DISCLAIMER

The information contained within this document does not constitute medical advice or diagnosis and is intended for education and information purposes only. It was current at the time of publication and every effort is made to keep the document up to date.

The information contained herein includes both psychological and non psychological interventions. The delivery of psychological services requires a medical referral whilst non psychological services do not.

Each person is an individual and has a unique psychological profile, biochemistry, developmental and social history. As such, advice will not be given over the internet and recommendations and interventions within this website cannot be taken as a substitute for a thorough medical or allied health professional assessment or diagnosis.

Heart Rhythms and **H**eart **R**ate **V**ariability (HRV)

Article QUICK LINKS :

INTRODUCTION

In our materially oriented, mechanistic world, people have been taught that the heart is just a 300 gram muscle which pumps over 70 litres of blood per minute without interruption for 70 to 80 years. It beats 100,000 times per day and approximately 40 million beats per year, which equates to around 3 billion pulses per lifetime. Looked at biologically, the heart is nothing short of miraculous. Embryo logically, the heart starts beating before the formation of the brain and even though scientists do not know what triggers the beating, they do know that it is self initiated from within the heart itself. The heart begins to beat before the emotional centres and rational part of the brain begin to emerge. However, the heart is not just a simple pump. The heart is, in fact, a complex, sensory organ with its own functional "heart brain" that communicates with and influences the brain via the nervous system, hormonal system and other pathways. Research has shown that these influences profoundly affect brain function and most of the body's major organs.

Science now confirms what people have known for a long time- that anger, anxiety and worry significantly increase the risk of heart disease, including sudden cardiac death. At the forefront of the scientific arena, is a growing body of compelling evidence for the connection between stress, mental and emotional attitudes, physiological health and overall wellbeing. Unmanaged emotional stress is equally if not more important than physical variables in determining health outcomes. A conservative estimate is that 75% of visits to primary care physicians are due to stress-related disorders.

Through developmental studies from conception to old age it has been shown that heart rate (HR) activity varies in infants and children as a function of attentional states and emotion. Typically, the near term fetal HR is about 140 beats per minute (bpm), and during labour, HR rises to around 160 bpm. The newborn HR is around 140 bpm and this drops within the first year to around 120 bpm. At the age of ten, HR comes down to some 90 bpm. Newborns and young infants show HR decelerations ranging from 2-4 beats per minute when auditory or visual stimulation is terminated. (Berg, 1974; Porges, Stamps and Walter, 1974). Heart activity correlates to our emotions, stress, motivational levels, personality and social factors and at every living moment, there is implicit conditioning and interaction between the heart and the brain.

THE HEARTBEAT OR CARDIAC CYCLE

The heart has four chambers - the right and left atria (on top), and right and left ventricles (on bottom). The atria are receiving chambers for blood that has been returned to the heart by the veins, and the ventricles pump the blood via arteries to the lungs and the rest of the body.

The heartbeat which we can hear through a stethoscope and record with the electrocardiograph (ECG), represents the rhythmic muscular contractions that the heart does in order to pump blood to the rest of the body. The normal adult human heart contracts (beats) at a rate of about 72 (men) -76 (women) bpms at rest. The control of this beating is by both internal heart mechanisms and external interactions.

The heart's internal control mechanism consists of specialised fibres including the sinoatrial (S-A) node, located on the rear wall of the right atrium, the atrioventricular (A-V) node, the A-V bundle, and the left and right bundles of conducting fibres (Guyton, 1977). The S-A node is known as the pacemaker, with a rate of 120 bpm at normal body temperature. However, the vagus nerve (the Xth cranial nerve) inhibits the pacemaker and holds the rate down to between 70 and 80 bpm. The contractional impulse is slightly delayed at the A-V node before passing into the ventricles, and the A-V bundle then conducts the impulse into the ventricles. Fibres known as *Purkinje Fibres conduct the impulse to all parts of the ventricles.*

The contraction phase of the heart is known as systole and the relaxation phase is termed diastole.

