HRV SUITE™

USER MANUAL

For use with BioGraph INFINITI **version 6.0.4 or later**

CLASSIFICATION

- Type BF Equipment
- Internally powered equipment
- Continuous operation

- Read Instruction Manual

CAUTION

- US Federal Law restricts this device to sale by or on order of licensed health care practitioners.

WARNING

- Do not operate active sensor within 10 feet (3m) of an operating cellular phone, similar radio transmitting device, other powerful radio interference producing sources such as arc welders, radio thermal treatment equipment, x-ray machines or any other equipment that produces electrical sparks.
- All encoders are totally isolated from line (110 or 220VAC) power due to battery operation and fiber optic connections to computers. However, many hospitals and the FDA require that computers, printers and any other equipment used with medical devices be electrically isolated from line voltage to UL or CSA medical safety standards.
- Do not connect inputs or outputs of the encoder or sensors to line powered devices, except through the fiber optic cable.
- The PC used with the encoder must be placed outside the patient/client environment (more than 3 meters or 10 feet) or the PC must comply with EN60601-1.1 (system safety).
- After use, the disposable electrodes may be a potential biohazard. Handle and, when applicable, dispose of these materials in accordance with accepted medical practice and any applicable local, state and federal laws and regulations.
- To diminish the risk of spreading communicable diseases, always use good hygiene practices with reusable electrodes, particularly if abrasive substances are used. In all cases, refer to your facility's infection control procedure.
- Do not use in the presence of a flammable anesthetic mixture with air or with Oxygen or Nitrous Oxide.
- Not to be immersed in water.
- Take care in arranging patient and sensor cables to avoid risk of patient entanglement or strangulation.
- The operator is responsible for ensuring the safety of any devices controlled or triggered by Infiniti equipment or software, or by any software or hardware receiving data from Infiniti equipment. Infiniti equipment must not be configured or connected in such a way that failure in its data acquisition, processing or control functions can trigger patient feedback stimulus that poses an unacceptable level of risk.
- Use of any equipment in a biofeedback context should be immediately terminated upon any sign of treatment-related distress or discomfort.
- Not to be connected to a patient undergoing MRI, Electro surgery or defibrillation.

ATTENTION

- To prevent static discharge from damaging the sensor and/or encoders, use antistatic mats or sprays in your working area. A humidifier may also be used to help prevent static environments by conditioning hot, dry air.
- Not for diagnostic purposes. Not defibrillator proof. Not for critical patient monitoring.
- To prevent voiding warranty by breaking connector pins, carefully align white guiding dot on sensor plug with slot on sensor input.
- Make sure to remove electrodes from sensor snaps immediately after use.
- Apply conductive gel only to electrodes; never put gel directly on sensor snaps.
- Always use electrodes between the subject and the sensor.
- Sharp bends or winding the fiber optic cable in a loop smaller than 4 inches (10cm) may destroy the cable.
- A fiber optic cable not fully pushed into its receptacle may cause the unit not to operate; make sure that both ends of the cable are fully inserted into their receptive jacks and the nut is tightened firmly.
- Do not plug third party sensors directly into instrument inputs. Plug only Thought Technology active sensor cable connectors into instrument inputs. All electrodes and third party sensors must be connected to active sensors, either directly or through an adapter.
- Remove batteries when the device is not being used for extended period of time. Please dispose of battery following national regulations.

INTENDED PURPOSE

- Biofeedback, relaxation and muscle re-education purposes.

CONTRAINDICATIONS

- None.

NOTE

- No preventative inspections required; maintenance must be performed by qualified personnel.
- The supplier will make available, upon request, circuit diagrams, component parts lists and description or other information required for the repair of product by qualified personnel.
- If a fiber optic or patient cable is damaged or breaks, please replace it.

MAINTENANCE AND CALIBRATION

- Wipe encoder with a clean cloth.

STORAGE

- Store in its original case.
- Temperature
- Humidity (Non-condensing)
- Atmospheric Pressure

- -23 to +60C (-9.5 to 140F)
- 10% to 90%
- 70 to 106 kPa

TRANSPORTATION

- Transport in its original case.
- Temperature
- Humidity (Non-condensing)
- Atmospheric Pressure

- -23 to +60C (-9.5 to 140F)
- 10% to 90%
- 70 to 106 kPa

TABLE OF CONTENTS

Introduction

The heart rate variability (HRV) suite is a set of simple tools, designed to help you do biofeedback therapy with your clients, even if you have little or no experience with biofeedback. The tools in this suite will help you evaluate your client's heart rate variability and provide a multi-pronged approach to retraining the cardiovascular physiology underlying HRV.

The tools will also allow you to:

- Monitor HRV during therapy.
- Teach self-regulation with HRV biofeedback.
- Teach simple breathing techniques aimed at reducing tension and anxiety while maximizing HRV.

The HRV Suite works with the clinical grade ProComp 2 physiological data acquisition device and includes finger pulse and respiration sensors as well as the BioGraph Infiniti software. When using the HRV assessment tool, you have the option of connecting a blood pressure monitor (A&D UA-767PC) if you want to include blood pressure readings in the assessment measures.

This manual will guide you through the process of learning how to use your equipment, including:

- Connecting the device to the computer (*Hardware Setup* on page 13).
- Hooking-up sensors to the client (*Placing sensors on the client* on page 15).
- Using the software to assess HRV and do biofeedback training (*HRV assessment* on page 17, *Biofeedback* on page 27, and *Learning relaxation* on page 33).
- Using the software to review sessions (*Reviewing the session* on page 21) and generate reports (*Generating session reports* on page 24).

Biofeedback and the Heart Rate Variability Suite

Biofeedback is a non-invasive therapeutic approach which has existed since the 1960s. It involves:

- Measuring physiological processes using specialized sensors.
- Showing a representation of the relevant physiological change to the client.
- Helping the client understand the effects of thoughts and emotions on their physiology.
- Coaching the client to learn new mental strategies and optimize self-regulation responses.

The HRV suite packages a number of tools with which you can view, record and give feedback on various HRV related metrics, generated from heart rate and respiration rate, which are directly related to cardiovascular health.

In the 1930s and 40s, Dr. Hans Selye (known as the "Father of Stress") observed and documented the sequence of physiological changes which occur in a living organism when subjected to stress for long periods of time. Most people understand the effect of stress on their own physiology, including increased heart rate, faster breathing, getting cold and clammy fingers and having difficulty sleeping. The more insidious effects of stress occur when a person is stressed for long periods of time without the ability to recuperate. These can include anxiety, insomnia, heart disease, weight gain and problems with memory and concentration.

Learning to properly manage one's stress is a key to living a happy, healthy and productive life, and biofeedback is a very effective and non-invasive tool for teaching proper stress management skills to your clients.

Heart rate variability biofeedback is a relatively new technique which monitors changes in the timing between heartbeats. Contrary to most people's intuition, a healthy heart doesn't beat regularly as clockwork. There are many physiological factors which influence the timing of heart beats, including respiration, blood pressure changes and the interplay between the sympathetic and parasympathetic nervous systems. HRV is an important physiological measure, because the loss of variability can be an indicator of serious cardiovascular health problems. The main objective of HRV biofeedback, therefore, is to exercise the cardiovascular system and try to maximize heart rate variability.

Because it involves dynamic relationships between multiple physiological processes, HRV can become very complicated to assess and understand. Researchers have explored a wide array of mathematical and statistical analysis methods and defined a number of metrics to represent HRV from various perspectives. For the purpose of this introductory level suite, we will mainly focus on understanding a handful of these metrics.
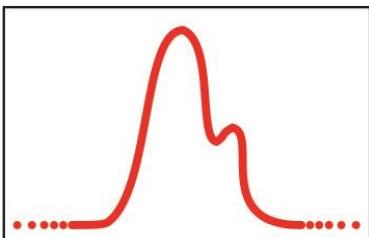
Physiological signals

One of the most important aspects of doing physiological monitoring and biofeedback is the ability to use your equipment correctly and understand what is happening when running a session and recording physiological data. If you are a novice to biofeedback, we recommend you spend some time learning about this technology. There are many books on the matter, and workshops, organized by professional associations, where you can acquire the necessary knowledge:

- *www.aapb.org*: Association for applied psychophysiology and biofeedback.
- *www.bfe.org*: Biofeedback federation of Europe.
- *www.bcia.org*: Biofeedback certification institute of America.
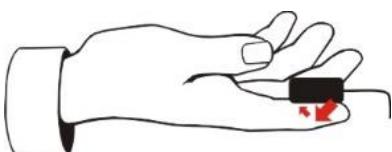
A physiological sensor is an electronic device designed to capture a specific body process, such as heart beats, breathing or brain waves, and convert it to a measure that computer software can understand and interpret. In general, a sensor translates the physiological process into electrical information – or signal – which is then captured by an encoder and sent to the software for processing. This happens continuously and instantaneously.

The resulting signal is a series of numbers which, when drawn onto a graph, appear as a sequence of points. Because the encoder outputs a lot of points per second, what we see is a line that moves up and down each time the heart beats. The illustration below shows a graphical representation of the finger pulse signal captured by the blood volume pulse (BVP) sensor.
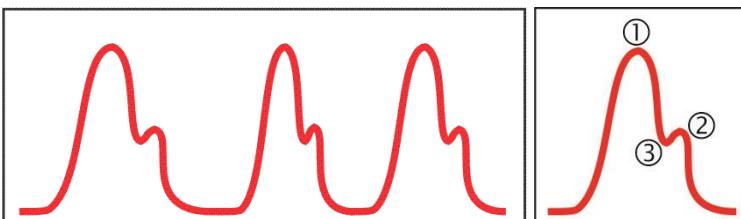
Finger pulse: Picking up heart beats

The finger pulse sensor (blood volume pulse or BVP) is a little box that is strapped around the finger. The sensor has two little windows on one side. One of them has an LED (light emitting diode) shining infrared (IR) light through the finger's skin and the other has an infrared sensor detecting the amount of IR light that is reflected from the finger.
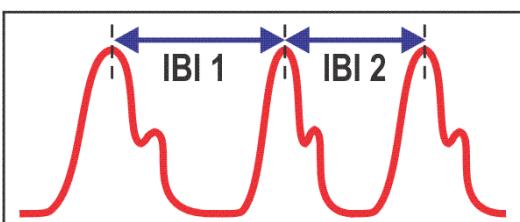
The amount of IR light that is reflected from the finger varies, depending on the amount of blood flowing through the flesh. Each time the heart contracts, a rush of blood is pushed through the body. When that wave reaches the finger, more IR light is reflected. As the rush of blood ebbs, the amount of IR light diminishes. This creates a characteristic wave pattern which goes up and down at each pulse, as shown in the illustration below. The larger bump (1) corresponds to the systolic wave. The second and smaller bump (2) appears when the systolic wave is reflected back after encountering the resistance provided by the narrow peripheral blood vessels. The groove between the two bumps (3) is called the dicrotic notch.

Signal processing: Generating meaningful information
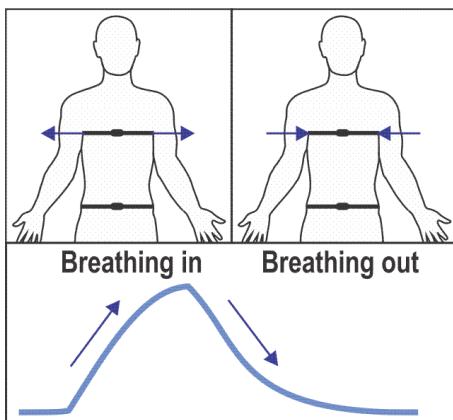
Signal processing refers to applying some sort of mathematical function to a physiological signal, in order to extract more information from it. The "raw" signal which comes from the finger pulse sensor needs to go through a series of mathematical processes before it becomes useful for HRV biofeedback and analysis. The first step is beat detection. Essentially, the software monitors the signal until it identifies a beat. As soon a second beat is detected, it can calculate the time between the two beats, which is the inter-beat interval (IBI, in milliseconds).

From each IBI value, the software calculates the beat-by-beat heart rate value (in beats per minute), which is useful for biofeedback because most people understand what heart rate is. The software calculates most HRV metrics from a series of IBI values that are collected over about a minute (64 seconds).

Respiration: Picking up breaths
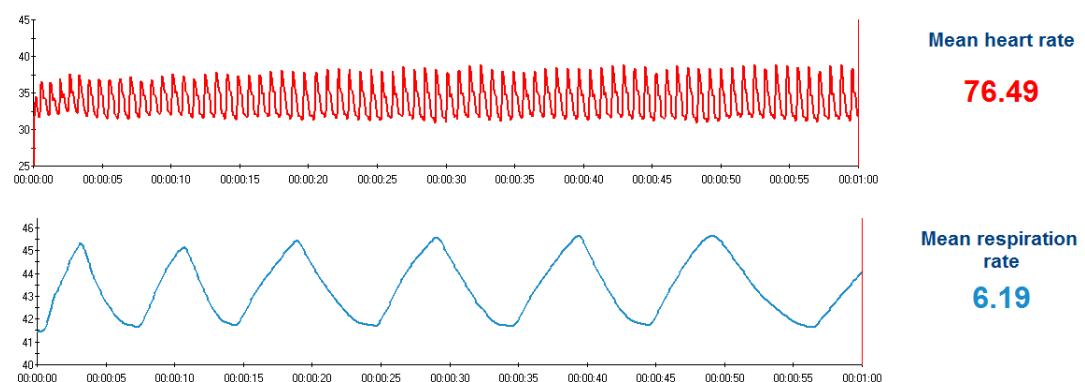
The respiration sensor is strapped around the chest or abdomen, and measures the expansion and contraction which occurs when the person breathes in and out. As t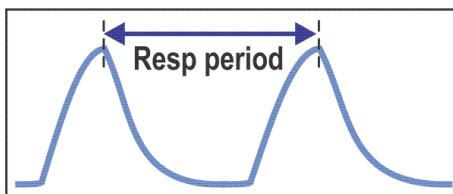he person breathes in, the chest expands and the signal rises, as the person breathes out, the chest contracts and the signal falls.

