The Appreciative Heart

The Psychophysiology of Positive Emotions and Optimal Functioning

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"In daily life, sometimes people use the word appreciation and sometimes the word gratitude without much thought about which is most appropriate. Use whichever word that means the most to you, based on your culture, upbringing, or personal preference, because it's the heart feeling behind the word and intent that counts. If you're coming from your heart, whether you describe it as gratitude or appreciation, it represents the same spark of spirit and care and has the same effectiveness. In the research lab, whether you're radiating appreciation or gratitude, it creates the same coherence and benefits to yourself and your environment."

—Doc Childre

Throughout history and across diverse cultures, religions, and spiritual traditions, the heart has been associated with spiritual influx, wisdom, and emotional experience, particularly with regard to other-centered, positive emotions such as love, care, compassion, and appreciation. Current research provides evidence that the heart does indeed play a role in the generation of emotional experience, suggesting that these long-surviving associations may be more than merely metaphorical. In this paper, we discuss a model of emotion that includes the heart, together with the brain, nervous, and hormonal systems, as fundamental components of a dynamic, interactive network from which emotional experience emerges. Further, we review research that has identified new physiological correlates associated with the experience of heartfelt positive emotions, with a specific focus on appreciation. We then describe several heart-based positive emotion-focused techniques designed to help people self-induce and sustain states of appreciation and gratitude as well as other positive emotions. Finally, we summarize the outcomes of several studies in which these techniques have been introduced in organizational, educational, and clinical settings.

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Definition of Terms

In recent years, increasing research has focused on exploring the psychology of positive emotions. A large part of that attention has been devoted to the emotion of gratitude.[1] Appreciation, which will be discussed in this paper, is related to gratitude, and forms an important aspect of our emotional landscape.

McCullough, Kilpatrick, Emmons, and Larson describe gratitude as "a felt sense of wonder, thankfulness and appreciation for life. It can be expressed to others, as well as to impersonal (nature) or nonhuman sources (God, animals, the cosmos)"[2] (p. 377). They conceptualize gratitude as an affect which guides people's cognitions and behaviors in the moral domain,[1]

Common dictionary definitions of appreciation include "the act of estimating the qualities of things according to their true worth"; "grateful recognition"; "sensitive awareness or enjoyment [of something/some-one]"; and "an increase in value." Cooperrider and Whitney define appreciation as: "valuing—the act of recognizing the best in people or the world around us. To perceive those things that give life (health, vitality, excellence) to living systems"[3] (p. 4). Paddison offers the following definition: "Appreciation' means to be thankful and express admiration, approval or gratitude"[4] (p. 231). She

also expands on the idea of appreciation as increasing in value and suggests that as one expresses more appreciation, one literally grows in value to both oneself and others. In the context of this paper, when we refer to appreciation we denote an active feeling of thankfulness, which has an energetic quality that uplifts one's energy and spirit.

Positive Emotions and Optimal Functioning

> *You feel a deep sense of peace and internal balance—you are at harmony with yourself, with others, and with your larger environment. You experience increased buoyancy and vitality. Your senses are enlivened—every aspect of your perceptual experience seems richer, more textured. Surprisingly, you feel invigorated even when you would usually have felt tired and drained. Things that usually would have irked you just don't "get to you" as much. Your body feels regenerated—your mind clear. At least for a period of time, decisions become obvious as priorities clarify and inner conflict dissolves. Intuitive insight suddenly provides convenient solutions to problems that had previously consumed weeks of restless thought. Your creativity flows freely. You may experience a sense of greater connectedness with others and feelings of deep fulfillment.*

Most people have at some point in their lives experienced a state similar to that described above. In many cases, individuals report that such "magical" moments, sometimes described as periods of increased "flow,"[5] are accompanied by the experience of a heartfelt positive emotion. Perhaps it was the feeling of being in love, feelings of gratitude for another's kindness, appreciation for the majesty of nature, or a sense of fulfillment spurred by one's own accomplishments.

For centuries, religious scholars, artists, scientists, medical practitioners, and lay authors alike have written about the transformative power of positive emotions. However, until recently, scientific exploration of these experiences has been largely lacking. Presently, a growing body of research is beginning to provide objective evidence that positive emotions may indeed be key to optimal functioning, enhancing nearly all spheres of human experience. Positive emotions have been demonstrated to improve health and increase longevity,[6-9] increase cognitive flexibility and creativity,[10, 11] facilitate "broad-minded coping" and innovative problem solving,[12-14] and promote helpfulness, generosity, and effective cooperation.[15]

Over the past ten years, our research group has focused on exploring *how* and *why* positive emotions improve health and performance and, specifically, on uncovering physiological correlates of positive emotional states that may help explain these observations. In recent years, our research has concentrated on elucidating emotion-related changes in the patterns of the heart's rhythmic activity and on understanding how heart-brain interactions affect physiological, cognitive, and emotional processes.

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 has gained momentum and is now widely accepted. The brain is an analog processor that relates whole concepts to one another and looks for similarities, differences, or relationships between them. It is nothing like a digital computer, in that it does not assemble thoughts and feelings from bits of data. This new understanding of how the brain functions has challenged several longstanding assumptions about emotions. For example, psychologists once maintained that emotions were purely mental expressions generated by the brain alone. We now know that this is not true—emotions have as much to do with the body as they do with the brain. Furthermore, of the bodily organs, the heart plays a particularly important role in the emotional system. Emotions are thus a product of the brain, heart, and body acting in concert.

Recent work in the relatively new field of neurocardiology has firmly established that the heart is a sensory organ and a sophisticated information encoding and processing center, with an extensive intrinsic nervous system sufficiently sophisticated to qualify as a "heart brain." Its circuitry enables it to learn, remember, and make functional decisions independent of the cranial brain.[16] Moreover, 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.[17-19]

One tool that has proven valuable in examining heart-brain interactions is heart rate variability analysis. Heart rate variability (HRV), derived from the electrocardiogram (ECG), is a measure of the naturally occurring beat-to-beat changes in heart rate. 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.[20, 21] Our research, together 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.[19, 20, 22-25] These changes in autonomic activity lead to dramatic changes in the *pattern* of the heart's rhythm, often without any change in the *amount* of heart rate variability. Specifically, we have found that during the experience of 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).[20, 22] 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 (Figure 1).[20, 22, 23, 26]

In addition to understanding how complex ANS activity patterns correlate with differing emotions, we are beginning to understand the role played by afferent neural signals, which flow from the heart and body to the brain, in the generation and experience of feelings and emotions. A substantial body of research has explored the influence of afferent signals from the heart and cardiovascular system on brain function. This research dates back to 1929 when it was found that stimulation of the vagus nerve inhibited motor activity and prolonged sleep.[27] Among the first modern psychophysiological researchers to systematically examine the "conversations" between the heart and brain were John and Beatrice Lacey.[28] During twenty years of research throughout the 1960s and 1970s, they observed that afferent input from the heart

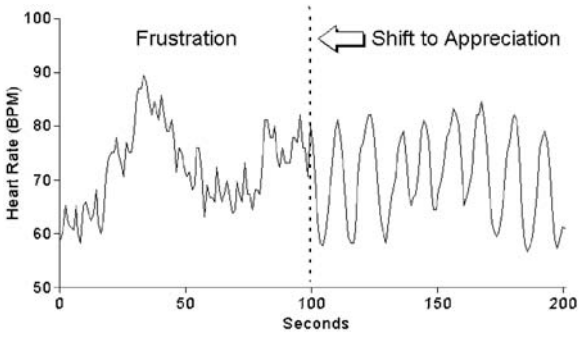

Figure 1. Emotions are reflected in our heart rhythm patterns.
Real-time heart rate variability (heart rhythm) pattern of an individual making an intentional shift from a self-induced state of frustration to a genuine feeling of appreciation by using the Freeze-Frame positive emotion refocusing technique. 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 as the individual uses the positive emotion refocusing technique and self-generates a heartfelt feeling of appreciation.*

and cardiovascular system could significantly affect *perception* and behavior. Their research produced a body of behavioral and neurophysiological evidence indicating that sensory-motor integration could be modified by cardiovascular activity.[29-33] One line of their research established relationships between the heart's afferent signals and reaction times. For example, they showed that decreasing heart rate in the anticipatory period of reaction time experiments quickens reaction times, while increasing heart rate slows reaction times.[33, 34] The Laceys introduced the terms "cortical inhibition" and "cortical facilitation" to describe these effects. Since that time, extensive experimental data have been gathered documenting the role played by afferent input from the heart in modulating such varied processes as pain perception,[35] hormone production,[36] electrocortical activity, and cognitive functions.[17, 28, 37, 38]

This research, however, did not generally consider the role of emotion or how patterns of afferent input affect *emotional* processes. Our research findings have led us to support a systems-oriented model of emotion that includes the heart, brain, and the nervous and hormonal systems as fundamental components of a dynamic, interactive network that

underlies the emergence of emotional experience.[19] The model builds on the theory of emotion first proposed by Pribram,[39] in which the brain functions as a complex pattern identification and matching system. In this model, past experience builds within us a set of familiar patterns, which are maintained in the neural architecture. Inputs to the brain from both the external and internal environments contribute to the maintenance of these patterns. Within the body, many processes provide constant rhythmic inputs with which the brain becomes familiar. These include the heart's rhythmic activity; digestive, respiratory and hormonal rhythms; and patterns of muscular tension, particularly facial expressions. These inputs are continuously monitored by the brain and help organize perception, feelings, and behavior. Recurring input patterns form a stable backdrop, or reference pattern, against which current experiences are compared. According to this model, when an input pattern is sufficiently different from the familiar reference pattern, this "mismatch" or *departure from the familiar* underlies the generation of feelings and emotions.

