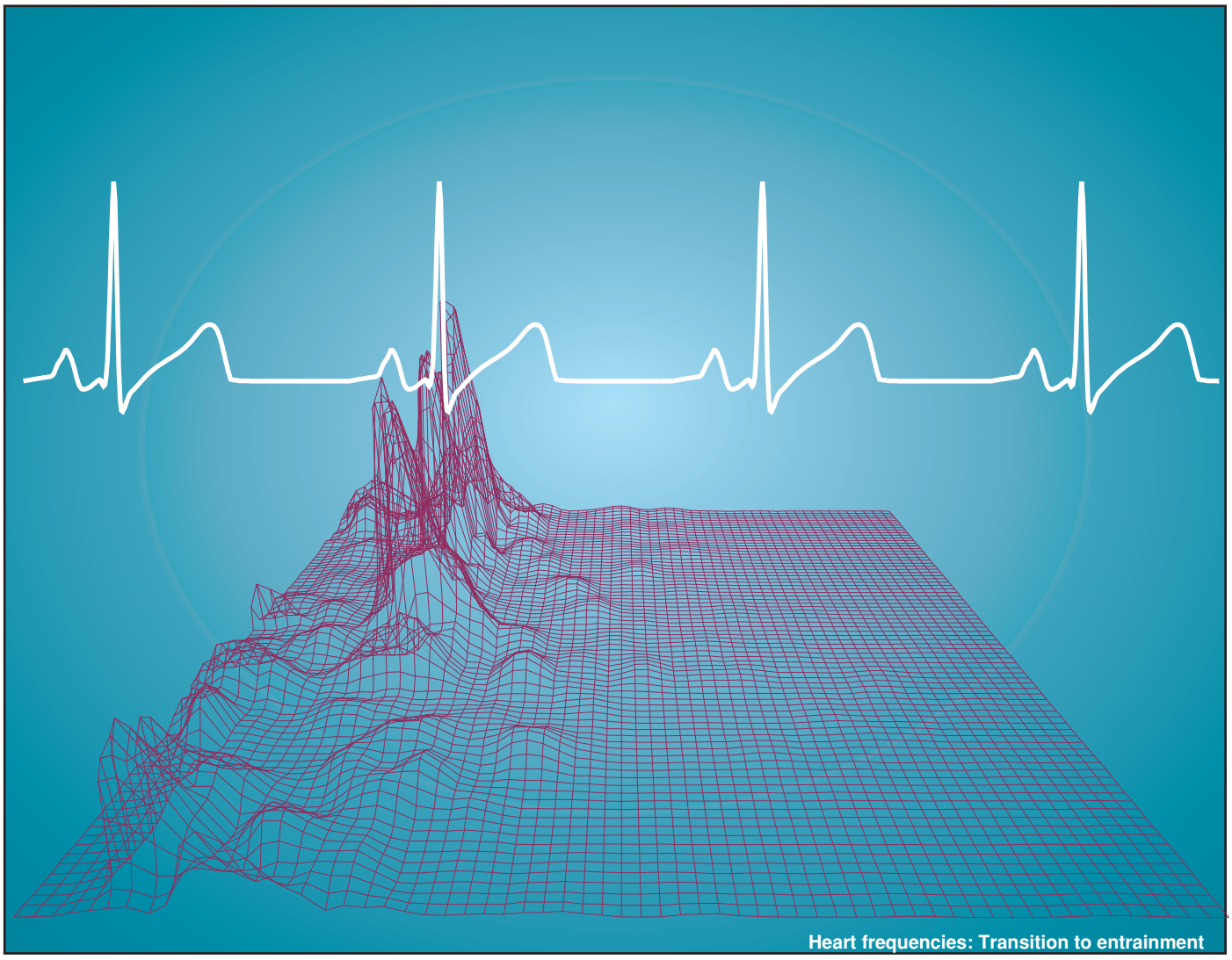
SCIENCE OF THE HEART

Exploring the Role of the Heart in Human Performance



Heart frequencies: Transition to entrainment

An overview of research conducted by the Institute of HeartMath®

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About the cover: The waterfall plot on the cover is a spectrum analysis of 20 minutes of heart rate variability data during which this individual shifted into the "entrained state" by using the Cut-Thru technique (HRV tachogram shown in Figure 23 on page 29). The classic signature of entrainment is the appearance of large peaks at a frequency near 0.1 Hertz. Entrainment occurs when different physiological systems synchronize.

HeartMath Research Center

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About the Institute of HeartMath

Incorporated in 1991 in Boulder Creek, California by Doc Childre, the Institute of HeartMath (IHM) is an innovative nonprofit 501 (c) (3) research and education organization which has developed simple, user-friendly tools people can use in the moment to relieve stress and break through into greater levels of personal balance, creativity, intuitive insight and fulfillment. This technology has formed the foundation of training programs conducted across the United States, Canada, Europe and Asia. These have included programs for major corporations, government and the armed forces; innovative learning enhancement programs for school children; specialized seminars for educators, health and human service professionals; programs for individuals with health challenges; gang risk intervention projects; and family retreats. The tools and technologies developed at IHM offer hope for new, effective solutions to the many daunting problems that currently face our society, beginning by restoring balance and maximizing the potential within the individual.

IHM's Mission

Through innovative research and public education, we aim to facilitate more balance and health in people's lives by:

- Researching the effects of positive emotions on physiology, quality of life, and performance.
- Helping individuals engage their hearts to transform stress and rejuvenate their health.
- Providing prevention and intervention strategies for improved emotional health, decision-making, learning skills, and violence reduction in communities, families, and schools.

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Introduction

For centuries, the heart has been considered the source of emotion, courage and wisdom. At the Institute of HeartMath (IHM) Research Center, we are exploring the physiological mechanisms by which the heart communicates with the brain, thereby influencing information processing, perceptions, emotions and health. We are asking questions such as: Why do people experience the feeling or sensation of love and other positive emotional states in the area of the heart and what are the physiological ramifications of these emotions? How do stress and different emotional states affect the autonomic nervous system, the hormonal and immune systems, the heart and brain? Over the years we have experimented with different psychological and physiological measures, but it was consistently heart rate variability, or heart rhythms, that stood out as the most dynamic and reflective of inner emotional states and stress. It became clear that negative emotions lead to increased disorder in the heart's rhythms and in the autonomic nervous system, thereby adversely affecting the rest of the body. In contrast, positive emotions create increased harmony and coherence in heart rhythms and improve balance in the nervous system. The health implications are easy to understand: Disharmony in the nervous system leads to inefficiency and increased stress on the heart and other organs while harmonious rhythms are more efficient and less stressful to the body's systems.

More intriguing are the dramatic positive changes that occur when techniques are applied that increase coherence in rhythmic patterns of heart rate variability. These include shifts in perception and the ability to reduce stress and deal more effectively with difficult situations. We observed that the heart was acting as though it had a mind of its own and was profoundly influencing the way we perceive and respond to the world. In essence, it appeared that the heart was affecting intelligence and awareness.

The answers to many of our original questions now provide a scientific basis to explain how and why the heart affects mental clarity, creativity, emotional balance and personal effectiveness. Our research and that of others indicate that the heart is far more than a simple pump. The heart is, in fact, a highly complex, self-organized information processing center with its own functional "brain" that communicates with and influences the cranial brain via the nervous system, hormonal system and other pathways. These influences profoundly affect brain function and most of the body's major organs, and ultimately determine the quality of life.

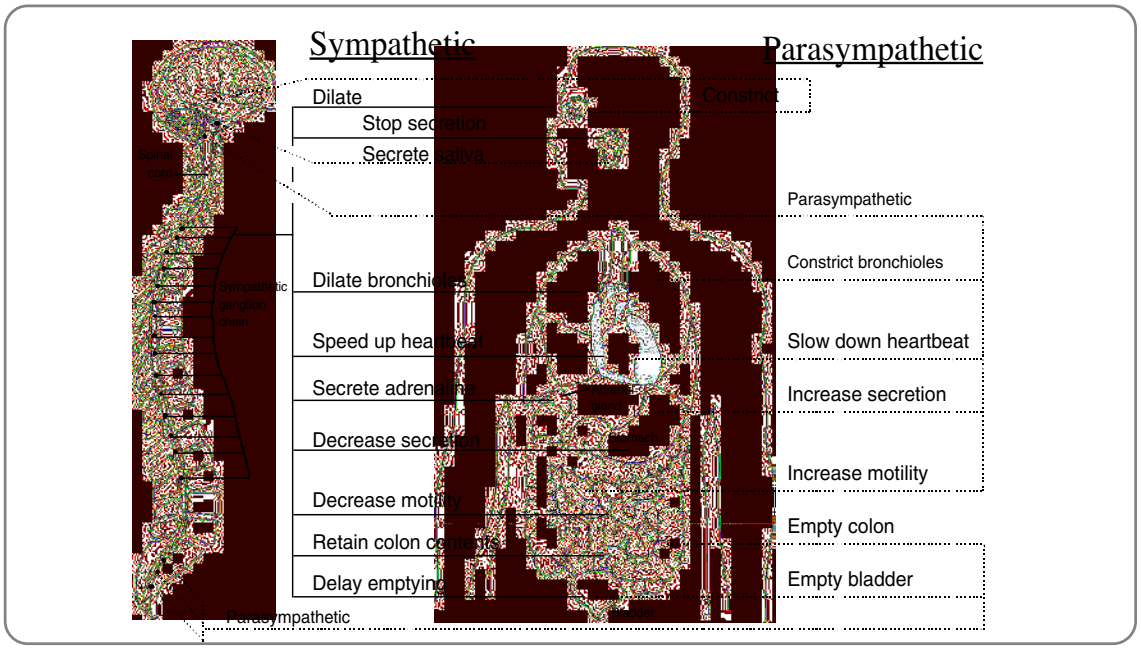

Figure 1. Innervation of the major organs by the autonomic nervous system. Sympathetic fibers pass through the cranium and sacrum; parasympathetic fibers are associated with thoracic and lumbar vertebrae. A number of health problems can arise in part due to improper function or balance in the ANS. The activity in the ANS and the balance between the two branches is greatly affected by emotions. For example, anger causes increased sympathetic activity and reduced parasympathetic. Constriction of the arteries resulting from excessive sympathetic stimulation can contribute to hypertension and heart attacks.

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The Intelligent Heart

Some of the first modern psychophysiological researchers to examine the conversations between the heart and brain were John and Beatrice Lacey. During 20 years of research throughout the 1960s and '70s, they observed that the heart communicates with the brain in ways that significantly affect how we perceive and react to the world.

A generation before the Laceys began their research, Walter Cannon had shown that changes in emotions are accompanied by predictable changes in heart rate, blood pressure, respiration and digestion. In Cannon's view, when we are "aroused," the mobilizing part of the nervous system (sympathetic) energizes us for fight or flight, and in more quiescent moments, the calming part of the nervous system (parasympathetic) cools us down. In this view, it was assumed that the autonomic nervous system and all of the physiological responses moved in concert with the brain's response to a given stimulus. Presumably, our inner systems tooled up together when we were aroused and simmered down together when we were at rest, and the brain was in control of the entire process.

The Laceys noticed that this simple model only partially matched actual physiological behavior. As their research evolved, they found that the heart seemed to have its own peculiar logic that frequently diverged from the direction of the autonomic nervous system. The heart appeared to be sending meaningful messages to the brain that it not only understood, but obeyed. Even more intriguing was that it looked as though these messages could affect a person's behavior. Shortly after this, neurophysiologists discovered a neural pathway and mechanism whereby input from the heart to the brain could "inhibit" or "facilitate" the brain's electrical activity. Then in 1974, the French researchers Gahery and Vigier, working with cats, stimulated the vagus nerve (which carries many of the signals from the heart to the brain) and found that the brain's electrical response was reduced to about half its normal rate. In summary, evidence suggested that the heart and nervous system were not simply following the brain's directions, as Cannon had thought.

Neurocardiology: The Brain in the Heart

While the Laceys were doing their research in psychophysiology, a small group of cardiovascular researchers joined with a similar group of neurophysiologists to explore areas of mutual interest. This represented the beginning of the new discipline of *neurocardiology*, which has since provided critically important insights into the nervous system within the heart and how the brain and heart communicate with each other via the nervous system.

After extensive research, one of the early pioneers in neurocardiology, Dr. J. Andrew Armour, introduced the concept of a functional "heart brain" in 1991. His work revealed that the heart has a complex intrinsic nervous system that is sufficiently sophisticated to qualify as a "little brain" in its own right. The heart's brain is an intricate network of several types of neurons, neurotransmitters, proteins and support cells like those found in the brain proper. Its elaborate circuitry enables it to act independently of the cranial brain – to learn, remember, and even feel and sense. The recent book *Neurocardiology*, edited by Dr. Armour and Dr. Jeffrey Ardell, provides a comprehensive overview of the function of the heart's intrinsic nervous system and the role of central and peripheral autonomic neurons in the regulation of cardiac function. The nervous system pathways between the heart and brain are shown in Figure 2.

The heart's nervous system contains around 40,000 neurons, called sensory neurites, which detect circulating hormones and neurochemicals and sense heart rate and pressure information. Hormonal, chemical, rate and pressure information is translated into neurological impulses by the heart's nervous system and sent from the heart to the brain through several *afferent* (flowing to the brain) pathways. It is also through these nerve pathways that pain signals and other feeling sensations are sent to the brain. These afferent nerve pathways enter the brain in an area called the medulla, located in the brain stem. The signals have a regulatory role over many of the autonomic nervous system signals that flow out of the brain to the heart, blood vessels and other glands and organs. However, they also cascade up into the higher centers of the brain, where they may influence perception, decision making and other cognitive processes.

Dr. Armour describes the brain and nervous system as a distributed parallel processing system consisting of separate but interacting groups of neuronal processing centers distributed throughout the body. The heart has its own intrinsic nervous system that operates and processes information independently of the brain or nervous system. This is what allows a heart transplant to work: Normally, the heart communicates with the brain via nerve fibers running through the vagus nerve and the spinal column. In a heart transplant, these nerve connections do not reconnect for an extended period of time, if at all; however, the

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transplanted heart is able to function in its new host through the capacity of its intact, intrinsic nervous system.

The intrinsic cardiac nervous system, or heart brain, is made up of complex ganglia, containing afferent (receiving) local circuit (interneurons) and efferent (transmitting) sympathetic and parasympathetic neurons. Multi-functional sensory neurites, which are distributed throughout the heart, are sensitive to many types of sensory input originating from within the heart itself. The intrinsic cardiac ganglia integrate messages from the brain and other processing centers throughout the body with information received from the cardiac sensory neurites. Once information has been processed by the heart's intrinsic neurons, the appropriate signals are sent to the sinoatrial and atrioventricular nodes as well as the muscles in the heart. Thus, under normal physiological conditions, the heart's intrinsic nervous system plays an important role in much of the routine control of cardiac function, independent of the central nervous system. Dr. Armour and his colleagues have shown that the heart's intrinsic nervous system is vital for the maintenance of cardiovascular stability and efficiency, and that without it, the heart cannot operate properly.

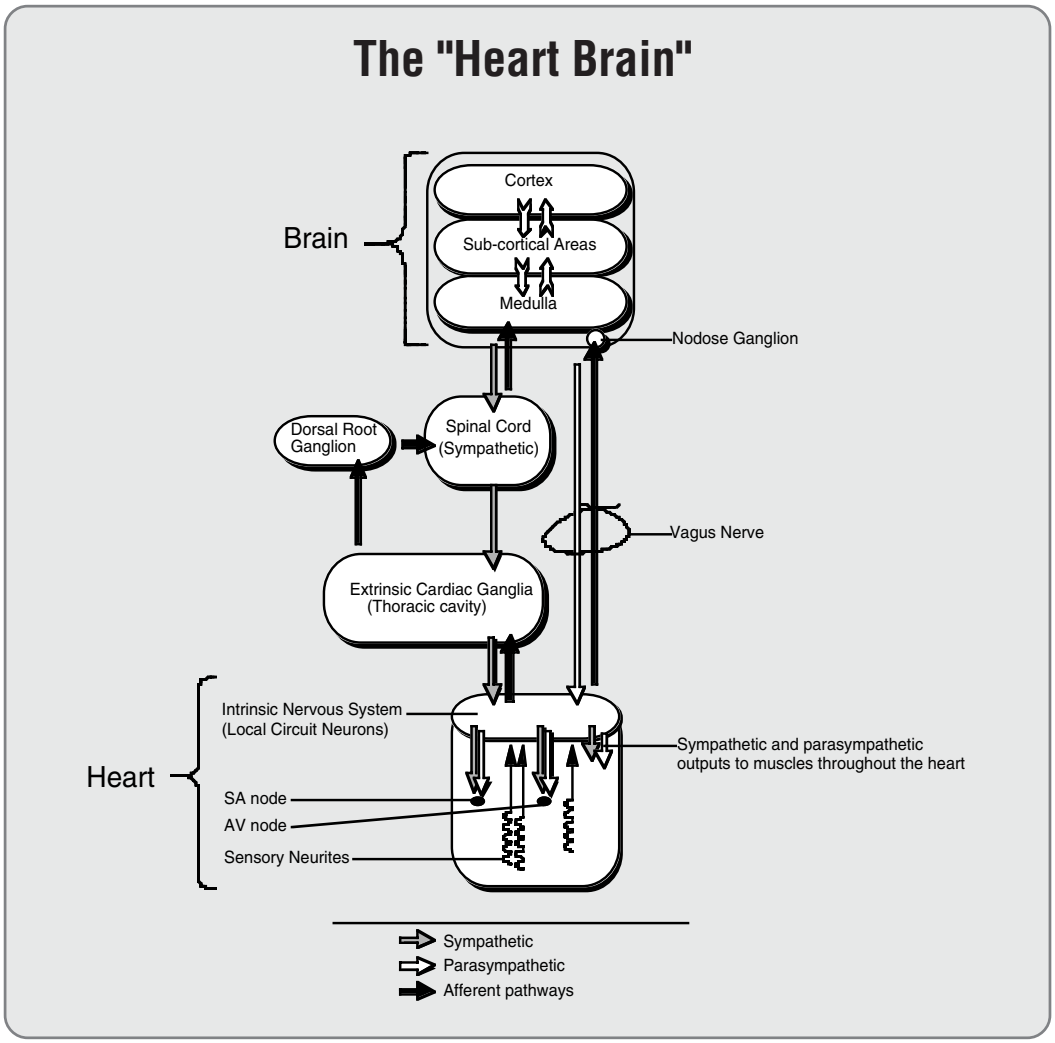

Figure 2. The neural communication pathways between the heart and the brain. The heart's intrinsic nervous system consists of ganglia, which contain local circuit neurons of several types, and sensory neurites, which are distributed throughout the heart. The intrinsic ganglia process and integrate inflowing information from the extrinsic nervous system and from the sensory neurites within the heart. The extrinsic cardiac ganglia, located in the thoracic cavity, have direct connections to organs such as the lungs and esophagus and are also indirectly connected via the spinal cord to many other organs, including the skin and arteries. The "afferent" (flowing to the brain) parasympathetic information travels from the heart to the brain through the vagus nerve to the medulla, after passing through the nodose ganglion. The sympathetic afferent nerves first connect to the extrinsic cardiac ganglia (also a processing center), then to the dorsal root ganglion and the spinal cord. Once afferent signals reach the medulla, they travel to the subcortical areas (thalamus, amygdala, etc.) and then to the cortical areas.

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The Heart as a Hormonal Gland

Another component of the heart-brain communication system was provided by researchers studying the hormonal system. The heart was reclassified as an endocrine or hormonal gland, when in 1983 a hormone produced and released by the heart called atrial natriuretic factor (ANF) was isolated. This hormone exerts its effects widely: on the blood vessels themselves, on the kidneys and the adrenal glands and on a large number of regulatory regions in the brain. Dr. Armour and his students also found that the heart contains a cell type known as "intrinsic cardiac adrenergic" (ICA) cells. These cells are classified as "adrenergic" because they synthesize and release catecholamines (norepinephrine and dopamine), neurotransmitters once thought to be produced only by neurons in the brain and ganglia outside the heart. More recently still, it was discovered that the heart also secretes oxytocin, commonly referred to as the "love" or "bonding hormone." Beyond its well-known functions in childbirth and lactation, recent evidence indicates that this hormone is also involved in cognition, tolerance, adaptation, complex sexual and maternal behaviors as well as in the learning of social cues and the establishment of enduring pair bonds. Remarkably, concentrations of oxytocin in the heart are as high as those found in the brain.

Had the complexity of the heart's intrinsic nervous system and the extensive influence of its hormonal secretions been more widely understood by the scientific community while the Laceys were doing their research, their theories might have been accepted far earlier; however, their insight and experimentation played an important role in elucidating the basic physiological and psychological processes that connect mind and body. In 1977, Dr. Francis Waldropin, Director of the National Institute of Mental Health, stated in a review article of the Laceys' work that: *"Their intricate and careful procedures, combined with their daring theories, have produced work that has stirred controversy as well as promise. In the long run, their research may tell us much about what makes each of us a whole person and may suggest techniques that can restore a distressed person to health."*

Indeed, this prediction has come to pass. Doc Childre and the Institute of HeartMath have built upon the work of others such as the Laceys and Dr. Armour to develop practical interventions that incorporate the understanding that the heart profoundly affects perception, awareness and intelligence. This technology has now helped thousands of individuals from many walks of life lead more productive, healthy and fulfilling lives by learning to live more with heart and mind in synchrony, operating from a constructive synergy of the intelligence of both mind and heart.

The Mental and Emotional Systems

Dating back to the ancient Greeks, human thinking and feeling, or intellect and emotion, have been considered separate functions. These contrasting aspects of the soul, as the Greeks called them, have often been portrayed as being engaged in a constant battle for control of the human psyche. In Plato's view, emotions were like wild horses that had to be reined in by the intellect, while Christian theology has long equated emotions with sins and temptations to be resisted by reason and willpower.

Of course, emotions are not always negative and do not always serve as antagonists to rational thought. Neurologist Antonio Damasio stresses the rationality of emotion in his book *Descartes' Error,* where he emphasizes the importance of emotions in decision making. He points out that patients with brain damage in the areas of the brain that integrate the emotional and cognitive systems can no longer effectively function in the day-to-day world, even though their mental abilities are perfectly normal. In the recent bestselling book *Emotional Intelligence,* Daniel Goleman argues that the pervading view of human intelligence as essentially mind intellect is far too narrow, for it ignores a range of human capacities that bear equal if not greater weight in determining our successes in life. He builds a case for a largely overlooked domain of intelligence, termed "*emotional intelligence*," which is based on such qualities as self-awareness, motivation, altruism and compassion. According to Goleman, it is a high "EQ" (emotional quotient) as much or more than a high IQ that marks people who excel in the face of life's challenges.

The latest research in neuroscience confirms that emotion and cognition can best be thought of as separate but interacting functions or systems, each with its unique intelligence. Our research is showing that the key to the successful integration of the mind and emotions lies in increasing the *coherence* (ordered, harmonious function) in both systems and bringing them into phase with one another. While two-way communication between the cognitive and emotional systems is hard-wired into the brain, the actual number of neural connections going from the emotional centers to the cognitive centers is greater than the number going the other way. This goes some way to explain the tremendous power of emotions, in contrast to thought alone. Once an emotion is experienced,

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it becomes a powerful motivator of future behaviors, affecting moment-to-moment actions, attitudes and long-term achievements. Emotions can easily bump mundane events out of awareness, but non-emotional forms of mental activity (like thoughts) do not so readily displace emotions from the mental landscape. Likewise, experience reminds us that the most pervasive thoughts – those least easily dismissed – are typically those fueled by the greatest intensity of emotion. Because emotions exert such a powerful influence on cognitive activity, at IHM we have discovered that intervening at the emotional level is often the most efficient way to initiate change in mental patterns and processes. Our research demonstrates that the application of tools and techniques designed to increase coherence in the emotional system can often bring the mind into greater coherence as well.

It is our experience that the degree of coherence between the mind and emotions can vary considerably. When they are out-of-phase, overall awareness is reduced. Conversely, when they are in-phase, awareness is expanded. This interaction affects us on a number of levels: Vision, listening abilities, reaction times, mental clarity, feeling states and sensitivities are all influenced by the degree of mental and emotional coherence experienced at any given moment.

Increasing Psychophysiological Coherence: The Role of the Heart

The results of research studies summarized in this overview, taken together, support the intriguing view that individuals can gain more conscious control over the process of creating increased coherence within and between the mental and emotional systems than might be commonly believed. This, in turn, can lead to greater physiological coherence, manifesting as more ordered and efficient function in the nervous, cardiovascular, hormonal and immune systems. We call the resulting state *psychophysiological coherence*, as it involves a high degree of balance, harmony and synchronization within and between cognitive, emotional and physiological processes. Research has shown that this state is associated with high performance, reduced stress, increased emotional stability and numerous health benefits. (The concept of coherence is discussed in further detail in the *Entrainment, Coherence and Autonomic Balance* section).

At IHM, we have found that the heart plays a central role in the generation of emotional experience, and therefore, in the establishment of psychophysiological coherence. From a systems perspective, the human organism is truly a vast, multi-dimensional information network of communicating subsystems, in which mental processes, emotions, and physiological systems are inextricably intertwined. Whereas our perceptions and emotions were once believed to be dictated entirely by the brain's responses to stimuli arising in our external environment, the current perspective more accurately describes perceptual and emotional experience as the *composite* of stimuli the brain receives from the external environment *and* the internal sensations or feedback transmitted to the brain from the bodily organs and systems. Thus, the heart, brain, nervous, hormonal and immune systems must all be considered fundamental components of the dynamic, interactive information network that determines our ongoing emotional experience.

Extensive work by eminent brain researcher and neurosurgeon, Dr. Karl Pribram, has helped advance the understanding of the emotional system. In Pribram's model, past experience builds within us a set of familiar patterns, which are established and maintained in the neural networks. Inputs to the brain from both the external and internal environments contribute to the maintenance of these patterns. Within the body, many processes and interactions occurring at different functional levels provide constant rhythmic inputs with which the brain becomes familiar. These inputs range from the rhythmic activity of our heart, to our digestive, respiratory and reproductive rhythms, to the constant interplay of messenger molecules produced by the cells of our body.

These inputs to the brain, translated into neural and hormonal patterns, are continuously monitored by the brain and help organize our perception, feelings and behavior. Familiar input patterns from the external environment and from within the body are ultimately written into neural circuitry and form a stable backdrop, or reference pattern, against which new information or experiences are compared. According to this model, when an external or internal input is sufficiently different from the familiar reference pattern, this "mismatch" or *departure from the familiar* underlies the generation of feelings and emotions.

The background physiological patterns with which our brain and body grow familiar are created and reinforced through our experiences and the way we perceive the world. For example, a person living in an environment that continually triggers angry or fearful feelings is likely to become familiar with these feelings, and with their neural and hormonal correlates. In contrast, an individual whose experience is

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dominated by feelings of security, love and care will become "familiar," with the physiological patterns associated with these feelings.

In our internal environment many different organs and systems contribute to the patterns that ultimately determine our emotional experience. However, research has illuminated that the heart plays a particularly important role. The heart is the most powerful generator of rhythmic information patterns in the human body. As we saw earlier, it functions as sophisticated information encoding and processing center, and possesses a far more developed communication system with the brain than do most of the body's major organs. With every beat, the heart not only pumps blood, but also transmits complex patterns of neurological, hormonal, pressure and electromagnetic information to the brain and throughout the body. As a critical nodal point in many of the body's interacting systems, the heart is uniquely positioned as a powerful entry point into the communication network that connects body, mind, emotions and spirit.

> *"Since emotional processes can work faster than the mind, it takes a power stronger than the mind to bend perception, override emotional circuitry, and provide us with intuitive feeling instead. It takes the power of the heart."*
>
> Doc Childre, founder, Institute of HeartMath

Numerous experiments have now demonstrated that the messages the heart sends the brain affect our perceptions, mental processes, feeling states and performance in profound ways. Our research suggests that the heart communicates information relative to emotional state (as reflected by patterns in heart rate variability) to the cardiac center of the brain stem (medulla), which in turn feeds into the intralaminar nuclei of the thalamus and the amygdala. These areas are directly connected to the base of the frontal lobes, which are critical for decision making and the integration of reason and feeling. The intralaminar nuclei send signals to the rest of the cortex to help synchronize cortical activity, thus providing a pathway and mechanism to explain how the heart's rhythms can alter brainwave patterns and thereby modify brain function.

Our data indicate that when heart rhythm patterns are coherent, the neural information sent to the brain facilitates cortical function. This effect is often experienced as heightened mental clarity, improved decision making and increased creativity. Additionally, coherent input from the heart tends to facilitate the experience of positive feeling states. This may explain why most people associate love and other positive feelings with the heart and why many people actually "feel" or "sense" these emotions in the area of the heart. In this way, as will be explored further in the studies presented in this Overview, the heart is intimately involved in the generation of psychophysiological coherence.

Research has shown that the heart's afferent neurological signals directly affect activity in the amygdala and associated nuclei, an important emotional processing center in the brain. The amygdala is the key brain center that coordinates behavioral, immunological and neuroendocrine responses to environmental threats. It also serves as the storehouse of emotional memory within the brain. In assessing the environment, the amygdala compares incoming emotional signals with stored emotional memories. In this way, the amygdala makes instantaneous decisions about the threat level of incoming sensory information, and due to its extensive connections to the hypothalamus and other autonomic nervous system centers, is able to "hijack" the neural pathways activating the autonomic nervous system and emotional response before the higher brain centers receive the sensory information.

One of the functions of the amygdala is to organize what patterns become "familiar" to the brain. If the rhythm patterns generated by the heart are disordered and incoherent, especially in early life, the amygdala learns to expect disharmony as the familiar baseline; and thus we feel "at home" with incoherence, which can affect learning, creativity and emotional balance. In other words we feel "comfortable" only with internal incoherence, which in this case is really discomfort. On the basis of what has become familiar to the amygdala, the frontal cortex mediates decisions as to what constitutes appropriate behavior in any given situation. Thus, subconscious emotional memories and associated physiological patterns underlie and affect our perceptions, emotional reactions, thought processes and behavior. One of the research studies summarized in this Overview explains how we believe these emotional memory traces can be repatterned using heart-focused interventions so that coherence becomes the "familiar" and comfortable state.

In sum, from our current understanding of the elaborate feedback networks between the brain, the heart

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and the mental and emotional systems, it becomes clear that the age-old struggle between intellect and emotion will not be resolved by the mind gaining dominance over the emotions, but rather by increasing the harmonious balance between the two systems – a synthesis that provides greater access to our full range of intelligence.

Stress, Health and Performance

People have long been aware of the connection between stress, mental and emotional attitudes, physiological health and overall well-being. However, in recent years, a growing body of compelling evidence is bringing these crucial relationships to the forefront of the scientific arena. Scientific research now tells us plainly that anger, anxiety and worry significantly increase the risk of heart disease, including sudden cardiac death. Landmark long-term studies conducted by Dr. Hans Eysenck and colleagues at the University of London have shown that chronic unmanaged emotional stress is as much as six times more predictive of cancer and heart disease than cigarette smoking, cholesterol level or blood pressure, and much more responsive to intervention.

In order to better understand the interactions and relationships between thoughts, emotions, physiological and psychological wellness, an appealing research-based model is the performance-arousal curve. These curves help clarify the relationships between emotional arousal, performance (the ability to do what has to be done) and health.

Figure 3 shows the performance-arousal curves developed from Lewis's observations of military training: some individuals have a higher potential for performance than others, but all decline when effort and stress carry them beyond their tolerance. Figure 4 illustrates a study of effort and stress experienced by soldiers in battle in World War II: The first stage of exhaustion on the curve is associated with hyperreactivity, anxiety, sleep disorder, overbreathing and cardiovascular dysregulation. Today, there is a rapidly growing interest in preventing the individual from reaching this phase, known in sports medicine as "overtraining." If stressors persist beyond the first stage, the individual becomes drained of energy, stamina and coping resources and sinks to a lower level of performance. The symptoms of this "emotional exhaustion" stage are virtually the same as those seen in chronic fatigue; however, this condition can be described more accurately as a state of extreme homeostatic depletion from which the individual can recover with proper rehabilitation measures. Individuals who have reached this stage often exhibit

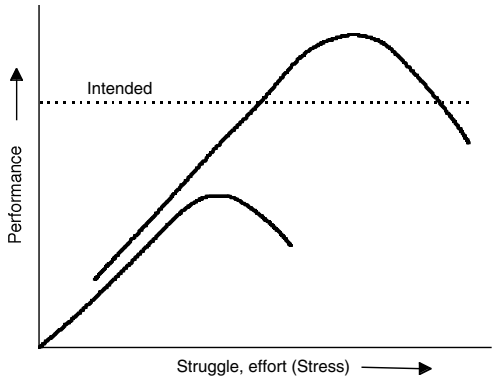

Figure 3. Performance increases with effort, to a higher level in some than others, but it falls when tolerance is exceeded in all individuals. (Graph redrawn from Watkins, 1997)

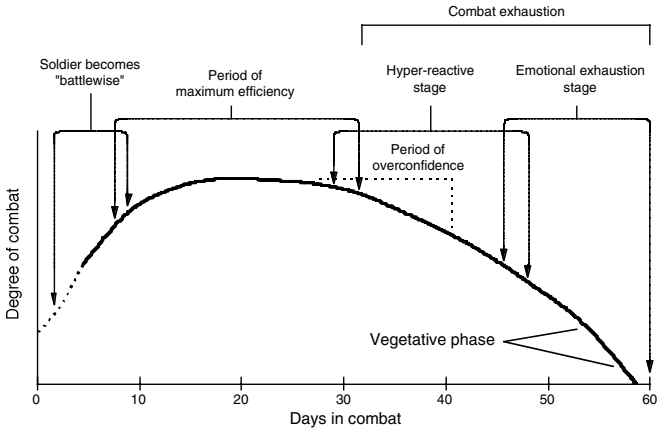

Figure 4. The relationship between battle stress and efficiency, and the phases of exhaustion on the downslope. (Reproduced from Swank and Marchland 1946; In: Watkins, 1997)

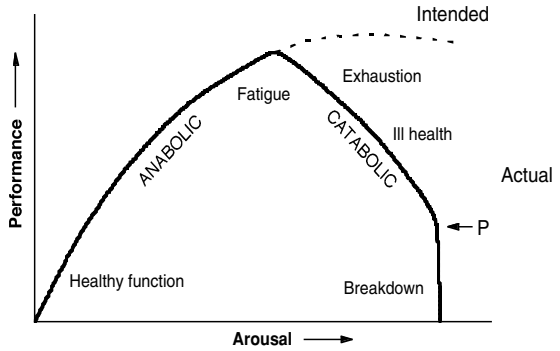

Figure 5. The human function curve model, which illustrates the relationship between performance, arousal and health. On the upslope, performance increases with arousal; the cardiovascular system is in an orderly state and metabolism anabolic (energy storage, regeneration). On the downslope, every increment of arousal (stress) reduces performance. The cardiovascular system is disordered and metabolism catabolic (energy depletion, breakdown). Some individuals are hardy, marked by high curves which permit higher performance, whereas others register lower curves and are more vulnerable to exhaustion, ill health and breakdown (P = breakdown point). The dotted line indicates the intended level of activity and the solid line the actual level of performance. The more individuals struggle to close the gap between what they can do and what they think they should achieve, the further down the curve they move and the worse they become. (Redrawn from Watkins, 1997)

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depletion or exhaustion of the autonomic nervous system, which can be measured by analysis of heart rate variability (See *Heart Rate Variability* and *Clinical Research* sections).