The resulting signal shows a series of bumps. Each bump is one breathing cycle. The software detects those bumps and calculates the respiration period and respiration rate.

The screen image below shows the finger pulse and respiration signals, as well as the mean values for heart rate and respiration rate, over a period of 1 minute:

Whether you are recording an assessment or running a biofeedback session, you will be mainly looking for changes in the heart rate and respiration rate to gather your clinical information but also at how the person's breathing influences his heart rate.
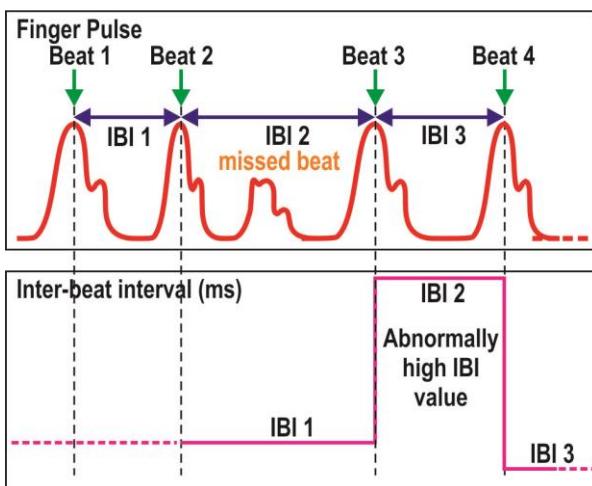
Artifacts: Noise in the signal

In an ideal situation, a physiological sensor picks up a perfect signal and the software generates valid IBI values and calculates reliable HRV metrics.
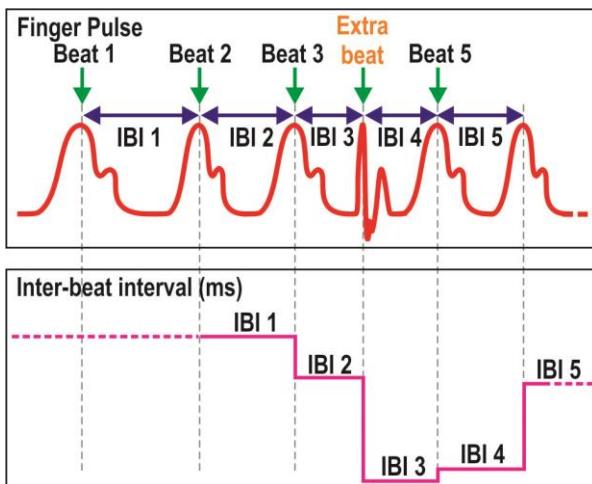
Unfortunately, ideal situations are not always easy to set up and physiological signals can end up distorted by "noise", which creates artifacts (signal pat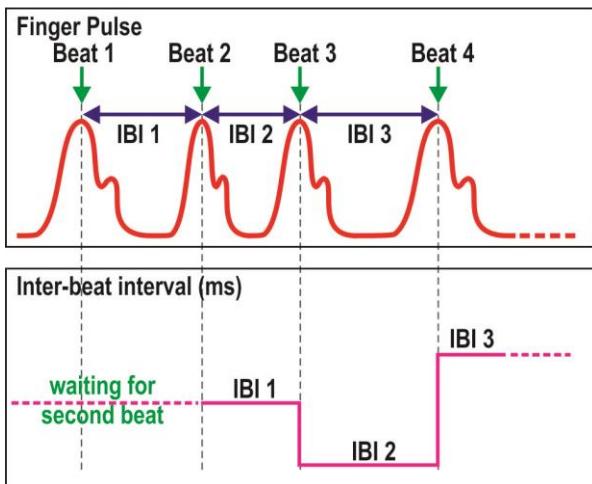terns that are not created by the physiological process of interest) and causes errors in the signal processing. In the case of the finger pulse signal, the most common type of artifacts occurs when the sensor is a little loose so that it is disturbed when the client moves, for example, by coughing, fidgeting or shifting his position on the chair. Learning good sensor placement methods is important because it helps minimize the occurrence of artifacts in the signals. Giving your client instructions on how to sit comfortably and rest his hands on his lap is also helpful. When doing HRV biofeedback, the most important types of artifacts are of two kinds, missed beats or extra beats.

- **Missed beats:** If the software doesn't recognize a beat as such, it will skip the beat and calculate the IBI value only when it picks up the next valid beat. This leads to the calculation of an abnormally high IBI value.

- **Extra beats:** In a similar way, any bump in the signal that is not caused by an actual systolic wave can be detected as a beat and lead to the calculation of two abnormally low IBI values.

Both types of artifacts will cause errors in the subsequent calculations and render any HRV metric unreliable. Therefore a lot of care has to be taken in order to minimize the risk of noise in the signals. Of course, artifacts cannot always be avoided, and your recorded data will include noise with the good data. In this case, you can remove artifacts, post-recording, using the artifact rejection function.

Measuring Heart Rate Variability

As previously suggested, HRV analysis goes far beyond calculating heart and respiration rates – it can get very complex. Over the last few years, researchers have defined a number of ways of processing IBI data to generate a multitude of metrics which reflect the many physiological processes involved in creating variability. For the purpose of this introductory suite, we will focus on understanding the various metrics in two ways:

1. How do they reflect variability?
2. How do they reflect changes in the level of stress?

When doing HRV analysis, it is important to distinguish situations where the client is breathing normally from situations where the client is doing HRV biofeedback and practicing breathing exercises. When monitoring or assessing someone's HRV, you are looking at how spontaneous physiological patterns create heart rate variability naturally. When doing HRV biofeedback, you are purposefully changing the client's natural state to exercise specific physiological factors of HRV. ***The interpretation of the various HRV metrics differs in both these states.*** Unless specified otherwise, the following descriptions apply only to situations where the client is breathing normally.

The various HRV metrics fall into two broad categories: time domain and frequency domain.

Time domain

In the time domain we find all the mathematical processes that analyze a series of IBI values gathered over time. These include statistical calculations, such as mean and standard deviation, and a few very specialized calculations. Key time domain metrics include:

SDRR (or SDNN): This metric looks at how much variability exists during a given period of time. It is the standard deviation of IBI values calculated over a minute, usually. Since the standard deviation is a representation of how spread-out the IBI values are, higher SDRR values represent greater variability.

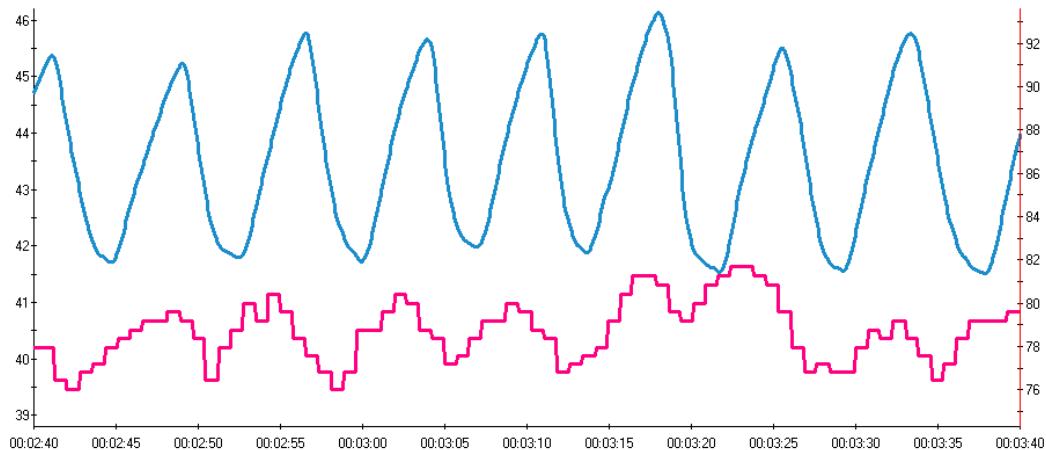**Note:** *RR stands for "R to R" and means "beat to beat". The R refers to the R spike of an EKG signal because EKG is the signal of choice for doing HRV research. Since we are using a BVP signal instead, the reference point for a beat is the maximum point of the first bump. NN means "normal to normal"; this nomenclature is specifically used to qualify a series of IBI values which has been cleaned of any artifacts (normalized).*
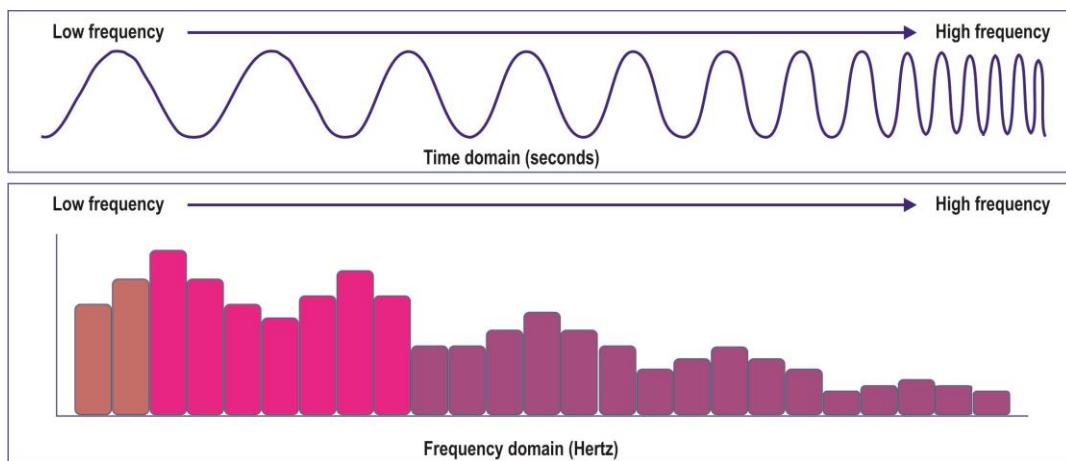
Heart rate max-min (HR max-min): This metric looks at how much variability exists during each respiration cycle. At the end of every breath, the software calculates the difference between the highest and lowest heart rate value obtained during that breath. Higher HR max-min values represent greater variability.

Frequency domain

The screen image below shows the respiration signal in blue and the heart rate signal in pink. The respiration signal is naturally rhythmic, and goes up and down with each breath. The graph also shows similar ups and downs in the heart rate signal, where it increases (accelerates) with the in-breath and decreases (decelerates) with the out breath. The entrainment effect that breathing has on the heart rate is called respiratory sinus arrhythmia (RSA), and is an important element of HRV biofeedback.

In order to assess the rhythmicity of a wavy signal, we have to process the time domain data through a mathematical function called a fast Fourier transform (FFT) to generate a frequency distribution (spectrum). The spectrum graph is a series of bars, from low to high frequency, and looks like the following illustration.
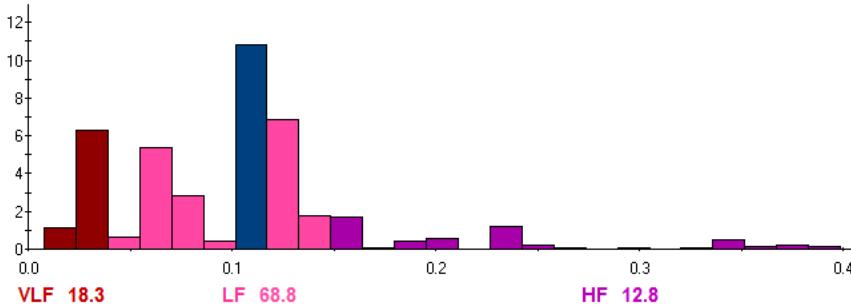
The frequency domain HRV metrics are generated by processing about a minute (64 seconds) of IBI data through an FFT. The resulting power spectrum shows frequencies from 0.016 Hertz to 0.4 Hertz (1 Hertz corresponds to 1 oscillation per second). The height of each bar is the amount of power in the signal at that particular frequency.

Because we are analyzing a short term collection of IBI data, the HRV spectrum is divided into 3 sub-bands: very low frequency (VLF, 0.016-0.04 Hz), low frequency (LF, 0.04-0.15 Hz) and high frequency (HF, 0.15-0.4 Hz). Each band has a specific physiological significance.

HRV spectrum & percentage of total power　　　　　　**Peak frequency (Hz):　0.11**

VLF **18.3**　　　　LF **68.8**　　　　HF **12.8**

There are many physiological processes which influence the timing of heart beats, including respiration, blood pressure changes and the interplay between the sympathetic and parasympathetic nervous systems. In general, changes in the power of a given HRV band reflect changes in the level of activity in one or more of these physiological processes. Some of these physiological changes are associated with greater relaxation and wellbeing; others with increased stress levels.