When the input to the brain does not match the existing program, an adjustment must be made in an attempt to achieve control and return to stability. One way to reestablish control is by taking an outward action. We are motivated to eat if we feel hungry, run away or fight if threatened, do something to draw attention to ourselves if feeling ignored, etc. Alternatively, we can reestablish stability and gain control by making an internal adjustment (without any overt action). For example, a confrontation at work may lead to feelings of anger, which can prompt inappropriate behavior (*e.g.*, outward actions such as yelling, hitting, etc.). However, through internal adjustments, we can *self-manage* our feelings in order to inhibit these responses, reestablish stability, and maintain our jobs. Ultimately, when we achieve stability through our efforts, the results are feelings of satisfaction and gratification. By contrast, when there is a failure to achieve stability or control, feelings such as anxiety, panic, annoyance, apprehension, hopelessness, or depression result.

This model distinguishes two sets of emotions: those that reflect current order in the neurophysiological systems and those that reflect expectation of future order. Emotions—the signals of perturbation and its cessation, and of the initiation of processes necessary to reestablish control—can thus be divided into the "concurrent" and the "prospective." The concurrent reflects the degree of match or mismatch between the current inputs and the reference pattern in the here-and-now.[39] Mismatch is reflected as arousal, while the achievement of regaining a match or control is characterized by gratification. The prospective affects can be divided into optimistic or pessimistic. Inputs to the neural system are appraised and compared to memories of past outcomes associated with similar inputs or situations. If the historical outcomes of similar situations are positive, an optimistic affect (*e.g.*, interest, confidence, or hope) will result. On the other hand, if the memory of past outcomes has led to the expectation of failure to achieve control, the current inputs are accompanied by pessimistic feelings regarding the future (*e.g.*, annoyance, apprehension, hopelessness, or depression). It is through practice and experience with outcomes that inputs become appraised as relevant or irrelevant, hopeful or hopeless. As we encounter new situations, experience new inputs, and learn how to gain or maintain control, we expand our repertoire of successful outcomes. The more repertoires available, the more likely a new input will be assessed as optimistic with a high probability of success in maintaining control. It is the organization of sequences of input patterns and behaviors into hierarchically arranged programs that gives a person flexibility and adaptability.

Once a stable baseline pattern or program is established, the neural systems attempt to maintain a match between the set program, current inputs, and future behaviors. If the baseline pattern becomes maladapted, the system will still strive to maintain a match to that pattern, even though it is not in our best interest. There are many examples of maladapted patterns. For example, if a child grows up in chaotic surroundings, chaos will become familiar, and therefore comfortable. The child will then automatically take actions that create various forms of chaos in his or her life in order to maintain a match with the internal program and thus feel comfortable. Another example of maladaptation is when people adapt to conveniences (*e.g.*, something is usually done for them, they always get what they want, etc.). These conveniences can then become *expectancies* and become taken for granted rather than truly appreciated. Thus, when a situation occurs where individuals do

not get what they want or expect, a mismatch occurs and they experience emotional dissonance.

Monitoring the alterations in the rates, rhythms, and patterns of afferent traffic is a key function of the cortical and emotional systems in the brain. Thus, input originating from many different bodily organs and systems is ultimately involved in determining our emotional experience. However, the heart, as a primary and consistent generator of rhythmic information patterns in the human body, and possessing a far more extensive afferent communication system with the brain than do other major organs, plays a particularly important role in this process.[19] With each beat, the heart not only pumps blood, but also continually transmits dynamic patterns of neurological, hormonal, pressure, and electromagnetic information to the brain and throughout the body. Therefore, cardiovascular afferent signals are a major contributor in establishing the dynamics of the baseline pattern or set point against which the "now" is compared. At lower brain levels, the heart's input is compared to references or "set points" that control blood pressure, affect respiration rate, and gate the flow of activity in the descending branches of the autonomic system.[40] From there, these signals cascade up to a number of subcortical or "limbic" areas that are involved in the processing of emotion.[37, 41]

Several lines of research support the perspective that cardiac afferent input exerts an important influence on central emotional processing. For example, validation comes from studies that have investigated the effects of afferent input on the amygdaloid complex—the amygdala and associated nuclei, which play a pivotal role in storing and processing emotional memory and in attaching emotional significance to sensory stimuli. Studies have shown that neural activity in the central nucleus of the amygdala is synchronized to the cardiac cycle and is modulated by cardiovascular afferent input.[18, 42] The importance of changes in the pattern of cardiac afferent signals is further illustrated by the finding that psychological aspects of panic disorder are frequently created by unrecognized paroxysmal supraventricular tachycardia (a sudden-onset cardiac arrhythmia). One study found that DSM-IV criteria for panic disorder were fulfilled in more than two-thirds of patients with these sudden-onset arrhythmias. In the majority of cases, once the arrhythmia was discovered and treated, the symptoms of panic disorder disappeared.[43] These arrhythmias generate a large and sudden change in the pattern of afferent signals sent to the brain, which is detected as a mismatch. This mismatch consequently results in feelings of anxiety and panic.

It is interesting to note that when one plots the heart rhythms generated by this type of arrhythmia, they look quite similar to the incoherent heart rhythm patterns produced by strong feelings of anxiety in an otherwise healthy individual. By contrast, coherent heart rhythm patterns, which are associated with sincere positive emotions, are familiar to most brains and evoke feelings of security and well-being. If this is the case, then interventions capable of shifting the pattern of the heart's rhythmic activity should modify one's emotional state. In fact, people commonly use just such an intervention—simply altering their breathing rhythm by taking several slow, deep breaths. Most people do not realize, however, that the reason breathing techniques are effective in helping to shift one's emotional state is because changing one's breathing rhythm modulates the heart's rhythmic activity. The modulation of the heart's rhythm by respiratory activity is referred to as respiratory sinus arrhythmia (RSA).[44] Later in this paper, we describe other, heart-focused interventions that also facilitate emotional shifts by generating changes in the heart's rhythmic patterns.

Physiological Correlates of Heartfelt Positive Emotions

Physiological coherence

Our research in emotional physiology has identified distinct physiological correlates of heartfelt positive emotional states. We have introduced the term ***physiological coherence*** to describe a functional mode encompassing a number of related physiological phenomena that are frequently associated with feelings of appreciation.

The term *coherence* has several related definitions, all of which are applicable to the study of emotional physiology. 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." Importantly,

however, these associations are not merely metaphorical, as different emotions are in fact associated with different degrees of coherence in the oscillatory rhythms generated by the body's various systems.

This leads us to the definitions of the term "coherence" found in physics, where it is used to describe the ordered or constructive distribution of power within a wave. 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.[20]

Coherence also describes two or more waves that are either phase- or frequency-locked. A common example is the laser, in which multiple waves phase-lock together, producing a coherent energy wave. In physiology, coherence is used to describe a functional mode in which two or more of the body's oscillatory systems, such as respiration and heart rhythms, become *entrained* and oscillate at the same frequency. The term *cross-coherence* is used to specify this type of coherence.

Interestingly, all the above definitions apply to the study of emotional physiology. We have found that sincere positive emotions such as appreciation are associated with a higher degree of coherence *within* the heart's rhythmic activity (autocoherence). Additionally, during such states there also tends to be increased coherence *between* different physiological oscillatory systems (cross-coherence/entrainment).[20, 22] 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.[45]

A related phenomenon that can also occur during physiological coherence is *resonance.* In physics, resonance refers to a phenomenon whereby an abnormally large vibration is produced in a system in response to a stimulus whose frequency is the same as, or nearly the same as, 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 also observed. This occurs because these oscillatory subsystems are all vibrating at the resonant frequency of the system (~0.1 hertz). Thus, in the coherent mode, the power spectrum of the heart rhythm displays an unusually large peak around 0.1 hertz (see Figure 2).

Most models show that the resonant frequency of the human cardiovascular system is determined by the feedback loops between the heart and brain.[46, 47] In humans and in many animals, the resonant frequency of the system is 0.1 hertz, which is equivalent to a 10-second rhythm. The system especially vibrates at its resonant frequency when an individual is actively feeling appreciation or some other positive emotion,[22] although resonance can also emerge during states of sleep and deep relaxation. In terms of physiological functioning, resonance confers a number of benefits to the system. For example, there is increased cardiac output in conjunction with increased efficiency in fluid exchange, filtration, and absorption between the capillaries and tissues; increased ability of the cardiovascular system to adapt to circulatory requirements; and increased temporal synchronization of cells throughout the body.[48, 49] This results in increased system-wide energy efficiency and metabolic energy savings. These findings provide a link between positive emotions and increased physiological efficiency, which may partly explain the growing number of correlations documented between positive emotions, improved health, and increased longevity. In addition, there are data suggesting that this more efficient functional mode also improves the cognitive processing of sensory information.[45, 50]

Appreciation, heart-brain synchronization, and cognitive performance

In addition to the phenomena discussed above, physiological coherence is also associated with increased *synchronization* between the heartbeat and alpha rhythms in the electroencephalogram (EEG). In experiments measuring heartbeat-evoked potentials, we found that the brain's alpha wave activity (8-12 hertz frequency range) is naturally synchronized to the cardiac cycle. However, when subjects used a positive emotion-focused technique

to self-induce a feeling of appreciation, their heart rhythm coherence significantly increased, as did the ratio of the alpha rhythm that was synchronized to the heart.[45, 50] In another study in which subjects self-generated feelings of appreciation while listening to music designed to foster positive emotions,[51] we found that the percentage of alpha-ECG synchronization significantly increased in the left hemisphere centered around the temporal lobe. Figure 3 shows the group mean topographical maps of the percentage of alpha activity that was synchronized to the heartbeat across different conditions. These plots are controlled for total amount of alpha activity and indicate only changes in synchronized activity from a resting baseline to actively feeling appreciation. As can be seen in the figure, the main brain areas that are synchronized to the heart shift from the right frontal area during the baseline period (the lighter the color, the more synchronized) to the left hemisphere centered around the temporal area and radiating outward from there during appreciation.

