REVIEW ARTICLE

Coherence: bridging personal, social and global health

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"All nature is a continuum. The endless complexity of life is organized into patterns which repeat themselves – theme and variations – at each level of system. These similarities and differences are proper concerns for science. From the ceaseless streaming of protoplasm to the many-vectored activities of supranational systems, there are continuous flows through living systems as they maintain their highly organized steady states." "Even more basic to this presentation than the concept of "system" are the concepts of "space," "time," "matter," "energy," and "information, because the living systems exist in space and are made of matter and energy organized by information." *James Grier Miller, Living Systems (1978)*

Introduction

Of the many new scientific perspectives that emerged from the twentieth century, one of the most profound is that the universe is wholly and enduringly interconnected and *coherent* (Bohm & Hiley 1993; Laszlo 1995; 2008). Complex living systems, including human beings, are composed of numerous dynamic, interconnected networks of biological structures and processes. Coherence implies order, structure, harmony and alignment within and amongst systems – whether in atoms, organisms, social groups, planets or galaxies. Thus every whole has a relationship with and is a part of a greater whole, which is again part of something greater. In this context, nothing can be considered as separate, alone or lacking relationships. One of the more surprising findings that has emerged from physics is quantum coherence, which has given rise to the prediction of non-locality and instantaneous communication between subatomic particles separated by vast distances (Bohm & Hiley 1993).

Most people know what it feels like to be in harmonious state, the place where our hearts, minds and bodies are united in a feeling of wholeness. This state is often referred to as "the zone," "flow," "oneness," etc. When we are in such states we typically feel connected not only to our deepest selves but to others, even to the earth itself. We call this state of internal and external connectedness "coherence." This overview discusses how increased personal coherence can be achieved as people learn to more consistently self-regulate their emotions from a more intuitive, intelligent and balanced inner reference and how this state is directly associated with increased intuition, improved health and cognitive functioning. It also describes how coherence is reflected in physiology and objectively measured. The discussion then expands to coherence in the context of families, workplaces, and communities. The article concludes with the perspective that being responsible for and increasing our personal coherence is not only reflected in improved personal health and happiness, but is also feeds into and is reflected in a global field environment. It is postulated that as increasing numbers of people add coherent energy to the global field, it helps strengthen and stabilize mutually beneficial feedback loops between human beings and the earth itself.

Concept of Coherence

The various concepts and measurements embraced under the term coherence have become central to fields as diverse as quantum physics, cosmology, physiology, and brain and consciousness research. Coherence has several related definitions, all of which are applicable to the study of human physiology, social interactions and global affairs. The most common dictionary definition is "the quality of being logically integrated, consistent and intelligible," as in a coherent statement (Stein 1975). A related meaning is the logical, orderly and aesthetically consistent relationship among parts (Stein 1975). Coherence always implies correlations, connectedness, consistency and efficient energy utilization. We refer to people's speech or thoughts as coherent if the words fit together well, and incoherent if they are uttering meaningless nonsense or presenting ideas that make no sense as a whole. Thus, coherence refers to wholeness and global order, where the whole is greater than the sum of its individual parts. In the example of organizing words into a coherent sentence, the meaning and purpose conveyed by the arrangement of the words is greater than the individual meaning of each word. For any system to produce a function, it must have the property of global coherence, and this is also true for our physical, mental, emotional and social systems. However, the energy efficiency and degree of coordinated action of any given system can vary widely and does not necessarily result in a coherent output or flow of behavior.

Coherence is also used to describe the coupling and degree of synchronization between different oscillating systems. In some cases, where two or more oscillatory systems operate at the same basic frequency, they can become either phase or frequency-locked as occurs between the photons in a laser (Strogatz & Stewart 1993). This type of coherence is called cross-coherence and this is the type of coherence that most scientists think of when they use the term. In physiology, cross-coherence occurs when two or more of the body's oscillatory systems, such as respiration and heart rhythms, become entrained and operate at the same frequency. However, global coherence does not mean that everyone or all the parts are doing the same thing simultaneously. In complex globally coherent systems, such as human beings, there is an incredible amount of activity at every level of magnification or scale that spans more than two thirds of the 73 known octaves of the electromagnetic spectrum (Ho 2005). It can appear at one level of scale that a given system is operating autonomously, yet it is perfectly coordinated within the whole. In living systems, there are micro-level systems, molecular machines, protons and electrons, organs and glands each functioning autonomously, doing very different things at different rates, yet all working together in a complex harmoniously coordinated and synchronized manner. If this were not the case, it would be a free-for-all among the body's independent systems, rather than a coordinated federation of interdependent systems and functions. Biologist Mae-Won Ho, has suggested that coherence is the defining quality of living systems and accounts for their most characteristic properties, such as long range order and coordination, rapid and efficient energy transfer, and extreme sensitivity to specific signals (Ho 2005).

Many contemporary scientists believe that it is the underlying state of our physiological processes that determines the quality and stability of the feelings and emotion we experience. The feelings we label as "positive" actually reflect body states in which "the regulation of life processes become efficient, or even optimal, free-flowing and easy." (Damasio 2003). Indeed, it appears that synchronized activity underlies conscious experience itself. For the brain and nervous system to function, the neural activity, which encodes information, must be stable and coordinated and the various centers within the brain must be able to dynamically synchronize their activity in order for information to be smoothly processed and perceived.

Our "coherent" perception of an object in the external world actually comes from millions of neurons involved in processing sensory information that are made globally coherent by being brought together and organized into a global conscious experience (Ratey 2001). We are not only conscious of external inputs, but of ourselves as a coherent whole. In fact, it is estimated that 40 to 65% of all activities in the brain are phase synchronized at any given time (John 2005). Coherence in this context is a measure of the correlated activity between brain regions which is orchestrated from direct neural connections between the regions, common input from the thalamus or other neocortical regions (Nunez 2000). Cross-coherence, however, also occurs between distant cortical structures that are not interconnected anatomically (Bressler *et al* 1993). The degree of coupling, which regulates synchronized activity in the networks, varies depending on the needs of the moment. It is this flexibility that allows us to quickly adapt to changing demands, such as focusing on external sensory input or an internal process. However, if the networks become either excessively coupled or are too loosely coupled, the system is less able to dynamically marshal the appropriate neural support systems it needs to respond to a particular demand (Ratey 2001). This is reflected in the alpha rhythm, which increases in amplitude and distribution when the neural populations are more tightly coupled and are not involved in processing information. Under these circumstances cognitive performance is reduced, especially tasks involving the processing of external sensory information. In terms of optimizing performance, this usually means that one should not be too relaxed (increased coupling). or overly stimulated (decreased coupling) when performing important cognitive tasks.

There are also many examples in physiology where synchronized activity occurs across different time

scales, which is characteristic of a globally coherent system. The brain rhythms operate over a wide range of frequencies, yet most of these exhibit various degrees of synchronized activity with the heart, which has much slower rhythms than the brain. For example, when heart rate increases, the activity and amplitude of the brain waves also tends to increase. When the heart rhythm is coherent, as described below, there also tends to be an increase in heart-brain synchronization (McCraty 2009). These are examples of a phase-amplitude relationship between macroscopic physiological rhythms, which reflect the constant intercommunication between different biological rhythms that take place in healthy organisms (Ho 2005).

Another aspect of coherence relates to the dynamic rhythms produced by a single oscillatory system. The term *auto-coherence* describes coherent activity within a single system. An ideal example is a system that exhibits sine wave like oscillations; the more stable the frequency, amplitude and shape, the higher the degree of coherence. When coherence is increased in a system that is coupled to other systems, it can pull the other systems into increased synchronization and more efficient function. For example, frequency pulling and entrainment can easily be seen between the heart, respiratory and blood-pressure rhythms as well as between very low frequency brain rhythms, craniosacral rhythms, and electrical potentials measured across the skin (Tiller *et al* 1996; Bradley & Pribram 1998).