VLF, LF and HF: These metrics show the power (level of activity) for each band of the HRV power spectrum. There is a lot of discussion going on about how to interpret VLF, LF and HF. Very generally, all three are influenced by various aspects of autonomic nervous system function. VLF reflects activity of the slower sympathetic processes (thermoregulatory, renin-angiotensin). LF is generally seen to be influenced by both sympathetic and parasympathetic activity while HF tends to be influenced mostly by the parasympathetic nervous system. This is, however, an oversimplified breakdown. The underlying physiology is more complex, since all components of the autonomic nervous system are constantly active in regulating homeostasis, and what changes is only the relative dominance of one system over the other. When doing HRV biofeedback, higher LF % power values represent greater variability.

Note:　*There are two ways to express VLF, LF and HF power values: total power and relative power. Total power is the sum of power of all the frequency bars within a frequency band, and is expressed in mS2/Hz (milliseconds squared per Hertz). A more convenient way to represent this information is to calculate the relative power, which is the power for each band expressed as a percentage of the total power. For the most part, the HRV suite uses relative power to express HRV band power.*

LF/HF ratio: The division of the total or relative power of LF by HF is broadly understood to be a measure of the balance between sympathetic and parasympathetic nervous system activity.

Note:　*The suite includes this metric because it is commonly listed in various HRV reports, but its interpretation is not straightforward.*

　　If the client is breathing normally (12-15 breaths/min at rest), high LF/HF ratio values represent sympathetic dominance (stress response) while low values represent parasympathetic dominance (relaxation response). Therefore low values are more desirable.

　　If the client is doing breathing exercises (less than 7 breaths/min), the power in the LF band becomes mainly influenced by the RSA effect (described above) and high ratio values, then, become desirable and represent greater variability.

Peak frequency: The peak frequency is the frequency bar with the most power (the tallest bar). This metric can be calculated within the whole spectrum or within a specific HRV band (ex. HF). When doing HRV biofeedback, the peak frequency is expected to move within the LF band because of the RSA effect. High peak frequency power in the LF band represents greater variability.

Performing biofeedback

Whereas physiological monitoring only involves looking at the changes happening within your client's physiology during a specific intervention, biofeedback uses audio and visual cues to give information (feedback) to the client about the direction of change of a given signal and whether or not it is in the desired state.

Most commonly, the clinician sets a threshold, which represents a clinical goal, and asks the client to make the line or bar, which represents the particular signal being monitored, move up or down and cross over or under the threshold in order to trigger the feedback. The client then tries various mental strategies (coached by the clinician) until he notices a reaction in the signal. He then learns to adjust his internal strategy (thoughts, visualization, breathing pattern, etc.) until the signal starts changing in the desired direction. If he reaches the goal and the signal crosses the threshold, the audio or visual reward acts as positive reinforcement, which helps him learn to accomplish this particular task.

It is important to know that, as a clinical intervention, biofeedback is non-invasive and doesn't do anything to change the client directly, it only give instantaneous physiological information which the client can use to learn a particular skill.
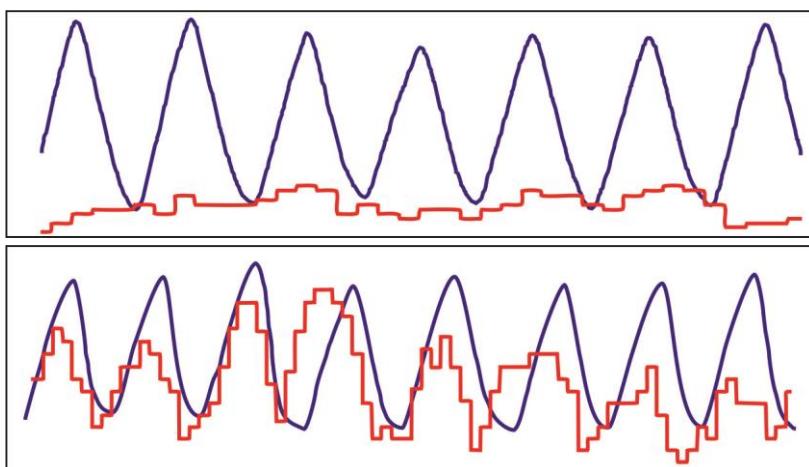
As with any learning process, becoming proficient with self-regulation requires two key components: motivation and practice. Individual sessions should be 15-20 minutes each, and frequent enough to allow retention between sessions (at least twice a week).

HRV biofeedback

Doing HRV biofeedback is slightly different from doing regular physiological biofeedback because it involves using one physiological effect to influence another. The HRV suite includes 5 feedback displays which you will use to train your clients to develop an awareness of their breathing patterns and to learn to relax, by practicing slow and regular breathing. Each display gives feedback using a different aspect of heart rate variability to help your client understand how his own personal physiological dynamics influence HRV.

Respiratory sinus arrhythmia (RSA)

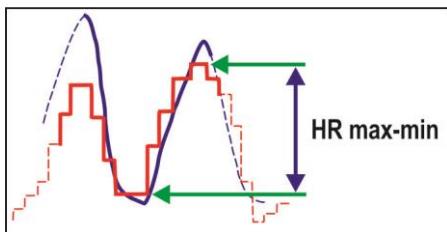The main feedback tool is a line graph showing the respiration and heart rate signals moving together. As the client consciously focusses on trying to breathe slowly and regularly, he is instructed to notice how the heart rate signal eventually starts moving up and down with his breathing and to try to make the HR waves as large as possible. After some practice, this pattern should become easier to generate.
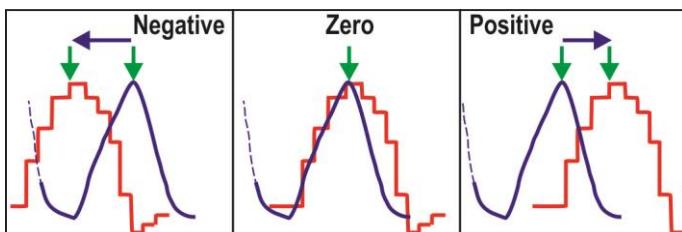
Characteristics of RSA

As the clinician, you will be looking for a number of characteristics and coaching your client to adjust his method in order to maximize them.

Heart rate max-min: From the peak of one breath to the peak of the next, the software monitors the heart rate values and calculates the difference between the highest and lowest values. The HR max-min amplitude increases as RSA entrainment increases, so the feedback rewards higher values.
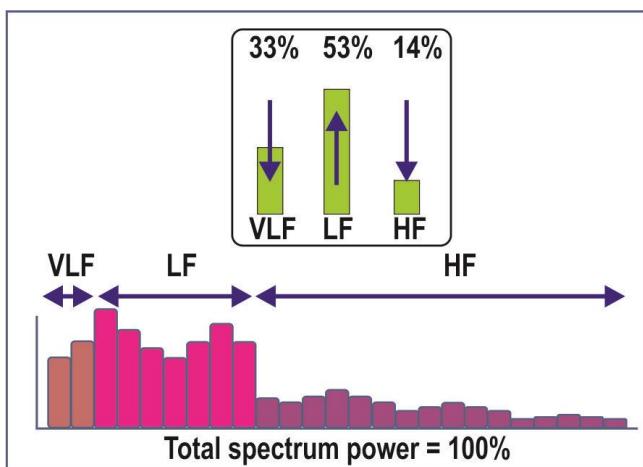

Respiration-HR Phase: Phase is not actually a measure of variability but of how "together" the respiration and heart rate signals are moving during each breath. In the same way as HR max-min, the software monitors the respiration signal to wait for a full breath cycle and then looks for the peak of both signals. If the HR peak precedes the respiration peak, then the phase is negative. If it follows the respiration peak then the phase is positive and if both signals peak together, then there is no phase (zero).

Phase values tend towards -180 degrees when the HR peak is to the left of the respiration peak, and towards +180 degrees when it is to its right. When practicing RSA breathing, you can train the client to maintain phase values as close as possible to zero.
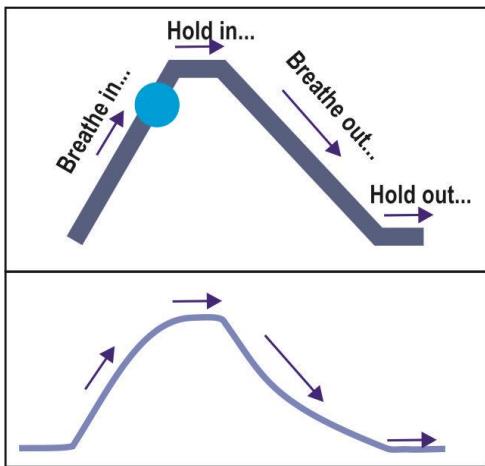

VLF, LF & HF Percentage of Total Power: The most common HRV feedback method calculates the percentage of total power that each HRV band represents, and shows color bars that increase or decrease in height to represent the power of each band. Feedback is given when the LF power is going up while the VLF and HF power is going down.

Respiration pacer

Four of the screens use a respiration pacer to teach your client how to breathe so as to entrain the desired heart rate variability. The pacer is a visual tool which shows a segmented line and a moving dot, as illustrated below.
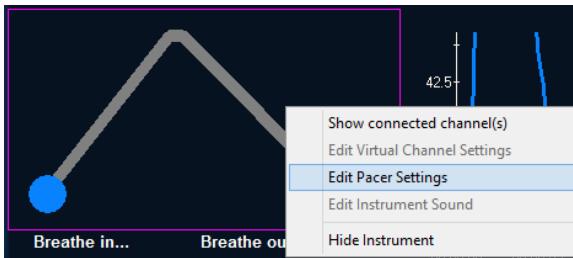

A full breathing cycle can be broken down into 4 steps: Breathing in, holding the air in, breathing out and holding the air out. The grey line shows a visual representation of the cycle. When you launch a biofeedback session, the dot moves from the lower left corner and follows the grey line. At the end, it jumps back to the left and starts again. The client should be instructed to follow the pacer by breathing along with the moving dot. While doing this, he should not be breathing too deeply, just deeply enough to avoid feeling like he needs more air. Breathing too deeply will make him feel dizzy; if this happens, tell him to take shallower breaths. At first some people may find it hard to pace their breathing, so reassure them that they don't need to be perfect, and that improvement comes with practice.

By default, the respiration pacer is set to pace at 6 breaths/minute because this rate specifically corresponds to 0.1 Hertz, which is right within the LF frequency band. You can adjust the pacer's target rate during a training session. Breathing rates between 3 and 9 breaths/min will keep the entrainment within the LF band.
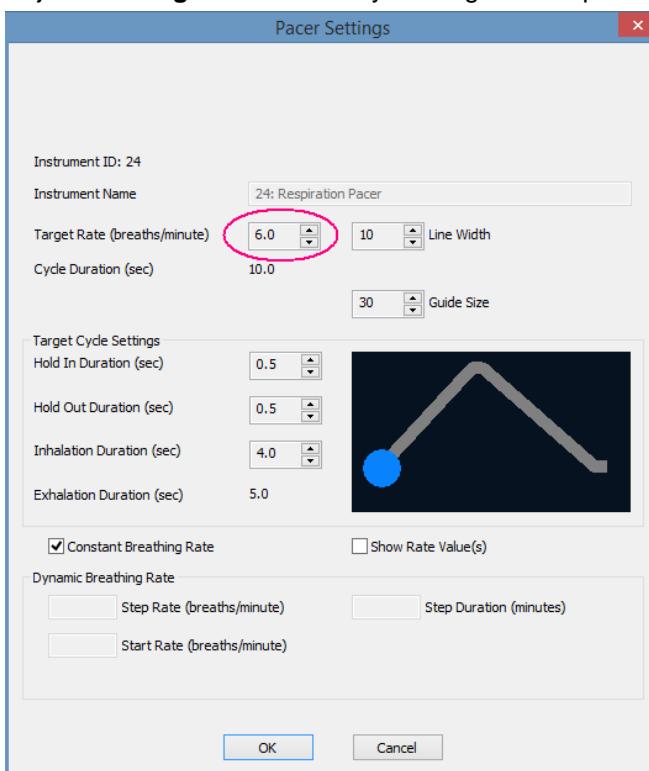
1. Click the **Pause** button in the tool bar.

2. Right-click over the pacer to open the pacer's menu and select **Edit Pacer Settings**.

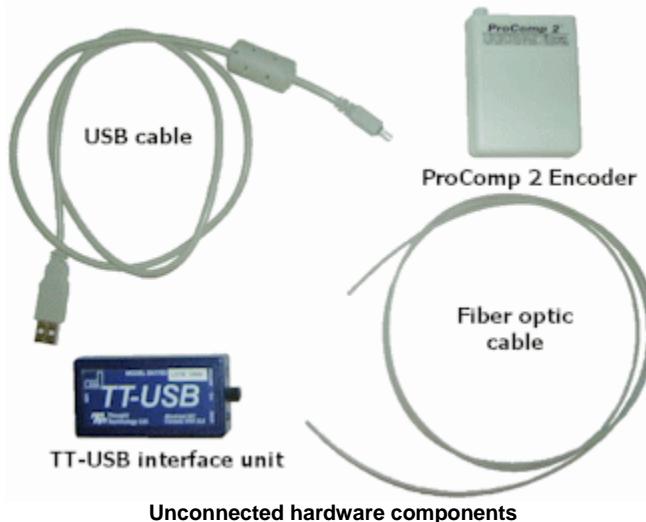3. Adjust the **Target Rate** value by clicking on the up or down arrow buttons.

