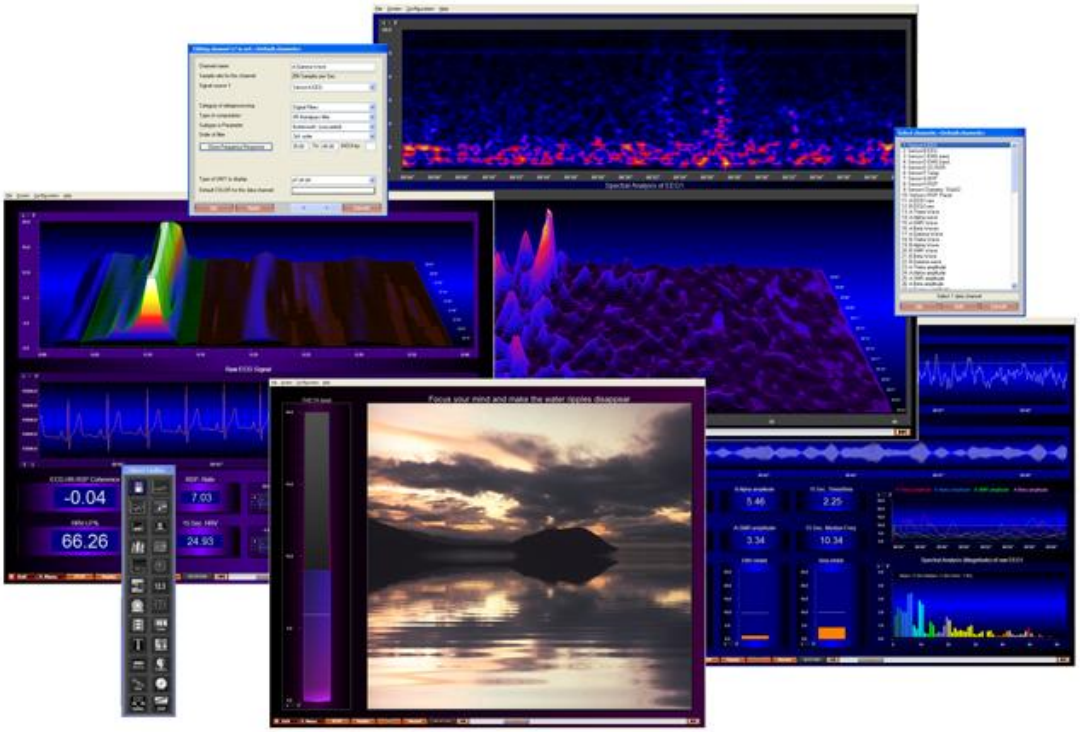
User Manual
for the
BioTrace+ Software



BioTrace+ is a product of
Mind Media B.V. Netherlands
www.mindmedia.info

Please read this manual carefully, before using the BioTrace+ Software!

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1.0 Installation of the Software

CONGRATULATIONS! by choosing **NeXus-10/NeXus-4** with BioTrace+ software, you have purchased leading edge technology. These platforms feature a rich set of advanced functions as well as an easy entry into the world of physiological monitoring and feedback!

This first chapter offers you a step-by-step approach to the BioTrace+ software installation. The second chapter contains directions to get you started with using the basic functions of the system. Enjoy!

1.1 Step 1: Check your Computer

BioTrace+ requires the Microsoft Windows ™ Operating System (OS). We strongly advise you to use **Windows 7** (or newer versions of Windows)

In case it is not possible for you to use Windows 7 or a newer version of Windows, you may choose to use Windows XP SP2. (Vista is not recommended)

Supported Versions of Windows:

Windows 7	32 bit and 64 bit. (Recommended)
Windows Vista	may work, but is not recommended
Windows XP SP2	May be used as an alternative to Windows 7.

Minimum requirements for your PC:

- 2 GHz AMD or Intel processor (dual or multi core recommended)
- 1 GB of system memory XP, 2 GB Windows 7
- 100 Gigabyte of free space on your hard disk. (for physiological data)
- 16 bit soundcard or integrated sound. (Creative Labs recommended)
- 1 free USB connection on your computer (for Bluetooth communication)
- 1 Graphics card with at least XGA 1024x768 resolution, or better. Dual monitor setup highly recommended! ATI or NVIDIA graphics card highly recommended!
- 17 Inch CRT or LCD monitor, CD or DVD drive.

An example of an optimum Computer for running BioTrace+:

- Windows 7 (32 or 64 bit)
- Basic features such as USB connections, CD and DVD drives
- Dual or multi-core Intel/AMD processor running at 2.4 Ghz or faster.
- 4 GB of system memory.
- 250 GB free hard disk space with an external drive for backups.
- NVIDIA or AMD graphic card with dual monitor capability
- Two 24 Inch LCD/LED monitors **

** *One primary monitor for yourself and the secondary monitor for your clients*

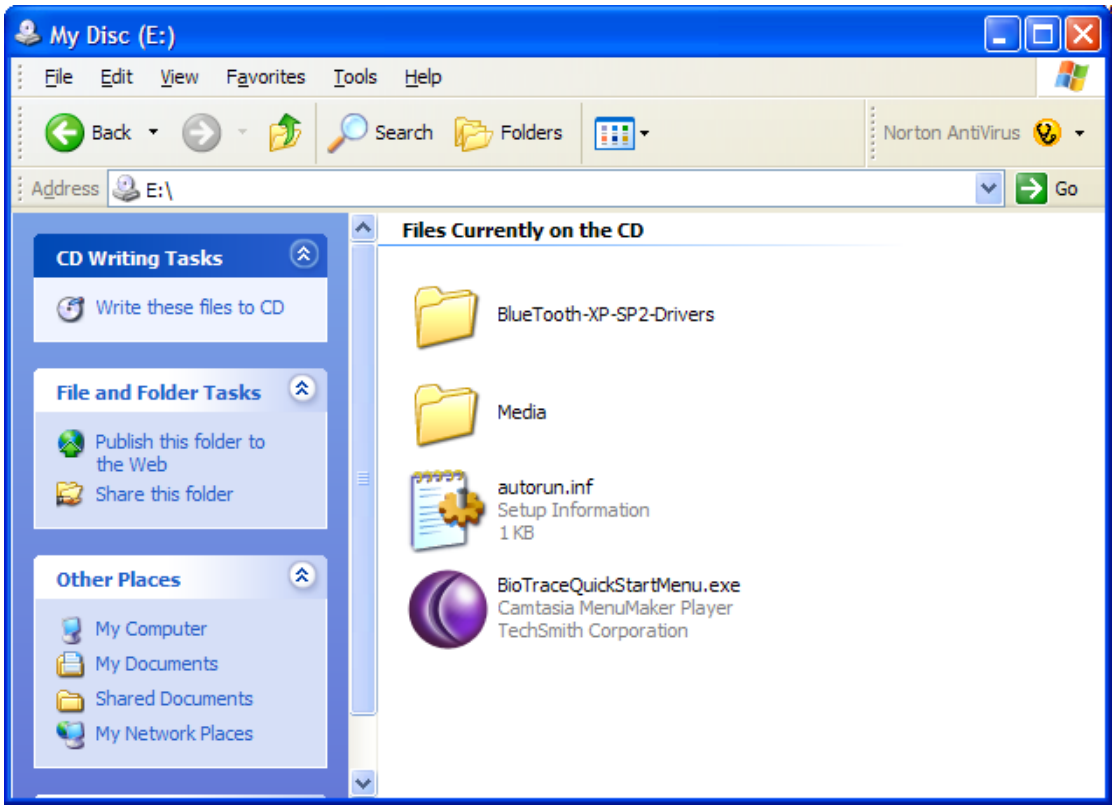
Remark: as an alternative you could use a 24 Inch monitor for your primary screen and use a beamer (LCD projector) for your secondary (client) screen.

Note: In case you want to read more on optimization and configuration of your computer for the use of BioTrace+, we advise you to read chapter 8 at the end of this manual!

1.2 Step 2: Start the Quick-Start-Menu

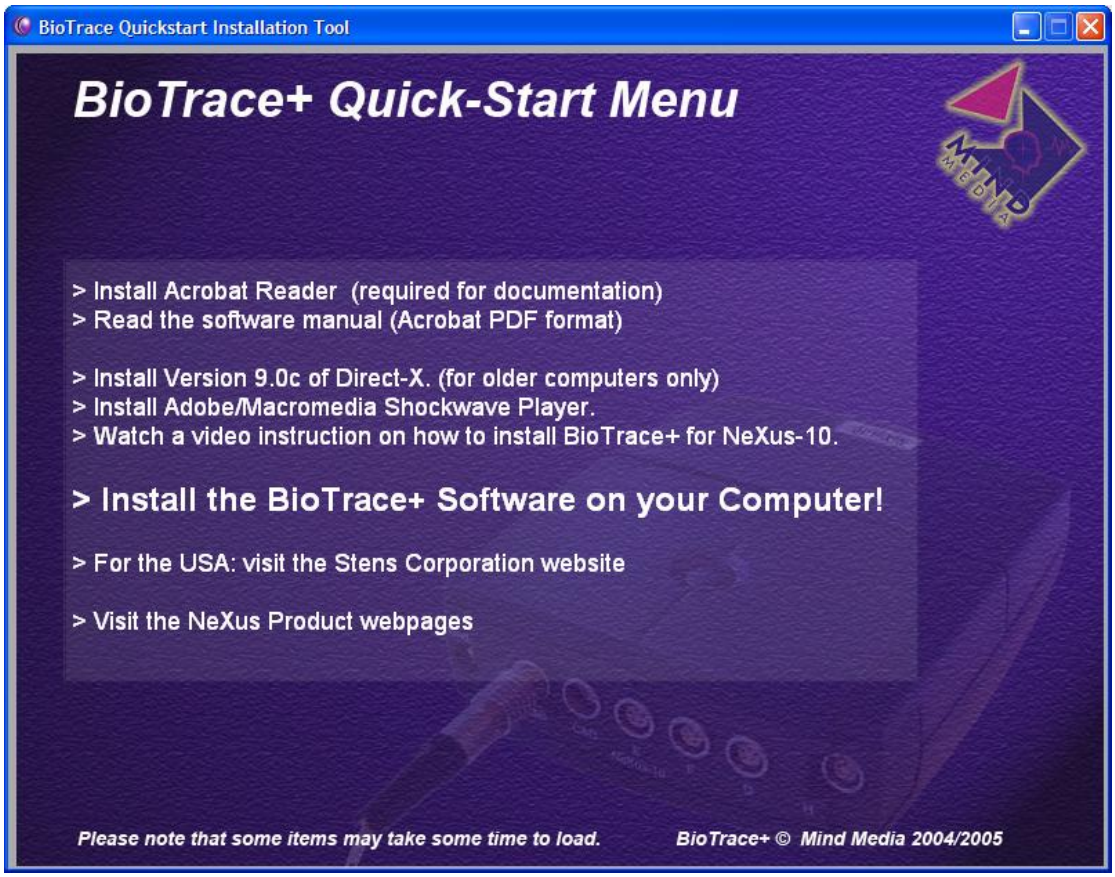
To install or update the BioTrace software, you need the supplied BioTrace Setup CD. Enter the CD in your CD or DVD drive and wait for the **quick-start menu** to appear.

In case your computer has not been configured to auto-start software from CD/DVD you need to start the menu manually. You can do this by double-clicking the **BioTraceQuickStartMenu.exe** shown below in the contents of your CD/DVD.



***Please note**: actual screen display of the content of your CD/DVD may be different on your computer.*

When the quick-start menu has been launched, a dialog box will appear that shows a number of software installation options.

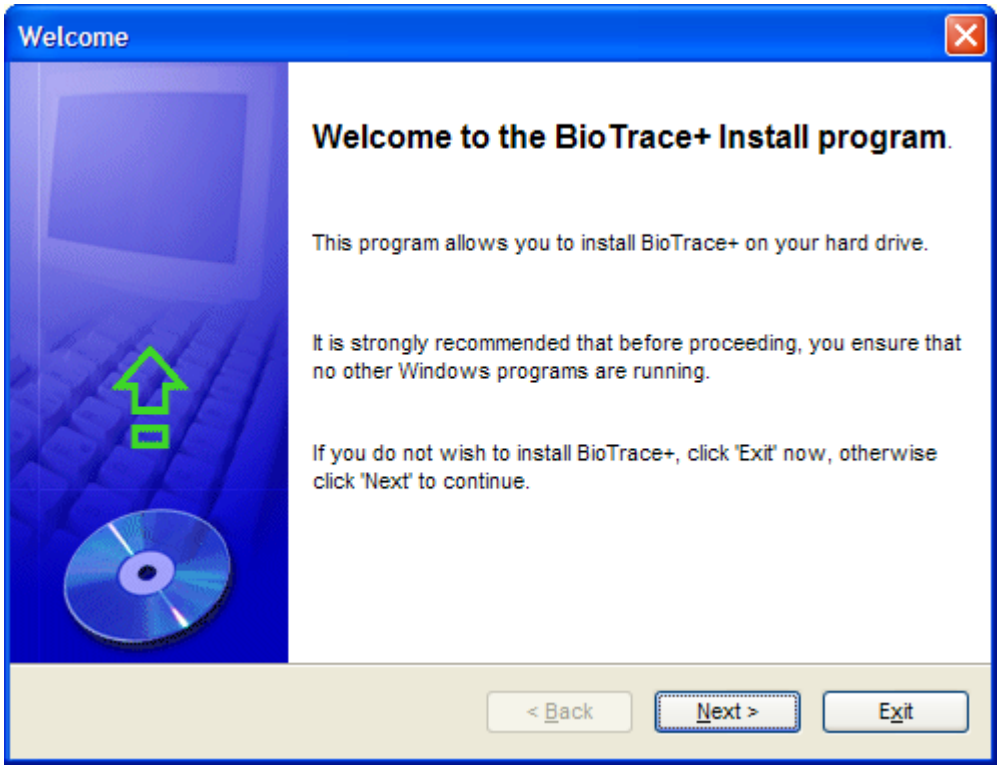


You can select the options shown here by pointing and clicking the mouse on the text options displayed above. (*example shown for NeXus-10*)

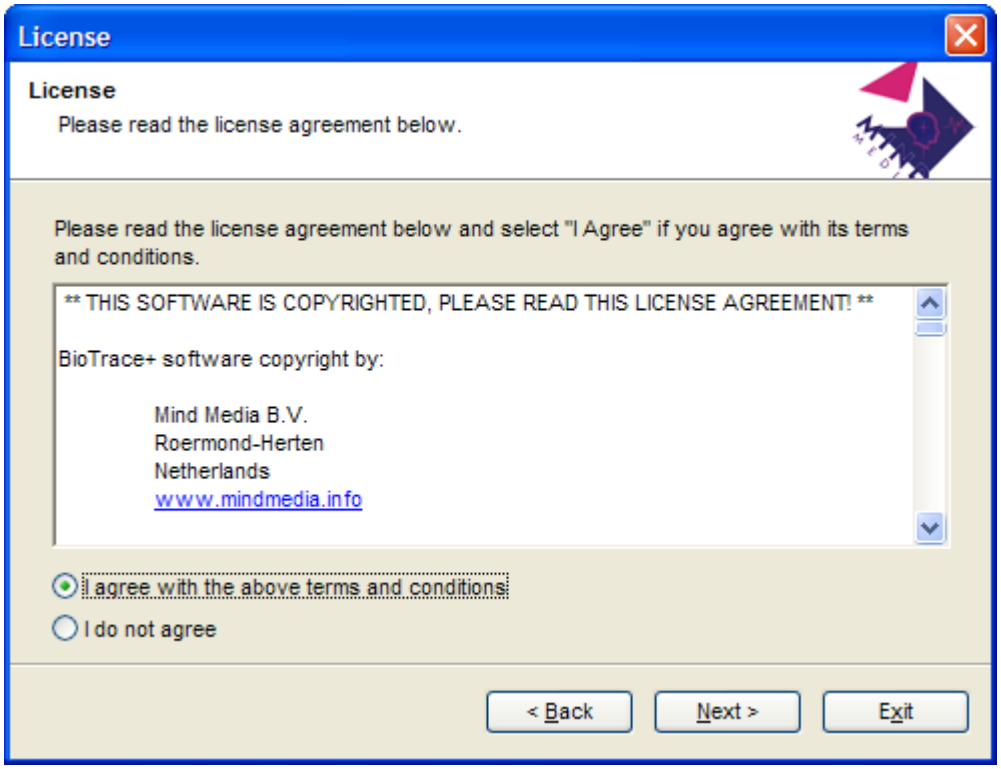
A) The first option will install Acrobat Reader on your computer. You need this to read the electronic versions of documents (such as this manual) on your computer. In case you already have a version of Acrobat Reader, you can skip this step.
B) The next option will open the PDF software manual for easy reference.
C) Direct-X: If you ever need to reinstall DirectX 9 you can choose this option. In case you have Windows XP with SP2 or newer, you can skip this option.
D) Install Shockwave Player: BioTrace+ uses shockwave and flash technology to play animations and videos. Please make sure you have installed these on your computer.
E) Video: we advise you to look at this short video instruction which shows an example of the BioTrace+ Software and Bluetooth driver installation on a Windows XP computer.
F) **Install BioTrace+**: this will do a complete installation of BioTrace+ on your computer. In case you are using it to update your BioTrace+ installation, it will leave previously stored sessions and the database intact. Note however that updating will cause default settings, channels sets and screens to be reset to their defaults!
G) Click the last options to open websites that contains more information about NeXus-4, NeXus-10, NeXus-16, NeXus-32, BioTrace+ and other Mind Media products.

1.3 Step 3: Install BioTrace+

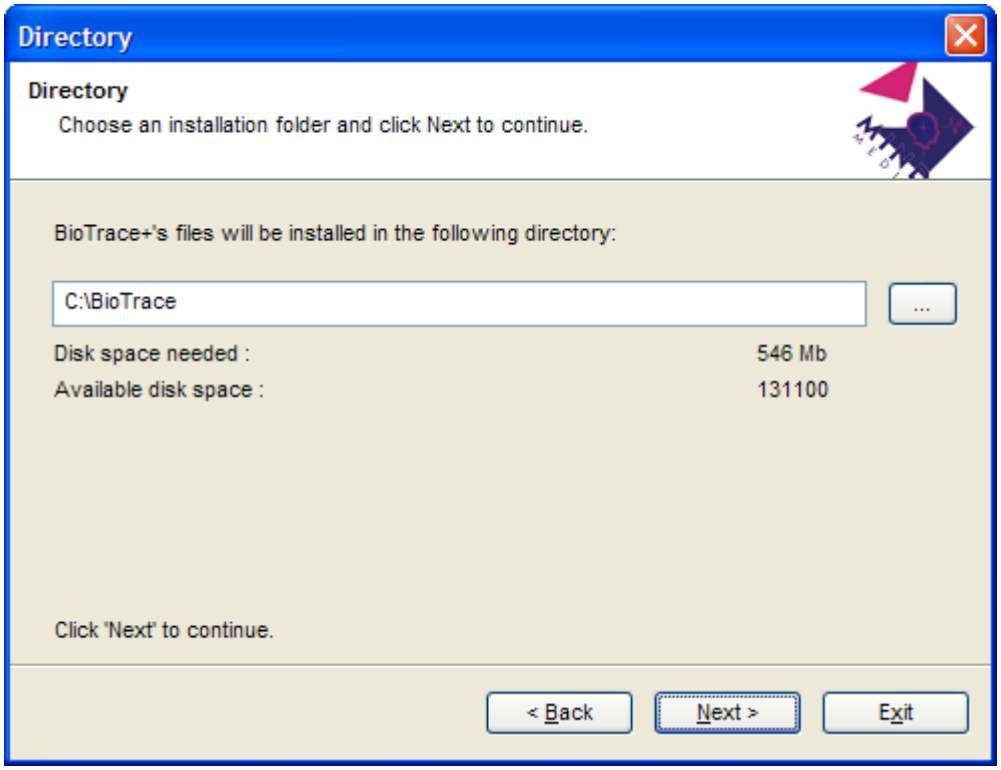
Now follows a step by step description of the SETUP process. This will start when you select the option: "**Install the BioTrace+ Software on your Computer!".** The first dialog box that will appear looks like this:



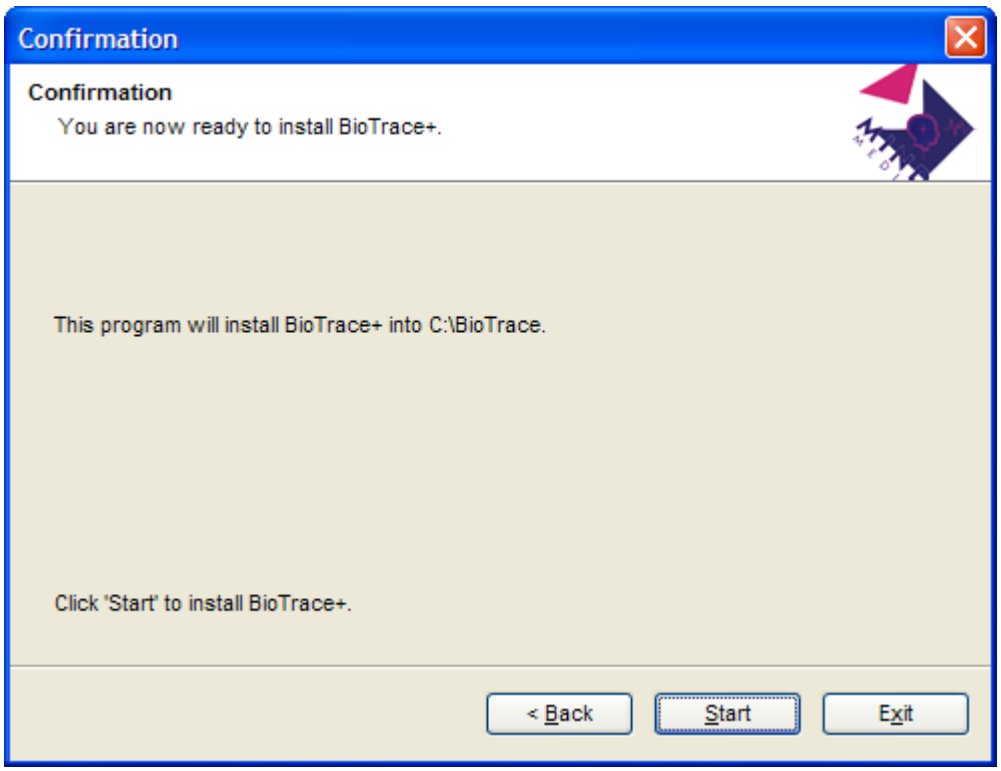
Press **"Next >"** to continue to the license agreement. If you agree, click next >.



Now the next dialog box is shown where you enter the installation directory of BioTrace+. For **NeXus-10** it is C:\BioTrace. For **NeXus-4** it is C:\BioTrace4.



We advise you to install BioTrace+ in a root directory such as “C:”, “D:” etc. so that it will be easy for you to locate BioTrace+ files on your computer. Make sure the drive has enough space. In the case shown above, the drive has over 130 gigabyte free space. In the next dialog box you can press **START** to begin the installation.



1.4 Step 4: Shockwave and DirectX Installation

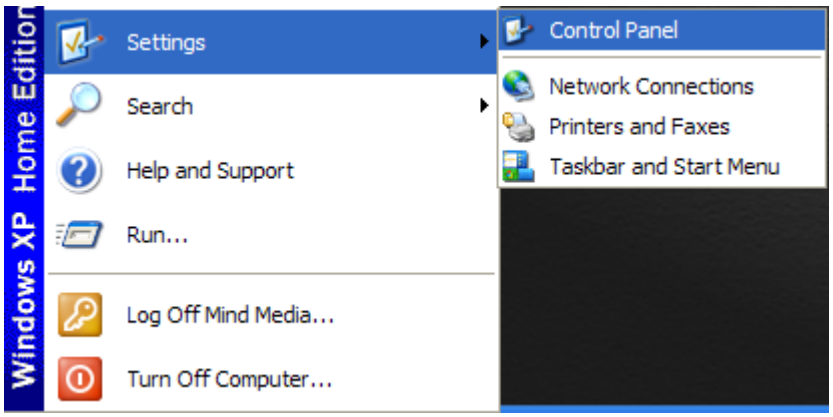
This chapter is only for Windows XP users: the BioTrace+ Software utilizes Adobe/Macromedia shockwave ™ technology. You can install this option from the **quick-start menu**. Please make sure your Internet browser is closed and follow the directions.

BioTrace+ uses DirectX hardware accelerated graphics and multi-media. It requires version 9.0 of DirectX or later. You can use the quick-start menu to Install Version 9.0 of DirectX. You can skip this part of step 4 if you have Windows XP with service pack 2 (SP2) or a newer version of Windows XP.

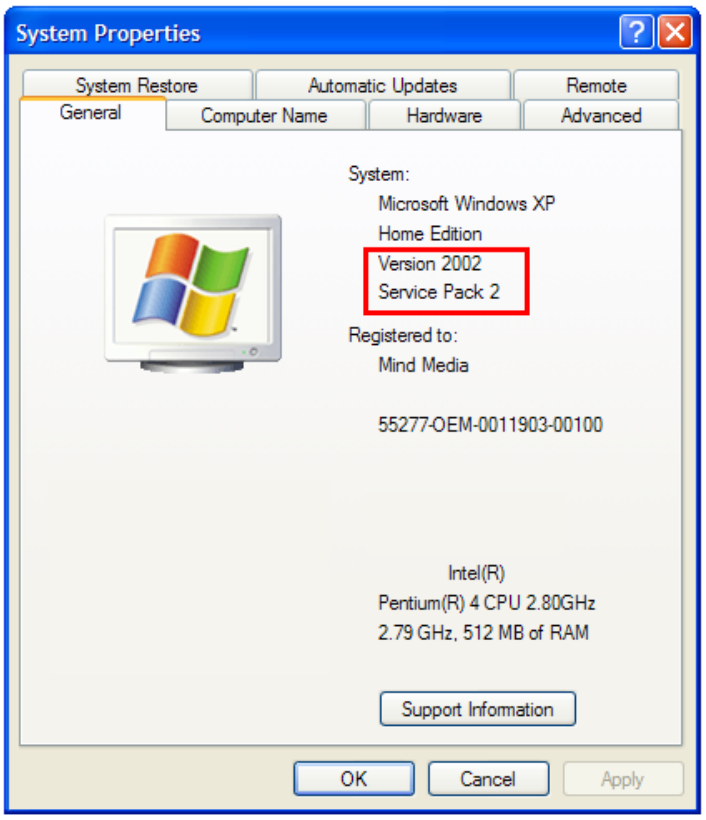
Please check "**I accept the agreement"** if you want to install this version of DirectX. In case you have already installed a more recent version of DirectX, don't worry, this installer will warn you, or you can select the cancel button.
When you install DirectX 9, keep on pressing the **Next >** buttons until a dialog box appears that asks you to restart the computer.