The Coherent Heart Rhythm of Positive Emotions

We introduced the term physiological coherence to describe the degree of order, harmony and stability in the various rhythmic activities within living systems over any given time period (Tiller *et al* 1996). This harmonious order signifies a coherent system, whose efficient or optimal function is directly related to the ease and flow in life processes. By contrast, an erratic, discordant pattern of activity denotes an incoherent system whose function reflects stress and inefficient utilization of energy in life processes. Interestingly, we have found that positive emotions such as appreciation and compassion, as opposed to negative emotions such as anxiety, anger, and fear, are reflected in a heart rhythm pattern that is more coherent (see ***Fig. 1***) (McCraty 2004; McCraty *et al* 1993; 1998b; 2004c; 2006; McCraty & Childre 2004; McCraty & Tomasino 2006a, b). The coherent state has been correlated with a general sense of well-being, and improvements in cognitive, social and physical performance. We have observed this association between emotions and heart rhythm patterns in studies conducted in both laboratory and natural settings, and for both spontaneous and intentionally generated emotions (Tiller *et al* 1996; McCraty *et al* 1995).

There is abundant evidence that emotions alter the activity of the body's physiological systems, and that beyond their pleasant subjective feeling, heart-felt positive emotions and attitudes provide a number of benefits that enhance physiological, psychological, and

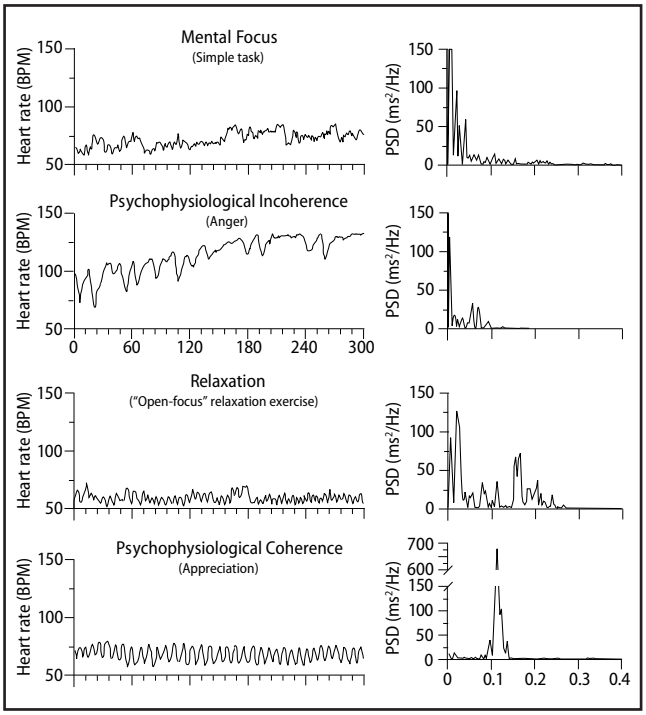

Fig. 1. Emotions are reflected in heart rhythm patterns. The left-hand graphs are heart rate tachograms which show beat-to-beat changes in heart rate. To the right are the heart rate variability power spectral density (PSD) plots of the tachograms at left. The examples depicted are typical of the characteristic aspects of the more general patterns observed for each state. *Mental Focus* is characterized by reduced HRV. Activity in all three frequency bands of the HRV power spectrum is present. Anger, an example of *Psychophysiological Incoherence,* characterized by a lower frequency, more disordered heart rhythm pattern and increasing mean heart rate. As can be seen in the corresponding power spectrum to the right, the rhythm during anger is primarily in the very low frequency region, which is associated with sympathetic nervous system activity. *Relaxation* results in a higher frequency, lower amplitude rhythm, indicating reduced autonomic outflow. In this case, increased power in the high frequency region of the power spectrum is observed, reflecting increased parasympathetic activity (the relaxation response). *Psychophysiological Coherence*, which is associated with sustained positive emotions (in this example, appreciation), results in a highly ordered, sine-wave-like heart rhythm pattern. As can be seen in the corresponding power spectrum, this psychophysiological mode is associated with a large, narrow peak in the low frequency region, centered around 0.1 Hz. Note the scale difference in the amplitude of the spectral peak during the coherence mode. 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 coherence 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.

social functioning (Fredrickson 2002; Isen 1999; Wichers *et al* 2007). As coherence tends to naturally emerge with the activation of heart-felt positive emotions such as appreciation, compassion, care and love, it suggests that such feelings increase the coherence and harmony in our energetic systems which are the primary drivers of our physiological systems (McCraty & Tomasino 2006b). This increased coherence and alignment in turn facilitate the body's natural regenerative processes. In this context the term energetic systems refers to the functions we cannot directly measure, touch or see, such as our emotions, thoughts and intuitions. Although these functions have loose correlations with biological activity patterns, they nevertheless remain covert and hidden from direct observation. Several notable scientists have proposed that such functions operate primarily in the frequency domain outside of time and space and have suggested mechanisms as to how they can interact with biological processes (Bradley 2007; Laszlo 2008; Marcer & Schempp 1998; Mitchell 2004; Pribram 1991; Pribram & Bradley 1998; Schempp 1992; Tiller *et al* 2001).

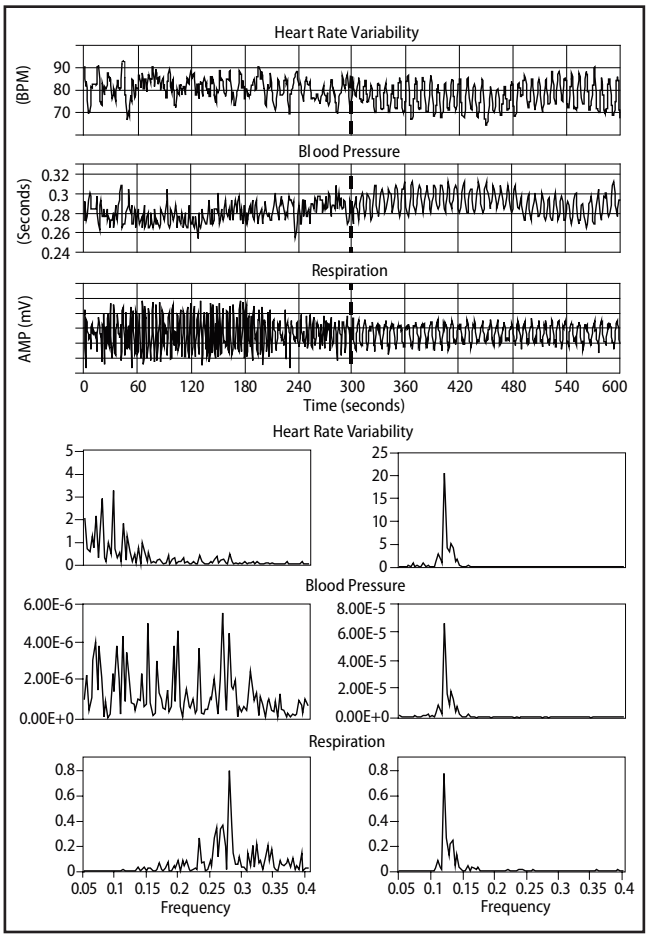

Fig. 2. Entrainment. The top graphs show an individual's heart rate variability, pulse transit time, and respiration rhythms over a 10-minute period. At the 300-second mark, the individual used the Freeze-Frame positive emotion refocusing technique, causing these three systems to come into entrainment. The bottom graphs show the frequency spectra of the same data on each side of the dotted line in the center of the top graph. Notice the graphs on the right show that all three systems have entrained to the same frequency.

It is important to note that although changes in heart rate often covary with emotions, our research has found that it is the pattern of the heart's rhythm that is primarily reflective of the emotional state, especially emotions that do not lead to large autonomic nervous system (ANS) activations or withdrawals (McCraty *et al* 1995; McCraty 2009; Tiller *et al* 1996). These changes in rhythmic patterns are independent of heart rate; that is, one can have a coherent or incoherent pattern at higher or lower heart rates. Thus, it is the pattern of the rhythm (the ordering of changes in rate overtime), rather than the rate (at any point in time) that is most directly related to emotional dynamics and physiological synchronization. Also, the coherent state is fundamentally different from a state of relaxation which requires only a lowered heart rate and not necessarily a coherent rhythm.

Physiological coherence, also referred to as heart coherence, cardiac coherence or resonance is a functional mode, measured by heart rate variability (HRV) analysis wherein a person's heart rhythm pattern becomes more ordered and sine-wave like at a frequency of around 0.1 Hz (10 seconds) (McCraty 2009). The term physiological coherence embraces several related phenomena – auto-coherence, cross-coherence, synchronization, and resonance – all of which are associated with increased order, efficiency, and harmony in the functioning of the body's systems. When one is in a coherent state, it reflects increased synchronization and resonance in higher-level brain systems and in the activity occurring in the two branches of the autonomic nervous system (ANS), as well as a shift in autonomic balance toward increased parasympathetic activity.