These observations may be related to findings indicating that increased left hemisphere activity is associated with happiness and euphoria while in-

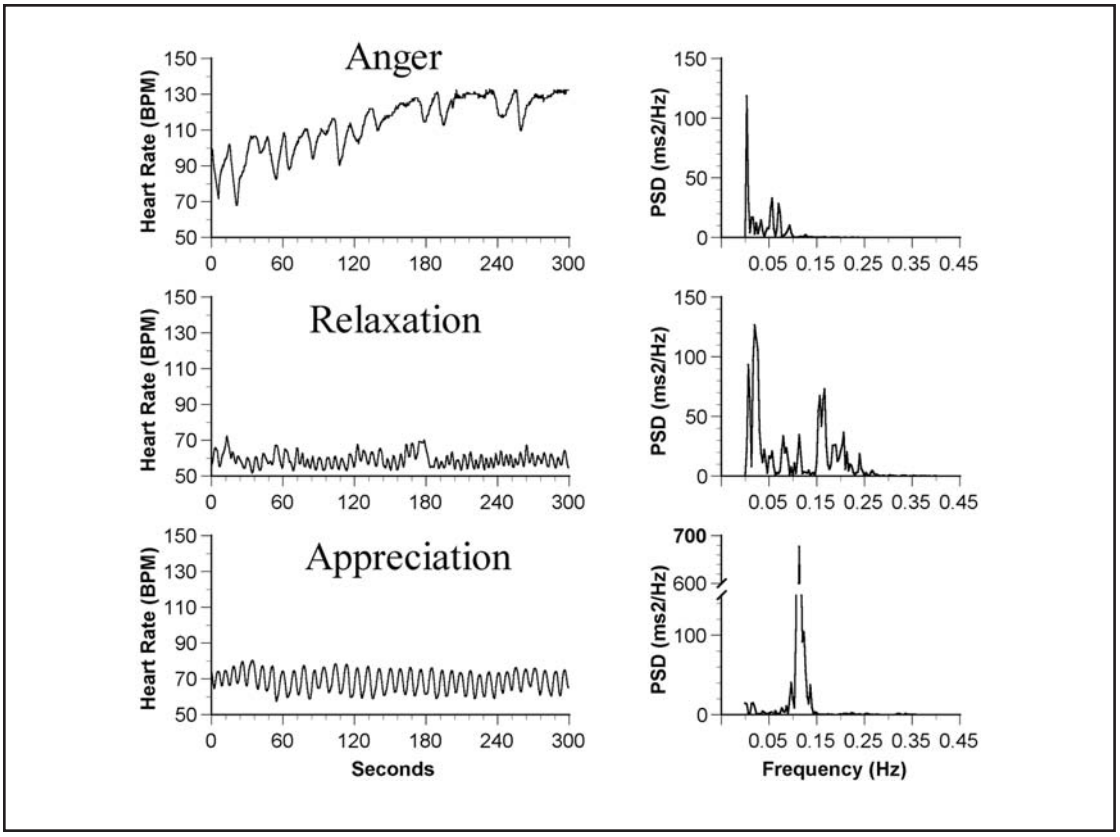

Figure 2. Heart rhythm patterns during different psychophysiological states.
Heart rate tachograms, showing beat-to beat changes in heart rate, (left) and heart rate variability power spectra (right) typical of different emotional/psychophysiological states. Anger (top) is characterized by a lower frequency, disordered heart rhythm pattern and increasing mean heart rate. As can be seen in the power spectrum, the rhythm is primarily in the very low frequency band, which is associated with sympathetic nervous system activity. Relaxation (center) results in a higher frequency, lower-amplitude rhythm, indicating reduced autonomic outflow. In this case, increased power in the high frequency band of the power spectrum is observed, reflecting increased parasympathetic activity (the relaxation response). In contrast, sustained positive emotions such as appreciation (bottom) are associated with a highly ordered, smooth, sine wave-like heart rhythm pattern (coherence). As can be seen in the power spectrum, this physiological mode is associated with a large, narrow peak in the low frequency band centered around 0.1 Hz. This indicates system-wide resonance, increased synchronization between the sympathetic and parasympathetic branches of the nervous system, and entrainment between the heart rhythm pattern, respiration, and blood pressure rhythms. The coherent mode is also associated with increased parasympathetic activity, thus encompassing a key element of the relaxation response, yet it is physiologically distinct from relaxation because the system is oscillating at its resonant frequency and there is increased harmony and synchronization in nervous system and heart-brain dynamics. In addition, the coherent mode does not necessarily involve a lowering of heart rate *per se, or a change in the* amount *of variability, but rather, a change in heart rhythm* pattern. *Also note the scale difference in the amplitude of the spectral peak during the coherent mode.*

creased right hemisphere activity is associated with depression and negative affect.[52, 53] It is clear that both the right and left hemispheres are involved in the processing and regulation of emotion; however, there is still a lack of clarity regarding the roles of hemispheres and how they interact in the emergence and perception of emotional experience.

In related experiments, we found that increased heart rhythm coherence correlates with significant improvements in cognitive performance in auditory discrimination tasks, which require subjects to focus and pay attention, discriminate subtle tone differences, and react quickly and accurately. Not only did increases in heart rhythm coherence accompany increased cognitive performance, but also the degree of coherence correlated with task performance across all subjects during all tasks. The control group, which had a relaxation period in place of the positive emotion self-induction task, showed no significant increase in heart rhythm coherence or improvements in cognitive performance.[45, 50]

These observations directly support the concept that the *pattern* of cardiac afferent input reaching the brain can inhibit or facilitate cortical function significantly beyond the micro-rhythm of inhibition/facilitation associated with simple changes in heart rate that was first documented by the Laceys. Thus, these findings provide a potential physiological link between appreciation and improvements in faculties such as motor skills, focused attention, and discrimination.

In summary, we use the term *coherence* to describe a physiological mode that encompasses entrainment, resonance, and synchronization—distinct but related phenomena, all of which emerge from the harmonious interactions of the body's subsystems. 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. The coherent mode is reflected by a smooth, sine wave-like pattern in the heart rhythms (heart rhythm coherence) and a narrow-band, high-amplitude peak in the low frequency range of the HRV power spectrum, at a frequency of about 0.1 hertz.

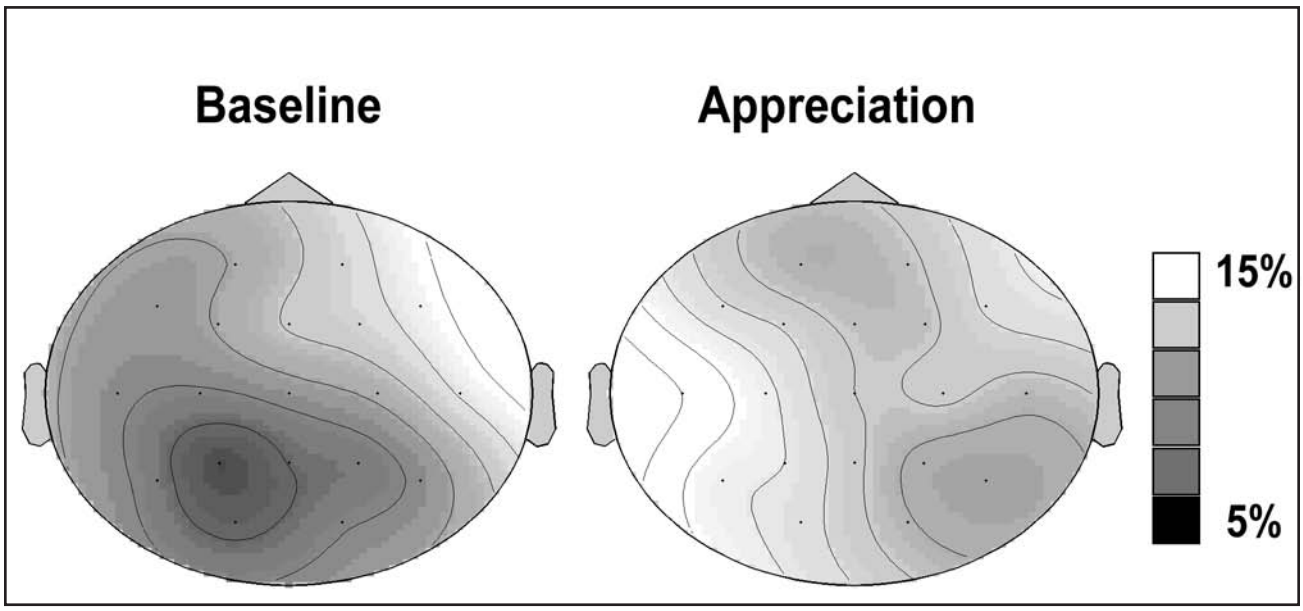

Figure 3. Alpha activity synchronized to the cardiac cycle.
Group mean topographical maps for 30 subjects, showing the percentage of alpha activity in different regions of the brain that is synchronized to the heartbeat during a resting baseline as compared to during actively feeling appreciation. The plots are controlled for total amount of alpha activity (which did not change significantly) and show only the amount of synchronized activity. As can be seen in the plots, the areas with the highest degree of synchronization shift from the right frontal area during the baseline period (lighter colors indicate higher levels of synchronization) to the left hemisphere centered around the temporal area and radiating outward from there during appreciation. This change was most pronounced at EEG site T3, although activity at adjacent sites was also significantly more synchronized to the heart.