1.5 Step 5: Restart and check Windows XP version

In case you are using Windows XP: after installation of the software, please restart the computer and check which version of Windows XP you have. You can do so by opening the **"control panel".** You find this under the **Windows Start button**, as shown below:



In the control panel, look for the **SYSTEM** icon and open it. You will then be prompted with the system settings. The version of Windows XP is shown and marked in red below. In this case it is Service Pack 2.



Note: we actually advise to use Windows 7 or a newer version of Windows.

1.6 Step 6: Bluetooth Driver Installation

For Windows XP users: before you can use the BioTrace software and the NeXus unit, the Bluetooth drivers must be installed. In ase you are using Windows XP: we advise you upgrade your computer to **Windows XP service pack 2** (or get a newer compatible version of Windows XP) before you install the Bluetooth drivers. In case you have XP service pack 1 or older and cannot upgrade, the Bluetooth installation procedure and drivers are different. In case you have previously installed Bluetooth drivers under SP1 that work reliably, you may decide to keep those drivers if they work for NeXus.

Note: USB and BlueTooth installation for Windows 7 is described in the hardware manual.

XP-SP2 driver installation:

Please turn your computer ON and put the supplied Bluetooth stick (in this sample an MSI stick is shown) in a free USB port.

From now on, this USB port will be your NeXus Bluetooth port, we advise you to always use this port, and not change to other USB ports.

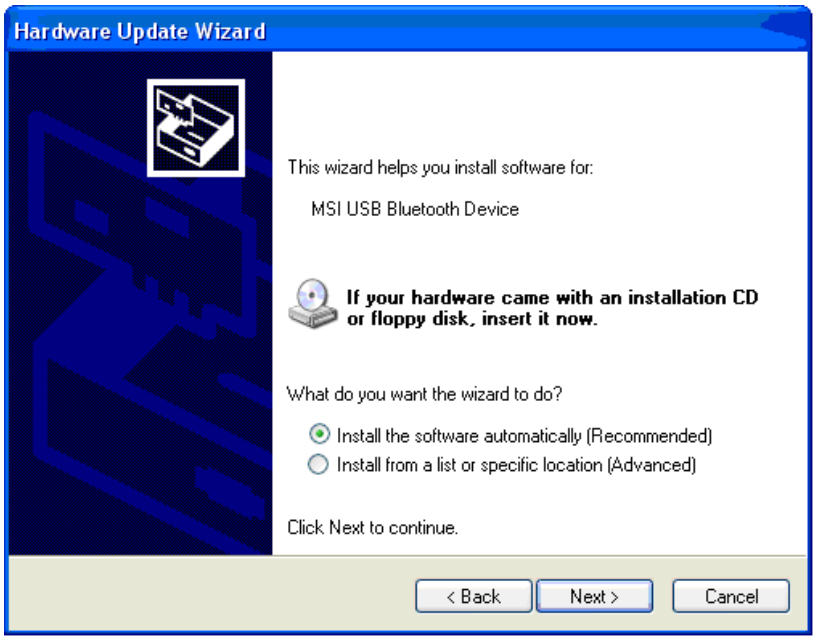
On notebooks we advise you use an extension cable, so the USB stick will not be damaged when the notebook is tilted. This extension cable may be short or up to 2 meters long.

Please note: different types of Bluetooth interfaces may be supplied with your NeXus. Therefore the brand and type of USB stick may look different than the one displayed above. NeXus also runs with LinkSys BlueTooth sticks.

Now a balloon text will show at the right bottom of your monitor screen.
(actual screen display may vary depending on type of interface)

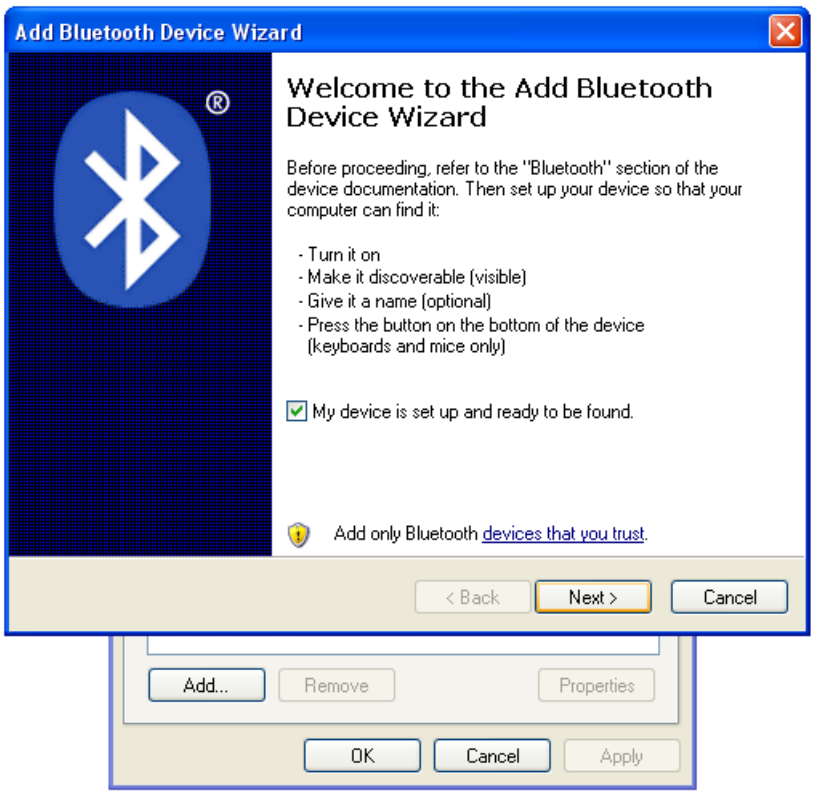
Windows will then in most cases ask you if you want to connect to the Windows Update (on internet) to search for a new driver. If that occurs simply select: "**No, not this time".**

Then a dialog box will appear when you can select where the driver software is located:

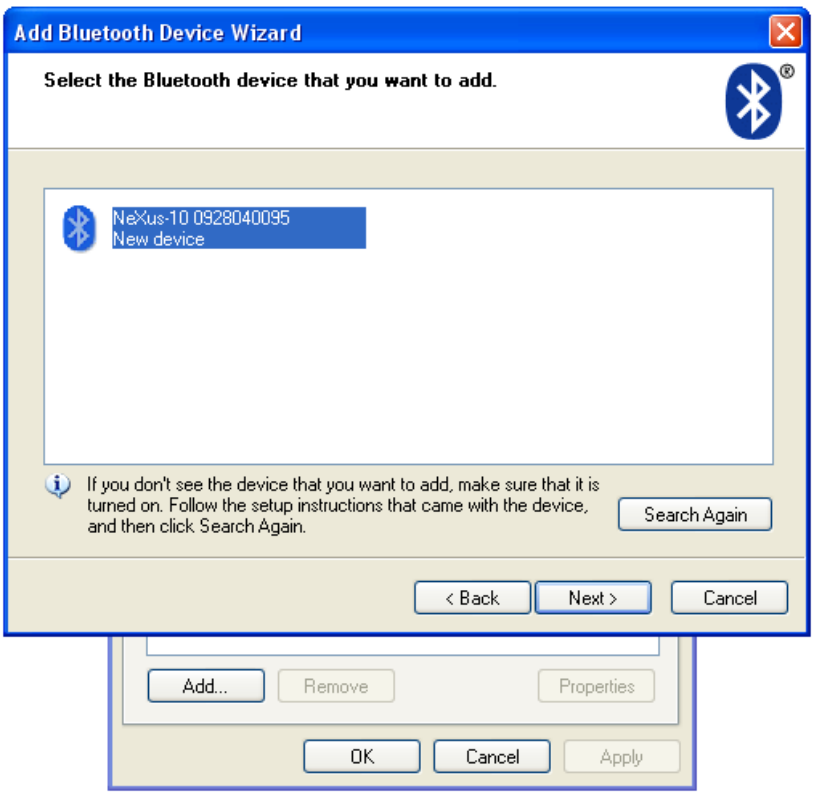


Select the option: "**Install software automatically"** and make sure your setup CD is located in the drive. Windows will then search for the drivers on the BioTrace+ setup CD.

In case Windows does not find the drivers, you can also choose "specific location" and use the **"BlueTooth-Drivers-XP-SP2"** directory on your CD.

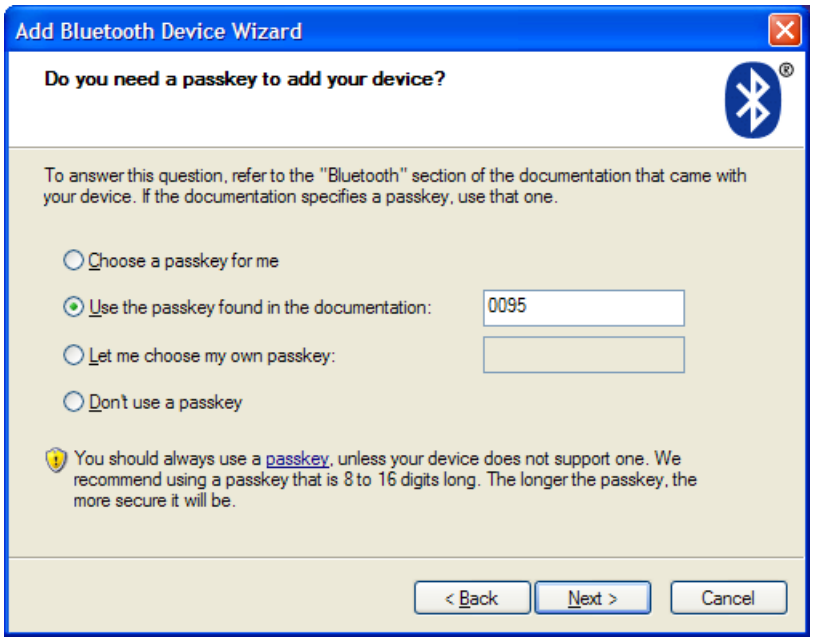


In the Bluetooth Device Wizard, you should now select the button "My device is set up and ready to be found". Switch the NeXus power to On. The Bluetooth stick will probably flash a blue light now. Then press then "**Next>"** button.



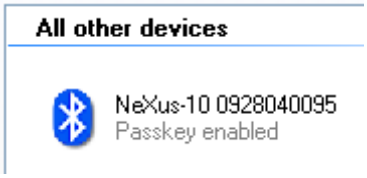
After a while the NeXus should be detected. Now select it with the left mouse button and click on the **"Next >"** button. Please note the serial number.

We will now need to enter the **PASSKEY** (also sometimes called the **pin code**) of the NeXus. This way Bluetooth protects you from other people that may otherwise connect to your NeXus. Each NeXus is linked to a single computer and this computer will only connect to your NeXus if it has this passkey.



Please select "Use the passkey found in the documentation" and enter the number. Note that this key comprises of the last four digits of the serial number. You can find this number on the label at the bottom of your NeXus. On the former page you will notice that this serial number is shown. Enter the four last digits of this number. The example above shows "**0095**" but your passkey will be different.

Then press the **"Next >"** button and wait for Windows to connect to your NeXus. It will show a number of messages and finally a message that the device has been installed. It may also reveal the COM port that is used to connect to the computer. This should be a port in the range between COM1-COM9. Press the **OK** button to finalize the installation.



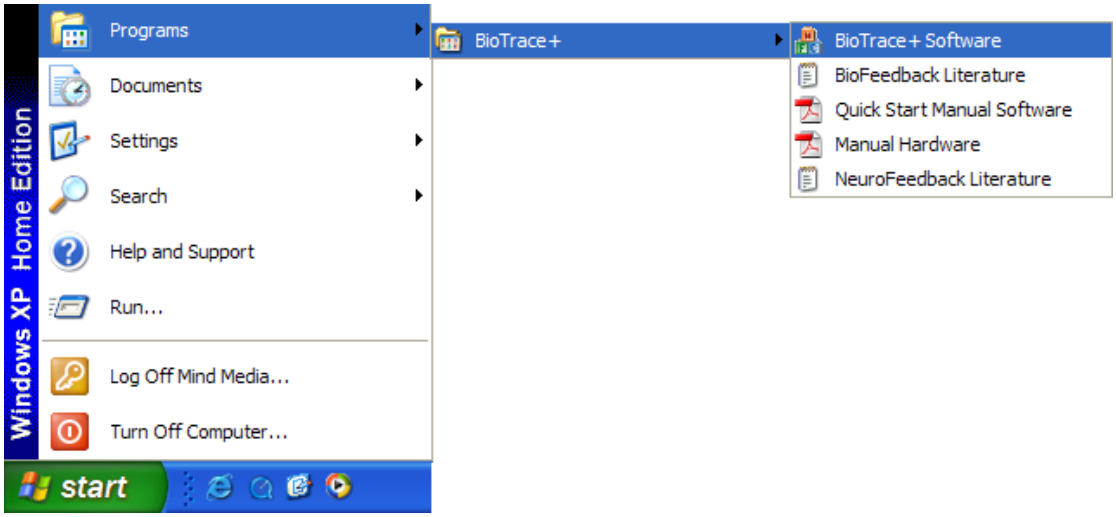
Note 1: In case the COM port is higher than COM9 or you need troubleshooting, please refer to appendix 1.

Note 2:The installation procedure is the same for NeXus-4 and NeXus-10.

1.7 Step 7: Finalize the Installation

After you have connected the NeXus to Bluetooth we advise you to restart the computer, so that all settings are stored and you do not need to re-enter them.

After you have restarted the computer, the next step you will take is to **launch the BioTrace+ Software** through the Windows ™ Start button.



(actual screen display may vary)

You will then be presented with the **MAIN MENU** of the software**.** This is the place where you can start to use the NeXus and run your first session!

In the next chapter we will explain this main menu and the main BioTrace+ functions to you, in a quick introduction. In chapter 3 and beyond you will find a lot more detail on the advanced functions and features of BioTrace+.

2.0 Getting Started: a Quick Introduction

2.1 About this manual

Welcome to the BioTrace+ Software. Now that you have installed the software, it is time to get to know and use it!

This manual is divided up in several chapters. As you have seen, the first part only deals with the software installation. **The BioTrace+ Software version for the NeXus-4 and NeXus-10 are very similar**, the 10 mainly has a few more advanced analysis functions.

This second chapter provides you with a quick overview of the software, while presenting the basic functions. In this chapter we will take the first steps to review sessions, start new sessions, load screens, look at session data and compute statistical results.

Chapter 3 deals with the key concepts of the BioTrace+ software architecture and explains what screens, data channels and sessions are. You need to understand these concepts if you want to use the more advanced functions of the software.

Chapter 4 covers the user interface and how to operate BioTrace+ with the mouse and keyboard.

Chapters 5 and beyond deal with the more advanced technical details and guide you in creating your own screens and protocols.

Intended use of this manual

Please note that this user manual only covers the use and handling of the technical functions of the BioTrace+ software. It does not deal with physiological or clinical applications. Nor is this user manual or the software intended to be a guide of how to use or interpret the physiological signals, data or session results. For that kind of information, please refer to the relevant professional literature and publications.

This manual assumes that you are familiar with all the basics of the Microsoft Windows ™ operating system and using the mouse and keyboard functions. This manual does not explain to you how to operate your computer or how to use the Windows operating system.

User feedback

We have taken great care in providing you with a complete and thorough manual. However we are always interested in your feedback on how we can improve the manual or enhance the Software. You are welcome to send us your suggestions at:

support@mindmedia.nl

For technical support: please always contact your NeXus reseller!

Now follows a list of warnings and disclaimers that are important for you to read before you will use the BioTrace+ software:

Disclaimers and warnings:

- Please read this user manual and the NeXus hardware manual carefully before using BioTrace+ with NeXus-4 or NeXus-10,

- The PC that is running BioTrace+ must be placed out of the clients reach for safety reasons. We advise 2 meters or more. Generic PCs and notebook computers are not medical devices and therefore may pose a hazard to you, the client or others. If safety is a concern we advise to run BioTrace+ only on a medical grade PC that conforms with EN-60601-1.

- The Microsoft Windows ™ operating system is not a medical device. Modern computers running Windows ™, although increasingly more powerful every year, may fail unexpectedly in terms of hardware (electronics) and software for various reasons. BioTrace+ Software was designed with state of the art software development tools, but it can not be guaranteed that the Computer or the Windows ™ OS or this Software will run error free under all conditions. This poses the risk that data, signals or statistics may be represented incorrectly, become invalid or data may get lost. Therefore we urge you to make regular backups if maintaining the data for the long term is important to you.

- The operator is responsible for the safety of any device (including the computer, printers, accessories and other attached apparatus) that is used by the BioTrace+ Software or attached to the computer that is running BioTrace+.

Attention:

- This software should never be used for diagnostic purposes, vital monitoring or for life supporting systems

Limitation of liability

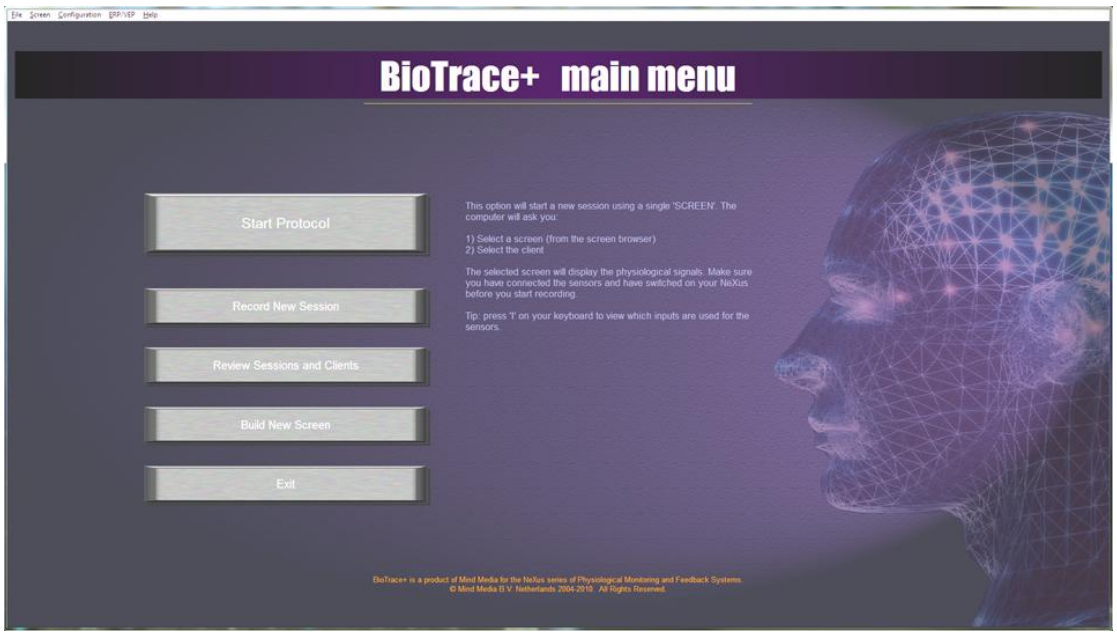
Insofar as is maximally permitted under the applicable prescriptive law, neither Mind media nor its suppliers or dealers are liable under any circumstances for any indirect, exceptional, incidental or consequential damages arising from the use of the Biotrace+ Software (the product) or from the inability to use it, including (but not restricted to) the damage arising from loss of goodwill, work interruption, computer defects or faults or any other damage or losses consequential upon business interruption, even if the possibility of these occurring had been mentioned and irrespective of the legal or impartial theory (agreement, unlawful act or otherwise) on which the losses are based.

In any case and pursuant to any of the provisions of the present agreement, the total liability of Mind media is limited in its entirety to the sum of the price that was paid for this product and the fee for the product support granted by Mind media under a (possible) separate support contract, with the exception of death or personal injury arising from negligence by Mind media insofar as the applicable prescriptive law forbids limitation of damages in such cases. Mind media cannot be held liable for the consequences of any incorrect information furnished by its staff or for any errors in this user guide and/or other accompanying documentation (including trade documentation).

The other party (the user of the product of his or her representative) must hold Mind media harmless and indemnify it against any third party damages, irrespective of their nature and irrespective of the relationship with the other party.

2.2 The Main Menu

Let's get started: when you launch the software, it will always show the **main menu,** a sample of this is shown below: *(actual screen display may vary)*



The main menu is an easy way to use the BioTrace+ software and a good way to start familiarizing yourself with the overall structure of the system and its simplicity of use.

Let's take a look at the demo protocols that come supplied with the software, to get there, click on the **START** button at the top of the main menu.

Note: you can always get to the main menu by pressing the ESCAPE key!

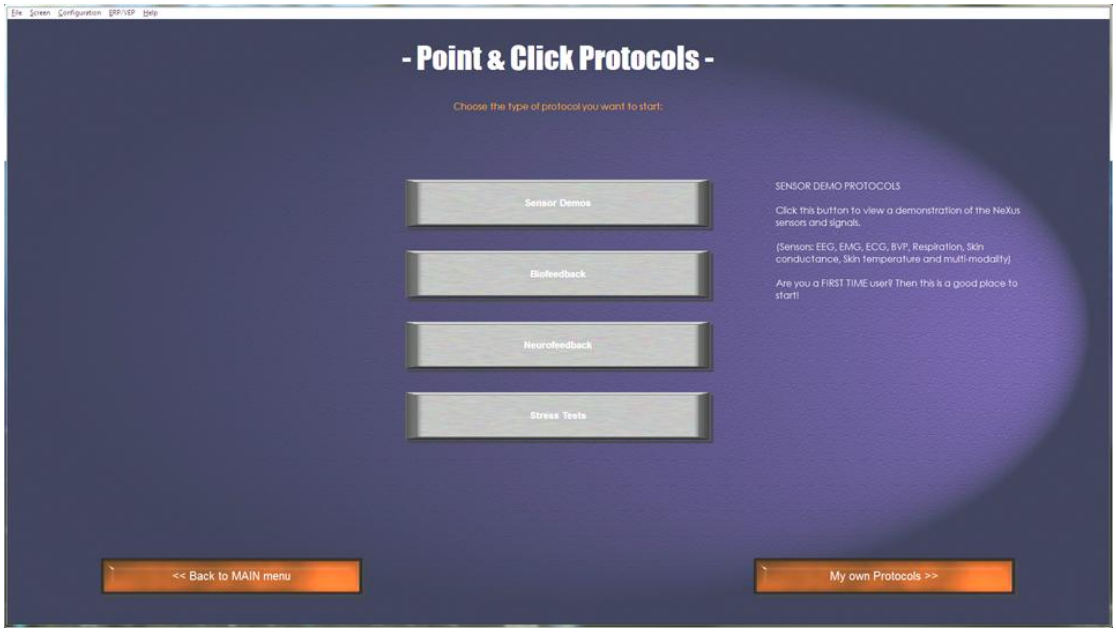
However, when you are in the middle of recording a session, you first need to stop and close the session, before you can switch back to the main menu.

2.3 Point and Click Protocols

BioTrace+ offers two levels to operate the software. The simplest way to use the software is through "**Point and Click Protocols".** These are preset protocols that are automated so the user can just start them and let BioTrace. The other way is through the "**Screen Editor Level**" which will be addressed later on.

The advantage of automated protocols is that many come pre-configured with the software and run automatically. Protocols consist of a number of **screens** that you navigate through by pressing **buttons** and are self-explanatory in most cases. In some cases the buttons are hidden and the progress of screens occurs according to a logic that is programmed into the hidden buttons. But all protocols are advanced through button actions

Below you see an example of a number of protocols. We will select the DEMO protocol.

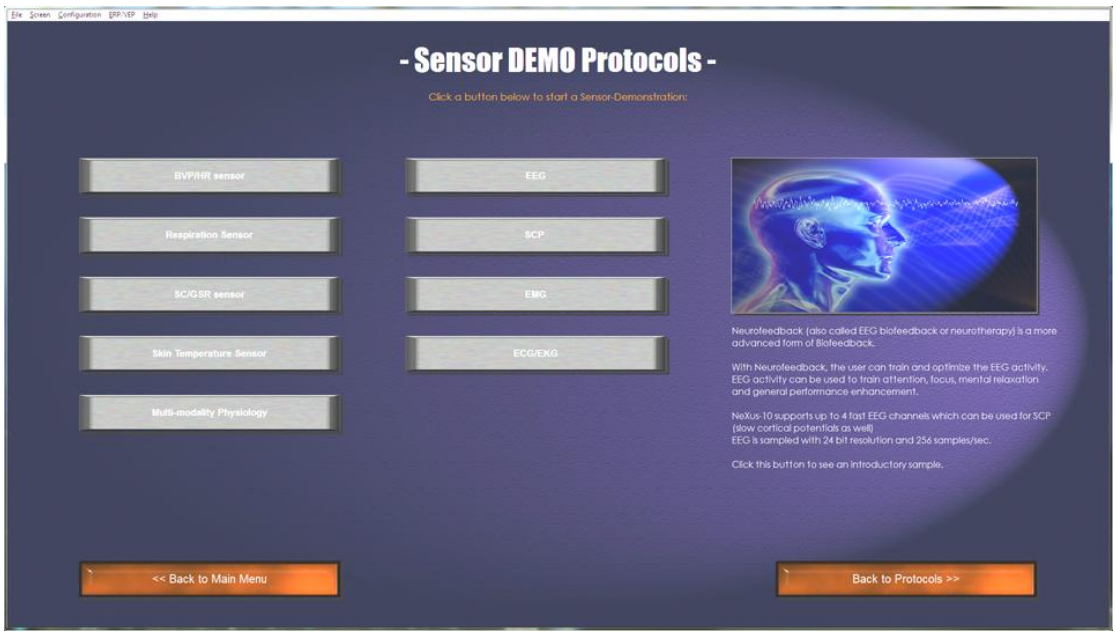


Please click the **SENSOR DEMOS** button to move to the next screen.