Psychologically, coherence reflects increased emotional and perceptual stability and alignment among the physical, cognitive, and emotional systems (***Fig. 2***). Coherence and resilience are closely related as each has the quality of being both a process and an outcome as they rely on physiological and psychological processes that create resilient outcomes. In addition, both are states rather then traits that vary over time as demands, circumstances and level of maturity change (Luthar *et al* 2000). Resilience is related to self-management and efficient utilization of energy resources across four domains; physical, emotional, mental and spiritual (***Fig. 3***). Physical resilience is basically reflected in physical flexibility, endurance and strength, while emotional resilience is reflected in one's ability to self-regulate the degree of emotional flexibility, positive emotions and relationships. Mental resilience is reflected in our attention span, mental flexibility, an optimistic world view and ability to integrate multiple points of view. Spiritual resilience is typically associated with our commitment to core values, intuition, and tolerance of others'

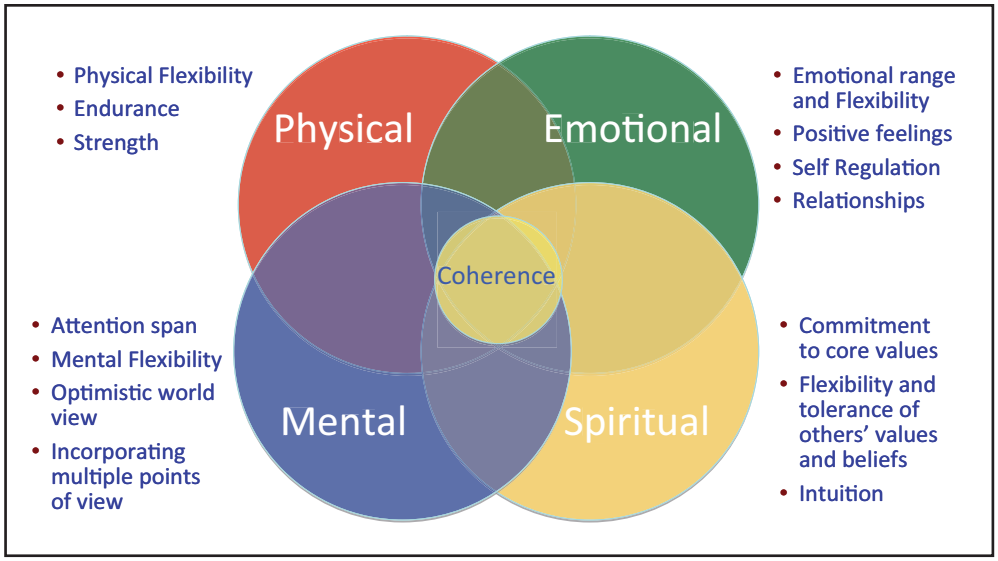

Fig. 3. Dimensions of resilience.

values and beliefs. When we are in a coherent state, the increased physiological efficiency and alignment of the mental and emotional systems accumulates resilience (energy) across all four energetic domains. Having a high level of resilience is important for not only recouping from challenging situations, but for preventing unnecessary stress reactions (frustration, impatience, anxiety) that deplete our physical and psychological resources.

Heart Rate Variability Coherence

HRV is widely considered a measure of neurocardiac function that reflects heart–brain interactions and ANS dynamics. All HRV measures are derived from the assessment of the naturally occurring changes in beat-to-beat heart rate. HRV is much more than an assessment of heart rate since it reflects the complex interactions of the heart with multiple body systems (McCraty 2009). An optimal level of variability within an organism's key regulatory systems is critical to the inherent flexibility and adaptability or resilience that epitomizes healthy coherent function and well-being. While too much instability is detrimental to efficient physiological functioning and energy utilization, too little variation indicates depletion or pathology (Umetani *et al* 1998). The amount or range of overall HRV is related to our age, with younger people having higher levels than older ones (Umetani *et al* 1998). Low HRV is a strong and independent predictor of future health problems, including all causes of mortality, (Levy *et al* 2002) and it is associated with numerous medical conditions (Arrone *et al* 1997; Lindmark *et al* 2006; Lindmark *et al* 2005; Lindmark *et al* 2003; Saul *et al* 1988). HRV is also an important indicator of psychological resiliency and behavioral flexibility as well as the ability to effectively adapt to changing social or environmental demands (Beauchaine 2001). In addition, resting levels of HRV are associated with individual differences in cognitive performance on tasks requiring utilization of executive functions (Thayer *et al* 2009).

Heart rhythm coherence is reflected in the HRV power spectrum as a large increase in power in the low frequency (LF) band (typically around 0.1 Hz) and a decrease in power in the very low frequency (VLF) and high frequency (HF) bands (McCraty *et al* 1995; McCraty 2009). A coherent heart rhythm can therefore be defined as a relatively harmonic (sine-wave-like) signal with a very narrow, high-amplitude peak in the LF region of the HRV power spectrum with no major peaks in the VLF or HF regions. Coherence thus approximates the LF/(VLF + HF) ratio (see ***Fig. 1***) (Tiller *et al* 1996). More specifically, coherence is assessed by identifying the maximum peak in the 0.04–0.26 Hz range of the HRV power spectrum, calculating the integral in a window 0.030 Hz wide centered on the highest peak in that region, then calculating the total power of the entire spectrum. The Coherence ratio is formulated as: (Peak Power / (Total Power – Peak Power))

Heart coherence is a highly efficient functional mode that is associated with efficient utilization of energy resources and numerous health related benefits. These include: (1) resetting of baroreceptor sensitivity, which is related to short-term blood pressure control and increased respiratory efficiency (Lehrer *et al* 2006); (2) increased vagal afferent traffic, which is involved in the inhibition of pain signals and sympathetic outflow (Foreman 1997); (3) increased cardiac output in conjunction with increased efficiency in fluid exchange, filtration, and absorption between the capillaries and tissues (Siegel *et al* 1984); (4) increased ability of the cardiovascular system to adapt to circulatory requirements; (5) increased temporal synchronization of cells throughout the body (Langhorst *et al* 1984); and (6)

increased synchronization in the reciprocal activity of the branches of the ANS (McCraty 2009). Thus, coherence results in increased system-wide energy efficiency and metabolic energy savings (Langhorst *et al* 1984; Lehrer *et al* 2003; Siegel *et al* 1984)

Another aspect of the coherence mode is the phenomenon of resonance. Resonance occurs in an oscillatory system when there is a large sudden increase in amplitude at a specific frequency. The frequency at which this large increase in amplitude occurs is defined as the resonance frequency of the system. Most mathematical models show that the resonance frequency of the human cardiovascular system is determined by the feedback loops between the heart and brain (Baselli *et al* 1994), (deBoer *et al* 1987). In humans and in many animals, the resonance frequency of the system is approximately 0.1 Hz. It is reasonable to conclude that coherence and resonance are characteristic of the natural physiological state associated with heart-felt positive emotions.

The Central Role of the Heart

There is substantial evidence that the heart plays a unique role in synchronizing the activity across multiple systems and levels of organization (Langhorst *et al* 1984; McCraty 2009; Siegel *et al* 1984). As the most powerful and consistent generator of rhythmic information patterns in the body, the heart is in continuous communication with the brain and body through multiple pathways: *neurologically*, (through the ANS) *biochemically* (through hormones), *biophysically* (through pressure and sound waves), and *energetically* (through electromagnetic field interactions). The heart is uniquely well positioned to act as the "global coordinator" in the body's symphony of functions to bind and synchronize the system as a whole. Because of the extensiveness of the heart's influence on physiological, cognitive, and emotional systems, the heart provides a central point of reference from which the dynamics of such processes can be regulated.