Tolerance of stress varies among individuals. Those with higher tolerance curves can perform at higher levels for longer periods without generating homeostatic disorders. They are deemed "hardy" or "resilient," qualities developed through successful self-management of negative emotional reactions and adapting linked with a strong commitment to life's goals, a sense of control over the outcome of life's course, and an abundance of energy that makes it possible to enjoy the challenges of life. Those with lower curves are less resilient; they have a lesser capacity for coping and adapting, and a greater propensity to exhaustion and illness. However, even individuals with a higher tolerance will succumb to exhaustion and illness if their tolerance threshold is exceeded and they cross over the top of the curve.

The onset of exhaustion depends upon the interplay between the initial condition of one's defenses and the magnitude and rate of the stressors that challenge one's coping skills and adaptive capacity (Figure 5). Up to a point, regeneration can be achieved by rest and relaxation, but beyond that point the individual embarks on an enduring downhill course of decline in performance and health. In other words, the top of the curve represents the dividing line between healthy function and reversible fatigue on the upslope, and the self-perpetuating depletion of health and performance on the downslope.

While most of the adult population reports experiencing personal or emotional problems in the course of a year, about 50% of these people say that they are unable to solve their problems and about one-third state that they are unable to do anything to make their problems more bearable.

The "intended" line acts as a reminder that maladaptive behavior is often adopted when people go "over the top." As the gap between actual ability and intended performance widens, they neglect the need for rest and tend towards increased negative mental and emotional inner turmoil, which further drives them downwards towards breakdown. Movement over the top of the curve into exhaustion and ill health can be due to both intrinsic and extrinsic factors. Intrinsic

A growing body of compelling scientific evidence is demonstrating the link between mental and emotional attitudes, physiological health and long-term well-being.

- *A Harvard Medical School Study of 1,623 heart attack survivors found that when subjects became angry during emotional conflicts, their risk of subsequent heart attacks was more than double that of those that remained calm.*
  M. Mittleman et al. Circulation. 1995; 92(7)
- *Men who complain of high anxiety are up to six times more likely than calmer men to suffer sudden cardiac death.*
  I. Kawachi et al. Circulation. 1994; 89(5).
- *A 20-year study of over 1,700 older men conducted by the Harvard School of Public Health found that worry about social conditions, health and personal finances all significantly increased the risk of coronary heart disease.*
  L. Kubzansky et al. Circulation. 1997; 95(4)
- *Over one-half of heart disease cases are not explained by the standard risk factors—such as high cholesterol, smoking or sedentary lifestyle.*
  R. Rosenman. Integr Physiol Behav Sci. 1993; 28(1)
- *An international study of 2,829 people between the ages of 55 and 85 found that individuals who reported the highest levels of personal "mastery"— feelings of control over life events—had a nearly 60% lower risk of death compared with those who felt relatively helpless in the face of life's challenges.*
  B. Penninx et al. Am J Epidemiol. 1997; 146(6)
- *According to a Mayo Clinic study of individuals with heart disease, psychological stress was the strongest predictor of future cardiac events, such as cardiac death, cardiac arrest and heart attacks.*
  T. Allison et al. Mayo Clin Proc. 1995; 70(8)
- *Three 10-year studies concluded that emotional stress was more predictive of death from cancer and cardiovascular disease than smoking; people who were unable to effectively manage their stress had a 40% higher death rate than non-stressed individuals.*
  H. Eysenck. Br J Med Psychol. 1988; 61(Pt 1)
- *A recent study of heart attack survivors showed that patients' emotional state and relationships in the period after myocardial infarction are as important as the disease severity in determining their prognosis.*
  S. Thomas et al. Am J Crit Care. 1997; 6(2)
- *In a study of 5,716 middle-aged people, those with the highest self-regulation abilities were over 50 times more likely to be alive and without chronic disease 15 years later than those with the lowest self-regulation scores.*
  R. Grossarth-Maticek & H. Eysenck. Person Individ Diff. 1995; 19(6)

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causes include high levels of anger, anxiety, tension, lack of self-management skills, restlessness, guilt, loneliness and inability to be satisfied by achievement.

External environmental stressors such as the acceleration of change in society can drive individuals beyond physiological tolerance. The working environment can also have a major impact on health. For example, Beale and Nethercott examined workers in the 2-year period between learning that their job security was threatened and actually losing their jobs. These workers evidenced a 150% increase in visits to the family doctor, a 70% increase in the number of episodes of illness, a 160% increase in the number of referrals to hospital outpatient departments and a 200% increase in the number of attendances at outpatient departments. Numerous other studies have also demonstrated that job dissatisfaction can predict heart attacks.

Tools that Enhance Human Performance

With stress levels continuing to rise all over the world, people are becoming more conscious not only of the long-term effects of stress, but also of how unmanaged emotions compromise the quality of one's day-to-day life, limiting mental clarity, productivity, adaptability to life's challenges and enjoyment of its gifts.

At the same time, most of us have experienced how positive emotional states, such as appreciation and care, add a quality of buoyancy and coherent flow to life, significantly increasing our efficiency and effectiveness. Doc Childre, founder of the Institute of HeartMath, understood years ago that the key to enhancing human performance would be a simple, practical system that would help people achieve these more coherent inner states with greater continuity, even in the face of external stresses. Through many years of research, Childre devised what is now known as the HeartMath system: a set of practical techniques to help people transmute stress and negative emotions in the moment, improve performance and enrich the quality of life.

"The emotional frontier is truly the next frontier to conquer in human understanding. The opportunity we face now, even before that frontier is fully explored and settled, is to develop our emotional potential and accelerate rather dramatically into a new state of being."

Doc Childre

Core HeartMath Tools

Freeze-Frame

- ***Stops stress by shifting perception in the moment***
- ***Arrests or prevents the physiological stress response***

Heart Lock-In

- ***Promotes sustained states of psychophysiological coherence***
- ***Establishes increased physiological efficiency, mental acuity and emotional stability as a new baseline***

Cut-Thru

- ***Extinguishes recurring, intrusive thought patterns and emotions (e.g. anxiety, depression, overwhelm)***
- ***Reinforces more positive perceptions and efficient emotional responses***

It is commonly believed we have little control over the mind or emotions. For example, neuroscientist Joseph LeDoux, who studies brain circuits and the emotion of fear in animals, writes that:

> "Emotions are things that happen to us rather than things we will to occur. Although people set up situations to modulate their emotions all the time – going to movies and amusement parks, having a tasty meal, consuming alcohol and other recreational drugs – in these situations, external events are simply arranged so that the stimuli that automatically trigger emotions will be present. We have little direct control over our emotional reactions. Anyone who has tried to fake an emotion, or who has been the recipient of a faked one, knows all too well the futility of the attempt. While conscious control over emotions is weak, emotions can flood consciousness." (Le Doux, 1996, p. 19)

While this is true for many people who have not learned how to train and develop their emotional systems, our research and experience show that *the emotional system can be developed and brought into coherence*. However, this requires tools and practice, in much the same way that it takes techniques and practice to learn and develop mental or athletic skills.

The science underlying the HeartMath techniques involves an understanding of the human heart as a far

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more complex, self-organized and intelligent system than has generally been acknowledged. As discussed in the preceding pages, the heart is intimately connected with our brain and emotional system; the "decisions" made within the heart can directly impact the way the brain perceives and processes information. *Freeze-Frame*, the most basic of the HeartMath techniques, in essence allows people to disengage from draining mental and emotional reactions in the moment by shifting their attention from the mind to the area around the heart and self-generating a sincere positive feeling state such as appreciation, love or care. This process prevents or reverses the body's normal destructive stress response, and changes the bodily feedback sent to the brain, thus arresting physiological and psychological wear and tear. As a result of using Freeze-Frame, perception can shift markedly: individuals find they can think more clearly and often transform an inefficient, emotionally draining response into a proactive, creative one. With practice, this tool can be used effectively in less than one minute.

In addition to the Freeze-Frame technique, the effectiveness of several other core HeartMath tools is assessed in the research studies presented in this Overview. The *Heart Lock-In* technique promotes physical, mental and emotional regeneration. It enables people to "lock in" the positive feeling states associated with the heart in order to boost their energy, heighten peace and clarity and effectively *retrain their physiology* to sustain longer periods of coherent function. With consistent practice, the Heart Lock-In facilitates the establishment of new reference patterns promoting increased physiological efficiency, mental acuity and emotional stability as a new baseline or norm. The technique involves focusing one's attention on the area around the heart and experiencing a sincere positive feeling state of love or appreciation. This process can be facilitated by music specifically designed to enhance mental and emotional balance (See *Music Research* section).

Cut-Thru is a tool designed to address recurring negative emotional reactions and patterns, sometimes referred to as negative "thought loops" or "emotional memories." Just as physical movements (such as walking, driving, and so on) become "stereotyped" and automatic through repetition, so do mental and emotional responses and attitudes. Often, these old mental and emotional patterns continue to be triggered even though they are outdated and inappropriate for present circumstances. The Cut-Thru technique helps people shift their typical "in the moment" response to stressors from negative to neutral or even positive. We propose that this process facilitates the restructuring of mental and emotional circuitry, reinforcing more positive perceptions and efficient emotional responses.

While the HeartMath tools are intentionally designed to be easily learned and used in day-to-day life, our experience working with people of diverse ages, cultures, educational backgrounds and professions suggests that these interventions often facilitate profound shifts in perception, emotion and awareness. Moreover, extensive laboratory research performed at IHM has shown that the physiological changes accompanying such shifts are dramatic. The research studies overviewed in the section titled *Entrainment, Coherence and Autonomic Balance* begin to map out many of these effects, beginning with the positive shifts that occur in the autonomic nervous system. It is demonstrated that the experience of sincere positive feeling states produces increased coherence in the rhythmic patterns generated by the heart. Through the various pathways outlined in the Introduction, this information is communicated throughout the body, and has the effect of driving other important physiological systems, including the brain, into increased coherence as well. The results summarized in the *Head-Heart Interactions* section provide additional insight into the ways in which the heart's rhythms influence the brain, ultimately affecting cognitive performance. Results help explain many of the positive effects experienced by people who practice the HeartMath tools—from greater physical vitality, to clearer thought processes, heightened intuition and creativity, to increased emotional balance and capacity to meet life's challenges with fluidity and grace.

The physiological and psychological outcomes of the HeartMath interventions are further explored in studies presented in *the Emotional Balance and Health* and *Music Research* sections. In the *HeartMath Technology in Business* section, case studies show how these benefits can also lead to organizationally-relevant gains. The *HeartMath in Education* section describes how HeartMath tools have been applied in elementary, middle school, high school and university settings to enhance learning, as well as promote psychosocial and behavioral improvements. Finally, the *Clinical Research* section includes studies demonstrating how the interventions have been used in diverse patient populations to facilitate health improvements and enhance quality of life.

To facilitate a more in-depth understanding of this research, we first provide a brief background on heart rate variability, a key measure of autonomic function and physiological coherence that is used throughout our work.

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Heart Rate Variability: An Indicator of Autonomic Function and Physiological Coherence

The autonomic nervous system (ANS) (Figure 1) is the portion of the nervous system that controls the body's visceral functions, including action of the heart, movement of the gastrointestinal tract and secretion by different glands, among many other vital activities. It is well known that mental and emotional states directly affect the ANS. Many of IHM's research studies have examined the influence of emotions on the ANS utilizing the analysis of *heart rate variability*, or *heart rhythms*, which serves as a dynamic window into autonomic function and balance. While the rhythmic beating of the heart at rest was once believed to be monotonously regular, we now know that the rhythm of a healthy heart under resting conditions is actually surprisingly *irregular*. These moment-to-moment variations in heart rate are easily overlooked when average heart rate is calculated. Heart rate variability (HRV), derived from the electrocardiogram (ECG), is a measurement of these naturally occurring, beat-to-beat changes in heart rate.

Systems-oriented models propose that HRV is an important indicator of both physiological resiliency and behavioral flexibility, reflecting the individual's capacity to adapt effectively to stress and environmental demands. It has become apparent that while a large degree of instability is detrimental to efficient physiological functioning, too little variation can also be pathological. An optimal level of variability within an organism's key regulatory systems is critical to the inherent flexibility and adaptability that epitomize healthy function. This principle is aptly illustrated by a simple analogy: just as the shifting stance of a tennis player about to receive a serve may facilitate swift adaptation, in healthy individuals, the heart remains similarly responsive and resilient, primed and ready to react when needed.

The normal variability in heart rate is due to the synergistic action of the two branches of the ANS, which act in balance through neural, mechanical, humoral and other physiological mechanisms to maintain cardiovascular parameters in their optimal ranges and to permit appropriate reactions to changing external or internal conditions. In a healthy individual, thus, the heart rate estimated at any given time represents the net effect of the parasympathetic (vagus) nerves, which slow heart rate, and the sympathetic nerves, which accelerate it. These changes are influenced by emotions, thoughts and physical exercise. Our changing heart rhythms affect not only the heart but also the brain's ability to process information, including decision-making, problem-solving and creativity. They also directly affect how we feel. Thus, the study of heart rate variability is a powerful, objective and noninvasive tool to explore the dynamic interactions between physiological, mental, emotional and behavioral processes. The next page shows examples of hour-long HRV tachograms recorded in individuals under various conditions.

- ***Thoughts and even subtle emotions influence the activity and balance of the autonomic nervous system (ANS).***
- ***The ANS interacts with our digestive, cardiovascular, immune and hormonal systems.***
- ***Negative reactions create disorder and imbalance in the ANS.***
- ***Positive feelings such as appreciation create increased order and balance in the ANS, resulting in increased hormonal and immune system balance and more efficient brain function.***

The mathematical transformation (Fast Fourier Transform) of HRV data into power spectral density (PSD) is used to discriminate and quantify sympathetic and parasympathetic activity and total autonomic nervous system activity. Power spectral analysis reduces the HRV signal into its constituent frequency components and quantifies the relative power of these

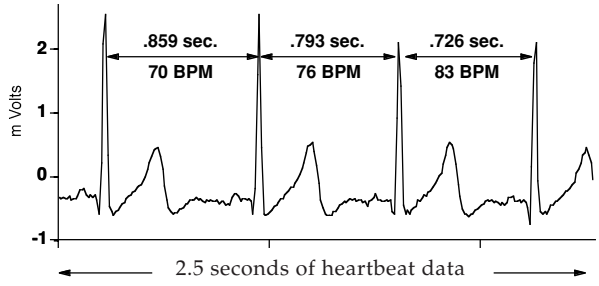

Figure 6. Heart rate variability is a measure of the beat-to-beat changes in heart rate.

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components. The power spectrum is divided into three main frequency ranges. The very low frequency range (VLF) (0.0033 to 0.04 Hz), representing slower changes in heart rate, is an index of sympathetic activity, while power in the high frequency range (HF) (0.15 to 0.4 Hz), representing quicker changes in heart rate, is primarily due to parasympathetic activity. The frequency range around the 0.1 Hz region is called the low frequency (LF) band and is also often referred to as the baroreceptor band, because it reflects the blood pressure feedback signals sent from the heart back to the brain, which also affect the HRV waveform. The LF band is more complex, as it can reflect a mixture of sympathetic and parasympathetic activity.

It has been shown in a number of studies that during mental or emotional stress, there is an increase in sympathetic activity and a decrease in parasympathetic activity. This results in increased strain on the heart as well as on the immune and hormonal systems. Increased sympathetic activity is associated with a lower ventricular fibrillation threshold and an increased risk of fibrillation, in contrast to increased parasympathetic activity, which protects the heart.

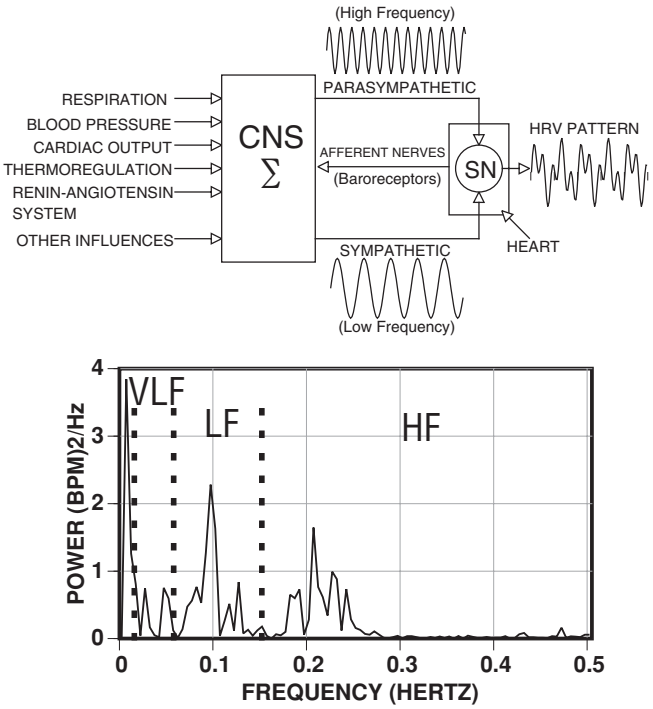

Figure 7. The top diagram illustrates the nervous system links between the heart and brain. The sympathetic branch speeds heart rate while the parasympathetic slows it. Heart rate variability is due to the interaction between the two branches of the nervous system and the afferent signals sent from the heart to the brain (baroreceptor network). The bottom graph shows a power spectrum of the HRV waveform. The power (height of the peak) in each band reflects the activity in the different branches of the nervous system.

The research studies summarized in the next section employ PSD analysis of HRV to measure changes in total ANS power and sympathetic/parasympathetic balance that occur during different emotional states.

At IHM, we have also found that the assessment of heart rhythm patterns can also provide a useful objective measurement of *physiological coherence*, a term we have introduced to describe a high-performance state characterized by a high degree of order and harmony in the functioning of the body's diverse oscillatory systems. We have found that heart rate variability patterns are extremely responsive to emotions, and heart rhythms tend to become more ordered or *coherent* during positive emotional states. Thus, the term *psychophysiological coherence* is used to refer to states in which a high degree of order and harmony in the emotional domain translates as increased coherence in physiological patterns and processes. These findings are explored in further depth in the section which follows.

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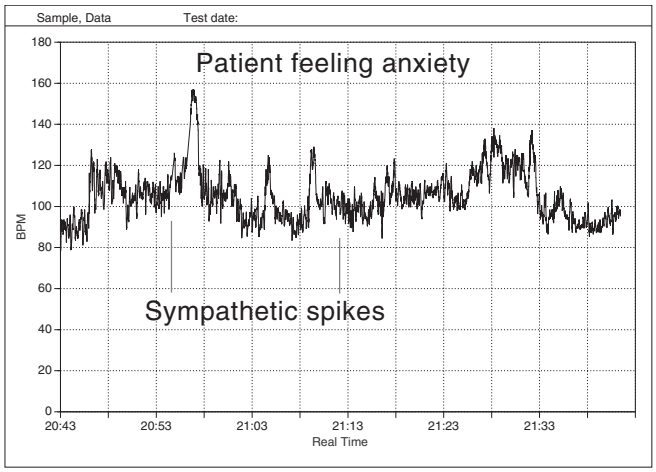
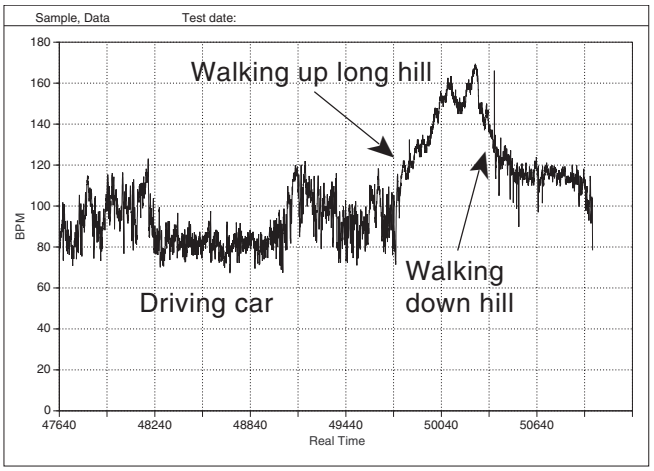
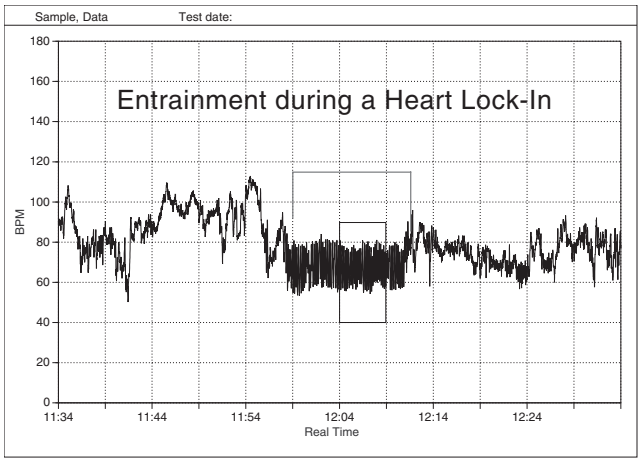
Heart Rate Variability Tachograms: Hour-Long Examples

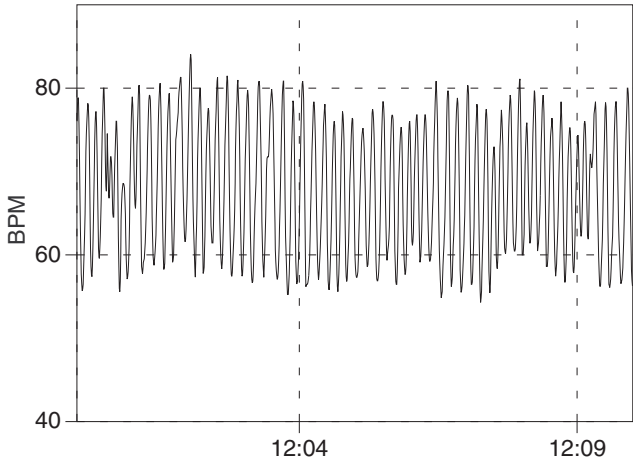


Heart rhythm of a 33-year-old male experiencing anxiety. The prominent spikes are due to pulses of activity in the sympathetic nervous system.

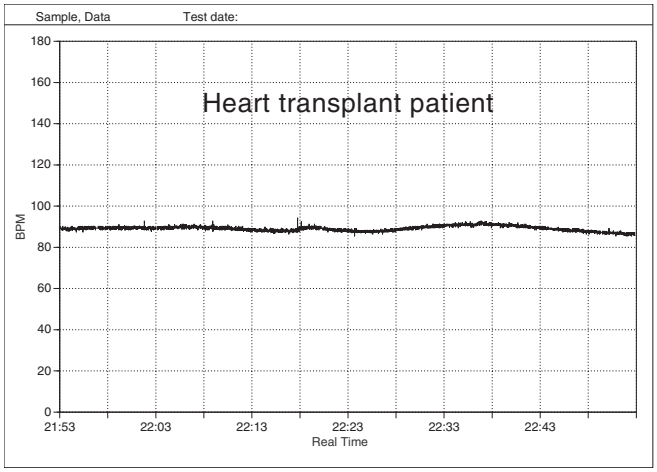


Heart rhythm of a healthy 30-year-old male driving car and then hiking uphill.

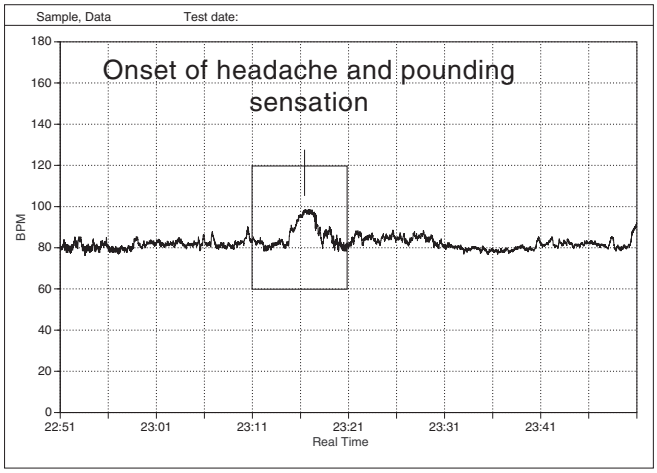




Entrainment during a Heart Lock-in. Entrainment is reflective of autonomic nervous system balance and is commonly experienced when using the Freeze-Frame and Heart Lock-in techniques. The graph on the right is an enlarged view of the section outlined by the box in the lefthand graph.



Heart rhythm of a heart transplant recipient. Note the lack of variability in heart rate, due to loss of autonomic nervous sytem input to the heart.



Heart rhythm of a 44-year-old female with low heart rate variability while suffering from headaches and pounding sensation in her head.

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Entrainment, Coherence and Autonomic Balance

The concept of *coherence* is useful in understanding how physiological patterns change with the experience of different emotions. The term "coherence" has several related definitions, all of which are applicable to the study of human function. A common dictionary 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." We describe positive emotions such as love or appreciation as coherent states, whereas negative feelings such as anger, anxiety or frustration are examples of incoherent states. Importantly, however, these associations are not merely metaphorical. The research studies presented in this section provide intriguing evidence that different emotions lead to measurably different degrees of coherence in the oscillatory rhythms generated by the body's systems.

Definitions of Coherence

Clarity of thought and emotional balance

The quality of being orderly, consistent, and intelligible (e.g. a coherent argument)

Synchronization between multiple systems

A constructive waveform produced by two or more waves that are phase- or frequency-locked (e.g. lasers)

Ordered patterning within one system

An ordered or constructive distribution of power content within a single waveform; autocoherence (e.g. sine wave)

This leads us to a second use of the term "coherence." In physics, the term is used to describe two or more waves that are phase- or frequency-locked together to produce a constructive waveform. A common example is the laser, in which multiple light waves phase-lock to produce a powerful, *coherent* energy wave. In physiology, the term is similarly used to describe a state in which two or more of the body's oscillatory systems, such as respiration and heart rhythm patterns, become synchronous and operate at the same frequency. This type of coherence is called *entrainment*.

The term coherence is also used in mathematics to describe the ordered or constructive distribution of the power content within a *single* waveform. In this case, the more stable the frequency and shape of the waveform, the higher the coherence. A good example of a coherent wave is the sine wave. In the engineering and signal processing sciences, the term *autocoherence* is used to denote this type of coherence. When we speak of physiological coherence in this sense, we are referring to the degree of order and stability in the waveform that reflects the rhythmic activity of any given physiological system over a specified period of time. Interestingly, as shown below, we have found that in states in which there is a high degree of coherence *within* the HRV waveform, there also tends to be increased coherence *between* the rhythmic patterns produced by different physiological oscillatory systems (*e.g.* synchronization and entrainment between heart rhythms, respiratory rhythms and blood pressure oscillations).

Physiological Coherence

A state characterized by:

- ***High heart rhythm coherence (sine wave-like rhythmic pattern)***
- ***Increased parasympathetic activity***
- ***Increased entrainment and synchronization between physiological systems***
- ***Efficient and harmonious functioning of the cardiovascular, nervous, hormonal and immune systems***

Our research has elucidated a clear and definable mode of physiological function that we call *physiological coherence*. This mode is associated with a sine wave-like pattern in the heart rhythms, a shift in autonomic balance towards increased parasympathetic activity, increased heart-brain synchronization and entrainment between diverse physiological systems. In this mode, the body's systems function with a high degree of efficiency and harmony, and natural regenerative processes are facilitated. Although physiological coherence is a natural human state which can

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occur spontaneously, sustained episodes are generally rare. While specific rhythmic breathing methods may induce coherence and entrainment for brief periods, our research indicates that individuals can maintain extended periods of physiological coherence through actively self-generating positive emotions. Using a positive emotion to drive the coherent mode allows it to emerge naturally, and results in changes in the patterns of afferent information flowing from the heart to the respiratory and other brain centers. This, in turn, makes it easier to sustain the positive emotional state and coherent mode for longer periods, even during challenging situations.

When the physiological coherence mode is driven by a positive emotional state, we call it *psychophysiological coherence*. This state is associated with sustained positive emotion and a high degree of mental and emotional stability. In states of psychophysiological coherence, there is increased synchronization and harmony between the cognitive, emotional and physiological systems, resulting in efficient and harmonious functioning of the whole. As we will see in subsequent sections, studies conducted across diverse populations have linked the capacity to self-generate and sustain psychophysiologically coherent states at will with numerous benefits. Observed outcomes include: reduced stress, anxiety and depression; decreased burnout and fatigue; enhanced immunity and hormonal balance; improved cognitive performance and enhanced learning; increased organizational effectiveness; and health improvements in a number of clinical populations.

Psychophysiological Coherence

A state associated with:

- ***Sustained positive emotion***
- ***High degree of mental and emotional stability***
- ***Constructive integration of the cognitive and emotional systems***
- ***Increased synchronization and harmony between the cognitive, emotional and physiological systems***

In brief, the research studies summarized here show that different emotional states are associated with different physiological information patterns that are transmitted to the brain and throughout the body. When an individual is under stress or experiencing negative emotions such as frustration, anger and anxiety, heart rhythms become less coherent and more erratic, indicating less synchronization in the reciprocal action that ensues between the parasympathetic and sympathetic branches of the autonomic nervous system. This desynchronization in the ANS, if sustained, taxes the nervous system and bodily organs, impeding the efficient flow of information throughout the body. On the other hand, sustained positive emotions, such as appreciation, love or care, lead to increased heart rhythm coherence, greater synchronization between the activity of the two branches of the ANS and a shift in ANS balance toward increased parasympathetic activity. Further, we show that when the heart generates a coherent signal, it has a much greater impact on other biological oscillatory systems than when it is generating an incoherent or chaotic signal. When functioning in a coherent mode, the heart pulls other biological oscillators into synchronization with its rhythms, thus leading to entrainment of these systems. The entrainment mode is an example of a physiological state in which there is increased coherence *between* multiple oscillating systems and also *within* each system.

In sum, our findings essentially underscore what people have intuitively known for some time: Positive emotions not only feel better subjectively, but tend to increase synchronization of the body's systems, thereby enhancing energy and enabling us to function with greater efficiency and effectiveness.

THE EFFECTS OF EMOTIONS ON SHORT-TERM POWER SPECTRAL ANALYSIS OF HEART RATE VARIABILITY

Rollin McCraty, PhD, Mike Atkinson, William A. Tiller, PhD, Glen Rein, PhD and Alan D. Watkins, MBBS. American Journal of Cardiology. 1995; 76 (14): 1089-1093.

Key findings: *Different emotions affect autonomic nervous system function and balance in measurably different ways. Anger tends to increase sympathetic activity, while appreciation is associated with a relative increase in parasympathetic activity.*

Summary: In this study, power spectral density (PSD) analysis of HRV was used to compare autonomic activation and sympathovagal balance in subjects during a 5-minute baseline period, in contrast to a 5-minute period of self-induced anger and a 5-minute period of appreciation. It was found that both anger and appreciation caused an overall increase in autonomic activation, as demonstrated by an increase in power in all frequencies of the HRV power spectrum

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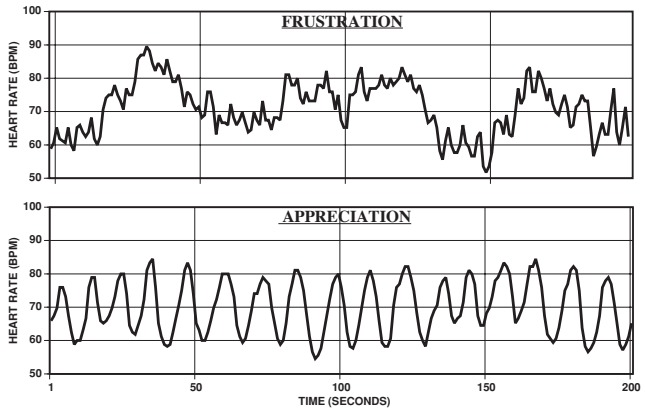

Figure 8. The heart rate variability pattern shown in the top graph, characterized by its random, jerky form, is typical of feelings of anger or frustration. Sincere positive feeling states like appreciation (bottom) can result in highly ordered and coherent HRV patterns, generally associated with enhanced cardiovascular function.