2.4 Demo Protocols: BVP example

You will now see a list of the **DEMO protocols**. The demo protocols display signals from various sensors and use stored session data. So there is no need to connect any sensor to your body.

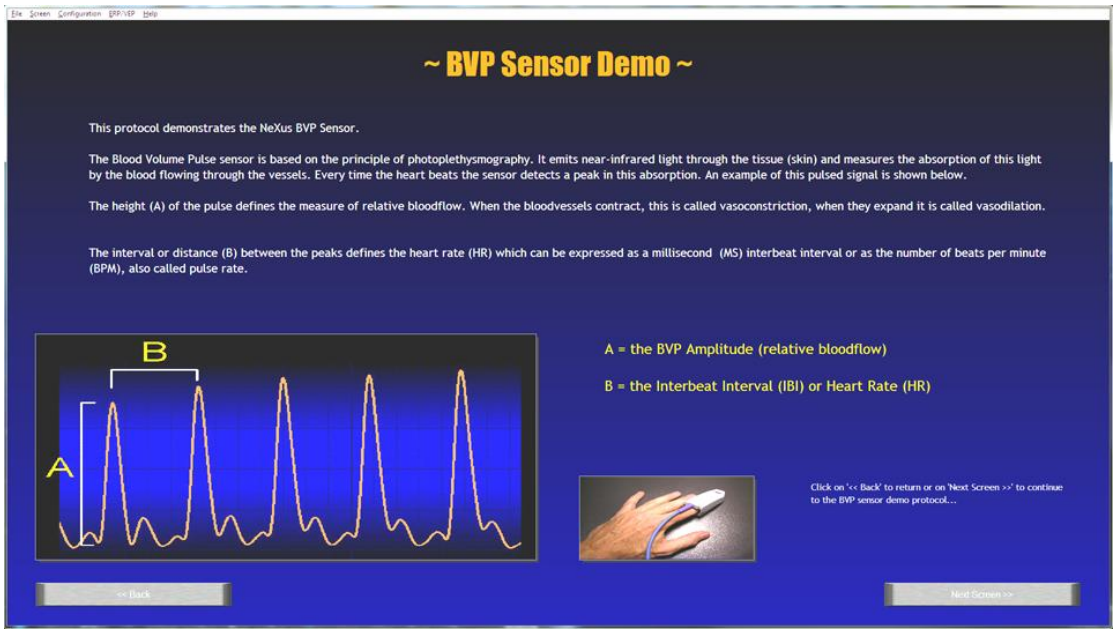
Let's try out the first demo protocol that shows a signal from the BVP (blood volume pulse) sensor. Select the button that says: **BVP and HR sensor demo.**



When you move the mouse over this button, you will see an explanatory text appear on the right side of the screen. Now click the button.

You will first see an introductory screen that displays the position of the BVP sensor on the fingers. Click on the **NEXT >>** button.

Next you will see an active BVP signal:



The BVP signal shows the relative (amplitude of the) blood volume, which varies for each pulse.

When the BVP amplitude increases the blood flow increases (vasodilation). When the BVP amplitude decreases, the blood flow decreases (vasoconstriction). The distance between the peaks indicates the heart-rate or heart beat frequency. The faster the heart rate, the closer together the peaks will be.

In this picture you can see how the peaks of the blood volume pulse are higher in the middle then in the beginning. This is an indication of vasodilation.

Keep pressing the **NEXT >>** button to see the next screens…

In this screen you see a combination of the BVP signal and the (derived) heart rate.

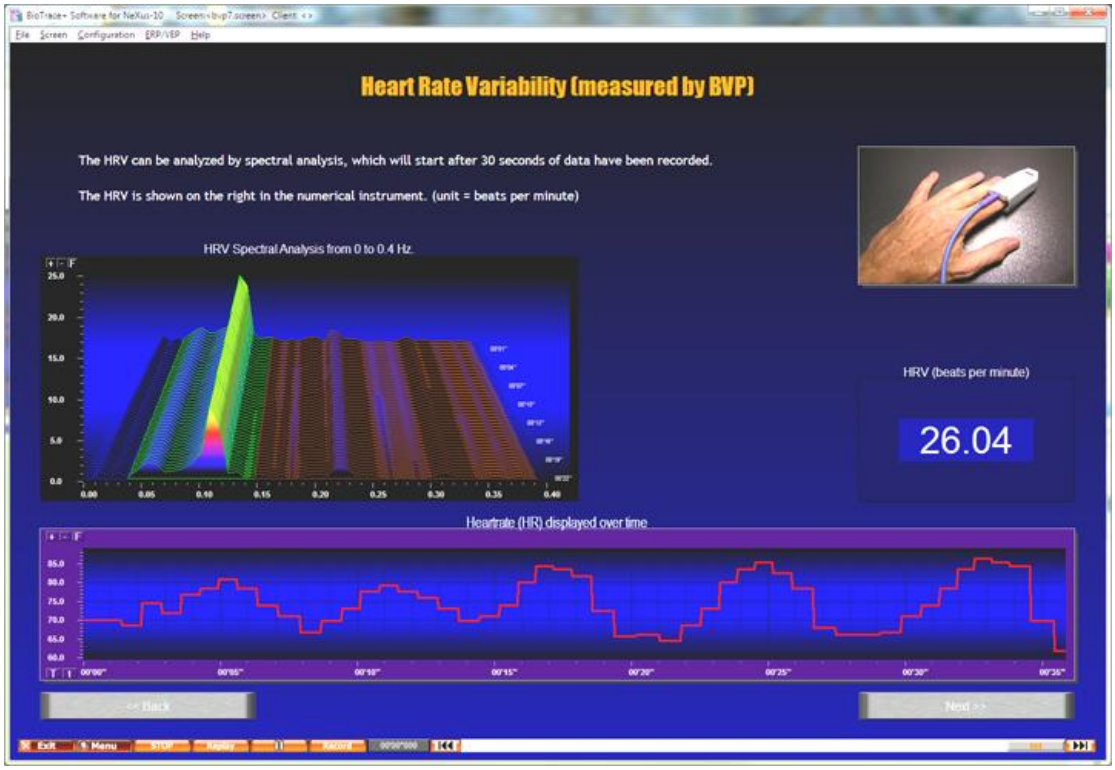
The heart rate is computed on a peak to peak basis, and updated every heart beat. So therefore the HR signal looks a little ‘blocky’. Notice that the time axis of the two line graphs is different.

You can also observe in this signal that the HR values vary significantly over time.

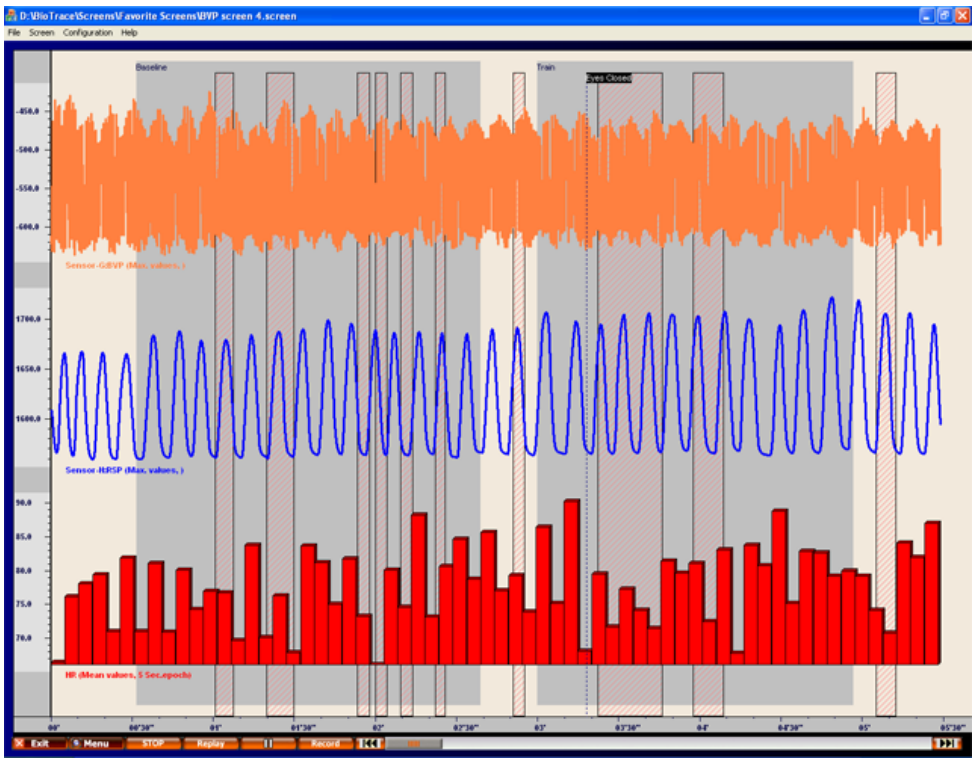
It shows a pattern where the HR increases and decreases over a period of about 10 seconds. In this case abdominal breathing causes it. The HR increases during inhalation and decreases during exhalation. This effect is called respiratory sinus arrhythmia (RSA), which is a representation of heart rate variability due to respiration over time. One of the functions of the BioTrace+ software is to analyze heart rate variability (HRV).

Keep pressing the **NEXT >>** button to see the next screens.

In this screen, you see the **heart rate** (HR) signal combined with a spectral analysis of the HRV (heart rate variability).



Now you can see what the relationship between the respiration and the heart rate is. In this case they are pretty synchronous. Now press the **Show Session Overview** button for the next screen:



The Session overview will show you the same signals (BVP, HR and RSP) but now **over the entire session**, which in this case is about 5 minutes. (You can also zoom in and out of this data)

In this particular overview, you can see how the heart rate varies between 70 and 90 beats per minute and how regular the abdominal breathing remains over the entire session. At the top of the screen you will see the BVP signal, but now compressed. Still it is possible to observe how the vasoconstriction and vasodilation alternate and synchronize with the breathing.

Now **press the TAB key on the keyboard** to switch back to the former screen.

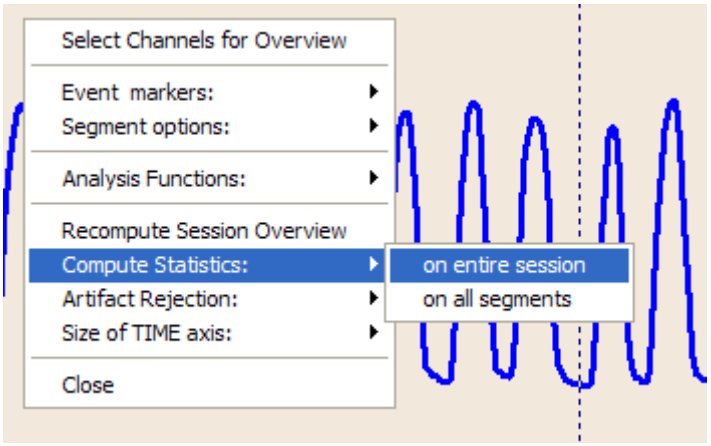
Note: Pressing the TAB key switches back and forth between the **real-time screen** and the **session overview screen.**

Press the TAB key a few times, so you get the feel for it.

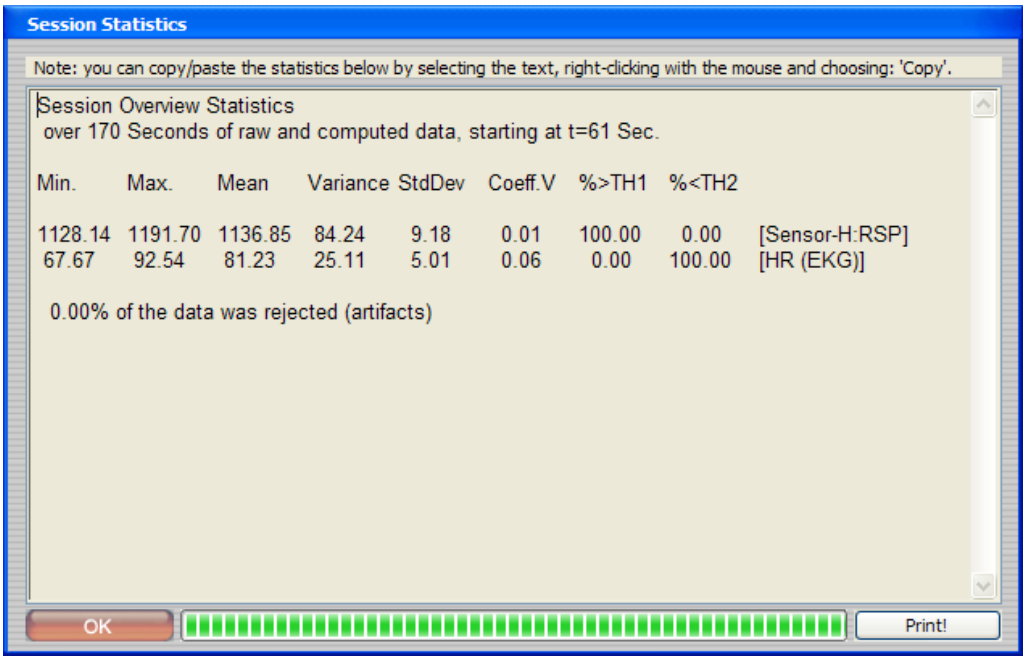
The **real time screen** is the place where you observe signals from the sensors in real time, which is at the time when they are being recorded and used for monitoring or biofeedback.

The **session overview screen** is where you observe the signals over the entire session (or the part that has been recorded so far). In Session overview mode you can compute statistics, see trends and define segments of data. We will go into more detail later on.

Let's compute a simple statistic from the session overview: **click the right mouse button** on the session overview screen, and a popup menu will appear. Then select: **Compute Statistics -> on entire session:**



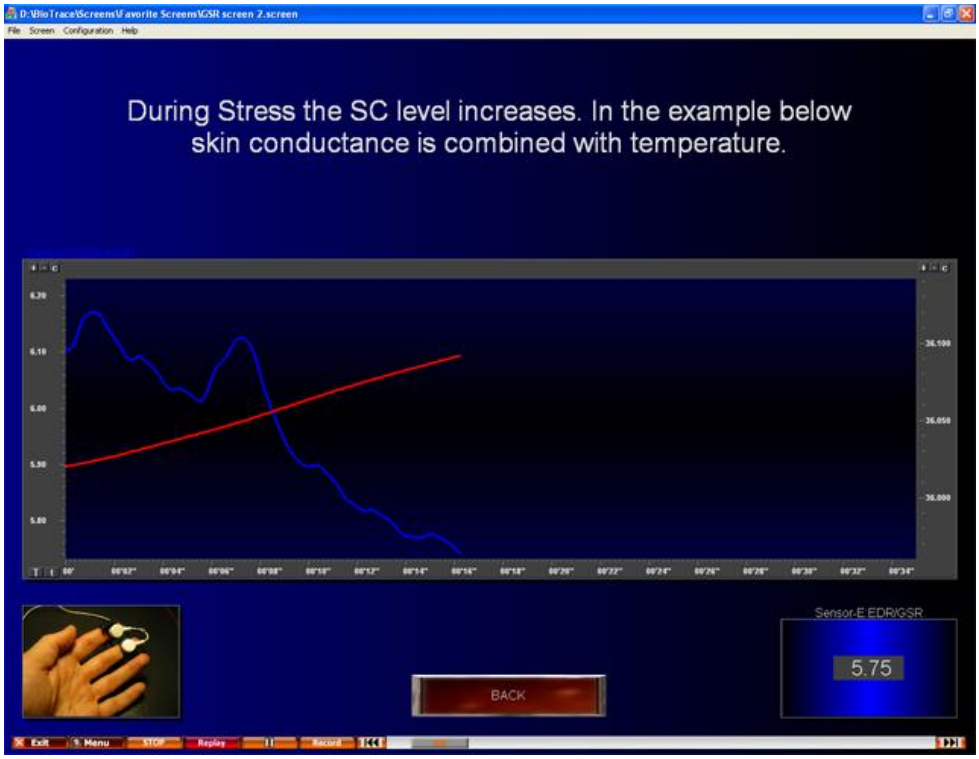
This will compute some basic statistics on the session which will show up in a dialog box:



There are many more functions that the session overview screen can perform as you will see later on in the manual. Let's now look at another demo protocol: press the **ESCAPE key** to return to the main menu. Then press **START** and then **DEMO protocols**.

2.5 SC/Temperature example

The 2nd example is a basic skin conductance demo, combined with temperature. After the first screen that explains the sensor, you will see the following screen:



Notice how the scales of the line graphs are automatically adjusting to the values they display. In this case you see a **dual line graph** instrument that can display two different signals, each with their own Y-scale.

This example displays a typical **relaxation response**: skin conductance decreases over time, while skin temperature increases.

2.6 Session control buttons

Now while the session is running (actually re-playing) press the smaller **PAUSE** button at the left bottom:

It will now appear **reddish** while the session will no longer replay but stop in its tracks.

Now, press the **pause** button again, or press the **replay** button, and the session will start replaying again.

Session control buttons: these buttons control the way the session is running

Now press the **STOP** button to stop the replay of this stored session.

The **Exit** button will exit the application. The **Menu** button will return to the main menu.

Let's do our first session recording; we will use the screen that is currently displayed.

2.7 Your first session recording

There are a few things to check before you start recording a session:

1) Make sure the NeXus has fresh batteries and is switched on
2) Make sure the sensors are plugged in

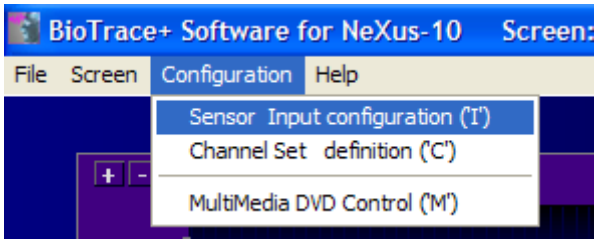
In this case we will use the **skin conductance** and/or **skin temperature** sensor. These are easy sensors to start with. For the NeXus-10 you plug the skin conductance sensor into **INPUT-E** and the temperature sensor into **INPUT-F.** For the NeXus-4 this will be **INPUT C+D.** Please will note that the connectors are marked with a red dot.

Input E&F on the NeXus-10 (mark I)

Input C&D on the NeXus-4

When you plug in the connectors, the red dots will be **UP**, as shown on the picture above. For this example it does not matter if you have both sensors, you could also plug in just one sensor. Put the SC and Temp. sensor on the non-dominant hand.

To find the information regarding which inputs are used by which sensors, you find this the menu bar (top left of the screen) under configuration as displayed in the picture below: (you can also press the '**I**' key on your keyboard)



This is an example of how you could attach the SC and Temp. sensors to your hand:

Notice that the SC (skin conductance) electrodes are placed on the inside of the fingertips and the temp. (skin temperature) sensor is placed underneath white tape. The tape ensures that the highly sensitive thermistor head is pressed onto the skin and that outside airflow is reduced to a minimum.

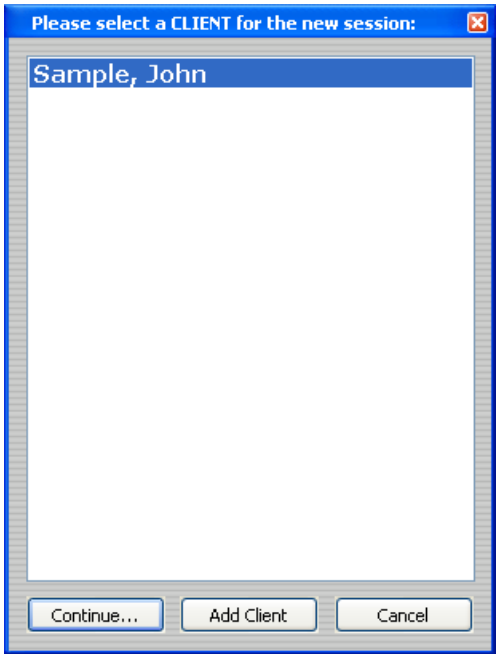
Please take into account that the skin temperature sensor needs about 1-2 minutes to adjust to the temperature of the hand.

Open the screen browser (press 'L' on the keyboard), select the **Basic Screens** category and double click on the '**Temperature and Skin Conductance' screen.**

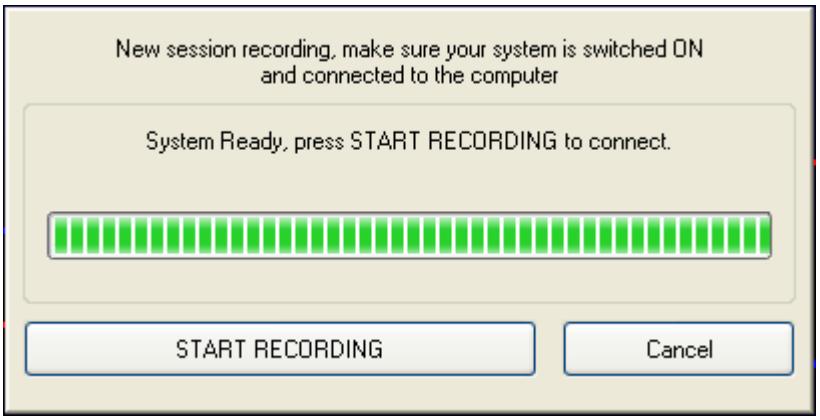
OK, let's start the session recording: press the **RECORD button** on the session controls, as follows:

This button will now turn red and a dialog box will appear on screen where the software asks you to select a **CLIENT**.

This is the dialog box that follows, where you select a **client.**



Let's keep things simple for now and use John Sample as our sample client. Click on the **Continue…** button and the next dialog box appears:



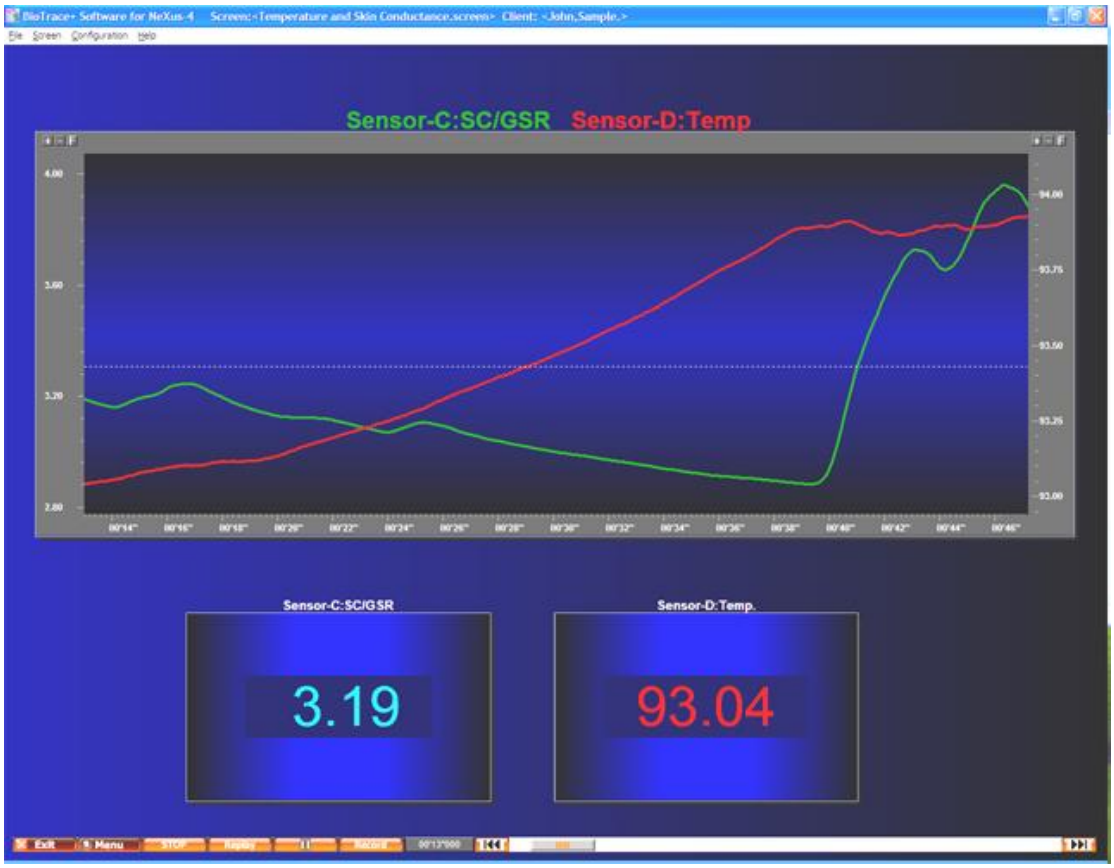
Now click in the **START RECORDING** button to start your first session!
(Make sure the NeXus is ON; the green LED should be lit)

The software will search for the NeXus for a few seconds and then start recording the new session. Depending on how relaxed you are you will probably see skin conductance values between 1 and 10 micro siemens and hand temperature levels between 30 and 36 degrees Celsius. (Roughly 80 to 97 degrees Fahrenheit)

Let the system run for a while and observe the signals. You will see that when you relax, your skin conductance will decrease and most likely your hand temperature will increase.

Note: NeXus has very high 24 bit ADC output on all sensors. For temperature this means you can detect changes that are smaller than 0.0001 degrees Celsius (1 / 10000th degree) and for skin conductance it means changes smaller than 0.001 micro siemens. In effect this enables you to see micro-physiological changes that older 12-14 bit equipment may not even detect anymore.