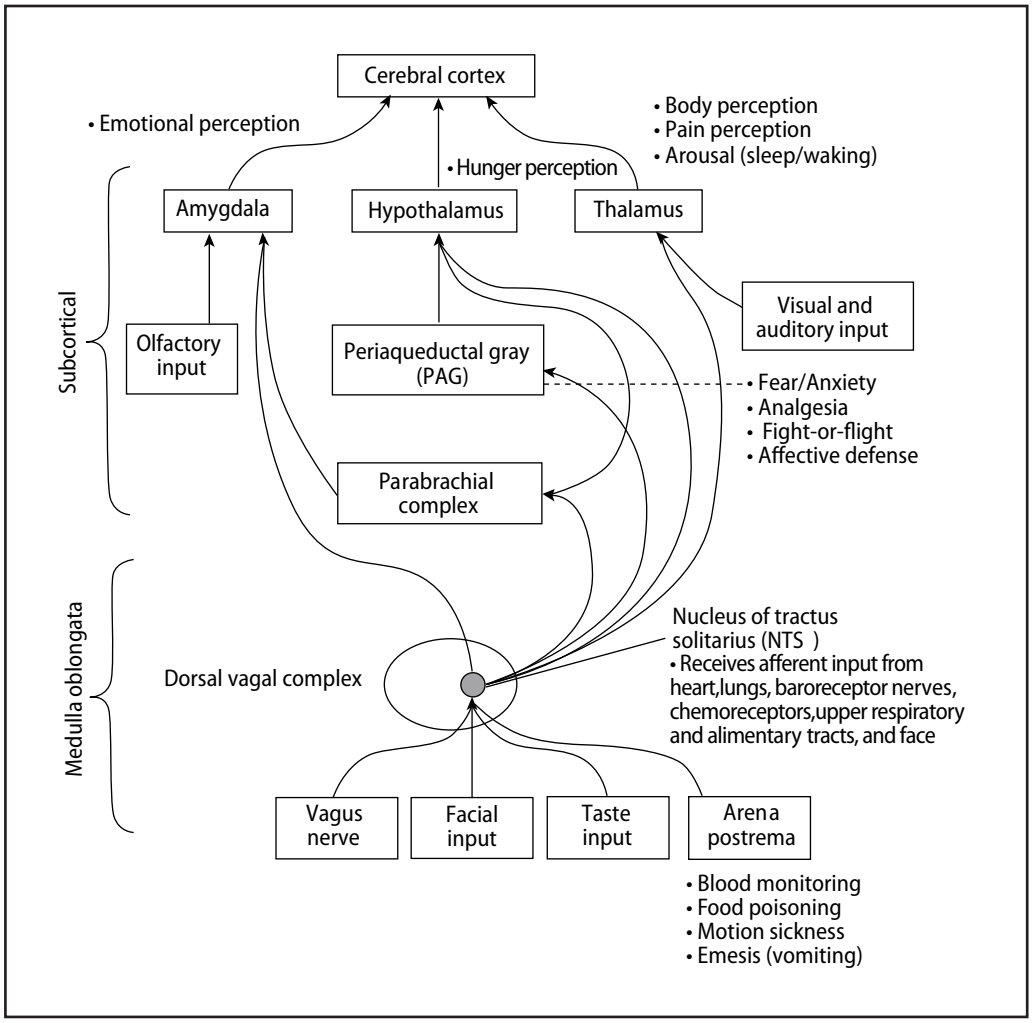

Fig. 4. Diagram of the currently known afferent pathways by which information from the heart and cardiovascular system modulates brain activity. Note the direct connections from the NTS to the amygdala, hypothalamus, and thalamus. Although not shown, there is also evidence emerging of a pathway from the dorsal vagal complex that travels directly to the frontal cortex

Although most discussions of the ANS focus on the efferent (descending) pathways, the afferent (ascending) nerves play a critical role in creating the heart rhythm and thus the coherent state. Although not well known, 85% to 90% of the nerves in the vagus nerve are afferents and the cardiovascular afferents send signals to the brain to a much greater extent than other major organs (Cameron 2002). While it is generally known that these afferent signals have a regulatory influence on many aspects of the efferent signals that flow to the heart, blood vessels, and other glands and organs, it is less commonly appreciated that they also have profound affects on the higher brain centers. Cardiovascular afferents have numerous connections to such brain centers as the thalamus, hypothalamus, and amygdala, and they play an important role in determining emotional experience (***Fig. 4***) (McCraty *et al* 2006; Cameron 2002; Foreman 1997; Frysinger & Harper 1990; Oppenheimer & Hopkins 1994; Zhang *et al* 1986).

The heart is particularly sensitive and responsive to changes in a number of other psychophysiological systems, especially changes in the activity of either branch of the ANS. The heart's intrinsic network of sensory neurons enables it to detect and respond to variations in hormonal levels in the blood flow and efferent ANS signals (Armour 1994). In addition to functioning as a sophisticated information processing and encoding center, (Armour & Kember 2004) the heart is also an endocrine gland that produces and secretes hormones and neurotransmitters (Cantin & Genest 1985, 1986; Gutkowska *et al* 2000; Huang *et al* 1996; Mukoyama *et al* 1991). Andrew Armour, a leading neurocardiologist, has suggested that the heart's extensive intrinsic nervous system is sufficiently sophisticated to qualify as a "heart brain" in its own right (Armour 1991). Its complex circuitry enables it to sense, remember, self-regulate, and make decisions about cardiac control independent of the central nervous system (Armour & Kember 2004; Armour 2003). The heart's sensory neurons translate hormonal and mechanical information into neurological impulses which are processed in the intrinsic nervous system and then sent to the brain via afferent pathways in the vagus nerve and spinal column.

The Intuitive Heart

Given the central role of the heart in creating coherence and positive emotions, it is not surprising that one of the strongest common threads uniting the views of diverse cultures, religious and spiritual traditions throughout human history, has been the universal regard for the human heart as the source of love, wisdom, intuition and positive emotions. Everyone is familiar with such expressions as "put your heart into it", "learn it by heart", "speak from your heart" and "sing with all your heart" – all of which suggests that the heart is more than just a physical pump that sustains life. What such expressions reflect is something that might be called the "intuitive heart" or "spiritual heart." The intuitive heart is what people have associated with their "inner voice" throughout history. Each passing year, more and more people are including the practice of "listening" to their heart for inner guidance or to what some refer to as their "higher power" – or source of wisdom and intelligence. In research conducted in our laboratory we found that coherence is of prime importance in connecting us with our intuitive inner guidance (McCraty *et al* 2004a, b).

There is compelling evidence to suggest that the heart's energy field (energetic heart) is coupled to a field of information that is not bound by the classical limits of time and space. This evidence comes from a rigorous experimental study conducted to investigate the proposition that the body receives and processes information about a future event before the event actually happens (McCraty *et al* 2004a, b). The study's results provide surprising data showing that both the heart and brain receive and respond to pre-stimulus information about a future event. Even more tantalizing are indications that the heart receives intuitive information *before* the brain, and that the heart sends a different pattern of afferent signals to the brain which modulates the frontal cortex. In addition, when study participants were in a positive emotion-driven coherent state prior to the experimental protocols, they were significantly more attuned to the information from the heart (McCraty *et al* 2004b). This suggests that the heart is directly coupled to a subtle energetic field of information that is entangled and interacts with the multiplicity of energetic fields in which the body is embedded – including that of the quantum vacuum.

What is meant by terms such as the "intuitive heart" or "heart intelligence" is that the energetic heart is coupled to a deeper part of oneself. Many call this their "higher power" or their "higher capacities" and is what physicist David Bohm calls our implicate order and undivided wholeness (Bohm & Hiley 1993). When we are heart-centered and coherent, we have a tighter coupling and closer alignment with our deeper source of intuitive intelligence (McCraty *et al* 2004b). There is an increased flow of intuitive information which is communicated via the emotional energetic system to the mind and brain systems resulting in a stronger connection with our "inner voice." From this perspective, the practice of heart coherence offers increased ratios of access to the largely untapped potential for bringing our mental and emotional faculties into greater balance and self-directed control. Practicing shifting to a more coherent state increases intuitive awareness and leads to shifts in perception and world views from which better informed and more intelligent decisions can be made. This, in turn, has profound health and wellness benefits but can also help people more successfully make business decisions. In a study of repeat entrepreneurs, using electrophysiological measures of intuitive perception, shifts in autonomic system (HRV) activity which

were predictive of the future outcome occurred 6 to 7 seconds before the actual outcome of the investment choice was known (Bradley *et al* 2010).