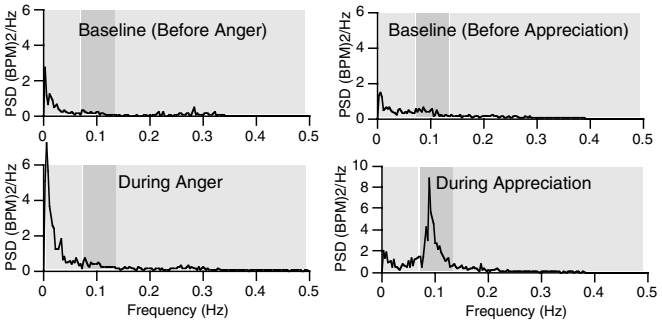

Figure 9. Mean power spectral density analysis of a group of subjects comparing the effects of anger and appreciation on the autonomic nervous system. Anger caused a large increase in the activity of the sympathetic system, which is reflected as increased power in the far left-hand region of the power spectrum. Appreciation, on the other hand, increased the activity in the parasympathetic system, which helps protect the heart.

and in mean heart rate standard deviation. However, the two emotional states produced different effects on sympathovagal balance. Anger produced a sympathetically dominated power spectrum, whereas appreciation produced a power spectral shift toward increased parasympathetic activity. The technique used to generate a feeling state of appreciation was Freeze-Frame, a new method of intentionally shifting emotional states in the moment through heart focus. The positive shifts in ANS balance that all subjects were able to achieve in this study through using the Freeze-Frame technique may be beneficial in the control of hypertension and in reducing the likelihood of sudden death in patients with congestive heart failure and coronary artery disease.

CARDIAC COHERENCE: A NEW, NONINVASIVE MEASURE OF AUTONOMIC NERVOUS SYSTEM ORDER

William A. Tiller, PhD, Rollin McCraty, PhD and Mike Atkinson.
Alternative Therapies in Health and Medicine. 1996; 2 (1): 52-65.

Key findings: *The experience of sincere positive feeling states may be accompanied by distinct modes of heart function which drive physiological systems into increased coherence. Such shifts are attainable not only under controlled laboratory conditions, but also during real-life stressful situations.*

Summary: This study expands the findings discussed in "The effects of emotions on short-term power spectral analysis of heart rate variability," above. HRV analysis reveals that sincere feelings of appreciation,

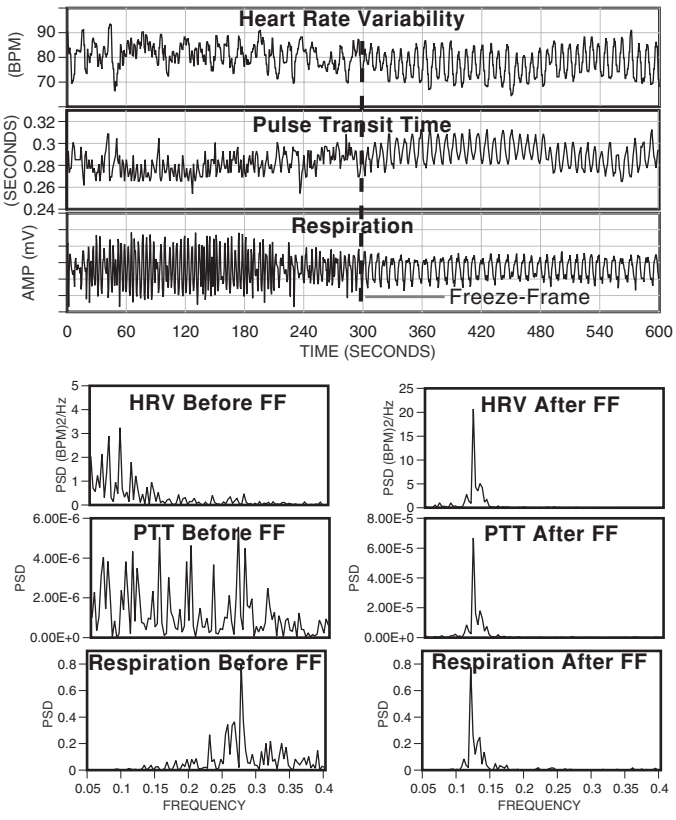

Figure 10. The top graphs show an individual's heart rate variability, pulse transit time and respiration patterns for 10 minutes. At the 300 second mark, the individual Freeze-Framed and all three systems came into entrainment, meaning the patterns are harmonious instead of scattered and out-of-sync. The bottom graphs show the spectrum analysis view of the same data. The left-hand side is the spectral analysis before Freeze-Framing. Notice how each pattern looks quite different from the others. The graphs on the right show how all three systems are entrained at the same frequency after Freeze-Framing.

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as experienced through the Freeze-Frame technique, create positive shifts in ANS function and these shifts are accompanied by distinct modes of cardiac function. While feelings of frustration create a disordered or incoherent HRV waveform, characterized by an irregular, jerky pattern, appreciation produces an ordered sine wave-like pattern in the HRV waveform, indicating increased balance and efficiency in ANS function. It is demonstrated that when the heart is operating in this more ordered mode, frequency locking occurs between the HRV waveform (heart rhythms) and other biological oscillators; this mode of cardiac function is thus referred to as the "entrainment mode."

Another distinct mode of cardiac function, termed the "internal coherence mode," is shown to characterize a positive inner feeling state called "amplified peace," also achieved through using the Freeze-Frame technique. In this state, internal mental and emotional dialogue is largely reduced and the sympathetic and parasympathetic outflow from the brain to the heart appears to be decreased to such a degree that the oscillations in the HRV waveform become nearly zero. In addition, when the heart is functioning in the internal coherence mode, the amplitude spectrum derived from the ECG exhibits a harmonic series (Figure 11).

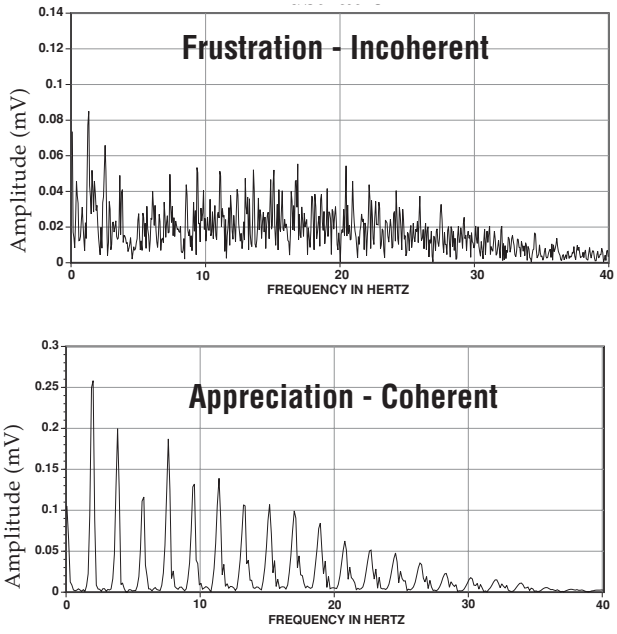

Figure 11. The top graph is a typical spectrum analysis of the electrocardiogram (ECG) showing the electrical frequencies generated by the heart when a person experiences *frustration*. This is called an **incoherent spectrum** because the frequencies are scattered and disordered. The bottom graph shows the frequency analysis of the ECG during a period when the person is experiencing deep, sincere *appreciation*. This is called a **coherent spectrum** because the power is ordered and harmonious.

This study was conducted with the same group of subjects in two different environments: under controlled laboratory conditions and during a normal business day in their workplace. For the workplace portion of the study, subjects wore portable Holter recorders to monitor their ECG and were asked to use the Freeze-Frame technique on at least three occasions when they were feeling stress or out of balance. Results showed that the positive shifts in emotional state, autonomic balance and more coherent modes of cardiac function measured in the laboratory could be attained through the practice of the Freeze-Frame intervention during real-life stressful situations in the workplace, for which the technique is designed.

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Head-Heart Interactions

Traditionally, the study of communication pathways between the "head" and heart has been approached from a rather one-sided perspective, with scientists focusing primarily on the heart's responses to the brain's commands. However, we have now learned that communication between the heart and brain is actually a dynamic, ongoing, two-way dialogue, with each organ continuously influencing the other's function. Research has shown that the heart communicates to the brain in four major ways: *neurologically* (through the transmission of nerve impulses), *biochemically* (via hormones and neurotransmitters), *biophysically* (through pressure waves) and *energetically* (through electromagnetic field interactions). Communication along all these conduits significantly affects the brain's activity. Moreover, our research shows that messages the heart sends the brain can also affect performance.

The heart communicates with the brain and body in four ways:

- ***Neurological communication*** **(nervous system)**
- ***Biophysical communication*** **(pulse wave)**
- ***Biochemical communication*** **(hormones)**
- ***Energetic communication*** **(electromagnetic fields)**

The studies described in this section probe several of these communication pathways, looking specifically at how the brain responds to patterns generated by the heart during positive emotional states. The first two studies focus primarily on neurological interactions, demonstrating that the afferent signals the heart sends the brain during positive emotions can alter brain activity in several ways. In the first study, we find that cardiac coherence can drive entrainment between very low frequency brainwaves and heart rhythms, thus further expanding our understanding of the physiological entrainment mode described in the previous section. In the second study, we learn that coherent heart rhythms also lead to increased heart-brain synchronization. The implications of these findings are explored in the third study, which shows that in states of high heart rhythm coherence, individuals demonstrate significant improvements in cognitive performance.

Taken together, the results of these studies demonstrate that intentionally altering one's emotional state through heart focus modifies afferent neurological input from the heart to the brain. The data suggest that as people experience sincere positive feeling states, in which the heart's rhythms become more coherent, the changed information flow from the heart to the brain may act to modify cortical function and influence performance. These findings may also help explain the significant shifts in perception, increased mental clarity and heightened intuitive awareness many individuals have reported when practicing the HeartMath techniques.

The final two studies in this section are concerned with energetic communication by the heart, which we also refer to as *cardioelectromagnetic communication*. The heart is the most powerful generator of electromagnetic energy in the human body, producing the largest rhythmic electromagnetic field of any of the body's organs. The heart's electrical field is about 60 times greater in amplitude than the electrical activity generated by the brain. This field, measured in the form of an electrocardiogram (ECG), can be detected anywhere on the surface of the body. Furthermore, the magnetic field produced by the heart is more than 5,000 times greater in strength than the field generated by the brain, and can be detected a number of feet away from the body, in all directions, using SQUID-

The Heart's Electromagnetic Field

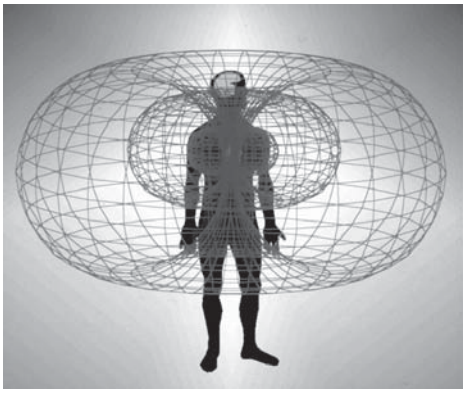

Figure 12. The heart's electromagnetic field—by far the most powerful rhythmic field produced by the human body—not only envelops every cell of the body but also extends out in all directions into the space around us. The cardiac field can be measured several feet away from the body by sensitive devices. Research conducted at IHM suggests that the heart's field is an important carrier of information.

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based magnetometers (Figure 12). Prompted by our findings that the cardiac field is modulated by different emotional states (described in the previous section), we performed several studies to investigate the possibility that the electromagnetic field generated by the heart may transmit information that can be received by others.

Thus, the last two studies summarized in this section explore interactions that take place between one person's heart and another's brain when two people touch or are in proximity. This research elucidates the intriguing finding that *the electromagnetic signals generated by the heart have the capacity to affect others around us*. Our data indicate that one person's heart signal can affect another's brainwaves, and that heart-brain synchronization can occur *between* two people when they interact. Finally, it appears that as individuals increase psychophysiological coherence, they become more sensitive to the subtle electromagnetic signals communicated by those around them. Taken together, these results suggest that cardioelectromagnetic communication may be a little-known source of information exchange between people, and that this exchange is influenced by our emotions.

HEAD-HEART ENTRAINMENT: A PRELIMINARY SURVEY

Rollin McCraty, PhD, William A. Tiller, PhD and Mike Atkinson.
In: Proceedings of the Brain-Mind Applied Neurophysiology EEG Neurofeedback Meeting. Key West, Florida, 1996.

Key findings: *As people learn to sustain heart-focused positive feeling states, the brain can be brought into entrainment with the heart.*

Summary: This study examines in further detail the entrainment mode of cardiac function described previously in "Cardiac Coherence: A new noninvasive measure of autonomic nervous system order." In the previous investigation it was found that when the heart is functioning in the entrainment mode, there is a marked shift in the HRV power spectrum to the resonant frequency range of the baroreceptor feedback loop (around 0.1 Hz), and frequency locking between the HRV waveform, respiration and pulse transit time occurs. The present study shows that as individuals learn to maintain the entrainment mode through sustaining sincere, heart-focused states of appreciation or love, the brain's electrical activity can also come into entrainment with the heart rhythms. Figure 13, below, shows an example of entrainment occurring between a subject's HRV and the very low frequency band region of the electroencephalograph (EEG) recordings after the individual practices the Freeze-Frame intervention for 5 minutes. There is nearly a hundred-fold increase in power in the 0.1 Hz frequency range of the HRV power spectrum after the Freeze-Frame intervention and a correlated 4 to 5-fold increase in the EEG signal power in that same frequency range. Our present hypothesis is that a strong and sustained increase in baroreceptor system activity leads to greatly increased coupling between the heart (HRV) and the brain (EEG) via nerve con-

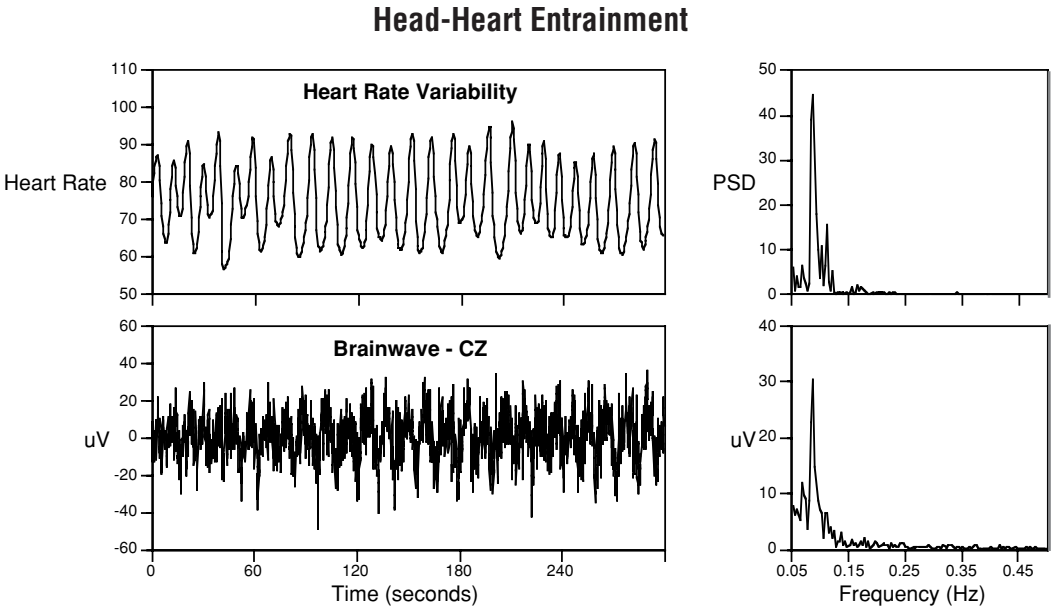

Figure 13. Illustrates the entrainment that can occur between the HRV and EEG waveforms. The lefthand graphs show the time domain signals for the HRV and the EEG (brainwaves), while the righthand panels show the frequency spectra during the entrained state. Note the large peak at the entrainment frequency (~0.12 Hz) in both the HRV and the EEG while the subject is in the entrained state.

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ducted signals and increased coherence in the vascular system. The results of this experiment provide one example of how increasing coherence in the heart rhythms, by intentionally generating positive emotions, can alter brain activity.

CARDIAC COHERENCE INCREASES HEART-BRAIN SYNCHRONIZATION

Influence of afferent cardiovascular input on cognitive performance and alpha activity [Abst.]. Rollin McCraty, PhD and Mike Atkinson. In: Proceedings of the Annual Meeting of the Pavlovian Society, Tarrytown, NY, 1999. Full paper in preparation.

Key findings: *The brain's alpha wave activity is synchronized to the cardiac cycle. During states of high heart rhythm coherence, alpha wave synchronization to the heart's activity significantly increases.*

Summary: This investigation explores further how the heart's activity influences that of the brain. In this pilot study, *heartbeat evoked potentials* were analyzed in ten individuals. The analysis of heartbeat evoked potentials is a signal processing technique used to identify segments of the EEG (brainwaves) that are correlated to or affected by the heartbeat (Figure 14). In this way, it is possible to determine specific changes in the brain's electrical activity that are associated with afferent signals from the heart.

The subjects' EEGs were recorded using electrodes placed along the medial line and the frontal sites. To determine which brainwave frequencies showed cardiac-related activity, the region of the EEG between 50 and 600 milliseconds post R-wave was then subjected to spectrum analysis. As a control, this procedure was repeated but instead of using the ECG as the signal source, an artificial, randomly generated signal with the same mean inter-beat interval and standard deviation as the original ECG was used for the time reference. It was found that the brain's alpha wave activity (8-12 Hz frequency range) is synchronized to the cardiac cycle. There was significantly more alpha rhythm synchronization when the real ECG was used for the signal source as compared to the control signals. Additionally, analyses revealed that brainwave activity at a lower frequency than alpha is also synchronized to the ECG signal.

In the next phase of the study, we sought to determine if there is a change in the degree of alpha rhythm synchronization to the ECG during periods of increased heart rhythm coherence. In this phase, subjects used the Cut-Thru technique, an emotional refocusing exercise, a means of quieting inner emotional dialogue, instilling a positive emotional state and increasing heart rhythm coherence. Subjects' heart rhythm coherence and heartbeat evoked potentials were analyzed during a 10-minute baseline period, and again while they practiced the Cut-Thru technique for 10 minutes. There was a significant increase in heart rhythm coherence during the period that subjects used the Cut-Thru technique. Heartbeat evoked potential data showed that in this state of increased heart rhythm coherence, alpha wave synchronization to the cardiac cycle increases significantly (Figure 15).

In conclusion, this study shows that the brain's activity is naturally synchronized to that of the heart, and also confirms that intentionally altering one's emotional state through heart focus modifies afferent neurological input from the heart to the brain. Results indicate that the brain's electrical activity becomes more synchronized during psychophysiologically coherent states. Implications are that this increased synchronization may alter information processing by the brain during the experience of positive emotions.

The Brain's Response to the Heart's Signals

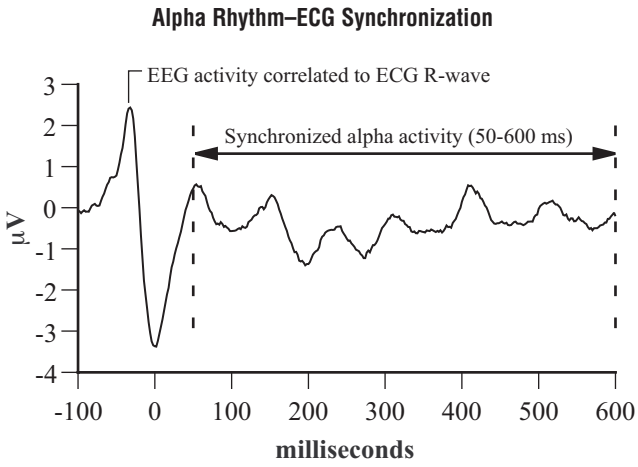

Figure 14. Signal averaging is a technique used to trace afferent neural signals from the heart to the brain. The ECG R-wave is used as the timing source for event-related changes in the brain's activity, and the resulting waveform is called a *heartbeat evoked potential*. This graph illustrates an example of a heartbeat evoked potential waveform showing alpha activity in the EEG that is synchronized to the cardiac cycle.

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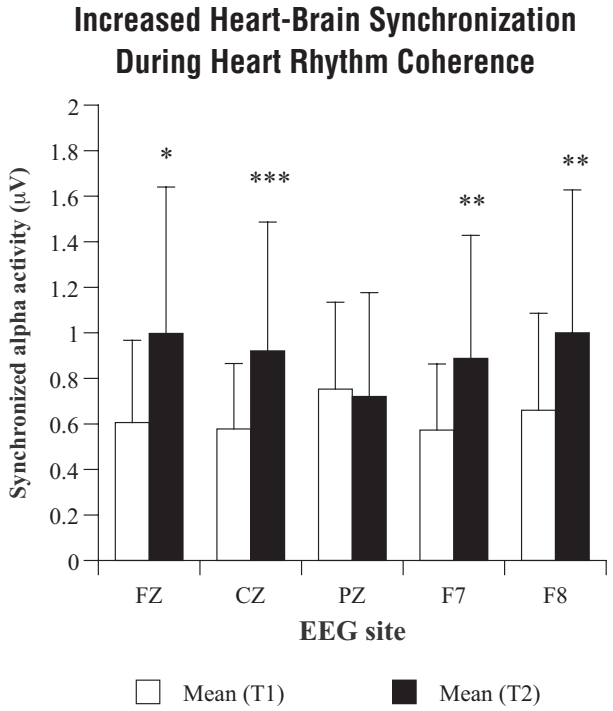

Figure 15. Changes in alpha wave synchronization during high heart rhythm coherence. There was a significant increase in alpha rhythm synchronization to the ECG at most EEG sites during the use of the Cut-Thru intervention (high heart rhythm coherence). *p <.05, **p <.01, ***p <.001.

CARDIAC COHERENCE IMPROVES COGNITIVE PERFORMANCE

Influence of afferent cardiovascular input on cognitive performance and alpha activity [Abst.]. Rollin McCraty, PhD and Mike Atkinson. In: Proceedings of the Annual Meeting of the Pavlovian Society, Tarrytown, NY, 1999. Full paper in preparation.

Key findings: *States of increased heart rhythm coherence are associated with improvements in cognitive performance.*

Summary: Given our previous findings (above) indicating that states of increased heart rhythm coherence give rise to distinct changes in the brain's activity, we subsequently performed an experiment to determine whether these changes might have a measurable impact on cognitive performance. Thus, this study assessed changes in cognitive performance associated with states of increased heart rhythm coherence. In this investigation, 30 subjects were randomly divided into matched control and experimental groups based on age and gender. Cognitive performance was assessed by determining subjects' reaction times in an oddball auditory discrimination task before and after practicing the Cut-Thru emotional self-management technique to increase cardiac coherence. In this test, subjects listened to a series of two different tones through headphones. They were presented with 300 tones, each with a 50-millisecond duration. Eighty percent of the tones were 1000 Hertz sine waves (standard), and the other 20 percent were 1100 Hertz tones (odd) randomly mixed in between the standard tones, spaced around two seconds apart. Subjects were instructed to push a button as quickly as possible upon hearing an odd tone. The interval between the presentation of the tone and the pressing of the button is the reaction time.

Following a 10-minute baseline period, subjects were given a practice session to gain familiarity with pressing the button and identifying the different tones. This was followed by the first 10-minute auditory discrimination task. Thereafter, the experimental group subjects were asked to employ the Cut-Thru self-management technique for 10 minutes, while control subjects engaged in a relaxation period during this interval. Following this, all subjects performed a second 10-minute auditory discrimination task, the results of which were compared to the first. Subjects' ECGs, pulse transit time and respiration were continuously monitored throughout this entire experimental sequence.

Heart rhythm coherence, derived from the ECG, was calculated for all subjects during each phase of the testing sequence. As shown in Figure 16, there was a

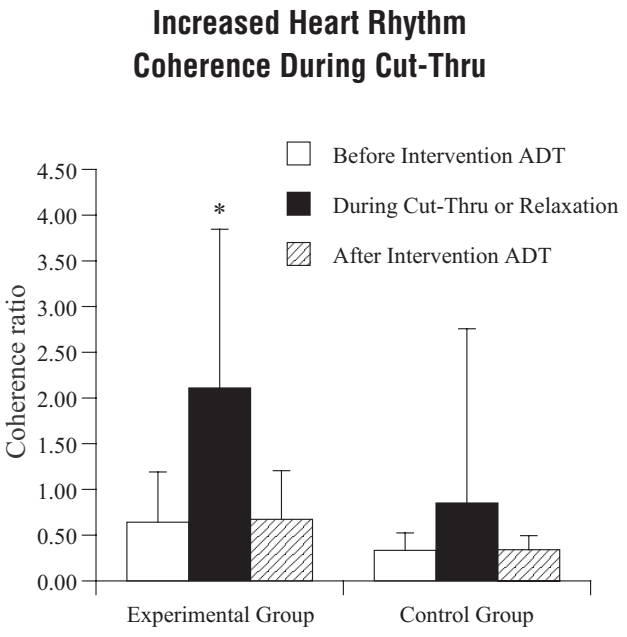

Figure 16. Shows changes in heart rhythm coherence across experimental conditions. The experimental group used the Cut-Thru intervention in the interval between the two auditory discrimination tasks, while the control group engaged in a relaxation period during this time. (ADT = auditory discrimination task.) *p < .05.

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significant increase in heart rhythm coherence in the subjects who used the Cut-Thru technique that was not evident in the relaxation group.

As compared to the control group, subjects using the Cut-Thru technique demonstrated a significant decrease in reaction times in the discrimination task following the application of the technique, indicating improved cognitive performance (Figure 17). In addition, a significant relationship was found between the degree of heart rhythm coherence and reaction times. Increased cardiac coherence was associated with a significant decrease in reaction times (improved performance).

The results of this study support the hypothesis that the changes in brain activity that occur during states of increased psychophysiological coherence lead to changes in the brain's information processing capabilities. Results suggest that by using heart-based interventions to self-generate coherent states, individuals can significantly enhance cognitive performance.

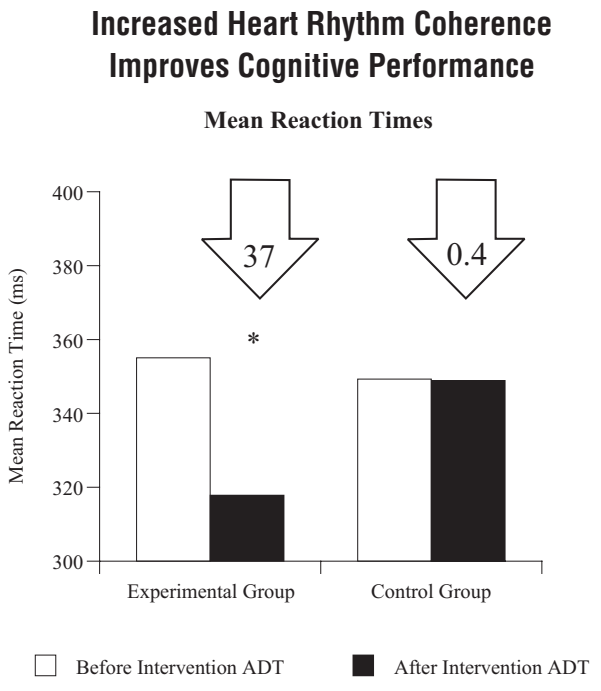

Figure 17. Mean reaction times for the experimental versus control group during the first (pre-intervention) and second (post-intervention) auditory discrimination tasks. By using the Cut-Thru technique to generate a state of increased heart rhythm coherence, the experimental group achieved a significant reduction in mean reaction time, indicative of improved cognitive performance. Note that control group participants, who simply relaxed during the interval between tests, showed no change in mean reaction time from the first to the second discrimination task. (ADT = auditory discrimination task.) $*p < .05$.

THE ELECTRICITY OF TOUCH: DETECTION AND MEASUREMENT OF CARDIAC ENERGY EXCHANGE BETWEEN PEOPLE

Rollin McCraty, MA, Mike Atkinson, Dana Tomasino, BA and William A. Tiller, PhD. In: Proceedings of the Fifth Appalachian Conference on Neurobehavioral Dynamics: Brain and Values. 1997. Mahwah, NJ: Lawrence Erlbaum Associates.

Key findings: *When people touch or are in proximity, one person's heartbeat signal is registered in the other person's brainwaves.*

Summary: The concept of an energy exchange between individuals is central to many healing techniques. This concept has often been disputed by Western science due to the lack of a plausible mechanism to explain the nature of this energy or how it could affect or facilitate the healing process. The fact that the heart generates the strongest electromagnetic field produced by the body, coupled with our findings that this field becomes measurably more coherent as the individual shifts to a sincerely loving or caring state, prompted us to investigate the possibility that the field generated by the heart may significantly contribute to this energy exchange. This study presents a sampling of results which provide intriguing evidence that an exchange of electromagnetic energy produced by the heart occurs when people touch or are in proximity. Signal averaging techniques are used to show that one person's electrocardiogram (ECG) signal is registered in another's electroencephalogram (EEG) and elsewhere on the other person's body (See Figure 18 for an example). While this signal

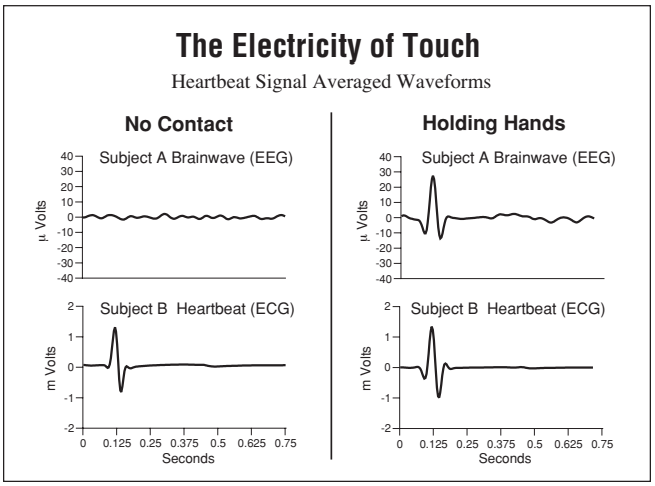

Figure 18. Heartbeat signal averaged waveforms showing a transference of the electrical energy generated by Subject B's heart which can be detected in Subject A's EEG (brainwaves) when they hold hands.

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is strongest when people are in contact, it is still detectable when subjects are in proximity without contact.

This study represents one of the first successful attempts to directly measure an energy exchange between people, and provides a solid, testable theory to explain the observed effects of many healing modalities that are based upon the assumption that an energy exchange takes place. Nonlinear stochastic resonance is a mechanism by which weak, coherent electromagnetic fields, such as those generated by the heart of an individual in a caring state, may be detected and amplified by biological tissue, and potentially produce measurable effects in living systems. Evidence that the cardiac field changes as different emotions are experienced, combined with this study's finding that this field is registered physiologically by those around us, provides the foundation of one possible mechanism to describe the impact of our emotions on others at a basic physiological level. One implication is that the effects of therapeutic techniques involving contact or proximity between practitioner and patient could be amplified by practitioners consciously adopting a sincere, caring attitude, and thus increasing coherence in their cardiac field.

THE ROLE OF PHYSIOLOGICAL COHERENCE IN THE DETECTION AND MEASUREMENT OF CARDIAC ENERGY EXCHANGE BETWEEN PEOPLE

Rollin McCraty, PhD, Mike Atkinson and William A. Tiller, PhD. In: Proceedings of the Tenth International Montreux Congress on Stress, Montreux, Switzerland, 1999.

Key findings: *When two people are at a conversational distance, the electromagnetic signal generated by one person's heart can influence the other person's brain rhythms. When an individual is generating a coherent heart rhythm, synchronization between that individual's brainwaves and another person's heartbeat is more likely to occur.*

Summary: This investigation was designed to determine whether cardioelectromagnetic communication between individuals is affected by the degree of subjects' cardiac coherence. In this experiment we looked at heart-brain interaction effects across larger distances in subject pairs who were not in physical contact. As in the previous study, subjects' ECGs and EEGs were simultaneously monitored, and signal averaging techniques were employed to discern heart-brain interaction effects. In addition, heart rate variability patterns were analyzed to determine the degree of heart rhythm coherence for each subject.

Data showed that in subjects separated by several feet, synchronization can occur between the alpha waves in one person's EEG and the other's ECG signal. However, in this experiment, whether the "receiving" subject's brainwaves synchronized to the "source" subject's heart signal was determined by the degree of coherence in the *receiving subject's* heart rhythms. Subjects who demonstrated high heart rhythm coherence were more likely to show alpha wave synchronization to the other subject's ECG. This effect was not apparent in subjects with low heart rhythm coherence.

Figure 19 shows the results for one set of subjects who were seated four feet apart, facing each other. Note the change in Subject 2's brainwave patterns (onset of alpha rhythms) that is synchronized to the R-wave of Subject 1's ECG. The bottom-most trace displays Subject 2's heart rhythm patterns, which were highly coherent during this experiment. Figure 20 is an over-

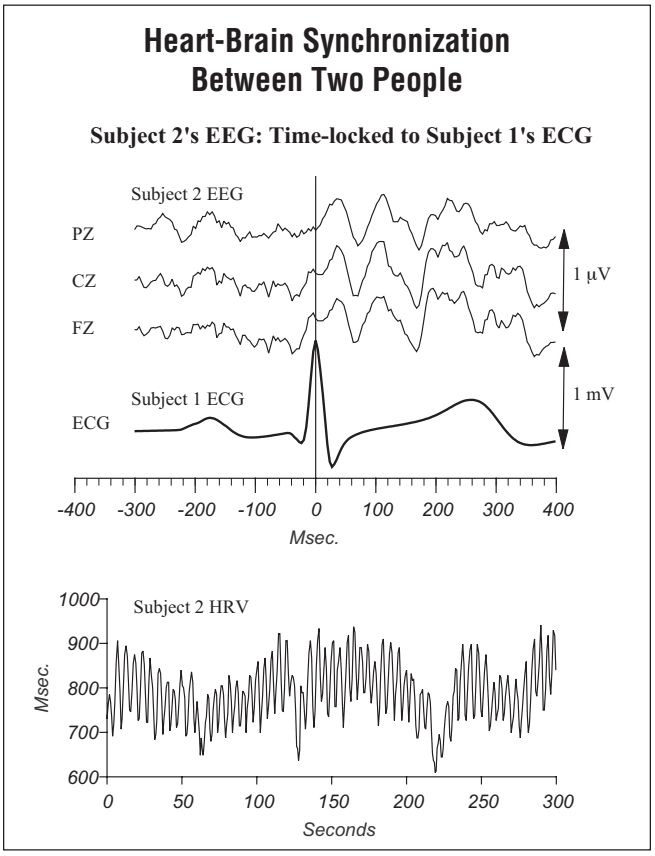

Figure 19. This set of graphs shows an example of the heart-brain synchronization that can occur between two people at a conversational distance. The top three traces are Subject 2's brainwaves, which are synchronized to Subject 1's ECG (heartbeat signal). Below that is Subject 1's signal averaged ECG waveform, which was used as the timing source for the signal averaging. The lower graph is a sample of Subject 2's heart rhythm pattern, which was coherent throughout the majority of the record. Interestingly, only those subjects with high heart rhythm coherence displayed brainwave synchronization to their partner's heart signal.

