The Electricity of Touch: Detection and measurement of cardiac energy exchange between people

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Summary

The idea that an energy exchange of some type occurs between individuals is a central theme in many healing techniques. This concept has often been disputed by Western science due to the lack of a plausible mechanism to explain the nature of this energy or how it could affect or facilitate the healing process. The fact that the heart generates the strongest electromagnetic field produced by the body, coupled with the recent discovery that this field becomes more coherent as the individual shifts to a sincerely loving or caring state prompted us to investigate the possibility that the field generated by the heart may significantly contribute to this energy exchange.

We present a sampling of results which provide intriguing evidence that an exchange of electromagnetic energy produced by the heart occurs when people touch or are in proximity. Signal averaging techniques are used to show that one's electrocardiogram (ECG) signal is registered in another person's electroencephalogram (EEG) and elsewhere on the other person's body. While this signal is strongest when people are in contact, it is still detectable when subjects are in proximity without contact.

This study represents one of the first successful attempts to directly measure an energy exchange between people, and provides a solid, testable theory to explain the observed effects of many healing modalities that are based upon the assumption that an energy exchange takes place. Nonlinear stochastic resonance is discussed as a mechanism by which weak, coherent electromagnetic fields, such as those generated by the heart of an individual in a caring state, may be detected and amplified by biological tissue, and potentially produce measurable effects in living systems. One implication is that the effects of therapeutic techniques involving contact or proximity between practitioner and patient could be amplified by practitioners consciously adopting a sincere caring attitude, and thus introducing increased coherence into their cardiac field.

KEY WORDS: Touch, energy, healing, ECG, EEG, coherence, emotion, stochastic resonance, signal averaging

INTRODUCTION

The concept of an energy exchange between individuals is culturally a universal belief and is a central theme in many of the healing arts of both Eastern and Western medicine, now often referred to as Energy Medicine. One of the main blocks to the acceptance of these so-called alternative therapies by western science has been the lack of a plausible mechanism that could explain the nature of this energy or how it is exchanged. Nevertheless, numerous of studies of Therapeutic Touch practitioners, healers and other individuals have demonstrated a wide variety of effects on healing rates of wounds,[1, 2] pain,[3, 4] hemoglobin levels,[5, 6] conformational changes of DNA and water structure[7] as well as psychological improvements.[8, 9] If we define energy as the capacity to produce an effect, these experiments suggest that an exchange of energy has occurred. It has also been demonstrated that many of these therapeutic effects occur without physical touch, indicating that energy of some kind is radiated or broadcast between practitioner and patient.[8]

References to the concept of an energy exchange between people can also be found in the psycho-therapeutic field as a sense of energetic interaction between the practitioner and patient. This concept dates back at least to Freud, who proposed in *The Anxiety Neuroses* that an energy exchange between practitioner and patient operated at an unconscious level to bring about changes in the patient's mental, emotional and physical well-being.[9]

Many of the healing professions emphasize the importance of the attitude or intention of the practitioner in order for the greatest facilitation of the healing process to occur.[8, 10, 11] The importance of intention has been demonstrated in several studies,[12] including one at our laboratories.[7] In addition, we have previously shown that a person's inner emotional state directly affects the coherence in the electromagnetic field generated by the heart,[12, 13] and that sincere feelings of appreciation, love or care produce increased coher-

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ence in the cardiac field. This is especially significant, as the heart generates the strongest electromagnetic field produced by the body, measurable a number of feet away from the body with SQUID-based magnetometers[13] and sensitive electrostatic detectors.[14]

It has been argued that even if there were an energy exchange between people, the energy contained in the signal would be too weak to produce significant effects in a biological system. However, recent research has established that the noise in biological systems can play a constructive role in the detection of weak periodic signals via a mechanism known as stochastic resonance.[15] In essence, stochastic resonance is a nonlinear cooperative effect in which a weak, normally sub-threshold periodic (coherent) stimulus entrains ambient noise, resulting in the periodic signal becoming greatly enhanced and able to produce large scale effects. The signature of stochastic resonance is that the signal-to-noise ratio in the system rises to a maximum at some optimal noise intensity, corresponding to the maximum cooperation between the signal and the noise. Essentially, the noise acts to boost the sub-threshold signal to a level above the threshold value, enabling it to generate measurable effects. Stochastic resonance is now known to occur in a wide range of systems, including sensory transduction, neural signal processing and oscillating chemical reactions,[15, 16] and is firmly established as a valid and far more general phenomenon than previously thought.

There has been much debate over the capacity of extremely low frequency electromagnetic fields to affect living tissue. Theoretical estimates predict the interaction energies of these fields after penetrating the tissue to be up to three orders of magnitude smaller than the average energy of thermal fluctuations.[16] However, the effect of stochastic resonance operating in the noisy environment of a biological tissue would be to greatly amplify the external field's energy, possibly to the point of enabling it to have significant repercussions in the system. The electromagnetic energy patterns produced by the human heart when an individual is in the internal coherence mode, a state reached when feeling sincere love (Figure 1), is a clear example of a coherent, extremely low frequency electromagnetic field.[17, 18] Recent advances in our understanding of the interaction between coherent signals and noise in nonlinear systems has led to the hypothesis that under certain circumstances these nonthermal, coherent electromagnetic fields are detectable by biological systems at the cellular and sub-cellular level.[15, 19, 20] For example, it has recently been demonstrated that nonthermal, extremely low frequency electromagnetic signals can affect intracellular calcium signaling.[21] In addition, coherent electromagnetic fields have been shown to produce substantially greater effects than incoherent signals on enzymatic pathways, such as the ornithine decarboxylase pathway.[22] This suggests that increased cardiac coherence, and thus one's emotional state, may affect cellular function.