Establishing a New Baseline

Shifting a system into a more coherent mode requires effort and energy, especially when first becoming familiar with the state and overcoming the inertia of our well established baseline modes. However, there is evidence that the on-going practice of coherence-building techniques facilitates a *repatterning process* in the neural architecture where coherence becomes established as a new, stable baseline reference or norm. Self-regulation of emotions and stress responses then becomes increasingly familiar and, eventually, automatic (McCraty *et al* 2003b; 2006; McCraty & Childre 2004). This makes it easier for individuals to maintain their "center" which increases their mental and emotional flexibility and capacity to remain in charge of themselves, which is the essence of resiliency. Such flexibility and resiliency can dramatically reduce stress-related energy drains during day-to-day activities and interactions, even in the midst of more stressful or challenging situations. The occurrence of such a repatterning process is supported by electrophysiological evidence demonstrating a greater frequency of spontaneous (without conscious practice) periods of heart rhythm coherence in individuals who have practiced coherence-building techniques (Bradley 2011). In the HeartMath (HM) certification program for health-care professionals, one of the primary goals is helping patients establish a new physiological and psychological baseline of self-regulation and coherence. Without this baseline shift, it is extremely difficult, if not impossible, to achieve sustained behavioral change, or reductions in blood pressure in patients with hypertension.

Increasing Coherence

Within each individual, the level of stress and degree of global and heart coherence fluctuate from day to day, as does the quality or our thoughts and emotions (Tiller *et al* 1996). In varied ways we all strive to increase ease and flow in our lives and decrease the chaos within and around us. Many are intuitively aware of the interconnections between our thoughts, emotions and physical processes and make conscious efforts to increase personal, social and global balance and coherence through such activities as prayer, meditation, and focused intentions. However, a good portion of people's meditation or prayer time is often spent trying to calm down, get focused and quiet the mind, leaving little time and energy for reflective insight.

The accelerating pace of change, stress and social incoherence in much of the world makes it difficult for many to maintain personal health, stay focused and carry out their positive intentions. Effectively dealing with stress and establishing a new baseline involves learning to recognize and consciously shift the ongoing emotional undercurrents (judgment, negative projection, insecurity, worry) that create incoherence and waste energy and learning to increasingly replace these feelings with more positive, regenerative attitudes and perceptions. A series of tools and techniques, collectively known as the HeartMath (HM) System, were developed by Doc Childre and his associates at the Institute of HeartMath to provide a systematic process that enables people to shift into the coherent state, increase their resiliency and ability to better self-regulate stress and improve performance (Childre & Martin 1999; Childre & Rozman 2002, 2005). Many of these techniques include the intentional generation of a heart-felt positive emotional state combined with a shift in attentional focus to the area of the heart (where many people subjectively experience positive emotions). This shift in feeling allows the coherence mode to emerge naturally and helps to reinforce the inherent associations between physiological coherence and positive feelings.

We have found that self-regulation of emotional experience and increasing the ratio of positive to negative emotions to be a very effective approach to reducing stress and increasing coherence and resilience. The association between positive states and coherence was also illustrated in a study of Buddhist monks. While meditating on generating compassionate love, the monks tended to exhibit increased coherence. Another study found that more advanced Zen monks tended to have highly coherent heart rhythms in their resting state, while the novices did not (Lehrer *et al* 2003). This does not imply, however, that all meditation or relaxation approaches lead to coherence; as we and others have observed, approaches that focus attention to the mind – in general do not induce coherence, unless the state is driven by a focus on breathing at a 10-second rhythm. One study found that a coherent rhythm could be induced by rhythmically reciting rosary or bead prayers and yoga mantras, but not by random verbalization or breathing. This study also found that by passively listening to music in which the tempo of the rhythm (rather than the style) was the main determinants inducing the coherent state. The authors of the study ascribed the mechanisms of these finding to the participants changing their breathing patterns to a six cycles per minute rhythm. They concluded that the rhythm of mantras and rosary prayers were intentionally created to induce breathing patterns that induce coherent heart rhythms by people who had an intuitive understanding of the benefits of this inner rhythm (Bernardi *et al* 2005). Although respiration can clearly be used to increase coherence at the physiological level (Lehrer *et al* 2000b), given our findings that emotional shifts also lead to increased coherence independent of conscious shifts in breathing (Tiller *et al* 1996; McCraty *et al* 1995), it is also likely that prayers and mantras can induce coherence beyond that of just breathing associ-

ated with their recital. It has also been shown that tensing the large muscles in the legs in a rhythmical manner at a 10 second rhythm can induce a coherent rhythm (Lehrer *et al* 2009).

Paced breathing at a 10 second rhythm (0.1Hz) is a common approach to inducing a physiologically coherence state (Lehrer *et al* 2000b). This is because we have conscious control over our breathing rate and depth and can therefore use it to modulate the heart rhythm and induce coherence. When we use breathing to help shift into the coherent state, it changes the afferent neural patterns sent to the brain centers that regulate autonomic outflow, emotion, and cognitive processes (McCraty 2009). Thus, breathing exercises are effective primarily due to the modulation of the heart's rhythmic patterns. While rhythmic breathing methods are an effective way to induce heart rhythm coherence, cognitively-directed paced breathing is difficult for many people to maintain. Most can do so for about one minute before it becomes uncomfortable and distracting. In our laboratory at the HM research center we have found that when people are able to activate a heartfelt positive emotion rather than focusing on a specific breathing rhythm, they typically enjoy the experience more and are able to maintain coherence for extended periods. However, some individuals, especially those who are first learning the self-regulation techniques, cannot make the shift into coherence by activation of a positive emotion alone. In these instances, paced breathing is an effective way to facilitate the shift, and for this reason the HM techniques include a heart-focused breathing component combined with the activation of a positive feeling.

Heart Rate Variability Coherence Feedback

Learning self-regulation skills can be facilitated with the use of heart rhythm coherence feedback monitors. A number of HRV coherence training systems are available and have become increasingly used in many health-care, law enforcement, corporate, military and educational settings. Most of the systems use a pulse sensor as a noninvasive measurement of the beat-to-beat heart rate. Two systems – the emWave Desktop available from HeartMath and a system from Wild Divine display the heart rhythm in real time and record the level of heart rhythm coherence achieved. HeartMath also offers a portable handheld device for home and other mobile uses. HRV coherence or resonance feedback has been shown to significantly improve outcomes in a number of clinical populations with PTSD (Vanderbilt *et al* 2008; Zucker *et al* 2009), depression (Karavidas *et al* 2007; Siepmann *et al* 2008), asthma (Lehrer *et al* 2000a; Lehrer *et al* 2004a; Lehrer 2006; Lehrer *et al* 2003; Lehrer *et al* 2004b), congestive heart failure (Luskin *et al* 2002; Swanson *et al* 2009), hypertension (McCraty *et al* 2003b), anxiety, fibromyalgia (Hassett *et al* 2007), and insomnia (McLay & Spira 2009).

Coherence and Cognitive Performance: The Heart Rhythm Coherence Hypothesis

Over the years we have received numerous reports that coherence training has improved performance in a wide range of cognitive capacities, both short and long-term. These include tasks requiring eye-hand coordination, speed and accuracy, and coordination in various sports as well as cognitive tasks involving executive functions associated with the frontal cortex such as maintaining focus and concentration, problem solving, self-regulation, and abstract thinking.

Some of the most seminal work on the relationship between heart–brain interactions was conducted by John and Beatrice Lacey, who were the first to postulate a causal role of the cardiovascular system in modulating perceptual and sensory-motor performance (Lacey 1967; Lacey & Lacey 1970; 1974). They suggested that the cardiovascular system modulates cortical functions via afferent input from the baroreceptors in the heart, aortic arch, and carotid arteries (Lacey 1967; Ostir *et al* 2001). The primary focus of their research was on the activity occurring within a single cardiac cycle, and although they were able to confirm that the heart's activity modulated cognitive performance, later studies produced inconsistent results. The inconsistency was resolved by Wölk and Velden at the University of Osnabrück in Germany who showed that cognitive performance actually fluctuated across the entire cardiac cycle at a rhythm around 10 Hz. They updated the hypothesis by showing that the influence on cortical function was mediated via a synchronizing affect on the neurons in the thalamus, which in turn synchronizes global cortical activity (Lacey 1967; Lacey & Lacey 1970; 1974; Velden & Wölk 1987; Wölk & Velden 1987, 1989). They also found that it is the *pattern* and *stability* (the rhythm)of the afferent input within the cardiac cycle, rather than the number of neural bursts that are important (Armour & Kember 2004).