Drivers of physiological coherence

Although physiological coherence is a natural state that can occur spontaneously, sustained episodes are generally rare. While specific rhythmic breathing methods can induce coherence and entrainment for brief periods, cognitively-directed, paced breathing is difficult for many people to maintain. On the other hand, our findings indicate that individuals can produce extended periods of physiological coherence by actively generating and sustaining a feeling of appreciation. Sincere feelings of appreciation 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 having an optimistic outlook and maintaining emotional stability, even during challenging situations.

Consciously generating feelings of love and appreciation while pretending to breathe through the area of the heart appears to confer a far wider range of benefits than simply "forcing" the system into coherence using breathing techniques alone. In order to distinguish between physiological coherence that naturally emerges as a result of positive emotions exciting the system at its resonant frequency, and coherence that is induced by cognitively-driven approaches (*e.g.*, paced breathing), we have introduced the term *psychophysiological coherence* to denote emotionally-driven coherence.[45]

During states of psychophysiological coherence, bodily systems function with a high degree of synchronization, efficiency, and harmony, and the body's natural regenerative processes appear to be facilitated. Psychologically, this mode is associated with improved cognitive performance, increased emotional stability, and enhanced psychosocial functioning and quality of life. Additionally, many people report experiencing a notable reduction in inner mental dialogue along with feelings of increased peace, self-security, and sustained positive emotions after practicing maintaining this mode even for short periods such as a few days or weeks.[20, 23, 26, 45]

Emotional Management: The Missing Dimension

Throughout the ages, in every culture, and in countless different ways, we have been exhorted repeatedly with the same fundamental message: to love one another, to have care and compassion for our fellow human beings, and to live in appreciation of life's gifts. Yet, in our view, genuine positive emotions and attitudes are not as prevalent in most people's lives as one might presume. Such states, along with their numerous benefits, remain, for the most part, mental concepts, which are transient and unpredictable experiences in the majority of people's lives. They are too often dependent on the arrangements of external events, rather than being fundamental traits. For example, people may find it relatively easy to genuinely experience feelings such as happiness, buoyancy, or appreciation during life's "highs"—special occasions or events that frequently involve a high degree of sensory stimulation; however, people rarely sustain such regenerative feelings as a norm in the midst of their ordinary day-to-day lives. At the other end of the spectrum, there are many examples in which a tragedy or crisis elicits feelings and actions of care, compassion, and unprecedented cooperation among members of a family community, or organization—only for people to fall back into old patterns of separation, judgment, and self-centered thought and action some time after the event has passed.

Although most people intuitively know that they *feel* best and operate more efficiently and effectively when experiencing positive emotions, why is it that they do not more consistently engage such states in their day-to-day lives? Why do genuine positive emotional experiences remain transient and unpredictable occurrences for most people? We propose that a main factor underlying this discrepancy is a fundamental lack of mental and emotional self-management skills. In other words, people generally do not make efforts to actively infuse their daily experiences with greater emotional quality because they sincerely do not know how.

Despite our best intentions, the human "negativity bias"—the natural tendency to focus on inputs (including thoughts and emotions) perceived as negative to a greater extent than neutral or positive stimuli—is a very real phenomenon with a sound

neurophysiological basis.[54] Although most people definitively claim that they love, care, and appreciate, it might shock many to realize the large degree to which these feelings are merely assumed or acknowledged cognitively, far more than they are actually experienced in their feeling world. In the absence of *conscious efforts* to engage, build, and sustain positive perceptions and emotions, we all too automatically fall prey to feelings of irritation, anxiety, worry, frustration, judgmentalness, self-doubt, and blame. As negative feelings are repeatedly "rehashed," these patterns reinforce their familiarity in the neural architecture, thus becoming stereotyped and increasingly automatic and mechanical. Many people do not realize the extent to which these habitual response patterns dominate their internal landscape, diluting and limiting positive emotional experience, and eventually becoming so familiar that they become engrained in their sense of self-identity.

Unmanaged negative mental, and, particularly, emotional processing drains vital energy from our psychological energy reserves, which we call the "emotional energy accumulators." Emotional energy or buoyancy is important for smooth mental processes. When our energy accumulators are drained, this leads to unregulated nervous system activity, which decreases clarity and our ability to make accurate assessments and quick, effective decisions. This, in turn, often serves to perpetuate the cycle of stress and disturbed feelings. In essence, the "inner noise" generated from unmanaged mental and emotional processes consumes our energy and keeps us from functioning to our full potential.

Various stress management practices have been developed to help people manage their emotions in order to reduce these energy drains. The majority of these approaches are based on a cognitive model in which all emotions follow a cognitive assessment of sensory input, which then leads to a behavioral response. Therefore, these approaches rely on strategies that engage or restructure cognitive processes. The basic theoretical framework is that if emotions always follow thought, then by changing one's thoughts, one can gain control over the emotions. However, in the last decade, research in the neurosciences has made it quite clear that emotional processes operate at a much higher speed than thoughts, and frequently bypass the mind's linear reasoning process entirely.[55] In other words, not all emotions follow thoughts; many (and in fact most in certain contexts) occur independently of the cognitive systems and can significantly bias or color the cognitive process and its output or decision.[55, 56]

This is why strategies that encourage "positive thinking" ***without also engaging positive feelings*** may frequently provide only temporary, if any, relief from emotional distress. While a conceptual shift may occur (which is important), the fundamental source of the emotional stress (a maladapted reference program) remains largely intact. This has significant implications for emotion regulation interventions and suggests that intervening at the level of the emotional system may in many cases be a more direct and efficient way to override and transform historical patterns underlying maladaptive thoughts, feelings, and behaviors and instill more positive emotions and prosocial behaviors.

Tools and Techniques to Promote Positive Emotions and Physiological Coherence

The recent Positive Psychology movement has emphasized the importance of encouraging not only the reduction of negative emotions, but also the cultivation of positive emotions in daily life.[57] Yet, psychology has seen a notable scarcity of interventions that focus directly and systematically on increasing positive emotional experiences. Recognizing this need many years ago, one of us (D.C.) undertook the development of practical, heart-based positive emotion-focused tools and techniques, which are designed to facilitate the self-regulation of emotions.[4, 58-63] Collectively known as the HeartMath system, these techniques utilize the heart as a point of entry into the psychophysiological networks that underlie emotional experience.[58, 63] The model of emotion we briefly summarized earlier emphasizes the central role played by cardiac afferent signals in emotional perception and experience. In essence, because the heart is a primary generator of rhythmic patterns in the body—influencing brain processes that control the ANS, cognitive function, and emotion—it provides an access point from which system-wide dynamics can be quickly and profoundly affected.[45]

In brief, HeartMath techniques combine a shift in the focus of attention to the area around the heart (where many people subjectively feel positive emotions) with the intentional self-induction of a

sincere positive emotional state, such as appreciation. We have found that appreciation is one of the most concrete and easiest of the positive emotions for individuals to self-induce and sustain for longer periods.

Such a shift in focus and feeling serves to increase heart rhythm coherence, which results in a change in the pattern of afferent cardiac input sent to the cognitive and emotional centers in the brain. This coupling of a more organized afferent pattern with an intentionally self-generated feeling of appreciation reinforces the natural conditioned response between the physiological state and the positive emotion. This subsequently strengthens the ability of a positive feeling shift to initiate a physiological shift towards increased coherence, or a physiological shift to facilitate the experience of a positive emotion. Once this association is firmly conditioned, simply pretending to breathe through the area of the heart, during a challenging situation where it may be hard to self-induce a positive emotion, can often facilitate an emotional shift.

Positive emotion-focused techniques can thus enable individuals to effectively replace stressful thought patterns and feelings with more positive perceptions and emotions *in the moment* when they are needed most. In turn, this frequently leads to more effective communication, improved decision making, and greater creativity and resourcefulness in problem solving. However, there are also benefits that extend beyond reducing stress and negative emotions in the present moment. Learning to self-generate positive emotions with increasing consistency can give rise to long-term improvements in emotion regulation abilities, attitudes, and relationships that affect many aspects of one's life.

In keeping with our model of emotion, we suggest that these enduring benefits stem from the fact that as people experience appreciation and its consequent physiological coherence with increasing consistency, the coherent patterns become ever more familiar to the brain. Thus, these patterns become established in the neural architecture as a new, stable baseline or norm, which serves as a set point or frame of reference that the system then strives to maintain. Therefore, when stress or emotional instability is subsequently experienced, the familiar coherent, stable state is more readily accessible, enabling a quicker and more enduring emotional shift. Even brief periods of coherence can stabilize nervous system dynamics, thereby reducing the tendency for inputs, whether internally or externally generated, to cause an emotional disturbance. Through this repatterning process, positive emotions and coherent physiological patterns progressively replace maladaptive emotional patterns and stressful responses as the habitual way of being.