The fact that the heart's electromagnetic field (ECG) can be measured anywhere on the surface of the body and also several feet away from the

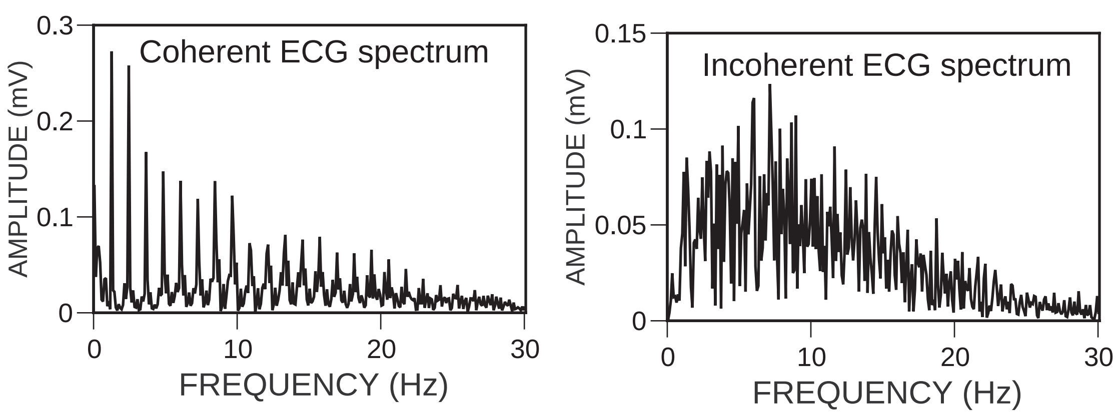

Figure 1. Coherent and incoherent ECG spectra. Both of the above graphs are amplitude spectra of 10-second epochs of ECG data. The lefthand graph is an example of the internal coherence mode of heart function. This coherence is associated with sustained, sincere feelings of love and other positive emotions. The graph on the righthand side depicts an incoherent spectrum and is typical of feelings of anger or frustration.

body, coupled with the recent discovery that this field can become more coherent as the individual shifts to a sincerely loving or caring state, prompted us to investigate the possibility that the field generated by the human heart may be the source of the energy exchanged between practitioner and patient in many healing practices. We therefore set out to develop a method of measuring an electrical exchange between people when they touch or are in proximity. This paper presents a few examples from a number of experiments demonstrating that when individuals touch or are in proximity, one person's electrocardiogram (ECG) signal is registered in the other person's electroencephalogram (EEG) and elsewhere on the other person's body. Simultaneously and independently, Russek and Schwartz conducted similar experiments in which they also showed the registration of one individual's cardiac signal in another's EEG recording when two people sat quietly opposite one another.[23] In a recent publication entitled "Energy Cardiology,"[24] Russek and Schwartz discuss the implications of this finding in the context of what they call a "dynamical energy systems approach" to describing the heart as a prime generator, organizer and integrator of energy in the human body.

The research described here was not designed as a comprehensive, rigorous study to yield results to be subject to statistical analysis, and is not intended to be presented or evaluated as such a study. Rather, we present here a small sampling of results gathered over several years of experimentation that provide intriguing evidence of the exchange of electromagnetic energy produced by the human heart that occurs when two people touch or are in proximity, as well as an experimental protocol that allows such effects to be measured. The results described in this paper are representative examples of the types of data that have been collected from numerous experiments conducted with many different subjects over several years' time. We recognize that these results raise more questions that they answer; and it is our intention that this initial compilation of data might stimulate other interested researchers to pursue the challenge of designing and conducting experiments that further address some of these questions.

Signal Averaging

The measurements presented in this paper were achieved using signal averaging techniques. Signal averaging is a digital procedure for separating a repetitive signal from noise without introducing signal distortion (Figure 2). The superimposition of any number of equal-length epochs, each containing a repeating periodic signal, emphasizes the periodic signal at the expense of irregular variations constituting the noise. The technique was first used in detecting radar signals and was later applied in human physiology to detect and record cerebral cortical responses to sensory stimulation, now known as the cortical evoked potential or event-related potential.[25] The procedure is also used in cardiology to analyze the ECG and is known in this field as micropotential analysis. In this study, the signal averaging technique was applied 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 body surface.

METHODS

Subjects were either seated in comfortable, high-back chairs to minimize postural changes or were lying down on a massage table. Prior to each session, subjects were informed of the tasks they were to perform and asked to refrain from talking, falling asleep or engaging in exaggerated body movements. The subjects were carefully monitored to ensure that there were no exaggerated respiratory or postural changes during the session.

Disposable silver/silver chloride electrodes were used for all bipolar ECG measurements. The positive electrode was located on the left side at the sixth rib and the reference was placed in the right supraclavicular fossa. Grass model 7P4 amplifiers were used for ECG amplification and Grass model P5 amplifiers were used for EEG and body surface measurements. The low frequency filters were set at the 1 Hertz setting and the high frequency filters at 35 Hertz. EEG electrodes were attached according to the International 10-20 system; the various recording sites and referencing are specified in each experimental session. Electrode resistance was measured with a UFI model 1089 electrode tester. Electrode to electrode resistance was typically in the range