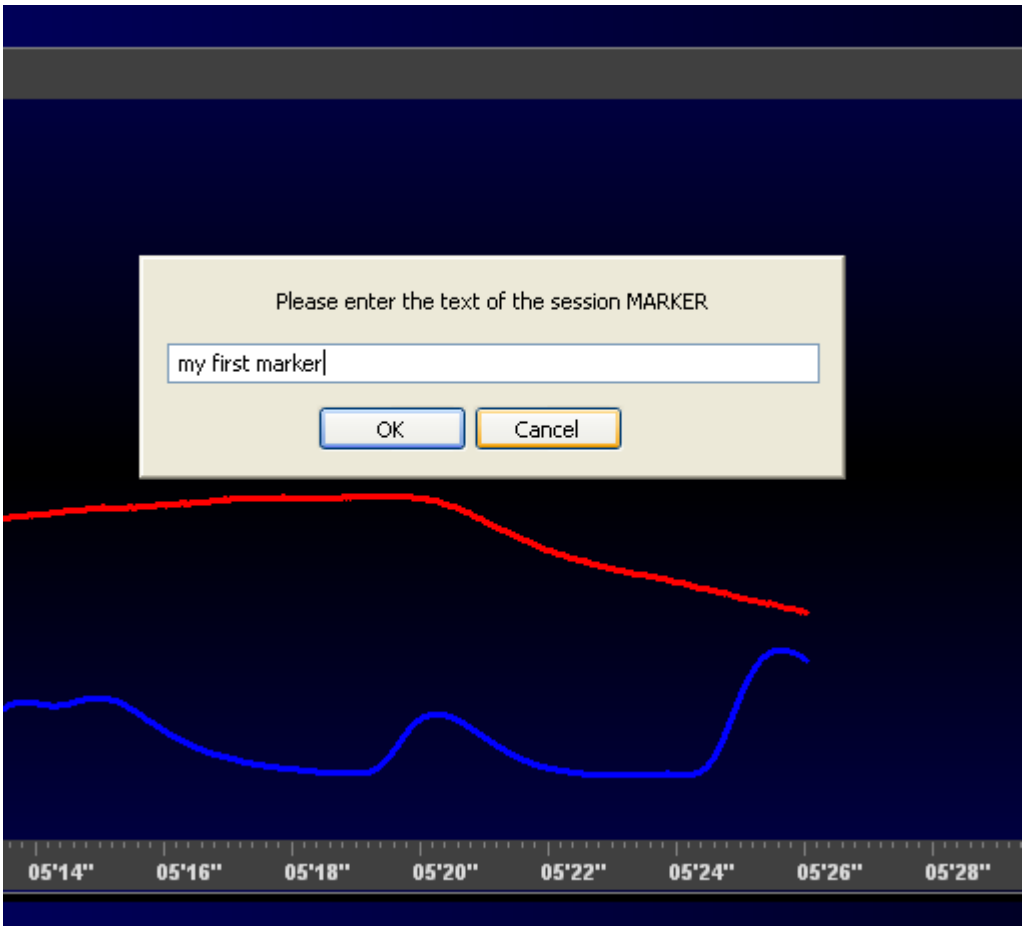
You should now see something like this on your screen:



Note: the example above is shown for signals from Input C+D on the NeXus-4.

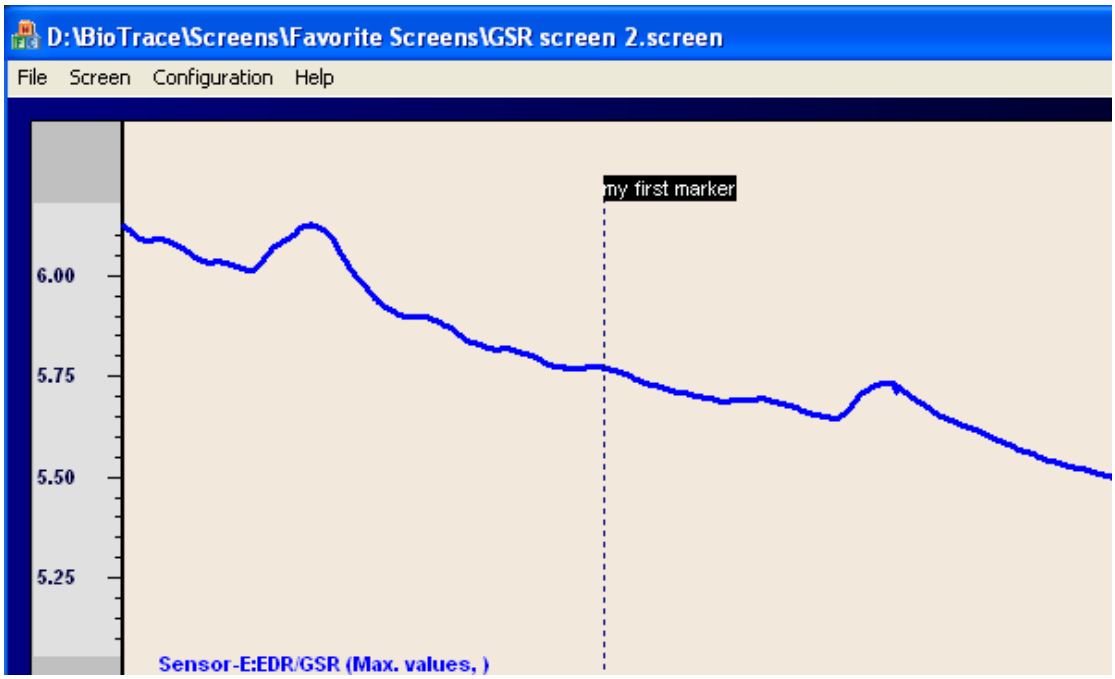
Let's add an **EVENT MARKER** while we are recording. Event markers are used to make notes during a session that you can read back and later view in the **session overview** screen.

You can simply do this by hitting the **RETURN** key and type in your text. This action will not interrupt the session recording.



When you want to see the marker, you simply press the **TAB** key to switch to the session overview.

An example is shown below:



So here you see it is very easy to place markers in real time during a session and view them in the session overview.

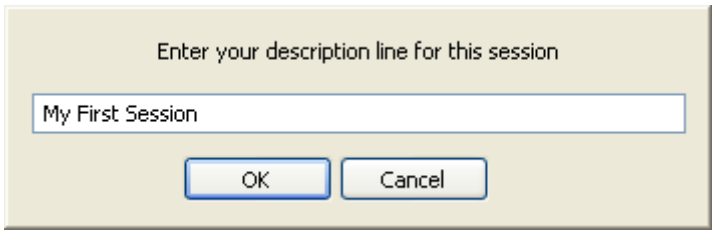
Next we will **STOP** and **SAVE** the session.

2.8 Saving a Session

Press the **STOP button** on the session control bar:

Now an alert box will appear that asks you if you want to **SAVE** the session that you have just recorded.

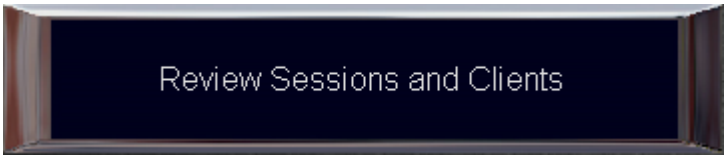
Click in the OK button and then enter a description of your session. The Continue button will continue the session. Choosing 'NO' will end the session without saving it.



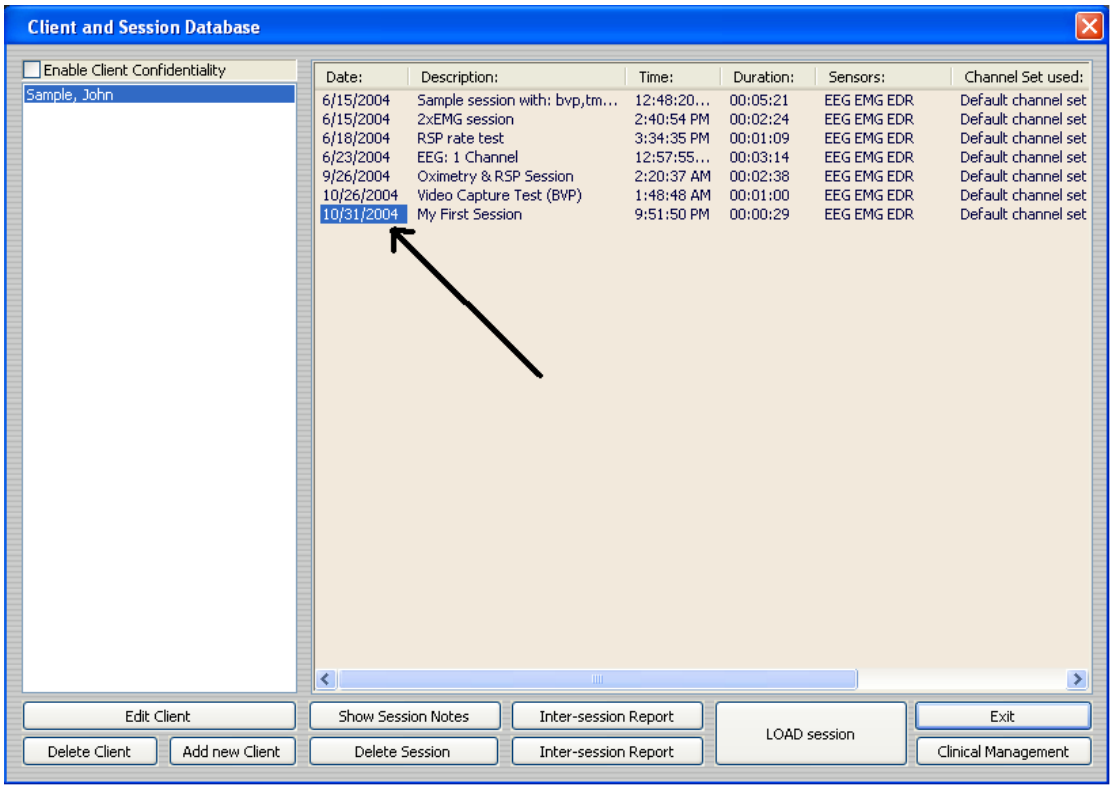
Then confirm with the **OK** button, the session is now saved.
You will need this session description later on to identify the session.

2.9 Loading a Session

When you want to retrieve a session for review, you can load the session via the main menu. Press the **ESCAPE** button to open the main menu, and then select the **Review Sessions and Clients** button:



You can also press the **'O'** key on our keyboard to get here. We will now load the session that we just recorded. Click on the button above and you will see the session selection dialog box. In case the screen selector comes up, just cancel that.



On the left side you see the list of **clients** that are stored in your database.
On the right side you see a list of **sessions** for each client that you select.

Let's load the session: by left clicking it with the mouse, select the first column labeled **Date:** Now **double click** this date to load it.

Another way of loading a session is by selecting the session (turns blue), then push the **Load Session** button and then press Exit.

After loading the session you can replay it or review it in the **session overview screen**.

2.10 Summary of what you have learnt

To summarize what you have learned so far:

1) You have learned how to install the BioTrace+ software.
2) You have learned how to connect the NeXus to the computer via the wireless Bluetooth link
3) You have learned how to operate the demo protocols and use the button controls
4) You have learned how to record a new session, review and store it.

Of course these are just the basics, but getting this far is a good start.

Now it is time for some theoretical background information on the **key concepts** that are used in the BioTrace+ software. These cover the essential building blocks of the software and are explained in the next chapter. Knowing these key concepts will enhance your understanding of the BioTrace+ software.

3.0 Key concepts in BioTrace+

This chapter will introduce the five **key concepts** that the BioTrace is based on. You need to understand these concepts if you want to use the more advanced features of BioTrace+ or want to create your own screens or channel sets. The key concepts are:

1) **Display Screens**
2) **Data Channels**
3) **Sessions**
4) **Clients**
5) **Biofeedback option & inhibit states**

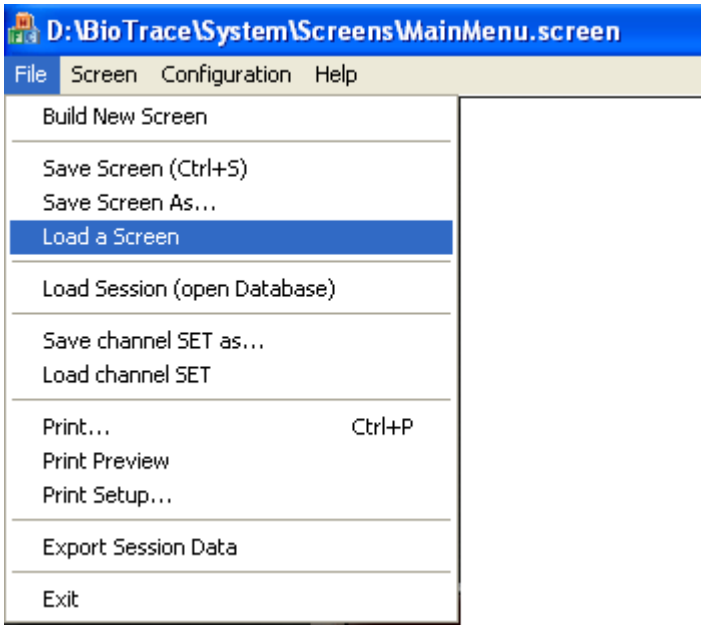
We will now describe these concepts to you.

3.1 Display Screens

The software displays the acquired physiological data in screens. Screens consist of display elements, or objects, that display a **signal** (such as a heartbeat, temperature and other signals), or they display **information** (text, images, video). Objects that display data are called (**virtual) instruments**; objects that display information are simply called **screen objects.**

You can build and edit these screens by switching to the **EDIT mode** and by dragging and dropping the diverse objects onto the screen. This fully featured editor is a WYSIWYG editor (what you see is what you get) and comes standard with the BioTrace+ software. Building or changing screens is about as easy as building a Microsoft PowerPoint ® business presentation.

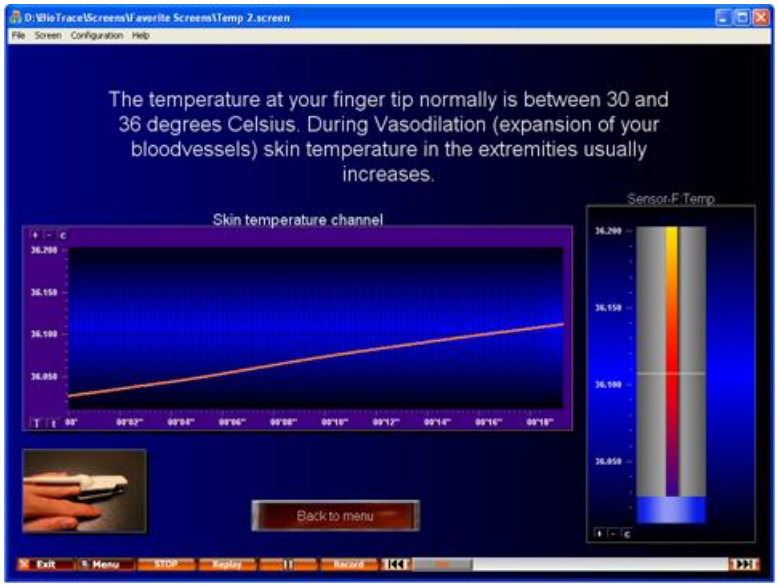
Let's **load a screen** and then enter the EDIT mode. You can load a screen via the main menu (button: Review Sessions and Clients), or do the same through the menu bar at the top of the screen.



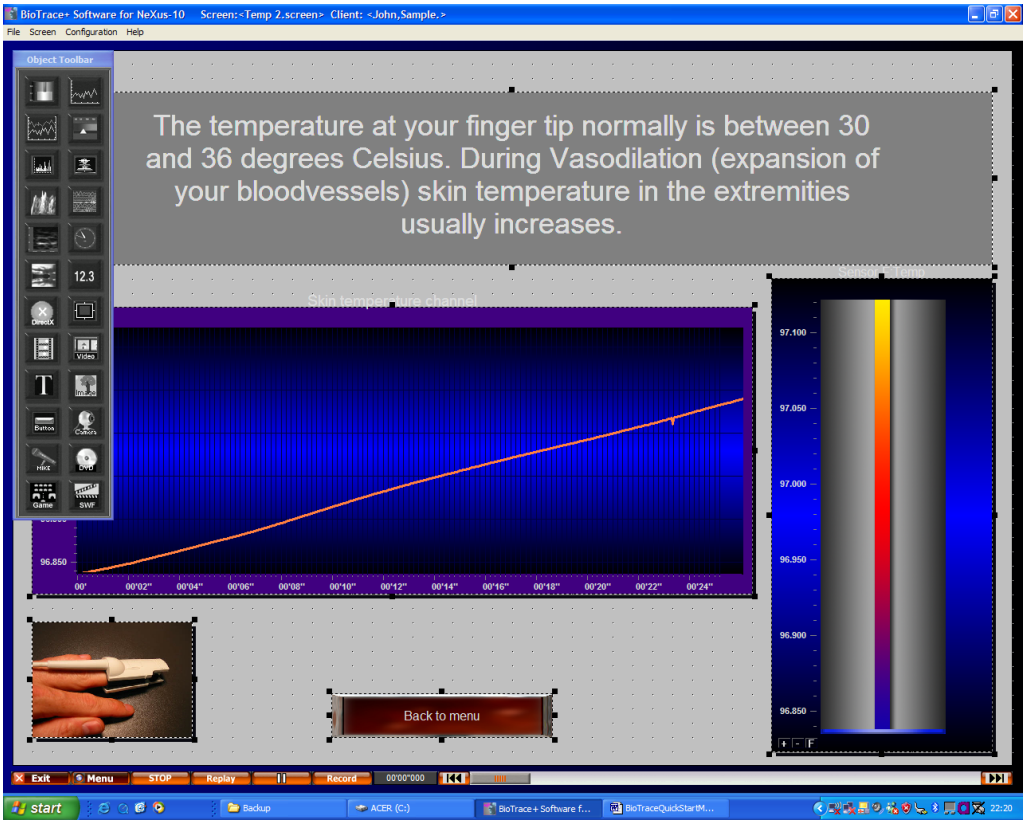
After you select this, the **screen browser** dialog box will be displayed:

TIP: another quick and easy way to **LOAD** a screen and open up the screen browser, is by pressing the **'L'** key on your keyboard.

1) Select the **Favorite Screen** category by clicking on it with the **left mouse.**
2) Then select the **Temp 2** screen (at the bottom) by double left clicking it. It will be loaded and displayed.



We will now switch to the **screen editor mode** by pressing the **'E' key** on the keyboard. The screen will now be displayed in the edit mode:

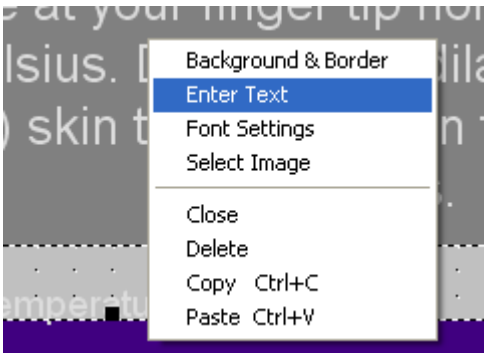


You will now see the **object toolbar** appear on the left side of the screen. You can drag this toolbar to other positions if you wish.

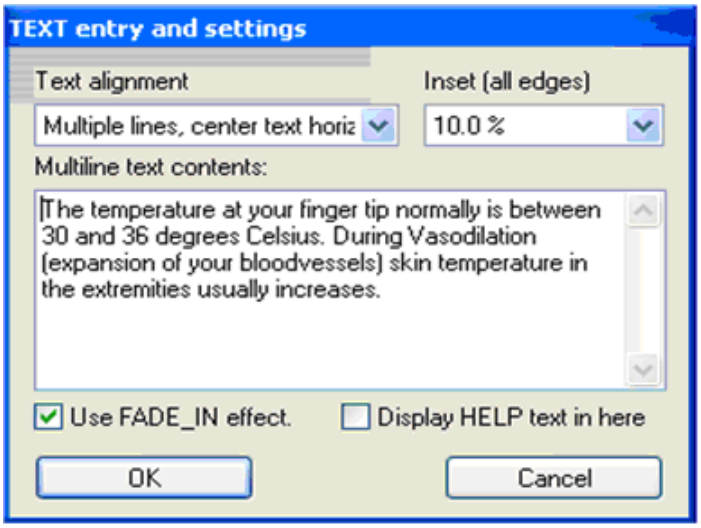
Also you will see that the different objects (a text object at the top, a line graph instrument below it, an image object at the left bottom, etc.) all appear with **selection handles** around them. You can position the object by left clicking the mouse on them and holding the mouse button down, then move the mouse. This is called dragging. You can add **virtual instruments** or **objects**, by clicking in the toolbar on an object and then clicking on the screen somewhere, where there is space. This will drop the object onto the screen leaving it to be sized to your preference.

Right clicking & property menus:

Another **major concept** within the BioTrace+ software is that the properties of most objects that you see can always be edited **by right-clicking them**. For instance **right click** the text object that you see at the top. A Property menu will drop down:

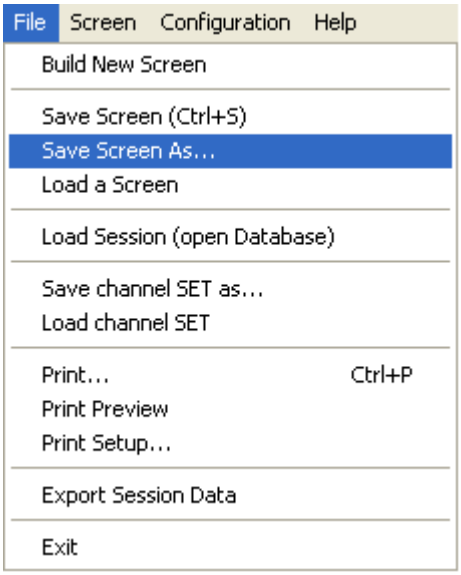


Select the **ENTER TEXT** option to change the text of this object:



You can change the text properties in this dialog box and confirm them by pressing the **OK** button. After that, press the **'E' key** to refresh and rebuild the screen.

This dialog box offers you several text alignment and text inset options, just like the ones that are used in DTP (desktop publishing) applications. Feel free to experiment with them. When you are done, we will **save the screen**. Go out of the edit mode and select the **Save Screen As…** option from the menu bar:



In the screen selector box, click the **Add New category** button and Type in your own category description, like **"My Own Screens".** Then click the **"Save (this screen)"** button and type in the name of the screen. After saving the screen, it will appear as a small thumbnail image in the list of screens.

Dual monitors: Primary and secondary screens

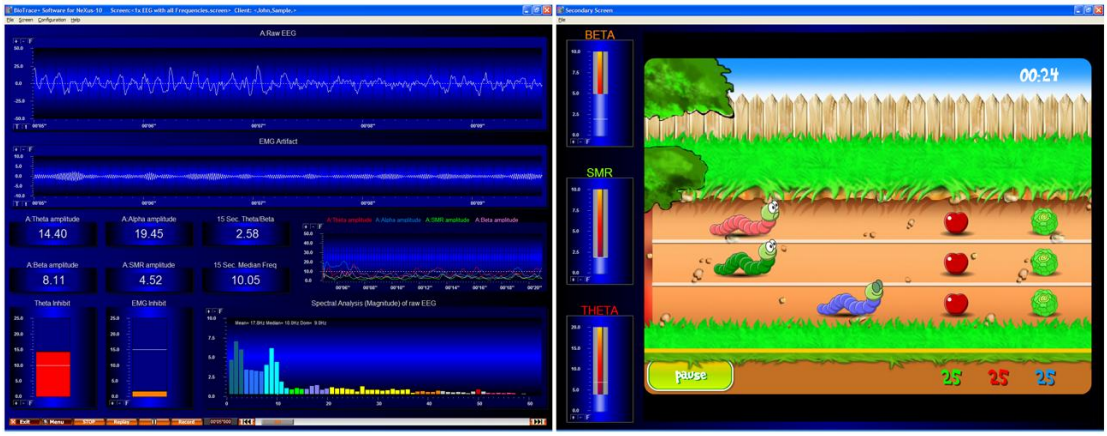
BioTrace+ has built-in true dual monitor support. This means that screens can be loaded individually on the primary or secondary monitor and function independently.

When you load a screen in the screen browser you can load them as 'primary' or 'secondary'. When loading through a short-cut function key, you can hold the '**Ctrl**' key down to display a screen inside the secondary monitor.

Note: you must connect a secondary monitor to your PC and enable the dual monitor support in Windows ™, before this will work. The last chapter in this manual describes how to do this.

An example of a dual screen configuration is shown below:

Primary Screen **Secondary Screen**



In this example the primary screen displays the EEG signals, statistics and a spectral analysis. The secondary screen displays a biofeedback driven game.

Generally the primary screen will be used as a master screen (clinician screen) and the secondary screen will be used for the client.

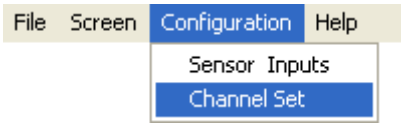
Note: BioTrace+ uses fast graphics, DVD and DirectX technology. In most cases Windows graphics and video take up more computer processing time when run on a secondary monitor. In other words, graphics and video run faster on the primary monitor. This is one of the reasons we advise the use of a graphics accelerator.

If this poses a problem and the graphics run slow on the secondary monitor, it is possible to swap the use of the primary and secondary monitor. You can drag your Windows 'Taskbar' to the secondary screen and decide to use the primary monitor (showing the primary screens) as a client screen.

