HEART RATE VARIABILITY (HRV)

Dr. Robert Nolan

Please tell us a little about yourself and your work?

I recently took on the position of Coordinator of Behavioral Cardiology Research at the Toronto General Hospital-University Health Network. I have been doing research into cardiovascular response to stress, smoking cessation treatments, and behavioral adjustment to heart disease for the past ten years. I am excited about my current opportunities and resources for developing an active program of clinical research regarding heart rate variability (HRV) and biofeedback treatments to reduce the negative effect of stress on the cardiovascular system. I am pleased to have recently been awarded a grant from the Heart and Stroke Foundation of Canada to assess whether HRV biofeedback training can significantly help smokers who are trying to control their urge to smoke in the early stage of quitting. The pilot phase for this research was supported by a grant from the Biofeedback Foundation of Europe (BFE www.bfe.org). It is in this capacity that I have also begun a workshop training series on HRV biofeedback in association with the Biofeedback Foundation of Europe.

What is Heart Rate Variability?

Heart rate variability refers to the regulation of the sinoatrial node, the natural pacemaker of the heart by the sympathetic and parasympathetic branches of the autonomic nervous system. Our assumption, when we assess HRV, is that the beat-to-beat fluctuations in the rhythm of the heart provide us with an indirect measure of heart health, as defined by the degree of balance in sympathetic and vagus nerve activity.

In the evolving field of healthcare, biofeedback, as a treatment and evaluation tool, is playing an increasingly more important role. Biofeedback is used by a diversity of health professionals to treat an ever-lengthening list of conditions. Health professionals such as psychiatrists, psychologists, nurses, physiatrists, physical and occupational therapists and physicians in various specialties have come to use biofeedback, either independently or as an adjunctive technique, with positive results.

The Expert Series is an on-going series of interviews with leading clinicians in the field of biofeedback lending the insights and techniques they have acquired through their many years of practice.

Thought Technology is very pleased to be part of this educational project. For over 25 years, Thought Technology has been committed to making biofeedback more accessible through innovation in technology and educational initiatives.

The Expert Series interviewed Dr. Robert Nolan.

Dr. Robert Nolan is coordinator of Behavioral Cardiology Research at the University Health Network in Toronto, Canada, and is an accredited member of BCIA. He has chaired conferences on Cardiovascular Heart Disease, led professional workshops and made public and academic presentations.
He is a member of the Canadian Register of Health Service Providers in Psychology, a registered Psychologist with the College of Psychologists of Ontario and a member of both the Society of Behavioral Medicine and the Ontario Psychological Association.
He consults regularly to national health care organizations.

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What is Respiratory Sinus Arrhythmia (RSA)?

RSA is the natural cycle of arrhythmia that occurs through the influence of breathing on the flow of sympathetic and vagus impulses to the sinoatrial node.

The rhythm of the heart is primarily under the control of the vagus nerve, which inhibits heart rate and the force of contraction. When we inhale, the vagus nerve activity is impeded and heart rate begins to increase. When we exhale this pattern is reversed. The degree of fluctuation in heart rate is also controlled significantly by regular impulses from the baroreceptors (pressure sensors) in the aorta and carotid arteries. When RSA is enhanced through biofeedback, the goal is usually to reinforce the natural feedback activity of the baroreceptors through our breathing pattern.

Why is heart rate variability such an important factor?

HRV is important because it provides a window to observe the heart's ability to respond to normal regulatory impulses that affect its rhythm.
A primary focus of clinical work and research is in observing or modifying the balance in regulatory impulses from the vagus nerve and sympathetic nervous system. Some researchers are focussing attention on other factors that regulate the heart, such as chemoreceptors, thermoreceptors, and the renin-angiotensin system.

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Similar research has demonstrated the clinical importance of HRV for patients with other cardiac conditions.

How does age and health affect HRV?

We have good evidence that heart rate variability is affected by several factors such as age and health status. HRV decreases with age. It is also lower among people who have an inactive lifestyle and among those who have medical conditions such as coronary heart disease, hypertension and diabetic neuropathy.

Does age and health affect RSA as well?

That is an important question. Yes, definitely, age and ill health would affect the range that you observe in beat-to-beat intervals related to RSA. For example, after a heart attack or with congestive heart failure, there is a phenomenon called "vagal withdrawal", which means that the vagus nerve is inhibited from slowing the activity of the sinoatrial node and from buffering the degree of contraction throughout the cardiac tissue (myocardium). This occurs for survival purposes. The important question for biofeedback practitioners is whether or not RSA biofeedback can significantly assist a person in increasing their heart rate variability and overall cardiac health.
A related issue for assessment, treatment planning and evaluation, is that we need to use a different set of HRV norms when we are working with persons who are older or who have a medical condition that affects heart health.

How do you measure HRV?

HRV can be assessed by time domain or frequency domain indices. The time domain measures are based on the amount of time, in milliseconds, in the beat-to-beat intervals of the heart or from the differences between the normal beat-to-beat intervals. Technically, the beat-to-beat interval is defined as the time in milliseconds between normal "R" to "R" waves on an EKG. The standard deviation of the normal RR interval (SDNN) is one of the most important and clinically meaningful time domain measures.
The gold standard for time domain measures is to examine a 24-hour assessment of HRV that has been recorded with a Holter monitor.
A brief five minute assessment of HRV has also been found to be

clinically valid and meaningful. One essential guideline that biofeedback therapists need to keep in mind is that it is NOT valid to compare HRV estimates that are derived from different time durations, as variability is significantly influenced by the length of the signal that is sampled. Frequency domain measures of HRV provide information on the frequency distribution of the components of HRV using power spectral density analysis. Spectral analysis of HRV is characterized by four main components: the high frequency (HF) component (.15Hz -.40 Hz) measures the influence of the vagus nerve in modulating the sinoatrial node.