4. Click **OK** to close the dialog box and click the **Pause** button again to resume the session.

Hardware Setup

This section of the manual describes briefly how to connect the ProComp2 encoder and the sensors, place the sensors on the client, and enter the key codes for the encoder into the software.

Note: *Detailed information about the ProComp2 encoder is provided in the device's hardware manual.*

Connecting the TT-USB and the ProComp2 encoder

Unconnected hardware components

Insert one end of the fiber optic cable carefully into the fiber optic port on the encoder as far as it will go. Tighten the nut gently so that the cable won't slip out.

Do the same with the other end of the fiber optic cable and the fiber optic port of the TT-USB interface unit.
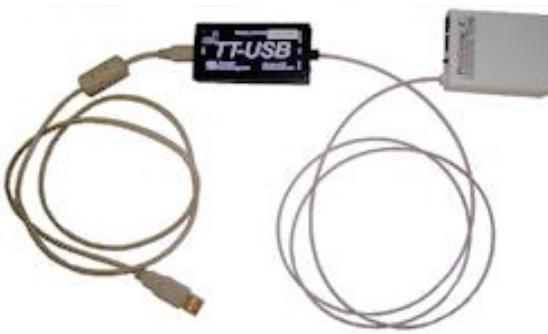
Note: *The fiber optic connectors may break if they are hit directly, for instance, if the encoder falls onto the floor. To prevent damage, we recommend using the belt clip to fasten the encoder to the client or to a chair.*

Insert the small connector of the USB cable into the USB port on the TT-USB interface device.

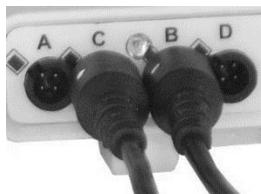Insert the large connector of the USB cable into the USB port of your PC.

Connected hardware components

USB ports on a PC are generally located at the back of the base unit. You may also find a USB port at the front of your base unit; you can connect the other end of the USB cable to it. On a laptop, USB ports are usually located at the side or the back of the laptop. It is recommended to always use the same USB port for connecting the TT-USB to your computer.
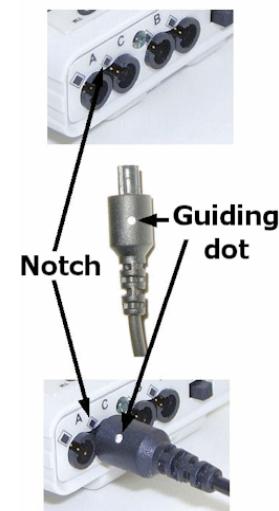
Connecting sensors to the ProComp2 encoder

The ProComp2 encoder and Thought Technology sensors use specially designed connectors that have all metallic surfaces recessed within the plastic casing. These connectors, with protected pins, require care when you are plugging and unplugging sensor cables to the encoder or an extender cable to the sensor head.

When connecting a sensor cable to the ProComp2, make sure to properly line up the guiding dot on the top of the plug with the notch in the encoder input socket, as shown in the illustration. Forcing the plug into the jack in any other position may damage your equipment.

- The BVP sensor cable connects to the input socket labeled B.
- The Respiration sensor cable connects to the input socket labeled C.

Connecting the third party blood pressure monitor to the system

Third party blood pressure monitor

SmartCable

The blood pressure monitor is purchased separately from the HRV Suite. It connects to the PC using a SmartCable with a phono jack on one end and a USB connector on the other.

Insert the phono jack end of the SmartCable into the port on the back of the blood pressure monitor.

Insert the USB connector of the SmartCable into the USB port of your computer.

After you start a session using the blood pressure monitor, the monitor's user interface screen flashes three rows of dashes to indicate that it is ready to be controlled by the software.

Note: *The blood pressure device drivers must be installed on your computer before you can use the blood pressure monitor. Detailed installation instructions for the device drivers are included in the BioGraph Infiniti documentation.*

Placing sensors on the client

The HRV Suite uses two sensors, a blood volume pulse (BVP) sensor and a respiration sensor.

If you are using the optional blood pressure monitor, put the blood pressure cuff on the client before you attach the sensors.

Note: *Do not place the BVP sensor and the blood pressure cuff on the same arm.*

Blood volume pulse
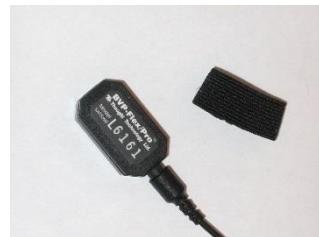
An elastic strap is provided with the BVP sensor.

Place the sensor against the fleshy part of the first joint of any finger.

Note: *Place the sensor label up, so that the electronic sensor components (the two small square openings) on the back of the sensor (not shown) are against the finger.*

As an alternative, Coban tape can be used to provide a more secure fit attachment.

With elastic strap

With Coban tape

Respiration

The respiration sensor is fixed to a long hook and loop strap that can be placed around the chest or abdomen.

Note: *For use with the HRV Suite, placement around the abdomen is required.*

Unravel the strap and attach it around the abdomen so that the sensor is in the front. The fit should be snug enough that the strap stays fixed when the subject is relaxed.

There should also be enough slack in the rubber strap of the sensor so that expansion of the abdomen causes this rubber strap to expand without being overextended.

The rubber strap stretches when the abdomen expands during breathing.
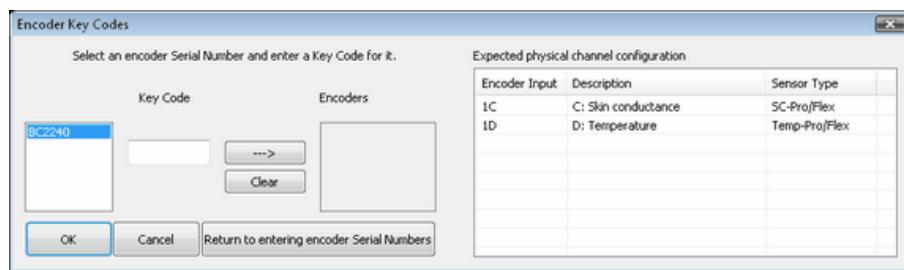
Entering key codes

The first time you use a ProComp2 encoder to record a session, the BioGraph Infiniti software will check for its key codes and ask you to enter them. This registers the encoder with the software, and you won't need to enter the key codes again.

Note: *If you have more than one ProComp2 encoder, you will need to enter key codes for each unit the first time you use it to record a session.*

1. Click **Quick Start**, select a name from the **Clients** list and a protocol from the **Favorites** list, and then click **OK**.

   The **Encoder Key Codes** dialog box opens.

2. Click to highlight your unit's serial number in the left table (in this example, BC2240; this is the same number as on the back of the unit).

The serial number is found on the back of the encoder.

3. Enter the **Encoder Key Code** (found inside the encoder battery compartment) in the **Key Code** text box.

4. Click [--->] to move the serial number from the left table to the right table.

5. When the serial number appears in **Encoders**, click **OK**.

Now the **Application Key Code** dialog box opens.

6. Enter the Application Key Code.

   This number is found in the battery compartment with the encoder key code.

7. When done, click **OK**.

If the key codes have been entered properly and there is no problem with your encoder setup or your sensor connections, the recording screen will open.

Note: *Detailed instructions for using the software are provided in document SA7913, Getting Started with BioGraph Infiniti, which is provided with BioGraph Infiniti.*

Using the HRV suite

The HRV suite offers you an easy way to perform 3 main tasks:

- Assess and document your client's baseline HRV levels by running the 3 step HRV assessment
- Teach your clients awareness and control of breathing patterns, and how breathing influences heart rate
- Train your clients to use breath control to entrain deep and effective relaxation

First step: Assessing

Before you start doing HRV biofeedback with your clients, it is important to assess your client's current heart rate variability baseline. The HRV – 3 Step Assessment is a quick tool to evaluate how your client's cardiovascular system adjusts to changes in position and breathing patterns.

HRV is greatly influenced by the interplay between the sympathetic and parasympathetic branches of the autonomic nervous system. Specifically, the SNS (sympathetic nervous system) is in charge of the stress response, and prepares the body for fight or flight by accelerating bodily functions, while the PNS (parasympathetic nervous system) is primarily involved in relaxation, preparing the body to rest and recover after the stressful situation is over. The 3 steps of the assessment take the client through state changes which should influence the balance between SNS and PNS dominance. The report shows how the various time domain and frequency domain metrics change from step to step, so you can identify normal and abnormal patterns. During the assessment, you will be recording finger pulse and respiration data in 3 different situations:

1. 2 minutes in a relaxed but standing position, breathing normally.
2. 2 minutes, sitting in a comfortable position, breathing normally.
3. 2 minutes, sitting in a comfortable position, breathing at a specific rate.

Note: *The assessment also includes a 2 minute period before the first and after the last step, to take a blood pressure reading.*

Step 1 – Standing: In a standing position, your client is under mild stress because standing up without moving requires attention. His cardiovascular system is also under mild stress because it has to maintain balanced blood flow and blood pressure to both the lower part of the body - where gravity pulls the blood down towards - and the upper part of the body - where blood volume is much less dense. In this position, the sympathetic nervous system is expected to dominate, therefore heart rate and blood pressure might be elevated and HRV reduced.
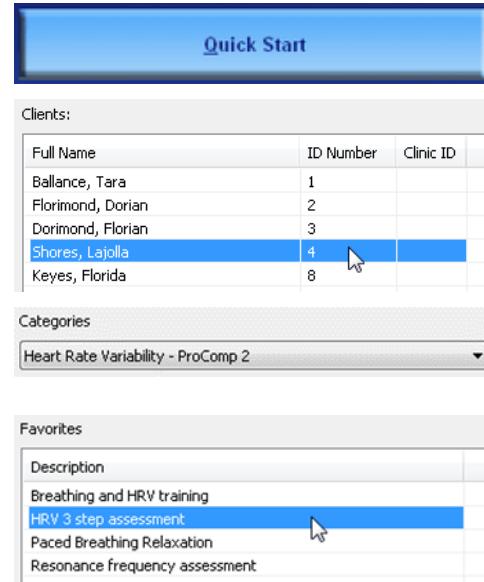
Step 2 - Sitting: Going from standing to sitting puts your client's cardiovascular system through a mild orthostatic challenge during which blood flow and pressure have to be adjusted rapidly to maintain homeostasis. Sitting is also a more relaxing position with less of a demand on attentiveness so, in time, you should notice a shift from sympathetic to parasympathetic dominance. Heart rate and blood pressure are expected to decrease and HRV increase.

Step 3 – Sitting, doing paced breathing: Paced breathing at 6 breaths per minute should definitely engage the respiratory sinus arrhythmia (RSA) effect, where the slow and regular breathing pattern entrains the heart rate to accelerate with the in breath and decelerate with the out breath. This is expected to trigger a strong relaxation response (more parasympathetic dominance) and significantly increase HRV. Average heart rate and blood pressure should be at their lowest.

Running the HRV 3 Step Assessment

1. Launch BioGraph Infiniti and click on **Quick Start**.

    Quick Start

2. In the **Clients** list on the left, select an existing client name or use **Add New Client** to create a record for this client.

Clients:		
Full Name	ID Number	Clinic ID
Ballance, Tara	1	
Florimond, Dorian	2	
Dorimond, Florian	3	
Shores, Lajolla	4	
Keyes, Florida	8	

3. If the list on the right is empty, click the **Categories** drop-down list and select **Heart Rate Variability – ProComp 2**.

Categories
Heart Rate Variability - ProComp 2

4. In the list of **Favorites**, select **HRV 3 Step assessment** and click **OK**.

Favorites
Description
Breathing and HRV training
HRV 3 step assessment
Paced Breathing Relaxation
Resonance frequency assessment

5. Ensure that:
    - The sensors are properly hooked up on the client.
    - The device is properly connected to the PC.
    - Your ProComp 2 is turned ON (green light is on).
    - Optionally, the blood pressure monitor is connected to the PC.

6. Click the **Start** button ▶ to start the session, and follow the instructions in the *Assessment screen sequence* which follows.

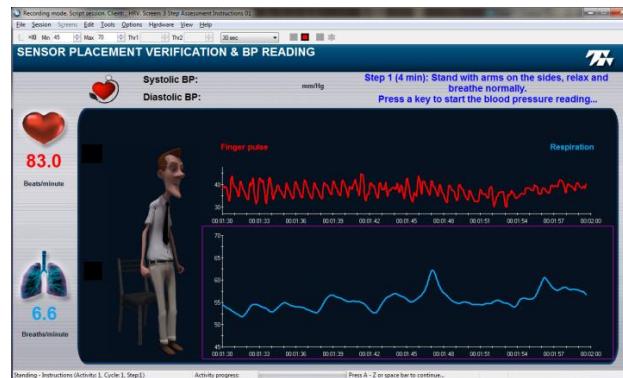7. When the script ends, click **Yes** to save the session.

Assessment screen sequence

Introduction screen

When you launch the **HRV 3 step assessment** session **Quick Start**, after selecting a client and clicking **OK**, the introduction screen appears.

Describe what the assessment is about to your client, and click the **Start** button when your client is ready to go.