Further research in neurocardiology has established that the interactions between the heart and brain are much more complex than previously thought and that patterns of afferent activity occur over time scales ranging in milliseconds to minutes, and not just within a single cardiac cycle (Wölk & Velden 1987, 1989). The heart's intrinsic nervous system has both a short-term and long-term memory capacity which affects afferent rhythms related to both mechanical factors (pressure, HR, and rate of change) occurring over milliseconds (single cycle) and activity related to hormonal and mechanical factors that operate over seconds to minutes (Armour & Kember 2004; Ardell *et al* 2009; Armour 2003). This led our research team to postulate that the organization of the heart's rhythmic activity

over longer time scales could also have a direct affect on cognitive processes. We called this the *heart rhythm coherence hypothesis* (McCraty 2009). It postulates that the pattern and stability of beat-to-beat changes in heart rate encode information over macroscopic time scales which can influence cognitive performance and emotional experience. Several studies have since indicated that heart rhythm coherence is indeed associated with significant improvements in cognitive performance (Ginsberg 2010; Lloyd 2010; McCraty 2009). Significant outcomes have been observed in discrimination and reaction time experiments and more complex domains of cognitive function, including memory and academic performance (Bradley 2010; McCraty 2009). One study found that being in a state of coherence for 5 minutes prior to a discrimination task produced a *six fold* greater improvement in performance than the performance fluctuations typically observed within a single cardiac cycle. It also showed the predicted carry-over effect of being in the coherence mode on subsequent cognitive performance as well as a significant correlation between participants heart rhythm coherence and performance (McCraty 2009).

A study conducted in the United Kingdom found that regular practice of the coherence-shifting techniques to self-regulate stress enhanced a broad range of cognitive functions, including long-term memory, which also correlated with improvements in participants' coherence measures. In a study of US high school students, a significant reduction in test anxiety and higher test scores were observed in students those who had learned coherence-building techniques (Bradley 2011). In a UK study that directly assessed cognitive performance there was a wide range of significant improvements in middle school students with clinically diagnosed with attention-deficit hyperactivity disorder (Lloyd 2010). In another study conducted at the VA facility in Columbia South Carolina with soldiers who had recently returned from Iraq and were diagnosed with PTSD, a relatively short period of coherence biofeedback training resulted in significant improvements in cognitive functions, especially in the ability to self-regulate and inhibit negative responses, which again correlated with coherence measures (Ginsberg 2010). Another recent study with pilots engaging in flight simulator tasks found an association between both self-report and expert ratings on task load and task performance and heart rhythm measures (Lehrer 2010). Thus, the coherence mode promotes a calm, emotionally balanced, yet alert and responsive state that is conducive to cognitive and task performance, including problem-solving, decision-making, and activities requiring perceptual acuity, attentional focus, coordination, and discrimination.

Health and Wellness Benefits of Coherence

The use of interventions utilizing the HM self-regulation techniques and HRV coherence feedback technology to reduce stress has significantly improved key markers of health and wellness. These include: immune function,(Rein *et al* 1995; McCraty *et al* 1996). ANS function and balance, (Tiller *et al* 1996; McCraty *et al* 1995) and significant reductions in stress hormones (McCraty *et al* 1998a). A study of California correctional officers with high workplace stress found reductions in total cholesterol, glucose, and both systolic and diastolic blood pressure (BP), as well as significant reductions in overall stress, anger, fatigue and hostility with projected savings in annual heath care costs of $1179 per employee (McCraty *et al* 2009). Another work-place study of employees with a clinical diagnosis of hypertension showed significant reductions in (BP) and a wide range of stress measures (McCraty *et al* 2003b). A study conducted at Stanford University of patients with congestive heart failure showed significantly improved functional capacity and reduced depression (Luskin *et al* 2002) and a study of diabetes patients found improved overall quality of life and glycemic regulation, which correlated with use of the self-regulation techniques (McCraty *et al* 2000).

Psychophysiologist Paul Lehrer PhD has shown that HRV feedback to facilitate a state of physiological coherence (which he calls "resonance") resulted in lasting increases in baroreflex gain, independent of respiratory and cardiovascular changes (Lehrer *et al* 2003). In a large controlled study in patients with asthma, those using the HRV resonance training had improved lung function, decreased symptoms, no asthma exacerbations and they were able to reduce steroid medications (Lehrer *et al* 2004a). In other studies Lehrer demonstrated that the pulmonary function improvements occurred in both older and younger patients even though older individuals have lower HRV (Lehrer *et al* 2006) and that the improvements occur with HRV biofeedback training, but not with relaxed breathing or muscle tension relaxation (Lehrer 1997). He also published a report of 20 case studies which showed uniform improvements in pulmonary function in children with asthma (Lehrer *et al* 2000b). Lehrer also showed improvements in a controlled study of patients with multiple unexplained symptoms and depression (Karavidas 2011) and improvements in patients with fibromyalgia (Hassett *et al* 2007) and with major depression (Karavidas *et al* 2007).

A number of significant outcomes were found in two recent workplace pilot studies of utility line workers and employees of an online travel company. These studies focused on reducing stress and metabolic syndrome risk factors with the HM self-regulation techniques combined with HRV coherence feedback. In both studies there were significant reductions in Organiza-

tional Stress (life pressures, relational tensions work related stress), Emotional Stress (anxiety, depression, anger), and Stress Symptoms (fatigue, sleep headaches, etc), and significant increases in Emotional Vitality (emotional vitality, contentment, etc). Both studies also showed reductions in the number of participants who were classified as having metabolic syndrome. In the utility company cohort total cholesterol and LDL cholesterol were significantly reduced, and the travel company cohort had significant reductions in both systolic and diastolic BP and triglycerides (manuscript in preparation). In a study undertaken with pastors from the Reformed Church of America, who were spread across the U.S., the HM techniques were taught by a certified health coach in six phone sessions. Participants also used a handheld coherence feedback device (emWave Personal Stress Reliever) to support learning stress self-regulation tools. In addition to a number of significant improvements in stress and well-being measures, an independent analysis of data revealed that the HeartMath group showed an overall decrease in health care costs of 3.8% (resulting in an annual cost savings of $585 per participant), while the control group had a 9% increase in health care costs. The largest reduction in costs was related to improvements in hypertension (Bedell & Kaszkin-Bettag 2010).

In terms of healthier psychological and emotional functioning, significant reductions in stress, depression, anxiety, anger, hostility, burnout, and fatigue and increases in caring, contentment, gratitude, peacefulness, resilience and vitality have been measured across diverse populations. (Luskin *et al* 2002; Arguelles *et al* 2003; Barrios-Choplin *et al* 1997; McCraty 2003; McCraty & Atkinson 1998; McCraty *et al* 2003a). Most people report that when they are in the coherent state, they experience a sense of connectedness with their heart intuition, greater clarity on troublesome issues, a reduction in inner "mental noise" associated with stress, and a deeper sense of well-being.

Coherence at the Social and Global Levels

Social coherence relates to pairs, family units, groups or larger organizations in which a network of relationships exists among individuals who share common interests and objectives. Social coherence is reflected as a stable, harmonious alignment of relationships which allows for the efficient flow and utilization of energy and communication required for optimal collective cohesion and action (Bradley 1987). There are of course cycles and variations in the quality of family, team or group coherence, similar to variations in an individual's coherence level. Coherence requires that group members are attuned and emotionally aligned, and that the group's energy is globally organized and regulated, by the group as a whole (Bradley 1987). Group coherence involves the same principles of global coherence described in the introduction to this paper, but in this context it refers to the synchronized and harmonious order in the relationships between and among the individuals, rather than the systems within the body. The principles, however, remain the same; in a coherent team there is freedom for the individual members to do their part and thrive while maintaining cohesion and resonance within the group's intent and goals. Conversely, when relations are discordant and social organization is incoherent, not only is optimal action not possible but psychosocial dysfunction and instability are likely consequences (Pribram & Bradley 1998). Just as individual incoherence leads to pathologies within the individual, group incoherence leads to social pathologies – violence, abuse, terrorism, etc. There is a feedback loop between the individuals in any group and the group's level of coherence. When individuals are not well self-regulated or are acting in only their own best interests without regard to others, it generates social incoherence. Stressful or discordant conditions in a given group act to increase emotional stress among its members. Unfortunately, social incoherence is characterized by a lack of unity, common purpose, peace and harmony, in or among families, neighbors or employees in workplace environments (deBoer *et al* 1987). Consequently, the need for mental and emotional self-management and high quality social coherence is greater now than ever.