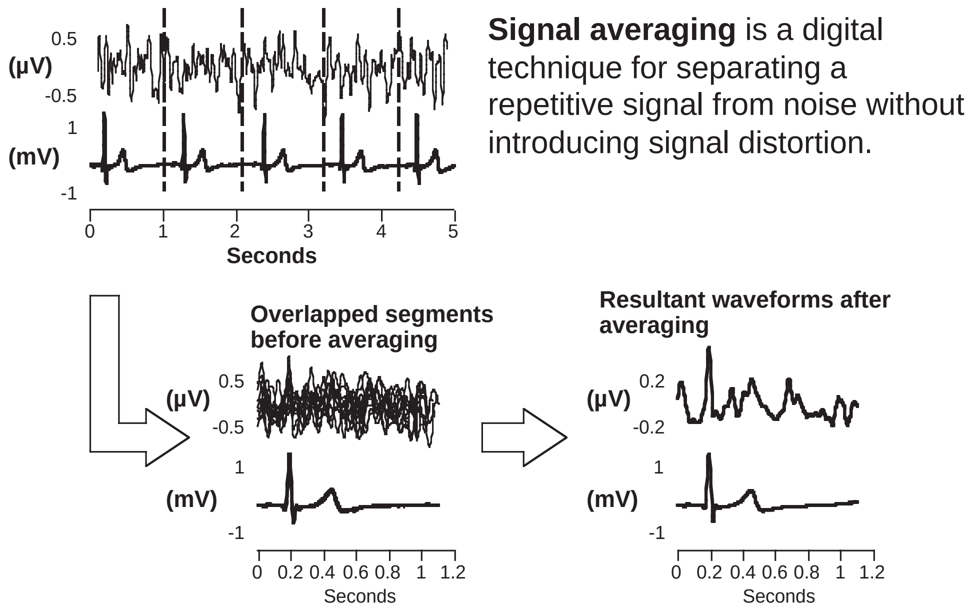

Figure 2. The signal averaging technique. The sequence of the signal averaging procedure is shown above. First, the signals recorded from two subjects are digitized and recorded in a computer. The R-wave (peak) of the ECG recorded from the individual designated as the "signal source" is used as the time reference for cutting the two signals into individual segments. The individual segments are then averaged together to produce the resultant waveforms. Only signals that are repeatedly synchronous with the signal source's ECG are present in the resulting waveform. The signals which are not related to the signal source are eliminated by the process.

of 2 to 5 KΩ. All data were digitized by a Bio Pac 16 bit digitizer and software system. The sample rate was 256 Hz. All post analysis was done with DADiSP/32 digital signal processing software.

All of the experiments monitored various recording sites on 2 subjects simultaneously. In all experiments, both subjects were wired with ECG electrodes as described above. To clarify the direction in which the signals were analyzed, the subject whose ECG R-wave peak was used as the signal time reference for the signal averaging is referred to as the "signal source," or simply "source." It should be emphasized that the subject designated as the source did not consciously intend to send or transmit a signal. The subject whose EEG or body surface recordings were analyzed for the registration of the source's ECG signal is referred to as the "signal receiver," or simply "receiver." Signal averaging techniques were used to detect the appearance of the source's ECG signal on the surface of the receiver's body at various electrode locations. The resulting waveform appearing on the receiver is referred to as the signal-averaged waveform (SAW). The signal-averaged waveforms were triggered by the peak of the source's ECG R-wave. The number of averages used in the majority of the experiments was 250 ECG cycles or roughly 4 minutes of data.

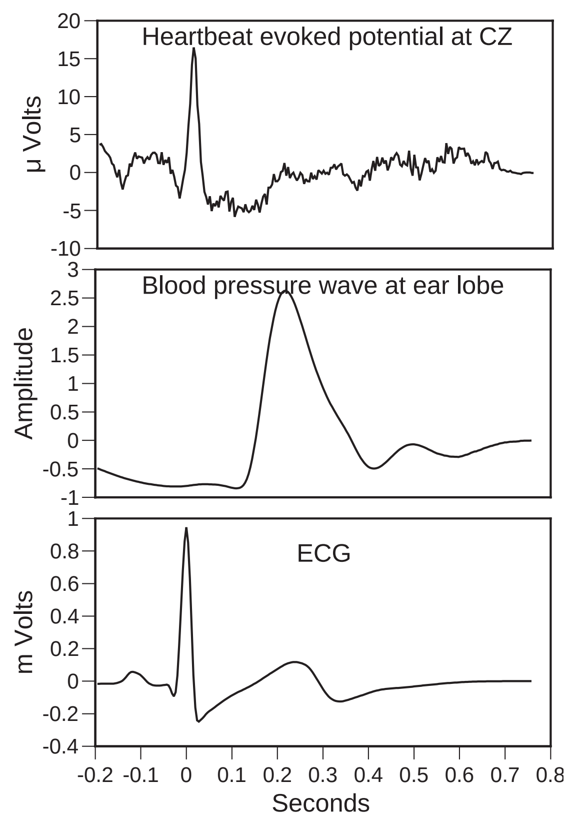

Figure 3. Heartbeat evoked potential. Illustrates an example of the heartbeat evoked potential when a subject's own ECG is used as the signal source. The top trace is the EEG recorded at the CZ location and the middle trace is the blood pressure wave, which was recorded at the earlobe. The signal from the heart arrives at the CZ location around 10 milliseconds after the ECG R-wave and the blood pressure wave arrives around 240 milliseconds later.

It is well known that the electrical potential generated by one's heartbeat can be recorded from any site on the body, including the sites recorded by the EEG.[23, 26, 27] (Figure 3). Therefore, in each of our experiments, the possibility had to be considered that the signal appearing in the receiving subject's recordings was the receiver's own ECG rather than that of the other subject designated as the source. Given the signal averaging procedure employed, this would only be possible if the ECG of the source was continually and precisely synchronized with the receiver's ECG. To definitively rule out this unlikely possibility, in all experiments both the source and the receiver's ECG were recorded.

EXPERIMENTAL EXAMPLES

Example 1: Holding hands

The purpose of these experiments was to test the hypothesis that when 2 people touch, an exchange of electrical energy produced by their hearts occurs. In the experiments reported on here, 6 subjects were paired in groups of 2. Each pair was monitored on a separate day. The experiment was designed to test for the appearance of the source's ECG signal in the receiver's EEG recording when the subjects were sitting several feet apart and when they held hands but made no other contact. Data were also analyzed to check for the transfer of energy in the reverse direction.

The subjects were seated and fitted with ECG and EEG electrodes. The EEG electrodes were attached to the CZ, C3 and C4 locations on both subjects. The reference for both the C3 and C4 electrode was at the CZ location. The 2 subjects were simultaneously monitored using a 10-minute baseline period during which they were separated by 4 feet, followed by a 5-minute hand holding period. In this experiment subjects were instructed to hold hands and were not instructed to have any specific intention or feeling state.

Signal averaging was used to detect the appearance of the source's ECG signal in the receiver's signal-averaged waveform (SAW) at the various electrode locations. The SAW in the receiver was triggered by the R-wave (250 ECG cycles) of the source's ECG.