▶

HRV 3 STEP ASSESSMENT

Step 1 Standing baseline instructions

The instruction screen describes the next step of the assessment, which consists of recording baseline measures in a standing position. Explain this to your client and remind him that the step starts with a blood pressure reading.
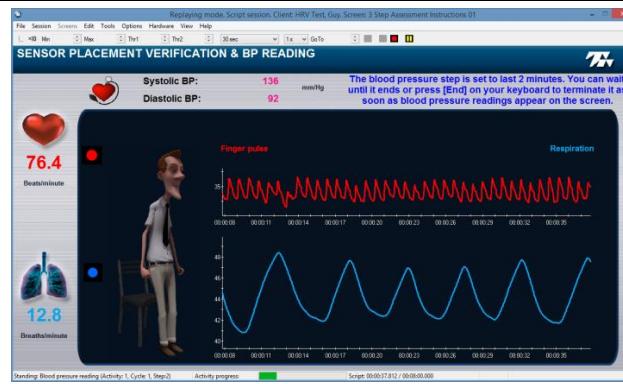
Check that the sensors are placed on the client correctly and that you are seeing valid physiological measures before pressing the [**Space bar**] to continue.

Step 1 Standing baseline & BP reading

The blood pressure reading may take 1 to 2 minutes. Remind the client that he should remain quiet and breathe normally for the duration.

As soon as the blood pressure values appear on the screen you can end this phase and jump to the baseline reading by pressing the [**End**] key on your keyboard.

Step 1 Standing baseline recording

The baseline recording step takes 2 minutes. Make sure that the client is standing quietly with arms at their sides and breathing normally for the period.

Step 2 Sitting baseline instructions

The instruction screen describes the next step of the assessment, which consists of recording baseline measures in a sitting position. Explain this to your client and ask him to sit comfortably with his hands on his lap and breathe normally.

Check that the sensors are still picking up valid physiological measures and press the [**Space bar**] to continue.
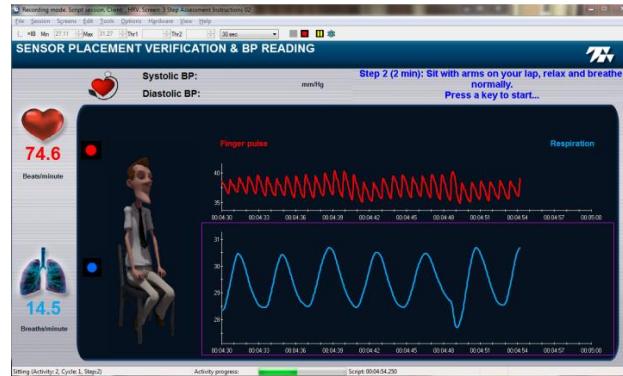
Step 2 Sitting baseline recording

The baseline recording step takes 2 minutes. Make sure the client is sitting quietly with arms on his lap and is breathing normally for the period.

Step 3 Sitting with paced breathing instructions

The instruction screen describes the next step of the assessment, which consists of recording baseline measures in a sitting position while the client is breathing with a respiration pacer. Explain this to your client and ask him to sit comfortably with his hands on his lap and follow the pacer as best as he can.
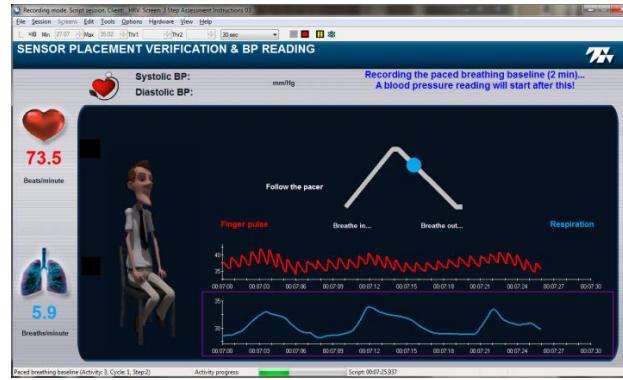
Check that the sensors are still picking up valid physiological measures and press the [**Space bar**] to continue.

Step 3 Sitting baseline & BP reading

The baseline recording step takes 2 minutes. Make sure the client is sitting quietly with arms on his lap and is able to follow the pacer without feeling dizzy for the period.

Remind your client that the step ends with a blood pressure reading.

Step 3 Sitting BP reading

The blood pressure reading may take 1 to 2 minutes. Remind the client that he should remain quiet and breathe normally for the duration.

As soon as the blood pressure values appear on the screen you can end this phase by pressing the [**End**] key on your keyboard.

End of script

After the script finishes, BioGraph Infiniti displays an on-screen prompt to save the session data.

Thank the client for doing a good job and unhook the sensors carefully. Ask for feedback and insights.

Reviewing the assessment session

After you save the **HRV 3 Step Assessment** session, BioGraph Infiniti asks if you want to review or replay the session.
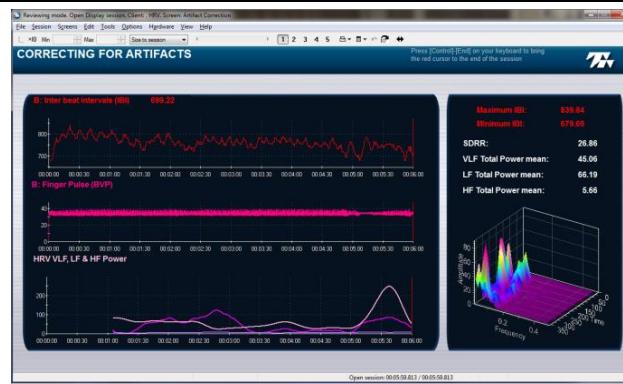
Click **Review**.

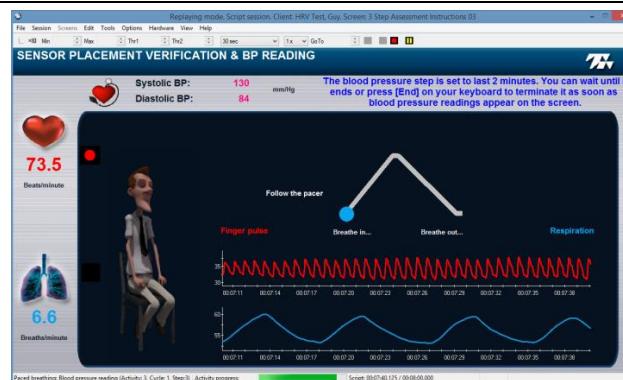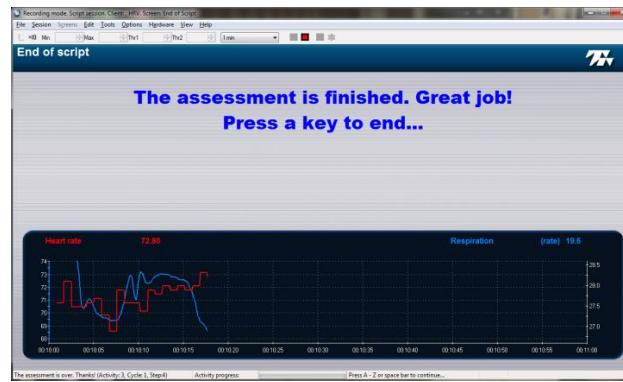The system loads the review screens, which show you session graphs and appropriate statistics. If you used the optional blood pressure monitor, some of the screens will also show systolic and diastolic blood pressure values.

Artifact Correction

The 3 line graphs on the left show IBI, Finger Pulse and the VLF, LF & HF total Power signals (bottom graph). Along the right side, you can see the VLF, LF & HF Total power means, SDRR and a 3D Power Spectrum graph. The red numbers on the right show the minimum and maximum IBI values that were recorded during the whole session (if the red time marker is all the way to the right). These numbers will be extremely high or low if there are artifacts in the session.
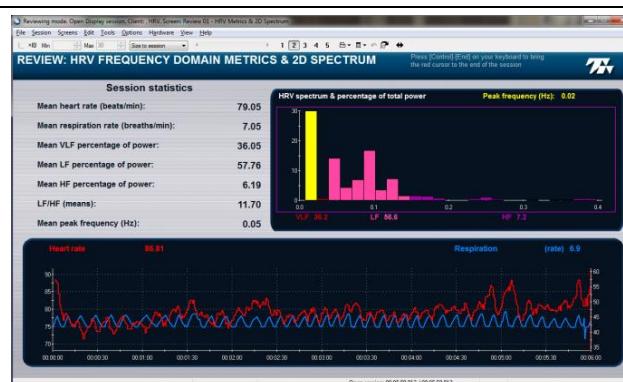
Use this screen to detect and reject artifacts.

Review 01 - HRV Metrics & 2D Spectrum

This screen shows a graph of the respiration and heart rate signals on the bottom, a table of frequency domain metrics on the left and a 2D frequency spectrum graph on the right.

Press [**Control**]-[**End**] on your keyboard or click & drag the red time marker line to bring the red cursor to the end of the recording and see statistics for the whole session.

Review 02 - HRV Metrics & 3D Spectrum

This screen is similar to the previous screen but shows a 3D frequency spectrum graph on the right.

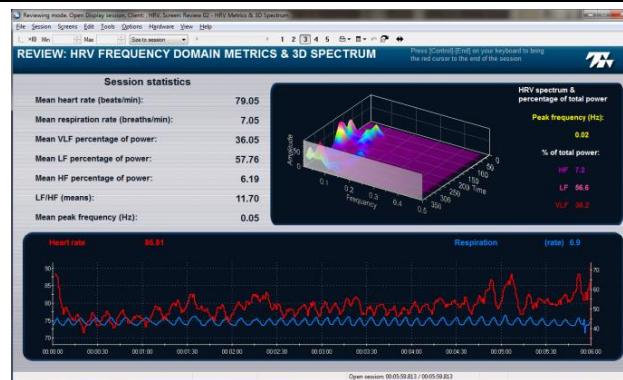Press [**Control**]-[**End**] on your keyboard or click & drag the red time marker line to bring the red cursor to the end of the recording and see statistics for the whole session.

Review 03 - HRV Time Domain Metrics

This screen lists all the Time Domain metrics on the top half of the display, and a graph of the respiration and heart rate signals at the bottom.
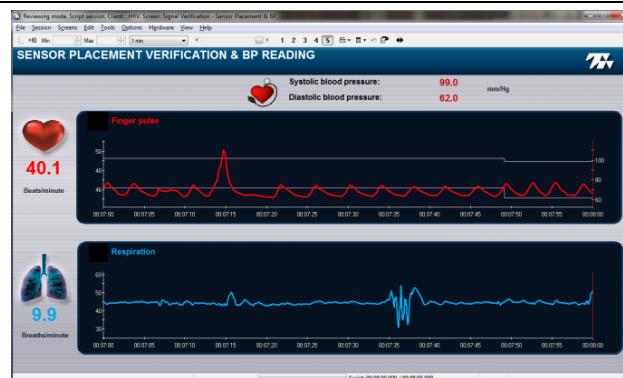
Press [**Control**]-[**End**] on your keyboard or click & drag the red time marker line to bring the red cursor to the end of the recording and see statistics for the whole session.

Physiological Viewer & BP

The Physiological Viewer & BP screen allows you to review the finger pulse and respiration signals that were recorded during the session, along with any blood pressure readings made during the first and last step of the assessment.

When the time scale is set to **Size to session**, you can drag the time marker along the graphs to see moment by moment changes in the signal.

Dealing with artifacts
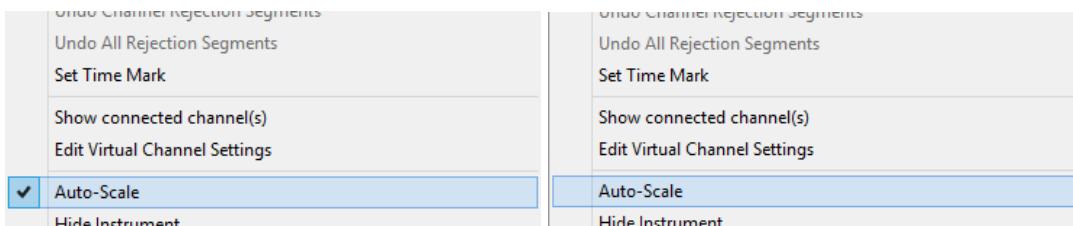
Artifacts are patterns in the signal that are not created by the physiological process of interest. They happen when the signal gets distorted by movement or other sources of noise. Artifacts can cause errors in the signal processing calculations and make the data analysis unreliable. Prior to generating a report, it is always a good idea to review the recorded data and correct it for artifacts. Doing this normalizes the data and ensures that the program generates correct statistics.

The Artifact Correction screen allows you to review a session and see how missed or extra beats on the finger pulse signal (in pink) distort the inter-beat interval (IBI) data (in red).
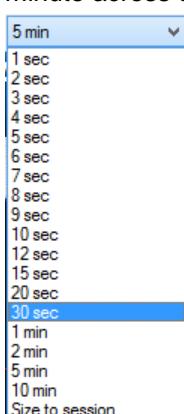
The easiest method for correcting artifacts is to visually review the IBI signal and place artifact rejection segments over each artifact. To do this:

1. If the **Auto-Scale** setting is on, right-click over the IBI graph and uncheck it from the pop-up menu to turn it off.
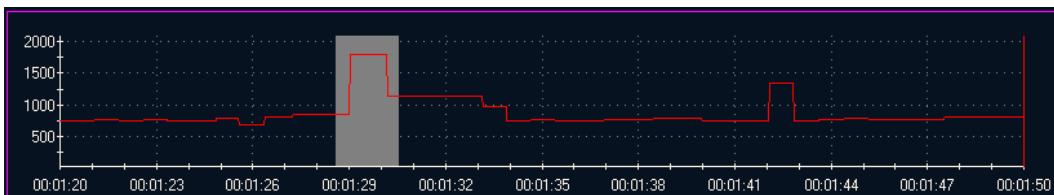
2. If the signal is too compressed for you to see it very clearly, change the time scale to 30 seconds or a minute across the screen.