HeartMath tools and techniques can be divided into two basic categories: (1) positive emotion refocusing techniques and (2) emotional restructuring techniques. Below we describe one example from each category: the Freeze-Frame and Heart Lock-In techniques. These tools are intentionally designed as simple, easy-to-use interventions that can be adapted to virtually any culture or age group. They are free of religious or cultural bias, and most people feel an enjoyable emotional shift and experience a broadened perception the first time that they use them. Although most age groups can effectively use the Freeze-Frame and Heart Lock-In techniques, tools specifically for children and young adults have also been designed.[62, 64, 65] We have also created a number of tools for use in specific contexts in organizational, educational, and health care settings.[58, 61, 66]

Freeze-Frame: A positive emotion refocusing technique

Freeze-Frame is a positive emotion refocusing exercise that enables individuals to intervene in real time to greatly reduce or prevent the stress and energy drains created from inappropriate or unproductive emotional triggers and reactions.[60] The technique's name is derived from the concept that conscious perception works in a way that is analogous to watching a movie, and perceiving each moment as an individual perceptual frame. When a scene becomes stressful, it is possible and helpful to freeze that perceptual frame and isolate it in time so that it can be observed from a more detached and objective viewpoint—similar to putting a VCR on pause for the moment. We have found that the process of deenergizing and disengaging from distressing thoughts and emotions can be greatly facilitated by shifting one's attention to the area around the heart (center of the chest) and self-generating a *feeling* of sincere appreciation. This process prevents or interrupts the

body's normal stress response and facilitates a shift toward increased physiological coherence (see Figure 1). The resulting change in the pattern of afferent signals reaching the brain's cognitive and emotional centers reinforces the feeling shift and also facilitates higher cognitive faculties that are normally compromised during stress and negative emotional states. This sharpens one's discernment abilities, increases resourcefulness, and often facilitates a perceptual shift, which allows problematic issues, interactions, or decisions to be assessed and dealt with from a broader, more emotionally balanced perspective.

The Freeze-Frame technique consists of five simple steps, which can be effectively applied in real time in the midst of a stressful situation or day-to-day activities (*e.g.*, while driving, sitting in a meeting, interacting with others, etc.). (See box below.)

The key elements of the technique are: *Shift* (to the area of the heart), *Activate* (a positive feeling), and *Sense* (what is the best perspective or attitude for this situation). In most training contexts, we first lead people through several exercises designed to aid them in identifying their deepest core values and the people, places, or events they truly appreciate. This helps them with Step 3, where they are asked to self-generate a feeling of appreciation or other positive emotion. This shift to a positive emotional state, or at least to a more neutral feeling, is an important aspect of the technique's effectiveness. For those people for whom it may be initially difficult to self-generate a feeling of appreciation in the present moment, it is generally helpful to suggest that they remember a time or experience in the past when they felt sincere appreciation and then attempt to reexperience that feeling in the present. With practice, however, most people become able to self-generate feelings of appreciation in real time and no longer need the past time reference.

As previously stated, the Freeze-Frame technique is designed to enable individuals to intercede in real time while stress is being experienced—rather than try to recuperate after the fact. The benefits of this cannot be overstated. Using Freeze-Frame in the "heat of the moment" saves tremendous amounts of energy that otherwise would have been drained and often prevents hours of emotionally-induced wear and tear on the body and psyche. It can also reduce the time and energy spent dealing with the

The Steps of Freeze-Frame:

1. **Take a time-out so that you can temporarily disengage from your thoughts and feelings—especially stressful ones.**
2. **Shift your focus of attention to the area around your heart—now feel your breath coming in through your heart and out through your solar plexus.**

   (Practice breathing this way a few times to ease into the technique).
3. **Make a sincere effort to activate a positive feeling.**

   (This can be a genuine feeling of appreciation or care for someone, some place or something in your life.)
4. **Ask yourself what would be an efficient, effective attitude or action that would balance and de-stress your system.**
5. **Quietly sense any change in perception or feeling and sustain it as long as you can.**

   (Heart perceptions are often subtle. They gently suggest effective solutions that would be best for you and all concerned.)

consequences of impulsive decisions or emotionally charged reactions, such as regret, embarrassment, guilt, accidents, and damaged relationships.

One of the long-term benefits to be gained from the practice of emotion refocusing techniques is increased emotional awareness, a fundamental step in the process of improving emotional well-being. In addition to helping people modify their responses to stressful events in the external environment, such techniques also help individuals identify and modify more subtle "internal" stressors (*i.e.*, persistent self-defeating and energy-depleting thought patterns and feelings, such as anxiety, fear, hurt, resentment, judgmentalism, perfectionism, and projections about the future). As individuals practice "freezing the frame" when feeling inner turmoil, they gain increased awareness of the habitual mental and emotional processes that underlie their stress, and become more able to catch the onset of these feelings and patterns, thus diminishing their influence.

Most individuals find the Freeze-Frame technique applicable to a variety of purposes beyond stress reduction. Additional applications include: facilitating decision making and problem solving, increasing mental focus and clarity, enhancing creativity, improving work and sports performance, improving communication effectiveness, and increasing team coherence. Since the technique takes only a minute or less to employ, many people report using it frequently throughout the day to clear their "mental screen" and consciously add a higher quality of emotional experience to their daily activities.

Heart Lock-In: An emotional restructuring technique

The Heart Lock-In[58, 59] is an emotional restructuring technique, which is generally taught as a companion tool to Freeze-Frame. The Heart Lock-In technique focuses on building the capacity to sustain heartfelt positive emotions and physiological coherence for longer periods. If desired, practice of this technique may also be facilitated by music specifically created to promote emotional balance and augment the favorable psychological and physiological effects of positive affective states.[67, 68]

In essence, the Heart Lock-In technique is designed to reinforce or "lock in" the coherent psychophysiological patterns associated with appreciation and other positive affective states. With practice, these coherent patterns become increasingly familiar, thus promoting increased physiological efficiency, mental acuity, and emotional stability as the new, familiar baseline or norm. Once this is accomplished, the system then attempts to maintain this state automatically.

At the physiological level, the occurrence of this "repatterning" process is supported by electrophysiological evidence demonstrating a greater frequency of spontaneous (without conscious practice of the intervention) periods of coherence in the heart rate tachograms of individuals practiced in the Heart Lock-In technique in comparison to the general population (unpublished data). To the extent that the Heart Lock-In helps establish appreciation and coherence as a familiar and accessible state, it becomes easier to effectively apply the Freeze-Frame tool during stressful or challenging situations.

The key elements of the technique are: *Focus* (in the area of the heart), *Appreciate*, and *Radiate* (love and care). In the midst of life's perpetual activity, the Heart Lock-In offers a simple way to cultivate and amplify heartfelt positive feelings and their nourishing effects on the body and psyche. As with the Freeze-Frame technique, it is important in the Heart Lock-In to try and genuinely experience the *feeling* of appreciation, as opposed to merely calling up a mental concept or image. Because of its active emotional focus, the Heart Lock-In imparts a state that is physiologically distinct from that induced by most relaxation exercises, whose main aim is to lower arousal levels. Relaxation is associated with an increase in parasympathetic activity, but generally does not produce prolonged periods of physiological coherence (see Figure 2). The coherent mode previously described is also associated with a shift in autonomic balance toward increased parasympathetic activity, thus encompassing a main element of the relaxation response, yet it is physiologically distinct from relaxation because, unlike relaxation, it is also characterized by system-wide resonance and increased harmony and synchronization in nervous system and heart-brain dynamics.

The increased physiological coherence generated in Steps 2 and 3 of the Heart Lock-In technique reinforces and amplifies positive feeling states such

as appreciation, care, and love. As individuals practice Step 4, they may imagine themselves gently emanating these feelings from the heart area. This process is typically accompanied by feelings of deep peacefulness, harmony, and a sense of inner warmth, and is often an effective means to diffuse accumulated stress and negative feelings. Also, in quieting mental dialogue through this process, many report the spontaneous emergence of an "intuitive clarity" relative to problems or troublesome issues.

Many people find it beneficial to begin and end their day with a Heart Lock-In. By using the technique first thing in the morning, before negative thoughts, worries, projections, or even "useful" plans start to engage the mind, one can help set the emotional tone for the day. This practice tends to anchor feelings of appreciation, buoyancy, and emotional stability, which increases the probability of carrying such feelings over into and throughout the day, thus reducing the likelihood of their being diminished by daily hassles and stressful events. Likewise, at day's end, using this tool can help one unwind, rebalance, and let go of worries, concerns, and negative feelings that have accumulated throughout the day. Focusing on heartfelt feelings of appreciation before going to bed at night often leads to more peaceful and rejuvenating sleep and reduces the carry-over of negative thoughts and emotions into the following day. Thus, creating a coherent internal environment prepares the physiological, mental, and emotional systems to more fully derive the regenerative benefits of sleep.

Heart rhythm coherence feedback training

Heart rhythm feedback training is a powerful tool to assist people in using positive emotion-focused techniques effectively and learning to self-generate increased physiological coherence.[69] Technologies have been developed that enable physiological coherence to be objectively monitored and quantified. One such device is the Freeze-Framer heart rhythm-monitoring and coherence-building system (HeartMath LLC, Boulder Creek, CA). This interactive hardware/software system monitors and displays individuals' heart rate variability patterns in real time as they practice the positive emotion refocusing and emotional restructuring techniques taught in an on-line tutorial. Using a fingertip sensor to record the pulse wave, the Freeze-Framer plots changes in heart rate on a beat-to-beat basis. As people practice the 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 feel appreciation and

Heart Lock-In Steps:

1. **Gently shift your attention to the area around your heart.**
2. **Shift your breathing so that you are breathing in through the heart and out through the solar plexus.**
3. **Activate a genuine feeling of appreciation or care for someone or something in your life.**
4. **Make a sincere effort to sustain feelings of appreciation, care or love while radiating them to yourself and others.**
5. **When you catch your mind wandering, gently focus your breathing back through the heart and solar plexus and reconnect with feelings of care or appreciation.**

(After you've finished, sincerely sustain your feelings of care and appreciation as long as you can. This will act as a cushion against recurring stress or anxiety.)

other positive emotions. This process reinforces the natural association between the physiological coherence mode and positive feelings. The real-time physiological feedback also essentially takes the guesswork and randomness out of the process of self-inducing a positive emotional state, resulting in greater consistency, focus, and effectiveness in practicing emotional shifts.