Results

When the subjects were seated 4 feet apart, there was no indication of a transfer of energy between them from the 250 averages used in these experiments. However, when they held hands, the source's ECG could be clearly detected in the receiver's SAW at both the C4 and C3 locations. Figure 4 shows the data from one set of

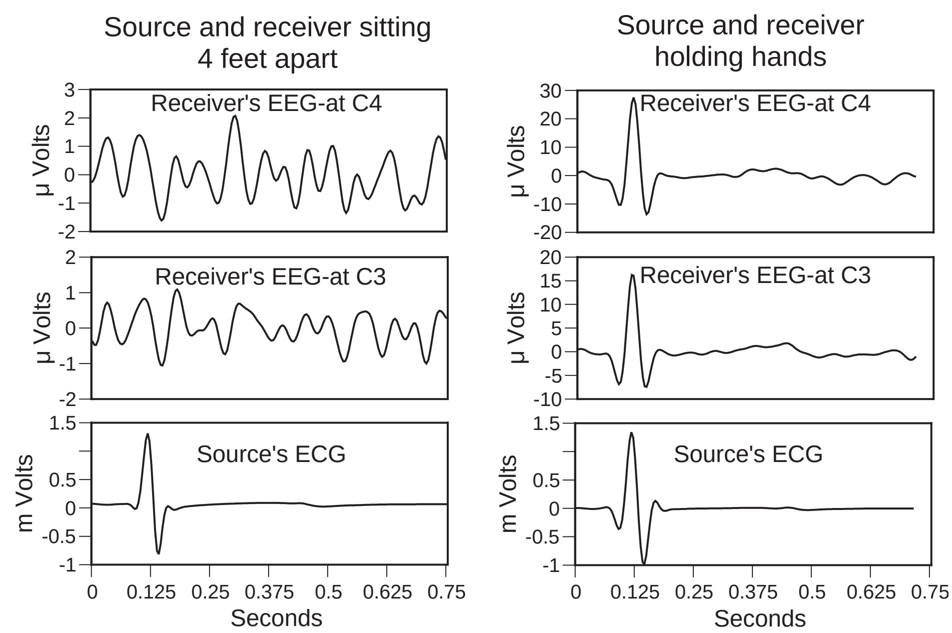

Figure 4. Cardiac signal averaged waveforms before and while holding hands. Signal averaged waveforms showing a transference of the electrical energy generated by the source's heart to the receiving subject's head. The baseline recording (lefthand column) was from a 10-minute period during which the subjects were seated 4 feet apart. The righthand column of panels shows the recording from a 5-minute period during which the subjects held hands. The EEG electrodes on the receiver were placed at the C3 and C4 locations.

subjects. In this particular subject pair, we were not able to detect an energy transfer in the reverse direction (*i.e.* the receiver's ECG did not appear in the source's SAW).

In all 3 sets of subjects, the ECG of one of the subjects was easily detected in the other's SAW. However, in only one set of these 3 experiments were we able simultaneously to see the effect in both directions.

The data were also analyzed to see if the ECG of the source was synchronized with the receiver's ECG. It was determined that there was no synchronization between the two ECG's, thus confirming that the ECG signal appearing in the receiver's recordings was indeed transmitted from the source's heart rather than the receiver's own. This was true in all the experimental examples which follow.

Example 2: Hand holding orientation

This experiment was designed to determine whether the transfer of cardiac energy, as observed in Example 1, would be affected by changes in the orientation of the subjects' hand holding (*i.e.* source's left hand holding receiver's right hand *vs* source's right hand holding receiver's left hand, etc.). Subjects were seated and fitted with ECG and EEG electrodes. Electrode placement was the same as in Example 1, with the exception that the EEG electrodes were referenced to linked ears. The subjects held hands for 5 minutes in each of the four possible orientations (source's left hand holding receiver's left hand; source's right hand holding receiver's left hand; source's left hand holding receiver's right hand; source's right hand holding receiver's right hand). The recordings were analyzed as in Example 1.

Results

In the four different hand holding orientations tested, measurable differences were observed in the transfer of cardiac energy between subjects, as measured by the amplitude of the source's ECG signal appearing in the receiver's EEG recording. As seen in Figure 5, the source's ECG appeared with the largest amplitude in the receiver's SAW at the CZ location when the receiver's right hand was held by either the source's left or right hand (top right and bottom

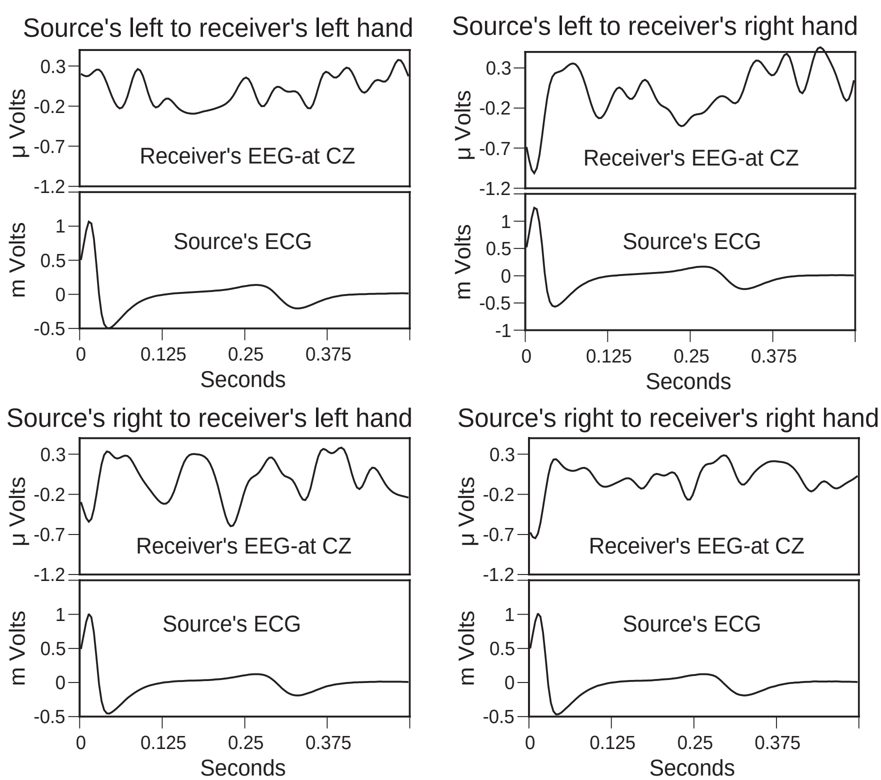

Figure 5. Cardiac signal averaged waveforms with different hand holding orientations. Signal averaged waveforms showing differences in the transference of the electrical energy generated by the source's heart to the receiving subject's head depending on which hand holding orientation was adopted. Subjects held hands for 5 minutes in each of the four orientations shown. Data shown are from the CZ location on the receiver.

right panels). When the receiver's left hand was held by the source's right hand, the source's ECG was could still be detected in the receiver's SAW, but at a somewhat lower amplitude. Finally, when the receiver's left hand was held by the source's left hand, the source's ECG signal was not detected in the receiver's SAW.