3. Scroll to the place where you can see an artifact.

4. Place the mouse cursor over the last normal IBI value, just to the left of the distorted section.

5. Press and hold the [**Control**] key on your keyboard, then click and hold down the left mouse button while sliding the mouse cursor toward the right until you reach the end of the distorted section.

6. Let go of the mouse button.
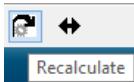
7. This places a grey segment over that artifact.

8. Do this over any section of signal which appears distorted.

9. Click the Recalculate button in the toolbar.

10. Remember to turn the **Auto-Scale** setting back on.
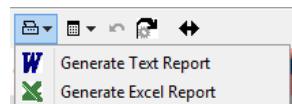
The images below show the pre and post artifact rejection statistics. Note that the second table of numbers shows much smaller values.

Maximum IBI:	1792.97	Maximum IBI:	937.50
Minimum IBI:	320.31	Minimum IBI:	640.63
SDRR:	114.68	SDRR:	38.41
VLF Total Power mean:	833.51	VLF Total Power mean:	85.93
LF Total Power mean:	1856.20	LF Total Power mean:	140.25
HF Total Power mean:	1516.10	HF Total Power mean:	170.69

Note: *For the purpose of this suite, we are mostly interested in removing the most obvious artifacts. This quick method of artifact rejection is generally acceptable for simple assessments such as the HRV 3 Step assessment, but the requirements for normalizing IBI data for HRV research are much more stringent.*

Generating a report
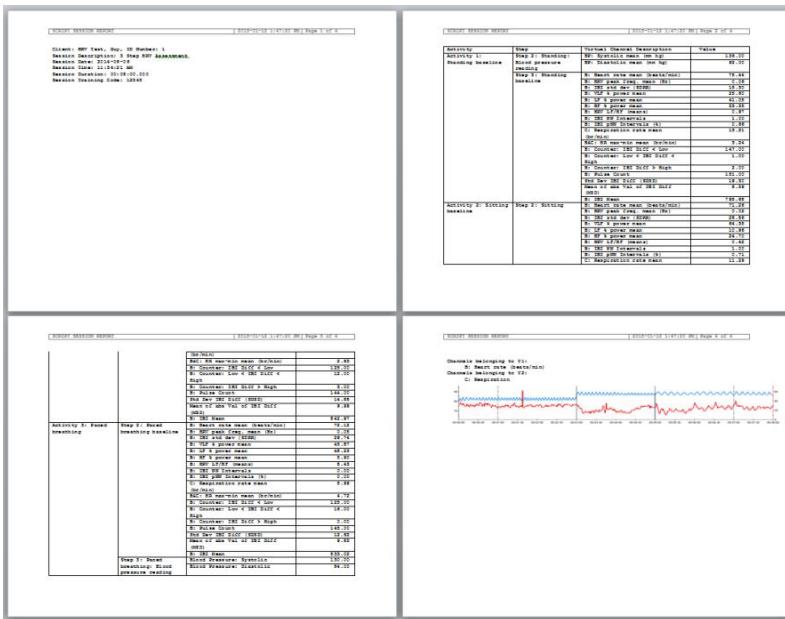
Two types of reports can be generated from the stress test review screen. In the Tool Bar, at the top of the screen, you can click the **Session Report** button to open the drop-down list with two items, **Generate Text Report** and **Generate Excel Report**.
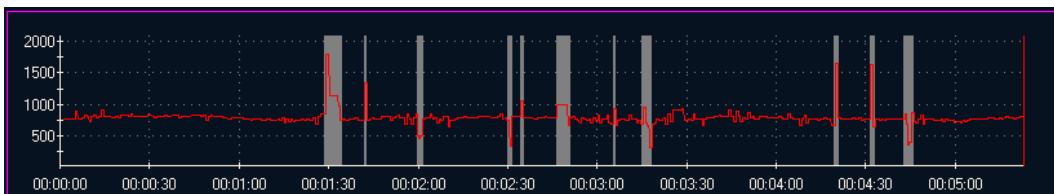

Both reports require that you have Microsoft® Office with Word® and Excel® installed on your computer (contact Thought Technology Tech support to find out compatible versions).

Text report
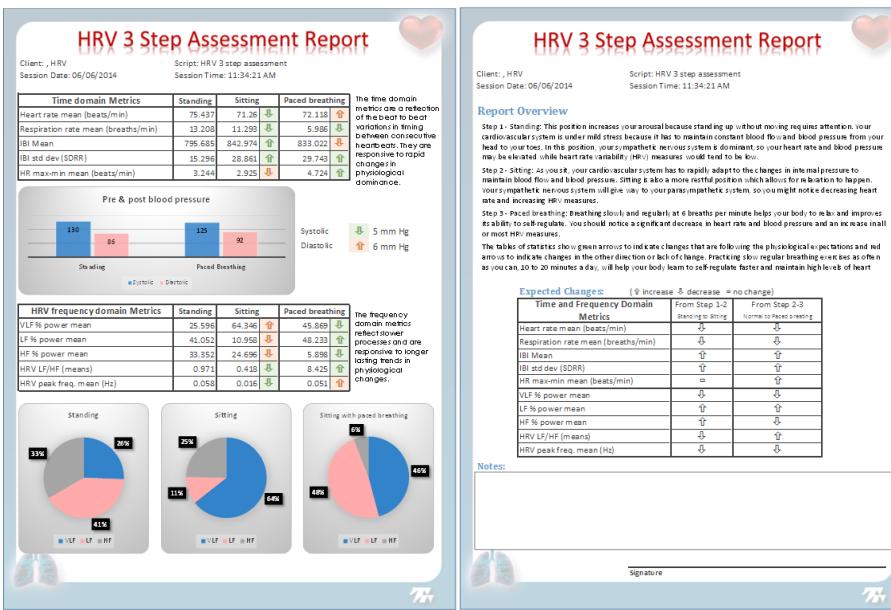
The **Text Report** dialog box offers a selection of report components that you can include or exclude by selecting appropriate check boxes. When you click **Generate Report**, the software creates a Word document which can include table of statistics and signal graphs.

Once the report is generated, you can add or remove components and enter session notes and comments. If you want to keep a record of the session report, use Word's **Save as** function to save a copy of the report in a document folder location of your choice. (This is the only way to keep a permanent copy of a report.)

Excel report

The Excel report generates a two page review of the HRV 3 Step assessment.

The first page shows:

1. A table of Time Domain metrics, with up or down arrows showing the direction of change from Step 1 (standing baseline) to Step 2 (sitting baseline), and from Step 2 to Step 3 (paced breathing).
2. Below the table, a bar graph shows the pre and post changes in systolic and diastolic blood pressure measures from Step 1 to Step 3.

3. A table of Frequency Domain metrics with up or down arrows showing the direction of change from Step 1 (standing baseline) to Step 2 (sitting baseline) and from Step 2 to Step 3 (paced breathing).
4. Pie charts representing the percentage of total power taken by the VLF, LF and HF frequency bands.

The second page shows:

1. A brief description of how to interpret the report.
2. A **Notes** box where you can enter comments and other additional information.

If you want to keep a record of the session report, use Excel's **Save as** function to save a copy of the report in a document folder location of your choice. (This is the only way to keep a permanent copy of a report.)

Understanding the report

The tables below show the various time and frequency domain HRV metrics that are calculated for the assessment and give an indication of the expected direction of change, from step 1 to step 2 and from step 2 to step 3.

⇧ Increase
⇩ Decrease
▫ No change

Blood Pressure	Step 1-3	
Systolic & Diastolic	⇩	

Time Domain	**Step 1-2** **Standing to sitting**	**Step 2-3** **Normal to paced breathing**
Heart rate mean	⇩	⇩
Respiration rate mean	⇩	⇩
IBI mean	⇧	⇧
IBI Std Dev (SDRR)	⇧	⇧
HR max-min mean	▫	⇧

Frequency Domain	**Step 1-2** **Standing to sitting**	**Step 2-3** **Normal to paced breathing**
VLF % power mean	⇩	⇩
LF % power mean	⇧	⇧
HF % power mean	⇧	⇩
HRV LF/HF (means)	⇩	⇧
HRV Peak frequency mean	⇩	⇩

To recapitulate:

Step 1: in a standing position, the client's arousal levels should be somewhat increased because standing up without moving requires attention. The parasympathetic system should be dominant, so expect a relatively high resting heart rate and high blood pressure values. Because the parasympathetic system is dominant, we can also expect that most HRV metrics would indicate low variability.

Step 2: Shifting from standing to sitting forces the cardiovascular system into rapid adaptation but also puts the client into a more restful state where the parasympathetic system can let the sympathetic nervous system take over. You can expect to see decreasing heart rate and increasing HRV measures.

Step 3: Finally, breathing slowly and regularly at 6 breaths per minute should engage the respiratory sinus arrhythmia effect (RSA). Breathing at this rate should also trigger a relaxation response during which the sympathetic nervous system would be even more active. You should notice a significant decrease in heart rate and blood pressure and an increase in all or most HRV measures.

The report shows a table of values with arrows to indicate the direction of change between Step 1 and 2 and between Step 2 to 3. Green arrows indicate that the change happened in the expected direction while red ones indicate the opposite direction. Explain to your client that doing HRV biofeedback teaches him a powerful self-regulation technique which can provide long-lasting benefits to his cardiovascular health. This may, in the long run, have a normalizing effect on the mechanisms of HRV.

Second step: Biofeedback

Once you have run the HRV 3 Step Assessment, you can start doing biofeedback sessions with your client using the Breathing and HRV training feedback screens.

Running a biofeedback session

1. Launch BioGraph Infiniti and click on **Quick Start**.

2. In the **Clients** list on the left, select an existing client name or use **Add New Client** to create a record for this client.

3. If the list on the right is empty, click the **Categories** drop-down list and select **Heart Rate Variability – ProComp 2**.

4. In the list of **Favorites**, select **Breathing and HRV training** and click **OK**.

5. Ensure that:
   - The sensors are properly hooked up on the client.
   - The device is properly connected to the PC.
   - Your ProComp 2 is turned ON (green light is on).

6. Click the **Start** button to start the session.

7. During the session, to switch between feedback screens, click the numbered buttons in the Tool Bar.

General concepts

The 5 feedback screens which come with the HRV suite are designed to minimize clinician intervention by being set to do many things automatically. You do not have to set scales or threshold values, because the software manages this for you. As you record feedback sessions with your clients, you should notice these features and explain what is happening to your client so they don't confuse him and disturb the training session.

Automatic scaling

As the respiration and heart rate signals are plotted along the line graph, they also move up and down as the client is responding to your coaching and changes in his breathing patterns. If one of the signals reaches the top or bottom of the graph, the software automatically scrolls the scale (vertical axis) up or down by a few units to keep the signal into view. Each time this happens, your client may notice that the signal jumps a bit on the screen.

Bar graphs

Screens 4 and 5 also use bar graphs to help give feedback. As the signal increases or decreases, the color bar gets taller or shorter along its scale. These graphs do not show thresholds, but respond to whether the signal is increasing or decreasing. The color of the bars changes from red to green to indicate that the signal is changing in the desired direction.

Proportional tone feedback

Screens 1, 2 and 3 give proportional audio feedback related to the metric that is being trained. As the client practices the exercise, he can hear when its value is going up or down. Proportional tone feedback is useful if the client wants to close his eyes and practice the exercise without looking at the visual indications on the screen.

High/Low Volume Music feedback

All 5 screens use High/Low volume music feedback to indicate when the signal enters and remains within the desired target range or condition. The music plays louder when success is attained and goes quiet when the signal gets out of condition.

Video feedback

All screens provide video feedback in the form of animations.

Screens 1, 2 and 3 use the same animation. They show the animation moving forwards and backwards as the signal increases or decreases. This form of proportional feedback gives instantaneous information on where the trained metric is on the scale. In this particular training mode, the goal is to keep the animation centered.

Screens 4 and 5 use different animations. They play their animations forward when the success condition is achieved, and backwards when it is lost.

Biofeedback screen descriptions

Training 01 – Breathing Slowly

Use this screen to teach your client to breathe slowly and regularly at a breathing rate between 4 and 8 breaths/minute. When respiration at this rate is detected, the animation is centered, the music plays loudest and points are accumulated.

A tone, proportional to the signal value, is heard when the respiration rate increases or decreases, so the client can close his eyes and listen to the tones and the music.

Training 02 – Breathing with pacer

This screen is similar to the one above with the addition of a respiration pacer. By default, the pacer is set to 6 breaths/min to help the client learn how to breathe more regularly.
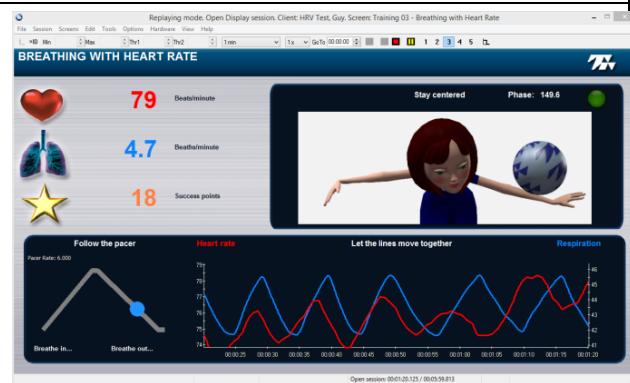
You can toggle between screens 1 and 2 to train the client to sustain slow regular breathing without the pacer.

