm can therefore be defined as a relatively harmonic (sine-wave-like) signal with a very narrow, high-amplitude peak in the LF region of the HRV power spectrum with no major peaks in the VLF or HF regions.

Coherence at the Social and Global Levels

Social coherence relates to pairs, family units, groups or larger organizations in which a network of relationships exists among individuals who share common interests and objectives. Social coherence is reflected as a stable, harmonious alignment of relationships which allows for the efficient flow and utilization of energy and communication required for optimal collective cohesion and action. There are of course cycles and variations in the quality of family, team or group coherence, similar to variations in an individual's coherence level. Coherence requires that group members are attuned and emotionally aligned, and that the group's energy is globally organized and regulated by the group as a whole. Group coherence involves the same principles of global coherence described in the introduction to this paper, but in this context it refers to the synchronized and harmonious order in the relationships between and among the individuals rather than the systems within the body. The principles, however, remain the same; in a coherent team there is freedom for the individual members to do their part and thrive while maintaining cohesion and resonance within the group's intent and goals. Anyone who has watched a championship sports team or experienced an exceptional concert knows that something special can happen in groups that transcends their normal performance. It seems as though the players are in sync and communicating on an unseen energetic level. A growing body of evidence suggests that an energetic field is formed between individuals in groups through which communication among all the group members occurs simultaneously. In other words, there is a literal group "field" that connects all the members. Sociologist Raymond Bradley in collaboration with neuroscientist Karl Pribram, developed a general theory of social communication to explain the patterns of social organization common to most groups, independent of size, culture, degree of formal organization, length of existence, or member characteristics. They found that most groups have a global organization and a coherent network of emotional energetic relations interconnecting virtually all members into a single multi-level hierarchy.[25] We have found that there is a direct relationship between the heart rhythm patterns and the spectral information encoded in the frequency spectra of the magnetic field radiated by the heart. Thus, information about a person's emotional state is encoded in the heart's magnetic field that is communicated throughout the body and into the external environment. In essence, it appears that a bioenergetic communication system may indeed exist that serves to inform function and behavior in highly coherent groups.[26]

Humans are embedded within social networks that exist on the earth, which is part of the solar system. Therefore, it should not be surprising that human physiological rhythms and global behaviors are synchronized with solar and geomagnetic activity.[27,28] Energetic influxes from solar and geomagnetic fields have been associated with numerous aspects of human health and wellness, both positively and negatively. The Global Coherence Initiative (GCI), which is discussed in a separate chapter in this book, is focused on examining the interactions between humans and the earth's energetic fields.

In summary, we use coherence as an umbrella term to describe a physiological mode that encompasses entrainment, resonance, synchronization, social cohesion, and globally connected complex systems. Correlates of physiological coherence include increased synchronization between the two branches of the ANS, a shift in autonomic balance toward increased parasympathetic activity, increased heart-brain synchronization, increased vascular resonance, and entrainment between diverse physiological oscillatory systems.

Benefits of Coherence

Coherence confers a number of benefits to the system in terms of both physiological and psychological functioning. Practicing certain techniques that increase physiological coherence is associated with both short-term and long-term improvement in several objective health-related measures, including enhanced humoral immunity[29,30] and an increased DHEA/cortisol ratio.[19]

Increased physiological coherence is similarly associated with psychological benefits, including improvements in cognitive performance and mental clarity as well as increased emotional stability and well-being.[2,31] Studies conducted in diverse populations have documented significant reductions in stress and negative affect and increases in positive mood and attitudes in individuals using coherence-building techniques.[18,19,30–32]

Improvements in clinical status, emotional well-being and quality of life have also been demonstrated in various medical patient populations in intervention programs using coherence-building approaches. For example, significant blood pressure reductions have been demonstrated

in individuals with hypertension[33–35], improved functional capacity and reduced depression in congestive heart failure patients,[36] improved psychological health and quality of life in patients with diabetes,[37] and improvements in asthma.[38] Another study reported reductions in pathological symptoms and anxiety and significant improvements in positive affect, physical vitality, and general well-being in individuals with HIV infection and AIDS.[34,35,39,40]

Increasing Coherence

Although physiological coherence is a natural state that can occur spontaneously during sleep and deep relaxation, sustained episodes during normal daily activities are generally rare. While specific rhythmic breathing methods can induce coherence for brief periods, paced breathing is difficult for many people to maintain. Conversely, our findings indicate that individuals can produce extended periods of physiological coherence by actively generating and sustaining a feeling of appreciation or other positive emotions. Sincere positive feelings appear to excite the system at its resonant frequency, allowing the coherent mode to emerge naturally. This typically makes it easier for people to sustain a positive emotion for much longer periods, thus facilitating the process of establishing and reinforcing coherent patterns in the neural architecture as the familiar reference. Once a new pattern is established, the brain strives to maintain a match with the new program, thus increasing the probability of maintaining coherence and reducing stress, even during challenging situations.[12]

Doc Childre, founder of the Institute of HeartMath, has developed a number of practical positive emotion refocusing and emotional restructuring techniques that allow people to quickly self-generate coherence at will.[41,42] Known as the HeartMath system, these techniques utilize the heart as a point of entry into the psychophysiological networks that connect the physiological, mental, and emotional systems. In essence, because the heart is a primary generator of rhythmic neural and energetic patterns in the body, it influences brain processes that control the ANS, cognitive function and emotion. It also provides an access point from which system-wide dynamics can be quickly and profoundly affected. Research studies and the experience of numerous health care professionals indicate that HeartMath coherence-building techniques are easily learned. They have a high rate of compliance, and are highly adaptable to a wide range of demographic groups.[43,44]

Heart Rhythm Coherence Feedback

Used in conjunction with positive emotion-based coherence-building techniques, heart rhythm feedback training can be a powerful tool to assist people in learning how to self-generate increased physiological coherence.[45] We have developed a portable heart rhythm monitoring and feedback system that enables physiological coherence to be objectively monitored and quantified. Known as the emWave Pro, emWave2, and Inner Balance Trainer (HeartMath LLC, Boulder Creek, CA, USA), these interactive systems monitor and display individuals' heart rate variability patterns in real time as they practice the self-regulation techniques. Using an ear or fingertip sensor to record the pulse wave, the emWave plots changes in heart rate on a beat-to-beat basis. As people practice the coherence-building techniques, they can readily see and experience the changes in their heart rhythm patterns, which generally become more ordered, smoother, and more sine wave-like as they experience positive emotions. This process reinforces the natural association between the physiological coherence mode and positive feelings. The real-time physiological feedback essentially takes the guesswork and randomness out of the process of self-inducing a coherent state, resulting in greater consistency, focus, and effectiveness in shifting to a beneficial psychophysiological mode.