Example 3: Wearing glove

This experiment was designed to see if the source's ECG could be picked up on the receiver's arms and to determine whether the signal was being transferred by means of electrical conduction or by radiation. Electrodes were placed 8 inches apart on the reciever's right upper arm and in the standard locations for ECG measurement on both subjects. Once a 5-minute baseline period was recorded, the subjects joined hands and recording continued for the next 5 minutes. The experiment was then repeated with the source wearing a form-fitting full-length latex lab glove.

Results

The lefthand panel in Figure 6 shows that the source's ECG could be clearly detected on the receiver's right arm when neither subject was wearing a glove. The righthand panel depicts the results when the source was wearing the latex glove. In this case, the source's ECG signal was still present in the receiver's SAW; however it was approximately tenfold lower in signal strength.

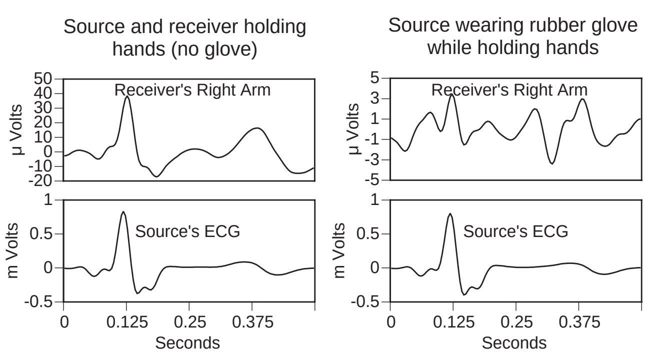

Figure 6. Cardiac signal averaged waveforms: holding hands with and without glove. Illustrates the difference in signal strength measured on the receiver's arm with (righthand panels) and without (lefthand panels) the source wearing a latex glove when they held hands. Note that the source's ECG signal is still present in the receiver's SAW when the glove is worn; however, its amplitude is reduced by a factor of 10 (note scales).

Example 4: Light touch

This purpose of this experiment was to determine whether the signal could be transferred by the source lightly touching the receiver's body at different locations. In this experiment, the receiver was lying supine on a padded massage table while the source stood next to the table. Three separate trials were performed: In the first, the source lightly placed his right hand on the receiver's forehead; in the second, he placed his right hand lightly on the receiver's stomach; in the third trial, the source placed one hand on the receiver's forehead and the other on his stomach. Electrodes were placed 4 inches apart on the receiver's left and right lower arms and on the standard locations for ECG measurements on both subjects.

Results

In all three trials, the source's ECG signal was clearly detectable in the receiver's SAW on both arms; however, the signal measured across the receiver's right arm was consistently 5 times greater in amplitude than the signal picked up on the left arm (Figure 7; note scales).

Example 5: Wired together

This experiment was designed to determine whether the cardiac energy transfer could be increased through forming a hard wire connection between the subjects. The subjects were seated side by side with 18 inches between them. After baseline recordings were established, 5 minutes of data were collected with the subjects wired together. A hard wire connection between subjects was created by placing ECG electrodes on the right side of each subject's rib cage and connecting the electrodes with a 36-inch ECG lead wire. Electrodes were placed 4 inches apart on the receiver's left and right lower arms, 2 inches apart on the receiver's forehead and at the standard locations for ECG measurements on both subjects.

Results

The source's ECG signal was detected in the receiver's SAW on both arms and on his forehead; however, the amplitude of the transferred signal was not increased with respect to the hand holding or light touch experiments. (Figure 8).

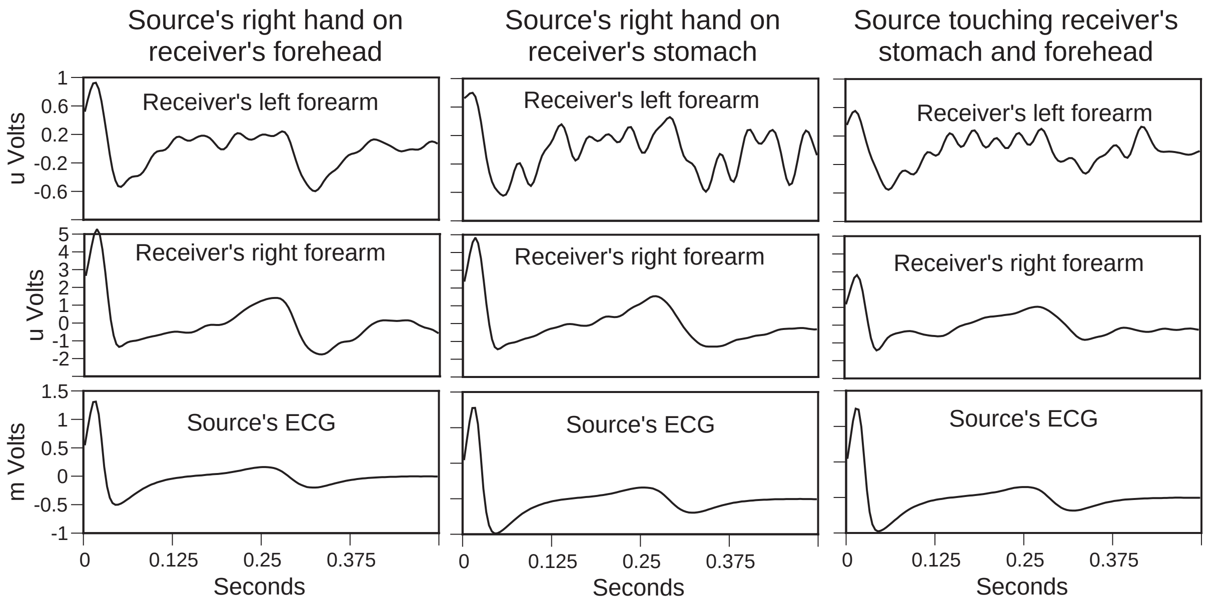

Figure 7. Cardiac signal averaged waveforms: light touch. Signal averaged waveforms showing the transference of the electrical energy generated by the source's heart to the receiving subject's forearms when the source lightly touched the receiver's forehead (lefthand panels), the receiver's stomach (middle panels), or both stomach and forehead (righthand panels).