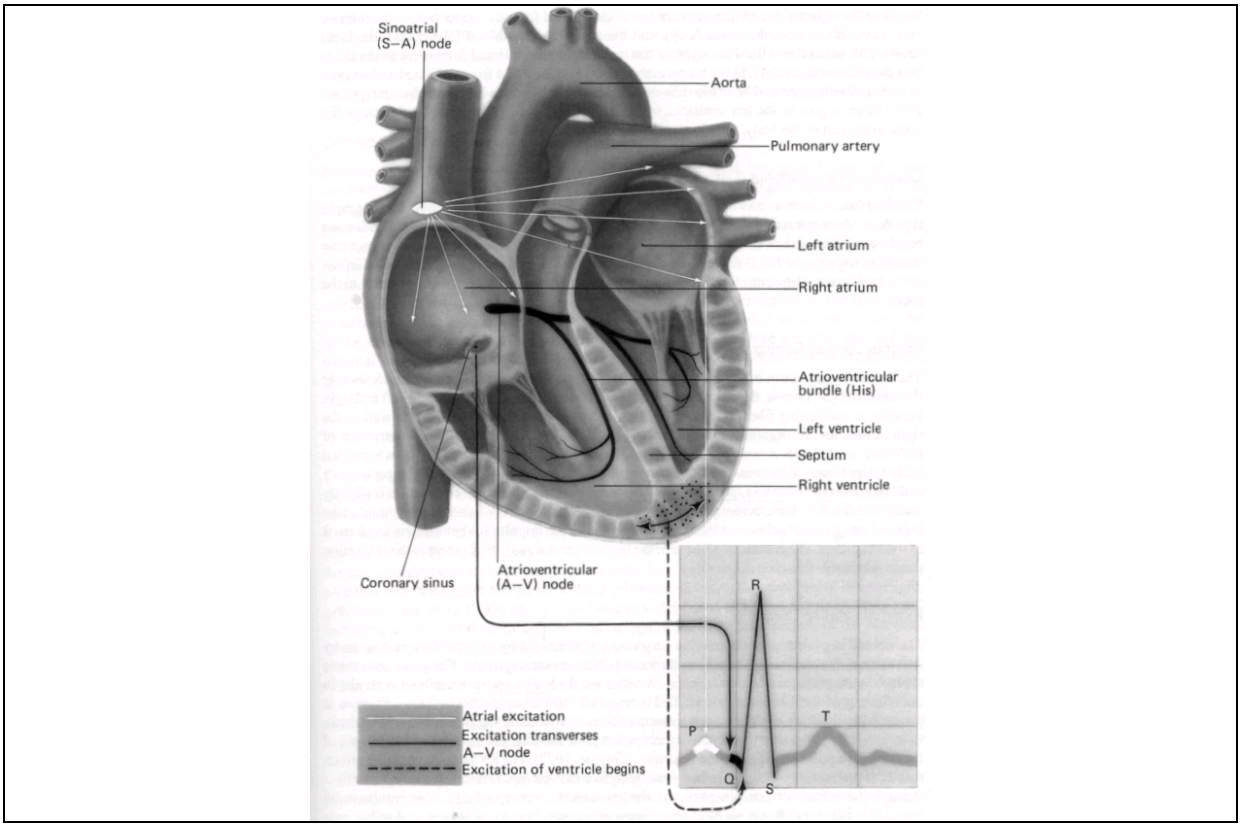


Image Source : Psychophysiology-Human Behaviour and Physiological Response

The normal electrocardiogram (ECG) is comprised of characteristic deflections referred to as P,Q,R,S,and T waves. The P wave is caused by the current generated just before the contraction of the atria. The complex QRS wave is the result of the currents generated in the ventricles during depolarisation just prior to ventricular contraction, the R wave being the dominant component.
The T wave is caused by repolarisation of the ventricles. *Depolorisation* occurs as a result of the ionic activity within the fibre becoming positive in respect to the outside, and *repolorisation* is a return to the internal negativity with respect to external positivity. This particular action of the cardiac muscle is similar to the polarisation that occurs in neurons.