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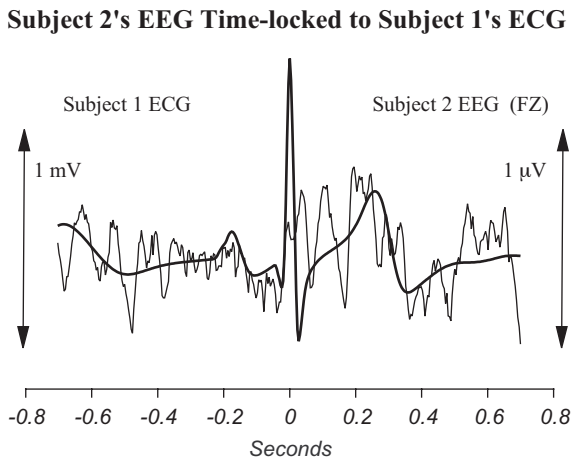

Figure 20. This graph is an overlay plot of the same EEG and ECG data shown in Figure 19. Note the similarity of the wave shapes, indicating a high degree of synchronization.

lay plot of one of Subject 2's EEG traces and Subject 1's ECG. Note the similarity of the wave shapes, indicating a high degree of synchronization between the two waves.

This study's findings have intriguing implications, suggesting that individuals in a physiologically coherent state become more sensitive to the subtle electromagnetic information encoded in the heart signals of others around them. Interestingly, this also supports extensive behavioral data and experience with a HeartMath communication technique called *Intuitive Listening*. This technique involves focusing on the heart and maintaining a neutral or appreciative attitude while listening to another person. When individuals apply this tool, they often not only report hearing the speaker's words with more clarity and focus because of a reduction in their own internal dialogue, but also acknowledge becoming more aware of deeper and more subtle aspects of the communication that are not contained in the words alone. This is often described as an increased sensitivity and intuitive awareness of the other person's underlying feelings and the "essence" of their communication. The results shown above support the concept that this deeper, more sensitive form of communication, which establishes a heartfelt connection between people, may occur based on the increased heart rhythm coherence generated by the listener (receiver) when using the Intuitive Listening technique.

In conclusion, this study represents a further step in uncovering the physiological underpinnings of subtle, ongoing energetic forms of communication between people. Results have countless implications, and invite continued scientific exploration of the relationship between emotions, physiology and human interactions.

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Emotional Balance and Health

The studies reviewed in this section continue to illustrate the direct and profound impact that emotions exercise on overall health. They also provide data demonstrating how emotional management and intentional shifts to sincere positive feeling states achieved via HeartMath techniques can cause substantial favorable changes in a number of key indicators of physiological and psychological well-being.

> *75 to 90% of all visits to primary care physicians result from stress-related disorders.*
>
> Paul Rosch, M.D., President, American Institute of Stress

Several important physiological parameters were measured in these investigations. The first study examines the impact of different emotions on secretory immunoglobulin A (S-IgA). S-IgA is the predominant antibody class found in mucosal secretions and is the first line of defense against pathogens in the upper respiratory tract, the gastrointestinal system and the urinary tract. Because cells that produce this antibody (B-lymphocytes) are a major component of the immune system, S-IgA levels are also viewed as an indicator of overall immune function.

Another study in this section assesses changes in the levels of two essential hormones, DHEA and cortisol, in a group of people who practiced a HeartMath emotional management intervention over one month's time. DHEA, known as the "anti-aging hormone," is the precursor to the human sex hormones estrogen and testosterone. Its varied physiological effects include enhancing the immune system, stimulating bone deposition, lowering cholesterol levels and building muscle mass. DHEA has been found to be deficient in individuals who suffer from many diseases, including obesity, diabetes, hypertension, cancer, Alzheimer's, immune deficiency, coronary artery disease and various autoimmune disorders. Cortisol, a glucocorticoid hormone, is involved in protein, carbohydrate and fat metabolism and is widely known as the "stress hormone" because it is secreted in excessive amounts when people are under stress.

- *Separate studies showed that the risk of developing heart disease is significantly increased for people who impulsively vent their anger as well as for those who tend to repress angry feelings.*
  A. Siegman et al. J Behav Med. 1998; 21(4)
  D. Carroll et al. J Epidemiol Comm Health. 1998; Sept.
- *In a groundbreaking study of 1,200 people at high risk of poor health, those who learned to alter unhealthy mental and emotional attitudes through self-regulation training were more than four times more likely to be alive 13 years later than an equal-sized control group.*
  R. Grossarth-Maticek & H. Eysenck. Behav Res Ther. 1991; 29(1)

> *"We are coming to understand health not as the absence of disease, but rather as the process by which individuals maintain their sense of coherence (i.e. sense that life is comprehensible, manageable, and meaningful) and ability to function in the face of changes in themselves and their relationships with their environment."*
>
> Aaron Antonovsky (1987). *Unraveling the Mystery of Health: How People Manage Stress and Stay Well.*

In recent years a number of investigators have proposed the DHEA/cortisol ratio to be an important biological marker of stress and aging. When individuals are under prolonged stress, a divergence in this ratio results, as cortisol levels continue to rise while DHEA levels decrease significantly. The effects of DHEA/cortisol imbalance can be severe, and may include elevated blood sugar levels, increased bone loss, compromised immune function, decreased skin repair and regeneration, increased fat accumulation and brain cell destruction.

That effective emotional management can have such profound positive effects on the cardiovascular, immune, hormonal and autonomic nervous systems may provide a basis for the improved physical health and vitality reported by many individuals who regularly use the HeartMath tools. These effects may also help explain the health improvements and symptom reduction experienced by individuals suffering from diverse diseases and disorders after using the techniques (results described in *Clinical Research* section).

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THE PHYSIOLOGICAL AND PSYCHOLOGICAL EFFECTS OF COMPASSION AND ANGER

Glen Rein, PhD, Mike Atkinson and Rollin McCraty, PhD.
Journal of Advancement in Medicine. 1995; 8 (2): 87-105.

Key findings: *Heart-focused, sincere, positive feeling states boost the immune system, while negative emotions may suppress the immune response for up to six hours following the emotional experience.*

Summary: Secretory IgA (measured from saliva samples), heart rate and mood were measured in thirty individuals before and after experiencing the emotional states of either care and compassion or anger and frustration. Two methods of inducing the emotional states were compared: self-induction versus external induction via video tapes. Anger produced a significant increase in total mood disturbance and heart rate but not in S-IgA levels. On the other hand, sincere positive feeling states of care and compassion, self-induced via the Freeze-Frame technique, produced a significant decrease in total mood disturbance and a significant increase in S-IgA levels. Examining the effects over a 6-hour period, we observed that a 5-minute experience of anger produced a significant inhibition of S-IgA from one to five hours after the emotional experience. In contrast, a tendency toward increased S-IgA levels was observed over the six hours following a 5-minute experience of care (Figure 21).

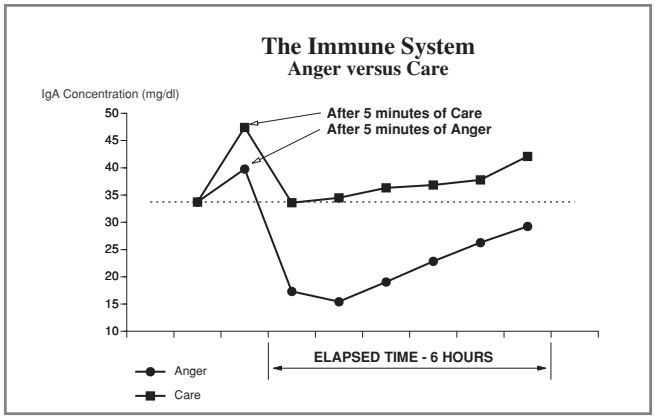

Figure 21. This graph shows the impact of one 5-minute episode of recalled anger on the immune antibody IgA over a 6-hour period. The initial slight increase in IgA was followed by a dramatic drop which persisted for six hours. When the subjects used the Freeze-Frame technique and focused on feeling sincere care for five minutes there was a significant increase in IgA, which returned to baseline an hour later and then slowly increased throughout the rest of the day.

Results indicate that self-induction of positive emotional states using Freeze-Frame is more effective in stimulating S-IgA levels than previously used external methods. In a previous study, "The effects of emotions on short-term power spectral analysis of heart rate variability" (*Entrainment, Coherence and Autonomic Balance* section), we observed that feelings of appreciation self-generated by the Freeze-Frame technique shift autonomic nervous system balance towards increased parasympathetic activity. As salivary secretion is primarily activated by parasympathetic nerves, autonomic regulation offers a possible mechanism to explain the immediate increases in S-IgA following the experience of positive emotions. The results of this study indicate that the Freeze-Frame technique may be an effective method to improve mood and minimize the long-term immunosuppressive effects of negative emotions.

THE IMPACT OF A NEW EMOTIONAL SELF-MANAGEMENT PROGRAM ON STRESS, EMOTIONS, HEART RATE VARIABILITY, DHEA AND CORTISOL

Rollin McCraty, PhD, Bob Barrios-Choplin, PhD, Deborah Rozman, PhD, Mike Atkinson and Alan D. Watkins, MBBS.
Integrative Physiological and Behavioral Science. 1998; 33 (2): 151-170.

Key findings: *Subjects who used the Cut-Thru and Heart Lock-In interventions for one month significantly reduced their cortisol levels and increased their DHEA. These positive shifts in hormonal balance occurred in conjunction with significant improvements in emotional health, including reductions in stress, anxiety, burnout and guilt, along with increases in caring and vigor.*

Summary: This study examined the effects on healthy adults of a new stress reduction and emotional management program consisting of two key techniques, Cut-Thru and the Heart Lock-In. These techniques are designed to create and sustain shifts in dispositional orientation toward stressors by changing interpretive styles, breaking negative thought loops and extinguishing unhealthy emotional patterns. It is postulated that recurring negative emotional patterns may lead to adverse effects on physiology and well-being through unnecessary and inappropriate activation of the autonomic nervous system and glucocorticoid secretions. This research therefore examined the effects of the Cut-Thru and Heart Lock-

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In techniques on participants' emotions, stress, cortisol/DHEA levels and autonomic nervous system balance.

Forty-five healthy adults participated in the study, fifteen of whom acted as controls. DHEA and cortisol levels were measured from saliva samples, autonomic nervous system balance was assessed by heart rate variability analysis, and emotions were measured with a psychological questionnaire. Individuals in the experimental group were assessed before and four weeks after receiving training in the stress management techniques. To facilitate the heart focus and emotional shifts, participants practiced the Cut-Thru technique during a Heart Lock-In with the music *Speed of Balance* five times a week during the study period. Participants also used Cut-Thru any time they felt out of balance emotionally.

After one month, the experimental group experienced significant increases in Caring and Vigor and significant decreases in Guilt, Hostility, Burnout, Anxiety and Stress Effects, while no significant changes were seen in the control group. There was a mean 23% reduction in cortisol and a 100% increase in DHEA levels in the experimental group. A positive shift in autonomic nervous system balance was measured in 80% of the sample during the use of the techniques. Some of the participants developed the entrainment mode of heart function while using the Cut-Thru technique during a Heart Lock-In (Figure 23).

The significant increase in subjects' DHEA/cortisol ratio was in accordance with the psychological results, which showed a significant reduction in stress, burnout and negative emotion experienced by participants as a result of using the techniques. Reduced stress diminishes the system's cortisol demand, and

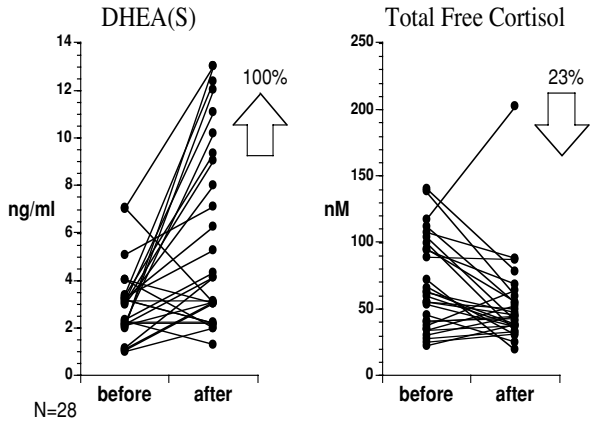

Figure 22. DHEA and cortisol values before and after subjects were trained in and practiced the Cut-Thru technique for one month. There was a 100% average increase in DHEA and a 23% decrease in cortisol.

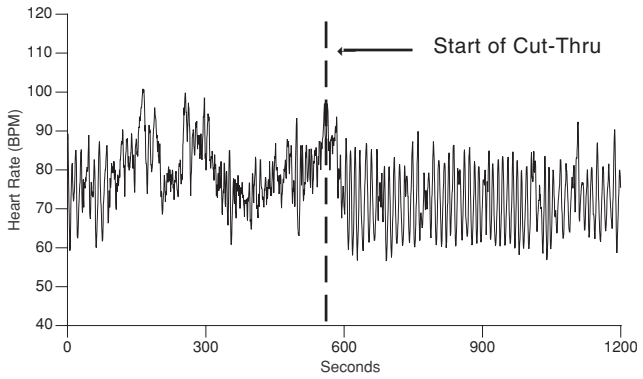

Figure 23. This graph is a typical HRV example from one of the subjects while practicing the Cut-Thru technique (beginning at approximately 600 seconds). Here the subject developed the entrainment state, which is indicative of autonomic system balance and physiological coherence.

can result in the diversion of pregnenolone, a common precursor of DHEA and cortisol, from cortisol production into DHEA synthesis. Additionally, the entrainment mode achieved by many of the participants during the use of the techniques is characterized by increased baroreceptor activity. Baroreceptor stimulation has been demonstrated to cause a reflex decrease in plasma cortisol levels, believed to be due to inhibition of ACTH at the pituitary gland. Given that the normal physiological variability of DHEA and cortisol levels from month to month is nonsignificant, the exceptional average increase in subjects' DHEA/cortisol ratio measured after one month of practice of Cut-Thru is noteworthy and consistent with our hypothesis that Cut-Thru facilitates the release and reprogramming of draining mental and emotional memory traces at the level of the brain's neural circuitry.

This study advances our understanding of stress and emotional responses in several ways. First, it establishes that interpretive styles associated with stress and negative emotions can be changed within a short period of time. Second, it illustrates that these changed perspectives do influence stress, emotions and key physiological parameters. The substantial changes observed in the neuroendocrine measures support the concept that perceptions and emotions can affect health, as these hormones are significantly correlated to health outcomes. Finally, results suggest that people have greater control over their health than previously recognized, as participants who learned to "reprogram" their conditioned emotional responses experienced significantly lower stress levels, less negative emotion and increased positive emotion, all vital building blocks to a healthier lifestyle.

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Music Research

The research studies summarized thus far in this Overview, taken together, have painted a picture of the profound favorable effects that mental/emotional balance and heart-focused positive feeling states have on the body and psyche—from promoting increased autonomic balance and greater coherence in cardiac and brain function, to boosting natural immunity and DHEA levels, to significantly reducing stress and negative affect and increasing positive affect. Understanding the significance of this impressive range of effects, as well as the power of music as a universal mode of expression, Doc Childre, as a composer, sought to scientifically design music for the specific purpose of promoting mental and emotional balance in listeners, facilitating the experience of heart-focused positive feeling states and the use of the HeartMath tools. Through several years of research in IHM's 24-track recording studio, Childre created two musical works which integrate specific rhythmic patterns, tone textures, chord progressions and harmonic resonances to produce their intended effects. The results of the research studies reviewed in this section clearly demonstrate this music to elicit specific beneficial responses in listeners' physiological, mental and emotional systems.

Music that Enhances Emotional Balance and Mental Clarity

Doc's first release, *Heart Zones*, spent 50 consecutive weeks on Billboard's Adult Alternative chart and introduced a new musical genre: "designer music," a term used to describe music that is intentionally designed to affect the listener in specific ways. *Heart Zones* was specifically designed to facilitate stress reduction, boost vitality and increase buoyancy and clarity. The music has been described as a "mental and emotional workout" and is intended to produce a "calm yet energetic alertness" in the listener. Childre's second designer music release, entitled *Speed of Balance - A Musical Adventure for Mental and Emotional Regeneration*, was composed with the intent to facilitate mental and emotional balance in listeners, enabling people to experience clearer and more positive perceptions. Among the intended effects of *Speed of Balance* are to energize the listener, enhance creativity and improve clear decision making.

Numerous studies have shown that music affects emotions and mood states and can also modify physiological responses. It is well recognized, as demonstrated in many of the papers summarized in this overview, that changes in mental and emotional activity alter autonomic nervous system function. The ANS, in turn, regulates cardiovascular, neuroendocrine and immune system activity. Thus, it is postulated that since music alters mood and emotional state, the immune, hormonal, cardiovascular and other physiological changes observed after people listen to music are likely to be mediated by the ANS.

The studies presented below provide evidence that it is through this mechanism that Childre's designer music exerts its effects on listeners. In the first study, *Heart Zones*, in contrast to other types of music tested, is shown to produce significant increases in listeners' secretory IgA levels, accompanied by corresponding increases in total autonomic activity. The second study demonstrates that *Speed of Balance* significantly affects listeners' mood and emotions, producing significantly greater increases in positive affect and decreases in negative affect than any other form of music tested. It appears that it is these profound favorable shifts in emotional state that directly impact the ANS, giving rise to the beneficial physiological repercussions of the music. This is further supported by the results seen when the music is used in conjunction with the HeartMath techniques. While research shows that simply casually listening to *Heart Zones* and *Speed of Balance* produces significant beneficial psychological and physiological effects, both pieces of music were designed to be maximally effective when used to facilitate the practice of the HeartMath emotional management interventions. Both studies below demonstrate that when people listen to *Heart Zones* or *Speed of Balance* while sustaining a sincere, heart-focused state of appreciation through the Heart Lock-In technique, significantly larger positive emotional, mental and physiological shifts are experienced as compared to listening to the music alone.

While the two studies reviewed below were specifically designed to examine the effects of the music, Childre's music was also used in conjunction with the Heart Lock-In and Cut-Thru interventions in a number of other studies described in this Overview (see *Emotional Balance and Health* and *Clinical Research* sections). In addition, a growing number of case histories are demonstrating programs combining the use of the music with the HeartMath techniques to be effective in improving autonomic imbalances and symptomatology associated with many clinical conditions. *Heart*

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Zones has been shown to be particularly effective in facilitating the entrainment mode of cardiac function and restoring autonomic balance in patients with hypertension, arrhythmias and fatigue, while *Speed of Balance* is conducive to promoting emotional regeneration in individuals with anxiety, depression and panic disorder. The results suggest that regular use of music to facilitate emotional management interventions can be an inexpensive, effective method to generate significant psychological and physiological benefits.

MUSIC ENHANCES THE EFFECT OF POSITIVE EMOTIONAL STATES ON SALIVARY IGA

Rollin McCraty, PhD, Mike Atkinson, Glen Rein, PhD and Alan D. Watkins, MBBS. Stress Medicine. 1996; 12 (3): 167-175.

Key findings: *Music designed to promote mental and emotional balance can increase autonomic power and heighten the beneficial effects of positive emotional states on the immune system.*

Summary: This study examined the effect of music and positive emotional states on autonomic nervous system and immune system function in healthy individuals. Autonomic activity was assessed using power spectral density analysis of heart rate variability, and secretory IgA, measured from saliva samples, was used as a marker of immunity. The effects of rock and New Age music were compared to the designer music release *Heart Zones*, composed by Doc Childre. This music was specifically designed to facilitate mental and emotional balance, boost vitality, enhance learning and promote autonomic nervous system balance. Subjects listened to each category of music for 15 minutes on separate days. In addition, two separate sessions were conducted to test the effects of subjects sustaining a sincere, focused state of appreciation using the Heart Lock-In technique. In one session, subjects practiced the Heart Lock-In technique for 15 minutes with no music; in the other session, subjects performed the Heart Lock-In while listening to *Heart Zones*, which was specifically designed to facilitate the practice and heighten the beneficial effects of this technique.

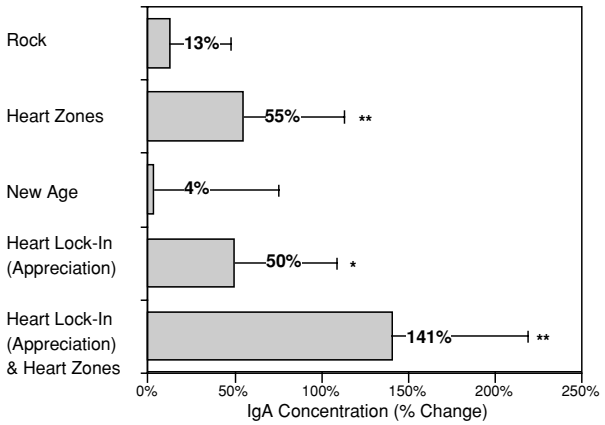

Figure 24. Average change in IgA levels after listening to the different types of music, doing a Heart Lock-In without music and a Heart Lock-In facilitated with the *Heart Zones* music. Note the synergistic effect of the Lock-In and *Heart Zones*. *$p < .05$, **$p < .01$.

There were significant increases in total autonomic activity and in S-IgA concentrations during the *Heart Zones* music session, the Heart Lock-In session and during the session combining the Heart Lock-In and *Heart Zones* music. In contrast, there were no significant changes in total autonomic activity or S-IgA concentrations during the New Age, rock music or no music control sessions. While both *Heart Zones* and the Heart Lock-In alone significantly increased S-IgA levels (increases of 55% and 50%, respectively, were measured), the combination of *Heart Zones* and the Heart Lock-In produced a significantly greater immunoenhancement (141% increase in S-IgA levels) than either condition alone (Figure 24).

This study provides evidence that the immunoenhancing effects of designer music and self-induced states of appreciation may be mediated by the autonomic nervous system, as an increase in autonomic spectral power was measured in all cases in which there was an increase in S-IgA. Our results demonstrate that *Heart Zones* music is effective in potentiating the immunoenhancing effects of the Heart Lock-In technique. We conclude that music can be designed to enhance the beneficial effects of positive emotional states on immunity and suggest that music and emotional self management may yield significant health benefits in a variety of clinical situations in which there is immunosuppression and autonomic imbalance.

THE EFFECTS OF DIFFERENT MUSIC ON MOOD, TENSION AND MENTAL CLARITY

Rollin McCraty, PhD, Bob Barrios-Choplin, PhD, Mike Atkinson and Dana Tomasino, BA. Alternative Therapies in Health and Medicine. 1998; 4 (1): 75-84.

Key findings: *Music designed to facilitate mental and emotional balance can produce significant increases in positive moods, vigor and mental clarity and decreases in tension, burnout and negative moods.*

***Summary*:** The previous study, "Music enhances the effect of positive emotional states on salivary IgA," demonstrated that designer music and the Heart Lock-

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In technique produce measurable changes in subjects' autonomic nervous system activity and immune function. In the present study, we provide evidence to support the hypothesis that these favorable shifts derive from positive changes produced in subjects' mood and emotional states, which are well known to affect the ANS.

This study investigated the impact of different types of music on individuals' tension, mood and mental clarity. A total of 144 adult and teenage subjects completed a psychological profile before and after listening for 15 minutes to four types of music: grunge rock, classical, New Age and designer. The designer music used in this study was *Speed of Balance*, created by Doc Childre to facilitate mental and emotional balance and help people experience clearer and more positive perceptions. The music is specifically intended to enhance creativity, promote clear decision making and boost physical energy. The effects of *Speed of Balance* were examined in two experimental conditions: first, in comparison to the other types of music in all subjects, and again, in a subgroup of individuals who practiced the Heart Lock-In technique while listening to the music.

Grunge rock music produced significant increases in hostility, fatigue, sadness and tension and led to significant reductions in caring, relaxation, mental clarity and vigor. In contrast, *Speed of Balance* produced significant increases in all positive scales: caring, relaxation, mental clarity and vigor. Significant decreases were produced in all negative scales: hostility, fatigue, sadness and tension. Both the adult and teenage subgroups were negatively affected by the grunge rock music and positively affected by *Speed of Balance*, with very little difference between the two groups' responses. Results for New Age and classical music were mixed (Figure 25).

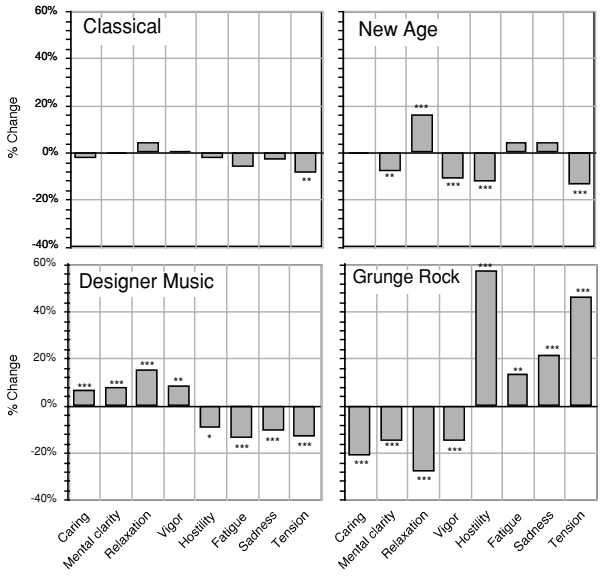

Figure 25. Percent change in mood, tension and mental clarity for each category of music. *$p < .05$, **$p < .01$, ***$p < .001$.

When participants listened to *Speed of Balance* while self-generating a sincere feeling of appreciation using the Heart Lock-In technique, the beneficial effects were heightened: Subjects experienced increases in caring, mental clarity and vigor which were significantly greater than the favorable shifts produced from listening to the music alone (Figure 26). Results indicate that all types of music created feeling shifts. Of the music used in this study, *Speed of Balance* was most effective in increasing positive feelings and decreasing negative feelings. Our results support the hypothesis that the positive shifts in autonomic nervous system activity and immune function measured in previous studies employing designer music and the Heart Lock-In technique derive from changes produced in subjects' feeling states. This study presents a rationale for the use of designer music and the Heart Lock-In technique in the treatment of tension, mental distraction and negative moods and the enhancement of emotional well-being and mental clarity. Given the connection between attitudes, emotions and health, these results indicate that music designed to facilitate emotional management can be an inexpensive and easy method to reduce stress and promote overall wellness.

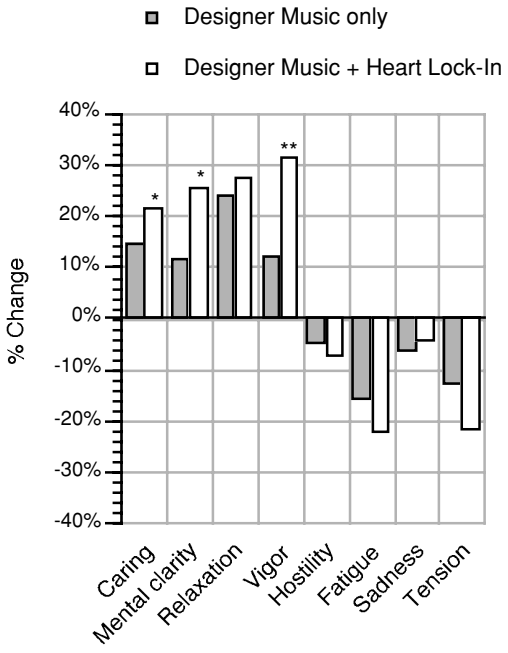

Figure 26. Compares the effects on mood, tension and mental clarity of listening to the *Speed of Balance* music alone versus practicing the Heart Lock-In technique while listening to *Speed of Balance*. The combination of the Lock-In + *Speed of Balance* resulted in significant positive shifts beyond the already significant improvements produced by the music alone. *$p < .05$, **$p < .01$.

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HeartMath Technology in Business

Occupational stress is pervasive and invasive. In a 1992 United Nations Report, "job stress" was cited as "*the* 20th century disease." A recent survey revealed that 75% of Americans describe their jobs as stressful, with more than one in four reporting experiencing high levels of stress "nearly every day." It is currently estimated that 60% of all absenteeism from work is caused by stress, resulting in roughly 1 million persons absent each workday. Moreover, nearly one-fifth of employed adults now acknowledge that workplace stress has caused them to quit a job.

American businesses pay the price of workers who suffer from job-related stress. Recent estimates are that job stress costs employers more than $200 billion a year in absenteeism, tardiness, burnout, lower productivity, high turnover, worker's compensation and medical insurance costs. To put this in perspective, this figure amounts to more than 10 times the cost of all strikes combined, or the sum total profits of the Fortune 500 companies.

Accelerating stress is clearly taking its toll on the health of the workforce. Dr. Paul J. Rosch, President of the American Institute of Stress, reports that 75 to 90% of all visits to healthcare providers result from stress-related disorders. Among the nation's top executives, an estimated $10 to $20 billion is lost each year through absence, hospitalization and early death, much of it a direct result of stress. Multiple long-term studies involving thousands of workers have now demonstrated that people who perceive they have little control over their jobs have significantly increased likelihood of developing heart disease; this association is independent of conventional coronary risk factors, including smoking and high cholesterol levels.

It has become increasingly clear from these and other studies that the leading source of stress for adults is their work. The problem of job stress has become so ubiquitous and so severe it is now described by the United Nations' International Labor Organization as a "global epidemic," with no occupation and no nation proving to be exempt. In this "information age," the world faces on the one hand, countless technological breakthroughs that promise unheard-of conveniences to make life easier for all, and on the other, the stark reality of a workforce that experiences ever-increasing levels of personal imbalance.

- *Job stress costs employers more than $200 billion each year in absenteeism, tardiness, burnout, lower productivity, high turnover, worker's compensation and medical insurance costs.*
  National Safety Council, 1995
- *An estimated 60% of all absenteeism from work is caused by stress.*
  C. Cooper & R. Payne, eds. Causes, Coping and Consequences of Stress at Work. 1988
- *A recent study determined that employees' perceptions of the psychological climate at work influenced job involvement, work effort and work performance.*
  S. Brown et al. J Appl Psychol 1996; 81(4)
- *Depression, a common problem among workers, costs the U.S. $44 billion per year in lost productivity.*
  National Foundation for Brain Research, 1999
- *The California Worker's Compensation Institute determined that job stress claims increased 700% from 1979 to 1988.*
  M. Lehmer et al. J Occup Environ Med. 1997; 39(1)
- *In a recent 3-year analysis of over 46,000 workers from six major U.S. companies, depression and unmanaged stress emerged as the top two most costly risk factors in terms of medical expenditures—increasing health care costs by 2 to 7 times as much as physical risk factors such as smoking, obesity and poor exercise habits.*
  R. Goetzel et al. J Occup Environ Med. 1998; 40(10)
- *A nationwide survey conducted by the New York Business Group on Health revealed that each employee suffering from stress, anxiety or depression is estimated to lose 16 days of work per year, as compared to an average of 4 to 6 lost workdays for all employees.*
  New York Business Group on Health, 1990
- *In a study of over 10,000 government employees, workers who perceived they had little control over their jobs had nearly twice the likelihood of developing coronary heart disease as employees with high perceived job control.*
  H. Bosma et al. British Medical Journal. 1997; 314(7080)
- *In a national survey of 1,305 employed adults, 13% reported that they or their coworkers had committed an act that they would describe as "desk rage" out of stress or anger, and nearly one in five had quit a job because of stress.*
  Caravan Opinion Research Corp. Int'l/L.A. Times, Dec. 10, 2000
- *Sustained positive emotion has been correlated with numerous organizationally-relevant benefits, including increased cognitive flexibility and innovative problem solving, improved decision making, negotiation style, creativity, job performance and achievement.*
  B. Staw et al. Organization Science 1994; 5(1)

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Limitations of Many Stress Management Approaches

Many stress-reduction approaches, such as exercise and fitness programs, time management techniques and nutritional education programs, have been implemented over the past ten to fifteen years to help people cope with increased stress in the workplace. Although some benefits have been realized from these programs, most have not resulted in the desired outcomes, and the level of stress experienced by workers has continued to rise. The proportion of workers who reported feeling "highly stressed" more than doubled from 1985 to 1990. Alarmingly, recent surveys reveal that workplace stress has driven a significant proportion of adults to cry, yell at coworkers, lose sleep, consume alcohol, damage workplace equipment or furniture, call in sick, and even quit their jobs. Increasing eruptions of hostile, explosive and violent behavior in the workplace, recently described as "desk rage," reflect a fundamental level of emotional turmoil among workers that remains unresolved.

> *"The main limitation of most stress-reduction approaches now in use in the workplace is that they do not provide a means to reduce or avoid stress in the moment, as it occurs."*
>
> Doc Childre

While situations, encounters or events may seem intrinsically "stressful," it is truly how an individual perceives and reacts to an event that determines whether or not the stress response is activated. The main limitation of most stress-reduction approaches now in use is that while helpful, they do not target the *real* source of people's stress, enabling them to transform their perceptions and reactions to potentially "stressful" situations in the moment they occur.

Inner Quality Management: Enhancing Human Performance and Organizational Effectiveness

Many businesses have been focusing on reengineering their organizations to enhance productivity and the bottom line. At IHM, researchers realized that any effort to unleash the full power of an organization would have to start with empowering the individual. When individuals are internally self-managed, they operate at their greatest potential, enabling the organization to maximize its productivity and quality. The HeartMath tools and techniques were specifically designed for practical use in the midst of life's fast-paced situations and often unpredictable stresses. Their fundamental purpose—to enable people to transform draining reactions and function with maximum effectiveness *in the moment*—makes them ideally suited for the practical setting of the workplace, where, as the statistics have shown, they are most needed. To enable people to bring the increased coherence associated with heart-focused management of the mind and emotions into the practical setting of the workplace, IHM developed the Inner Quality Management Program, a training program specifically tailored to the needs of businesses and organizations.