Heart rhythm coherence feedback training has been successfully used in clinical settings by physicians, and mental health professionals to facilitate health improvements in patients with numerous physical and psychological disorders.[46,47] It is also increasingly being utilized in corporate, military, law enforcement, and educational settings to enhance physical and emotional health and improve performance.[34,48,49]

BIOMAGNETIC COMMUNICATION

The first biomagnetic signal was demonstrated in 1963 by Gerhard Baule and Richard McFee in a magnetocardiogram (MCG) that used magnetic induction coils to detect fields generated by the human heart.[50] A remarkable increase in the sensitivity of biomagnetic measurements was achieved with the introduction of the Superconducting Quantum Interference Device (SQUID) in the early 1970s, and the ECG and MCG have since been shown to closely parallel one another.[51]

Biomagnetic Information Patterns

The heart generates a series of electromagnetic pulses in which the time interval between each beat varies in a complex manner. These pulsing waves of electromagnetic energy give rise to interference patterns when they interact with magnetically polarizable tissues and substances.

Figure 14.4 shows two different power spectra derived from an average of 12 individual 10 s epochs of ECG data recorded during differing psychophysiological modes. The plot on the left was produced while the subject was in a state of deep appreciation, whereas the plot on the right was generated while the subject experienced recalled feelings of anger. The difference in the patterns, and thus, the information they contain, can be clearly seen. There is a direct correlation between the patterns in the heart rate variability rhythm and the frequency patterns in the spectrum of the ECG or MCG. Experiments such as these indicate that psychophysiological information can be encoded into the electromagnetic fields produced by the heart.[15,52]

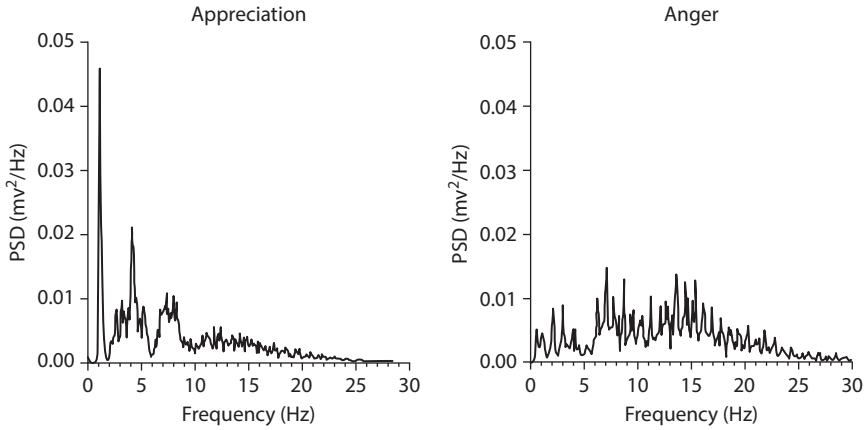

FIGURE 14.4 ECG spectra during different emotional states. The above graphs are the average power spectra of 12 individual 10 s epochs of ECG data, which reflect information patterns contained in the electromagnetic field radiated by the heart. The left-hand graph is an example of a spectrum obtained during a period of high heart rhythm coherence generated during a sustained heartfelt experience of appreciation. The graph on the right depicts a spectrum associated with a disordered heart rhythm generated during feelings of anger.

Biomagnetic Communication between People

The human body is replete with mechanisms for detecting its external environment. Sense organs, the most obvious example, are specifically geared to react to touch, temperature, select ranges of light and sound waves, etc. These organs are acutely sensitive to external stimuli. The nose, for example, can detect one molecule of gas, while a cell in the retina of the eye can detect a single photon of light. If the ear were any more sensitive, it would pick up the sound of the random vibrations of its own molecules.[53]

The interaction between two human beings, for example, the consultation between a patient and her clinician, is a very sophisticated dance that involves many subtle factors. Most people tend to think of communication solely in terms of overt signals expressed through facial movements, voice qualities, gestures and body movements. However, evidence now supports the perspective that a subtle yet influential electromagnetic or "energetic" communication system operates just below our conscious level of awareness. The following section will discuss data suggesting that this energetic system contributes to the "magnetic" attractions or repulsions that occur between individuals. It is also quite plausible that these energetic interactions can affect the therapeutic process.

The concept of energy or information exchange between individuals is central to many of the Eastern healing arts, but its acceptance in Western medicine has been hampered by the lack of a plausible mechanism to explain the nature of this "energy information" or how it is communicated. However, numerous studies investigating the effects of healers, therapeutic touch practitioners, and other individuals have demonstrated a wide range of significant effects including the influence of "energetic" approaches on wound healing rates,[54,55] pain,[56,57] hemoglobin levels,[58] conformational changes of DNA and water structure,[59,60] as well as psychological states.[61] Although these reports show beneficial results, they have been largely ignored because of the lack of any scientific rationale to explain how the effects are achieved.

Physiological Linkage and Empathy

The ability to sense what other people are feeling is an important factor in allowing us to connect or communicate effectively with others. The smoothness or flow in any social interaction depends to a great extent on the establishment of a spontaneous entrainment or linkage between individuals. When people are engaged in deep conversation, they begin to fall into a subtle dance, synchronizing their movements and postures, vocal pitch, speaking rates, and length of pauses between responses,[62] and, as we are now discovering, important aspects of their physiology can also become linked and synchronized.