The software also analyzes the heart rhythm patterns for coherence level, which is fed back to the user as an accumulated score or success in playing one of three on-screen games designed to reinforce the emotion refocusing skills. Finally, the software includes a multi-user database to store results and track one's progress.

Because this technology uses a fingertip pulse sensor and involves no electrode hook-up, it is extremely versatile, time-efficient, and easy to use in a wide variety of settings (*e.g.*, workplaces, homes, schools, etc.). Heart rhythm coherence feedback training has been successfully used in diverse contexts by mental health professionals, physicians, law enforcement personnel, educators, and corporate executives to decrease stress, anxiety, depression, and fatigue; promote improved academic and work performance; lower blood pressure; and facilitate health improvements in numerous clinical disorders.

Intervention Studies

Beneficial psychological and health outcomes associated with the use of positive emotion-focused techniques and heart rhythm coherence feedback training have been demonstrated across diverse populations in both laboratory and field studies.[70] Collectively, these results suggest that techniques which foster feelings of appreciation and increase physiological coherence are effective in producing sustained improvements in many aspects of psychological and physical health and in general well-being and performance. Further, results indicate that such techniques are easily learned, have a high rate of compliance, and are highly adaptable to a wide range of demographic groups.

Health-related outcomes

The human body has an inherent capacity for self-healing and regeneration. However, life's hectic pace coupled with frequent inefficient mental and emotional activity can compromise the system's natural regenerative processes. The energy drains produced by unmanaged emotions burden the system, placing added stress on the entire body, and can contribute to conditions such as fatigue, burnout, and increased susceptibility to both infectious and chronic disease.[71-74] The health implications are substantial, as there is now abundant evidence that the depletion of emotional energy plays a major and largely unrecognized role in both the genesis and aggravation of many health problems.[75-79]

By fostering a state of psychophysiological coherence, positive emotion-focused techniques help individuals create an internal environment that is conducive to both physical and emotional regeneration. We suggest that such techniques are effective in helping to ***build back energy*** that has been depleted by persistent mental processing or negative emotional arousal, thereby enhancing health and healing. A number of research studies provide support for this hypothesis, documenting both short-term and long-term health benefits associated with the use of positive emotion-focused techniques.

For example, studies have shown that practice of the Heart Lock-In or Freeze-Frame technique with a focus on appreciation, care, or compassion results in a significant increase in levels of secretory IgA, the predominant antibody class found in mucosal secretions that serves as the body's first line of defense against pathogens.[67, 80] Other research has documented significant favorable changes in hormonal balance with regular practice of Heart Lock-In and Cut-Thru (an emotional restructuring technique)[59] over a period of 30 days. In a study of 30 subjects, a 23% reduction in cortisol and a 100% increase in DHEA were measured after one month of practicing the tools. Increases in DHEA were significantly correlated to increases in the affective construct of Warmheartedness (represented by kindness, appreciation, tolerance, and compassion), while decreases in cortisol were significantly correlated to decreases in Stress.[23]

Improvements in clinical status, emotional well-being, and quality of life have also been demonstrated in various medical patient populations in intervention programs using positive emotion refocusing and emotional restructuring approaches. For

example, significant blood pressure reductions have been demonstrated in individuals with hypertension;[81] improved functional capacity and reduced depression in congestive heart failure patients;[82] and improved psychological health and quality of life in patients with diabetes.[83] 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.[84]

Additionally, patient case history data provided by numerous health care professionals report substantial improvements in health and psychological status and frequent reductions in medication requirements in patients with such medical conditions as cardiac arrhythmias, chronic fatigue, environmental sensitivity, fibromyalgia, and chronic pain.[85] Finally, positive emotion-focused techniques and heart rhythm feedback have been used with great success by mental health professionals in the treatment of emotional disorders, including anxiety, depression, panic disorder, and post-traumatic stress disorder.[85] Many therapists find that emotional restructuring techniques are an effective means to achieve therapeutic release without retraumatization and frequently shorten treatment time.

Organizational outcomes

We have examined the impact of positive emotion-focused interventions and heart rhythm feedback training in a diverse range of organizational settings, including high-tech companies, government agencies, global oil companies, hospitals, and law enforcement agencies. Collectively, this research shows that interventions that focus on increasing positive emotions can indeed be effectively implemented in a wide variety of workplace settings, yielding measurable improvements in both employee health and well-being and in organizational performance. Organizationally relevant outcomes documented include increases in productivity, goal clarity, job satisfaction, communication effectiveness, and reductions in employee turnover.[70, 81, 86-88] Positive emotion-focused intervention programs have also been used in helping organizations effectively meet the demands of specific challenges, such as downsizing and restructuring initiatives.

Educational outcomes

Programs incorporating HeartMath tools and techniques, introduced at the elementary, middle school, high school, and college levels, have been demonstrated to improve emotional well-being, classroom behaviors, learning, and academic performance.[70, 89] In one study, 32 at-risk middle school students exhibited significant improvements in nearly all areas of psychosocial functioning assessed, including stress and anger management, risky behavior, work management and focus, and relationships with teachers, family and peers. Furthermore, students were able to use the Freeze-Frame technique to quickly recover from acute emotional stress and positively modulate their autonomic response to stress in real time, thus demonstrating increased physiological stress resiliency in relation to a control group.[26]

Another study examined the impact of HeartMath tools and technology on reducing test-taking anxiety and improving test scores in high school seniors. Students who had failed their state-required exit exams and who needed to retake the tests in order to graduate from high school participated in a three-week intensive program. The course included instruction in the Freeze-Frame and Heart Lock-In techniques, with an emphasis on reducing test-related anxiety and instilling greater emotional stability and self-confidence. Students also received heart rhythm feedback training to help them learn how to self-generate physiological coherence. After the program, the trained students demonstrated improvements in test scores and passing rates that represented one to two years' growth in academic skills and greatly exceeded those achieved through standard academic preparation alone. As compared to a control group, the trained students also demonstrated significant reductions in hostility, depression, interpersonal sensitivity, somatization, and other key indices of psychological distress.[90]

In a study evaluating a program designed to decrease anger, improve psychosocial well-being, and engender forgiveness, Stanford University students were taught the Freeze-Frame and Heart Lock-In techniques in six weekly one-hour sessions. Participants were assessed by psychological self-report measures and their response to a vignette at baseline, at the completion of the training, and again ten weeks later. The students who received the training

demonstrated significant reductions in both trait and reactive anger as well as interpersonal hurt, and were more willing to use forgiveness as a problem-solving strategy as compared to the control group. Among the study group, there were also significant increases in hopefulness, self-efficacy towards managing emotion and interpersonal hurt, and measures assessing personal growth, compassion, spiritual issues, and quality of life. These results suggest that programs that foster appreciation can be effective in modifying psychosocial traits and facilitating the release of negative emotions accumulated from past hurts in a relatively brief period of time.[91]

Summary and Conclusion

Recent years have seen the emergence of a growing body of data linking positive emotions to the enhancement of human functioning. Collectively, these findings are beginning to substantiate what many people have long intuitively known—that positive emotions not only feel good at the subjective level, but also bolster one's ability to meet life's challenges with grace and ease, optimize cognitive capacities, sustain constructive and meaningful relationships with others, and foster good health. The research findings discussed in this paper add to this body of data by identifying and characterizing a distinct mode of physiological functioning that is associated with the feeling of appreciation. This mode, which we have termed physiological coherence, encompasses a number of related phenomena, including entrainment, synchronization, and resonance, all of which emerge from the efficient and harmonious interactions of the body's subsystems. We propose that coherent mode may provide a potential physiological link between positive emotions and a range of favorable health-related, cognitive, and psychosocial outcomes documented by an increasing number of research studies.

The model of emotion discussed in this paper suggests that the brain functions as a complex pattern identification and matching system, and highlights the role of afferent bodily input in establishing the familiar reference patterns that are critical in ultimately determining emotional experience. As a principal and consistent source of rhythmic information patterns that impact the physiological, cognitive, and emotional systems, the heart plays a particularly important role in the generation and perception of emotion.

We have demonstrated that emotions are reflected in the heart's rhythms, and that by initiating a change in heart rhythm patterns, it is often possible to bring about rapid and significant changes in perception and emotional experience. Positive emotion-focused techniques that couple a shift in the heart's rhythmic patterns with the intentional self-induction of a heartfelt feeling of appreciation have been shown to be effective means to reduce stress and negative emotions in the moment and instill more positive perceptions, emotions, and behaviors. Furthermore, as individuals learn to increasingly sustain positive emotions and physiological coherence with consistent practice of such techniques, we suggest that a repatterning process occurs whereby increased physiological efficiency, mental acuity, and emotional stability are established as a new, familiar baseline or norm. The establishment of a new reference pattern enables individuals increasingly to override maladaptive perceptual, emotional, and behavioral patterns accumulated through past experience and to cultivate more positive emotions, attitudes, and behaviors in daily life.

Positive emotion-focused techniques are easy to learn and use, and appear to be highly generalizable among individuals of diverse cultures, age groups, socioeconomic status, and spiritual persuasions. Studies conducted in laboratory, organizational, clinical, and educational settings have demonstrated both real-time and long-term improvements in emotional well-being, performance, and health-related measures with use of these techniques. Such approaches have also been used effectively by mental health professionals in the treatment of individuals with various affective disorders.