IQM Program Modules

- **Internal Self-Management**: *Managing stress and emotions to maximize individual flexibility, creativity and intelligence*
- **Coherent Communication**: *Enhancing information transfer between co-workers, with customers or constituents, and within oneself*
- **Boosting Organizational Climate**: *Creating a caring and healthy workplace culture—one that boosts productivity and effectiveness*
- **Strategic Processes & Renewal**: *Operationalizing the tools to build a coherent and self-renewing organization*

> *"Flexibility and adaptability do not happen just by reacting fast to new information. They arise from mental and emotional balance, the lack of attachment to specific outcomes, and putting care for self and others as a prime operating physiology. Flexible physiology means more resilience in times of challenge or strain. Staying open—emotionally—insures internal flexibility."*
>
> Doc Childre & Bruce Cryer (2000). *From Chaos to Coherence:*

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Many companies have discovered that the information age requires a new type of intelligence for people to sort through, filter and effectively process an incredible flow of information. As laid out in the Introduction to this overview, the physiological incoherence created by unmanaged reactions to stress may actually inhibit brain function, reducing us to extremely limited perspectives. Sadly, many people have adapted so thoroughly to the stressful conditions around them that they hardly realize just how limited their perspectives actually are. The basic premise of Inner Quality Management (IQM) is that as individuals learn to maintain a coherent *internal* environment through mental/emotional management, the heart and brain synchronize, and a synergy of intellectual, intuitive and emotional intelligence takes place. This expands our perspectives, allowing us to transform stressful reactions into healthy responses and effective solutions. It becomes quickly obvious that the benefits extend far beyond stress reduction. Studies with many major organizations have revealed that the IQM tools, sincerely practiced, allow individuals to maximize their personal balance, physical health, intelligence and performance. These benefits, extended to the organization, lead to enhanced interpersonal communication and team dynamics, more effective creative and intuitive problem solving, improved planning and decision making, greater care for customers and co-workers, and overall increased actualization of the organization's full potential.

> *"Living from the heart is business—the business of caring for self and others. Understanding this will take us past the age of information into the age of intuitive living."*
>
> Doc Childre

The following research studies demonstrate the profound impact that training in the IQM techniques has had on employees of diverse organizations. Major improvements were apparent in some cases after only six weeks' practice of the tools learned. The trainings were highly effective in workers at all levels of employment, and proved instrumental in helping several organizations move through particularly difficult circumstances and stressful transitions with increased facility and minimized energy drain. Results indicate that practice of the techniques has not only significantly improved employees' emotional balance and attitudes but has also affected their physical health, resulting in improved autonomic function, increased vitality and reductions in a variety of physical symptoms of stress (including sleeplessness, body aches, indigestion and rapid heartbeats). Notably, case studies show that hypertensive employees who used the HeartMath interventions were able to restore blood pressure levels to normal values without the aid of medication. Furthermore, the techniques have enabled employees to significantly increase their productivity, mental clarity, creativity and enjoyment of their work, improvements that profoundly impact overall workplace quality and effectiveness.

AN INNER QUALITY APPROACH TO REDUCING STRESS AND IMPROVING PHYSICAL AND EMOTIONAL WELLBEING AT WORK

Bob Barrios-Choplin, PhD, Rollin McCraty, PhD and Bruce Cryer, MA. Stress Medicine. 1997; 13 (3): 193-201.

Key findings: *Motorola employees trained in the IQM techniques experienced increased contentment, job satisfaction and communication and decreased tension, anxiety, nervousness and physical symptoms of stress six months after the training program. Blood pressure in hypertensive individuals was restored to normal levels and there were overall improvements in autonomic activity.*

Summary: This exploratory field study examined the impact of the Inner Quality Management program (IQM) on a sample of Motorola managers, engineers and factory workers. Both psychological and physiological measures were assessed. Emotional stressors and social attitudes, physical symptoms of stress and workplace effectiveness were measured by a survey conducted prior to, and three and six months following the training program. Autonomic activity, measured by short-term heart rate variability analysis, and blood pressure were also assessed before the training and again six months afterwards.

Results showed that caring, contentment, job satisfaction and communication significantly increased after the training, while tension, nervousness, anxiety and physical symptoms of stress significantly decreased. Of the 18 managers and engineers whose blood pressure was measured, five were classified as stage 1 or stage 2 hypertensive prior to the training. The number of participants with hypertension equaled 28% of the sample, which corresponds to the national average of 28% of the population with this disorder. None of these individuals were being treated by a doctor or taking any medications to control their hypertension.

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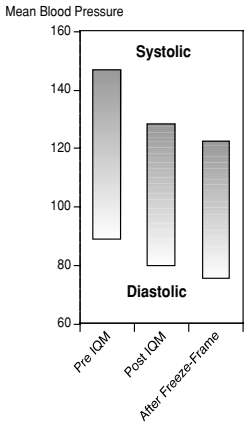
At the end of the six months, all participants were classified as either normal or high normal. Further reductions in blood pressure were achieved when participants practiced the Freeze-Frame technique for five minutes after a resting blood pressure reading was taken (Figure 27). There was also a significant reduction in resting autonomic activity at the end of the six months. This result supports the psychological changes measured, suggesting a shift in participants' baseline emotional state to one of decreased tension and anxiety.

Blood Pressure Measures – Executive Group



Subject #	Pre	Post	After Freeze-Frame	Pre-Post Delta
1	160	137.5	120	-22.5
	98	88	80	-10
2	143	114	115	-29
	76	76	70	0
3	162	138	136	-24
	80	69	65	-11
4	130	130	122	0
	96	87	84	-9
5	139	122	119	-17
	94	79	78	-15
Mean Systolic	146.8	128.3	122.4	-18.5
Diastolic	88.8	79.8	75.4	-9

Figure 27. Graph and table show the blood pressure levels of the five Motorola employees who were classified as hypertensive at the beginning of the 6-month study. After learning and practicing the IQM technology, all of these individuals had blood pressure readings that were classified as normal. Further reductions in blood pressure were achieved when participants used the Freeze-Frame technique for five minutes (see table).

Executives and Engineers Group

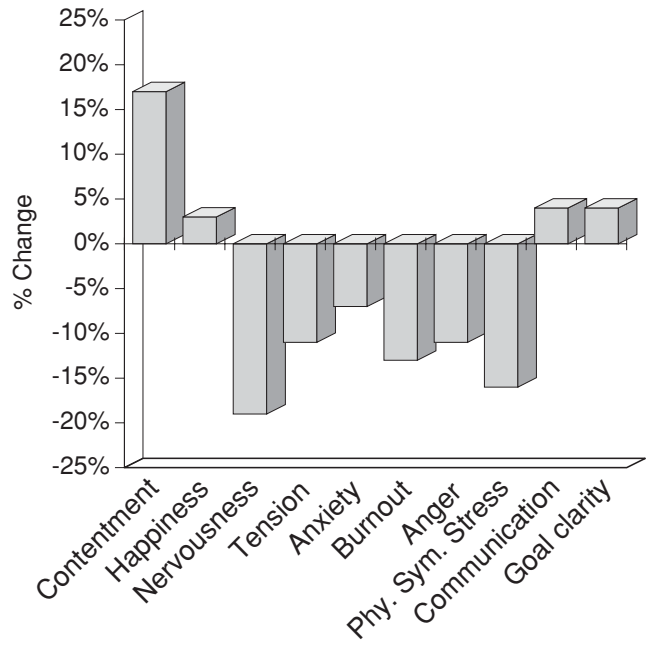


Figure 28. Shows the percent change in psychological measures, physical symptoms of stress and job-related measures for the Motorola executives and engineers group pre/post IQM training.

Factory Workers Group

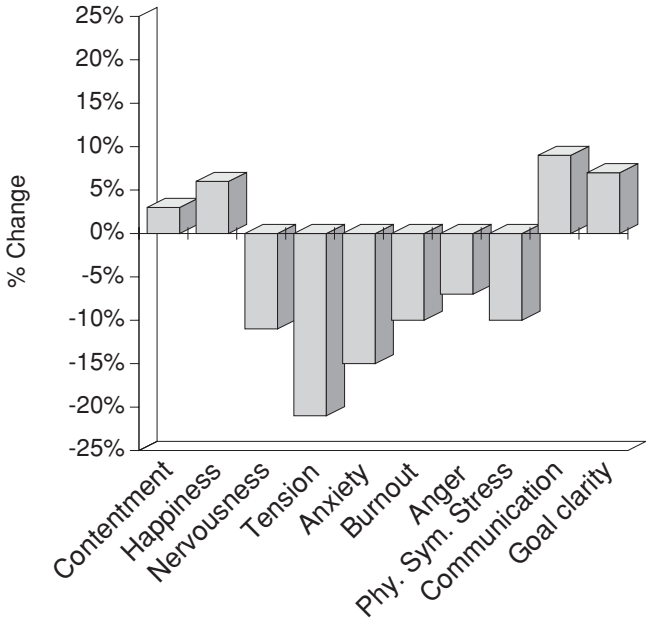


Figure 29. Shows the percent change in psychological measures, physical symptoms of stress and job-related measures for the Motorola factory workers group pre/post IQM training.

That improvements in the physical symptoms of stress and psychological parameters combined with reductions in blood pressure and improved heart rate variability occurred as a result of a self-management intervention illustrates the profound impact that stress can and does have on our physiology and work performance. By teaching participants how to manage their perceptions to control their emotional turmoil, the real source of stress was concurrently managed.

The Effect of Inner Quality Management Training on Change-Related Stress in a Government Agency

The effect of employee self-management training on personal and organizational quality. Bob Barrios-Choplin, PhD, Rollin McCraty, PhD, Joseph Sundram, MEd and Mike Atkinson. HeartMath Research Center, Institute of HeartMath, Publication No. 99-083. Boulder Creek, CA, 1999.

Key findings: *Training in the IQM techniques helped CalPERS employees effectively transform an environment of emotional turmoil that had developed in*

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response to the implementation of major organizational change. Compared to an untrained comparison group, employees who learned HeartMath tools experienced significant reductions in anger, anxiety, distress, depression, sadness, fatigue and physical stress symptoms after a 6-week IQM training. Trained employees also demonstrated significant increases in productivity, goal clarity, peacefulness and vitality relative to the comparison group. Results suggest that the HeartMath training enhanced employees' capacity to implement change with less resistance and friction.

Summary: This study investigated the impact of the IQM program on managers and staff within the Information Technology Services Division (ITSD) of the California Personnel Retirement System (CalPERS). The ITSD had recently initiated profound changes to meet the new realities in the information services marketplace. Shifting from a known technology that had outgrown its utility to a new technology requiring that the whole division learn new skills had proven to be a significant challenge. The stress generated by these changes, combined with simultaneous changes in the division's leadership created an emotional atmosphere of fragmentation, misperception and miscommunication in the workplace environment. Many employees were reportedly experiencing anger, anxiety, anger and resentment. This combination of stress and negative affect was likened to an "emotional virus," compromising the ability of the division to gracefully accept the changes and adapt to the new leadership style and technological direction.

The Inner Quality Management training was delivered over the course of six weeks to 54 employees of the ITSD, along with some members of the Change Management Team and the Human Resources Division. Participants spent this time learning and applying the IQM tools and techniques to the issues, challenges and opportunities inherent in fundamental organizational change. A psychological survey measuring dimensions of stress, emotions and organizational effectiveness was administered pre and post training. Results were compared with a comparison group of 64 employees who were awaiting training.

<u>After the completion of the training, seven weeks from the initial assessment, the HeartMath group demonstrated significant reductions in measures of stress and negative emotion, and significant increases in measures of positive emotion and organizational effectiveness in relation to the comparison group.</u> Key findings after the training indicated significant decreases in anger (20%), distress (21%) depression (26%), sadness (22%), and fatigue (24%), and significant increases in peacefulness (23%) and vitality (10%). There was also a reduction in stress symptoms, including anxiety (21%), sleeplessness (24%) and rapid heartbeats (19%). Organizational quality assessment revealed significant gains in goal clarity (9%) and productivity (4%). These changes were noteworthy in the light of the major organizational and emotional challenges faced by the participants, and the relatively short time in which the improvements took place. Results suggest that by facilitating increased self-management of participants' mental and emotional turmoil, the HeartMath interventions enhanced employees' capacity to defuse personal and organizational stress. The division's qualitative reports to the researchers indicated that these improvements were sustained over time and enabled a more efficient and harmonious change implementation process.

Improvements in Stress, Emotional Well-Being and Organizational Effectiveness in a Government Agency

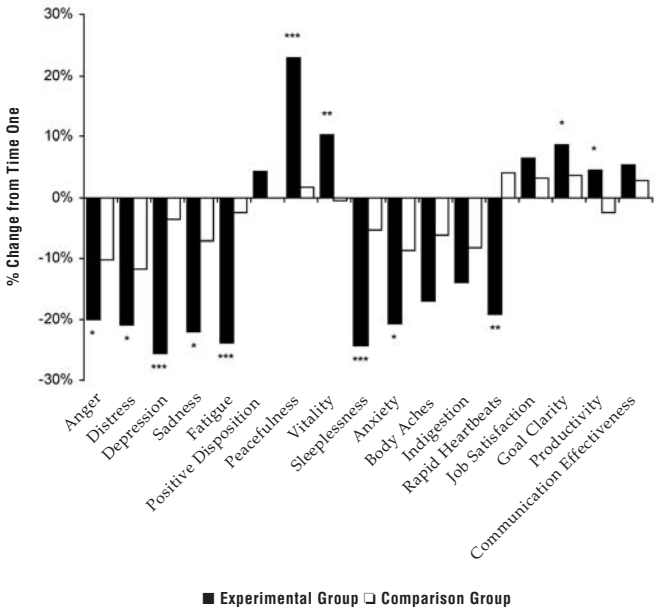

Figure 30. Graph shows percent change in measures of negative emotion, positive emotion, physical stress symptoms and organizational effectiveness for CalPERS employees after learning and applying the IQM techniques over a period of seven weeks. Data from the HeartMath group (n = 54; shaded bars) are compared to results from an untrained comparison group (n = 64; white bars). Asterisks indicate a significant difference between the two groups in raw score means at time two, after adjusting for baseline differences (ANCOVA). *$p < .05$, **$p < .01$, ***$p < .001$.

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IMPACT OF THE HEARTMATH SELF-MANAGEMENT SKILLS PROGRAM ON PHYSIOLOGICAL AND PSYCHOLOGICAL STRESS IN POLICE OFFICERS

Rollin McCraty, PhD, Dana Tomasino, BA, Mike Atkinson and Joseph Sundram, MEd. HeartMath Research Center, Institute of HeartMath, Publication No. 99-075. Boulder Creek, CA, 1999.

Key findings: *Police officers trained in the HeartMath techniques experienced decreased stress, negative emotions and fatigue, increased calmness and clarity under the acute stress of simulated police calls, and more rapid recalibration following these high-stress scenarios, as compared to an untrained control group. Trained officers also demonstrated improvements in work performance, communication and cooperation at work, and relationships with family after learning and practicing the techniques.*

Summary: The police officer is exposed to stress beyond the range of usual human experience. Without effective management, the various acute and chronic stressors inherent in police work impose a significant burden on physical and psychological health and may lead to adverse physiological, emotional and behavioral outcomes. Officers operating under severe and chronic stress are at greater risk of error, accidents and overreaction that can compromise performance, jeopardize public safety and pose significant liability costs to the organization. Research has also shown that police officers are more than twice as likely to develop cardiovascular disease as workers in other occupations. Furthermore, family relationships among law enforcement officers are often severely impacted by job-related stresses. However, police officers are rarely provided with effective stress management strategies to help alleviate these problems.

This study, sponsored by seven police chiefs and conducted in conjunction with Sunnyvale Public Safety (Sunnyvale, CA), explored the impact of the HeartMath interventions on the health and functioning of a group of police officers from seven different agencies in Santa Clara County, California. An Inner Quality Management training program, specifically tailored to address personal and work-related stressors faced by those in the law enforcement profession, was provided to an intervention group consisting of 29 officers. The training included instruction in Freeze-Frame, the Heart Lock-In and HeartMath techniques for effective communication. A waiting control group of 36 officers employed by the same agencies received the IQM training once the study was completed.

Key Benefits of the HeartMath Training for Santa Clara County Police Officers*

- ***Increased awareness and self-management of stress reactions***
- ***Greater confidence, balance and clarity under acute stress***
- ***Quicker physiological and psychological recalibration following acute stress***
- ***Improved work performance***
- ***Reduced competition, improved communication and greater cooperation within work teams***
- ***Reduced distress, anger, sadness and fatigue***
- ***Reduced sleeplessness and physical stress symptoms***
- ***Increased peacefulness and vitality***
- ***Improved listening and relationships with family***

*Compiled from the results of psychological and performance assessments, and a semi- structured interview conducted post-training.

The study was conducted over a 16-week period. Participants were assessed before and after the intervention program in the following areas: physical symptoms and vitality; emotional well-being; coping and interpersonal skills; work performance; workplace effectiveness and climate; family relationships; and physiological and psychological recalibration following acute stress. Holter monitoring was used to obtain continuous ECG data throughout a series of very realistic simulated police calls used in police training (a building search, high-speed car chase and domestic violence scenario) in order to determine the cardiovascular impact of acutely stressful situations typically encountered on the job. Two of these scenarios were conducted before the self-management training intervention, and one was conducted after the completion of the program. Given the particularly high incidence of cardiovascular disease among police officers, 24-hour heart rate variability data collected by the Holter monitor was used to assess risk for cardiovascular disease and premature mortality. Blood pressure recordings were also obtained before and after the scenarios.

Results indicated that the HeartMath training improved officers' capacity to recognize and manage stress and negative emotions in both work and personal contexts. Over the course of the study, officers

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Heart Rhythm of One Officer Using Freeze-Frame After the Domestic Violence Scenario

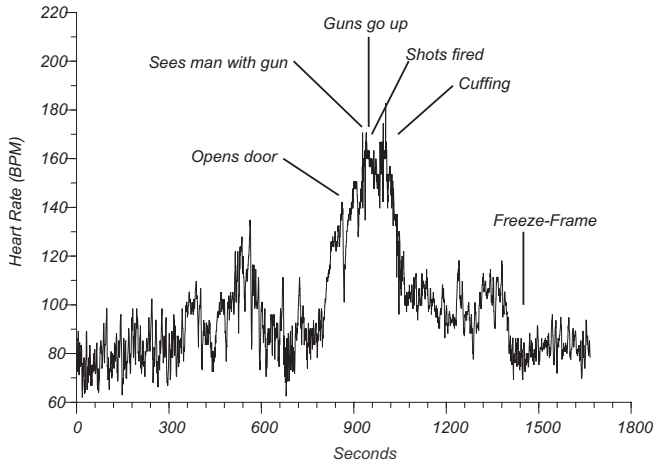

Figure 31. This graph provides an example of the change in heart rate experienced by one officer who used the Freeze-Frame technique to help recalibrate after the intense stress of the domestic violence scenario. Note that when the scenario ends (after "cuffing"), the participant's heart rate begins to drop, but initially stabilizes at a level above its normal baseline range. As the officer uses the Freeze-Frame technique, there is an immediate, further reduction in heart rate back to baseline. In this study, without the use of Freeze-Frame, the average time it took for officers' heart rhythms to normalize and heart rate to return to pre-scenario levels was 1 hour and 5 minutes.

trained in HeartMath techniques experienced reductions in stress, negative emotions, fatigue and physical symptoms of stress, as well as increases in positive emotions, peacefulness and physical vitality, as compared to the control group that had not received the training. In contrast, officers in the control group showed minimal positive changes and some indications of the worsening of symptoms over the same time period. Notably, feelings of depression rose 17% among the untrained officers, while the HeartMath-trained group demonstrated a 13% drop in depression during the same time period. Similarly, fatigue declined among the HeartMath group by 18% and distress by 20%, whereas the control group demonstrated only a 1% reduction in both these parameters. Enhanced work performance in the trained group was also noted, as well as improvements in strained family relationships and communication difficulties at work, two principal and well-recognized sources of stress in the policing profession.

Heart rate and blood pressure measurements taken during the simulated police calls (acutely stressful circumstances similar to those encountered by officers on the job) demonstrated a tremendous degree of physiological activation, with heart rates rising 40 to 55 beats per minute above baseline, and, on average, taking over one hour to restabilize to baseline levels. In several cases, systolic blood pressure rose to over 200 mm Hg during the simulations, reflecting increases in the range of 80-120 mm Hg above starting values. Activation such as this requires considerable time for the body to readjust to baseline levels. However, according to their responses in semi-structured interviews, the majority of participating officers felt that application of the HeartMath interventions increased their calmness, clarity and focus during the scenarios and facilitated a more rapid and fuller recovery, both physiologically and psychologically, following the acute stress. Trends in internally-conducted performance evaluations pre and post training were consistent with these self-reported improvements, as were blood pressure responses. Figure 31 shows an example of the change in heart rate experienced by one officer who used the Freeze-Frame technique to recalibrate after the domestic violence scenario, which participants rated as the most stressful of the simulations.

Autonomic nervous system assessment based on HRV analysis revealed that 11% of the police officers tested were at high risk for cardiovascular disease and premature mortality, more than twice the ratio of at-risk individuals expected to be found in the general population. These findings underscore the importance and potential long-term health implications of providing effective self-management interventions to individuals in high-stress professions such as law enforcement. The integration of such interventions in police training may enable officers to perform their jobs with greater effectiveness, to preserve and enhance their physical and emotional health, and ultimately to provide better protection to the citizens whom they serve.

The Effect of Inner Quality Management Training on Employees' Tension

Independent study conducted by Bob Barrios-Choplin, PhD.

Key findings: *Employees of Mainstream Access trained in the IQM techniques were able to alter their cognitive styles so as to significantly reduce their tension levels in the face of stress during the year following the training. Tension, in turn, was found to be significantly related to levels of burnout, anger, happiness and job satisfaction.*

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Summary: This longitudinal study examined the effects of the IQM program on employees of Mainstream Access, a Canadian human resource management consulting firm. The CEO of this organization became concerned that many of his employees were experiencing high levels of tension and in some instances might be approaching burnout. He felt one cause was the growth of the firm and resulting fast pace at work, and another source might be the employees overidentifying with clients who were experiencing problems. This latter source of stress, sometimes termed "overcare," occurs in many helping professions, as professionals become so concerned with their clients' emotions and problems that their own efficiency diminishes. The CEO decided to train his entire organization in techniques which would not only reduce current levels of tension, but also make employees more resilient in the face of future stressors.

Seventy employees attended an IQM training program. Participants completed a psychological survey to assess levels of tension and their relationship to feelings of burnout, anger, happiness and job satisfaction before the training and again three months and one year after the training.

There was a significant reduction in participants' tension over the course of the study. This was particularly notable in the light of company officials' assessments that stressors continued to increase over that period of time. Results showed that tension was positively related to burnout and anger, and negatively related to happiness and job satisfaction.

A widely accepted model of the stress process proposes that the frequency and intensity of stress reactions experienced by individuals are moderated by their appraisals of potential stressors, which, in turn, are influenced by their cognitive styles (modes of perceiving and interpreting reality). The results of this study suggest that these styles are not fixed, and that the revision of cognitive styles need not require lengthy and costly interventions. Instead, employees did make major shifts in their cognitive styles, as evidenced by lower levels of tension in the face of potentially highly stressful conditions, following a 2-day seminar and practice of the IQM techniques. Further, reduced tension can affect burnout, mood states and job satisfaction in the workplace, resulting in a healthier and more productive work environment.

CANADIAN IMPERIAL BANK OF COMMERCE (CIBC)

Independent, internally conducted study.

Key findings: *Employees of the Canadian Imperial Bank of Commerce trained in the Freeze-Frame technique showed an extremely high level of retention and consistent application of the technique both in business and personal life one year after the training. Employees placed high value on the technique, with most feeling it significantly affected their behavior and improved their health and overall well being.*

Summary: This study was conducted internally by the Canadian Imperial Bank of Commerce (CIBC), Canada's second largest financial institution. The bank had five employees trained to be certified in teaching the Freeze-Frame technique. These trainers subsequently delivered the Freeze-Frame portion of the IQM seminar to 1200 middle and senior-level employees, representing a cross-section of age, background and education. Employees were surveyed at several intervals after the training to determine the extent of their use of Freeze-Frame and the self-assessed effects of the technique on behavior, health and overall well-being.

Particularly striking was the high level of retention and continuous application of the Freeze-Frame technique even one year after the training, with no further instruction or follow-up. Results indicated that 71% of the employees continue to use Freeze-Frame one year after they were trained. Of the users, 86% practice the technique in business, 55% use it in personal life and 41% apply it to both business and personal issues. 73% feel that their behavior has changed as a result of using Freeze-Frame, and 82% feel that Freeze-Frame improves their overall health and well-being. At this point over 2,000 CIBC employees have participated in customized HeartMath programs. The impact that the HeartMath program has had on workplace effectiveness within this organization is summed up by a comment made by the Director of the Bank's Leadership Center: "(As a result of HeartMath), we are seeing tremendous growth in our team focus, communication and effectiveness. Overall there is a greater sense of coherence within our team. We see the universal application of this excellent program fitting into more of our existing Leadership trainings as well as using it as a stand-alone program that supports the needs of our business."

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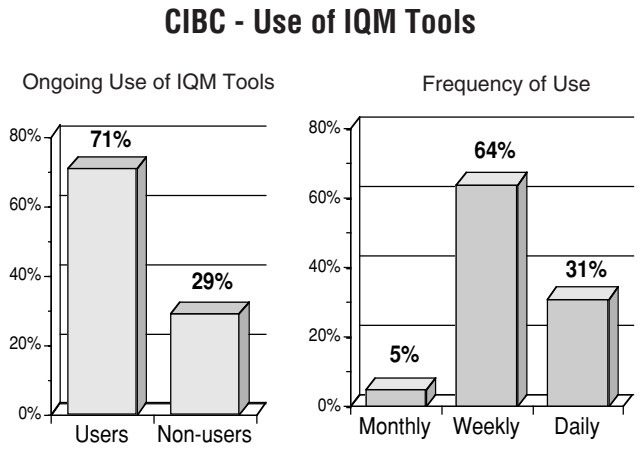

Figure 32. Shows the result of a survey conducted one year after the program to determine how many employees were still using the IQM tools and how often they used them.

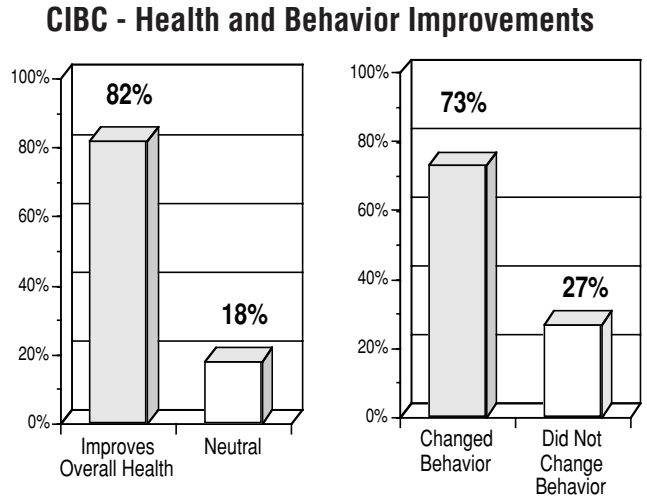

Figure 33. Shows the percentage of employees that felt the IQM tools had improved their health and behavior.

Royal Dutch Shell

Independent study conducted by Alan D. Watkins, MBBS.

Key findings: *A group of Royal Dutch Shell employees experienced significant reductions in physical symptoms of stress, decreased negative affect, increased positive affect, marked reductions in blood pressure and significant improvements in a variety of measures of workplace effectiveness after implementing the IQM technology.*

Summary: Seventeen members of the Senior Management Team of the Estates Division of Shell International participated in the IQM training program in London. Participants were middle and senior managers and included the Head of Human Relations and the Head of the company's Head Office in London. One week prior to the 2-day program, participants completed an extensive questionnaire covering both individual and business issues. Parameters assessed included physical and emotional symptoms of stress, positive affect, communication, goal clarity, productivity, decision making and job satisfaction. The majority of participants also had their blood pressure measured at this time. The psychometric and blood pressure measurements were taken again six weeks after the training to determine the impact of the IQM program. The analysis was conducted jointly with the company's own medical team.

Changes were culled from the subset of individuals exhibiting the strongest negative effects of stress on health and performance. Among this group, there were marked improvements six weeks following the IQM training in nearly all parameters assessed. Physical symptoms of stress significantly improved; rapid heartbeats declined by 38%, tension by 65% and aches and pains by 70%. These participants were 65% less angry, 70% less worried, 87% less fatigued and 68% happier. There was a 44% decrease in their desire to leave the company and a 52% decrease in the desire to quit their jobs. Their listening skills rose by 65%, intuitive decision making increased by 100%, alignment between personal and organizational goals increased by 107%, their meetings were 107% more organized, and the clarity of organizational goals increased by 197%. They experienced a 34% increase in focus, an 86% increase in efficiency, and a 119% increase in creativity and results. Notably, the company's own worldwide Employee Satisfaction Survey correlated very well with the pre-training data, adding additional validity to the findings.

Of the 14 individuals who had their blood pressure monitored, seven (50%) had borderline or high readings prior to the program. The group average prior to the program was 126/80 mm Hg. Six weeks after the IQM training, with no other lifestyle changes, the average blood pressure had fallen to 118/78 mm Hg. One particular individual whose blood pressure was very high prior to the program (160/100 mm Hg), had a normal reading (130/80 mm Hg) for the first time in 15 years, according to the Chief Occupational Health Physician, six weeks after the IQM program. These results are in keeping with the marked improvements in blood pressure measured after the IQM program in the Motorola case study, described earlier in this section.

A follow-up psychometric analysis performed six months after the training was also completed. Results indicate that the improvements in personal and organizational effectiveness have been sustained through participants' application of the IQM technology in their day-to-day work and life experiences. In many areas, further improvements have been achieved over time.

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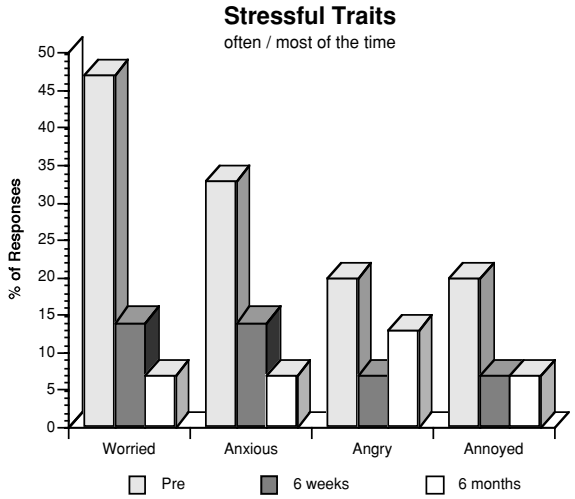

Figure 34. Reductions in stressful traits in Shell employees who experienced high stress often or most of the time, six weeks and six months after the implementation of the IQM program.

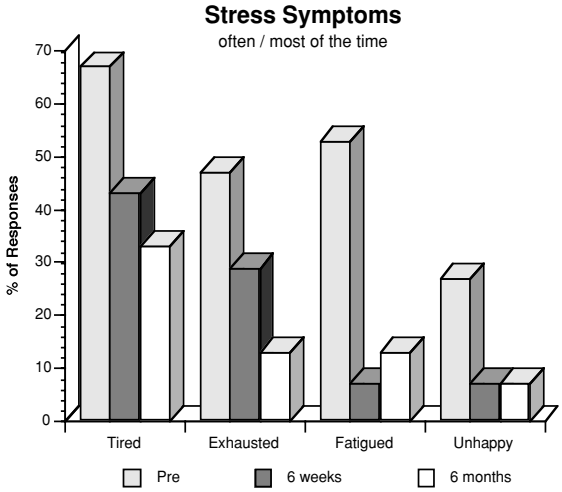

Figure 35. Reductions in stress symptoms in Shell employees six weeks and six months after the implementation of the IQM program.

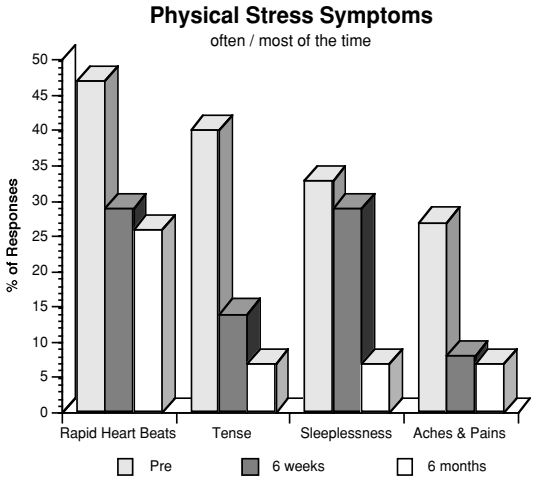

Figure 36. Reductions in physical stress symptoms in Shell employees six weeks and six months after the implementation of the IQM program.

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HeartMath in Education

With growing evidence of the tremendous benefits to be gained from learning to manage stress and enhance physiological, mental and emotional coherence through the heart, the importance of learning inner management techniques at an early age is becoming increasingly apparent. In today's fast-paced society, there is mounting pressure on children to achieve and excel in school at younger and younger ages. Today's children, however, experience considerably greater stress in their lives, shouldering far greater responsibilities and emotional burdens than youngsters their age did even as few as ten years ago. Many are part of deteriorating families or households where parents are rarely home and the responsibility of caring for themselves and younger siblings has become largely their own. The majority find little more comfort or security at school, where they fear becoming victims of violence, guns or abduction, and worry about the intense pressures to have sex and abuse drugs and alcohol. The prevalence of undesirable and dangerous behaviors among youth can serve to perpetuate the emotional atmosphere of fear, hostility and violence that pervades many school environments. Increasing media reports of extreme episodes of violence in schools have recently raised popular awareness of children's deteriorating emotional health and underscored the need for more than topical solutions to resolve these issues.