Several studies have investigated different types of physiological synchronization or entrainment between individuals during empathetic moments or between clinician and patient during therapeutic sessions. One study by Levenson and Gottman at the University of California at Berkeley looked at physiological synchronization in married couples during empathetic interactions. Researchers examined couples' physiological responses during two discussions: a neutral "How was your day?" conversation, to establish a baseline, and a second conversation containing more emotional content in which the couples were asked to spend 15 min discussing something about which they disagreed. After the disagreement, one partner was asked to leave the room while the other stayed to watch a replay of the talk and identify portions of the dialogue where he or she was actually empathizing, but did not express it. Both spouses individually engaged in this procedure. Levenson was then able to identify those segments of the video where empathy occurred and match the empathetic response to physiological responses in both partners. He found that in partners who were adept at empathizing, their physiology mimicked their partner's while they

empathized. If the heart rate of one went up, so did the heart rate of the other; if the heart rate slowed, so did that of the empathic spouse.[63] Other studies observing the psychophysiology of married couples while interacting were able to predict the probability of divorce.[64] A study by Hertenstein and Keltner examined the communication of emotion via touch, and gender related differences that could be observed.[65] In a study on interpersonal effects of nonverbal compassionate communication, measuring psychophysiologic effects, Kemper and Shaltout found significant changes in the receiver's autonomic nervous system.[66]

Although studies that have examined physiological linkages between therapists and patients have suffered from methodological challenges, they do support a tendency to autonomic attunement during periods of empathy between the therapist and patient.[67] Dana Redington, a psychophysiologist at the University of California, San Francisco, analyzed heart rate variability patterns during therapist-patient interactions using a nonlinear dynamics approach. Redington and colleagues used phase space maps to plot changes in the beat-to-beat heart rate of both the therapist and patient during psychotherapy sessions. They found that the trajectories in the therapist's patterns often coincided with the patient's during moments when the therapist experienced strong feelings of empathy for the patient.[68] Carl Marci at Harvard University found evidence of a more direct linkage between patients and therapists using skin conductance measures. During sessions of psychodynamic psychotherapy, Marci observed a quantifiable fluctuation and entrainment in the pattern of physiological linkage within patient-therapist dyads, which was related to the patient's perception of the therapist's empathy. In addition, the preliminary results of his studies indicate that during low physiological linkage there are fewer empathetic comments, more incidents of incorrect interpretations, less shared affect, and fewer shared behavioral responses when compared to episodes of high physiological linkage.[69]

Energetic Communication

An important step in testing our hypothesis that the heart's electromagnetic field could transmit signals between people was to determine if the field and the information modulated within it could be detected by other individuals.

In conducting these experiments, the question being asked was straightforward. Namely, can the electromagnetic field generated by the heart of one individual be detected in physiologically relevant ways in another person, and if so, does it have any discernible biological effects? To investigate these possibilities, we used signal-averaging techniques to detect signals that were synchronous with the peak of the R-wave of one subject's ECG in recordings of another subject's EEG or brain waves. My colleagues and I have performed numerous experiments in our laboratory over a period of several years using these techniques,[70] and several examples are included below to illustrate some of these findings. In the majority of these experiments, subjects were seated in comfortable, high-back chairs to minimize postural changes with the positive ECG electrode located on the side at the left sixth rib and referenced to the right supraclavicular fossa according to the International 10–20 system. The ECG and EEG were recorded from both subjects simultaneously so that the data (typically sampled at 256 Hz or higher) could be analyzed for simultaneous signal detection in both.

To clarify the direction in which the signal flow was analyzed, the subject whose ECG R-wave was used as the time reference for the signal averaging procedure is referred to as the "signal source," or simply "source." The subject whose EEG was analyzed for the registration of the source's ECG signal is referred to as the "signal receiver," or simply "receiver." The number of averages used in the majority of the experiments was 250 ECG cycles (~4 min). The subjects did not consciously intend to send or receive a signal and, in most cases, were unaware of the true purpose of the experiments. The results of these experiments have led us to conclude that the nervous system acts as an antenna, which is tuned to and responds to the magnetic fields produced by the hearts of other individuals. My colleagues and I call this energetic information exchange *energetic communication* and believe it to be an innate ability that heightens awareness and mediates important aspects of true empathy and sensitivity to others. Furthermore, we have observed that this energetic communication ability can be enhanced, resulting in a much deeper level of nonverbal communication, understanding, and connection between people. We also propose that this type of energetic communication between individuals may play a role in therapeutic interactions between clinicians and patients that has the potential to promote the healing process.

From an electrophysiological perspective, it appears that sensitivity to this form of energetic communication between individuals is related to the ability to be emotionally and physiologically coherent. The data indicate that when individuals are in the coherent mode, they are more sensitive to receiving information contained in the fields generated by others. In addition, during physiological coherence, internal systems are more stable, function more efficiently, and radiate electromagnetic fields containing a more coherent structure.[15]

The Electricity of Touch

The first step was to determine if the ECG signal of one person could be detected in another individual's EEG during physical contact. For these experiments we seated pairs of subjects 4 feet apart, during which time they were simultaneously monitored. Figure 14.5 shows a typical example of the results.

While in most pairs a clear signal transfer between the two subjects was measurable in one direction, it was only observed in both directions simultaneously in about 30% of the pairs (i.e., Subject 2's ECG could be detected in Subject 1's EEG at the same time that Subject 1's ECG was detectable in Subject 2's EEG). As shown later, an important variable appears to be the degree of physiological coherence maintained.