We have argued that for most people, the range of genuine positive emotional experience is limited by the automaticity of historical patterns that often operate at a level below conscious awareness to color perception, feelings, and behavior. It thus requires conscious choice and commitment to begin to recognize and gradually replace these maladaptive patterns with ones that are more appropriate, efficient, and conducive to well-being. However, because most people are not trained in emotional management skills, in practice, the experience of positive emotions remains largely dependent upon external

events and circumstances, rather than being within one's own conscious control. Heart-based positive emotion-focused techniques therefore offer people a simple and effective means to consciously intervene to progressively bring more quality of emotional experience to their feeling world. It is our experience that this process not only significantly reduces one's experience of stress, but can also lead to enduring positive changes in one's attitudes, relationships, world view, and sense of self.

As increasing emphasis is placed on learning to enrich the emotional aspects of our experience, we anticipate that positive emotion-focused techniques and intervention programs will be increasingly integrated in clinical, workplace, and academic settings for the enhancement of health, well-being, and performance. It is our hope that such interventions will help people to develop greater awareness and understanding of their emotional responses, both conscious and subconscious; to progressively learn to direct these responses in ways that benefit their health and well-being; and ultimately to take on a more proactive role in the orchestration of their own fulfillment.

References

1. McCullough ME, Emmons RA, Kilpatric SD, Larson DB. Is gratitude a moral affect? *Psychological Bulletin* 2001;127(2):249-266.

2. Emmons RA, McCullough ME. Counting blessings versus burdens: An experimental investigation of gratitude and subjective well-being in daily life. In preparation.

3. Cooperrider DL, Whitney D. A positive revolution in change: Appreciative inquiry. In: Cooperrider DL, Sorensen PF Jr., Whitney D, Yaeger TF, eds. *Appreciative Inquiry: Rethinking Human Organization Toward a Positive Theory of Change*. Campaign, IL: Stipes Publishing, 2000: 207-214.

4. Paddison S. *The Hidden Power of the Heart: Discovering an Unlimited Source of Intelligence*. Boulder Creek, CA: Planetary Publications, 1998.

5. Csikszentmihalyi M. *Flow: The Psychology of Optimal Experience*. New York: Harper and Row, 1990.

6. Blakeslee T. *The Attitude Factor: Extend Your Life by Changing the Way You Think*. London: Thorsons/HarperCollins, 1997.

7. Danner DD, Snowdon DA, Friesen WV. Positive emotions in early life and longevity: findings from the nun study. *Journal of Personality and Social Psychology* 2001;80(5):804-813.

8. Goldman SL, Kraemer DT, Salovey P. Beliefs about mood moderate the relationship of stress to illness and symptom reporting. *Journal of Psychosomatic Research* 1996; 41(2):115-128.

9. Russek LG, Schwartz GE. Feelings of parental caring predict health status in midlife: A 35-year follow-up of the Harvard Mastery of Stress Study. *Journal of Behavioral Medicine* 1997;20(1):1-13.

10. Ashby FG, Isen AM, Turken AU. A neuropsychological theory of positive affect and its influence on cognition. *Psychological Review* 1999;106(3):529-550.

11. Isen AM. Positive affect. In: Dalgleish T, Power M, eds. *Handbook of Cognition and Emotion*. New York: John Wiley & Sons, 1999.

12. Fredrickson B. Positive emotions. In: Snyder CR, Lopez SJ, eds. *Handbook of Positive Psychology*. New York: Oxford University Press, 2002.

13. Aspinwall LG. Rethinking the role of positive affect in self-regulation. *Motivation and Emotion* 1998;22(1):1-32.

14. Isen AM, Daubman KA, Nowicki GP. Positive affect facilitates creative problem solving. *Journal of Personality and Social Psychology* 1987;52(6):1122-1131.

15. Isen AM. Positive affect, cognitive processes, and social behavior. *Advances in Experimental Social Psychology* 1987;20:203-253.

16. Armour JA, Ardell JL, eds. *Neurocardiology*. New York: Oxford University Press, 1994.

17. Sandman CA, Walker BB, Berka C. Influence of afferent cardiovascular feedback on behavior and the cortical evoked potential. In: Cacioppo JT, Petty RE, eds. *Perspectives in Cardiovascular Psychophysiology*. New York: The Guilford Press, 1982: 189-222.

18. Frysinger RC, Harper RM. Cardiac and respiratory correlations with unit discharge in epileptic human temporal lobe. *Epilepsia* 1990;31:162-171.

19. McCraty R. Heart-brain neurodynamics: The making of emotions. In: Childre D, McCraty R, Wilson BC, eds. *Emotional Sovereignty*. Amsterdam: Harwood Academic Publishers, forthcoming.

20. Tiller WA, McCraty R, Atkinson M. Cardiac coherence: A new, noninvasive measure of autonomic nervous system order. *Alternative Therapies in Health and Medicine* 1996;2(1):52-65.

21. McCraty R, Singer DH. Heart rate variability: A measure of autonomic balance and physiological coherence. In: Childre D, McCraty R, Wilson BC, eds. *Emotional Sovereignty*. Amsterdam: Harwood Academic Publishers, forthcoming.

22. McCraty R, Atkinson M, Tiller WA, Rein G, Watkins AD. The effects of emotions on short term heart rate variability using power spectrum analysis. *American Journal of Cardiology* 1995;76:1089-1093.

23. McCraty R, Barrios-Choplin B, Rozman D, Atkinson M, Watkins AD. The impact of a new emotional self-management program on stress, emotions, heart rate variability, DHEA and cortisol. *Integrative Physiological and Behavioral Science* 1998;33(2):151-170.

24. Ekman P, Levenson RW, Friesen WV. Autonomic nervous system activity distinguishes among emotions. *Science* 1983;221(4616):1208-1210.

25. Collet C, Vernet-Maury E, Delhomme G, Dittmar A. Autonomic nervous system response patterns specificity to basic emotions. *Journal of the Autonomic Nervous System* 1997;62:45-57.

26. McCraty R, Atkinson M, Tomasino D, Goelitz J, Mayrovitz HN. The impact of an emotional self-management skills course on psychosocial functioning and autonomic recovery to stress in middle school children. *Integrative Physiological and Behavioral Science* 1999;34(4):246-268.

27. Heymans C, Neil E. *Reflexogenic Areas of the Cardiovascular System*. Boston: Little, Brown, 1958.

28. Rosenfeld SA. *Conversations between heart and brain*. Rockville, MD: National Institute of Mental Health, 1977.

29. Lacey JI. Psychophysiological approaches to the evaluation of psychotherapeutic process and outcome. In: Rubinstein E, Parloff M, eds. *Research in Psychotherapy*. Washington, DC: American Psychological Association, 1959: 160-208.

30. Lacey JI, Kagan J, Lacey BC, Moss HA. The visceral level: Situational determinants and behavioral correlates of autonomic response patterns. In: Knapp PH, ed. *Expression of the Emotions in Man*. New York: International Universities Press, 1963: 161-196.

31. Lacey JI. Somatic response patterning and stress: Some revisions of activation theory. In: Appley MH, Trumbull R, eds. *Psychological Stress: Issues in Research*. New York: Appleton-Century-Crofts, 1967: 14-42.

32. Lacey JI, Lacey BC. Some autonomic-central nervous system interrelationships. In: Black P, ed. *Physiological Correlates of Emotion*. New York: Academic Press, 1970: 205-227.

33. Lacey BC, Lacey JI. Studies of heart rate and other bodily processes in sensorimotor behavior. In: Obrist PA, Black AH, Brener J, DiCara LV, eds. *Cardiovascular Psychophysiology: Current Issues in Response Mechanisms, Biofeedback, and Methodology.* Chicago: Aldine, 1974: 538-564.

34. Lacey BC, Lacey JI. Cardiac deceleration and simple visual reaction in a fixed foreperiod experiment. Paper presented at the meeting of the Society for Psychophysiological Research, Washington, D.C., October 1964.

35. Randich A, Gebhart GF. Vagal afferent modulation of nociception. *Brain Research Reviews* 1992;17:77-99.

36. Drinkhill MJ, Mary DA. The effect of stimulation of the atrial receptors on plasma cortisol level in the dog. *Journal of Physiology* 1989;413:299-313.

37. Rau H, Pauli P, Brody S, Elbert T. Baroreceptor stimulation alters cortical activity. *Psychophysiology* 1993;30:322-325.

38. van der Molen MW, Somsen RJM, Orlebeke JF. The rhythm of the heart beat in information processing. In: Ackles PK, Jennings JR, Coles MGH, eds. *Advances in Psychophysiology*, Vol. 1. London: JAI Press, 1985: 1-88.

39. Pribram KH, Melges FT. Psychophysiological basis of emotion. In: Vinken PJ, Bruyn GW, eds. *Handbook of*

Clinical Neurology. Amsterdam: North-Holland Publishing Company, 1969: 316-341.

40. Langhorst P, Schulz G, Lambertz M. Integrative control mechanisms for cardiorespiratory and somatomotor functions in the reticular formation of the lower brain stem. In: Grossman P, Janssen KHL, Vaitl D, eds. *Cardiorespiratory and Cardiosomatic Psychophysiology*. New York and London: Plenum Press, 1983: 9-39.

41. Oppenheimer S, Hopkins D. Suprabulbar neuronal regulation of the heart. In: Armour JA, Ardell JL, eds. *Neurocardiology*. New York: Oxford University Press, 1994: 309-341.

42. Zhang JX, Harper RM, Frysinger RC. Respiratory modulation of neuronal discharge in the central nucleus of the amygdala during sleep and waking states. *Experimental Neurology* 1986;91:193-207.