Basic Social Coherence

There are obvious benefits to interacting and working with individuals who have a high level of personal coherence. When members of any work group, sports team, family or social organization get along well there is a natural tendency towards good communication, cooperation and efficiency. One of the main sources of stress and incoherence stems from communication problems with co-workers, family members or teammates. When individuals maintain relationships over extended periods, a "surface level" of cooperation and harmony usually develops wherein people are basically civil and cooperative. This can be considered the basic functional level of coherence necessary for a group to endure and accomplish goals. However, in most groups, many of the individuals have anxieties, judgments, frustrations, and preconceptions of each other or other teams that remain unspoken and beneath the surface. As we will see below, these unsaid feelings are unconsciously communicated and create energetic separations or "closed hearts" resulting in miscommunication and other relational problems. It has also become apparent that social incoherence not only influences the way we feel, relate, and communicate with one another, they also impact physiological processes that directly affect health. Numerous studies have found that people undergoing social and cultural changes, or living in situations characterized by social disorganization, insta-

bility, isolation or disconnectedness are at increased risk for acquiring many types of disease (Berkman & Syme 1979; Hermes *et al* 2009; Marmot & Syme 1976; Neser *et al* 1971; Ornstein & Sobel 1987). James Lynch provides a sobering statistic on the impact of social isolation on individuals. His research in social isolation shows that loneliness produces a greater risk for heart disease than smoking, obesity, lack of exercise, and excessive alcohol consumption *combined* (Lynch 2000). Unfortunately, in today's modern world many people are far more socially isolated than in the past. On the other hand, there is an abundance of literature showing that close relationships and social networks are highly protective. Numerous studies of diverse populations, cultures, age groups and social strata have shown that individuals who are involved in close and meaningful relationships have significantly reduced mortality, reduced susceptibility to infectious and chronic disease, increased mortality, improved recovery from post-myocardial infarction, as well as improved outcomes in pregnancy and childbirth (Cohen & Syme 1985; Ornish 1998; Uchino *et al* 1996).

There are times when an external event such as a natural disaster brings groups, neighborhoods and communities to an increased level of cooperation, where the usual separations and self-centered behaviors give way to more care and compassion. Events such as these tend to open people's hearts, bring people together, and lead them to give to and sacrifice for others so as to benefit the community. After experiencing such an event, people are often amazed at what they were able to accomplish and the lasting friendships and bonds that they forged. However, as time passes and normalcy returns, the community spirit that was ignited by a dramatic event fades as people revert to their familiar, comfortable operational baselines. Fortunately, organizations, teams and communities hoping to increase cooperation and harmony do not to have to wait for a disaster to strike. There are practical steps and practices that can be taken to build and stabilize group coherence and resilience. There are increasing numbers of hospitals, corporations, military units, schools and athletic teams, which are actively working towards increasing their team, group or organizational coherence. Such collective coherence is built by working first at the individual level. As individuals become more capable of self-management and establishing heart-coherence, the group increases its collective coherence and can achieve its objectives more effectively.

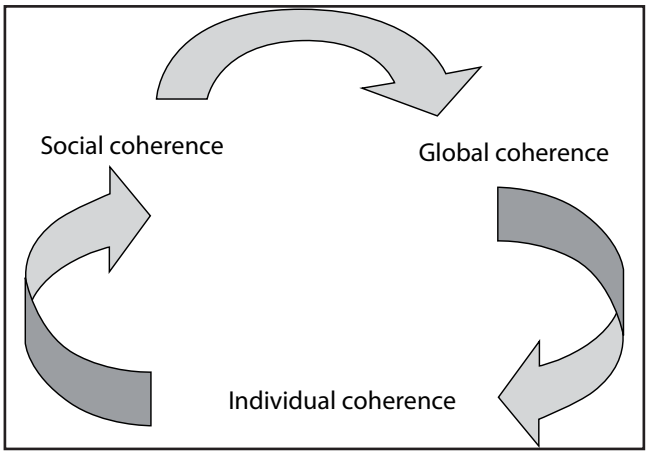

Fig. 5. Increasing individual coherence leads to increasing social coherence which in turn leads to increased Global Coherence in an iterative process. As individual and social coherence increase, there are numerous personal benefits in terms of improved health, well-being and a broadened field of perception, numerous social benefits including improved communication and relationships, and there are social coherence benefits to organizations hoping to improve actualization of their mission and impact.

Various organizations have found that interventions providing stress and emotional self-regulation skills combined with heart rhythm coherence training, result in improved workplace communication, satisfaction, productivity, innovative problem solving and reduced employee turnover which can translate into a significant return on investment, not only financially, but socially (Barrios-Choplin *et al* 1999). For example hospitals implementing HM programs implementing have seen increased personal, team and organizational coherence. The measures most often assessed are staff retention and employee satisfaction. Cape Fear Valley hospital system in Cape Fear, North Carolina, reduced nurse turn over from 24% to 13%, and Delnor Community Hospital in Chicago saw a similar reduction from 27% to 14% – as well as a dramatic improvement in employee satisfaction, results that have been sustained over an eight year period. Similarly, Duke University's Health System reduced turnover from 38% to 5% in its emergency services division. An analysis of the combined psychometric data from 3,129 matched pre-post HM coherence trainings found that fatigue, anxiety, depression and anger were reduced by almost half. Another workplace study conducted in large chain of retail stores with in-store pharmacies that employed 220 pharmacists across multiple locations found a reduction is medical errors ranging from 40 to 71%, depending on the store location (HeartMath 2009).

The benefits of increasing coherence in education are evident from several studies. For example, a large multi-methods study involving 10th grade students in two large California high schools found that a self-regulation skills and coherence training curriculum, taught by teachers significantly reduced test anxiety and negative affect, emotional discord and interactional difficulty, while also significantly increasing positive class experience and elevating English and math test scores (Bradley *et al* 2007). Students in this study were more aware of others' feelings and better able to avoid arguments and fights. The study also included a sub-sample of 140 students who were part of an electrophysiology study where their HRV was assessed. The results showed improvements across all HRV measures, indicating that the intervention group had learned how to

better manage their emotions and to self-activate the coherence state under stressful conditions; in addition, these students had shifted their baseline, increasing HRV and HRV coherence even *without* conscious use of the self-regulation tools (Bradley 2011)

High Group Coherence: Energetic Interactions

Anyone who has watched a championship sports team or experienced an exceptional concert knows that something special can happen in groups that transcends their normal performance. It seems as though the players are in sync and communicating on an unseen energetic level. Many teams, including Olympic and professional sports teams, and Special Forces military units, understand the importance of team coherence. While they may refer to coherence as, "team spirit" or "bonding", they instinctively know there is a palpable "team energy" that effects a team's performance. Such elite teams pay close attention to the group's cohesion and team leaders actively take steps to resolve any interpersonal conflicts or distortions that may hinder or erode it. They know that internal group discord or conflict have a negative impact on the team.

A growing body of evidence suggests that an energetic field is formed between individuals in groups through which communication among all the group members occurs simultaneously. In other words, there is a literal group "field" that connects all the members. Sociologist Raymond Bradley in collaboration with neuroscientist Karl Pribram developed a general theory of social communication to explain the patterns of social organization common to most groups, independent of size, culture, degree of formal organization, length of existence or member characteristics (Bradley 1987). They found that most groups have a global organization and a coherent network of emotional energetic relations interconnecting virtually all members into a single multi-level hierarchy. By mapping all possible relationships between each pair of members in a group they found a direct relationship between the number and structure of reciprocated positive emotional bonds and control or power relations among the members that predicted group stability and performance two years later (Bradley & Pribram 1998). The model that best fits the data was one based on a field concept where information about the group as a whole was distributed to all members is such a way that information about the group's global organization could be obtained from any member within the field – a collective consciousness, as it were a "social hologram" (Bradley 1987). It requires energy to shift a system into a more coherent mode, and the key to creating stable, coherent groups is related to establishing positive emotions, and dissipating negative emotional tensions, interpersonal conflicts and other stressors within the individuals in that group.

Research conducted in our laboratory has confirmed the hypothesis that when an individual is in heart coherence, the heart radiates a more coherent electromagnetic signal into the environment, which can be detected by nearby animals or the nervous systems of other people (McCraty 2004). Of all the organs, the heart generates the largest rhythmic electromagnetic field, one that is approximately 5,000 times stronger than that produced by the brain (Russek & Schwartz 1996). This field can be detected several feet from the body with sensitive magnetometers (McCraty *et al* 1998a). This magnetic field provides a plausible mechanism for how we can "feel" or sense another person's presence and emotional state, independent of body language, or other factors (McCraty *et al* 2004c).