The low frequency (LF) component (.04Hz-.15 Hz) provides an index of sympathetic effects on the heart, particularly when these are measured in normalized units. The very low frequency (VLF) component (.003Hz -.04 Hz) reflects the influence of several factors on the heart, including chemoreceptors, thermoreceptors, the renin-angiotensin system, and other non-regular factors. Almost all of the variability from a short-term spectral analysis of HRV is captured in these three components. An ultra low frequency (ULF) component (≤.003 Hz) can also be observed in the HRV spectrum analysis of a longer sample. Unfortunately, a clear interpretation of the ULF component is not yet available to us. During the 24-hour recording of HRV, approximately 90% of variability in the heart's rhythm will be distributed within the ULF and VLF.

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Will a client feel better from HRV biofeedback?

When people have more heart rate variability it is because there is a better balance in the ongoing sympathetic and parasympathetic influence on the heart. Generally, people have greater heart rate variability when they are relaxed and when they are breathing in a regular or slow pattern.

In short, HRV biofeedback training appears to offer a more precise method for helping clients to moderate the heightened sympathetic activity that is associated with stress, anxiety, and dysphoric mood.

There have been several small-scale studies that have provided supporting evidence to bolster this hope for HRV biofeedback. At the same time though, we need larger scale clinical trials to firmly establish HRV biofeedback as an evidence-based treatment for reducing negative effects or for improving heart health.

What type of feedback do you give to clients?

In order to do HRV biofeedback training you need to use an EKG module, in which the normal beat-to-beat interval in heart rate can be derived and from which the variation in heart rate (normal RR intervals) can be measured. The respiration module is also necessary to measure the rhythm of breathing and its influence on HRV. It is advisable to use complementary biofeedback modules that assess peripheral vascular activity. A photoplethysmograph (blood volume pulse sensor) and thermistor are quite useful for this purpose. In fact, there is some exciting research that has emerged regarding wave form analysis of the BVP signal from the photoplethysmograph and this new analysis has great potential for enriching our interpretation of HRV.

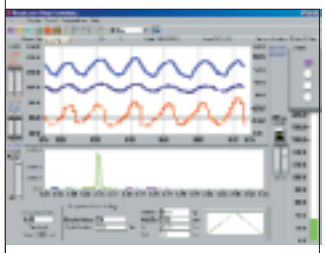
1 - Heart rate variability: Standards of measurement, physiological interpretation, and clinical use. Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology. European Heart Journal (1996) 17, 354–381.

2 - Committee Report. Heart rate variability: Origins, methods and interpretive caveats. Berntson GG, Bigger JT, Eckberg DL, Grossman P, Kaufmann PG, Malik M, Nagaraja HN, Porges SW, Saul JP, Stone PH, Van der Molen MW. Psychophysiology 1997; 34: 623-648.

3 - The effects of stress-anxiety and coping styles on heart rate variability. Fuller BF. Int. J Psychophysiol 1992; 12(1): 81-86.

4 - Cardiac sympathetic and parasympathetic activity during self-regulation of heart period. Hatch JP, Borcherding S, German C. Biofeedback and Self-Regulation 1992; 17(4): 89-106.

WINDOWS TO THE HEART



To maximize RSA visibility, CardioPro displays a line graph for one or two respiration signals along with the graph of the EKG heart rate.

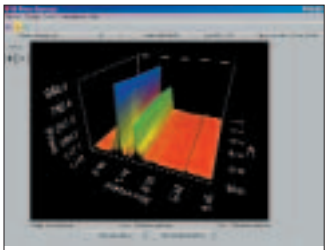
Measures of heart rate variability (HRV) are a reliable reflection of the many physiological factors modulating the normal rhythm of the heart. In fact, they provide a powerful means of observing the interplay between the sympathetic and parasympathetic nervous systems.

A growing number of studies indicate that increased variability in the heart's interbeat interval is physiologically desirable.

CardioPro is a specialized biofeedback application that provides a sophisticated array of feedback tools for monitoring HRV and Respiratory Sinus Arrhythmia (RSA); it is an effective adjunct to any relaxation and self-regulation training program.

Real-time audio and visual feedback on the standard deviation of the IBI provides an immediate indication of changes in heart rate variability.

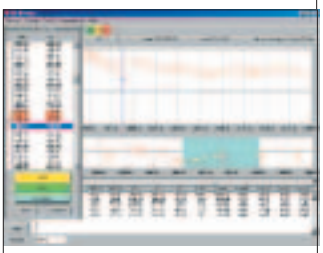
A programmable respiration pacer allows the user to define breathing cycles that include inspiration and expiration time as well as breath holding pauses.



The full-color 3D frequency spectrum display shows changes in HRV over time, both in record and review modes.

The Statistical Report printout of standard calculations* includes power analysis for the LF, HF and VLF components of the HRV spectrum, SDNN, NN50 and PNN50.

CardioPro's export function for the IBI data ensures compatibility with third-party data analysis software packages.



A sophisticated data editor, with time-correlated cursors on EKG and IBI graphs and color-coded operations, allows users to perform normalizing operations on the IBI tables in just a few seconds.

A true 32-bit Windows™ application, CardioPro offers the best combination of user-friendly graphical interface and powerful features to make it the most competitive software package available for respiration, RSA/HRV biofeedback and research.

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* Statistics are calculated as recommended in the Special Report on Heart Rate Variability Standards of Measurement, Physiological Interpretation and Clinical Use. Published by the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (European Heart Journal (1996) 17, 354-381).

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