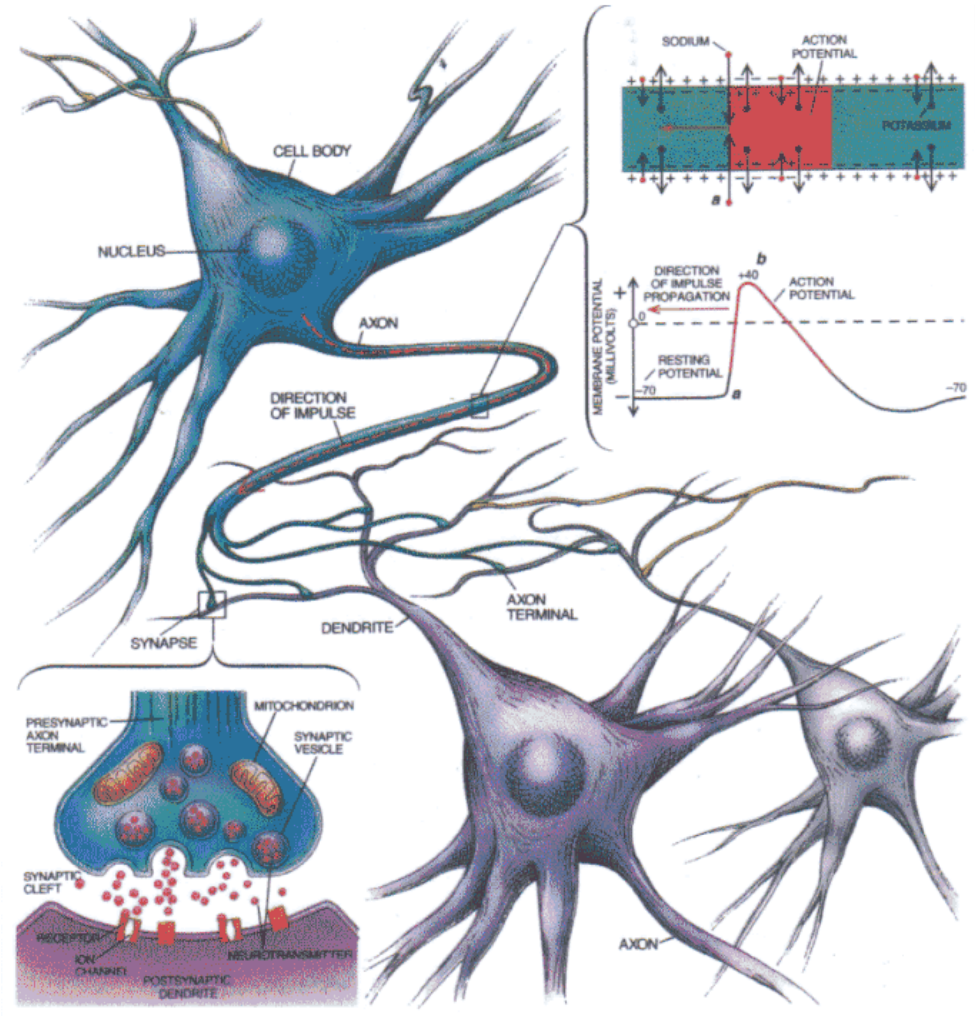
Externally, the rate of contraction may be influenced via nerve impulses from both the autonomic (ANS) and central (CNS) nervous systems. The parasympathetic (PNS) system, a division of the ANS, influences the S-A and A-V nodes via the vagus nerve. This influence is produced by release of the neurotransmitter acetylcholine at the vagus nerve endings which result in the slowing of activity at the S-A node (or cardiac pacemaker) and a slowing of the cardiac impulse passing into the ventricles (Guyton, 1977). The sympathetic nervous system (SNS) has the opposite effect through the release of norepinepherine at the sympathetic nerve endings. The SNS acts to increase output in certain emotional situations or extreme levels of exercise.
For further information on the human nervous system, please see the article: The Relationship Between Vital Energy And The Human Brain And Nervous System

Neurological impulses are sent from the heart to the brain through several "afferent" (flowing to the brain) pathways. Feeling sensations are also sent to the brain through these nerve pathways. These afferent nerve pathways enter the brain in the medulla which is located in the brain stem. These signals regulate many of the autonomic nervous system signals that flow out of the brain to the heart, blood vessels and other glands and organs as well as cascading up into the higher centres of the brain.

In 1983, the heart was in fact reclassified as an endocrine or hormonal gland, when, a hormone produced and released by the heart called atrial natriuretic factor (ANF) was isolated. This hormone has far ranging effects on the blood vessels themselves, on the kidneys and the adrenal glands and on a large number of regulatory regions in the brain. More recently it has been found that the heart contains cells that make and release a large number of neurotransmitters such as norepinephrine and dopamine which were originally thought to be produced only by the brain and nervous system.