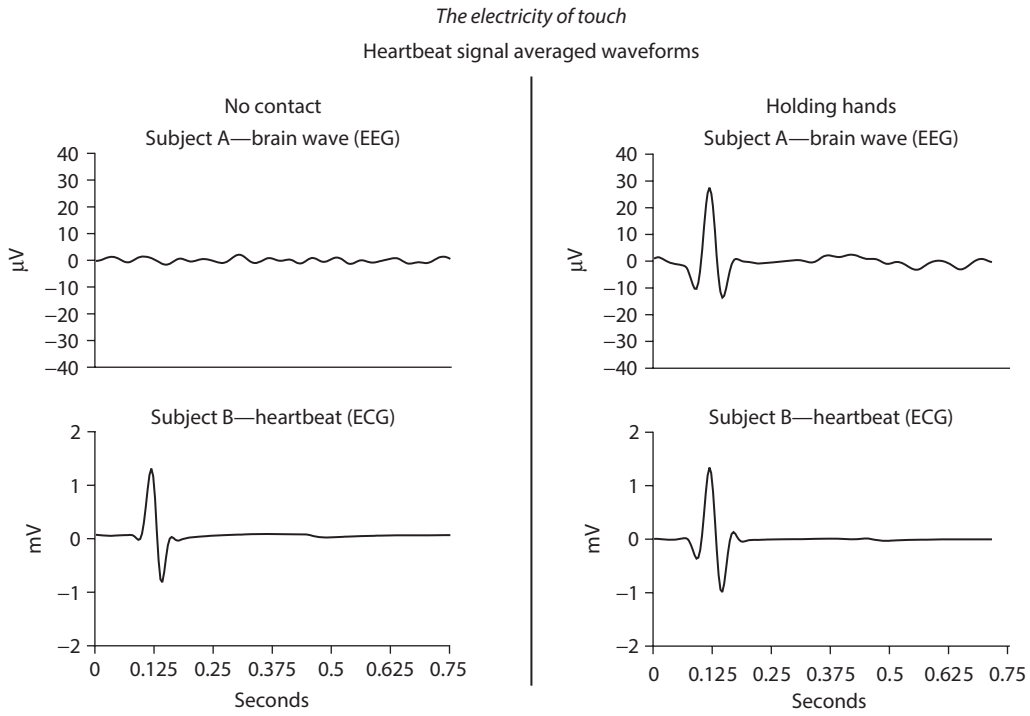

FIGURE 14.5 Signal averaged waveforms showing the detection of electromagnetic energy generated by the source's heart in the receiving subject's EEG. The baseline recording (left side) is from a 10 min period during which time the subjects were seated 5 feet apart without physical contact. The right column shows the recording from the 5 min period during which the subjects held hands. The EEG data shown here were recorded from the C3 site of the EEG.

After demonstrating that the heart's activity could be detected in another's EEG during physical contact, we completed a series of experiments to determine if the signal was transferred via electrical conduction alone or if it was also energetically transferred via magnetic fields. The results suggest that a significant degree of signal transfer occurs through skin conduction, however is also radiated between individuals.[71]

The possibility exists that in some cases the signal appearing in the receiving subject's recordings could be the receiver's own ECG rather than that of the other subject. Given the signal averaging procedure employed, this could only occur if the source's ECG was continually and precisely synchronized with the receiver's ECG. To definitively rule this out, the data in all experiments were checked for this possibility.

Simultaneously and independently, Russek and Schwartz at the University of Arizona conducted similar experiments in which they were also able to demonstrate the detection of an individual's cardiac signal in another's EEG recording in two people sitting quietly, without physical contact.[72]

Heart-Brain Synchronization during Nonphysical Contact

As the magnetic component of the field produced by the heartbeat is radiated outside the body and can be detected several feet away with SQUID-based magnetometers,[73,74] we further tested the transference of signals between subjects who were not in physical contact. In these experiments, the subjects were either seated side by side or facing each other at varying distances. In some cases, we were able to detect a clear QRS-shaped signal in the receiver's EEG, but not in others. Although the ability to obtain a clear registration of the ECG in the other person's EEG declined as the distance between subjects was increased, the phenomenon appears to be nonlinear. For instance, a clear signal could be detected at a distance of 18 inches in one session, but was undetectable in the very next trial at a distance of only 6 inches. Although transmission of a clear QRS-shaped signal is uncommon at distances over 6 inches in our experience, physiologically relevant information is clearly communicated between people at much further distances, and is reflected in synchronized activity.

Figure 14.6 shows the data from two subjects seated facing one another at a distance of 5 feet, with no physical contact. The subjects were asked to use the Heart Lock-In technique,[41] that has clearly been shown to produce sustained states of physiological coherence.[19] There was no intention to "send energy" and participants were not aware of the purpose of the experiment. The top three traces show the signal-averaged waveforms derived from the EEG locations along the medial line of the head.

Note that in this example, the signal averaged waveforms do not contain any semblance of the QRS complex shape as seen in the physical contact experiments; rather they reveal the occurrence of an alpha wave synchronization in the EEG of one subject that is precisely timed to the R-wave of the other subject's ECG. Power spectrum analysis of the signal

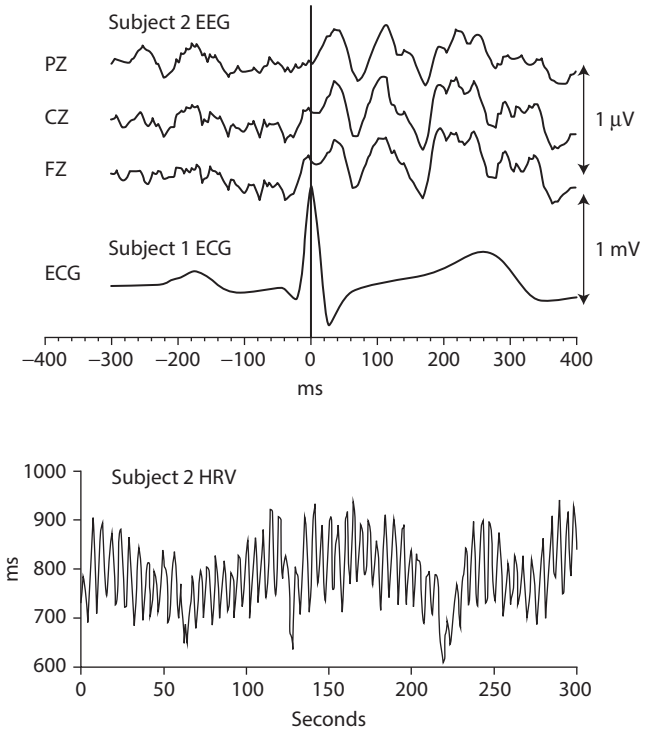

FIGURE 14.6 Heart-brain synchronization between two people. The top three traces are Subject 2's signal averaged EEG waveforms, which are synchronized to the R-wave of Subject 1's ECG. The lower plot shows Subject 2's heart rate variability pattern, which was coherent throughout the majority of the record. The two subjects were seated at a conversational distance without physical contact.