> *"We are educated in school that practice precedes effectiveness, whether in reading, writing, computers, or whatever. We are rarely taught how to practice care, compassion, appreciation or love—essential for family balance."*
>
> Doc Childre

Our educational systems focus on honing children's cognitive skills from the moment they enter the kindergarten classroom. But virtually no emphasis is placed on educating children in the management of the inner conflicts and unbalanced emotions they bring with them to school each day. As new concepts such as "emotional intelligence" become more widely applied and understood, more educators are realizing that cognitive ability is not the sole or necessarily the most critical determinant of young people's aptitude to flourish in today's society. Proficiency in emotional management, conflict resolution, communication and interpersonal skills is essential for children to develop inner self-security and the ability to effectively deal with the pressures and obstacles that will inevitably arise in their lives. Moreover, increasing evidence is illuminating the link between emotional balance and cognitive performance. Growing numbers of teachers agree that children come to school with so many problems that it is difficult for them to focus on complex mental tasks and the intake of new information—skills essential for effective learning. At IHM we are showing, conversely, that when mental and emotional turmoil is managed, the increased physiological coherence and heart-brain synchronization that ensues stimulates greater mental clarity and expands the mind's capacities.

> *"Some students came to me having memorized the definition of peace, for instance, and they had no idea what it really meant—especially for them personally."*
>
> Edie Fritz, Ed.D., educational psychologist

Applying HeartMath tools for emotional management and learning enhancement—like mastering any new skill—requires practice. But we have found that children are among the quickest to intuitively understand and naturally integrate the tools into their lives. A child's brain continues to develop throughout childhood and adolescence. New nerve connections are formed while others atrophy based on external stimuli and internal attitudes and reaction modes that become "familiar." In today's society, it is easy for children to become familiar with incoherence early on and develop entrained mental and emotional attitudes that perpetuate that incoherence, with deleterious repercussions on body and psyche. Establishing coherence as the norm for children from an early age can be accomplished by surrounding them with a balanced, caring environment and ensuring that they are taught how to maintain a coherent *inner* environment through effective emotional management.

With this intent, many educational administrators and teachers have begun to integrate the HeartMath curriculum into core classroom academics. The following studies are several examples of the rapid success with which HeartMath has been incorporated into educational systems throughout the U.S. Results

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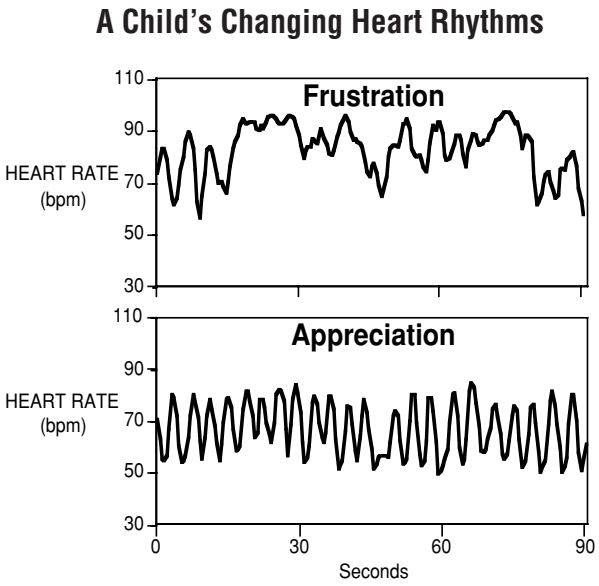

Figure 37. This graph shows the heart rate variability patterns of a 11-year-old boy when he was asked about something that frustrated him (top). He was then asked to do a Freeze-Frame and appreciate someone he cared about (bottom).

indicate that the techniques have not only increased children's stress management abilities, interpersonal skills and comfort in the classroom environment, but have also significantly enhanced learning—heightening students' energy and motivation, sharpening their work management skills, increasing their understanding of academic materials and improving test-taking performance

Additionally, there are positive ramifications for educators who practice the HeartMath tools. One case study summarized here demonstrates how educational administrators have found that using the techniques themselves allows them to respond more effectively to the challenges of their jobs, thereby benefiting the whole learning environment.

Palm Springs Middle School, Dade County, Florida. The impact of an emotional self-management skills course on psychosocial functioning and autonomic recovery to stress in middle school children

Rollin McCraty, PhD, Mike Atkinson, Dana Tomasino, BA, Jeff Goelitz, MEd and Harvey N. Mayrovitz, MD. Integrative Physiological and Behavioral Science. 1999; 34 (4): 246-248.

Key findings: *Middle school students enrolled in a HeartMath self-management skills course exhibited significant improvements in areas including stress*

- *In 1940, the top problems in American public schools, according to teachers, were: talking out of turn, chewing gum, making noise and running in the halls. In 1990, teachers identified the top problems as drug abuse, alcohol abuse, pregnancy, suicide and robbery.*
  Motorola. The Role of the Adult in the Life of a Child, 1995.
- *Since 1978, assaults on teachers have risen 700%.*
  F.B. Nahser & S. Mehrtens. What's Really Going On? 1993
- *One in six youths between the ages of 10 and 17 has seen or knows someone who has been shot.*
  Children's Defense Fund Poll/Newsweek, Jan. 10, 1994
- *According to a recent report, only 22% of youth feel that their school provides a caring, encouraging environment, only 30% feel that there are people in their neighborhood who care about them, and only 15% feel the community values them.*
  The Cornerstone Project, Santa Clara County, CA/Search Institute, 2000
- *One study found that in a group of neglected children, the cortex, or thinking part of the brain, was 20% smaller on average than in a control group.*
  U.S. News & World Report, Nov. 11, 1996
- *Positive emotions have been found to produce faster learning and improved intellectual performance.*
  B. Fredrickson. Rev Gen Psychol. 1998; 2(3)
- *In a sample of youth ages 7 to 11 years old in the Pittsburgh, PA area, over 20% were determined to have a psychiatric disorder.*
  E. Costello et al. Arch Gen Psychiatry. 1988;45(12)
- *More than half of 6th through 12th grade students have personally witnessed some type of crime or victimization at school, and about one in eight reports being directly victimized at school.*
  National Center for Education Statistics/National Household Education Survey, 1993
- *Children under 18 are 244% more likely to be killed by guns than they were in 1986.*
  FBI Uniform Crime Reports/Newsweek, Jan. 10, 1994
- *Only 37% of youth report feeling a sense of personal power, and only half feel that their life has a purpose.*
  The Cornerstone Project, Santa Clara County, CA/Search Institute, 2000
- *Since 1960 the rate at which teenagers are taking their own lives has more than tripled. Suicide is now the second leading cause of death among adolescents.*
  W. Bennett. Index of Leading Cultural Indicators. 1994
- *Almost 4,000 young people drop out of high school every day in this country.*
  Motorola. Crisis in American Education, 1991.
- *The more teenagers feel loved by their parents and comfortable in their schools, the less likely they are to have early sex, smoke, abuse alcohol or drugs, or commit violence or suicide.*
  M. Resnick et al. JAMA. 1997; 278(10)

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and management, risky behavior, work management and focus, and relationships with teachers, family and peers. Students who used the Freeze-Frame technique to recover from acute emotional stress were able to positively modulate their physiological stress responses, increasing heart rhythm coherence, physiological entrainment and parasympathetic activity.

Summary: This joint research study between the Institute of HeartMath and the Miami Heart Research Institute examined the impact of a HeartMath program on psychosocial functioning and physiological responses to stress in students at Palm Springs Middle School (located in Hialeah, Florida, near Miami). An initial phase of the study measured psychological and behavioral changes in 32 at-risk seventh grade students (age range 12-13 years, mean age 12.2 years) who participated in a HeartMath emotional self-management skills program. School counselors had observed that many of these students were distracted at school by various social pressures and negative emotions such as anxiety and depression, which diverted their attention from focused academic learning, even among students with high ability. A preliminary analysis reinforced the need for the school to implement the self-management training, indicating that a number of the students were at risk for anxiety, school dropout, risky behavior problems and negative peer influence, and many had difficult home lives. The HeartMath program comprised a total of 16 hours of training, delivered over the course of two weeks. Pre and post evaluations of children's achievement aptitude, interpersonal skills and mental attitudes were conducted using the Achievement Inventory Measure (AIM). This test requires students to report on how they deal with issues at school, at home with friends, and on internal self-talk.

Results indicated significant improvements following the HeartMath program in 17 of the 19 areas of psychosocial functioning measured by the inventory, including anger management, teacher comfort, self-reliance, work management and focus, perceptions of family support/satisfaction and decreases in risky behavior. After the training, the students scored well above the average range on many of scales on which they had previously scored below the norm. Complete results are shown in Figure 38.

In summary, the data indicated that after learning the HeartMath techniques, students felt more motivated at school, were more focused in their school work and better able to organize and manage their time, both at school and at home. Their leadership and communication skills improved, and harmful behavior

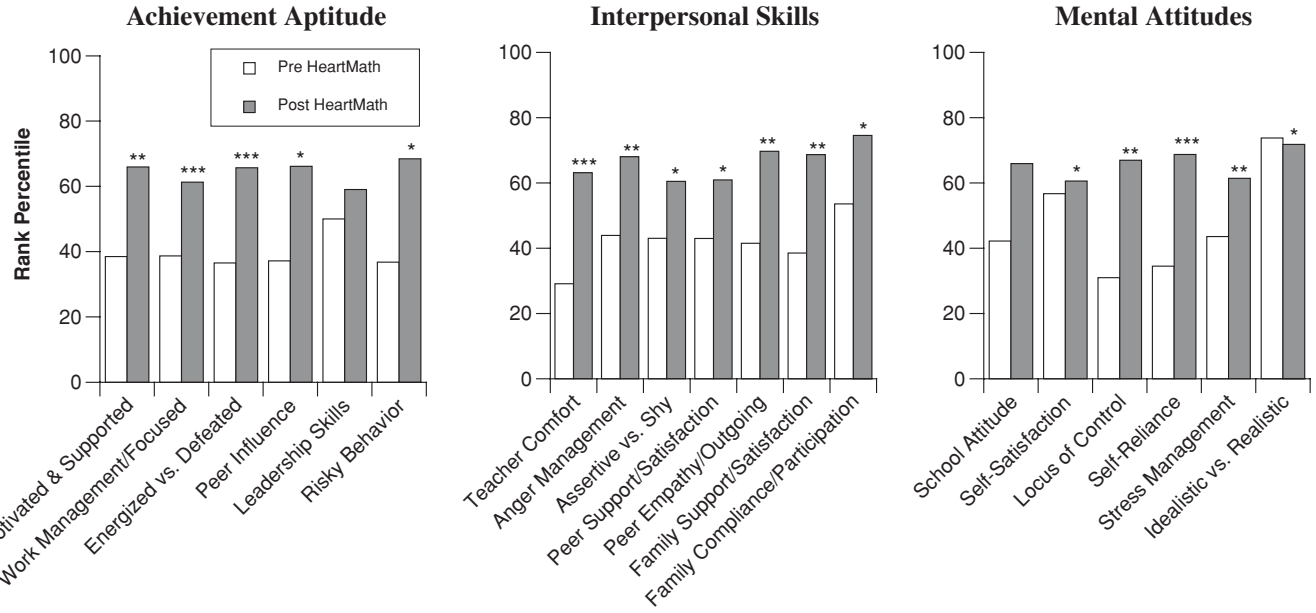

Figure 38. Psychological and behavioral improvements in at-risk seventh grade students after learning HeartMath tools and techniques. The Achievement Inventory Measurement test was administered one week before and one week after the completion of the emotional self-management skills program. Scales measured by the test are divided into three general categories: Achievement Aptitude, Interpersonal Skills and Mental Attitudes. Results are reported as percentile rankings based on norms established from analysis of an extensive age- and gender-matched student population. Following the program, students demonstrated significant gains in nearly all measures. A 6-month follow-up analysis indicated that many of these improvements were sustained over time (data not shown). $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$. (Significance based on pre/post raw scores.)

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problems decreased. They felt more supported by their families and friends, more comfortable with their teachers and showed increased compassion with their peers. The children also felt more comfortable with themselves, were more assertive and independent in their decision making, more resistant to the demands of peer pressure, and better able to manage their stress, anger and negative internal self-talk. In essence, the children showed increased satisfaction and control over their lives while with friends, at school and around their families. Notably, these significant improvements occurred within a short period of time in an at-risk population with below-average levels of psychosocial functioning. Further, a follow-up analysis indicated that many of these changes were sustained over the following six months.

After observing the improvements in their children's attitudes, behavior and performance, many of the students' parents also attended HeartMath trainings in order to have a common language and set of tools. In addition, 15 of this study's seventh graders volunteered to participate in a cross-age mentoring program at a community elementary school, where they tutored 55 at-risk second and third graders in the HeartMath techniques.

In a second phase of the study, the HeartMath program was expanded into the middle school curriculum as a full-year elective course called Heart Smarts. The course was designed to reinforce resiliency skills and positive citizenship among students, while counteracting the negative effects of mental and emotional stress on learning. The course reinforced the application of the techniques through a variety of fun, experiential games and activities, including participation in a cross-age mentoring program with elementary school students. The students' training also included a heart rhythm education component, in which students were given the opportunity to see changes in their heart rhythm patterns in real time when they used the Freeze-Frame and Heart Lock-In

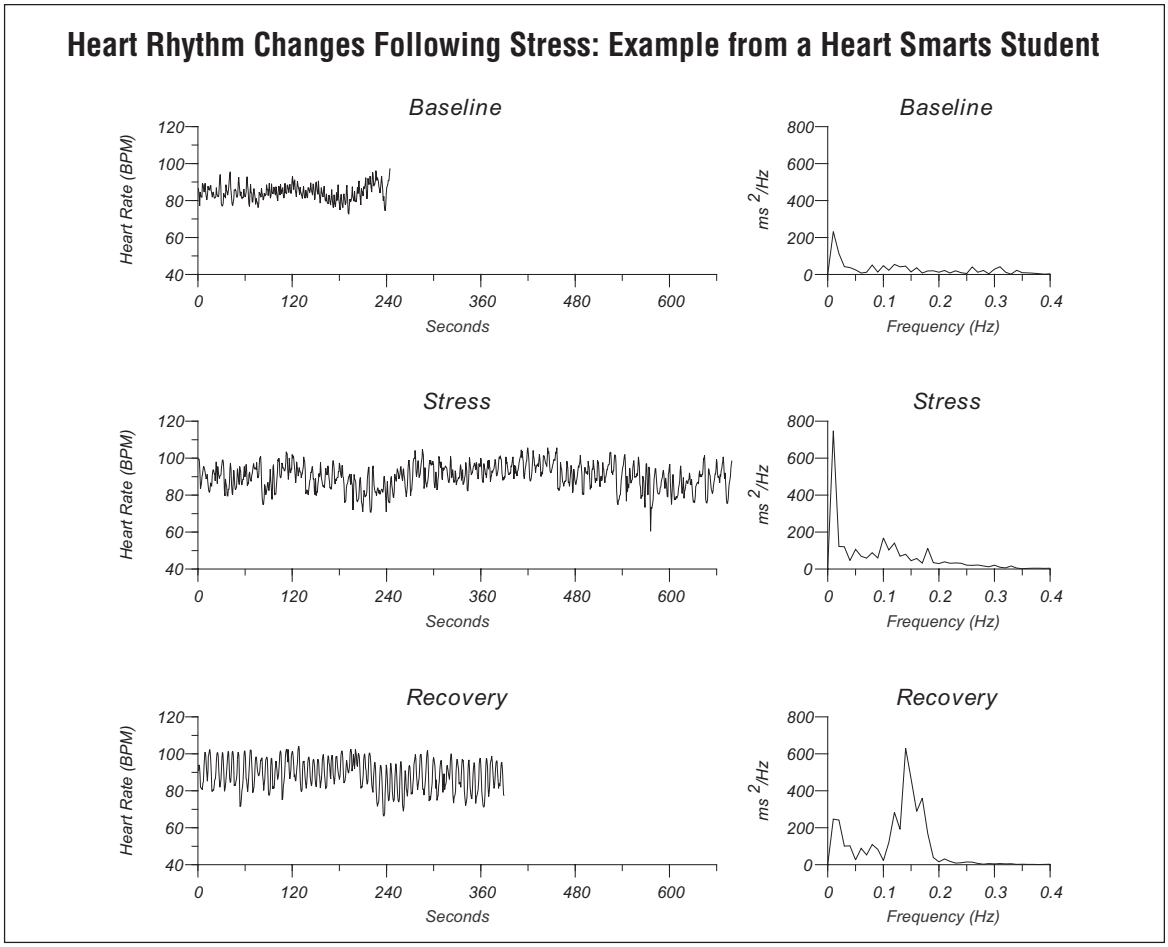

Figure 39. The heart rate tachograms and HRV power spectra of one trained student show a representative example of the changes in heart rhythm patterns and autonomic balance that occurred in the Heart Smarts group throughout the stressful interview. As this student used the Freeze-Frame technique during the recovery interval, note the shift to a near sine wave-like pattern in the HRV trace, and the corresponding marked increase in the LF region of the power spectrum (large peak). This pattern reflects a state of increased heart rhythm coherence. This type of favorable physiological shift was not observed in control group participants.

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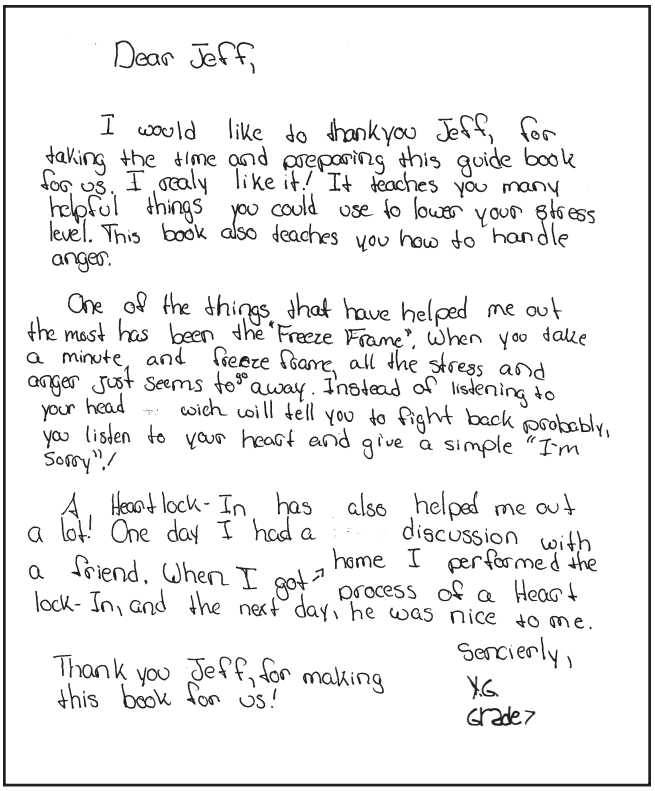
techniques. The course was provided to 60 children in grades sixth through eighth (age range 12-14 years, mean age 13.2 years) in two separate classes. From this group, 30 children were randomly selected to form the experimental group. An additional 30 children, randomly selected from classmates not enrolled in the Heart Smarts course, comprised the control group.

In this phase of the study, the impact of the Freeze-Frame self-management intervention on children's autonomic responses to acute emotional stress was assessed by measuring heart rate variability parameters immediately prior to, during and following a structured interview designed to elicit emotional responses to real-life stressful issues. HRV analysis was performed to assess stress-induced changes in autonomic activity and balance, and to determine any significant changes upon application of the Freeze-Frame technique immediately following the stressful interview.

Results showed that both trained and untrained students exhibited significantly enhanced cardiovascular reactivity and autonomic activation during the stressful interview. However, Heart Smarts students who used the Freeze-Frame technique immediately after the interview showed significant differences in ANS function and balance in relation to the control group, who were asked to recover by relaxing in any way they normally would. As compared to the control group, trained students demonstrated significantly increased HRV and more rhythmic, sine wave-like heart rhythm patterns during recovery (See Figure 39). This favorable response pattern reflects increased parasympathetic activity and heart rhythm coherence, associated with increased heart-brain synchronization and entrainment of the body's major oscillatory systems.

In summary, results suggest that by applying the Freeze-Frame technique in a stressful situation, middle school children were effectively able to positively modulate their physiological responses to emotional stress in real time. As increased physiological coherence is associated with improved cognitive performance, emotional balance, mental clarity and health outcomes, it is proposed that these types of physiological shifts could also serve to promote the sustained psychological, behavioral and performance-related improvements observed in students who applied the emotional management techniques. This study clearly demonstrates that practical emotional self-management skills can be effectively taught to middle school-aged children, and further illustrates the generalizability of the Freeze-Frame technique to diverse age groups and conditions. Results support the concept that learning emotional competence skills in childhood may help establish healthier psychological and physiological response patterns, which can benefit learning, behavior and long-term health.



Dear Jeff,

I would like to thank you Jeff, for taking the time and preparing this guide book for us. I realy like it! It teaches you many helpful things you could use to lower your stress level. This book also teaches you how to handle anger.

One of the things that have helped me out the most has been the "Freeze Frame". When you take a minute and freeze frame, all the stress and anger just seems to go away. Instead of listening to your head which will tell you to fight back probably, you listen to your heart and give a simple "I'm sorry"./

A Heart lock-In has also helped me out a lot! One day I had a discussion with a friend. When I got home I performed the lock-In, and the next day, he was nice to me. process of a Heart

Thank you Jeff, for making this book for us!

Sencierly,
XG
Grade7

Letter written by a seventh grade student enrolled in the HeartMath program at Palm Springs Middle School to Jeff Goelitz, trainer for HeartMath's educational programs.

Minneapolis Public School District, Minnesota. Improving test-taking skills and academic performance in high school students using HeartMath learning enhancement tools

Collaborative study conducted by the Institute of HeartMath, Pam Aasen, PhD and Stephanie J. Thurik, MEd. HeartMath Research Center, Institute of HeartMath, Publication No. 00-10. Boulder Creek, CA, 2000.

Key findings: *High school seniors who received a 3-week training in HeartMath learning enhancement skills demonstrated substantial improvements in test scores and passing rates on state-required Math and Reading tests. Students also experienced significant reductions in hostility, depression and other key indices of psychological distress after learning HeartMath tools.*

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Summary: In Minnesota, high school students must pass the state-required Basic Standards Tests in Reading and Math in order to graduate. Each year, a percentage of students do not receive their high school diploma because they fail to pass these exams. In some cases, the Basic Standards Tests represent a seemingly insurmountable challenge, with students having to re-take the tests up to seven or eight times in order to obtain a passing grade. Thus, these tests represent a significant source of stress and anxiety for many high school seniors.

Some teachers and school counselors in the Minneapolis Public School District had noted that test-taking anxiety appeared to be a major factor in keeping students from passing the Basic Standards Tests. Many students were so worried about passing, particularly in cases where they had already failed the tests, that they were unable to perform effectively, even if extremely well-prepared academically. Thus, in this study, the HeartMath self-management techniques were implemented as part of a Spring Training Camp designed to reduce test-taking anxiety and prepare students mentally and emotionally, as well as academically, for the state tests.

> *"Students had the knowledge, but were unable to perform on the tests because of anxiety and stress."*
>
> Pam Aasen, Ph.D., clinical psychologist

Twenty high school seniors who needed to re-take the Basic Standards Test in Reading or Math enrolled in the Spring Training Camp. The program comprised 25 hours of instruction over three weeks' time, including four 4-hour sessions conducted over Spring Break and five 2-hour after-school sessions both preceding and following Spring Break. The academic portion of the program utilized the same standardized curriculum that is used throughout the school district for state test preparation. In addition, about one-third of the time was spent teaching participants HeartMath tools as strategies to help them reduce their test-taking anxiety and improve performance. The students journaled daily, set goals for themselves and regularly practiced the Freeze-Frame and Heart Lock-In techniques. Participants also worked with the Freeze-Framer Emotional Management Enhancer (a computer-based performance enhancement system) to reinforce their use of the tools and to learn to self-generate states of increased physiological coherence, associated with improved emotional balance, mental clarity and cognitive performance. Students' psychological well-being was assessed pre and post-intervention using the Brief Symptom Inventory (BSI), which measures key indicators of psychological distress.

As compared to a control group that also completed the psychological assessment at the same time points, the HeartMath-trained students demonstrated significant improvements following the program. These included reductions in hostility, depression, interpersonal sensitivity (feelings of personal inadequacy, inferiority and self-doubt), paranoid ideation (fearfulness, suspiciousness and mistrust), somatization (physical symptoms due to stress) and global indices of distress (Figure 40).

Academic test results indicated that the emotional preparedness skills students learned in the Spring Training Camp resulted in test-taking performance improvements above and beyond those achieved through standard academic preparation alone. As shown in Figure 41, students in the program showed a mean gain in their Math test scores of 35%. The mean gain in Reading was 14%. Several students were able to increase their test scores by more than 75% after the 3-week program.

Of the 20 students who participated, 13 (65%) passed one or both tests in April, 2000. Of those students taking the Math test, 64% passed, while 55% passed in Reading. Both of these passing rates were substan-

Psychological Improvements in High School Seniors Following HeartMath Training

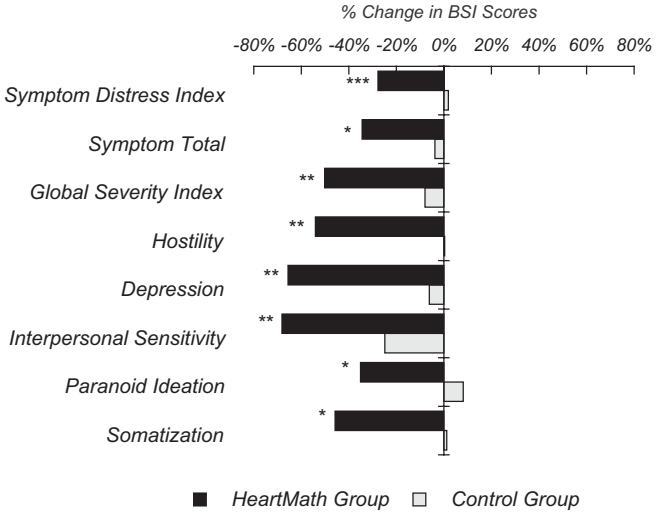

Figure 40. Significant reductions in symptoms of psychological distress (Brief Symptom Inventory) experienced by HeartMath-trained students from pre to post- training, as compared to students in an untrained control group. Asterisks denote significant differences between the two groups in raw score means from time one to time two (three weeks later). *$p < .05$, **$p < .01$, ***$p < .001$.

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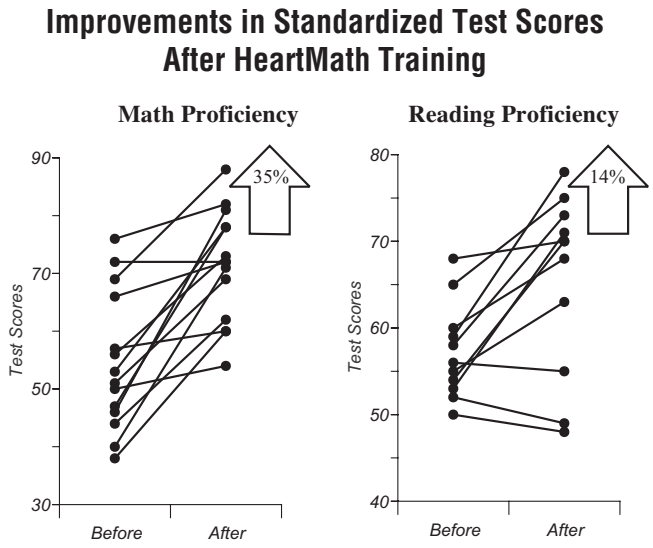

Figure 41. Students' mean scores on the Minnesota Basic Standards Tests before versus after HeartMath training. Students showed an average 35% improvement in Math and a 14% gain in Reading test scores after learning and practicing HeartMath tools for three weeks. As compared to district averages, these improvements represented one to two years' growth in proficiency in both subjects.

tially above the district average for seniors re-taking the test in April; of those students district-wide who re-took the Math test, only 42% passed, and only 31% passed the Reading test. It should be emphasized that the HeartMath tools were the only difference in preparatory training received by the study group versus other students in the school district, as the same academic preparatory curriculum was utilized for all students re-taking the tests.

This study's results were particularly impressive to school administrators, given the magnitude of the changes attained after only a brief intervention. Study investigators noted that the 14% average gain in Reading scores achieved by students in the program after only three weeks of instruction was nearly double the improvement that the average student could expect to achieve over *one year's time* with standard preparation. The 35% increase in students' Math scores was even more notable, as there had been no substantial improvement in average performance on the Math test district-wide for the previous three years. Thus, the HeartMath group was the first student group to increase their scores considerably, and accomplished this with minimal instruction within a strikingly short time frame.

"The students made gains that were significant, because they represented one to two years' growth in reading or math with only one month of preparation and instruction. This clearly shows that in teaching students how to use the HeartMath tools, they were able to reduce their test-taking anxiety and more accurately 'show us what they know.'"

Stephanie J. Thurik, M.Ed., secondary reading curriculum specialist, Minneapolis Public Schools

"If you can teach these kind of tools in three weeks with that powerful an effect, then teachers should be able to facilitate great strides in performance in very short periods of time – which is very important."

Pam Aasen, Ph.D.

Because of the success of this pilot study, district curriculum specialists have implemented training in the HeartMath interventions for Reading and Math teachers throughout the district, in efforts to provide a greater number of students with access to the techniques. The school district has also acquired over 30 Freeze-Framers for classroom use, and plans to initiate a study with a larger student group to determine district-wide effects of HeartMath programs on test-taking performance.

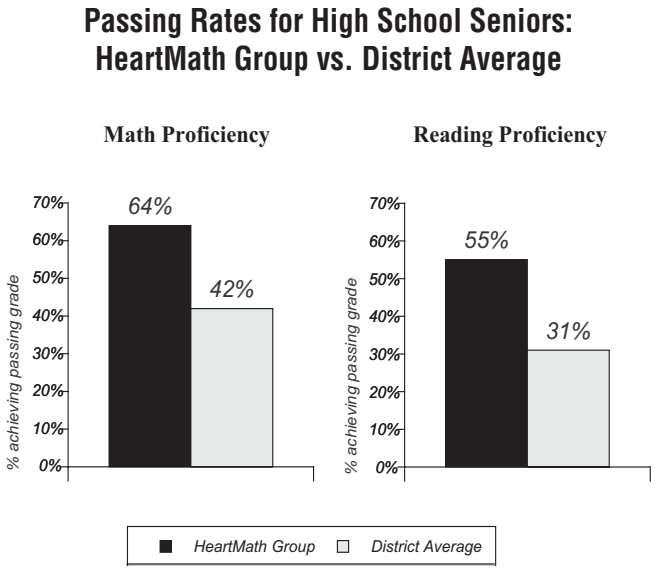

Figure 42. Percentage of HeartMath-trained students passing the Minnesota Basic Standards Tests in Math and Reading in April, 2000, as compared to the district average passing rate for all seniors re-taking the tests at that same time.

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CREIGHTON ELEMENTARY SCHOOL DISTRICT SUMMER ACADEMY, PHOENIX, ARIZONA. HEARTMATH TOOLS IMPROVE READING PROFICIENCY IN ELEMENTARY SCHOOL SPECIAL EDUCATION STUDENTS

Independent investigation conducted by Edie Fritz, EdD.

Key findings: *Fourteen days of instruction in the HeartMath techniques allowed a special education class of fifth and sixth graders to significantly improve their reading proficiency.*

Summary: Dr. Edie Fritz, an educational psychologist at an inner city Phoenix elementary school, has worked with learning disabled students using the HeartMath tools. During a 3-week summer session in 1996, a small group of struggling fifth and sixth graders, most with behavioral and/or academic problems were placed in her class—"How to Be Cool: Learn to Manage Your Anger and Improve Reading." The class was intended to improve reading skills and thereby allow many of the children to be promoted to the next grade. The class met for 1.25 hours each day for a total of 14 days within a 3-week period. Pre and post evaluations of students' reading skills were accomplished using the Wide Range Achievement Test (WRAT).

In their regular classes, the students had already practiced a variety of learning methodologies for years, with very minimal improvement, and their self-esteem was extremely low. Dr. Fritz perceived that the students were under tremendous stress, and had learned to cope in one of two basic ways: acting out the frustration and rage they felt in a defiant, aggressive manner or withdrawing and retreating from these feelings of being battered. Given the short time period available and her perception of the children's true needs, Dr. Fritz decided to focus on teaching the students the HeartMath techniques and provided very little traditional reading instruction. At the end of the three weeks, not only were improvements in the classroom environment, children's attitudes and behavior apparent, but every student's reading scores improved dramatically, ranging from a two month jump in reading proficiency for a bilingual student to over three years' growth (average growth of 1.5 years in grade level). Dr. Fritz's conclusion: "When techniques are presented that children are able to internalize and use to reduce stress, reduce the emotional pain of perceived failure, develop more sensitive communication and relax, they are able to access what they have already learned."

"The students had no idea they were capable of creating peace within themselves in the same way they could create fear or worry."

Edie Fritz, Ed.D.

Improvement in Reading Skills in Special Education Students After HeartMath Program

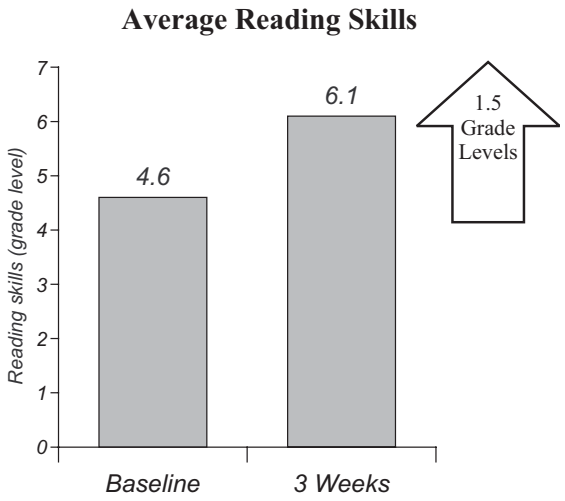

Figure 43. Shows the average improvement in reading skills in fifth and sixth grade students with learning disabilities, after the children practiced HeartMath techniques for three weeks. Reading skills were measured by the Wide Range Achievement Test test before and after the program, and scores shown represent average reading grade level. Students demonstrated an average improvement of 1.5 years' growth in reading proficiency over the 3-week period.