We have found that there is a direct relationship between the heart rhythm patterns and the spectral information encoded in the frequency spectra of the magnetic field radiated by the heart. Thus, information about a person's emotional state is encoded in the heart's magnetic field which is communicated throughout the body and into the external environment (McCraty *et al* 1998a). In essence, it appears that a bio-energetic communication system may indeed exist which serves to *in-form* function and behavior in highly coherent groups. Further support for this hypothesis is provided in a study examining the possibility that people trained in achieving high states of heart coherence could facilitate coherence in other people in close proximity. The results showed that the coherence of untrained participants was indeed facilitated by others who were in a coherent state. In addition, evidence of heart rhythm synchronization between group participants was revealed through several evaluation methods and higher levels of coherence correlated to higher levels of synchronization between participants (Morris 2010). In addition, there was a statistical relationship between this synchronization and relational measures (bonding) among the participants. The authors concluded that "evidence of heart-to-heart synchronization across subjects was found which lends credence to the possibility of heart-to-heart bio-communications."

Global Coherence

This article began with the statement that the universe is enduringly coherent and interconnected and that every "whole" is a part of a greater whole. We discussed the critical importance of coherent communication and order across levels of scale and time for healthy function – in fact, for the preconditions of life itself. Humans are embedded within social networks which exist on the earth, which is part of the solar system. Therefore, it should not be surprising that human physiological rhythms and global behaviors are synchronized with solar and geomagnetic activity (Halberg *et al* 2000; Halberg *et al* 2008). Historically, cultures such as the Egyptian, Hopi, Ancient Indian, and ancient

Chinese believed that their collective behavior could be influenced by the sun. The first scientific evidence of this belief was provided by Alexander Tchijevsky, a Russian scientist who noticed that more severe battles during WWI occurred during peak sunspot periods. He conducted a thorough study of global human history and constructed an index of Mass Human Excitability dating back to 1749 which he then compared to the solar cycles over this time period (Tchijevsky 1971) (***Fig. 6***). Since his pioneering work, energetic influxes from solar and geomagnetic fields have been associated with numerous aspects of human health and wellness, both positive and negative (Cornelissen *et al* 1999; Halberg *et al* 2008; Otsuka *et al* 2008). The scientific community and the media tend to focus on such negative correlations, such as societal conflicts, crime, terrorism, traffic accidents, mortality from heart attacks and strokes etc. However, the greatest levels of human flourishing also occur during these cycles (Ertel 1998).

The Global Coherence Initiative (GCI) is a science-based organization focused on examining the interactions between humans and the earth's energetic fields (www.glcoherence.org). One of the projects hypotheses is that the earth's magnetic and geomagnetic fields created in the ionosphere in turn create a bidirectional feed-forward and feedback loops with the collective emotional energy of humanity. More and more people are realizing that solar and universal energetic influxes are part of a natural cycle with potential benefits to humanity. Yet people have a responsibility for their own energy and how it can be used to create deeper connections and more caring interactions with others and with the earth itself, including all living entities.

There is substantial evidence of a global field effect when large numbers of people have similar emotional responses to events or organized global peace meditations. Research conducted by the Global Consciousness Project which maintains a worldwide network of random number generators has found that human emotionality affects the randomness of these electronic devices in globally correlated manner (Bancel 2008). One of the goals of GCI is to test the hypothesis that large numbers of people intentionally generating positive emotions from a heart-coherent state can modulate the earth's energetic and geomagnetic fields (Deyhle 2010). If, as some contend, all living systems are indeed

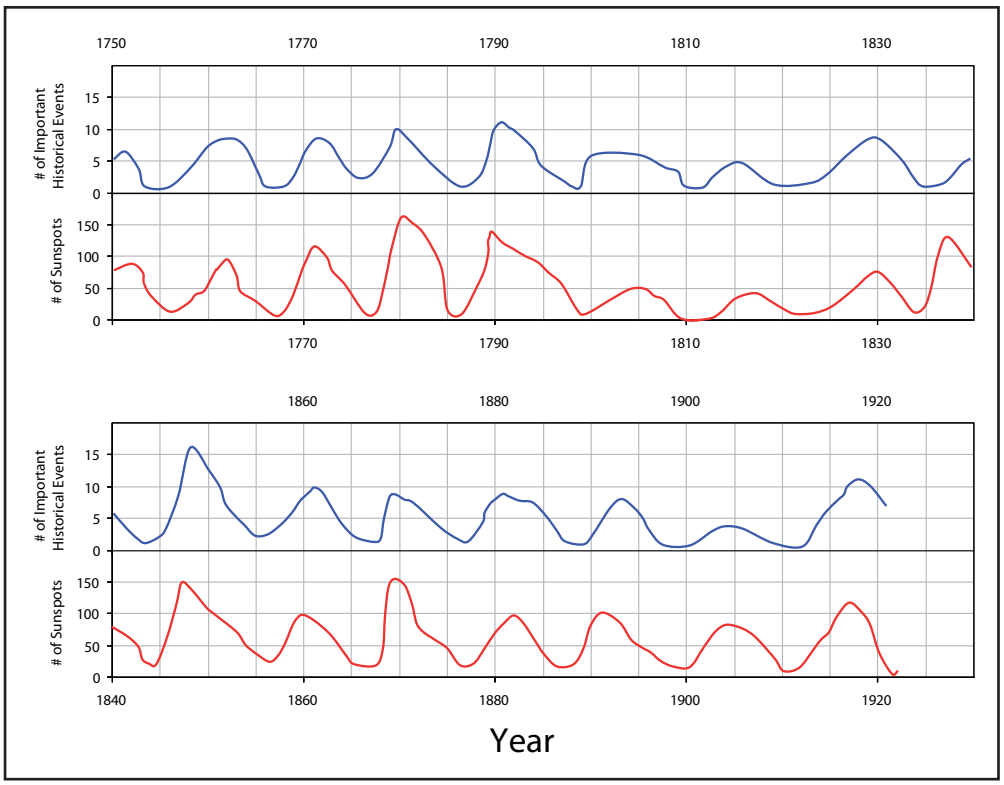

Fig. 6. Solar activity ad human activity levels. Created from data provided in the translation of Tchijevsky's paper *Physical Factors of the Historical Process* (Tchijevsky 1971). In the graph, the number of important historical events is plotted in blue on top, the number of sunspots below in red. Alexander Tchijevsky constructed an "Index of Mass Human Excitability" (published in Russian 1926). The histories of 72 countries were compiled and plotted against the sunspot activity from 1750 to 1922. Tchijevsky found that 80% of the most significant human events occurred during the ca. 5 years of maximum solar activity. He also found that 80% of the most significant human events occurred during the 5 years or so of maximum sunspot activity. A solar maximum can increase human warfare activity, as well as human creativity.

interconnected and communicate with each other via biological and electromagnetic fields, it stands to reason that humans can work together in a co-creative relationship to consciously increase global coherence. This can only emerge as enough individuals and social groups increase their coherence baseline and utilize that increased coherence in innovative problem solving and intuitive discernment for addressing social, environmental and economic problems. In time, global coherence will be indicated by countries adopting a more coherent planetary view. At this level of scale, social and economic oppression, warfare, cultural intolerance, crime, and disregard for the environment can then be addressed meaningfully and successfully.

Conclusion

Everyone knows what it feels like to be in harmonious state, the place where our hearts, minds and bodies are united in a feeling of wholeness. We speak of this variously as "the zone," "flow," "oneness," etc. When we are in this state we feel connected not only to our deepest selves but to others – past, present and future – to all living plants and creatures and even to the cosmos itself. We call this state of internal and external connectedness "coherence." Increased personal coherence can be achieved as people learn to more consistently self-regulate their emotions from a more intuitive, intelligent and balanced inner reference. When more individuals in families, workplaces, and communities increase and stabilize their coherence baselines, it can lead to increased social and global coherence which is further stabilized through self-reinforcing feedback loops. Being responsible for and increasing our coherence baseline, is not only reflected in our personal health and happiness, it is also reflected in the global field environment which helps strengthen a mutually beneficial feedback loop between human beings and the earth itself.

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