CONNECTIVITY - NEURONAL CIRCUITS AND LEARNING

The brain is made up of nerve cells or neurons — specialized cells for signalling, processing and integrating information. Most types of neurons have a cell body, dendrites (providing inputs to the neuron) and axons (conducting the outputs of the neuron). The axons branch out into axon terminals which are highly specialized to convey information to other neurons, the spinal cord and autonomic centers, muscles and glands throughout the body. At the ends of the axon terminals special terminals called synapses or synaptic endings make contact with the dendrites or cell body of other neurons or target cells. When electrically stimulated, the synapses release chemicals called neurotransmitters which modify the electrical properties of the cell with which they are in contact.



How Neurons Communicate

A neuron that has been excited (*turquoise*) conveys information to other neurons (*purple*) by generating impulses known as action potentials. These signals propagate like waves down the length of the cell's single axon and are converted to chemical signals at synapses, the contact points between neurons.

When a neuron is at rest, its external membrane maintains an electrical potential difference of about −70 millivolts (the inner surface is negative relative to the outer surface). At rest, the membrane is more permeable to potassium ions than to sodium ions, as indicated by the lengths of the dark arrows in the inset at the top right. When the cell is stimulated, the permeability to sodium increases, leading to an inrush of positive charges (*a*). This inrush triggers an impulse—a momentary reversal (*b*) of the membrane potential. The impulse is initiated at the junction of the cell body and the axon and is conducted away from the cell body (*red arrows*).

When the impulse reaches the axon terminals of the presynaptic neuron, it induces the release of neurotransmitter molecules (*inset at bottom left*). Transmitters diffuse across a narrow cleft and bind to receptors in the postsynaptic membrane. Such binding leads to the opening of ion channels and often, in turn, to the generation of action potentials in the postsynaptic neuron. For the sake of clarity, several elements are drawn larger than scale.

Neurons do not function in isolation; rather, they are organized into circuits that process specific kinds of information. Neural connections are typically made in a dense tangle of axon terminals, dendrites and synapses, which together form the connectivity web. It is the electrical activity of the connectivity web that generates the brainwaves or electroencephalogram (EEG). It takes about 20,000 neurons operating in synchrony to create a signal strong enough to be detected.

The heart produces an electric field 60 times stronger than that produced by the brain, and it's electromagnetic field is 5000 times stronger than the field generated by the brain. This is why the *quality* of the variation of the heart beat can also subtly influence people who are in our proximity (under 1.5 m distance). As the electrical activity in the heart displays a much stronger signal than the electrical activity of the brain, the ECG (electrocardiograph) is less difficult to obtain.

Neurophysiologists have discovered a neural pathway and mechanism whereby input from the heart to the brain can "inhibit" or "facilitate" the brain's electrical activity. One of the early pioneers in neurocardiology, Dr. J. Andrew Armour, introduced the concept of a functional "heart brain" in 1991.

Within this context, the heart is considered a single entity. The 'brain in the heart' is a network of neurons, neurotransmitters and proteins that send messages between neurons. Like the brain, the heart also has support cells and a complex circuitry that enables it to act independently, learn, remember, and produce the "feelings of the heart." The type of information sent from the heart to the brain has profound effects on higher brain functions, influencing our perceptions, emotions, thought processes and learning abilities.

THE ROLE OF MENTAL AND EMOTIONAL COHERENCE TO GOOD HEALTH AND WELLBEING

Contrary to popular belief, emotions are not always negative and do not always serve as antagonists to rational thought. Instead, emotion and cognition can best be thought of as separate but interacting functions or systems, each with its own unique type of intelligence. Neurologists now stress the rationality of emotion and emphasize the importance of emotions in decision making. It is now known if the brain is injured in the areas that integrate the emotional and cognitive systems a person can no longer effectively function in the day-to-day world, even though their mental abilities are perfectly normal.

Studies are 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. Within the wiring of the brain, the neural connections from the emotional system to the cognitive systems are stronger and more numerous than the connections from the cognitive to the emotional system. Once an emotion is experienced, it becomes a powerful motivator of future behaviors, affecting our moment-to-moment actions, attitudes and long-term achievements. Emotions can easily knock mundane events out of our awareness, but non-emotional events (like thoughts) do not easily displace emotions from awareness.

Research is showing that by using techniques to increase the coherence in the emotional system, we can often bring the mind into greater coherence as well.