3.2 Data Channels

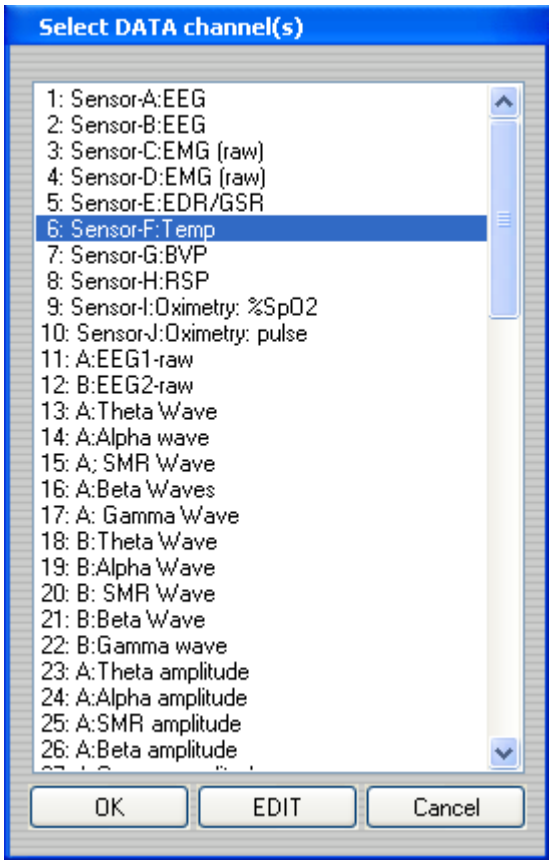
The physiological signals obtained from the sensors are stored in (virtual) **data channels**. The simplest data channel is one where a data channel is simply represents a sensor. In that case, the data channel does not compute anything but only stores and displays the sensor data.

When you look at the data channel list, you will see that the first 10 data channels (for the NeXus) are representing the sensors. You can display the channel set by selecting the following option:



Or by pressing the 'C' key on your keyboard.

The sample list of data channels below shows you the **default channel set**:



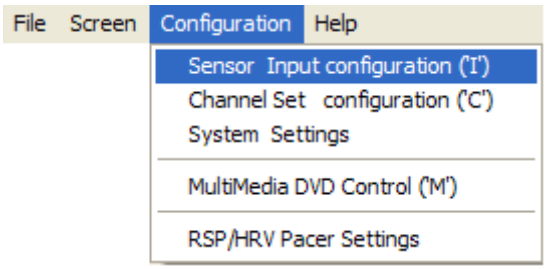
In case of the NeXus, data channels 11-80 are **computed data channels**. BioTrace+ computes these data channels on the fly. An example is channel 16 which computes the Beta Wave by applying a digital filter to the EEG data coming from input A.

So effectively BioTrace+ extends the amount of inputs (channels) that you can use for biofeedback or analysis to 80 channels. Once you get to know BioTrace+ better you can create your own data channels and channels sets.

Let's look at an example: The NeXus can record EEG from inputs A-D, but does so in a wide frequency range. In fact the signals on input A have a frequency range from 0 Hz (DC) to about 800 Hz. In most cases you only want to use a small portion of that range if you use the input for EEG. (For instance 2-45 Hz)

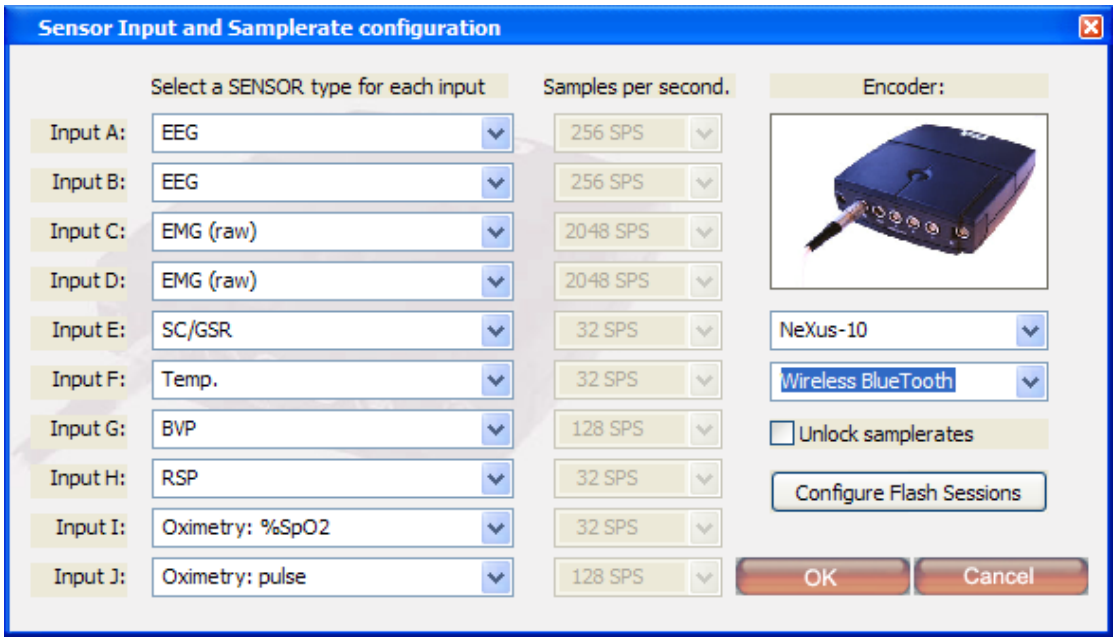
Sensor configuration

Let's begin by looking at the sensor input definition. Select this from the menu bar:



or press 'I" (for INPUTS) on your keyboard.

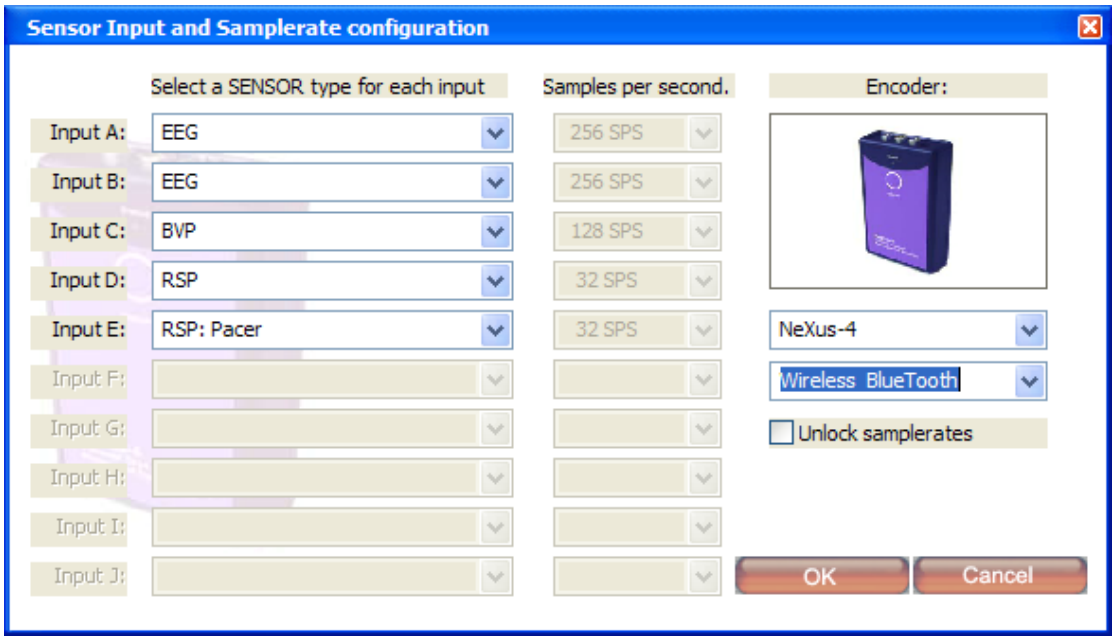
You will now see how the sensors have been allocated to the NeXus inputs. This is controlled completely by the software. The NeXus itself does not care which sensors you connect. The standard sensor configuration for the NeXus-10 is shown below:



We advise you to use this standard configuration for your standard applications and not change the sample rates of the default configuration. However, you can make your own channel sets with different configurations if you choose to do so.

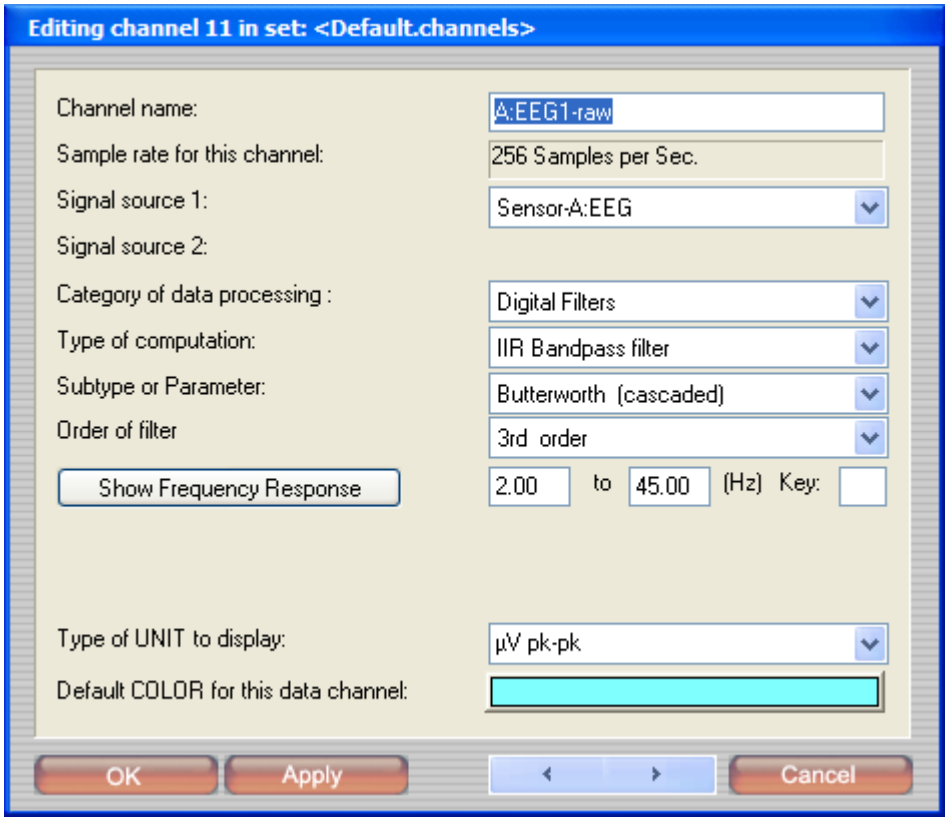
As you can see here, the EEG is sampled at 256 samples per seconds on input A and B. We only need to use the signal to be in the range from 2 to 45 Hertz, so let's see how this channel is defined:

The standard configuration for the NeXus-4 is shown below:



Please note that because the NeXus-4 has fewer inputs, there more channel sets are required for the different sensor combinations.

Below you see the definition of the EEG1 (input A) raw signal. It has been derived from the sensor input A: which has been passed through a 3rd order band pass filter between 2 and 45 Hertz.

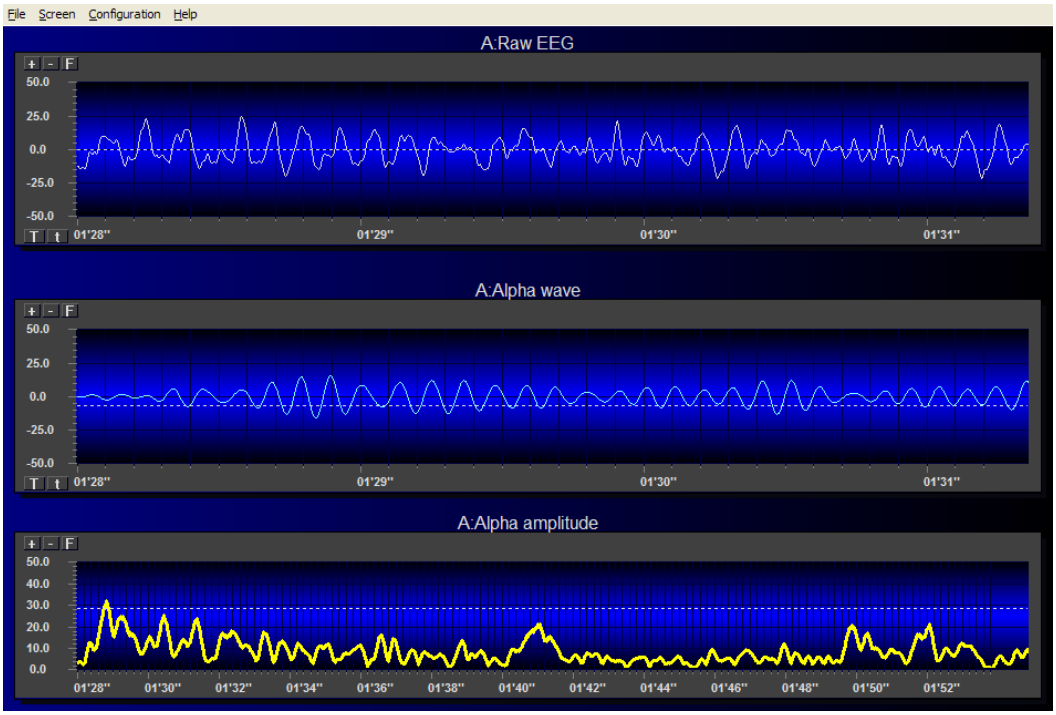


Note: these filters (and in fact all data processing functions) are implemented in software only; the NeXus hardware itself does need to process any data. The advantage of this is that you are free to configure your data processing at any time which offers flexibility that hardware fixed processing is never able to match.

EEG signals, such as Theta, Alpha and Beta waves are derived from the EEG sensor input in the same way. Those AC wave signals are also sampled at 256 samples per second and their filter settings are set according to their proper definitions.

Then using the filtered waves, the amplitudes of the EEG bands are derived. In this fashion the Theta Amplitude is derived from the Theta Wave. Theta Amplitude is computed 32 times per second and is always positive.

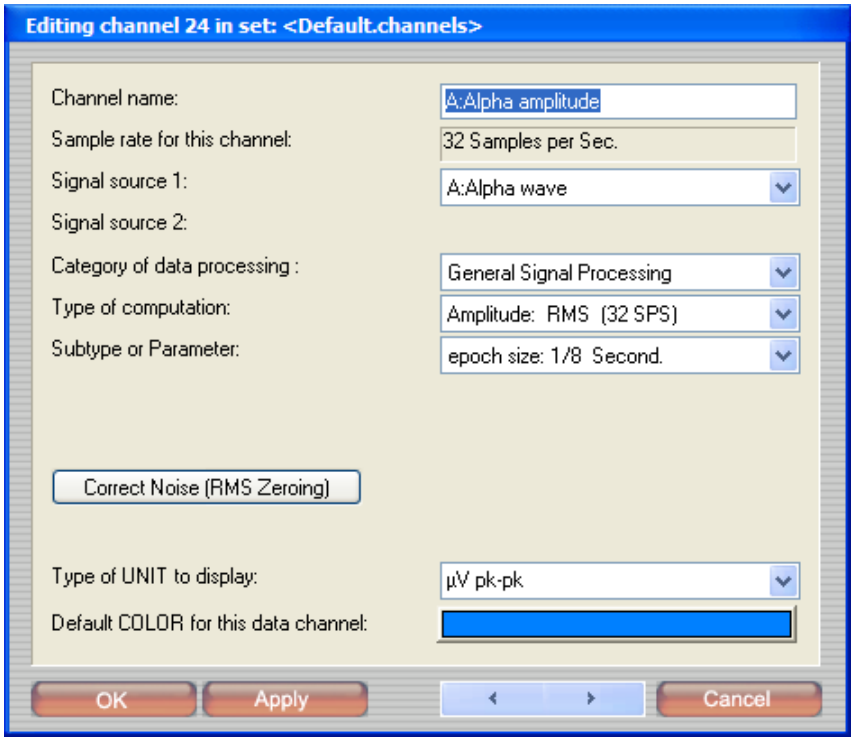
Use the Theta amplitude, another data channel can be computed, called the Alpha Theta Ratio by dividing the Alpha amplitude by the Theta Amplitude. And so on. You can see there are many possibilities. More of this is described in the advanced reference manual. In the screen on the next page, this principle is displayed visually.



At the top of the screen you see the raw EEG filtered in the AC from 2-45Hz (the original source is the DC-800Hz signal acquired from Sensor A)

The second line graph shows the Alpha **Wave**, which is the derived from the same Sensor A, but now filtered in the range from 8-12 Hz.

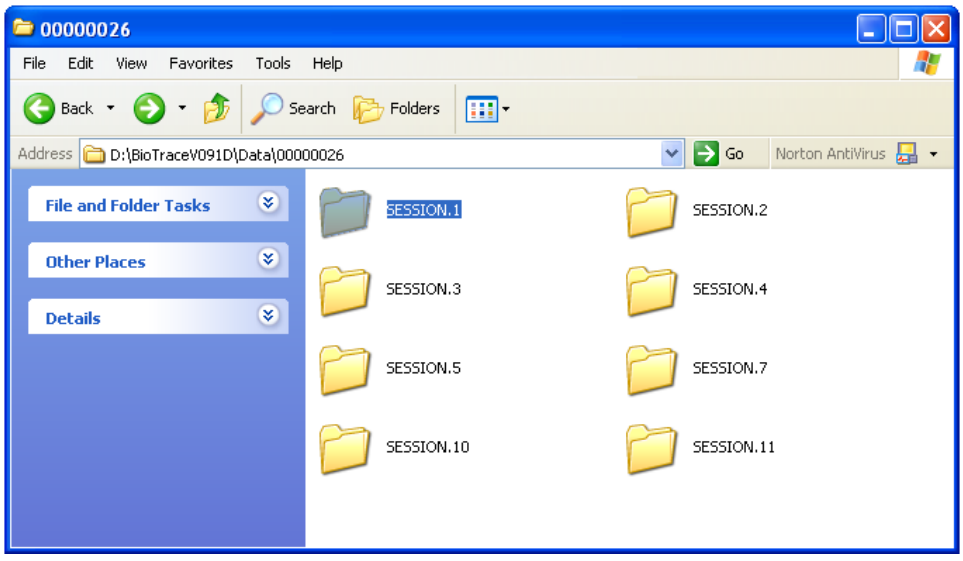
The third line graph shows the Alpha **Amplitude**. Please note the difference between the WAVE and the AMPLITUDE. The Amplitude is derived from the Alpha Wave, by computing an RMS value (the surface below the Alpha Wave) 32 times per second over a size of 1/8th of a second.



3.3 Sessions

When you record a session, the **raw sensor data** is stored and in addition to that, the event markers, segments, video files etc. The computed data channels are not stored, but always re-computed on the fly. The advantage of this, is not only that it saves disk space, but also that your data is not fixed. You can change a data channel (even while recording) and immediately observe how the signal changes accordingly.

In fact a **session** is the collection of stored sensor data, markers, segments and optionally video or audio capture files. The session files are stored in an individual subdirectory on your hard disk as (compressed) binary files, which only the BioTrace can read and write to. However in case you need direct access to the data in the sessions, it is possible to **export** session data to other software applications, for post processing. When you export data, it will be exported in an ASCII format.



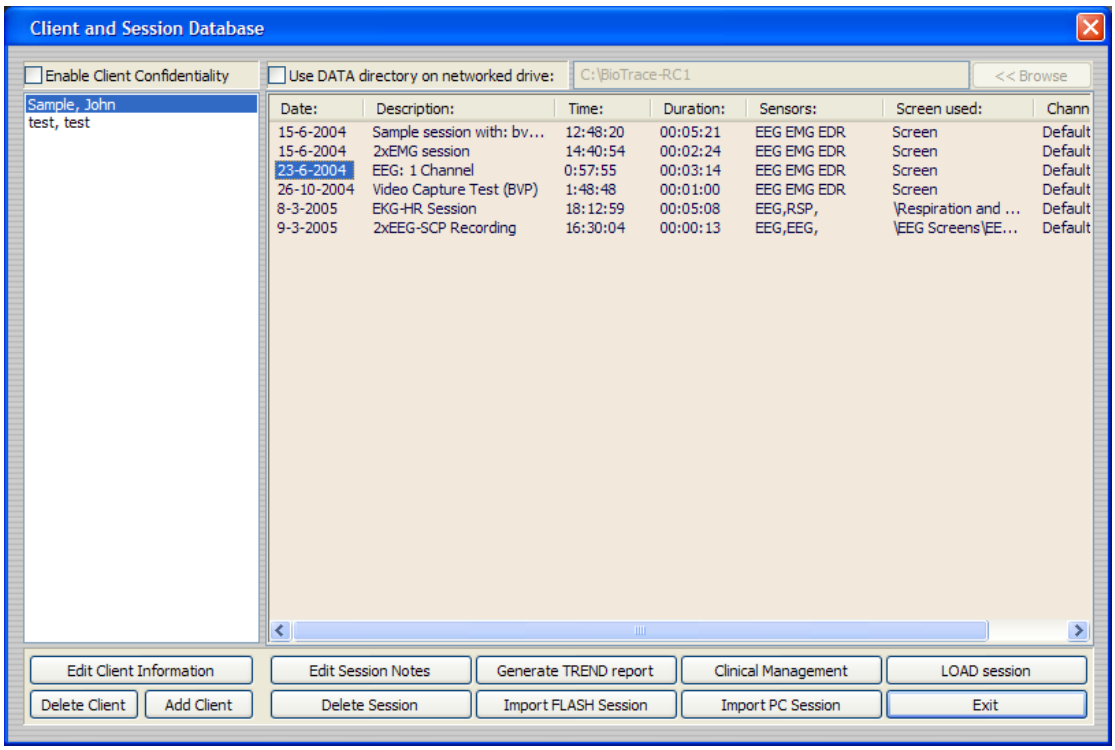
Note: you will only deal with sessions through the BioTrace software. But you may make backups of the files located in the \BioTrace\Data directory directly through the windows explorer.

Session backups: all client and session data is stored in the \BioTrace\Data subdirectory. In case you want to make manual backups, you can compress and store the DATA subdirectory on an external storage device, such as a DVD writer or network drive.

3.4 Clients

Sessions are always connected to a **client**. You cannot store a session unless you select a client. Before you record a new session you will always be asked to select a client first. You can select and load clients and sessions through the client database.

TIP: a quick and easy way to **OPEN** a client & session is by pressing the **'O'** key on your keyboard.



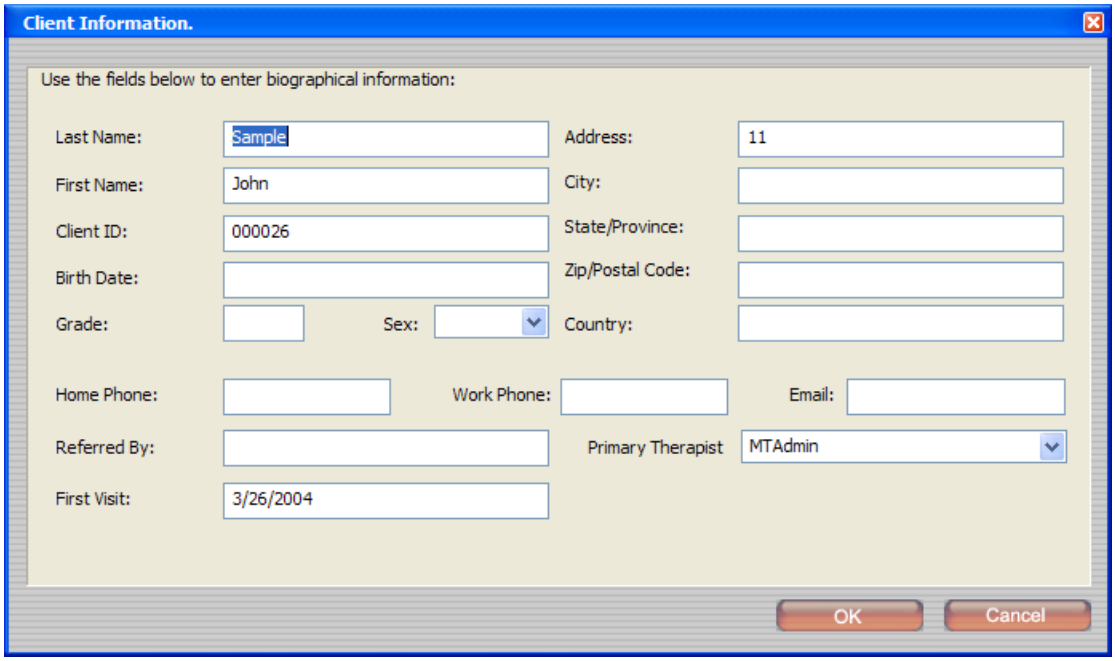
The client information is stored in the integrated database that you can access through the dialog box shown above. The Session data is stored in separate subfolders, contained in the main \BioTrace\Data directory.

When you record a new session you are always required to select a client for whom this session will be stored.

In case you add a new client to the database, the minimum information that you should supply is: the **first and last name** of the client.

In the picture below you see and example of the dialog box that is shown when you click the '**Edit Client Information'** button or '**Add Client**' button.

Client Properties



The two required fields that must be filled out are the **first** and **last name.** The computer will assign a default Client ID, but you may change that ID.

3.5 Biofeedback options & Inhibit functions

Most of the built-in Windows multi-media features for audio and visual feedback are available in the instruments and screens of BioTrace+.

Supported types of audio-visual feedback

The currently supported audio feedback features are:

1) MIDI tones and tone sequences
2) MIDI songs (*.mid format)
3) Digitized sound and music: MP3, WAV and WMA file formats.
4) Volume control on digitized sound
5) Audio CD feedback

The currently support visual feedback features are:

1) Animations (series of BMP and JPG images)
2) Flash Animations (Macromedia Flash ™ files *.SWF)
3) Video (AVI, WMV, MPG, MPEG, SWF and ASF file formats)
4) DVD
5) DirectX special effects
6) Biofeedback driven computer games
7) All the graphic instruments (bar graphs, etc.)

Positive and Negative Feedback & Inhibit states

When using feedback during a form of training or relaxation, you have to choose whether you will use positive feedback or negative feedback.

Positive feedback usually means that a person is rewarded when a 'desired' state or criterion has been reached. The reward can be an audio or visual signal, such as a musical sound or visual effect. Example: when a person's muscle tone (during relaxation) is lowered to a level below a certain threshold, a soft synthesizer sound is played.

Negative feedback means that a person is warned when an 'undesirable' state or criterion has been reached. An example: when the muscle tone (EMG) is too high, and has reached a level above a certain threshold, a high pitch bell sound is played.