Training 03 – Breathing with heart rate

This screen specifically looks at training the respiration sinus arrhythmia (RSA) effect and feeds back on phase between the breathing and heart rate waves. Phase approaches zero when the two lines move up and down together. When this happens, the animation is centered, the music plays loudest and points are accumulated.

A tone, proportional to the signal value, is heard when the phase increases or decreases so the client can close his eyes and listen to the tones and the music.

Training 04 – Breathing with power

This screen monitors the VLF, LF and HF percentage of total power values, and gives feedback when three conditions are met: LF is increasing (or stable) while VLF and HF are decreasing (or stable). When this happens, the music plays loudest, points are accumulated and the animation starts playing forward.
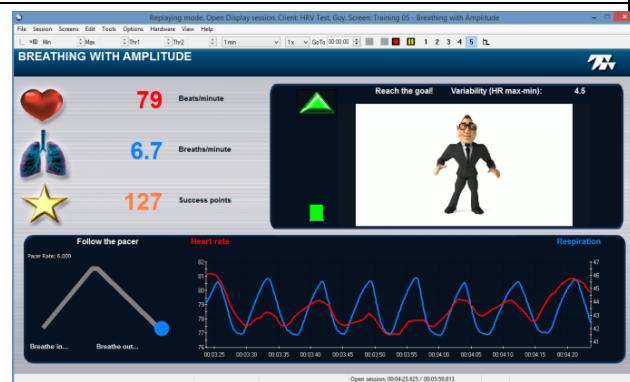
Your client's goal is to sustain the success condition until the arrow hits the target. The archer returns his arrow to the quiver when the condition is lost.

Training 05 – Training with amplitude

This screen specifically looks at the breath-by-breath heart rate max-min difference metric, and gives feedback when this value increases (or is stable). When this happens, the bar and arrow turn green, the music plays loudest, points are accumulated and the animation starts playing forward.

Your client's goal is to sustain the success condition long enough for the character to become a superhero. He changes back to his mild-mannered alter-ego when the condition is lost.

1. To end the session, click the **Stop** button ■ .
2. Click **Yes** when asked if you want to save the session.

Biofeedback sessions Review and Report

If you save the recorded feedback sessions, you can review them to see what happened while the client was practicing HRV biofeedback and following your coaching suggestions. When reviewing feedback sessions, the review screens described in the section **Reviewing the session**, above, are loaded.

Note that, since training sessions don't include a blood pressure step, the Physiological Viewer screen doesn't include blood pressure signals or values. You can review the data to reject artifacts and generate Word session reports.
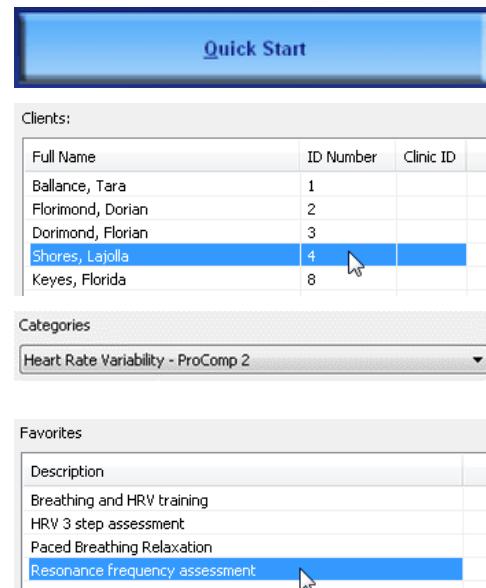
Resonance frequency assessment

Although teaching your client to practice slow regular breathing at 6 breaths/minute is a good method for increasing his heart rate variability, some evidence suggests that teaching him to breathe at a very specific breathing rate which corresponds to his "resonance frequency" is even more powerful.

Slow regular breathing triggers the respiratory sinus arrhythmia (RSA) effect, where breathing in entrains the heart rate to accelerate and breathing out entrains it to decelerate. The RSA effect causes a distinctly wavy pattern in the heart rate signal which, when processed through a fast Fourier transform (FFT) computation, appears as significantly increased power in the LF frequency band of the HRV spectrum.

The resonance frequency is attained when the client breathes at a rate which not only increases the power in the LF frequency band but maximizes it. The procedure involves getting the client to breathe for a couple of minutes at each of several different rates, and keeping track of the LF power value. After the assessment is done, the moment when the maximum LF value was reached is determined, and the rate the client was breathing at, at that moment, is noted. The Resonance Frequency Assessment session does exactly this.

Running the Resonance Frequency Assessment

1. Launch BioGraph Infiniti and click on **Quick Start**.

2. In the **Clients** list on the left, select an existing client name or use **Add New Client** to create a record for this client.

3. If the list on the right is empty, click the **Categories** drop-down list and select **Heart Rate Variability – ProComp 2**.

4. In the list of **Favorites**, select **Resonance frequency assessment** and click **OK**.

5. Ensure that:
   - The sensors are properly hooked up on the client.
   - The device is properly connected to the PC.
   - Your ProComp 2 is turned ON (green light is on).

6. Click the **Start** button to start the session, and follow the instructions in the **Resonance frequency assessment screen sequence** starting on page 31.

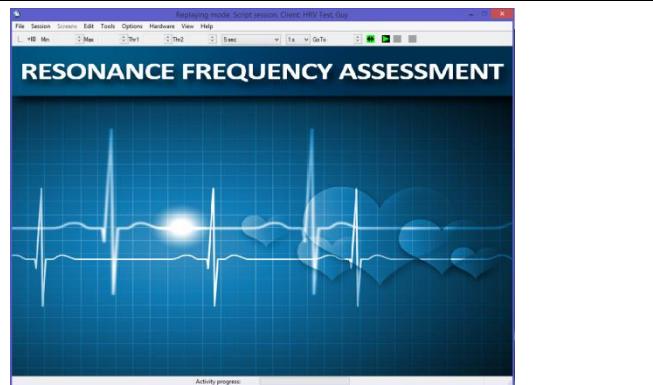7. When the script ends, click **Yes** to save the session.

Resonance frequency assessment screen sequence

Introduction screen When you launch the Resonance frequency assessment session **Quick Start**, after selecting a client and clicking **OK**, the introduction screen appears. Describe what the assessment is about to your client and click the **Start** button when your client is ready to go. ▶	
Physiological Viewer The Physiological Viewer screen shows the finger pulse and respiration signals. Check that the sensors are placed on the client correctly and that you are seeing valid physiological measures before pressing the [**Space bar**] to continue.	
Resonance Frequency Assessment The screen shows the finger pulse and respiration signals below a respiration pacer, which is set to automatically change its pacing rate from 8 breaths/min to 5 breaths/min. The pacer will decrease its rate by 0.5 br/min every 2 minutes. Encourage the client to stay with the pacer as best as he can for the duration.	
End of script After the script finishes, BioGraph Infiniti displays an on-screen prompt to save the session data. Thank the client for doing a good job and unhook the sensors carefully. Ask for feedback and insights.	
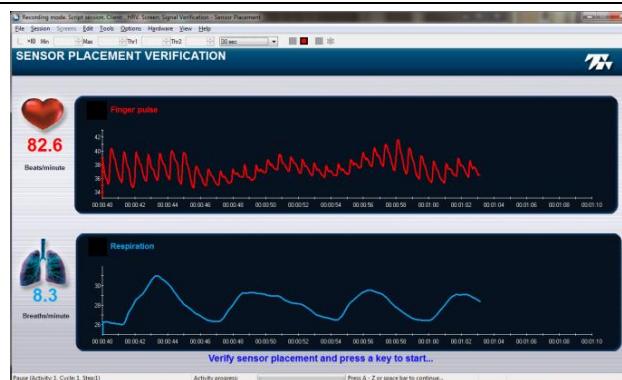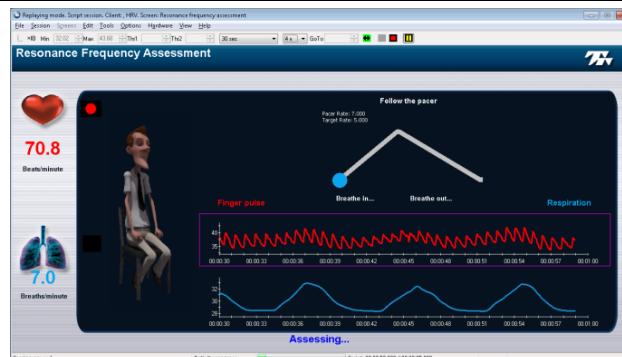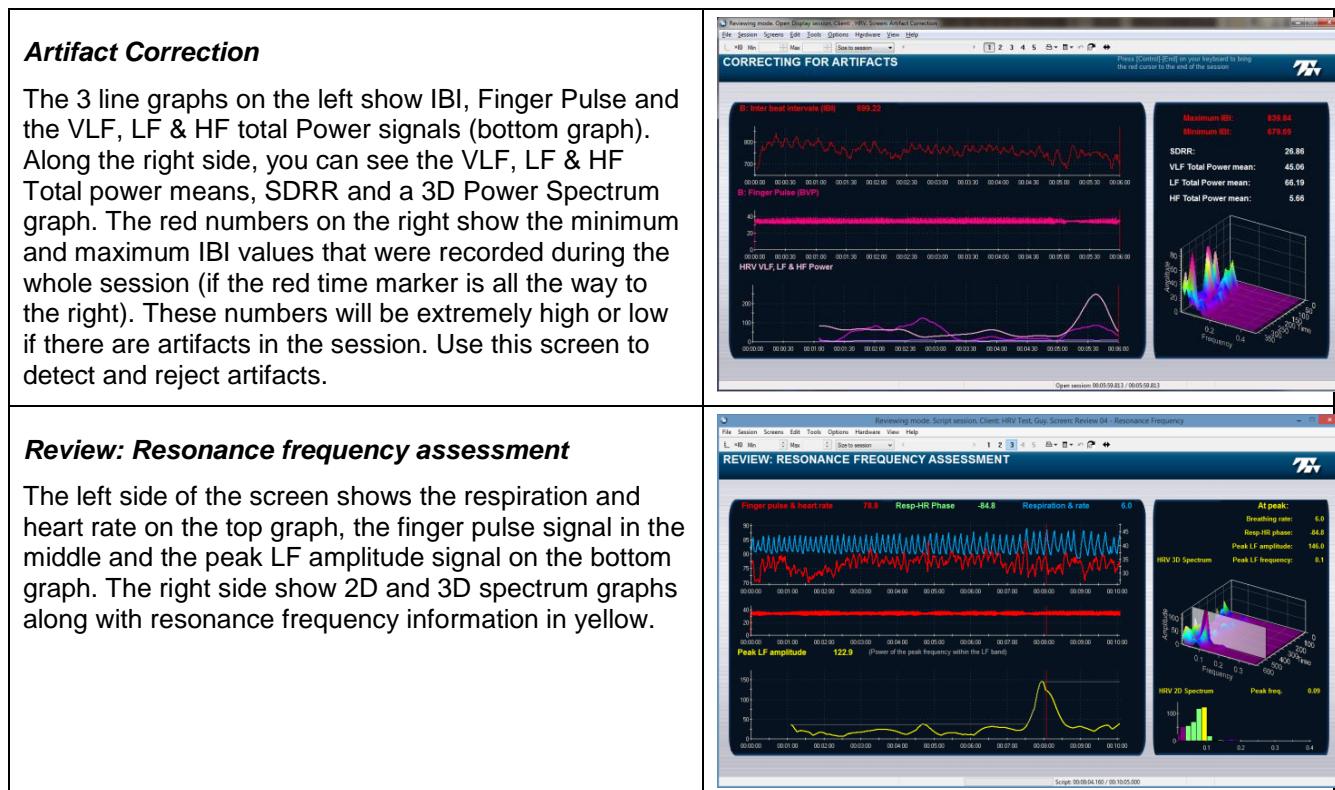
Reviewing the biofeedback session

After you save the Resonance Frequency assessment session, BioGraph Infiniti asks if you want to review or replay the session.

Click **Review**.

The system loads the review screens, which show you session graphs and appropriate statistics.

### *Artifact Correction* The 3 line graphs on the left show IBI, Finger Pulse and the VLF, LF & HF total Power signals (bottom graph). Along the right side, you can see the VLF, LF & HF Total power means, SDRR and a 3D Power Spectrum graph. The red numbers on the right show the minimum and maximum IBI values that were recorded during the whole session (if the red time marker is all the way to the right). These numbers will be extremely high or low if there are artifacts in the session. Use this screen to detect and reject artifacts.	
### *Review: Resonance frequency assessment* The left side of the screen shows the respiration and heart rate on the top graph, the finger pulse signal in the middle and the peak LF amplitude signal on the bottom graph. The right side show 2D and 3D spectrum graphs along with resonance frequency information in yellow.	

Using the Resonance Frequency Assessment Review screen

The key information on this screen is the Peak LF amplitude signal, shown in yellow on the bottom graph. The peak amplitude channel outputs the moment-by-moment power of the peak frequency within the LF band.

Click and hold the red Time Marker on the bottom line graph, then slowly slide it from the left to the right. As you do this, you can see, in the top graph, the breathing rate slowing down and the Peak LF amplitude moving up and down. Drag the time marker so it is just to the right of the highest point in the yellow signal. This is the point when the maximum LF power was obtained.