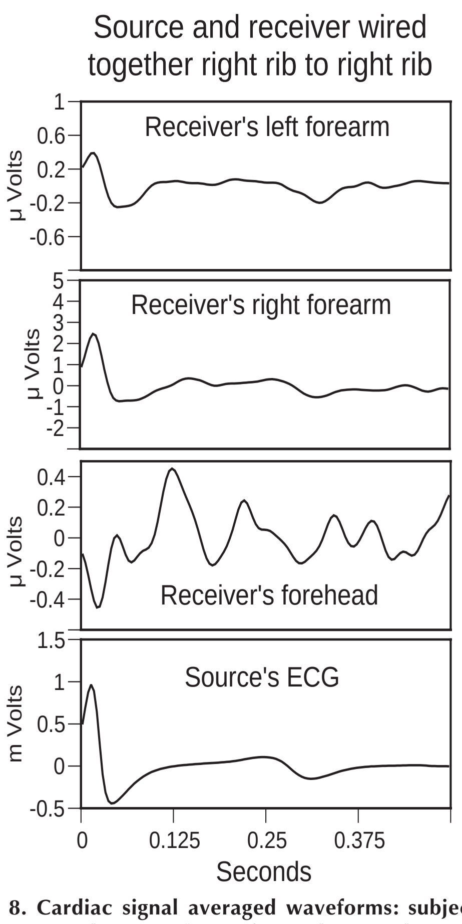

Figure 8. Cardiac signal averaged waveforms: subjects wired together. Signal averaged waveforms showing the transference of energy generated by the source's heart to the receiving subject's forearms and forehead when subjects were wired together right rib to right rib. No increase in the amplitude of the transferred signal was observed with respect to the experiments in which subjects held hands or touched lightly.

As was also observed in the light touch experiments (Example 4), the signal measured across the receiver's right forearm was approximately 5 times greater than that picked up on the left forearm.

Example 6: Proximity without contact

As the cardiac signal is known to be radiated outside the body, in this experiment we sought to determine whether the signal would be detected by the receiver when subjects were not touching. The subjects were seated side by side with 18 inches between them at the closest point. Electrodes were placed 4 inches apart on the receiver's left and right lower arms and on the standard locations for ECG measurements on both subjects. Two thousand averages were used for this experiment (approximately 30 minutes recording time).

Results

Figure 9 is an overlay plot showing the readings from the electrodes on the receiver's arms and the source's ECG. We were able to detect a signal on the receiver's arms; however, there was a phase shift of 10 ms between the source's ECG and the appearance of the signal across the electrodes on the receiver's arms.

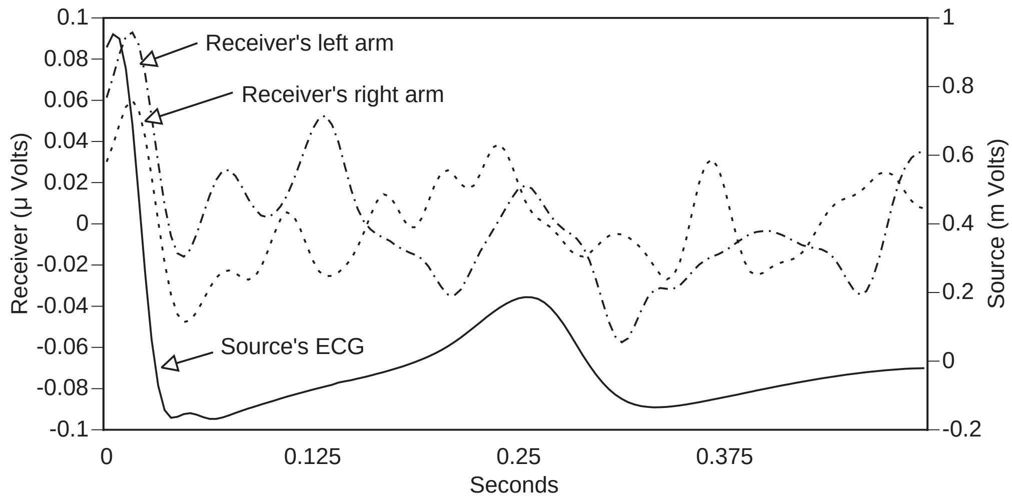

Figure 9. Cardiac signal averaged waveforms: subjects in proximity without contact. Overlay plot showing the signal averaged waveforms recorded from the receiver's arms and the source's ECG when subjects were seated 18 inches apart without touching. Note that the source's ECG signal is detected in the receiver's SAW on both arms, but is delayed by 10 milliseconds. Waveforms are the result of 2000 averages.

DISCUSSION

The data presented here clearly show that when people touch or are in proximity, a transference of the electromagnetic energy produced by the heart occurs. This energy exchange was evidenced by the registration of one individual's electrocardiogram R-wave peak at different sites on another person's body surface. The transference of the signal appears to depend on the distance between individuals, as would be expected if the signal transferred is electromagnetic in nature. The effect was evident when people were touching or positioned 18 inches apart, but it was not detectable when subjects were separated by a distance of 4 feet and 250 averages were used in the signal averaging process. However, it is quite possible that by measuring longer time periods and using more averages, signal transfer could be detected at greater distances. Russek and Schwartz's measurement of an exchange of cardiac energy between subjects separated by 3 feet certainly supports this possibility.[23] The observation that the signal was still transferred when subjects were not in contact demonstrates that the transference occurs at least to some degree through radiation. However, the tenfold reduction in the amplitude of the transferred signal observed in both the non-contact experiment and in the hand holding trial in which one subject wore an insulated glove suggests that skin-to-skin contact plays an important role in facilitating the signal transfer. Interestingly, forming a hard wire connection between subjects did not increase the amplitude of the transferred signal with respect to the experiments in which subjects simply held hands or touched lightly. The signal amplitude was also unaffected in other experiments (data not shown) in which electrode gel was used to decrease skin-to-skin contact resistance.