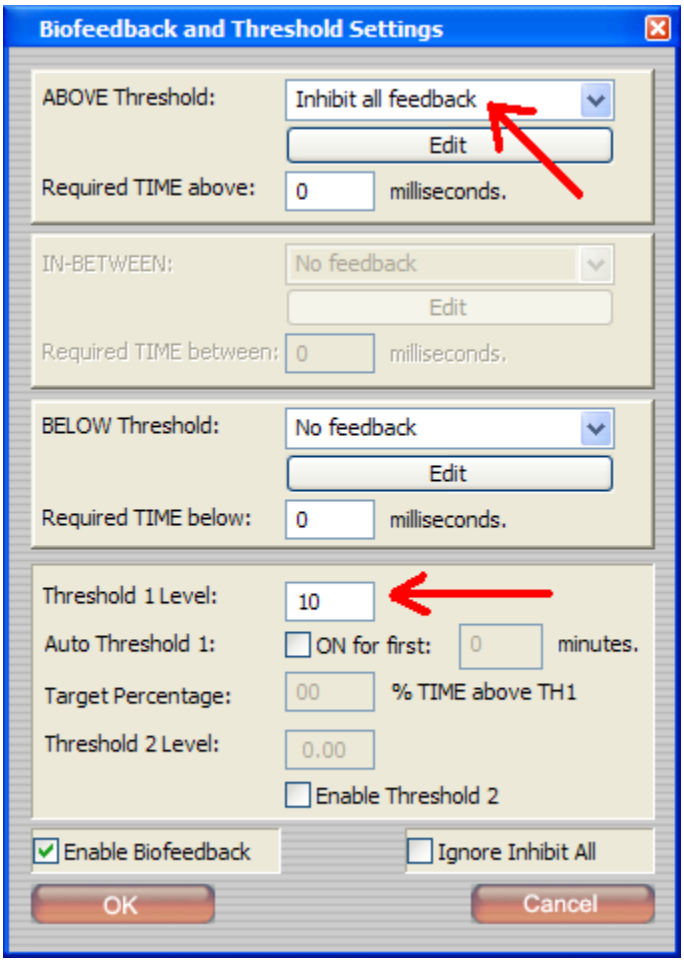
Another form of **negative feedback** is the **INHIBIT** which pauses feedback.

One or more instruments on the primary or secondary screen, can trigger an **inhibit state** when a certain level has been reached. (Too high or too low). The inhibit state is state that is set for the entire application, and effectively used to **turn things off.**

This means that when an **inhibit state** occurs, other feedback, whether it is audio (music or sounds that are playing) or visual (DVD, Video or animations) will be temporarily **paused!** No matter what screen is playing the feedback.

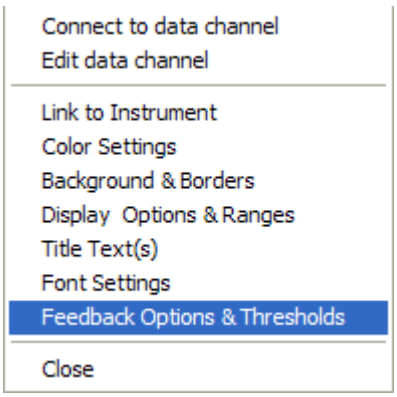
Example: an instrument on the primary screen, connected to EMG with a given threshold at 10 microvolts AND with a feedback setting that it should **inhibit all feedback** when above this threshold, will **turn off** (pause) one or more instruments on the primary & secondary screen that are currently playing sound or video.

An example of an instrument setting of **Inhibit above threshold** is shown below:



You can get here, by right-clicking on an instrument and choosing:

'Feedback Options & Thresholds' (see drop down menu below)



It is important to understand how inhibits work. Think of it as an application wide '**pausing'** event. Sounds turn off, video stops playing, until the inhibit goes away.

Note: **inhibit states** are application wide, meaning that a single instrument can turn one or more instruments which are playing audio-visual feedback, off. It does not matter which screen the instruments are on.

An instrument however can be set to '**Ignore Inhibit All**'. In that case this specific instrument's biofeedback will not be turned off by the inhibit state.

Tip: when the application wide **inhibit state** has been set, the background of the time display will temporary be shown in a darker color. (See example below)

Digital and Analog types of biofeedback

Another concept is the concept of digital feedback (threshold based) and analog (continuous feedback).

Digital feedback is always an **On-Off** situation where for instance a tone is played or switched off. The **inhibit** state is an example of this.

Example 1: when the Alpha level in the EEG gets above a threshold of for instance 20 microvolts, a soft musical sound is played, otherwise the sound is off.

Example 2: when the Theta level in the EEG gets above a certain threshold (for instance 10 microvolts) a biofeedback driven computer game 'pauses' and the music in the background stops playing. When below threshold the game continues.

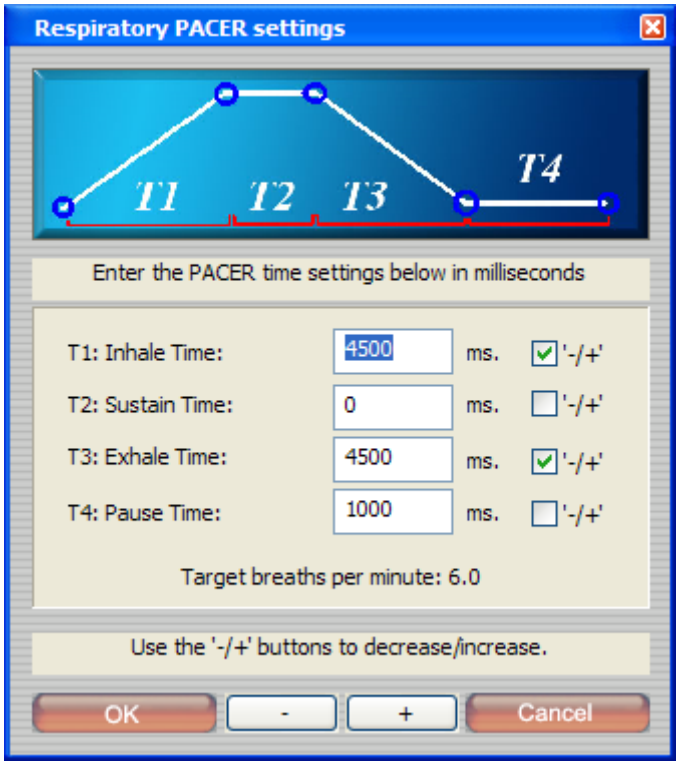
Analog feedback is a type of feedback where the level of a physiological signal is translated into a continuous feedback.

Example 3: the pitch of a tone sequence is used to reflect the level of the EMG activity. When the EMG level increases, the tone sequence plays upwards, when decreasing, the tone sequence plays downwards.

Example 4: a Flower animation is played in two directions (forwards and backwards) to indicate the level of Skin Conductance. When the SC level decreases, the flower opens up, when the SC level increases, the flower closes.

3.6 The Respiration / HRV Pacer

The BioTrace+ software contains a built-in '**PACER**' that can be used for 'pacing' or training signals using a template wave-form. It's most common use is for pacing the respiration. By trying to follow the pacer signal, a user can for instance learn to breathe slower or breathe in a certain 'rhythm'. But it could be used to train other signals, like EMG, as well.



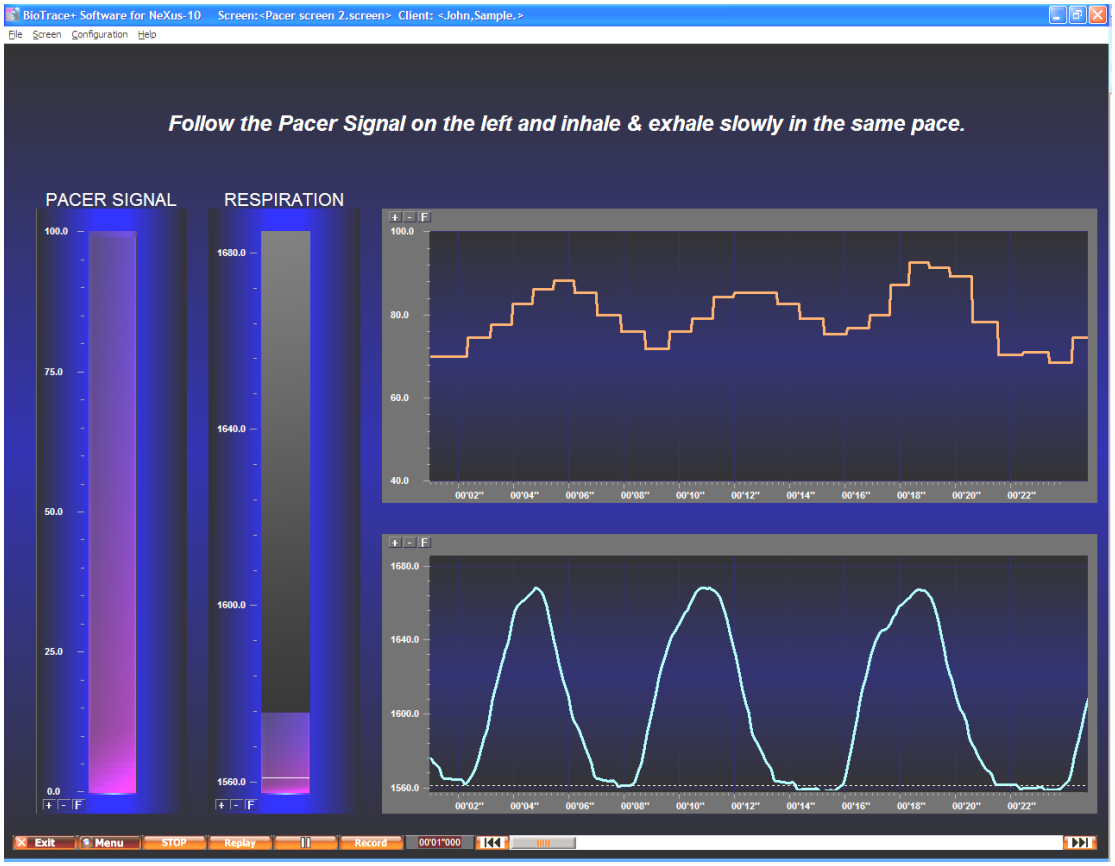
Pacer parameters:

In the pacer dialog box you can set the following parameters:

1) T1: The time it takes to go from baseline (0) to the maximum (inhalation). You enter this time in milliseconds
2) T2: the time the signal will be sustained (hold) at maximum.
3) T3: the time the signal will drop from maximum to baseline. (minimum)
4) T4: The 'pause time' in between this and the next cycle.

During a session recording you can press the '+' and '-' key in order to speed up or slow down the pacer. Else you can use this dialog box, to change the parameters, while the session is running.

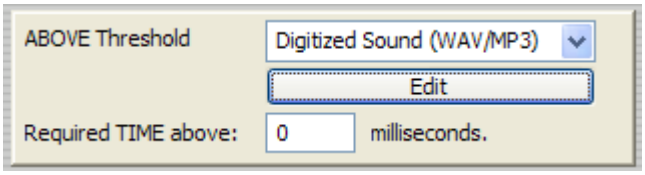
An example of a ‘Pacer’ screen is shown below. The bargraph at the left displays the pacer signal, whereas the second bargraph shows the actual respiration signal.



Please note: the pacer actually behaves like a ‘virtual sensor’ signal. This pacer signal is displayed and stored in the session files as if it were a data channel. The advantage is that you can review/replay the pacer signal, along with the respiration and heart rate or other signals and observe the measure of correlation between those signals.

Another advantage is that you can connect the pacer signal (usually found at sensor J, channel 10) to an instrument and use the biofeedback options in order to generate volume controlled digitized sound feedback.

Example: for instance you could use an MP3/WMA sound file of music or nature sounds, and control the volume of that sound by the pacer signal. The sound volume would go down when you are supposed to breathe out, and go up when you are supposed to breathe in. By setting the **inverse proportional** option in the volume feedback settings you can change that to the other way around. You find those options under the **Digitized Sound (WAV/MP3)** Feedback options of an instrument like the bargraph. (right-click the bargraph to get there)



4.0 The user Interface: main functions

We will now describe the main functions of the USER INTERFACE.
There are two ways to operate BioTrace+. The first way is by using the mouse and selecting options from the main menu bar or from drop down menus that appear when you 'right-click' with the mouse. The second way is by using keyboard shortcuts.

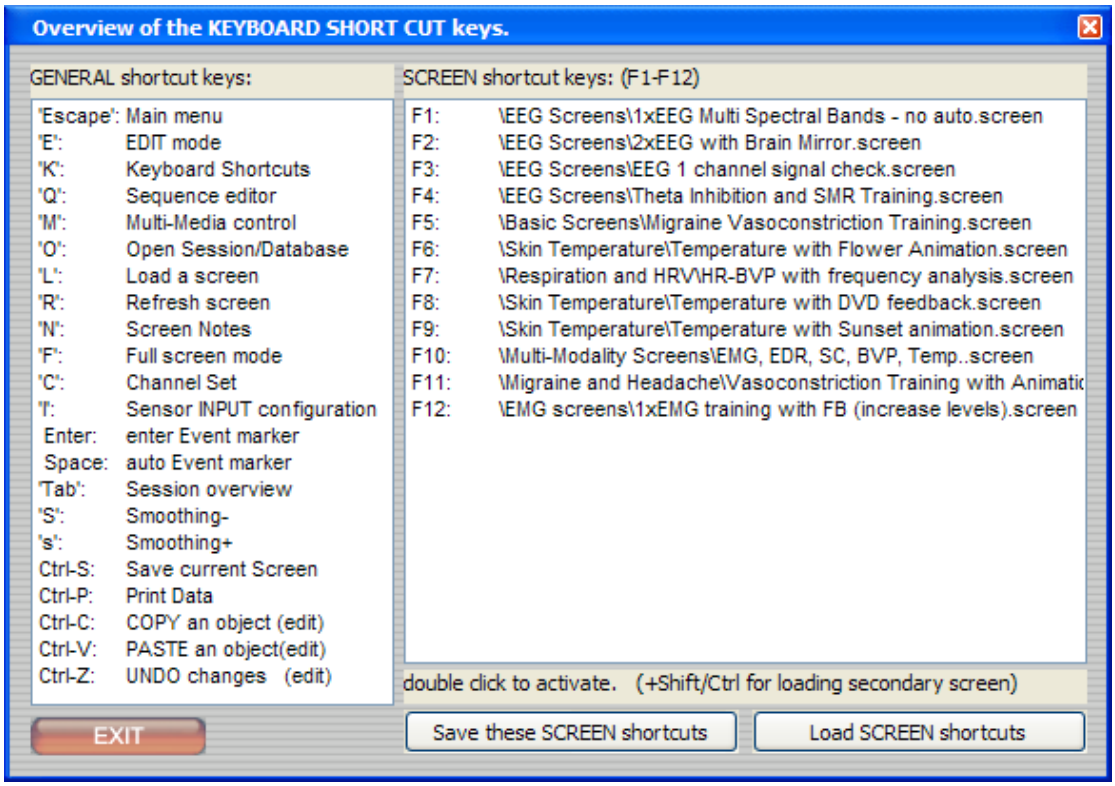
Keyboard shortcuts are a quick way to access most of the main functions, such as for example loading a screen ('L') or opening a session ('O'). We will now present an overview of these functions.

4.1 Shortcut keys and on the fly screen-switching

In order to see a list of the available keyboard shortcuts, you can use a single key:

Press the 'K" key on your keyboard to see a quick list and overview of all the available keyboard shortcuts!

You will see the following dialog box:



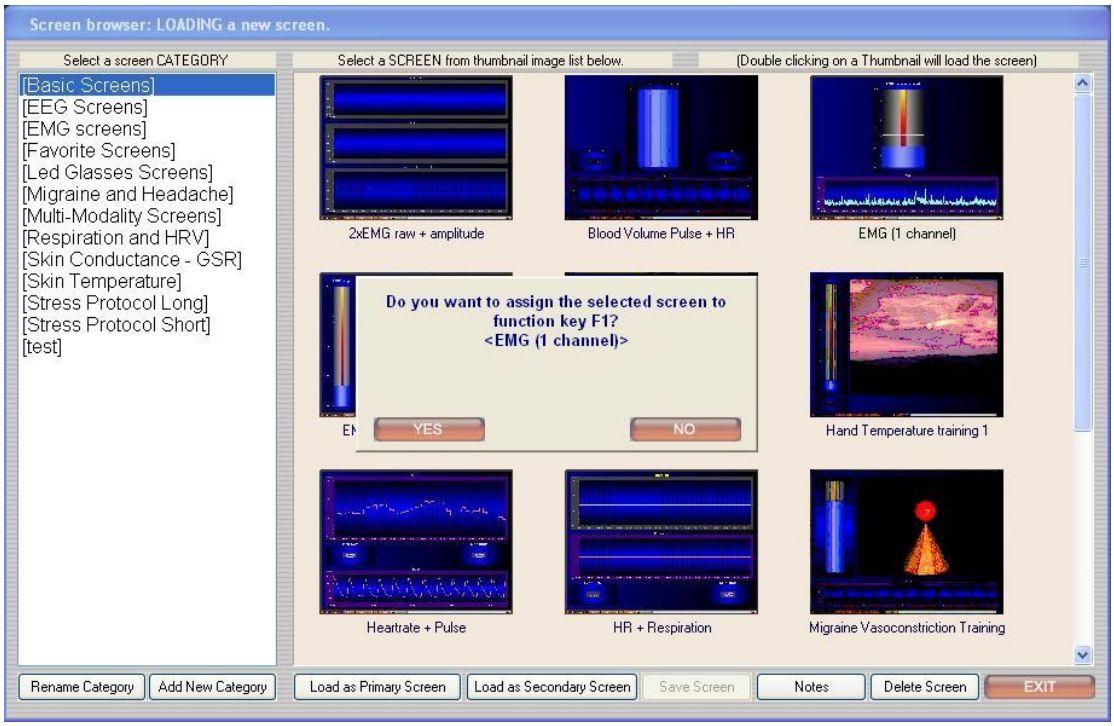
So the **'K'** key is the only short-cut key that you really have to remember, because through this key, you can get to all other keys. Now that you know these keys you can try them out. Close this dialog box by pressing Exit or by hitting the **Escape** key and press the **'L'** key. You will see that it will enable you to **L**oad a screen. Press **'O'** and you will see it will **O**pen the client and session database.

You can also activate these shortcuts by double clicking on the description line in the lists.

On the fly switching between screens

A special case of the short cut keys, are the **function keys.** These are labeled F1-F12 on your keyboard and can be used to instantly load a screen into the primary or secondary monitor (hold the **control** key to display on the secondary monitor)

Function key shortcuts are a quick and easy way to load a screen.
Open the screen browser and click once on a screen preview, in order to select it. Then press a function key (F1-F12) on your keyboard to assign that key to the screen you just selected. That will create the link.



An **alert box** will ask you if you want to **assign** the screen you just selected to the **function key** you pressed. Confirm it with YES. Then press **escape** to close the screen browser dialog box.

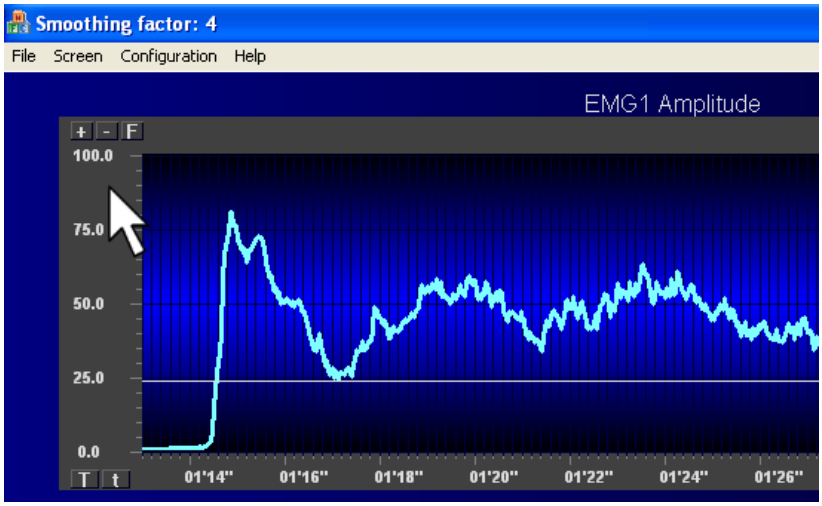
Now press the **F1** key (or the function key you selected) and your screen should appear instantly. Try pressing the other function keys, and you will see that BioTrace rapidly switches between those screens. If you forget what shortcut function keys you defined, simply press the '**K** ' key again and you will see the list on the right side.

Through the same short cut dialog box, you can use the **SAVE** and **LOAD** buttons to create multiple sets of screen shortcuts.

Quick overview of the keyboard short cuts

Escape key:	Will switch to the main menu. Pressing Escape again will return to the currently loaded screen. You can not use this function while you are recording a session.
'E' key:	Will switch to the WYSIWYG screen **Editor**. You can use this key at any time. Press it again to return to the normal mode.
'K' key:	Will show a list of all keyboard short cuts. Double click on a shortcut item, to active it. Double clicking a **function** key will load the screen. Hold **Ctrl** to load as secondary.
'Q' key:	This will open the **seQuence editor.** This is where you define a list of screens. These screens will be shown one after the other, with predefined durations, like a slide show.
'M' key:	The **Multi-media** control allows you to change multimedia content, like a video or DVD, on the fly.
'O' key:	**Opens** the client session database, where you can review client data and stored session data.
'L' key:	**Loads** a screen through the screen browser. Pick a category and select a primary or secondary screen (+**Ctrl)** by double clicking.
'R' key:	**Refreshes** the screen, in case anything needs to be redrawn.
'N' key:	Shows the screen NOTES.
'F' key:	Switches to and from **Full** screen mode. Press twice to switch back and forth.
'C' key:	Shows you the current **Channel** set.
'I' key:	Brings up the **Input** configuration box with an overview of the sensors and sample rates.
Enter key:	**Enters** an event marker. The marker is placed at the time you hit enter, and then opens up a box where you can type in the text. The event marker will show up in the session overview screen.
Space bar:	Places an automatic marker (labeled with a number). The will show up in the session overview screen, but not ask for text while you are placing it.
Tab key:	The will **Tab** (back and forth) to the session overview screen.
'S' key:	This key will set the **Smoothing** factor on the fly, of the instrument the mouse is currently over. Replay a session with

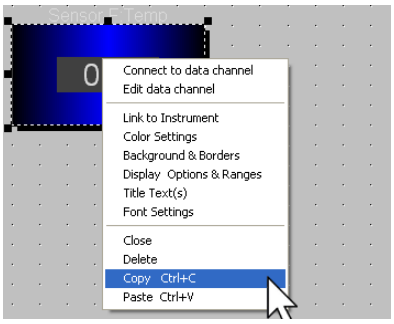
line graph data, for instance showing EMG amplitude. Move the mouse over the instrument graph and press ‘S’ with and without **shift** several times. You will see the graph becoming smoother (‘s’) and rougher (‘S’) as you press those keys. The mouse (arrow) can be placed anywhere over the instrument. In the top left of the window, the smoothing factor will be shown. (In the picture below the smoothing factor is 4)



Ctrl-S: **Save** the current screen.

Ctrl-P or ‘P’: **Print** the current session overview, statistics or analysis data.

Ctrl-C: **Copy** an object, when editing a screen. To copy an object, move the mouse cursor over the instrument/object and press Control and ‘C’. You can also right click the object and select this option from the drop down menu.



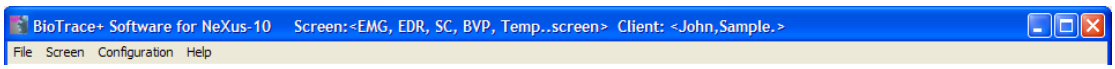
Ctrl-V: **Paste** the object. (Screen editor)

Ctrl-Z: **Undo** changes (up to the last 5 changes) in the screen editor.

Ctrl-Key When you move a threshold (left-click and drag the mouse) in an instrument while **HOLDING** the **ctrl.** key, all thresholds of other instruments using the same data channel will be updated. Example: this way you can change/set all thresholds connected to EMG1, in all instruments, to the same level.

4.2 The BioTrace+ Menu Bar: Function Overview

Apart from using the keyboard and shortcuts, you will otherwise use the mouse and the standard Windows ™ controls to operate the software. In this manual we assume that you know how to operate the mouse and the standard Windows™ user interface, so we will not describe its basic features such as minimizing/maximizing a window or starting and closing applications. You will find the main menu bar of BioTrace+ on top of the primary screen. The blue bar above it is used to display the title or name of the screen you are editing.



The 4 items listed here are: **File, Screen, Configuration** and **Help.**
Now follows an overview of the menu bar and the functions you can select here:

The File menu items

Build New Screen — This will close the current screen and switch to the screen editor, where you can create a new screen
You can also press the **'N'** key to activate this option.

Save Screen — This will save the current screen under the current name. It will remind you if you want to overwrite an existing screen.

Save Screen as… — This will open the **screen browser** so you can save the current screen under a **new name**. Select the category where you want to save the screen into and then click the **Save Screen** button.

Load a Screen — This will open the **screen browser** so you can **Load** a new screen. You can also press the **'L'** key to activate this option.

Open Session Database — This opens the **Client** and **Session** database. Use this to **load a session. You can also press the** 'O' **key to activate this option.**

Save channel SET as... — Here you **save** the current channel set, after you have made changes to it, or after you have created a new channel set. A channel set contains all the definitions of the sensor inputs and data processing functions.

Load channel SET — Use this function to **load** a previously saved channel set. The software will ask you if you want to attach this channel set to the current screen. If you confirm with yes, the screen will always load the channel set you just selected to that screen.

Print — This option will print the current session overview and statistics.

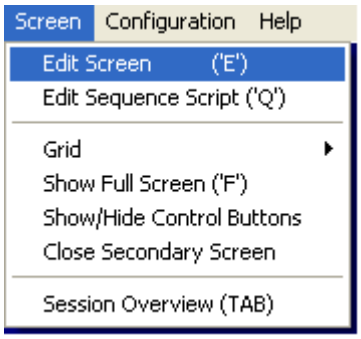
Print Preview — Same as above, but now with a preview.

Print Setup — Define your printer setup in here. You can change options such as size and orientation (portrait of landscape) through this function.