averaged EEG waveforms showed that the alpha rhythm was synchronized to the other person's heart. This alpha synchronization does not imply that there is increased alpha activity, but it does show that the existing alpha rhythm is able to synchronize to extremely weak external electromagnetic fields such as those produced by another person's heart. It is well known that the alpha rhythm can synchronize to an external stimulus such as sound or light flashes, but the ability to synchronize to such a subtle electromagnetic signal is surprising. As mentioned, there is also a significant ratio of alpha activity that is synchronized to one's own heartbeat, and the amount of this synchronized alpha activity is significantly increased during periods of physiological coherence.[2,22]

Figure 14.6 shows an overlay plot of one of Subject 2's signal averaged EEG traces and Subject 1's signal averaged ECG. This view shows an amazing degree of synchronization between the EEG of Subject 2 and Subject 1's heart. These data show that it is possible for the magnetic signals radiated by the heart of one individual to influence the brain rhythms of another. In addition, this phenomenon can occur at conversational distances (Figure 14.7).

Energetic Sensitivity and Empathy

Figure 14.8 shows the data from the same two subjects during the same time period, only it is analyzed for alpha

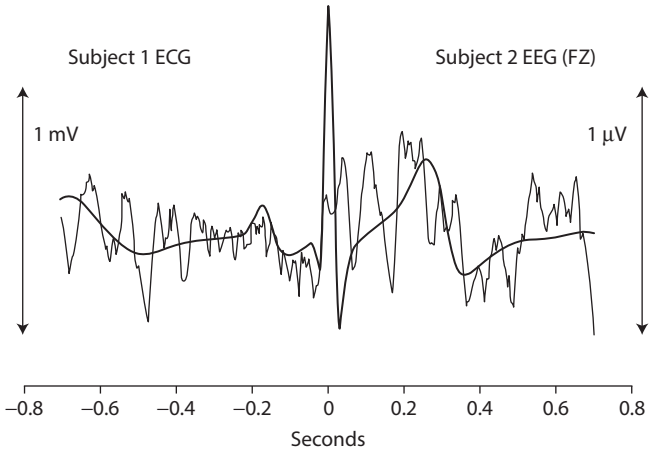

FIGURE 14.7 Overlay of signal averaged EEG and ECG. This graph is an overlay plot of the same EEG and ECG data shown in Figure 14.6. Note the similarity of the wave shapes, indicating a high degree of synchronization.

synchronization in the opposite direction (Subject 1's EEG and Subject 2's ECG). In this case, we see that there is no observable synchronization between Subject 1's EEG and Subject 2's ECG. The key difference between the data shown in Figure 14.6 and Figure 14.8 is the high degree of physiological coherence maintained by Subject 2. In other words, the degree of coherence in the *receiver's* heart rhythms

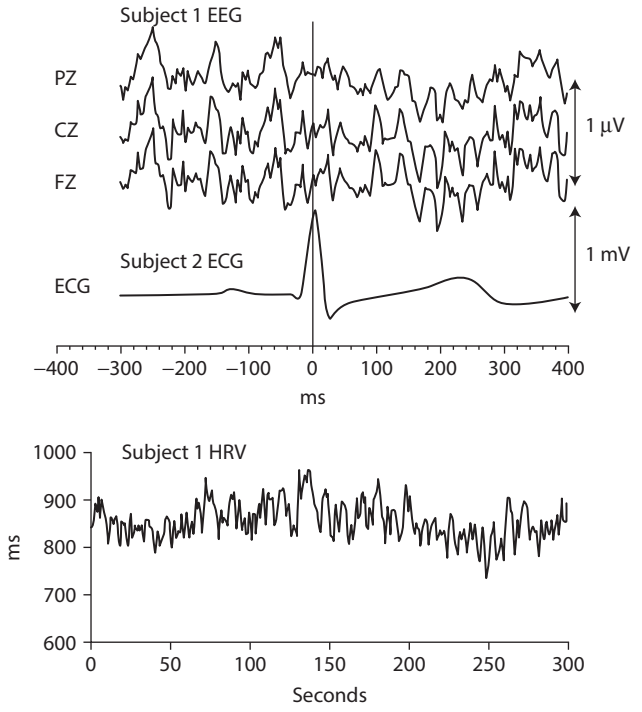

FIGURE 14.8 The top three traces are the signal averaged EEG waveforms for Subject 1. There is no apparent synchronization of Subject 1's alpha rhythm to Subject 2's ECG. The bottom plot is a sample of Subject 1's heart rate variability pattern, which was incoherent throughout the majority of the record.

appears to determine whether his/her brainwaves synchronize to the other person's heart.

This suggests that when one is in a physiologically coherent mode, one exhibits greater sensitivity in registering the electromagnetic signals and information patterns encoded in the fields radiated by the hearts of other people. At first glance the data may be interpreted that we are more vulnerable to the potential negative influence of incoherent patterns radiated by those around us. In fact, the opposite is true. When people are able to maintain the physiological coherence mode, they are more internally stable and thus less vulnerable to being negatively affected by the fields emanating from others. It appears that it is the increased internal stability and coherence that allows for the increased sensitivity to emerge.