"No matter what the physiology, socio-economic background, home environment, personal value system and/or learning problems, children need to feel good about themselves. They want techniques to help them access more of who they really are."

Edie Fritz, Ed.D.

DEKALB COUNTY SCHOOL SYSTEM, GEORGIA. IMPROVING RESILIENCY AND PERFORMANCE IN EDUCATIONAL ADMINISTRATORS

Independent study commissioned by Eugene Walker, PhD.

Key findings: *A group of educational administrators trained in the HeartMath techniques found them to be of significant value applied to challenges in the field of education.*

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Summary: The DeKalb County school system utilized the services of HeartMath to provide training and facilitation to 20 key administrative leaders and 90 Human Relations representatives from the school system. A formal evaluation of the training and analysis of the results was commissioned by Associate Superintendent, Dr. Eugene Walker. The following table shows the percentages of participants in the two groups who either "strongly agreed" or "agreed" that the HeartMath program had significant value and applicability to the following areas:

	Administrators	Human Relations Reps.
Work/life experiences	99%	100%
Job challenges	85%	95%
Would recommend training to other educators	86%	92%

As a result of the training, participants felt they would be able to make significant improvements in the following areas:

	Administrators	Human Relations Reps.
Dealing with stress	84%	100%
Conflict resolution	85%	95%
Time management	74%	74%

Dr. Walker's conclusion: "This work had very significant value to a broad spectrum of the district's personnel. I have no hesitation in commending their (IHM's) integrity or the effectiveness of their work."

Stanford University, Stanford, California. The Effect of Forgiveness Training on Psychosocial Factors in College Age Adults

Frederic Luskin, PhD, MFCC. PhD Dissertation, Counseling Psychology, Stanford University.

Key findings: *A 6-hour program integrating the HeartMath techniques was effective in decreasing trait anger and interpersonal hurt, improving psychosocial functioning and increasing the tendency to use forgiveness as a problem solving strategy in college-aged students.*

Summary: Unresolved issues between people who live or work closely together can often create feelings of hostility and tension and can become a significant ongoing energy drain. Gaining the capacity to find peace within oneself relative to past occurrences that have caused anger or hurt and to truly forgive others is an essential aspect of the process of self-empowerment. The purpose of this study was to determine the effectiveness of integrating the HeartMath techniques as part of a training program designed to decrease anger, improve psychosocial well-being and encourage forgiveness in college students with unresolved interpersonal emotional conflicts.

Fifty-five Stanford University students were recruited who had an unresolved interpersonal hurt involving someone with whom they were in a close relationship. After randomization, 28 students received a 6-hour training in forgiveness, conducted in weekly 1-hour sessions over a 6-week period. Twenty-seven students served as a wait-listed control group, whose participants were invited to attend a workshop at the completion of the study.

The HeartMath component of the training (approximately 60-65% of the program) included the application of the Freeze-Frame and Heart Lock-In techniques to help participants achieve the inner states of appreciation and "neutral." These techniques were interwoven with the cognitive disputation techniques of Rational Emotive Therapy, which help people challenge their cognitive beliefs that lead to anger and hurt. The two programs were combined and adapted for this forgiveness training with the aim of helping individuals take less offense, blame others less and offer more understanding towards those who had hurt them. Participants were assessed by self-report measures and their response to a vignette at baseline, at the completion of the training and again ten weeks later.

The research hypotheses for the study were that the intervention group relative to the control group would:

- Exhibit less anger;
- Exhibit greater psychosocial well-being;
- Forgive the person who had hurt them;
- Use forgiveness as a problem-solving strategy more readily in other situations.

Analysis of the data showed that there were no significant differences between the treatment and control groups before the training. After the training, the treatment group demonstrated significant reductions in both trait anger and "angry reaction" scales as compared to the control group. These improvements were stable over the follow-up assessment. The intervention group also felt significantly less interpersonal hurt than the control group at the completion of the study, and were more willing to use forgiveness as a problem-solving strategy. Gender differences

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emerged when analyzing participants' willingness to forgive the particular person by whom they were hurt. In this study the trained women were able to forgive more rapidly. Clear and stable improvement in the treatment group's psychosocial well-being was evident as well. At both post-test and follow-up, trained participants showed significant increases in hopefulness and in self-efficacy towards managing emotion and interpersonal hurt. Measures assessing personal growth, compassion, spiritual and quality of life issues significantly improved for the treatment group relative to the control group.

The results of this study suggest that HeartMath interventions can be an effective aid in facilitating perceptual shifts that allow negative emotions and psychosocial traits induced by past events to be released in a relatively brief period of time. The data suggest that the program helped students more effectively manage anger, transform feelings of hurt, adopt healthier strategies for resolving interpersonal conflicts and improve overall psychosocial well-being and quality of life. Moreover, the study investigators' reports indicate that the college-age students were extremely receptive to learning and implementing the HeartMath techniques.

Most interesting is the fact that at baseline, subjects had psychosocial scores in the normal or average range. That significant gains were observed in this population suggests that this brief intervention could substantially improve psychosocial functioning even in healthy individuals. This study provides an example of how the HeartMath techniques can be successfully integrated with other interventions used in psychotherapy to achieve specific positive emotional and behavioral outcomes. Such a training program could serve as a valuable addition to a college curriculum, given its effectiveness in facilitating anger reduction and psychosocial improvements in a brief period of time in normal, healthy student groups.

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Clinical Research

As far back as the middle of the last century, it was recognized that the heart "overtaxed by constant emotional influences or excessive physical effort and thus deprived of its appropriate rest" suffers disorders of function and becomes vulnerable to disease (Hilton, 1863). An early editorial on the relationships between mind and heart accepted the proposition that in about half of patients, heart failure was precipitated by gross emotional upsets. Current research suggests that the progression of a number of diseases is influenced by the consequences of carrying effort beyond physiological tolerance into a condition of depletion and exhaustion that leads to dysregulation of the autonomic nervous system. Unspecified negative emotional arousal, often described as stress, distress or upset, has been associated with a variety of pathological conditions, including hypertension, silent myocardial ischemia, sudden cardiac death, coronary disease, cardiac arrhythmia, sleep disorders, diabetes, digestive disorders, fatigue and many other disorders. Stress and negative emotions have been shown to increase disease severity and worsen prognosis in individuals suffering from a number of different pathologies. On the other hand, positive emotions and effective emotional self-regulation skills have been shown to prolong health and significantly reduce premature mortality.

> *"Natural forces within us are the true healers of disease."*
>
> Hippocrates

The fact that the HeartMath techniques target the *source* of people's emotional arousal, greatly enhance psychological well-being and lead to significant improvements in autonomic and hormonal function and balance makes them potent interventions to facilitate the healing process and improve clinical outcomes. Many health care professionals worldwide, representing both mental health and biomedical fields, have incorporated HeartMath interventions in treating patients, with notable success. A growing number of case histories document substantial reductions in symptomatology and improvements in clinical status achieved by patients with a wide variety of conditions after learning and practicing the interventions for a relatively brief time period, with no other changes in their lifestyle or treatment regimens. (See shaded box for a partial list of patient populations that have benefited from the HeartMath techniques). Many of these cases describe chronic conditions that are typically difficult to address using standard approaches. In several cases, autonomic nervous system analyses revealed the restoration of normal, healthy autonomic function and balance concurrent with symptom improvements in patients who practiced the techniques.

HeartMath interventions have facilitated health improvements in patients with:

- *Hypertension*
- *Arrhythmias*
- *Autoimmune disorders*
- *Environmental sensitivity*
- *Chronic pain*
- *Fibromyalgia*
- *Chronic fatigue*
- *Anxiety disorders*
- *Clinical depression*
- *Post-traumatic stress disorder*

Treatment outcome studies have examined the benefits of HeartMath interventions used with a number of clinical populations. Results of studies conducted on patients with hypertension, diabetes, congestive heart failure and HIV/AIDS are summarized here. This research showed that practice of the techniques was associated with improvements in a variety of health-related measures, including key indicators of physical health status, psychological well-being and quality of life. These pilot studies serve as useful models demonstrating how the HeartMath interventions can be successfully integrated in the treatment of patients with different types of medical conditions.

In addition to ongoing intervention studies, the HeartMath Research Center is actively involved in studying heart rate variability as a noninvasive clinical assessment and research tool. HRV is useful for monitoring autonomic function and assessing ANS involvement in a number of clinical conditions. Importantly, low HRV has been found to be predictive of increased risk of heart disease, sudden cardiac death as well as all-cause mortality. IHM has established and maintains an extensive HRV normals database which provides data on variations in measures of HRV among normal, healthy individuals. An understanding of how HRV varies naturally with age and gender (as described in one of the studies summarized below) greatly increases its value as a diagnostic and prognostic tool in clinical settings.

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HRV also provides an important research tool to expand our knowledge of the alterations in autonomic nervous system function that contribute to different pathologies. Low heart rate variability has been observed in an extremely wide range of disorders, including disease states as diverse as structural heart disease, congestive heart failure, hypertension, diabetes, chronic renal failure, AIDS, cancer, Alzheimer's disease, multiple sclerosis, alcoholism and obesity, to offer only an abbreviated list. Our research, together with others', also indicates that HRV is altered in individuals suffering from a number of psychological disorders, such as depression, anxiety and panic, suggesting that these emotional disturbances are associated with autonomic nervous system imbalances. Studies assessing HRV as an indicator of autonomic function in chronic fatigue and panic disorder are described in this section. Finally, the last study in this section uses HRV analysis as a probe to explore changes that occur in the heart's neural connections and rhythmic patterns following a heart transplant.

Treatment Outcome Studies

HeartMath Risk Reduction Program Reduces Blood Pressure and Improves Psychological Well-Being in Individuals with Hypertension

Maximizing performance while reducing risk. HeartMath Research Center, Institute of HeartMath, Publication No. 00-11. Boulder Creek, CA, 2000.

Key findings: *Hypertensive individuals enrolled in a workplace-based risk reduction program exhibited significant reductions in blood pressure after using HeartMath tools for three months. Participants also experienced significant reductions in distress and depression, concurrent with improvements in work performance-related parameters following the intervention.*

Summary: Hypertension, defined as a blood pressure (BP) of 140/90 mm Hg or higher, is considered one of the most prominent public health issues faced by the United States today, affecting approximately 60 million Americans, or one in four adults. This disease has been called the "Silent Killer" because it usually causes no symptoms. However, hypertension is a major risk factor for death and disability related to coronary heart disease, heart attacks, strokes, kidney disease and vascular complications. In addition, high systolic BP has been linked with decreased cognitive performance, memory loss and the loss of healthy brain tissue. Conversely, numerous controlled clinical trials have demonstrated that lowering blood pressure significantly reduces morbidity and premature mortality.

There is considerable evidence to suggest that high BP is linked to persistent stress and the way in which people cope. Chronically elevated sympathetic nervous system activity has been implicated in the development and maintenance of hypertension. Thus, behavioral interventions that reduce negative emotional arousal and stress-induced sympathetic activation have been shown to be effective non-pharmacological treatments for hypertension, resulting in clinically significant and sustainable BP reductions.

Results of previous pilot studies and case histories have shown the HeartMath techniques to be effective in improving BP in hypertensive individuals, many of whom had not responded to other treatment approaches. In the present study, the impact of a workplace-based HeartMath Inner Quality Management (IQM) Program was investigated in larger sample of hypertensive individuals, using a randomized controlled trial design. Specifically, the program sought to reduce employee stress, depression and high blood pressure, three major and well-recognized risks to the workforce. This study also sought to determine the general feasibility of the implementation of such an intervention in an organizational setting as a means to improve health, well-being and performance in a hypertensive employee population.

Thirty-two individuals, all employed by the same organization, participated in the study. All participants had been diagnosed with hypertension by their primary care physician and were either currently taking antihypertensive medication or had abnormal BP readings during the 4-week run-in period. Participants were assigned through incomplete randomization to the treatment group (18 participants) or waiting control group (14 participants). The Inner Quality Management Training was delivered to the treatment group in three sessions conducted over the course of two weeks. In the training, participants learned tools and techniques to reduce stress, improve health and enhance performance. During the three months following the training, participants were encouraged to practice the HeartMath tools daily. To facilitate learning and effective implementation of the interventions, six Freeze-Framer Emotional Management Enhancer units were made available to treatment group participants for use in the workplace and personal use during weekends. Participants used

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this computer-based performance enhancement system to visualize the positive shifts in autonomic function and balance they could achieve using the techniques, and to become familiar with the experience of the internal emotional shift necessary to increase physiological coherence. One optional 2-hour follow-up session was held eight weeks after the training to review the techniques and answer participants' questions and concerns regarding their practice. Treatment group participants were also encouraged to arrange informal meetings among themselves to support one another in their continued practice of the tools.

Blood pressure measurements were obtained using a standardized protocol, before and three months after the completion of the training program. Psychological and performance-related parameters were assessed concurrently with blood pressure changes to determine the overall impact of the program on employees' health, well-being and effectiveness.

Three months following the intervention program, the treatment group exhibited significant reductions in symptoms of depression and overall psychological distress, relative to the control group, as measured by the Brief Symptom Inventory (BSI). The Personal and Organizational Quality Assessment (POQA) survey also revealed reductions in stress symptoms along with improvements in items assessing emotional health and psychosocial functioning. These changes were concurrent with improvements measured in a number of work performance-related parameters, including perceived work quality, communication and attitude toward the organization.

Additionally, trained employees exhibited substantial reductions in blood pressure (BP) after the intervention program. As shown in Figure 44, the reduction in systolic BP in the treatment group was significantly larger than that in the control group. Specifically, the trained group demonstrated a mean adjusted reduction of 10.6 mm Hg in systolic BP and of 6.3 mm Hg in diastolic BP, as compared to reductions of 3.7 mm Hg (systolic) and 3.9 mm Hg (diastolic) in the control group. In addition, three individuals in the trained group were able to reduce their BP medication usage, with their physicians' approval, during the study period. Of these, one participant was permitted to discontinue antihypertensive medication usage entirely following completion of the study.

These BP improvements achieved by the treatment group are notable when viewed in comparison to blood pressure reductions typically achieved with other types of interventions. For example, the reduction in BP obtained with the HeartMath training in this study is similar in magnitude to the average reduction in BP reported in a meta-analysis of controlled trials of antihypertensive drug therapy of several years' duration. This reduction is the equivalent of a 40 lbs-weight loss, and is twice the size of the average reduction seen with a low-salt diet or exercise training.

Blood Pressure Reductions in Hypertensive Individuals

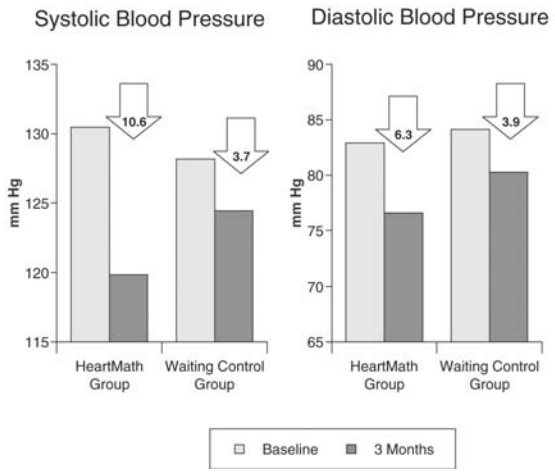

Figure 44. Changes in systolic and diastolic blood pressure in the HeartMath group versus the control group. BP was measured before and three months after the completion of the IQM program. The trained group demonstrated a mean adjusted reduction of 10.6 mm Hg in systolic BP and of 6.3 mm Hg in diastolic BP. (3-month measurements are adjusted for baseline BP, age, gender, Body Mass Index and medication status.) *$p < .05$.

Clinical evidence indicates that blood pressure reductions of the magnitude measured in this study, if sustained over 2 to 3 years, should be expected to significantly reduce long-term health risks, including morbidity and mortality from stroke, cardiovascular and coronary diseases, as well as impairment of cognitive function. For example, a meta-analysis of randomized trials of antihypertensive treatment, with BP reductions similar to the present trial, found that cardiovascular mortality decreased 22%, stroke mortality 33% and coronary mortality 26%. Moreover, research indicates that the reduction in systolic BP achieved in this study should be expected to lower the risk of later impairment of cognitive function by 7 to 9%.

In conclusion, results indicate that over a 3-month period, the HeartMath Inner Quality Management program was effective in reducing blood pressure in a group of hypertensive individuals, with no other changes to their lifestyle or health care regimens. Concurrent reductions in measures of emotional dis-

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tress and improvements in psychological well-being suggest that by learning to manage stress more effectively and decrease negative emotional arousal, participants were able to self-generate measurable and significant changes in their physiology and health status. Physiological and psychological improvements were also accompanied by performance-relevant gains, suggesting the interrelation among all these measures. The implications are that workplace-based programs that promote effective blood pressure management and improve well-being in hypertensive employees may result in a healthier and more productive workforce, reducing cognitive decline, performance impairment, morbidity and premature mortality. Results encourage the implementation of such programs either alone or in association with other treatment approaches to maximize blood pressure reduction and health maintenance.

EMOTIONAL SELF-REGULATION PROGRAM ENHANCES PSYCHOLOGICAL HEALTH AND QUALITY OF LIFE IN PATIENTS WITH DIABETES

Rollin McCraty, PhD, Mike Atkinson and Lee Lipsenthal, MD.
Submitted to Diabetic Medicine.

Key findings: *Diabetic patients demonstrated significant reductions in psychological distress and enhancement of quality of life after using the HeartMath interventions for six months. Increased practice of the Heart Lock-In technique was associated with HbA1c reductions in patients with Type II diabetes, indicating improved glucose regulation.*

Summary: Diabetes is one of the most common chronic diseases, affecting more than 16 million people in the U.S. alone. Individuals with diabetes commonly must undergo extensive lifestyle changes in order to effectively manage their disease, and often suffer substantial stress and negative affect. Studies confirm that people with diabetes frequently suffer from emotional disorders: diabetic patients are reported to have almost three times the rate of anxiety and at least three to four times the rate of depression found in the general population.

A recent report of the World Health Organization and International Diabetes Federation has drawn attention to the importance of encouraging psychological well-being in diabetic patients. The establishment and maintenance of psychological well-being is recognized as an important goal of diabetes management, which is expected to reduce the occurrence of metabolic problems and complications. Education in emotional self-regulation may have particular clinical relevance in diabetes, as emotional disturbances and ineffective coping styles have been associated with significantly poorer glycemic control, the increased report of clinical symptoms, decreased compliance and increased risk for complications. Emotional stress can contribute to the exacerbation of diabetes by direct physiological effects on glucose regulation, as well as by reducing adherence to self-care behaviors. Conversely, studies have shown that significant relationships exist between self-efficacy, self-care and measures of glycemic control. Thus, multiple lines of evidence clearly support the integration of an effective stress reduction and emotional management intervention program as a fundamental component of any diabetes management regimen.

A collaborative 6-month pilot study was undertaken by IHM and LifeScan to determine the efficacy of the HeartMath interventions in improving hematologic measures, health and psychological well-being in a sample of individuals with Type I and Type II diabetes. Twenty-two subjects (mean age 49, age range 31-67) participated in the study. Fourteen of the participants had Type II diabetes and eight had Type I. Participants attended a 2-day workshop in which they learned the HeartMath interventions. The program included instruction and practice in Freeze-Frame, Heart Lock-In and communication techniques, as well as various practical applications of the techniques specifically geared toward addressing stressors and challenges inherent in the lives of individuals with diabetes. Participants also used the Freeze-Framer to facilitate their practice of the techniques and visualize the shifts to increased physiological coherence they could achieve through using the interventions. For the duration of the study, participants were asked to perform at least five 15-minute Heart Lock-Ins per week with the music *Heart Zones,* and to keep a written record of their Lock-In practice. Three 2-hour follow-up sessions were conducted once per month for the first three months after the initial training to help reinforce the use of the interventions, and during the last three months of the study participants received regular support from an IHM health coach.

Psychological self-report surveys assessing participants' stress, emotions, psychological symptoms and quality of life were administered three weeks before and six months following the initial training. Physiological measurements, including hemoglobin A1c (HbA1c), cholesterol and triglyceride levels, and blood pressure, were also collected at these time points.

Results of pre- versus 6-month post-treatment assessments revealed significant decreases in psychological distress as indicated by the Global Severity Index, the

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Positive Symptom Total, and the Positive Symptom Distress Index of the Brief Symptom Inventory (BSI). Significant improvements in the following individual symptom scales were also measured: Somatization, Interpersonal Sensitivity, Depression, Anxiety, Phobic Anxiety, Psychoticism and Paranoid Ideation (Figure 45). Consistent with these results, participants experienced significant reductions in global negative emotion, anger, distress, depression, sadness, fatigue, sleeplessness and anxiety, and significant increases in peacefulness, vitality and social support, as measured by the Personal and Organizational Quality Assessment (POQA). Overall quality of life improved as indicated by significant increases on the Quality of Life Inventory (QOLI). Before the training the participants' mean score for overall quality of life was near the bottom of the average range, whereas after the intervention it had moved into the high range (Figure 46). In addition, there were significant improvements in the individual scales of Health, Self-Esteem, Love and Home. The Daily Stress Inventory (DSI) results showed no significant change in the number of daily stressful events participants commonly experienced; however, both the Impact score (perceived stressfulness of the events) and the Impact/Events ratio (sensitivity to the events) dropped significantly following the intervention.

Linear regression analysis revealed a significant relationship between self-reported practice of the Heart Lock-In intervention and the pre-post change in hemoglobin A1c levels, a key indicator of glycemic control, in participants with Type II diabetes. Increased intervention practice was associated with reductions in HbA1c, indicating improved glucose

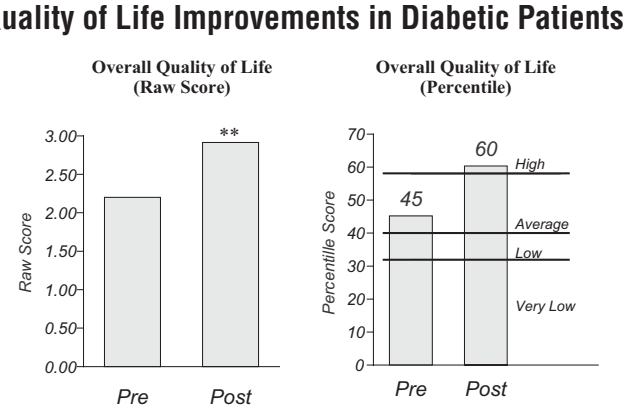

Figure 46. The lefthand graph illustrates the significant increase in the group's mean overall quality of life raw score, as measured by the Quality of Life Inventory three weeks before versus six months after the HeartMath program. $^{**}p < .01$. The righthand graph plots the mean overall quality of life percentile score for study participants as compared to normative data. Before the intervention program, the group's mean percentile score plotted very near the bottom of the average range, whereas six months after the program it had moved into the high range.

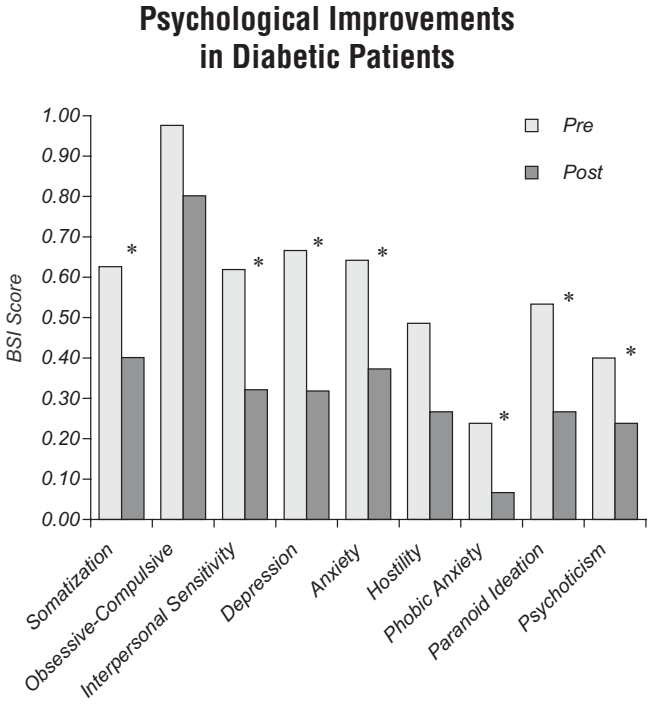

Figure 45. Diabetic patients demonstrated significant reductions in a numerous psychological symptoms (Brief Symptom Inventory) after practicing the HeartMath interventions for six months. $^{*}p < .05$.

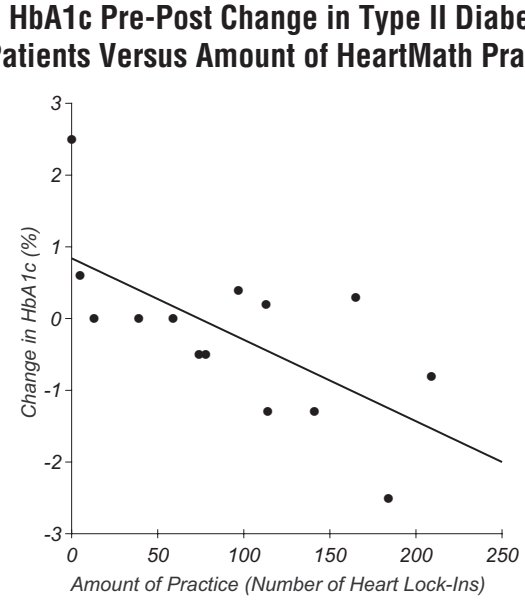

Figure 47. Linear regression analysis showing the significant relationship between the amount of self-reported practice of the Heart Lock-In intervention and the pre-post change in hemoglobin A1c (HbA1c) levels in Type II diabetic patients (n = 14) ($R^2 = .43$; $p < .01$) Increased practice of the Heart Lock-In technique was associated with reductions in HbA1c over the 6-month study period. Decreased HbA1c concentrations are indicative of improved glucose tolerance, suggesting that the intervention practice may help normalize glucose regulation in this population.

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metabolism, while HbA1c increased in patients who did not practice or practiced only minimally (≤ 5 Heart Lock-Ins) throughout the study period (Figure 47). A similar trend was observed in the Type I diabetic patients, although the relation did not achieve statistical significance in this small sample.

Anecdotal evidence from interviews and informal interactions with the participants indicated their receptivity, appreciation and enthusiasm regarding learning and practicing the techniques. Substantial positive shifts in participants' attitudes, behavior and overall psychological demeanor impressed both the trainers and researchers who interacted directly with them, as well as participants' spouses and family members. Notably, during the post-intervention follow-up period, a number of the participants experienced major and unforeseen stressful life events. Participants who faced these stressors reported being able to maintain far greater peace and emotional balance in addressing them than they anticipated, thus lessening the intensity and duration of their distress considerably; all attributed this to their consistent practice of the techniques during the challenging periods.

In conclusion, the results of this pilot study suggest that practice of the HeartMath interventions can lead to a substantial reduction in psychological stress, enhancement of quality of life, and improved glycemic control in individuals with diabetes. It is likely that these effects were mediated, at least in part, by reduced cortisol production, decreased inappropriate autonomic activation and improved autonomic balance as a result of using the techniques to transmute stress and negative emotions, and enhance positive emotions and physiological coherence. The indication that diabetic patients can lower their HbA1c levels by utilizing practical, straightforward stress management techniques is of particular clinical relevance, as patients who are able to maintain lower levels reduce their risk for major complications, such as blindness, kidney disease and nerve damage, and incur significantly lower health care costs. In addition, improvements in patients' emotional well-being and attitudes toward their health are likely to lead to increased compliance with self-care behaviors critical to the effective management of their disease. Collectively, the positive outcomes achieved in this study can be expected to reduce health care usage and both short- and long-term costs to the health care provider. This study provides a practical model for a stress and emotional management intervention that can be easily integrated into existing diabetes management programs and expanded to meet the needs of larger diabetic populations.

A CONTROLLED PILOT STUDY OF STRESS MANAGEMENT TRAINING OF ELDERLY PATIENTS WITH CONGESTIVE HEART FAILURE

Frederic Luskin, PhD, Megan Reitz, BA, Kathryn Newell, MA, Thomas Gregory Quinn, MD, and William Haskell, PhD.
Submitted to the Archives of Internal Medicine. Abstract in: Journal of Cardiopulmonary Rehabilitation. 2000; 20 (5): 303.

Key findings: *Patients with congestive heart failure demonstrated significantly increased functional capacity as well as reduced stress and depression after learning HeartMath techniques.*

Summary: A pilot study conducted by the Stanford Center for Research in Disease Prevention at Stanford University examined the effectiveness of HeartMath interventions used with elderly congestive heart failure (CHF) patients. Despite recent advances, heart failure remains a difficult condition to manage in clinical practice and is the single most frequent cause of hospitalization in adults over the age of 65. The hallmark of CHF is exercise intolerance and activity restriction most commonly due to symptoms of impaired breathing and fatigue. These symptoms result in low functional capacity and progressive physical disability, often requiring intensive medical management. In addition to physical decline, patients with CHF often report depressed mood, anxiety and increased incidence of hostility.

Chronic heart failure has been associated with abnormalities in autonomic control of the cardiovascular system that include chronic sympathetic activation, decreased parasympathetic activity and impaired arterial baroreflex activity. Because of the relationship between autonomic imbalances, progression of the disease and increased mortality, recent studies have examined various types of pharmacological interventions that may reduce sympathetic activity and improve autonomic balance in patients with heart failure. However, nonpharmacological interventions for this patient population have generally been limited to exercise training. Comparatively little attention has been paid to psychosocial interventions and their impact on physiological processes, functional capacity and psychosocial functioning in CHF patients. A strongly needed next step is to evaluate the feasibility and efficacy of various nonpharmacologic therapies and to establish an optimal intervention that has a positive impact on the progression of heart failure as well as on the psychosocial environment of the individual. To our knowledge, this pilot study, funded by the National Institute of Health and the Office of Alternative Medicine, is one of the few to examine the

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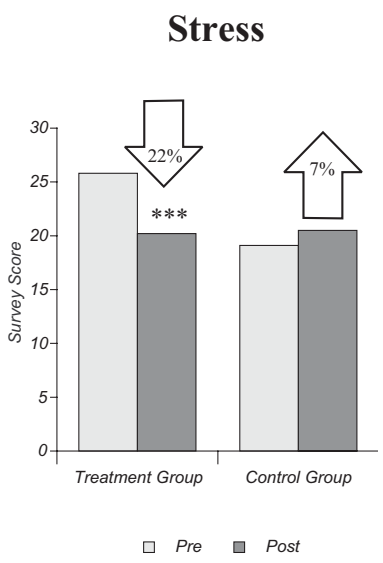

Figure 48. Reduction in stress in congestive heart failure patients after the psychosocial intervention program. Stress dropped 22% in the treatment group following the intervention, while it rose 7% in the control group over the 3-month study period. (Perceived Stress Scale) ***$p < .001$.

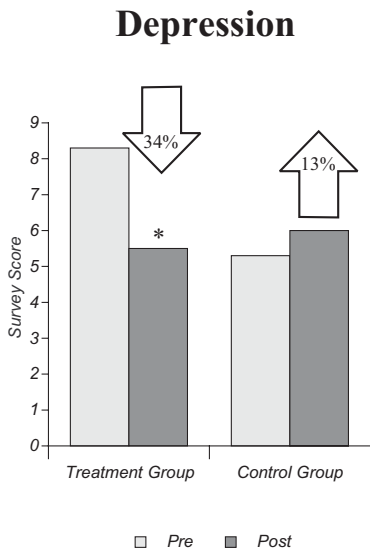

Figure 49. Reduction in depression in congestive heart failure patients after the psychosocial intervention program. Depression decreased by 34% in the treatment group whereas it increased by 13% in the control group over the study period. (Geriatric Depression Scale) *$p < .05$.

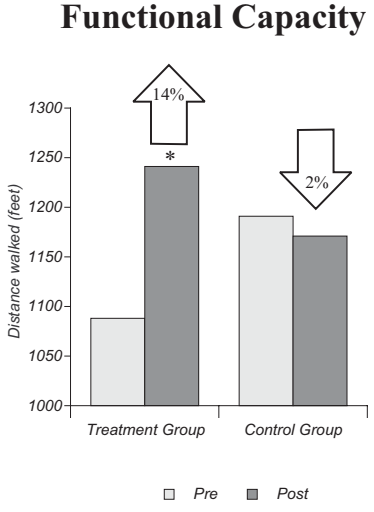

Figure 50. Improvements in functional capacity in congestive heart failure patients after the psychosocial intervention. Functional capacity, as measured by performance on the Six-Minute Walk, increased 14% in the treatment group while it declined 2% in the control group. Treatment group participants were able to walk an average of 153 feet further in six minutes at post-test than at pre-test. *$p < .05$.

effects of stress and emotional management training on psychosocial functioning and functional capacity in patients with CHF.

Thirty-three patients (mean age 66) participated in the study. All participants had had a NYHA Class I-III diagnosis of CHF for at least three months and had been on a stable medication regimen for at least one month. Participants were assigned to an 8-week psychosocial intervention or a wait-listed control group through incomplete randomization. Treatment group participants received a total of ten hours of training offered during eight weekly 75-minute sessions spread over ten weeks. The program was conducted in small groups of six to eight participants in a psychoeducational format. All training was performed by a licensed psychotherapist who was also a certified HeartMath trainer. Participants were taught Freeze-Frame and the Heart Lock-In as the core techniques in the intervention program, with an emphasis on guided practice of the techniques. For the study's duration, each participant was asked to do two 15-minute Heart Lock-Ins per day and to use Freeze-Frame at least three times per day, as well as to look for additional opportunities during the day to practice Freeze-Frame. Measurements of psychosocial functioning and functional capacity were obtained one to two weeks prior to the intervention, and again one to two weeks following the program.

Post-intervention, the treatment group exhibited significant reductions in perceived stress (Perceived Stress Scale) and depression (Geriatric Depression Scale) relative to the control group. Further, as compared to control subjects, treatment group participants demonstrated significant improvements in mental health and vitality as measured by the SF-36 Health Status Profile. Positive trends were noted for measures of anxiety, optimism, perceived physical fitness and health-related quality of life. Finally, on the Six-Minute Walk, a measure of functional capacity, patients in the treatment group significantly improved performance by over 14 percent (1088 feet pre-intervention - 1241 feet post-intervention), while control group subjects showed a slight decline (1191 feet pre-test - 1171 feet post-test).