Export Session Data — Through this function you can export your session data or parts of it, to an ASCII file that can be read and imported by Microsoft Excel ®, SPSS or MatLab ®.

Exit — This will exit the BioTrace+ application.

The Screen menu items



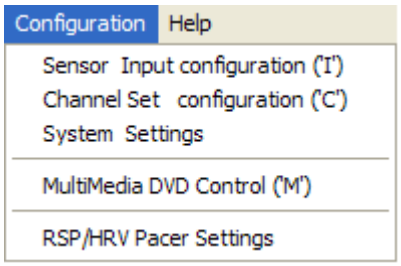
Edit Screen — This will switch to the **screen editor**, where you can change the current screen, move and size instruments and objects, or create new objects. You can also press the **'E'** key to activate this option.

Edit Sequence Script — Opens the **sequence editor**. Here you define a list of screens that are played one after the other, like a slide show. The sequence is stored in a **script** file that can be loaded and started through a **button** object.

Grid	Set the size of the **grid** in the screen editor mode. You can choose **off, medium or fine.** The grid is used to align instruments and object.
Show Full Screen	Selecting this item will get rid of most of the Windows ™ background and desktop options. Sometimes these options are distracting while you are recording a session and you do not want to see them. Selecting it once more will switch back to a 'Windowed' screen.
Show/Hide control buttons	At the bottom of the BioTrace+ screen you will often see the **session control** buttons. These are used to start, stop and pause sessions. You can activate or de-activate these control buttons in here.

Close Secondary Screen	Does what it says. You cannot always see the secondary monitor from where you work, so through this function you can close it.
Session Overview	Switches between the **real-time screen** and the **session overview** screen. The real-time screen shows the actual current data (up to 30-60 seconds), video, images and generates the visual and auditory feedback. The session overview screen shows the entire session, markers and segments. The Session overview can be shown during recording, but will only show the data up to the point where it has been recorded. In the session overview screen you compute statistics and observe changes and trends in your data.

The Configuration menu items

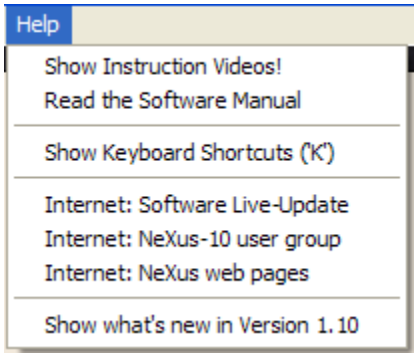


Sensor Input Config.	Brings up the sensor and sample rate configuration box. You can also press the **'I'** key to activate this option.
Channel Set Configuration	Choose this or press '**C**' to view and edit the channels.
System Settings	Choose this menu to view and edit system settings.

MultiMedia DVD Control In case you want to change the DVD chapter or tile that is currently playing, you can do so here. You can also press the '**M**' key to activate this option.

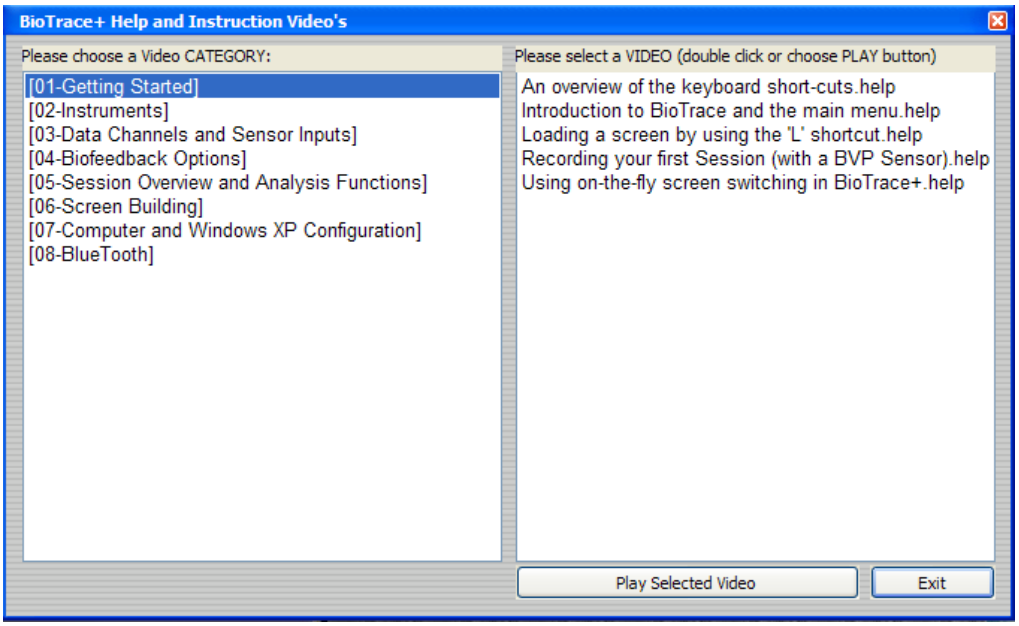
RSP/HRV Pacer Settings This is where you can edit the **Pacer** settings.

The Help menu items



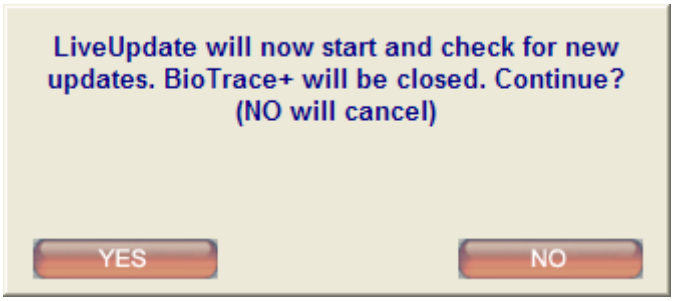
Show Instruction Videos This option will bring up a dialog box with a list of videos that contain 5 minute (or longer) presentation on the main features of the BioTrace+ software. These video presentations are an extension of this manual.

Read Software Manual: This will display the (PDF) software manual.

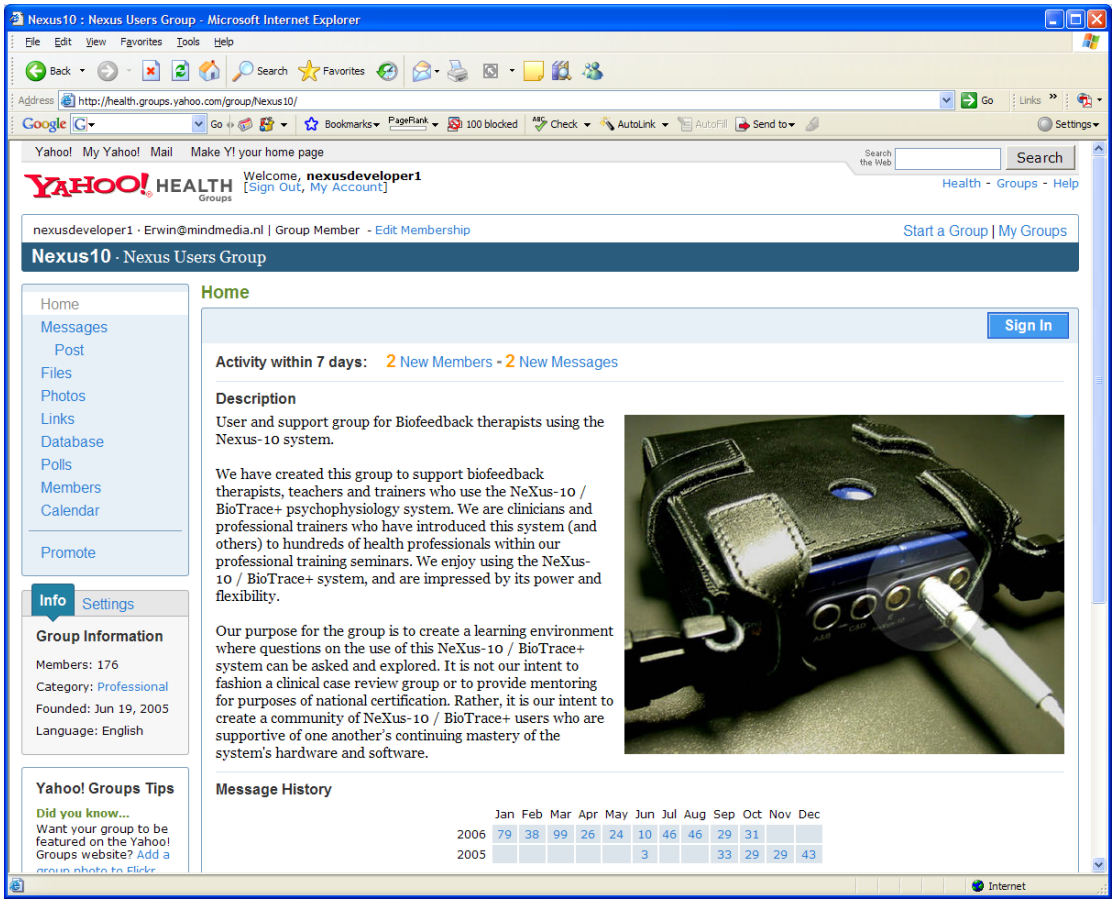


Show Keyboard Shortcuts Brings up the overview of all the **keyboard shortcuts**. You can also press the **'K'** key to activate this option.

Software Live-Update! Use this function to update your software to the latest version through the Internet. BioTrace+ can only update itself when no sessions are running. **LiveUpdate,** will close BioTrace+. (also see chapter 8.5)



NeXus User group This will open the NeXus user group web pages In your webbrowser. You can join this group and contact other NeXus-4 and NeXus-10 (/BioTrace+) users and exchange information or ask questions.



Note: the address is: http://health.groups.yahoo.com/group/Nexus10/

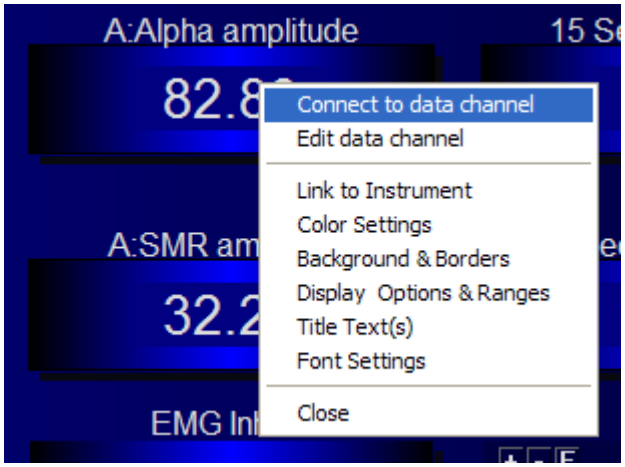
NeXus Web pages: This will open the special webpages that are dedicated To the NeXus, NeXus-16, NeXus-32 and other NeXus products. You will be able to find and download technical information and special documentation here. The address is: www.nexusproductinfo.com

'Whats New…' This will show a PDF document with the latest improvements and new functions of the software.

4.3 Right-Clicking & Drop-down menus

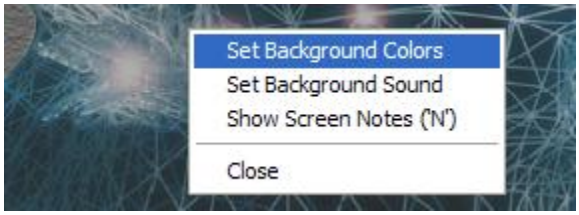
Apart from the main menu bar, which is always visible at the top of the primary screen, you will often use drop down menus that appear when you **right-click** an object. (You click with the button on the right-side of your mouse).

Properties of Instruments & Objects



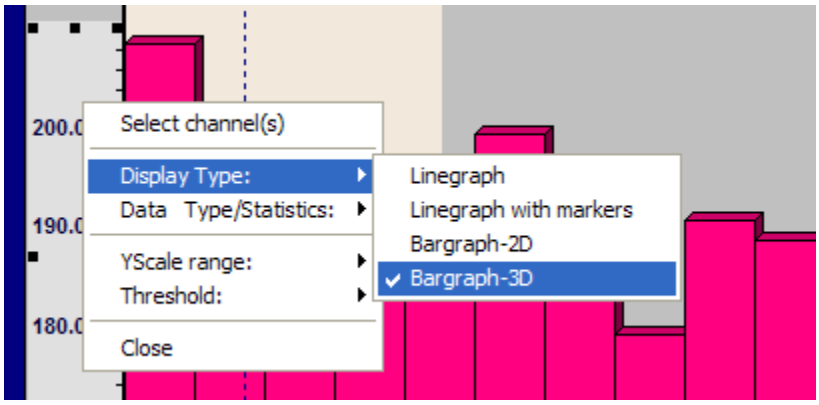
If you right-click an instrument or object on a screen, you will see a drop down menu that allow you to view and change all the properties of that instrument. For instance the data channel it is connected to.

Properties of the screen



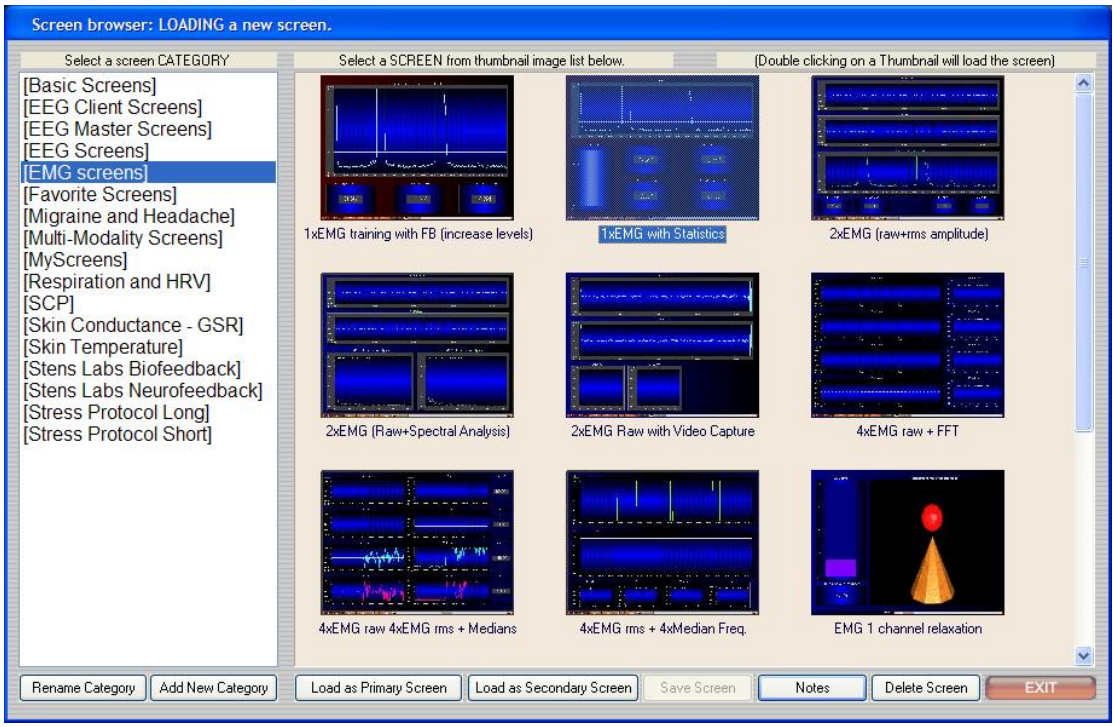
The same applies to screens; right clicking them will for instance show the background settings for that screen. In the session overview you can set the display properties of the data channels.

Properties of scales in the session overview mode:



4.4 The Screen Browser.

The screen browser is the place where you load, save and select screens. The quickest way to access it, is by pressing the **'L'** key on your keyboard. (for '**Load a screen'**)



Screen Categories

Before you select a screen, you will first need to select a "screen category". These can be found in a list on the left side of the screen browser. For your information: the description of the screen category is used to create a subdirectory in the BioTrace directory with the same name. So in this case you will find the contents of the **"EMG screens**" category in the directory "\BioTrace\Screens\EMG screens".

The button "**Rename Category"** will change the name of a selected category. We advise to use this function carefully. If a protocol has been designed that uses screens from a specific category, renaming may have the effect that the protocol can't find the screens. For that reason we advise you not to rename the "Favorite Screens" category.

The button **"Add Category**" will create a new (empty) category.

Screen Thumbnail Previews

After you select a screen category, all the screens present, will be shown in a list on the right as 'thumbnail' images. You can select them by left-clicking on them with the mouse.

Loading Screens in the screen browser

You can load a screen by selecting it and clicking one of the "**Load as primary Screen**" or the "**Load as Secondary Screen**" buttons. However a faster way to load a screen is by simply double-clicking the selected screen.

- Load a primary screen: double click the selected screen
- Load a secondary screen: double click while holding the '**Ctrl**' key down.

Screen Function keys (quick load)

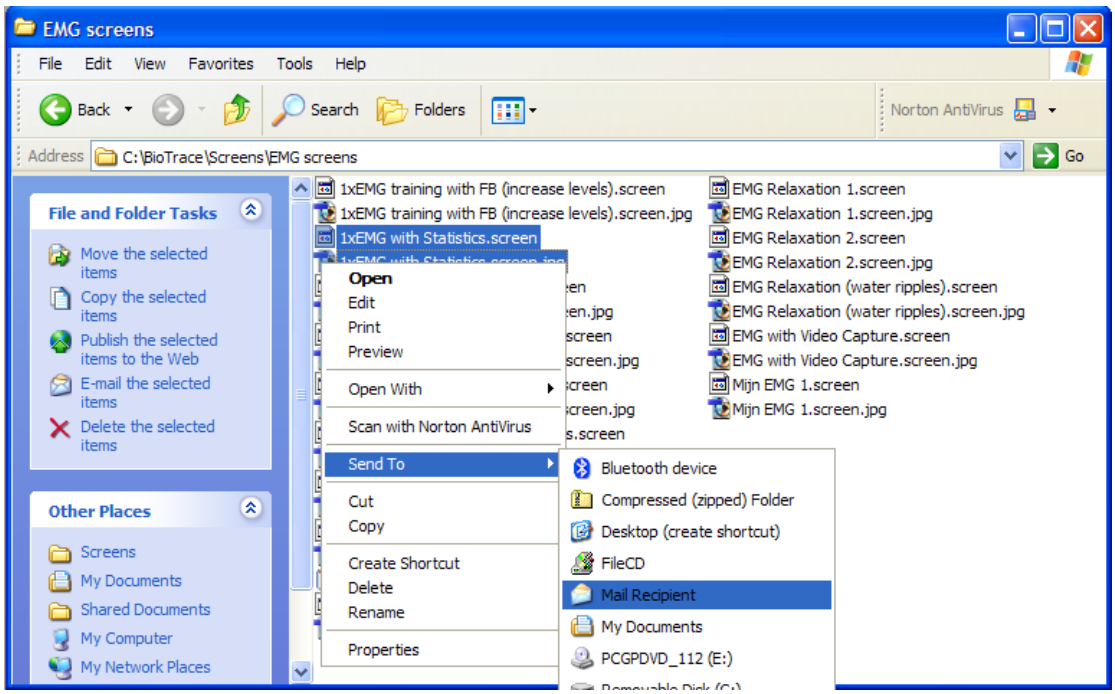
An alternative way of loading a screen is by selecting it (left mouse button) and pressing a function key. This will assign this function key (for instance F1) to the selected screen. Next time you press the F1 key, it will quick-load the screen. Holding the '**Ctrl**' key while pressing F1 will quick-load the screen as the secondary screen.

Deleting Screens

You can delete a screen in the screen browser by selecting it and clicking the '**Delete Screen**' button.

Copying or Emailing screens

If you ever want to send a copy of a screen that you have created to another person, you can simply open the category of the screen on your hard drive (see the example above) and copy files or email them. An example of how you can send a screen to somebody else through email is shown below:



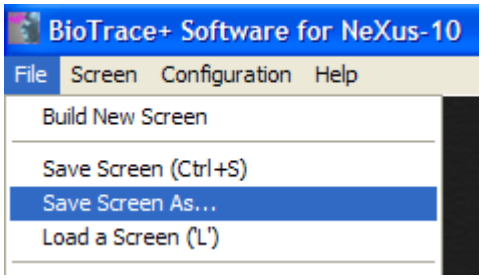
Please note that each screen comprises of two files: a ".screen" file and a thumbnail image ending with ".screen.jpg". You need to copy (or Email) both files. The receiver should then place these files into a designated BioTrace+ screen directory, in order for the screen browser to find them. (for instance \BioTrace\Screens\EMG Screens)

Screen Notes

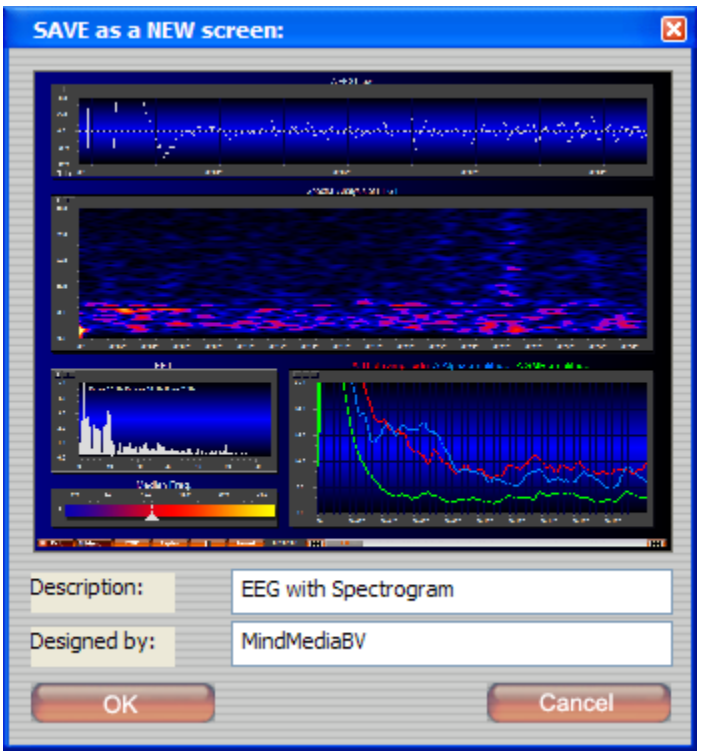
In order to make it easier for users of the BioTrace+ Screens, you may enter screen notes. These screen notes by be edited/viewed by selecting a screen and clicking in the '**Screen Notes**' button. The user can view these notes later on by pressing the **'N'** key on the keyboard when the screen is displayed in the primary screen.

Saving Screens

The screen-browser is also used to save screens. When the "**Save Screen As…**" option is selected from the main menu bar, you can save the current (primary) screen as enter a description (name).



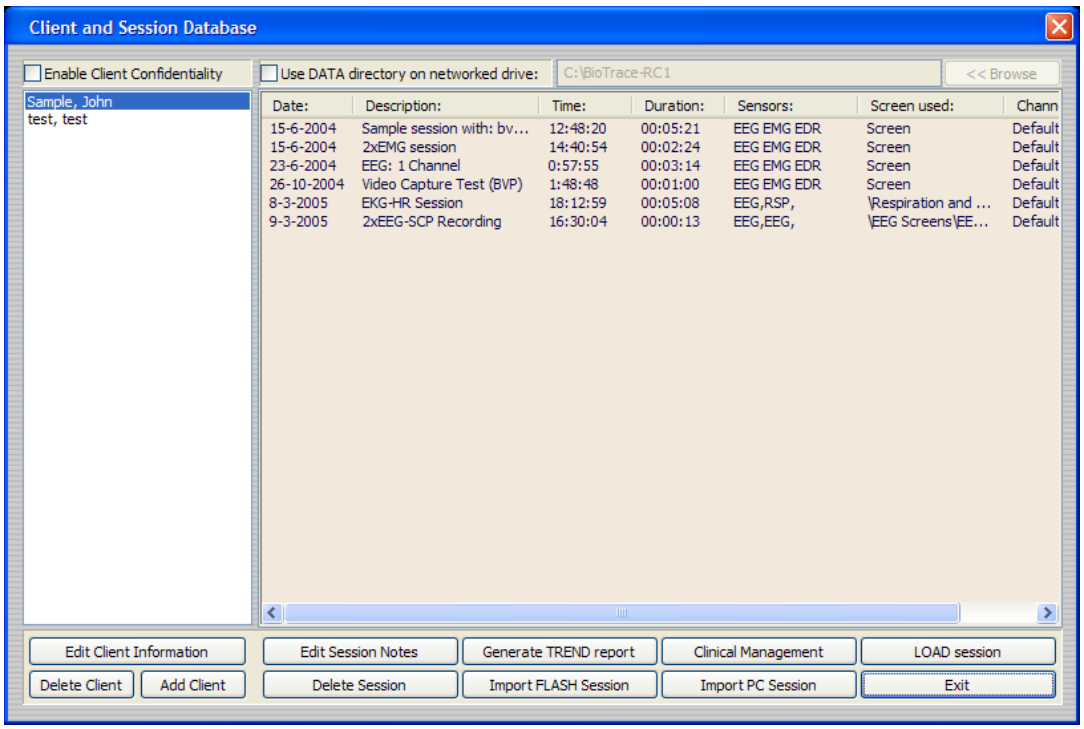
When you are saving a screen, the preview thumbnail will be shown and you can enter the description of the screen and the name of the person who designed it.



Please note: we advise you to save screens in the 'Feedback' mode. This will make sure the thumbnail will show up correctly. Saving a screen while in the session overview mode, will show a different thumbnail.