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

THE RELEVANCE OF HRV TO PSYCHOLOGICAL PROBLEMS

How are HRV measurements relevant to the field of psychology? Perhaps the best answer to this question is contained in the recent study by Damasio, et al. (2000). The influence of emotions on the ANS can be seen by analysing heart rate variability (HRV) as this serves as a non-invasive method providing a dynamic window into autonomic function and balance, thus affording an objective measure of an individual's emotional state. Damasio found areas of the brain associated with various emotions were also associated with autonomic nervous system (ANS) activity.

The normal variability in heart rate, which can be determined from the electrocardiogram (ECG), or from the pulse wave, is due to the synergistic action of the two branches of the ANS. The ANS strives toward balance via neural, mechanical, humoral and other physiological mechanisms in order to maintain cardiovascular (and other bodily system) parameters in their most favourable ranges to facilitate optimal reaction to changing external or internal conditions.

Low HRV has been linked to psychological problems. A number of studies have demonstrated that patients with anxiety and phobias exhibit low HRV (Middleton, 1990; Kawachi, Sparrow, Vokonas & Weiss, 1995; Freidman & Thayer, 1998a; Freidman & Thayer, 1998b; Watkins, Grossman, Krishnan & Blumenthal, 1999).

Similarly, subjects with post traumatic stress disorder (PTSD) consistently show lower HRV, even when not exposed to a trauma related prompt, than those who did not have PTSD (Cohen, et al., 1998). Furthermore, data also suggests a connection between low HRV and depression (Carney, et al., 1995; Krittayaphong, et al, 1997), although not all studies found this association (Watkins, et al., 1999; Yeragani, et al., 1991) thus, some controversy still exists in this realm (Carney, Freedland & Stein, 2000).

Additionally, a study by Dishman, et al., 2000, illustrated the relationship between low HRV and anxiety, and showed a statistically significant correlation between subjects' self-rated anxiety and emotional stress and low HRV. Importantly, this relationship existed independent of age, gender, trait anxiety, cardiorespiratory fitness, heart rate, blood pressure and respiration rate.

EMOTIONAL MEMORY

Much of our perception is colored by the emotional memories we accumulate throughout our lives, which contribute to the configuration of the neural circuitry or pathways laid down within the brain. Our emotional memories, "recorded" in our neural networks, and become the filter through which we perceive, interpret and experience new situations and events.

Our perception of an external or internal stimulus immediately generates thoughts and feelings. These mental reactions and particularly our emotional responses can generate instantaneous physiological changes in the autonomic nervous system, hormonal and immune systems, which have profound effects throughout the entire body and brain. These physiological responses, in turn feed back to the brain where they can either strengthen or weaken existing neural circuits. Plato, the Greek philosopher/metaphysician (347 B.C.), once said "All learning has an emotional base", and when we look at the concept of emotional memory, we can easily see what he meant.

Physical movements such as walking, riding a bike, or driving a car become "stereotyped" and automatic through repetition and the development of new neural circuitry sometimes referred to as 'muscular memory'. Likewise, mental and emotional responses and attitudes can also become 'ingrained' or automatic. Emotional memory is recorded and stored in circuits concentrated in the amygdala and other related brain structures. The amygdala is also a key brain centre in the coordination of behavioural, immunological and neuroendocrine responses to environmental threats.

One function of the amygdala is to compare new incoming sensory information with information stored in the emotional memory banks and thereby determine the significance of an event. The amygdala makes instantaneous decisions about the potential threat that incoming sensory information may pose. Since it has extensive connections to the hypothalamus and other autonomic nervous system centers in the brain stem the amygdala can "hijack" other neural pathways, activating an autonomic and emotional response before our higher brain centers receive the sensory information.

In this way, emotional memory patterns affect our moment-to-moment perceptions, emotions and behaviors. In the figure, this individual sees a person that reminds them of someone they had a bad experience with, it could be that they remind them of a bully from school, or the person in the office that manages "push their button". An emotional memory is triggered. Emotional in that you "see" him as if he were a monster and react. Emotional memories can often set in motion inappropriate responses based on past situations rather than on one’s current reality.