There were a number of interesting observations made for which we feel there is not yet sufficient data to attempt to offer an explanation at this point. These include: (1) While in all cases a signal transfer between two subjects was measurable at least in one direction, a transfer was sometimes, but not always, detectable in both directions (*i.e.* In some cases the designated "receiver's" ECG was not observed in the "source's" recordings). From other experiments we have done, this does not appear to be related to the gender of the subjects. (2) Significant differences were observed in the amplitude of the transferred signal depending on the hand holding orientation adopted. The amplitude was highest when the receiver's right hand was held by the source's left hand, and the transfer was not detected at all when subjects held hands left hand to left hand. (3) In the light touch and wired together trials reported on here (Examples 4 and 5), the signal picked up on the receiver's right forearm was consistently 5 times greater in amplitude than the signal registered on the left forearm. This difference was observed in some, but not all, similar experiments performed. (4) In the non-contact experiment (Example 6), but in none of the other trials, a phase shift of 10 ms between the sender's ECG and the appearance of the signal across the receiver's arms was observed. All of these observations pose intriguing research questions and invite additional experimentation to determine whether they do, in fact, represent significant trends to consider in further characterizing this energy exchange.

It should be noted that the appearance of the source's ECG signal in the receiver's EEG does not necessarily indicate that the signal has produced an alteration in the receiver's brainwaves. These data simply indicate that the source's ECG signal can be measured on the receiver's scalp as well as at other sites on the receiver's body surface, such as the forearms and legs. The fact that the signal is indeed registered, however, together with the recent demonstration of nonlinear stochastic resonance effects in several biological systems, certainly raises the possibility that it may exert some effect on the receiving subject's brain and/or other components of the receiver's physiology.

This possibility is in fact supported by experiments conducted by Schandry and co-workers which demonstrated that cortically generated potentials are affected by one's own ECG. These experiments have shown that the registration of one's own ECG R-wave in the EEG is modulated by psychological factors such as attention and motivation, in a fashion analogous to the cortical processing of external stimuli.[26, 28-30] This is also supported by work in our laboratory which has shown that when individuals focus their attention in the area of the heart and consciously generate a positive emotion, the heart rate variability patterns become more orderly and coherent.[17] When a person is in this more coherent state, the portion of the heartbeat evoked potential which reflects cortical processes[28] is dramatically changed.[27] The idea that the registration of another person's ECG across the scalp could also give rise to characteristic cortical potentials is certainly a possibility that deserves further investigation.

A biological response to an externally applied field implies that the field has caused changes in the system greater than those due to random fluctuating events, or "noise." Traditional linear theory predicted that weak, extremely low frequency electromagnetic fields, such as that radiated from the human heart, could not generate enough energy to overcome the thermal noise limit and thus to affect biological tissue. However, a number of experiments have revealed cellular responses to electric field magnitudes far smaller than the theoretical estimates for the minimum field strength required to overcome the thermal noise limit in these systems.[31-33] (cited in [34]). It has been proposed that this discrepancy can in part be accounted for by biological cells' capacity to rectify and essentially signal average weak oscillating electric fields through field-induced variation in the catalytic activity of membrane-associated enzymes or in the conformation of membrane channel proteins.[20, 34] Signal rectification and averaging provide a mechanism by which a signal from an external periodic electric field could be accumulated over time by a cell, and would significantly lower theoretical estimates of the system's threshold of response to external fields, though still not enough to fully explain all the experimental data.

Theoretical estimates of the limitations on the detection of very small signals by sensory systems imposed by the presence of thermal noise (thermal noise limit) were traditionally made using linear approximation under the assumption that the system is in a state of equilibrium.[35] More recently, it has been recognized that a linear and equilibrium approach is not appropriate for biological systems, which are intrinsically nonlinear, nonequilibrium and noisy. The recent advent of the nonlinear stochastic resonance concept[15] has caused further revisions of the theoretical estimates for the minimum field strengths required to affect biological systems. The concept of stochastic resonance was first used in a theoretical study of the ion binding model for the explanation of weak EMF effects on biological systems.[19] The effect of very weak, coherent electromagnetic signals as small as one hundred to one thousand times smaller than the amplitude of the surrounding random noise was studied using numerical simulation. It was shown that coherent signals having an amplitude substantially below that of the background thermal noise could change the mean time it takes for a biological ion to escape from the binding site of a regulatory protein, and thus influence cellular response.[19] Remarkably, in subsequent experimental studies[36-38] the effect of subthermal, coherent signals was observed in different biological systems for signal amplitudes as small as one-tenth or even one-hundredth the amplitude of the random noise component. Whereas initial studies of stochastic resonance in biological systems dealt exclusively with single-frequency signals embedded in a broadband noise background, recent experimental work has shown that stochastic resonance can also be observed with broadband stimuli,[37] thus further generalizing this phenomenon. In addition, a voltage-dependent ion channel system has recently been shown to exhibit stochastic resonance with no detectable response threshold.[38] These data confirm that biological systems under certain circumstances are able to detect arbitrarily small coherent signals. Theory, simulation and experimental data all suggest that nonlinear stochastic resonance may play an important role in the dynamics of sensory neurons,[15, 37, 39] and the demonstration of over a thousand-fold increase in signal transduction across voltage-dependent ion channels induced by the addition of external noise provides evidence that stochastic resonance may also be operative at a sub-cellular level.[36, 38]