43. Lessmeier TJ, Gamperling D, Johnson-Liddon V, Fromm BS, Steinman RT, Meissner MD, Lehmann MH. Unrecognized paroxysmal supraventricular tachycardia: Potential for misdiagnosis as panic disorder. *Archives of Internal Medicine* 1997;157:537-543.

44. Hirsch JA, Bishop B. Respiratory sinus arrhythmia in humans: How breathing pattern modulates heart rate. *American Journal of Physiology* 1981;241(4):H620-H629.

45. McCraty R, Atkinson M. Psychophysiological coherence. In: Childre D, McCraty R, Wilson BC, eds. *Emotional Sovereignty*. Amsterdam: Harwood Academic Publishers, forthcoming.

46. Baselli G, Cerutti S, Badilini F, Biancardi L, Porta A, Pagani M, Lombardi F, Rimoldi O, Furlan R, Malliani A. Model for the assessment of heart period variability interactions of respiration influences. *Medical and Biological Engineering and Computing* 1994;32:143-152.

47. deBoer RW, Karemaker JM, Strackee J. Hemodynamic fluctuations and baroreflex sensitivity in humans: A beat-to-beat model. *American Journal of Physiology* 1987;253(3 Pt 2):H680-H689.

48. Langhorst P, Schulz G, Lambertz M. Oscillating neuronal network of the "common brainstem system." In: Miyakawa K, Koepchen HP, Polosa C, eds. *Mechanisms of Blood Pressure Waves*. Tokyo: Japan Scientific Societies Press, 1984: 257-275.

49. Siegel G, Ebeling BJ, Hofer HW, Nolte J, Roedel H, Klubendorf D. Vascular smooth muscle rhythmicity. In: Miyakawa K, Koepchen HP, Polosa C, eds. *Mechanisms of Blood Pressure Waves*. Tokyo: Japan Scientific Societies Press, 1984: 319-338.

50. McCraty R. Influence of cardiac afferent input on heart-brain synchronization and cognitive performance. *International Journal of Psychophysiology* 2002;45(1-2):72-73.

51. Childre D. *Heart Zones* [music]. Boulder Creek, CA: Planetary Publications, 1991.

52. Davidson RJ. Anterior electrophysiological asymmetries, emotion, and depression: conceptual and methodological conundrums. *Psychophysiology* 1998;35(5):607-614.

53. Lane RD, Reiman EM, Bradley MM, Lang PJ, Ahern GL, Davidson RJ, Schwartz GE. Neuroanatomical correlates of pleasant and unpleasant emotion. *Neuropsychologia* 1997;35(11):1437-1444.

54. Ito TA, Larsen JT, Smith NK, Cacioppo JT. Negative information weighs more heavily on the brain: The negativity bias in evaluative categorizations. *Journal of Personality and Social Psychology* 1998;75(4):887-900.

55. LeDoux J. *The Emotional Brain: The Mysterious Underpinnings of Emotional Life*. New York: Simon and Schuster, 1996.

56. LeDoux JE. Cognitive-emotional interactions in the brain. In: Ekman P, Davidson RJ, eds. *The Nature of Emotion: Fundamental Questions*. New York: Oxford University Press, 1994: 216-223.

57. Seligman MEP, Csikszentmihalyi M. Positive psychology: An introduction. *American Psychologist* 2000;55(1):5-14.

58. Childre D, Martin H. *The HeartMath Solution*. San Francisco: HarperSanFrancisco, 1999.

59. Childre D, Rozman D. *Overcoming Emotional Chaos: Eliminate Anxiety, Lift Depression and Create Security in Your Life*. San Diego: Jodere Group, 2002.

60. Childre D. *Freeze-Frame: A Scientifically Proven Technique for Clear Decision Making and Improved Health*. Boulder Creek, CA: Planetary Publications, 1998.

61. Childre D, Cryer B. *From Chaos to Coherence: The Power to Change Performance*. Boulder Creek, CA: Planetary, 2000.

62. Childre D. *Emotional Security Tool Kit for Children and Teens*. Boulder Creek, CA: Institute of HeartMath, 2001. Available on the World Wide Web at www.heartmath.org.

63. Childre D, McCraty R, Wilson BC, eds. *Emotional Sovereignty*. Amsterdam: Harwood Academic Publishers, forthcoming.

64. Childre D. *Teaching Children to Love: 80 Games and Activities for Raising Balanced Children in Unbalanced Times*. Boulder Creek, CA: Planetary Publications, 1996.

65. Childre D. *The How To Book of Teen Self Discovery: Helping Teens Find Balance, Security and Esteem*. Boulder Creek, CA: Planetary Publications, 1992.

66. Institute of HeartMath. *TestEdge: Getting in Sync for Test Success*. Boulder Creek, CA: Institute of HeartMath, 2002.

67. McCraty R, Atkinson M, Rein G, Watkins AD. Music enhances the effect of positive emotional states on salivary IgA. *Stress Medicine* 1996;12:167-175.

68. McCraty R, Barrios-Choplin B, Atkinson M, Tomasino D. The effects of different music on mood, tension, and mental clarity. *Alternative Therapies in Health and Medicine* 1998;4(1):75-84.

69. McCraty R. Heart rhythm coherence – An emerging area of biofeedback. *Biofeedback* 2002;30(1):23-25.

70. McCraty R, Atkinson M, Tomasino D. *Science of the Heart*. Boulder Creek, CA: HeartMath Research Center, Institute of HeartMath, Publication No. 01-001, 2001.

71. Cohen S, Tyrrell DA, Smith AP. Psychological stress and susceptibility to the common cold. *New England Journal of Medicine* 1991;325(9):606-612.

72. Boone JL, Christensen JF. Stress and disease. In: Feldman MD, Christensen JF, eds. *Behavioral Medicine in Primary Care: A Practical Guide*. Stamford, CT: Appleton & Lange, 1997: 265-276.

73. Sterling P, Eyer J. Biological basis of stress-related mortality. *Social Science and Medicine* 1981;15E:3-42.

74. Kubzansky LD, Kawachi I, Spiro A, III, Weiss ST, Vokonas PS, Sparrow D. Is worrying bad for your heart? A prospective study of worry and coronary heart disease in the Normative Aging Study. *Circulation* 1997;95(4):818-824.

75. Wickramasekera I. Secrets kept from the mind but not the body or behavior: The unsolved problems of identifying and treating somatization and psychophysiological disease. *Advances in Mind-Body Medicine* 1998;14(2):81-132.

76. Allison TG, Williams DE, Miller TD, Patten CA, Bailey KR, Squires RW, Gau GT. Medical and economic costs of psychologic distress in patients with coronary artery disease. *Mayo Clinic Proceedings* 1995;70(8):734-742.

77. Grossarth-Maticek R, Eysenck HJ. Self-regulation and mortality from cancer, coronary heart disease and other causes: A prospective study. *Personality and Individual Differences* 1995;19(6):781-795.

78. Purcell H, Mulcahy D. Emotional eclipse of the heart. *British Journal of Clinical Practice* 1994;48(5):228-229.

79. Hafen BQ, Frandsen KJ, Karren KJ, Hooker KR. *The Health Effects of Attitudes, Emotions and Relationships*. Provo, UT: EMS Associates, 1992.

80. Rein G, Atkinson M, McCraty R. The physiological and psychological effects of compassion and anger. *Journal of Advancement in Medicine* 1995;8(2):87-105.

81. McCraty R, Atkinson M, Tomasino D. Impact of a workplace stress reduction program on blood pressure and emotional health in hypertensive employees. Submitted to the *Journal of Occupational Health Psychology*.

82. Luskin F, Reitz M, Newell K, Quinn TG, Haskell W. A controlled pilot study of stress management training of elderly patients with congestive heart failure. *Preventive Cardiology* 2002;5(4):168-172, 176.

83. McCraty R, Atkinson M, Lipsenthal L. *Emotional self-regulation program enhances psychological health and quality of life in patients with diabetes*. Boulder Creek, CA: HeartMath Research Center, Institute of HeartMath, Publication No. 00-006, 2000.

84. Rozman D, Whitaker R, Beckman T, Jones D. A pilot intervention program which reduces psychological symptomatology in individuals with human immunodeficiency virus. *Complementary Therapies in Medicine* 1996;4:226-232.

85. McCraty R, Tomasino D, Atkinson M. Research, clinical perspectives and case histories. In: Childre D, McCraty R, Wilson BC, eds. *Emotional Sovereignty*. Amsterdam: Harwood Academic Publishers, forthcoming.

86. Barrios-Choplin B, McCraty R, Cryer B. An inner quality approach to reducing stress and improving physical and emotional wellbeing at work. *Stress Medicine* 1997;13:193-201.

87. Barrios-Choplin B, McCraty R, Atkinson M. *The effect of employee self-management training on personal and organizational quality*. Boulder Creek, CA: HeartMath Research Center, Institute of HeartMath, Publication No. 99-083, 1999.

88. Barrios-Choplin B, McCraty R, Atkinson M. *Impact of the HeartMath self-management skills program on physiological and psychological stress in police officers*. Boulder Creek, CA: HeartMath Research Center, Institute of HeartMath, Publication No. 99-075, 1999.

89. Arguelles L, McCraty R, Rees RA. The heart in holistic education. Submitted to *ENCOUNTER: Education for Meaning and Social Justice*.

90. McCraty R, Tomasino D, Atkinson M, Aasen P, Thurik SJ. *Improving test-taking skills and academic performance in high school students using HeartMath learning enhancement tools*. Boulder Creek, CA: HeartMath Research Center, Institute of HeartMath, Publication No. 00-010, 2000.

91. Luskin F. *The effects of forgiveness training on psychosocial factors in college-age adults*, Ph.D. Dissertation, Counseling Psychology, Stanford University, 1999.