This fits quite well with our experience in training thousands of individuals in how to self-generate and maintain coherence while they are communicating with others. Once individuals learn this skill, it is a common experience that they become much more attuned to other people and are able to detect and understand the deeper meaning behind spoken words. They are often able to sense what someone else really wishes to communicate even when the other person may not be clear about that which he is attempting to say. This technique, called Coherent Communication, helps people to feel fully heard and promotes greater rapport and empathy between people.[75]

Our data are also relevant to Russek and Schwartz's findings that people, who are more accustomed to experiencing positive emotions, such as love and care, are better receivers of energetic signals from others.[76] In their follow-up study of 20 college students, those who had rated themselves as having been raised by loving parents exhibited significantly greater registration of an experimenter's ECG in their EEG than others who had perceived their parents as less loving. Our findings, which show that positive emotions such as love, care, and appreciation are associated with increased physiological coherence, suggest the possibility that the subjects in Russek and Schwartz's study had higher ratios of physiological coherence, which could explain the greater registration of cardiac signals.

Heart Rhythm Synchronization between People

When heart rhythms are more coherent, the electromagnetic field that is radiated outside the body correspondingly becomes more organized, as shown in Figure 14.4. The data presented thus far indicate that signals and information can be communicated energetically between individuals, but so far have not implied a literal synchronization of two individuals' heart rhythm patterns. We have found that synchronization of heart rhythm patterns between individuals is possible, but usually occurs only under very specific conditions. In our experience, true heart rhythm synchronization between individuals is very rare during normal waking states. We have found that individuals who have a close working or living relationship are the best candidates for exhibiting this type of synchronization. Figure 14.9 shows an example of heart rhythm synchronization between two women who have a close working relationship and practice coherence-building techniques regularly. For this experiment, they were seated 4 feet apart, and, although blind to the data, were consciously focused on generating feelings of appreciation for each other.

A more complex type of synchronization can also occur during sleep. Although we have only looked at couples who are in long-term stable and loving relationships, we have been surprised at the high degree of heart rhythm synchrony observed in these couples while they sleep. Figure 14.10 shows an example of a small segment of data from one couple. These data were recorded using an ambulatory ECG recorder with a modified cable harness that allowed the concurrent recording of two individuals on the same recording.

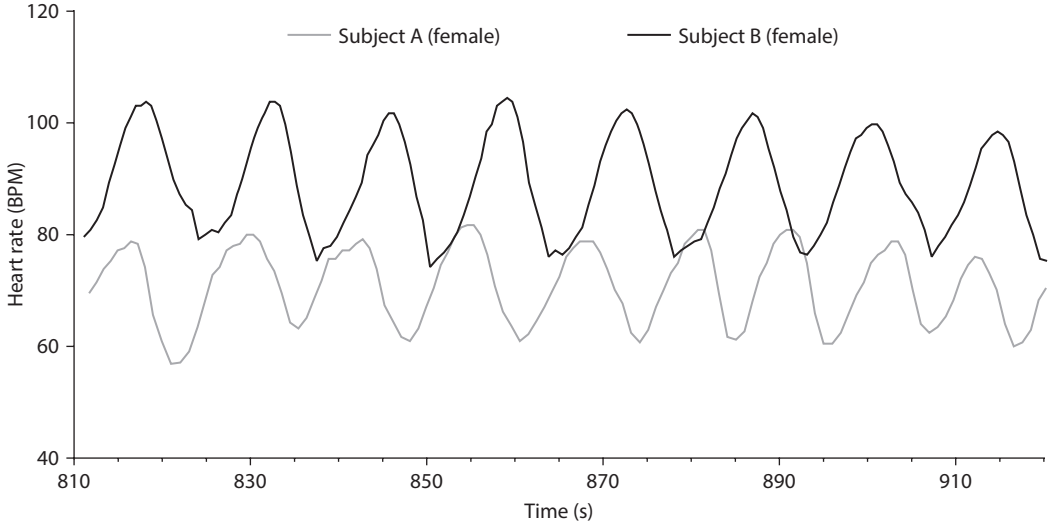

FIGURE 14.9 Heart rhythm entrainment between two people. These data were recorded while both subjects were practicing the Heart Lock-In technique and consciously feeling appreciation for each other. It should be emphasized that in typical waking states, entrainment between people such as in this example is rare.

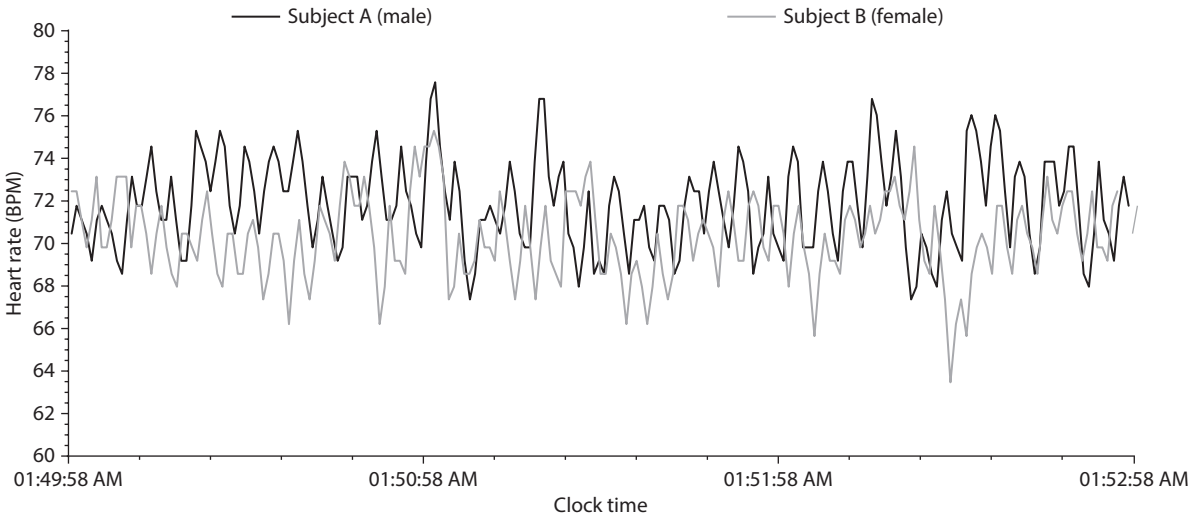

FIGURE 14.10 Heart rhythm entrainment between husband and wife during sleep.