Many healing modalities involving contact or proximity between practitioner and patient, including Therapeutic Touch, holoenergetic healing, healing touch, Chi Gong, Reiki, Shiatsu, the Trager technique and polarity therapy, are based upon the assumption that an exchange of energy occurs to facilitate healing. While there exists scientific evidence to substantiate the physiological and psychological effects of many of these treatments, science has as yet not been able to describe a mechanism by which this putative energy exchange between individuals takes place. This study, together with the work of Russek and Schwartz, represents one of the first successful attempts to directly measure an exchange of energy between people. As such, it provides a foundation for a solid, testable theory to explain the observed effects of these healing modalities. We propose that through cellular signal averaging and nonlinear stochastic resonance, a therapist's cardiac field, registered by the patient, may be amplified so as to produce significant effects. As a weak field signal becomes more coherent, the greater its capacity becomes to entrain ambient noise and thus to produce effects in biological tissue. Recent research has shown that the heart's electromagnetic field decreases in electrical coherence as an individual becomes angry or frustrated and increases in coherence as a person shifts to such positive emotional states as sincere love, care or appreciation.[17] Preliminary results indicate, further, that individuals who intentionally increase their cardiac coherence by maintaining a focused state of sincere love or appreciation can induce changes in the structure of water[7] and in the conformational state of DNA.[40] An obvious implication, if the stochastic resonance model is valid, is that the effects of therapeutic techniques involving contact or proximity between practitioner and patient could be amplified by practitioners adopting a sincere caring attitude, and thus introducing increased coherence into their cardiac field.

This may explain why many healing practices have as a core tenet that the therapeutic effects of the treatment are dependent upon the intention of the practitioner to help or heal the patient. The Therapeutic Touch literature describes the role of the practitioner of this technique as attempting "to focus completely on the well-being of the recipient in an act of unconditional love and compassion.[41] It has been demonstrated that hospitalized cardiovascular patients treated with Non-Contact Therapeutic Touch experienced a significantly greater decrease in post-treatment state anxiety than did patients who were administered a control intervention in which nurses mimicked the movements of the Therapeutic Touch technique but did not focus their intention on helping the patients.[8] Of particular relevance to the work described in the present study is Russek and Schwartz's finding that people more accustomed to receiving love and care appear to be better receivers of others' cardiac signals.[23] In a group of subjects in late adulthood, those who in college had rated themselves as having been raised by loving parents exhibited significantly greater registration of an experimenter's cardiac signal in their EEG in a non-contact experiment than those who had rated their parents low in loving. This implies that the exchange of cardiac energy described here may be influenced not only by the degree of coherence of the transmitted signal (which, in turn, can depend on the source's emotional state and intention), but also by the degree of the receiver's receptivity to the signal. Individuals raised in an environment which they perceive to be loving are not only more accustomed to receiving others' love, but also often tend to be more loving themselves. Thus, it is possible that signal registration may be enhanced by increased coherence in the receiver's system. It is not surprising that many of the healing modalities mentioned above emphasize not only that the practitioner have the intention to heal but also that there be a mutually caring relationship between practitioner and patient.

It should also be mentioned that there is an extensive literature concerning nonlocal effects, prayer and distance healing. Larry Dossey has pointed out that the term "energy" as it is used in this paper may not be the appropriate term to describe nonlocal effects, which cannot be explained by conventional electromagnetic theory.[42] We use the term "energy" here, as we believe that the results described in this paper can be explained by conventional electromagnetic theory. This paper does not attempt to explain nonlocal effects; however, it would be interesting to determine whether the effectiveness of nonlocal forms of healing is related to the degree of coherence in the practitioner's cardiac field. Gough and Shacklett[43] as well as Tiller[44] have proposed models which expand and connect conventional electromagnetic theory with an inherently nonlocal and multidimensional realm. Paddison has also written at length concerning the coupling between the electricity generated by the heart and more subtle levels of reality.[45] According to these models, increased coherence in conventional electromagnetic fields would serve to enhance nonlocal effects.

If the electromagnetic field generated by our heart indeed has the capacity to significantly affect those around us, the implications of this would of course extend far beyond healer-patient interactions. It has long been observed that our emotions have the capacity to affect those in our proximity. Evidence that the cardiac field changes with different emotions experienced, combined with the finding that this field is registered physiologically by those around us provides the foundation of one possible mechanism to describe the impact of our emotions on others at a basic physiological level. In addition, if touch, as we have shown, serves to facilitate this exchange of cardiac energy between individuals, this would give new and more precise meaning to the concept of touch as the first and most fundamental means of communication[46] and facilitator of human interactions. Future study of the effects of the electrical exchange that occurs when individuals are in contact or proximity may eventually foster increased awareness of our inner feeling states both in therapeutic interventions and in the broader context of our daily interactions with those in our immediate environment.

Future Directions

These experiments represent an initial attempt to identify and objectively measure an exchange of energy between individuals. The phenomenon highlighted by the results presented here is an intriguing one that has many potential implications and certainly invites further characterization. It is our hope that these data will serve to stimulate critical discussion and encourage interested researchers to pursue further the investigation of the many unanswered questions that have been raised by this work. The repetition of the experiments discussed in this paper with expanded sample sizes will help to distinguish anecdotal observations from real trends and also begin to paint a picture of the variability that exists among individuals with regard to this phenomenon. To continue to characterize this energy exchange, it will be important to refine our understanding of how it varies with distance. More precisely mapping out how transmission of the signal decays with distance will allow us to determine whether there exists an effective "cut-off" point and whether this varies among individuals.

We feel that individual variability in both the transmission and reception of cardiac energy is an important area of investigation that raises a number of questions. Future research might seek to increase our understanding of how one's emotional state affects both energy transmission and reception as well as investigate the role that intention may play in facilitating the energy exchange. In particular, does consciously shifting to a state such as sincere love or appreciation, in which the heart's energy field becomes measurably more coherent, affect signal transference? Also along these lines, does the exchange vary according to the type of relationship people share? Would the signal transference be measurably different in subjects who did not know each other as compared to people who shared a close personal relationship? Finally, studies analyzing the exchange of cardiac energy between individuals in conjunction with the practice of various therapeutic techniques may serve to elucidate any relationships that may exist between this type of energy exchange and the physiological effects of these treatments.

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