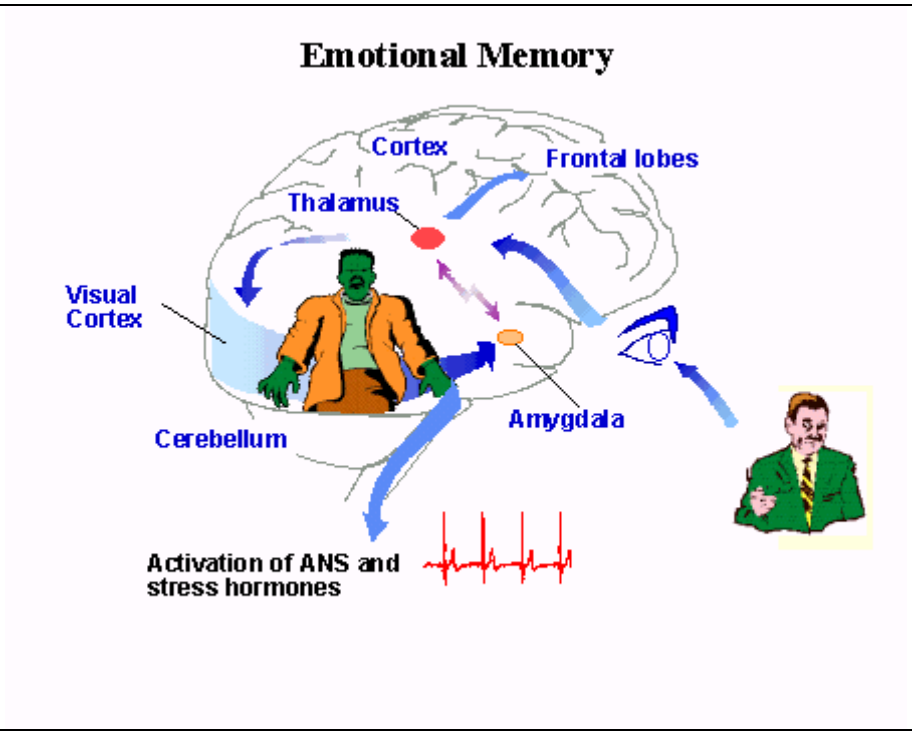


Diagram from: The Institute of HeartMath™

The amygdala also receives information from the heart. One of the functions of the amygdala is to organize what becomes "familiar." If the rhythm patterns generated by the heart are disordered and incoherent, especially as a young child, the amygdala learns to expect disharmony as familiar; 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 really is discomfort. On the basis of what has become familiar, the frontal cortex mediates decisions as to what is appropriate or not in any given situation. Thus, subconscious emotional memories underlie and affect our perceptions, emotional reactions and thought processes.

By learning how to self-generate coherent heart rhythms, and with consistent practice, it is believed that these emotional memory patterns can be reprogrammed so that coherence becomes the normal and comfortable state.

With growing evidence of the tremendous benefits to be gained from learning to manage stress and increase physiological, mental and emotional coherence, the importance of learning inner management techniques at an early age is becoming increasingly apparent. In today's fast-paced society, there is increasing pressure on children to achieve and excel in school at younger and younger ages. These same 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 10 years ago.

Our educational systems tend to focus upon honing children's cognitive skills from the moment they enter the kindergarten classroom, and virtually no emphasis is placed on educating children in the management of the inner conflicts and unbalanced emotions that they bring with them daily to school. As new concepts such as "emotional intelligence" become more widely used 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 become able to effectively deal with the pressures and obstacles that will inevitably arise in their lives.

Moreover, increasing evidence is showing that emotional balance and cognitive performance are indeed linked. Growing numbers of teachers are agreeing that children come to school with so many problems that it is difficult for them to be good students. Conversely, when mental and emotional turmoil is managed, the increased physiological coherence and heart-brain entrainment stimulates greater mental clarity and expands the mind's capacities.

Children are among the quickest to intuitively understand and naturally integrate these tools into their lives. A child's brain continues to develop throughout childhood and adolescence, forming new nerve connections and letting 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 which perpetuate that incoherence and its 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.

TOOLS TO ACHIEVE HEART / BRAIN COHERENCE AND ENTRAINMENT

Many people who are good candidates for biofeedback demonstrate an imbalance in the autonomic nervous system.

Generally, stress related problems have too much sympathetic activity, too little parasympathetic (or vagal) activity, or both. Examples of this are anxiety, hypertension, cardiac disease, asthma, irritable bowel syndrome, and hyperventilation syndrome.