Note how the heart rhythms simultaneously change in the same direction and how heart rates converge. Throughout the recording, clear transition periods are evident in which the heart rhythms move into greater synchronicity for some time, and then drift out again. This implies that unlike in most wakeful states, synchronization between the heart rhythms of individuals can and does occur during sleep.

Another line of research that has shown physiological synchronization between people was in a study of a 30-min long Spanish fire-walking ritual. Heart rate data was obtained from 38 participants and synchronized activity was compared between fire-walkers and spectators. They showed fine-grained commonalities of arousal during the ritual between firewalkers and related spectators but not unrelated spectators. The authors concluded that their findings demonstrated that a collective ritual can evoke synchronized arousal over time between active participants and relatives or close friends. They also suggest that the study links field observations to a physiological basis and offers a unique approach for the quantification of social effects on human physiology during real-world interactions and that mediating mechanism may be informational.[77]

Morris[26] studied the effect of heart coherence in a group setting with 15 participants who were trained in HeartMath's Quick Coherence® Technique. He conducted 148 10-minute trials in which three trained participants were seated around a table with one untrained participant. During each trial, three of the trained participants were placed with one of 25 untrained volunteers to determine whether the three could collectively facilitate higher levels of HRV in the untrained individual. The coherence of the HRV of the untrained subject was found to be higher in approximately half of all matched comparisons when the trained participants focused on achieving increased coherence. In addition, evidence of heart rhythm synchronization between group participants was revealed through several evaluation methods and higher levels of coherence correlated to higher levels of synchronization between participants and there was a statistical relationship between this synchronization and relational measures (bonding) among the participants. The authors concluded that "evidence of heart-to-heart synchronization across subjects was found which lends credence to the possibility of heart-to-heart bio-communications."

Using signal averaging techniques, we were also able to detect synchronization between a mother's brainwaves (EEG-CZ) and her baby's heartbeats (ECG). The pair was not in physical contact, but when the mother focused her attention on the baby, her brainwaves synchronized to the baby's heartbeats. We were not able to detect that the infants EEG synchronized to the mother's heartbeats (Figure 14.11).

Biomagnetic Communication between People and Animals

Farmers and attentive observers know that most cattle and sheep, when grazing, face the same way. It has been demonstrated by means of satellite images, field observations, and

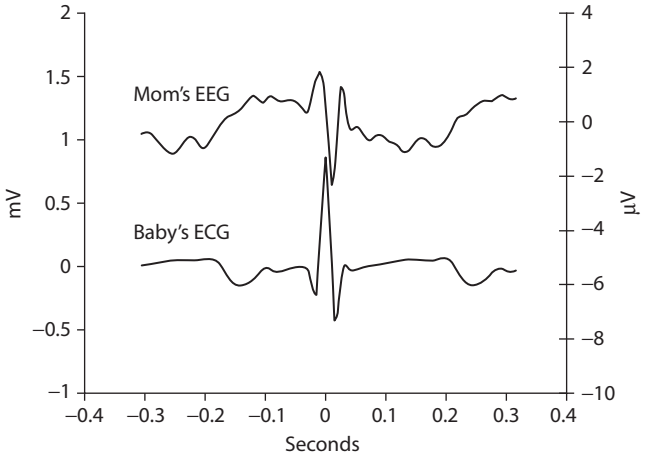

FIGURE 14.11 ECG and EEG synchronization between mother and baby.

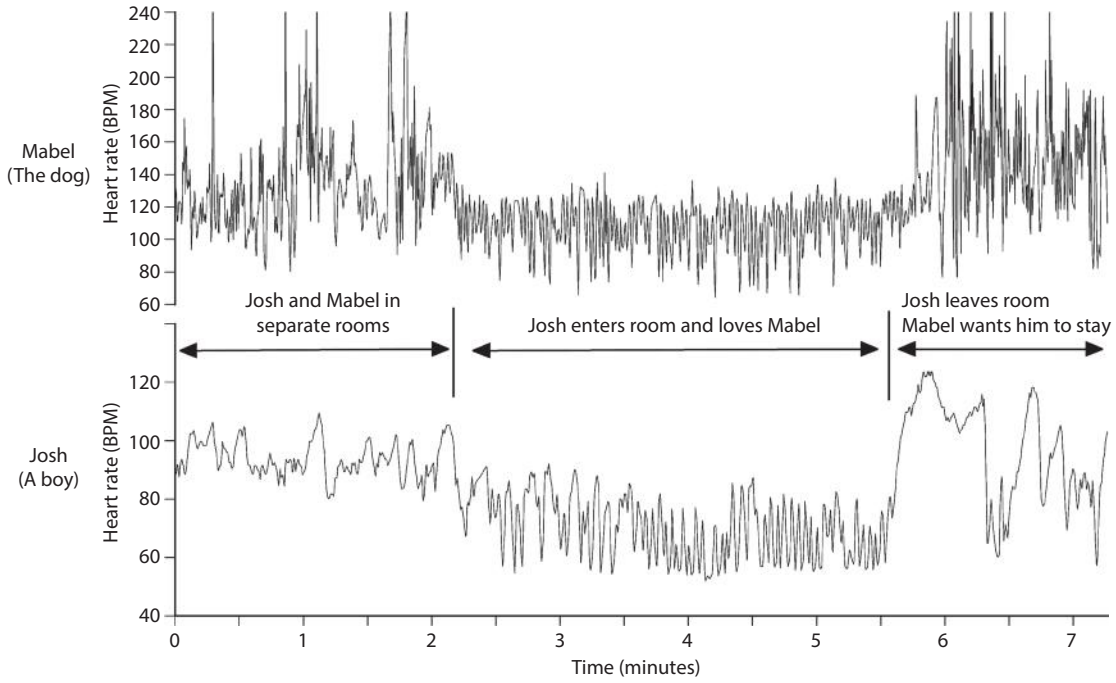

FIGURE 14.12 Heart rhythm patterns of a boy and his dog. These data were obtained using ambulatory ECG recorders fitted on both Josh, a young boy, and Mabel, his pet dog. When Josh entered the room where Mabel was waiting and consciously felt feelings of love and care towards his pet, his heart rhythms became more coherent and this change appears to have influenced Mabel heart rhythms, which clearly shifted to a more coherent rhythm. When Josh left the room, Mabel's heart rhythms became much more chaotic and incoherent, suggesting separation anxiety!

