FEATURE ARTICLE

Heart Rhythm Coherence – An Emerging Area of Biofeedback

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Abstract: *The analysis of heart rate variability (HRV), or heart rhythms, provides a reliable measure of autonomic nervous system dynamics that is particularly sensitive to changes in psychophysiological state. Whereas common methods of HRV analysis typically quantify the* amount *of variability in a given recording, additional information can be gained by* heart rhythm pattern analysis. *Research has shown that sustained positive emotions lead to a highly efficient and regenerative functional mode associated with increased coherence in heart rhythm patterns and greater synchronization and harmony among physiological systems. A new development in biofeedback technology is the recent introduction of heart rhythm feedback trainers, which monitor heart rhythm patterns and help people develop skills to maintain states of increased physiological coherence. The use of pulse wave sensors makes this technology extremely versatile, time-efficient, and easy to use in a wide variety of settings. Heart rhythm feedback trainers are currently utilized in medical, mental health, corporate, and academic settings to improve clinical, psychological, and performance outcomes. This technology holds promise as a powerful and practical tool for the enhancement of health and human potential.*

Heart Rate Variability and Its Significance

Heart rate variability (HRV) is a measure of the naturally occurring beat-to-beat changes in heart rate. The analysis of HRV, or *heart rhythms*, is a powerful, noninvasive measure of neurocardiac function that reflects heart-brain interactions and autonomic nervous system dynamics (Task Force of the European Society, 1996; McCraty et al., 1995; McCraty & Singer, in press). HRV can be derived either from the ECG (using electrodes placed on the chest) or from pulse wave recordings (using a plethysmographic optical sensor placed at the fingertip or earlobe). ECG recordings have the advantage of producing fewer movement-related artifacts. However, pulse wave recording devices also provide data suitable for most biofeedback applications, and, as they require no electrode hook-up, are more easily adaptable for use in a much wider variety of settings (*e.g.,* workplaces, schools, etc.). Of the two main types of pulse sensors available (fingertip and earlobe), the earlobe sensor is slightly less prone to yield artifacts produced by a person's movement.

Heart Rhythm Pattern Analysis

Typically, instruments used for recording HRV analyze the signal by means of time domain or frequency domain (spectral) analysis, both of which quantify the *amount* of variability in heart rate that exists in a given recording. A new approach to HRV monitoring and feedback, which I will describe briefly here, is the analysis of heart rhythm *patterns*. Heart rhythm pattern analysis, which analyzes the varying shape of the HRV waveform, shows promise to be an especially useful tool in psychophysiological research and biofeedback applications. This type of analysis can be particularly valuable in applications that aim to illuminate the physiological correlates of different mental and emotional states, assess the extensive interactions among the mental, emotional, and physiological systems in arousal-induced pathology, or examine psychophysiological responses to different interventions. There are a number of approaches that can be applied to HRV pattern analysis, which provide varying degrees of insight into the autonomic and physiological dynamics underlying the generation of the heart rhythm. In addition to quantifying how much variability exists, power spectral analysis can also be used to characterize certain aspects of the heart rhythm pattern. For example, spectral analysis is a useful approach for quantifying shifts in autonomic balance, vascular resonance, and entrainment, although it is not very useful in identifying more complex patterns. Nonlinear and geometric methods can be used for more complex pattern analysis; however, a detailed discussion of these methods is beyond the scope of this article.

HRV and Emotional States

Recent research conducted at the Institute of HeartMath (IHM) has demonstrated that HRV dynamics are particularly sensitive to changes in emotional state, and that positive and negative emotions can be readily distinguished by changes in heart rhythm patterns. Specifically, during the experience of negative emotions such as anger, frustration, or anxiety, heart rhythms become more erratic or disordered, indicating less synchronization in the reciprocal action that ensues between the parasympathetic and sympathetic branches of the autonomic nervous system. In contrast, sustained positive emotions, such as appreciation, love, or compassion, are associated with a highly ordered or *coherent* pattern in the heart rhythms, reflecting greater synchronization between the two branches of the autonomic nervous system (McCraty et al., 1995; Tiller, McCraty & Atkinson, 1996).

Our research on HRV and emotion has identified a distinct mode of physiological functioning that is frequently associated with the experience of sustained positive emotion. We call this mode *physiological coherence* (McCraty & Atkinson, in press). "Coherence" is used here as an umbrella term to describe a physiological mode that encompasses a range of distinct but related phenomena, including synchronization, entrainment, and resonance, all of which emerge from the harmonious interactions of the body's subsystems. Correlates of physiological coherence include a smooth, sine wave-like pattern in the heart rhythms (heart rhythm coherence), a shift in autonomic balance toward increased parasympathetic activity, increased heart-brain synchronization (alpha rhythms become more synchronized to the ECG), increased vascular resonance, and entrainment among diverse physiological oscillatory systems (*i.e.*, heart rhythm patterns, respiratory, craniosacral, and blood pressure rhythms) (McCraty & Atkinson, in press; Tiller, McCraty & Atkinson, 1996).