At Learning Discoveries Psychological Services, we utilise a form of biofeedback that directly measures and trains autonomic balance. The technique is called heart rate variability training (at the clinic we have three forms of HRV training - HeartMath™, Heart Tuner Pro and / or Physiolab). By measuring heart rate precisely and performing spectral analysis, the amount of sympathetic, parasympathetic, and combined activity influencing the heart rate can be correlated. Measuring heart rate variability is an effective, objective and non-invasive method providing a dynamic window into autonomic function and balance, thus affording an objective measure of an individual's emotional state by assessing interactions that take place between the physiological, emotional,

mental and behavior processes. Thus, HRV is a useful outcome measure of treatment interventions for negative emotions.

Training with heart rate variability is relatively easy. Because heart rate is aligned closely to respiration, breath work is a key feature of this technique. Once a person is trained to breathe in a specific pattern and see the immediate effects of proper breathing on their heart rate, they realise the effects of breathing patterns on heart rate and other physiological systems. The breathing techniques can then be fine tuned to the individual's specific physiology to their greatest benefit.

Stress due to the mismanagement of the human mind and emotions significantly harms our health, inhibits our ability to perform to our optimal potential and constricts the range of intelligence we can access. However, when we bring the mind and emotions into balance and coherence, we are able to self-activate a higher intelligence that results from the synergy of heart and mind working in concert. This intelligence is inherent in all human beings.

HEARTMATH™

The *Institute of HeartMath*® in the United States has developed a software programme to effectively train children and adults to achieve both coherence and heart brain entrainment through a simple set of exercises performed while seated in front of a computer and an infrared pulse detector placed upon the index finger.

The method has proved very effective in studies performed both at the institute and other centres around the world.

HeartMath™ is at the forefront of human development, holistic health, business and organisational development with techniques that utilise the transforming power of the heart to release stress, access higher levels of intelligence, establish emotional balance and stimulate higher brain functioning. The transformational HeartMath™ techniques have a major impact upon health, effectiveness, productivity and the experience of personal wellbeing. It has been used to train individuals and organisations such as hospitals, religious organisations, businesses and government agencies around the world.

HeartMath™ is a registered trademark of the Institute of HeartMath®

Physiolab: was developed by J and J Engineering and provides simultaneous heart rate and HRV, skin conductance and temperature, respiration, surface electro-myography (SEMG - muscle tension) and EEG biofeedback. The data collection device is CE and FDA approved for biofeedback in the United States.

FURTHER READING SUGGESTION

- The Relationship Between Vital Energy And The Human Brain And Nervous System
- Quantitative Electroencephalography - QEEG
- Neurofeedback - EEG Biofeedback - a Drug-Free Strategy for ADHD, Learning Disorders and Other Conditions

LINK

PLEASE NOTE :
Learning Discoveries offers the link below as a convenience to our clients and the users of this website. However, we do not control third party websites and we are not responsible for the websites content.

- Institute of HeartMath®

  http://www.heartmath.org/

  The Institute of HeartMath is an internationally recognized non-profit research and education organisation dedicated to heart based living with people relying on the intelligence of their hearts in concert with their minds to conduct their lives at home, school, work and play. HeartMath has been researching heart intelligence, stress and emotional management for more than 19 years and applied its findings to practical, easy-to-use tools that have been scientifically developed and tested.

For more information or to make an appointment please contact us on (02) 9637 9998 during business hours.

REFERENCES

1. Andreassi, J.L., (1995), Psychophysiology - Human Behaviour & Physiological Response. Lawrence Erlbaum & Asscoiates, Hillsdale, New Jersey.

2. Childre, D. & Martin, H., (1999), The HeartMath Solution, Harper Collins, San Francisco.

3. McCraty, Atkinson, & Tomasino, (2001), Science of The Heart, HeartMath Research Centre, Boulder Creek, CA.

4. Lacey, J & Lacey B. (1970): Some autonomic –central nervous system interrelationships. In: Black, P., Physiological Correlates of Emotion. Academic Press, New York. p205-227.

5. Armour, J. & Ardell, J. (eds): (1994): Neurocardiology. Oxford University Press, New York.

6. Childre, Doc (1994): Freeze Frame- A Scientifically Proven Technique for Clear Decision Making and Improved Health. Planetary Publications, Boulder Creek, CA.

7. Schandry, R. & Montoya, P. (1996): Event-related brain potentials and the processing of cardiac activity. Biological Psychology, 42:75-85.

8. Pribram, K, Rozman D (1997): Early Childhood Development and Learning: What New Research on the Heart and Brain Tells us about Our Youngest Children. Paper presented to the White House Conference on Early Development and Learning. San Francisco meeting , April 17, 1997.