Collectively, the data suggest that the significant reduction in stress and negative emotional arousal experienced by patients who practiced the techniques may have promoted physiological changes permitting the observed improvements in functional capacity. Given the significant sympathetic involvement in CHF, it is likely that a reduction in excessive or inappropriate emotionally-induced sympathetic activation and an increase in parasympathetic activity associated with

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use of the interventions may have precipitated improvements in patients' physical status.

The psychotherapist who administered the intervention program was particularly impressed with the patients' overall response to HeartMath. Attendance and compliance were excellent, and in post-test debriefings the participants expressed singular appreciation for the program, reporting that the experience was both enjoyable and valuable. Patients were extremely receptive to the idea that unmanaged stress could impede recovery from their disease, and many felt considerably more hopeful as a result of learning the techniques. Most mentioned the lack of psychosocial support they experienced for their condition and their frustration at the number of drugs required for medical management.

In conclusion, this pilot study suggests that HeartMath techniques are a feasible and effective intervention for CHF patients, demonstrating that stress and depression levels can be reduced and functional capacity increased in this population through training in emotional self-management. This study's promising indications clearly warrant larger-scale controlled trials to confirm the observed psychosocial and functional improvements and further explore the implications of such outcomes for physiological rehabilitation.

A PILOT INTERVENTION PROGRAM WHICH REDUCES PSYCHOLOGICAL SYMPTOMATOLOGY IN INDIVIDUALS WITH HUMAN IMMUNODEFICIENCY VIRUS

Deborah Rozman, PhD, Rupert Whitaker, PhD, Tom Beckman, BS and Dan Jones. Complementary Therapies in Medicine. 1996; 4 (4): 226-232.

Key findings: *Individuals with HIV infection and AIDS demonstrated significantly reduced anxiety and stress, improved psychological well-being, increased physical vitality and reductions in pathological symptoms after practicing HeartMath interventions for six months.*

Summary: Individuals with human immunodeficiency virus (HIV) infection and acquired immune deficiency syndrome (AIDS) face not only the extreme personal stress of living with a chronic, life-threatening condition with no effective cure, but also the social stress and frequent isolation generated by society's perceptions of HIV-positive individuals. A clear association between psychosocial factors and the prognosis of AIDS has been demonstrated. Negative emotions and attitudes, including anxiety and depression, and the lack of effective coping skills have been related to a more severe clinical progression. In contrast, psychological factors associated with improvements of AIDS symptoms and increased survival include the presence of a positive attitude, emotions or moods, as well as good coping ability. Research further suggests that the ability to manage stress effectively may deter the loss of natural killer cell function in HIV-positive individuals.

This pilot study was conducted to determine the efficacy of the HeartMath interventions in managing psychological status and improving quality of life in individuals with human immunodeficiency virus. The study was named "AIDS for Hope," denoting its intent to provide participants with tools (as in "aids") for less stressful and more hopeful lives. In this investigation, 24 HIV-seropositive men and women, most with AIDS, completed a HeartMath training program. The program provides tools for stress reduction and mental and emotional self-management that enable participants to recognize and minimize inefficient thoughts and feelings such as anger, resentment, fear, guilt and anxiety, as well as enhance positive emotional states, such as love, care and appreciation.

Participants attended three 2-day weekend training sessions, which were conducted at 3-month intervals over a period of six months. In addition, they were given home study assignments of approximately one hour in length per day for the 6-month study period. Two of the core HeartMath tools taught to participants were Freeze-Frame and the Heart Lock-In

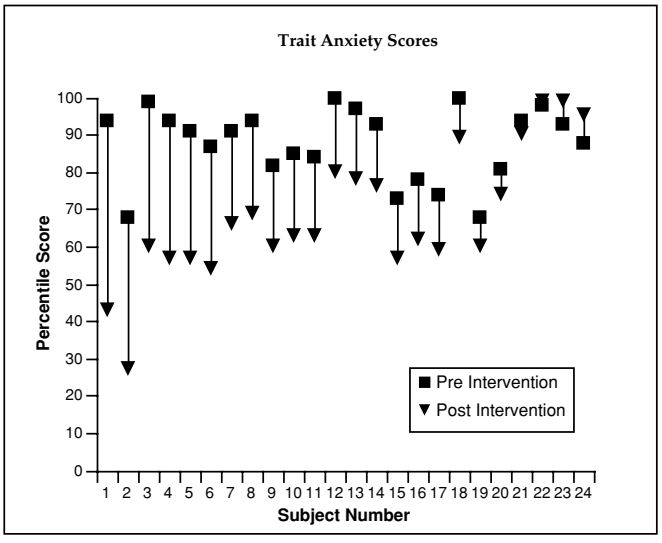

Figure 51. Trait anxiety scores for a group of individuals with HIV infection and AIDS before and six months after they completed the HeartMath program. Improvements in trait anxiety are rare, even in healthy populations, which underscores the effectiveness of the program.

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technique. Each participant committed to regularly using Freeze-Frame and practicing the Heart Lock-In five times a week with the music *Heart Zones* for the duration of the study. Further, each participant was assigned a counselor from the Institute of HeartMath who contacted the participant by telephone every two weeks throughout the study to answer questions and provide support regarding practice of the techniques. Participants were assessed prior to and at the completion of the 6-month period using (1) an Irritability Scale, (2) a Symptom Questionnaire developed to assess the number and severity of symptoms specifically associated with AIDS, (3) the State-Trait Anxiety Inventory, (4) the General Well-Being Scale, and (5) the Essi Systems StressMap® Research Tool.

At the end of the six months, there was a significant reduction in both state and trait anxiety, as well as significant improvements in irritability, positive affect, physical vitality, hardy outlook, behavioral and emotional symptoms of stress, and general well-being. Significant improvements were also measured in the following stress-related variables: major changes, work pressures, home environment, perspective and personal beliefs. Participants' self-reports indicated reductions in a wide variety of pathological symptoms, including infections, anemia, herpes and fatigue. Nine of the 18 participants who reported physical symptoms at the start of the study reported no symptoms after completion of the training program. The remaining nine individuals reported either fewer symptoms, less intense symptoms or no change. Two of the participants were able to discontinue their medications with their physicians' approval by the end of the study.

Results of this study are notable, given that other research has demonstrated the relative stability of psychological measures over time in HIV-positive individuals. Some of the participants stated that in using the HeartMath interventions, they experienced changes in perception, attitudes and behavior more profound than they had previously been able to achieve through years in various treatment programs, self-help groups and individual psychological counseling. It appears that through using the self-management tools to recognize and minimize unhealthy attitudes and feelings such as anger, resentment, fear, guilt and anxiety, and enhance positive emotions such as love, care and appreciation, participants were able to transform their outlook on life, reduce psychological symptomatology and in many cases improve their clinical status. Other studies demonstrating the impact of the HeartMath interventions on the immune, nervous and hormonal systems provide a potential basis for the observed health

Comments from *AIDS for Hope* Study Participants

"When I arrived at HeartMath, I was quite weak with fevers and AIDS-related symptoms. Today my physical condition is excellent, my mind clear, and my emotions calm. HeartMath has given me the power tools to help me manage a stressful illness. The HeartMath program taught me how to transform negative thoughts and feelings — the practices have had a measurably positive effect on my immune system."

- J. B.

"HeartMath has empowered me to focus on what is truly important in my life. Life is for living and experiencing. So much of my time has been spent dwelling on what poor decisions I made or how I didn't measure up to expectations. Now I have the ability to choose a happier, healthier emotion to get me through situations of despair or remorse. Each day brings me so much joy and opportunities to appreciate all that is around me - family, friends, and life are so precious. If this is all there is, I am choosing to make it the most pleasant, rich, and happy experience possible and HeartMath has given me the ability to make these choices."

- B. R.

"My arrival at HeartMath was accompanied by a hopelessness that had consumed my soul. I had been diagnosed HIV positive and felt sentenced to a meaningless death. The changes in both perception and attitude since that time are numerous! No longer waiting for that "meaningless death" - instead I have a mission, one of loving life and myself. Each day brings gifts, not despair. My life still has its stressors but they no longer bring me down into suicidal depression. The HeartMath practices have aided me in all aspects of my life, physical, mental and emotional."

- D. M.

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improvements. In conclusion, the results of this pilot study indicate that the HeartMath techniques hold promise as a nonpharmaceutical intervention that can significantly improve the well-being and quality of life in individuals with HIV infection and AIDS.

Heart Rate Variability and Autonomic Function

Twenty-four hour time domain heart rate variability and heart rate: Relations to age and gender over nine decades

Ken Umetani, MD, Donald H. Singer, MD, FACC, Rollin McCraty, PhD and Mike Atkinson. Journal of the American College of Cardiology. 1998; 31 (3): 593-601.

Key findings: *Twenty-four-hour time domain HRV decreases with normal aging and is affected by gender. This study establishes age-adjusted normal ranges for five standard 24-hour time-domain HRV measures over a 9-decade time span, thereby enhancing the diagnostic and predictive utility of HRV in clinical settings.*

Summary: Heart rate variability is an established index of autonomic activity. Low HRV is considered an independent marker of a number of pathophysiological conditions, including ischemic heart disease and risk of mortality / sudden cardiac death. However, the natural age-related decline in HRV may limit its clinical utility, due to difficulty in discriminating between low HRV associated with disease and risk of mortality and that associated with the normal aging process. Gender also influences HRV. However, there is little published information concerning the effects of aging and gender on 24-hour HRV over a broad age span. This study sought to define age and gender effects for healthy individuals on 24-hour time domain HRV and heart rate (HR) over nine decades and to establish age-adjusted normal ranges for each HRV measure.

HRV was determined for 260 healthy subjects, ages 10-99, on a decade basis. Five standard time domain measures of HRV were used: SDNN, SDANN, SDNN index, rMSSD and pNN50. All HRV measures decreased with aging, but at varying rates and to different degrees. The SDNN and SDANN decreased gradually over the nine decades. The pNN50 and rMMSSD declined at different rates, but both stabilized after age 59. The SDNN index decreased linearly with aging across the entire lifespan, thus providing a useful physiologic marker of aging. In some healthy subjects over 65, the SDNN index, rMSSD and pNN50 fell below published cut-off points for increased risk of mortality, suggesting the need for revision of these values. HRV in females below age 30 was lower than in age-matched males. Gender-related differences disappeared after age 50.

The results of this study expand our understanding of how HRV measures vary with age and gender in healthy individuals. The data acquired were applied to the establishment of new, age-adjusted normal ranges for each HRV measure. This information greatly enhances the clinical utility of 24-hour time domain HRV as a marker for risk of mortality and pathophysiologic states, particularly in older populations.

Assessment of Autonomic Function and Balance in Chronic Fatigue Patients Using 24-Hour Heart Rate Variability Analysis

Rollin McCraty, PhD, Stuart Lanson, MD and Mike Atkinson. Clinical Autonomic Research. 1997; 7: 237.

Key findings: *Assessment of 24-hour heart rate variability revealed impaired autonomic nervous system function in individuals with chronic fatigue syndrome. Measures of both sympathetic and parasympathetic activity were significantly lower in chronic fatigue patients as compared to healthy age- and gender-matched controls, suggesting that this syndrome is associated with autonomic exhaustion.*

Summary: Chronic fatigue syndrome (CFS) is a medically unexplained disorder characterized by chronic, disabling fatigue, muscle pain, impaired concentration and a variety of neurobiological symptoms that make everyday activities extremely difficult. While it has been suggested that patients with CFS may have impaired autonomic nervous system function, few studies have examined this question directly. Thus, this study compared autonomic function, as assessed by 24-hour heart rate variability (HRV) analysis, in 22 CFS patients (age range 31-69, mean age 45.5) versus healthy age- and gender-matched controls. Holter monitoring was performed on all subjects, and HRV data were evaluated by time domain, frequency domain and circadian rhythm analysis.

In CFS patients, the SDNN index (mostly sympathetic) and RMS-SD (parasympathetic) measures were significantly lower than in controls. In the frequency domain, 5-minute total power, very low frequency (VLF; mostly sympathetic), low frequency (LF) and

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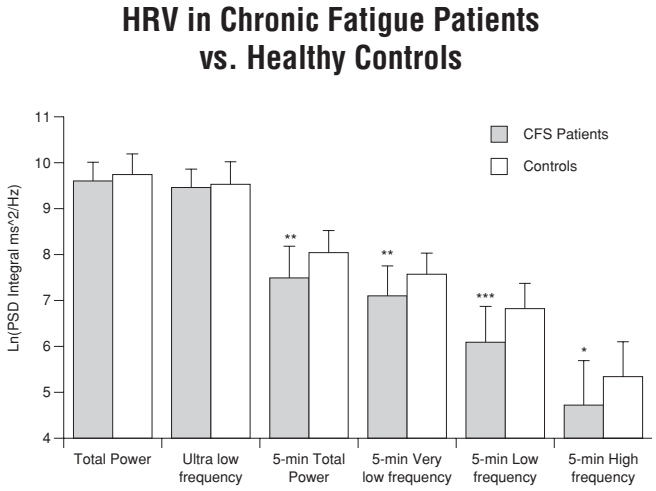

Figure 52. Frequency domain measures of 24-hour HRV in patients with chronic fatigue as compared with healthy, age- and gender-matched controls. Asterisks denote a significant difference between the two groups. *$p < .05$, **$p < .01$, ***$p < .001$.

high frequency (HF; parasympathetic) power were all significantly lower in CFS patients (Figure 52). Circadian rhythm analysis indicated that differences in time and frequency domain measures between patients and controls were significant primarily during the daytime hours; 5-minute total power, LF power and HF power were also significantly lower in CFS patients during the latter part of the sleep cycle. There were no significant differences in mean heart rate or in the LF/HF ratio. Results indicate that autonomic function is indeed impaired in CFS patients, as both sympathetic and parasympathetic activity are significantly depressed with respect to healthy age and gender-matched controls. This suggests that autonomic exhaustion may play an important role in the pathophysiology of chronic fatigue.

Analysis of Twenty-Four Hour Heart Rate Variability in Patients with Panic Disorder

Rollin McCraty, PhD, Mike Atkinson, Dana Tomasino, BA and William P. Stuppy, MD. Biological Psychology. 2001: In press.

Key findings: *Analysis of 24-hour heart rate variability in patients with panic disorder revealed that sympathetic nervous system activity is depressed with respect to healthy individuals, whereas parasympathetic activity is normal under usual life conditions.*

Summary: Since most psychological disorders are really emotional disorders and emotions affect the autonomic nervous system, it is not surprising that autonomic dysfunction has been documented in a wide range of such disturbances. Recently, measurements of HRV have been used to investigate autonomic function in various affective disorders, and aberrant patterns of autonomic regulation have been observed in individuals with conditions including depression, generalized anxiety and worry. Growing evidence suggests that alterations in autonomic function may also contribute to the pathophysiology of panic disorder (PD).

This retrospective study employed 24-hour HRV analysis of Holter records to compare autonomic function in 38 PD patients with healthy, age- and gender-matched controls. Both time and frequency domain HRV measures were calculated and a circadian rhythm analysis was performed to compare HRV patterns during waking and sleeping hours.

Data showed that the SDNN index, 5-minute total power, very low frequency (VLF) and low frequency (LF) power were significantly lower in panic patients relative to healthy controls over the 24-hour period; hourly means were significantly lower during some of the waking hours as well as the latter part of the sleep cycle. In contrast, mean heart rate, RMSSD and high frequency (HF) power were comparable in patients and controls. These results suggest that sympathetic activity is depressed and parasympathetic tone normal in individuals with PD under usual life conditions.

Previous short-term HRV studies have suggested that patients with panic disorder may be characterized by exaggerated sympathetic reactivity and/or parasympathetic withdrawal in response to certain laboratory-administered autonomic nervous system

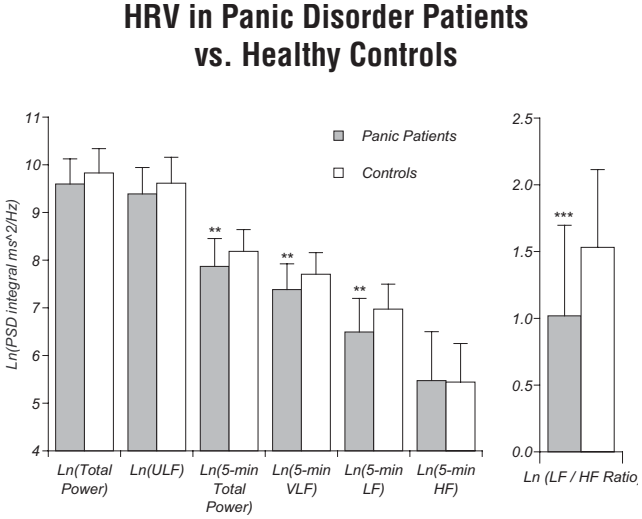

Figure 53. Frequency domain measures of 24-hour HRV in patients with panic disorder as compared with healthy, age- and gender-matched controls. Asterisks denote a significant difference between the two groups. **$p < .01$, ***$p < .001$.

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challenges. This study's 24-hour data extend previous findings, providing evidence that low baseline sympathetic tone and a relative predominance of parasympathetic activity characterize PD patients under nonchallenging conditions in their usual environments. If bouts of sympathetic hyperarousal are indeed implicated in the dramatic elevations in heart rate, blood pressure and other alarming somatic symptoms generally observed in panic attacks, it is possible that these surges of overactivity over time could lead to sympathetic exhaustion, causing the sympathetic system to adopt a lower set-point of baseline functioning.

Findings of low HRV in PD patients are consistent with the high rate of cardiovascular morbidity and mortality in this population, since reduced HRV has been identified as a powerful predictor of heart disease and increased risk of sudden cardiac death. Furthermore, given that high variability in heart rate is considered a marker of flexible responsivity and stress resiliency, findings of low HRV in this patient population are also consistent with the emerging view of panic as a disorder involving reduced flexibility and adaptability across biological, affective and behavioral dimensions. In sum, this study expands understandings of autonomic function in panic disorder and adds to the growing body of data confirming the value of HRV analysis as a sensitive tool to explore the relationships between autonomic dysfunction and psychopathology.

THE HEART REINNERVATES AFTER TRANSPLANTATION

David A. Murphy, MD, Gregory W. Thompson, BS, Jeffrey L. Ardell, PhD, Rollin McCraty, PhD, Robert S. Stevenson, BS, Virgilio E. Sangalang, MD, René Cardinal, PhD, Michael Wilkinson, PhD, Sylvia Craig, DVM, Frank M. Smith, PhD, John G. Kingma, PhD and J. Andrew Armour, MD, PhD. Annals of Thoracic Surgery. 2000; 69: 1769-1781.

Key findings: *One year after cardiac autotransplantation, sympathetic efferent nerves reinnervated canine hearts to some degree. Reinnervation by paraysmpathetic nerves occurred to a lesser extent, and was absent in some cases. Heart rate variability patterns in the transplanted heart may be due in part to rhythms generated by the heart's intrinsic nervous system, which undergoes a functional remodeling process after cardiac transplantation.*

Summary: Whether autonomic nerves reconnect to the heart after a heart transplant has remained controversial, despite extensive anatomical, physiological and pharmacological testing. Generally, heart transplant recipients tend to display little beat-to-beat heart rate variability, suggesting that cardiac autonomic neurons do not reinnervate the heart after transplantation. On the other hand, several studies have indicated that some variability does return post-transplant, which has been interpreted as evidence of autonomic reinnervation of the heart. Furthermore, those studies reporting reinnervation after transplantation have not elucidated the extent to which the sympathetic versus parasympathetic limb of the autonomic efferent nervous system influences the transplanted heart. Finally, recent evidence indicates that the heart's intrinsic nervous system influences cardiodynamics and heart rate variability, thus providing a potential intrinsic source of HRV in the transplanted heart; however, the role played by this intrinisic nervous system in maintaining cardiac function after long-term heart transplantation remains unknown.

To help resolve these issues, IHM participated in a collaborative study with Dr. J. Andrew Armour of Dalhousie University in Halifax, Canada, an acknowledged leader in the field of neurocardiology. This investigation was undertaken (1) to determine whether sympathetic and parasympathetic efferent neurons reinnervate the mammalian heart by one year after transplantation; (2) if reinnervation does occur, to determine the functional capacity of sympathetic versus parasympathetic neurons to influence cardiodynamics one year post-operatively; (3) to determine whether HRV, as assessed by power spectral analysis throughout the year following transplantation, correlates to the patterns of functional reinnervation by sympathetic and parasympathetic efferent neurons, (4) to assess whether the intrinsic cardiac nervous system remodels itself after cardiac transplantation.

In this study, HRV was assessed for one year after cardiac autotransplantation in nine dogs. At 3, 6, 9 and 12 months following autotransplantation, IHM's Research Center performed both time domain and power spectral analyses of 24-hour HRV from Holter recordings of these dogs. Holter monitoring and 24-hour HRV analysis was also performed on three control dogs (without operation) to obtain comparison data. At the conclusion of the year, a number of electrophysiological, histological, pharmacological and biochemical methods were used to determine if autonomic nerves reinnervated the transplanted hearts, and the extent to which sympathetic versus parasympathetic nerves influenced cardiac function in these animals.

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It was found that cardiac autonomic nerves did reinnervate the heart to some degree, but in a sporadic and inconsistent manner. The degree of cardiac reinnervation varied considerably from animal to animal. Overall, data showed that sympathetic neurons do reinnervate the canine heart within one year after transplantation, while parasympathetic neurons reinnervate the transplanted heart to a lesser extent, being absent in some cases. Interestingly, heart rate variability analysis was not able to predict either the extent of reinnervation or what type of reinnervation occurred in this study. Power spectral analysis revealed that the same spectral peaks present in normal dogs were also present in the autotransplanted animals, with little difference at 3, 6, 9 and 12 months post-transplantation. In fact, overall variability was greater in the transplanted group than in normal dogs.

This study also found that the intrinsic cardiac nervous system continues to function after transplantation and undergoes a remodeling process in order to sustain adequate cardiac function. These findings, coupled with the lack of correlation between HRV data and actual reinnervation patterns, suggests that heart rate variability after heart transplantation may be related not only to reinnervation of the heart by extrinsic efferent autonomic nerves, but also to the influence of intrinsic cardiac neurons. This would indicate that the heart is capable of generating complex rhythms and patterns independent of input from the brain and central nervous system. Among the clinical implications of this study is that remodeling of the intrinsic cardiac nervous system should be taken into consideration when studying the functional status of the heart after transplantation.

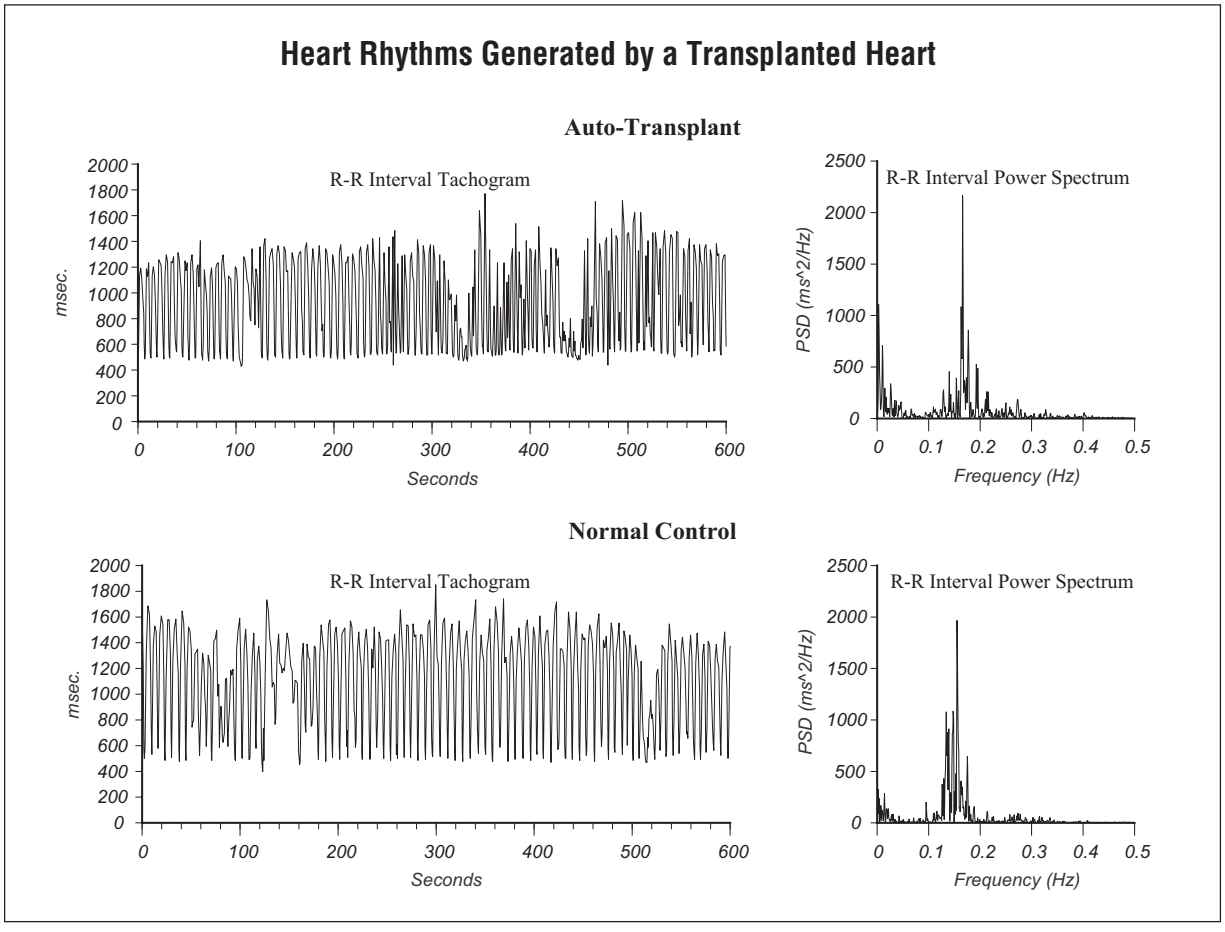

Figure 54. At top left is the heart rate tachogram of a dog after undergoing cardiac autotransplantation, with the accompanying graph on the right showing the HRV power spectrum. Bottom graphs show the heart rate tachogram and HRV power spectrum of a normal dog for comparison. Note the similarity between the two.

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Assessment Services

Heart rate variability analysis has proven an invaluable tool in gaining deeper insight into the nature of the autonomic imbalances and dysrhythmias now known to be associated with wide variety of pathologies. In addition, analysis of HRV is a useful, noninvasive method for assessing the effects of different treatments and interventions on the autonomic nervous system. The Autonomic Assessment Report, described next, is a detailed analysis that IHM has developed to measure autonomic nervous system function and balance. HeartMath Research Center employs this analysis to measure and monitor autonomic improvements in many patients who have chosen to incorporate the HeartMath emotional management interventions into their recovery programs. This service is also utilized by physicians and scientists in a variety of clinical and research settings.

THE AUTONOMIC ASSESSMENT REPORT: A COMPREHENSIVE HEART RATE VARIABILITY ANALYSIS — INTERPRETATION GUIDE AND INSTRUCTIONS

Rollin McCraty, PhD and Alan D. Watkins, MBBS. Boulder Creek, CA: Institute of HeartMath; 1996.

Key points: *The Autonomic Assessment Report is a powerful, noninvasive diagnostic tool that provides a comprehensive, quantitative analysis of autonomic nervous system function and balance. This analysis is of value in the diagnosis and treatment of disorders that involve autonomic dysrhythmias and in assessing the effects of therapeutic interventions on autonomic function. The HeartMath Research Center provides this analysis service to physicians and medical institutions throughout the U.S. and abroad.*

Summary: The Autonomic Assessment Report (AAR) is a sophisticated tool for quantifying autonomic function developed by the HeartMath Research Center. The aims of the AAR are: (1) to provide physicians with a new, powerful, noninvasive test which quantifies autonomic function and balance and aids in risk stratification; (2) to offer researchers a test that can measure the effects of their interventions on autonomic function, and (3) to generate data that will allow the autonomic profiles in a number of pathological conditions to be more fully characterized. The AAR is derived from 24-hour ambulatory ECG (Holter) recordings, and is based on analysis of heart rate variability (HRV), which provides a unique window into the interactions of sympathetic and parasympathetic control of the heart. The report includes time domain, frequency domain and circadian rhythm analysis, which together constitute a comprehensive analysis of autonomic activity, balance and rhythms. Time domain measures include the mean normal-to-normal (NN) intervals during a 24-hour recording and statistical measures of the variance between NN intervals. Power spectral density analysis is used to assess how power is distributed as a function of frequency, providing a means to quantify autonomic balance at any given point in the 24-hour period, as well as to chart the circadian rhythms of activity in the two branches of the autonomic nervous system.

Disease States Associated with Autonomic Dysrhythmias

- *Depression*
- *Irritable Bowel*
- *Hypoglycemia*
- *Fibromyalgia*
- *Panic Disorder*
- *Hypertension*
- *Sleep Disorder*
- *Chemical Sensitivity*
- *Premenstrual Syndrome*
- *Asthma*
- *Fatigue*
- *Anxiety*
- *Dizziness*
- *Migraine*
- *Nausea*
- *Arrhythmia*
- *Mitral Valve Prolapse*

Autonomic imbalances have been implicated in a wide variety of pathologies, including depression, fatigue, premenstrual syndrome, hypertension, diabetes mellitus, ischemic heart disease, coronary heart disease and environmental sensitivity. The AAR affords physicians a powerful diagnostic tool to detect abnormalities and imbalances in the autonomic nervous system and predict those at increased risk of developing various pathologies often before symptoms become manifest. Stress and emotional states have been shown to dramatically affect autonomic function. Self-management techniques, which enable individuals to gain greater control of their mental and emotional stress and improve their sympathovagal balance, can significantly impact a wide variety of

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disorders in which autonomic imbalance plays a role. The AAR analysis has permitted the quantitative demonstration of the effects of the HeartMath interventions in rebalancing the autonomic nervous system in many patients who have been able to significantly improve their symptomatology and psychological well-being through practice of the techniques.

The Autonomic Assessment Report Interpretation Guide and Instructions booklet, available from IHM, provides clinicians with understandable descriptions of HRV measures used in the report and how to interpret them in clinical applications. It includes instructions in Holter recorder use and a number of case histories and clinical examples.

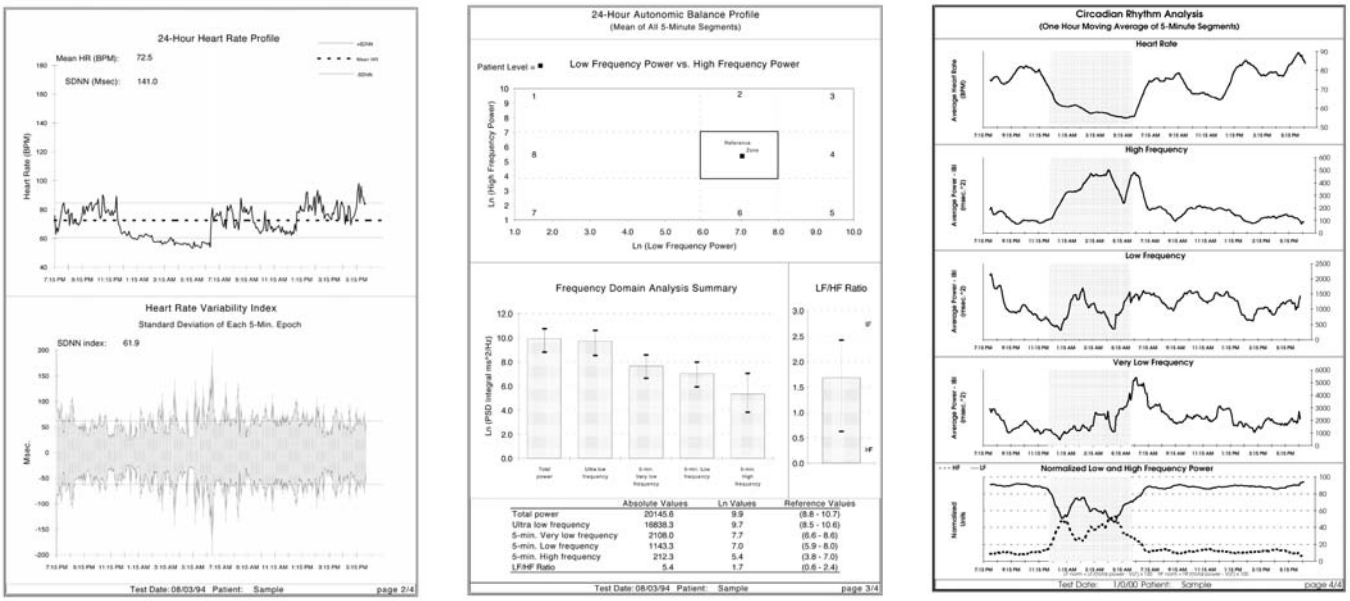

Figure 55. Sample pages from the Autonomic Assessment Report. Shown from left to right are: (1) 24-Hour Heart Rate Profile (top) and Heart Rate Variability Index plot (bottom), (2) 24-Hour Autonomic Balance Profile and (3) Circadian Rhythm Analysis page. Not shown are the data summary sheet and the 24-hour heart rate tachogram pages.

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The HeartMath Research Center's work is supported and reviewed by two boards of independent researchers, the Scientific Advisory Board and the Physics of Humanity Council. These groups are comprised of specialists in physics, mathematics, biology, psychology, health, medicine, engineering and computer science. The Scientific Advisory Board is a unique multi-disciplinary group of pioneering researchers whose objective is to accelerate new scientific understandings of the central role of the human heart in health and medicine.

The mission of the Physics of Humanity Council, chaired by Doc Childre, is to resolve fundamental scientific, psychological and health issues relative to enhancing the quality of life on earth. The Physics of Humanity Council members blend the mind's intellect with the heart's intuitive understanding to expand the boundaries of human awareness. The Council works closely with IHM research staff to facilitate insights and scientific breakthroughs concerning the nature of the heart's intelligence and its role in human consciousness.

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