Check the yellow numbers in the upper right corner of the screen. At peak (i.e. at the highest value in the Peak LF amplitude), the breathing rate is 6 breaths/min and the peak frequency is 0.1 Hz.

When you are doing HRV biofeedback with a client whose resonant frequency is attained at a different breathing rate, you can adjust the respiration pacer's target rate to match your client's ideal breathing rate.
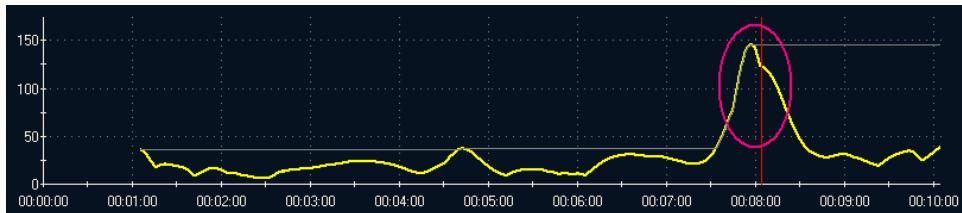
Sometimes, you will see more than one high point in the Peak LF amplitude signal. Move the Time Marker to the right side of each one and look at the Resp-HR phase value for each. Ideally, at the resonance frequency, the phase value is close to zero. Try training your client at the respiration rate corresponding to each peak, and see which one entrains HR with phase values as close to zero as possible.

Third step: Learning relaxation

Relaxation can be achieved using many different methods. There are many commercial tools, available on the market, which propose to help the user relax and let go of stress, anxiety and tension. Most of these tools don't give people the means to verify whether relaxation is actually occurring during the exercise.

Slow diaphragmatic breathing exercises are commonly taught in many stress management classes because they naturally promote relaxation. For this exercise to be done properly, you have to teach your client to breathe with his abdomen, instead of with his chest or shoulders. Have him place a hand, flat over his belly button, to feel the breathing movement and help him become aware of any chest expansion or shoulder movement.

When teaching your client to breathe abdominally, pay particular attention to how deeply he is breathing. Breathing too deeply can lead to over breathing and make him feel dizzy. Have the client reduce the depth of his breathing until it becomes slightly uncomfortable and then increase the depth of his breaths just enough to be comfortable again. Have him practice breathing like this on his own before starting with the exercise.

The Relaxation with paced breathing exercise uses a respiration pacer set to guide the client to breathe in and out at a specific rate, starting at 8 breaths/minute, all the way down to 6 breaths/minute. Once at this lower rate, it stays there until the end of the exercise.

The pacer plays sounds synchronized to inhalation and exhalation, so the client can close his eyes if this is more comfortable. We recommend that you connect headphones to the computer and let the client use them when practicing this relaxation exercise. It also helps if you can have the client recline, and if you can dim the lights in the biofeedback room during the session.

Running the Paced Breathing Relaxation session

1. Launch BioGraph Infiniti and click on **Quick Start**.

2. In the **Clients** list on the left, select an existing client name or use **Add New Client** to create a record for this client.

3. If the list on the right is empty, click the **Categories** drop-down list and select **Heart Rate Variability – ProComp 2**.

4. In the list of **Favorites**, select **Paced Breathing Relaxation** and click **OK**.

5. Ensure that:
    *   The sensors are properly hooked up on the client.
    *   The device is properly connected to the PC.
    *   Your ProComp 2 is turned ON (green light is on).
    *   Optionally, the blood pressure monitor is connected to the PC.

6. Click the **Start** button [▶] to start the session, and follow the instructions in the *Relaxation screen sequence* which follows.

7. When the script ends, click **Yes** to save the session.
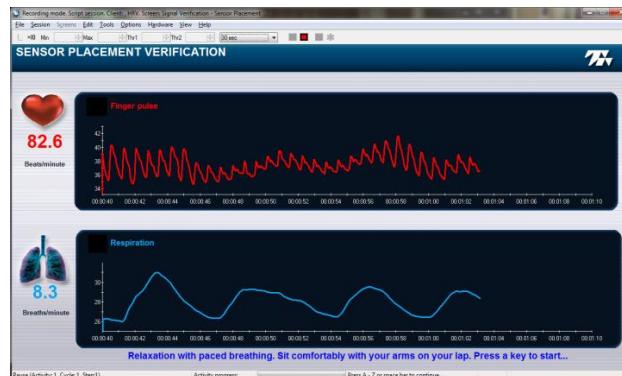
Relaxation screen sequence

Introduction screen When you launch the **Paced Breathing Relaxation** session **Quick Start**, after selecting a client and clicking **OK**, the introduction screen appears. Describe what the relaxation exercise is about to your client and click the **Start** button when your client is ready to go. [▶]	**PACED BREATHING RELAXATION**

Physiological Viewer

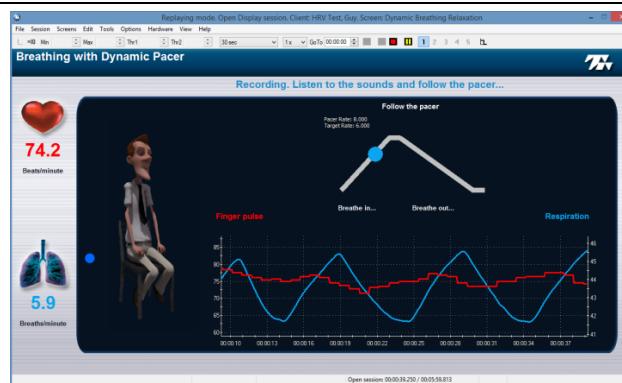The Physiological Viewer screen shows the finger pulse and respiration signals.

Check that the sensors are placed on the client correctly and that you are seeing valid physiological measures before pressing the [**Space bar**] to continue.

Breathing with Dynamic Pacer

The screen shows the respiration and heart rate signals below a respiration pacer, which is set to automatically change its pacing rate from 8 breaths/min to 6 breaths/min. The pacer will slowly decrease its rate by 0.5 br/min and stay at 6 breaths/minute for a few minutes.

Encourage the client to stay with the pacer as best as he can for the duration.

End of script

After the script finishes, BioGraph Infiniti displays an on-screen prompt to save the session data.

Thank the client for doing a good job and unhook the sensors carefully. Ask for feedback and insights.

Relaxation sessions Review and Report

If you save the relaxation sessions, you can review them to see what happened while the client was practicing HRV biofeedback and following the pacer. When reviewing feedback sessions, the review screens described in the section **Reviewing the session**, above, are loaded.

Note that, since relaxation sessions don't include a blood pressure step, the Physiological Viewer screen doesn't include blood pressure signals or values. You can review the data to reject artifacts and generate Word session reports.

What's next?

While clients can practice this exercise when they come to your office, being able to practice relaxation on their own would help them learn and retain this new skill more effectively. After a few relaxation sessions, you can teach your client how to transfer the skill to a situation with no biofeedback equipment for the strongest effect. A home training solution is a powerful method to help your client sustain a learned skill.

Paced breathing relaxation

Consider the EZ-AIR PLUS software, distributed by the Biofeedback Federation of Europe. This low cost software can be programmed to automatically pop-up at regular intervals and remind your client to practice slow abdominal breathing exercises while they are working on the computer.

- *www.bfe.org*: Biofeedback Federation of Europe.

Recommended reading about biofeedback and stress

- *Coping with Stress*. Heart & Stroke Foundation, Brochure HP4101E. V5.8. August 2013. (*www.heartandstroke.com*)

- *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. Circulation 1996; 93:1043–1065.

- *The ability of several short-term measures of RR variability to predict mortality after myocardial infarction*. Bigger JT, Fleiss JL, Rolnitzky LM, et al., Circulation. 1993; 88:927–934.

- *A Quantitative Systematic Review of Normal Values for Short-Term Heart Rate Variability in Healthy Adults*. David Nunan, PH.D., Gavin R. H. Sandercock, Ph.D. and David A. Brodie, Ph.D. PACE, Vol. 33, November 2010; 1407-1417.

- *Characteristics of Resonance in Heart Rate Variability Stimulated by Biofeedback*. Evgeny G. Vaschillo, Bronya Vaschillo and Paul M. Lehrer. Published online: 13 July 2006. Applied Psychophysiology and Biofeedback, Vol. 31, No. 2, June 2006 (C 2006) DOI: 10.1007/s10484-006-9009-3.

- *Biofeedback Mastery: An Experiential Teaching and Self-Training Manual*. Association for Applied Psychophysiology and Biofeedback. 2008-05-18. Peper et al. ISBN: 978-0984297900

- *The Clinical Handbook of Biofeedback. A Step-by-Step Guide for Training and Practice with Mindfulness*. Wiley-Blackwell. 2013. Inna Z. Khazan. ISBN: 978-1-119-99371-1

- *Biofeedback: A Practitioner's Guide, Third Edition*. The Guilford Press. 2005. Mark S. Schwartz, PhD, Frank Andrasik, PhD. ISBN: 978-1593852337

Technical Specifications and Support

Technical specifications

ProComp2 (SA7400)

Size (approx.)	2 ½ " x 2 3/16" x 5/8" (64mm x 56mm x 16mm)
Weight (approx., without batteries)	40 g
Input impedance (Input A)	1,000,000 mΩ
Input impedance (Input B, C, D)	2 mΩ
Resolution (Input A only)	0.1 µV RMS
Signal input range (Input A)	0-200 µV RMS
Signal input range (Input B, C, D)	2.0V – 3.6V
CM RR (Input A)	-130 @ 2 Hz to 45 Hz
Channel bandwidth	0 Hz – 45 Hz
Sample rate /channel (A, B)	200 or 256 samples/second
Sample rate /channel (C, D)	20 or 32 samples/second
Supply voltage	1.0V – 1.6V
Current consumption	75 mA - 150 mA @ 1.5 V
Battery life (Alkaline)	10 Hours (minimum)
Low battery warning	1.1 V ± 0.2 V
Data output protocol	19.2 or 38.4 Kbaud, 8 Bits, 1 Stop, No Parity
Analog to digital conversion	13 bits
System accuracy	+/- 5%

HR/BVP Flex/Pro Sensor (SA9308M)

Length (approx.)	0.72" x 1.33" x 0.41" (20mm x 34mm x 10mm)
Weight	20g (0.66 oz)
Input range	Unit less quantity displayed as 0% – 100%
Accuracy	±5%

Respiration Sensor (SA9311M)

Size (approx.)	132cm (52" long)
Weight	30g (1.0 oz)
Range	30% – 65%

Note: *ProComp2 and its sensors are sensitive electronic instruments and should be handled as such. Be especially careful to avoid both pulling on the electrode cable and getting moisture or electrode gel on the sensor snaps. If necessary, wipe the surface with a damp cloth or use a moistened Q-tip to remove gel from inside the sensor snaps. Wipe with a dry cloth.*

Ordering and Support

Placing Orders

Outside USA

Tel: 1-514-489-8251

Fax: 1-514-489-8255

E-Mail: mail@thoughttechnology.com

Or contact your local authorized distributor.

Technical Support

Outside USA

Tel: 1-514-489-8251

Fax: 1-514-489-8255

E-Mail: techsupport@thoughttechnology.com

Or contact your local authorized distributor.

In USA Toll-Free

Tel:1-800-361-3651

In USA Toll-Free

Tel: 1-800-361-3651

Warranty

The hardware (encoder and sensors) is guaranteed to be free from defects in material and workmanship for 1 year from the date of purchase.

In the unlikely event that repair is necessary, contact Thought Technology Ltd. to receive a Return Authorization number. Then send the unit back by a traceable method. Thought Technology will not be responsible for items not received. We will repair or replace your unit(s) that are still under warranty free of charge.

This warranty does not apply to damage incurred through accident, alteration, or abuse.

This warranty does not cover damage to the ProComp2 encoder or the temperature and skin conductance sensors caused by obvious mechanical mistreatment of the system.

Returning Equipment for Repair

Before returning the equipment, please contact first our service department and get an authorization number (RA number).

☎ Canada and International +1 514 489-8251

☎ USA 1-800-361- 3651

🖥 service@thoughttechnology.com

Then fill in the return form (the form can be found at the end of the manual). You must provide a detailed description of the problem you are experiencing, and your telephone/fax number and e-mail.

The unit(s) must be sent **postage prepaid** and **insured**, with proof of purchase to one of the following addresses.

All customs and duties charges will be billed to the customer if incurred by sending the unit to the **wrong** address.

In the USA, ship insured to:	**In Canada**, ship insured to:	**For international**, ship insured to:
Thought Technology Ltd. Cimetra LLC 8396 State Route 9 West Chazy, New York 12992, USA	Thought Technology Ltd. 8205 Montreal/ Toronto Blvd. Suite 223 Montreal West, Quebec Canada H4X 1N1	Thought Technology Ltd. 8205 Montreal/ Toronto Blvd. Suite 223 Montreal West, Quebec Canada H4X 1N1 Package must be marked "Broker: Livingston International - 133461".

Repair Return Form

Be sure to call for authorization before returning any equipment!

Copy and complete this form and include it with the unit(s).

Include a copy of the original invoice and return to the address in the **Returning Equipment** section.

Name

_____

Company

_____

Address

_____

_____

_____

_____

Phone No.

_____

Fax No.

_____

Date Purchased

_____

From Whom

_____

Model Name

_____

Serial No.

_____

Problem

_____

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