HeartMath's Freeze-Framer™ heart rhythm feedback trainer.

Heart Rhythm Feedback Trainers

A promising new development in the field of HRV instrumentation is the recent introduction of heart rhythm feedback training devices. Heart rhythm feedback training is a powerful tool to help people learn to self-generate states of increased physiological coherence at will, thereby reducing stress and improving health, emotional well-being, and performance. Technologies are currently available which enable physiological coherence to be objectively monitored and quantified. These heart rhythm feedback trainers also help individuals develop emotional self-regulation skills that increase the capacity to sustain coherent states and their associated benefits. Using a fingertip or earlobe plethysmographic sensor to detect the pulse wave, these interactive hardware/software systems plot changes in heart rate on a beat-to-beat basis. Heart rhythm feedback trainers can be used in conjunction with breathing techniques or positive emotion refocusing techniques that guide people in intentionally generating sustained positive emotional states and coherent heart rhythm patterns (Childre & Martin, 1999). As people practice the coherence-building techniques, they can readily see and experience the changes in their heart rhythm patterns, which generally become less irregular, smoother, and more sine wave-like as they enter the coherent mode. This process enables individuals to easily develop an association between a shift to a more healthful and beneficial physiological mode and the positive internal feeling experience that induces such a shift. These programs also analyze the heart rhythm patterns and calculate a coherence ratio for each session. The coherence level is fed back to the user as an accumulated score or success in playing on-screen games designed to reinforce coherence-building skills. The software generally includes a multi-user database to store results and track clients' progress.

Because this technology uses a pulse wave monitor and involves no electrode hook-up, it is extremely versatile, time-efficient, and easy to use in a wide variety of settings. Heart rhythm coherence feedback training has been successfully used by mental health professionals, physicians, educators, and corporate executives to decrease stress, anxiety, depression, and fatigue, treat children with ADHD and asthma, improve academic, work, and sports performance, lower blood pressure, and facilitate health improvements in numerous clinical disorders (Lehrer, Smetankin & Potapova, 2000; Luskin, Reitz Newell, Quinn, & Haskell, in press. 2000; McCraty, 2001; McCraty, Atkinson & Lipsenthal, in preparation; McCraty et al., 1999a; McCraty et al., in preparation; McCraty et al., 1999b).

Many health professionals have found heart rhythm monitoring and feedback to be an effective tool to support and facilitate a wide variety of therapies, both conventional and complementary. For example, this technology is increasingly being used by neurofeedback practitioners to calm clients and stabilize the nervous system before sessions. This preparation often allows for a shorter and more effective session. Many clinicians have found heart rhythm feedback to be an effective addition to treatment programs for chronic conditions that are associated with or exacerbated by emotional stress, including fibromyalgia, chronic fatigue, hypertension, asthma, environmental sensitivity, sleep disorders, dia-

betes, and cardiac arrhythmias, among many others. Practitioners also use heart rhythm feedback devices to monitor the real-time psychophysiological effects of various therapeutic interventions that affect autonomic nervous system dynamics.

Because of the sensitivity of HRV patterns to changes in psychophysiological state, many psychologists utilize heart rhythm monitoring effectively as a "camera on the emotions." Continuous monitoring of clients' HRV throughout a therapy session is easily accomplished and can give both therapist and clients immediate insight into clients' emotional responses, often enabling a more efficient and effective session. This technology often proves helpful in identifying subconscious feelings, reactions, and emotional triggers that operate at a level below an individual's conscious awareness but are nevertheless reflected in physiological patterns and processes. The sensitivity of heart rhythm monitoring to psychological variables is clearly illustrated by the account of one psychologist who uses this technology with clients with multiple personality disorder. This clinician finds that he is able to reliably distinguish between the different personalities his clients manifest on the basis of distinct changes in their heart rhythm patterns.

The Promise of Heart Rhythm Feedback

In summary, heart rhythm feedback is a versatile technology that has broad-based applications in clinical, workplace, and academic settings for the enhancement of health and human performance. In the future, we foresee that heart rhythm feedback training will be increasingly incorporated in programs for the prevention and treatment of cardiovascular diseases and arousal-induced pathologies. We also expect that its use will increase in education, as more schools incorporate programs that seek to educate students in emotional awareness and emotion regulation skills. Furthermore, we anticipate that future developments in research, heart rhythm monitoring technologies, and pattern analysis methods will enable an even more refined electrophysiological discrimination of emotion than is currently possible. This may help therapists guide clients in developing greater awareness and understanding of their emotional responses, both conscious and subconscious, and ultimately to achieve greater control over their emotional well-being and health.

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