measuring "deer beds" in snow that domestic cattle across the globe, and grazing and resting red and roe deer, align their body axes in roughly a north–south direction and orient their heads northward when grazing or resting. Wind and light conditions were excluded as a common determining factor and magnetic alignment with the earth's geomagnetic field was determined to be best explanation. Magnetic north was a better predictor than geographic north suggesting large mammals have magnetoreception capability.[78]

We have also found that a type of heart rhythm synchronization can occur in interactions between people and their pets. Figure 14.10 shows the results of an experiment looking at the heart rhythms of my son Josh (12 years old at the time of the recording) and his dog, Mabel. Here we used two Holter recorders, one fitted on Mabel and the other on Josh. We synchronized the recorders and placed Mabel in one of our labs. Josh then entered the room and sat down and proceeded to do a Heart Lock-In and consciously radiate feelings of love towards Mabel. There was no physical contact nor did he make any attempts to obtain the dog's attention. Note the synchronous shift to increased coherence in the heart rhythms of both Josh and Mabel as Josh consciously feels love for his pet (Figure 14.12).

Another example of an animal's heart rhythm pattern shifting in response to a human's shift of emotional states is shown in Figure 14.13. This was a collaborative study with Ellen Gehrke, who consciously shifted into a coherent state, as she sat in a corral with her horse, without touching or petting it. When she shifted into a coherent state, the horse's heart rhythm pattern also shifted to a more ordered pattern. Very similar shifts in the horses HRV patterns were seen in three out of four horses' heart rhythms. The one horse that

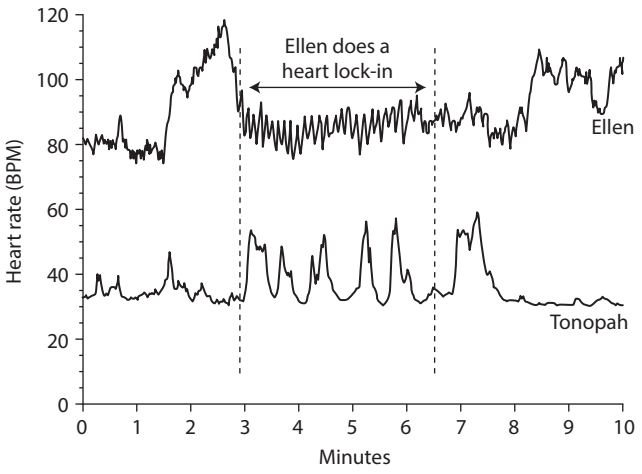

FIGURE 14.13 Heart rhythm patterns of woman and horse. These data were obtained using ambulatory ECG recorders fitted on both Ellen and Tonopah, her horse. When she did a Heart lock-In, her heart rhythms became more coherent and this change appears to have influenced the horse's heart rhythms.

did not show any response was well known for not relating well to humans or to other horses.

CONCLUSIONS AND IMPLICATIONS FOR CLINICAL PRACTICE

Bioelectromagnetic communication is a real phenomenon that has numerous implications for physical, mental, and emotional health. This chapter has focused on the proposition that increasing the coherence within and between the body's endogenous bioelectromagnetic systems can increase physiological and metabolic energy efficiency, promote mental and emotional stability, and provide a variety of health and social harmony benefits. It is further proposed that many of the benefits of increased physiological coherence will ultimately prove to be mediated by processes and interactions occurring at the electromagnetic or energetic level of the organism.

With the many physiological and psychological benefits that increased coherence appears to offer, helping patients learn to self-generate and sustain this psychophysiological mode with increased consistency in their day-to-day lives provides a new strategy for clinicians to assist their patients on multiple levels. There are several straightforward ways to help patients increase their physiological coherence. Teaching and guiding them in the practice of positive emotion refocusing and emotional restructuring techniques in conjunction with heart rhythm feedback has proved to be a simple and cost-effective approach to improving patient outcomes.[44] These coherence-building methods are not only effective therapeutic tools in and of themselves, but by increasing synchronization and harmony among the body's internal systems, may also help increase a patient's physiological receptivity to the therapeutic effects of other treatments.[35,44,79]

Coherence-building approaches may also help health care practitioners increase their effectiveness in working with patients. In self-generating a state of physiological coherence, the clinician has the potential to facilitate the healing process by establishing a coherent pattern in the subtle electromagnetic environment to which patients are exposed.[80] As even very weak coherent signals have been found to give rise to significant effects in biological systems,[81,82] it is possible that such coherent heart fields may provide unsuspected therapeutic benefits. Furthermore, by increasing coherence, clinicians may not only enhance their own mental acuity and emotional stability, but may also develop increased sensitivity to subtle electromagnetic information in their environment. This, in turn, could potentially enable a deeper intuitive connection and communication between practitioner and patient, which can be a crucial component of the healing process.

In conclusion, I believe that the electromagnetic energy generated by the heart acts as a synchronizing force within the body, a key carrier of emotional information, and a mediator of bioelectromagnetic communication between people. As such, the cardiac bioelectromagnetic field is an innate untapped resource that requires further investigation to explore its clinical applications. Such exploration is likely to provide further insight into the dynamics of health and disease that are strongly influenced by emotions and by interactions with others.

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