4.5 The Client-Session Database

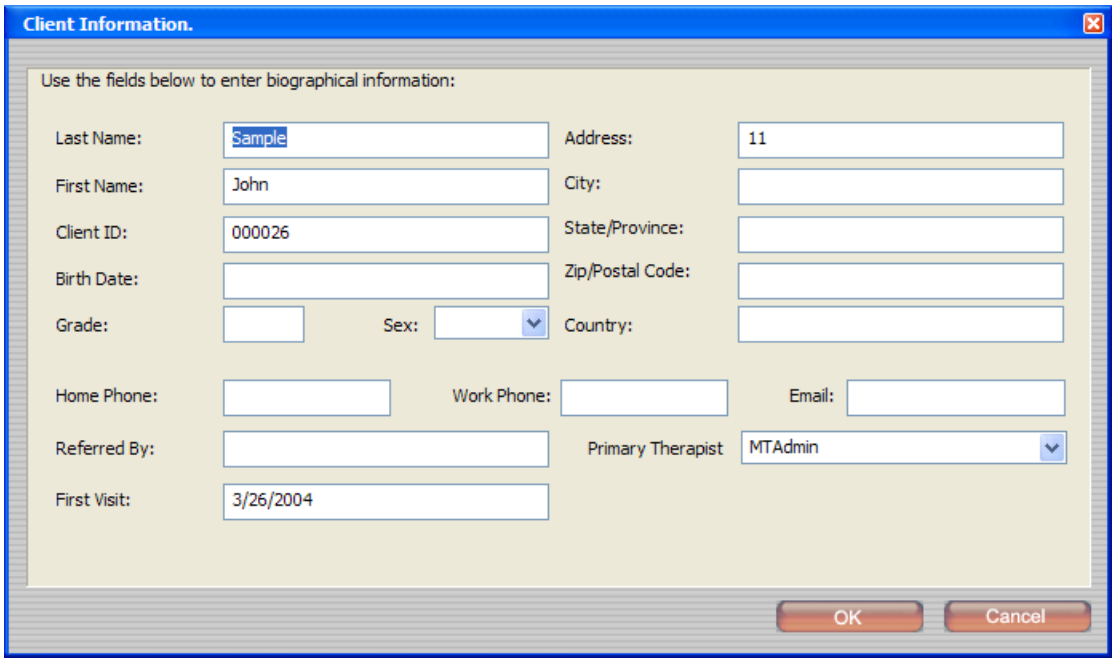
The quickest way to open the client-session database dialog box is by pressing the **'O'** key on your keyboard. Alternatively you can select it from the menu bar under '**File**'.



Through this dialog box you access all the client and session data. Let's begin with the client information. Click on the button labeled: '**Edit Client Information**'.

Edit Client Information

When you press this button, the client information dialog box is shown.

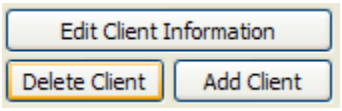


In this dialog box you enter the basic client information. The minimum you should enter are

- **the LAST NAME**
- **the FIRST NAME**
- **the CLIENT ID**

Note: The CLIENT ID is automatically generated by the computer, so you can use that ID if you like, or fill in a special ID number according to your own system.

Delete Client



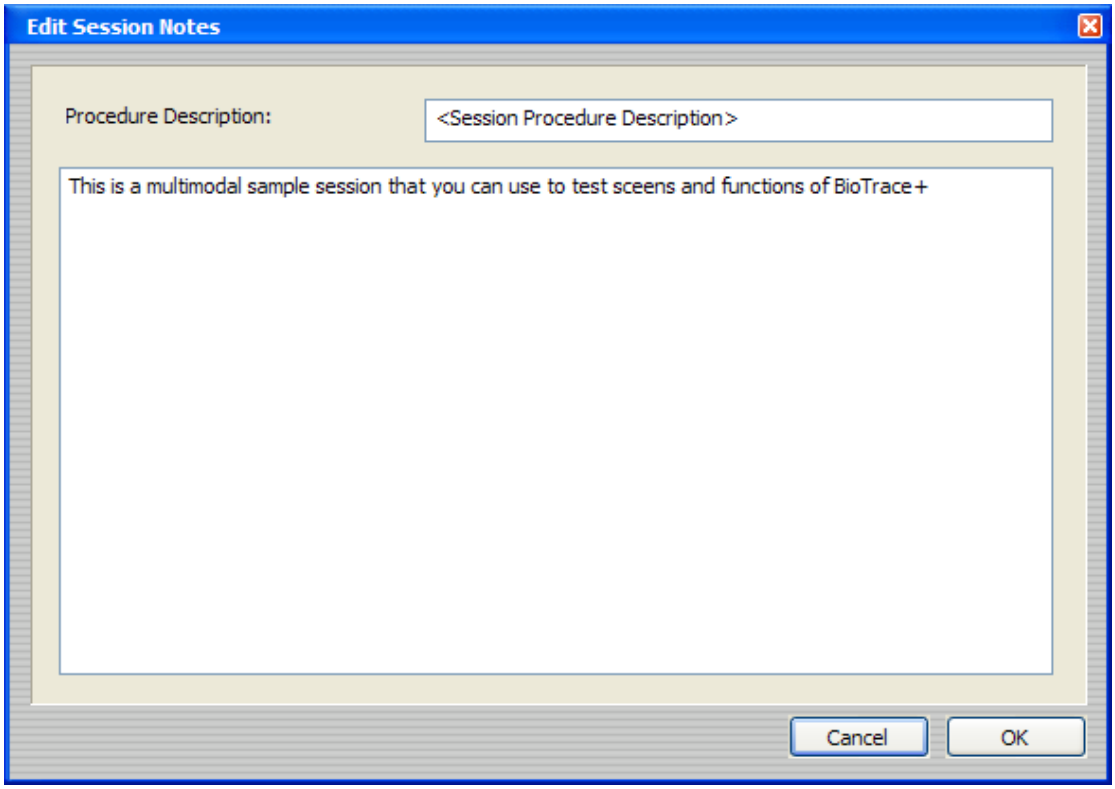
Click this button on your keyboard to delete the currently selected client. Be aware though that by deleting a client, all the client information, including all the sessions will be deleted!

Add Client

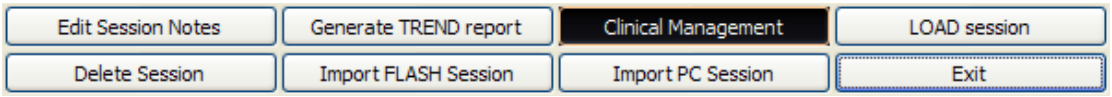
Click this button to add a new client to the database. Please note that the minimal data you need to input on a new client are the first and last name.
The software will generate a client ID. You may override this ID and replace it by another text.

Edit Session Notes

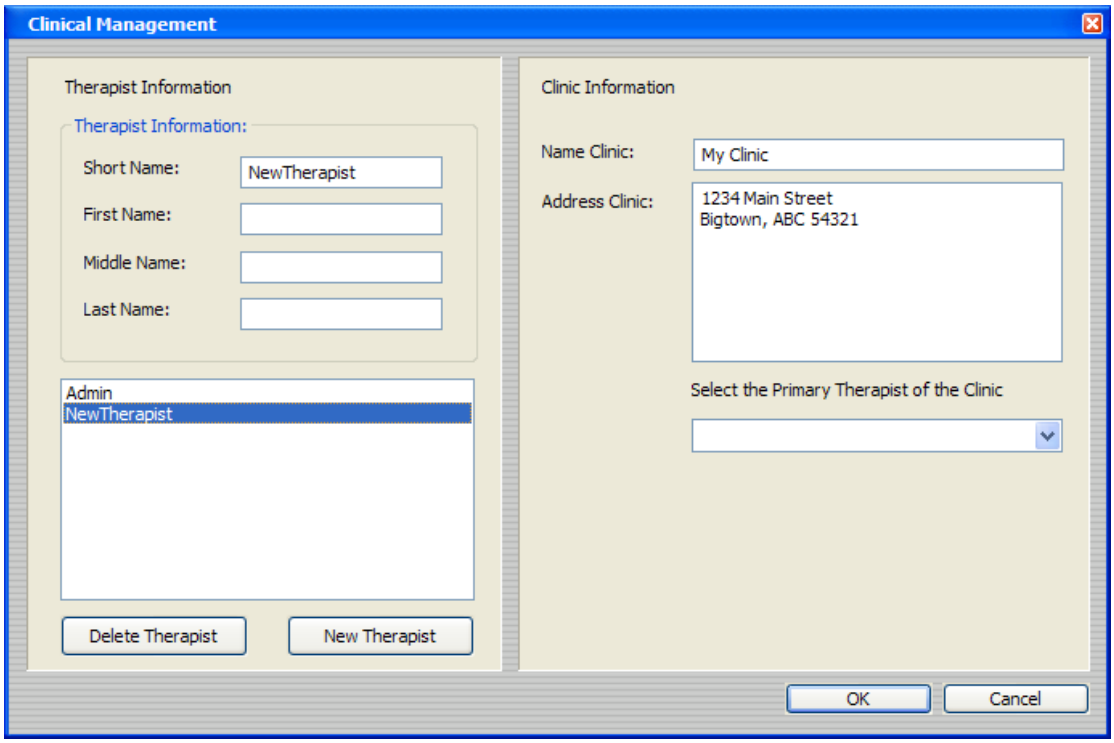
After a session has been created, you can enter session notes (comments) through a database dialog box.



Clinical Management



This option opens up the dialog box where you manage the basic information about the therapists and the clinic. You can enter the address and name of your clinic in here as well as add new therapists. This information can later be used for printing out reports.



Adding a Therapist

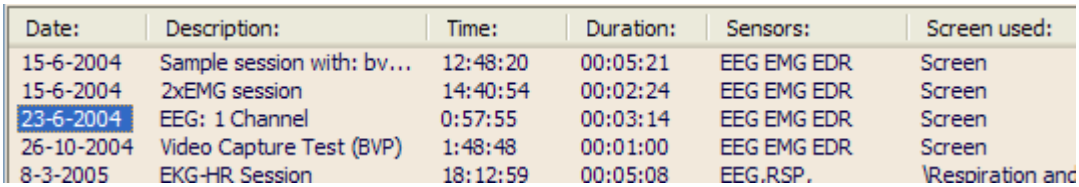
In case you want to **Add** a new therapist, you use the clinical management function shown above and click the '**new therapist/User**' button.

Delete Session

This option will delete a single session from the selected client. It will delete ALL the session files (including capture video or audio files), session notes etc.

Load Session

This option will load all the files belonging to the selected session. You may also load a session by double clicking on the first column (labeled date) of a session in the list of sessions. An example is shown below. Notice that the mouse pointer changes into a pointing hand when you are over the first column.

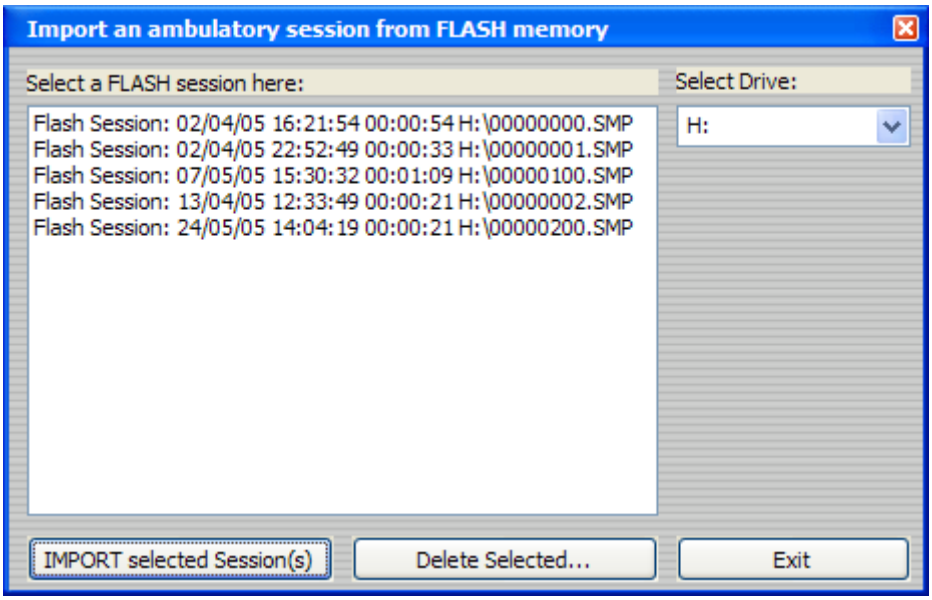


Date:	Description:	Time:	Duration:	Sensors:	Screen used:
15-6-2004	Sample session with: bv...	12:48:20	00:05:21	EEG EMG EDR	Screen
15-6-2004	2xEMG session	14:40:54	00:02:24	EEG EMG EDR	Screen
23-6-2004	EEG: 1 Channel	0:57:55	00:03:14	EEG EMG EDR	Screen
26-10-2004	Video Capture Test (BVP)	1:48:48	00:01:00	EEG EMG EDR	Screen
8-3-2005	EKG-HR Session	18:12:59	00:05:08	EEG.RSP.	\Respiration and

Importing a Flash Session

The NeXus is capable of storing 1 to 10 channels of physiological data on an internal flash memory card. (SD or MMC type) The SD card supports up to 1 gigabyte of memory space. The length of the session is only limited by the space available on the flash card and the lifetime of your batteries. (This again depends on the capacity of the batteries and the amount of sensors you use). Depending on these circumstances, you can store 2-20 hours of data per session. Before you start a flash session, you need to initialize and configure the flash card, so the NeXus knows which sensors should be stored. (See the Sensor Input Configuration box; open this by pressing 'I' on your keyboard) After a session has been stored, you take the flash card out of the NeXus and place it in a flashcard reader. Windows will then assign a drive letter to the card and you access the card as if it were a normal hard disk.

When you choose the '**Import Flash Session**' button, a dialog box will open up where you can choose which flash session you want to import to the PC. Importing in this case means, copying and decoding the files to the data directory, so that BioTrace+ can read it. A flash session is also called an '**Ambulatory Session**'.



In the example shown above, the flash card was found under drive letter 'H:'.

The list of sessions on the left display the date, the time and duration of each session and the flash file name (ending with .SMP). You may select one or more flash sessions and then select '**IMPORT selected Session(s)**' to actually import them into the data directory of the BioTrace+. When you choose '**Delete Selected…**' you will permanently delete the ambulatory sessions from the flash card. There is no way to restore them, so we advise you to first import the sessions and verify that the data is correct, before you delete them.

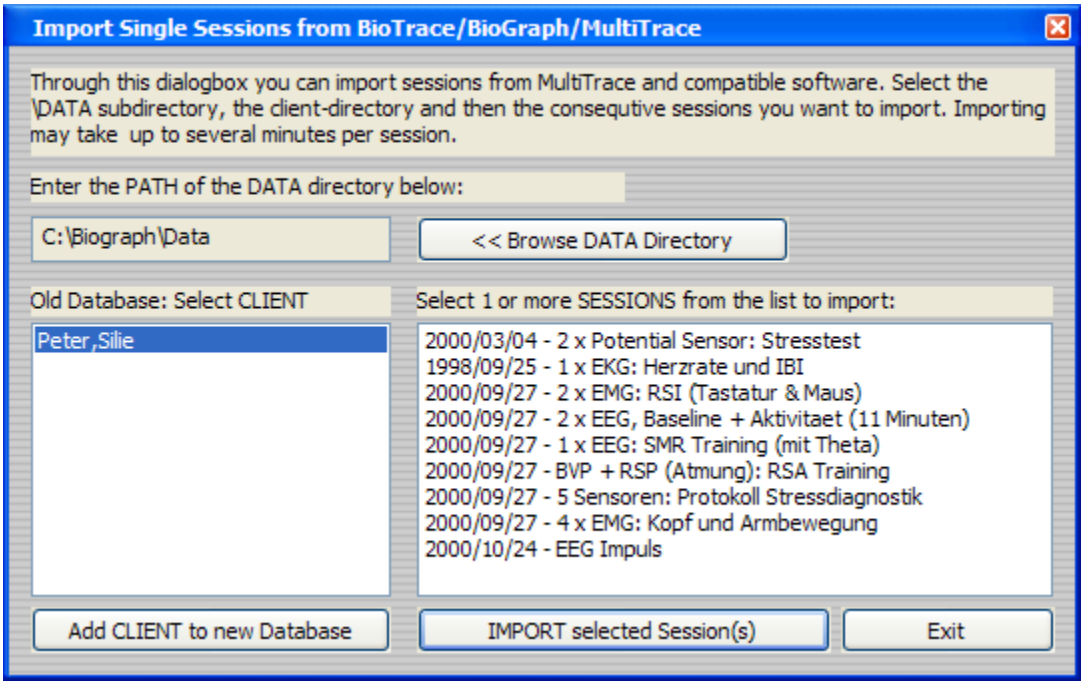
Note: The first time you use the flash import function, you may have to choose the correct 'Drive'. This drive letter generally is found in the range between 'E:' and 'I' or even higher. If you have correctly initialized and configured the flash card and

NeXus has stored one or more sessions on it, you will see a list of sessions appear, once you select the correct drive.

In case your computer does not yet have a built-in flash card reader, you can purchase one from most computer shops. A flash card reader simply connects to a standard USB port. Note that you can't import flash session through the Bluetooth wireless connection. The reason is that reading the files directly from a flash card (under a drive letter) is up to 100 times faster than using the wireless connection. So therefore the software only supports the import function through card reader.

Import PC Sessions

BioTrace+ can import session files from its 16 bit predecessors. (BioGraph 2.X ® or MultiTrace 2.X). First select the appropriate client in BioTrace+ before you import sessions to this client. Then click the '**Import PC session**' button to activate this function. The Session import dialog box will appear.

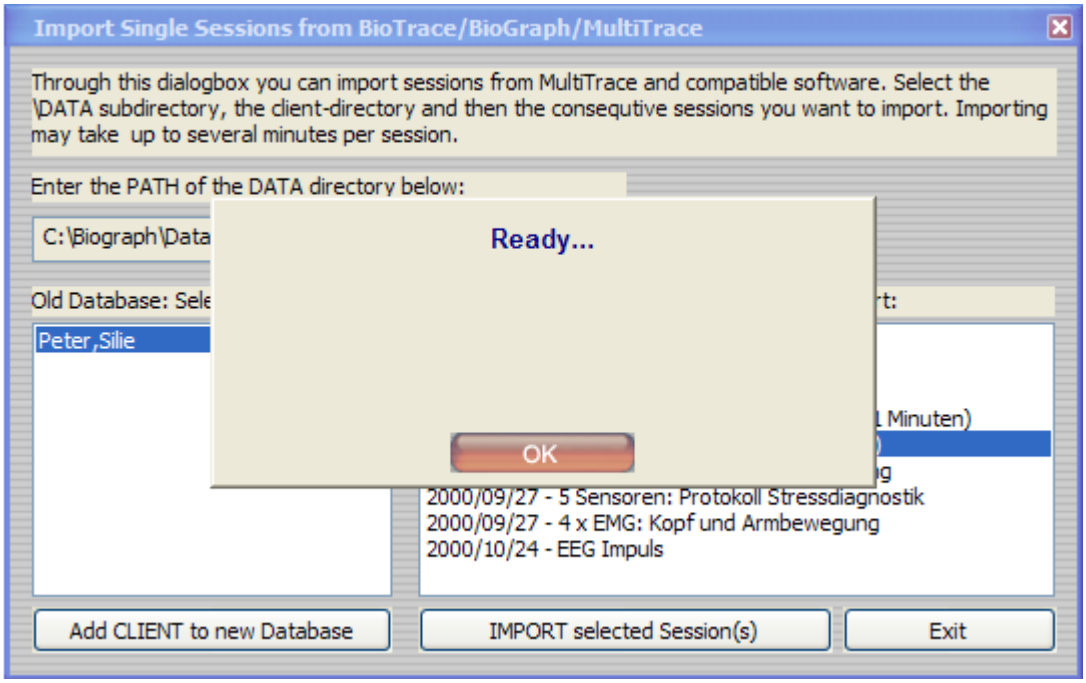


Before you can import the 'old' session format files, you will need to enter the location of the \DATA directory that was used to store these session files.

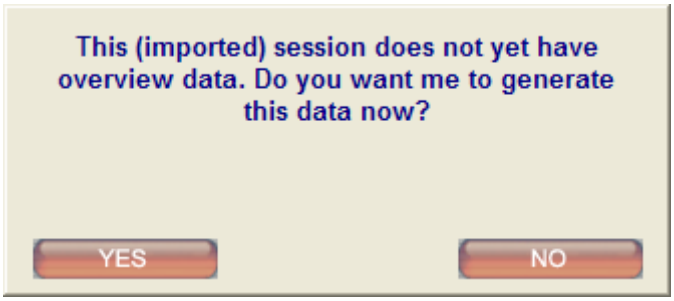
In case of the older 16 bit BioGraph ® Software (version 2.X) this may for instance be 'C:\BioGraph\Data'. Use the '**Browse DATA Directory**' button to set this location.

Once the location has been set correctly, the clients found in the old database format will be listed. When you select one of these clients, the sessions present in the old database will appear on the right.

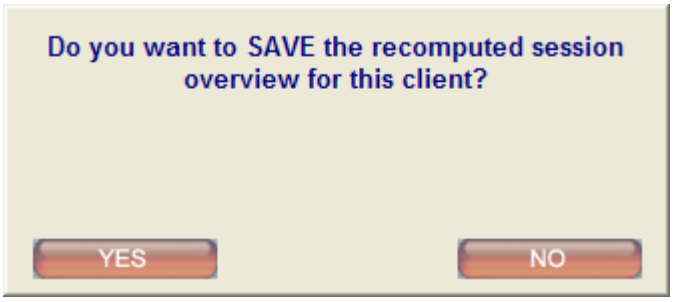
Select one or more of the sessions and then press the '**IMPORT selected Session(s)**' button. When the import function has ended, a message box will appear, indicating the session files have been converted and copied.



When you return to the session database dialog box, you will see the session file(s) that you have added, listed under the currently selected client. You can now view the session data in the currently loaded screen. Choose the '**Exit**' button to leave the import function. However the session overview data still has to be generated. So when you switch to the '**session overview screen**', the software will ask you if you want to generate the overview data.



After you have selected **'YES**' the software will generate this data,
The last question you will be asked is whether you want to 'Save' the generated session data.



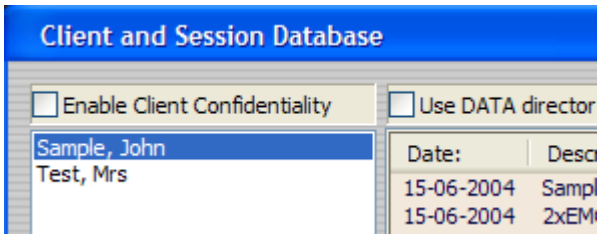
Again select the '**YES**' button. After these steps, the imported session can be accessed and used just like any native (NeXus) session. Please do notice that the encoders used with the older software's do not offer the same high 24 bit resolution that NeXus offers, so the signals may in some cases look a little noisier. This may be particularly noticeable with signals like Skin Conductance, Respiration and Skin Temperature.

*** BioGraph ® and the ProComp+/Infiniti ™ encoders are registered Trademarks and products of Thought Technology. BioGraph 16 bit ® was developed by the same company that has developed the new BioTrace+ software.*

So by importing old sessions, BioTrace+ is compatible with its predecessors. Screens developed by BioGraph ® and MultiTrace can not be imported by BioTrace+.

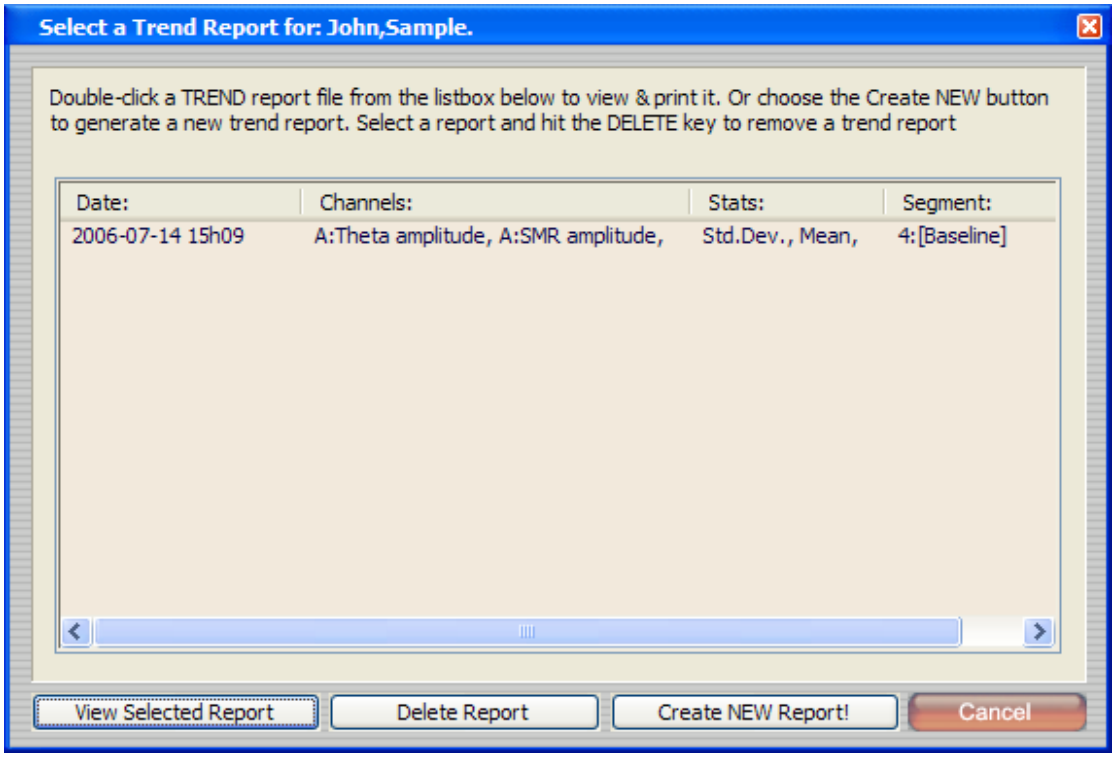
Generating a Trend Report

Open the database dialogbox ('O' key on your keyboard) and choose the client you want to generate the report for. (in this example John Sample has been selected)



Then click the **'Generate TREND report'** button.

Next the software will show you previously generated reports in the following dialog box:



This example shows a single report on the Theta and SMR amplitudes on the Baseline segments in 4 sessions (*4:[Baseline]*). Every time you generate a report the results will be stored for later review and will be added to this list. By clicking in the '**Create NEW Report!'** you can create (add) a new report.

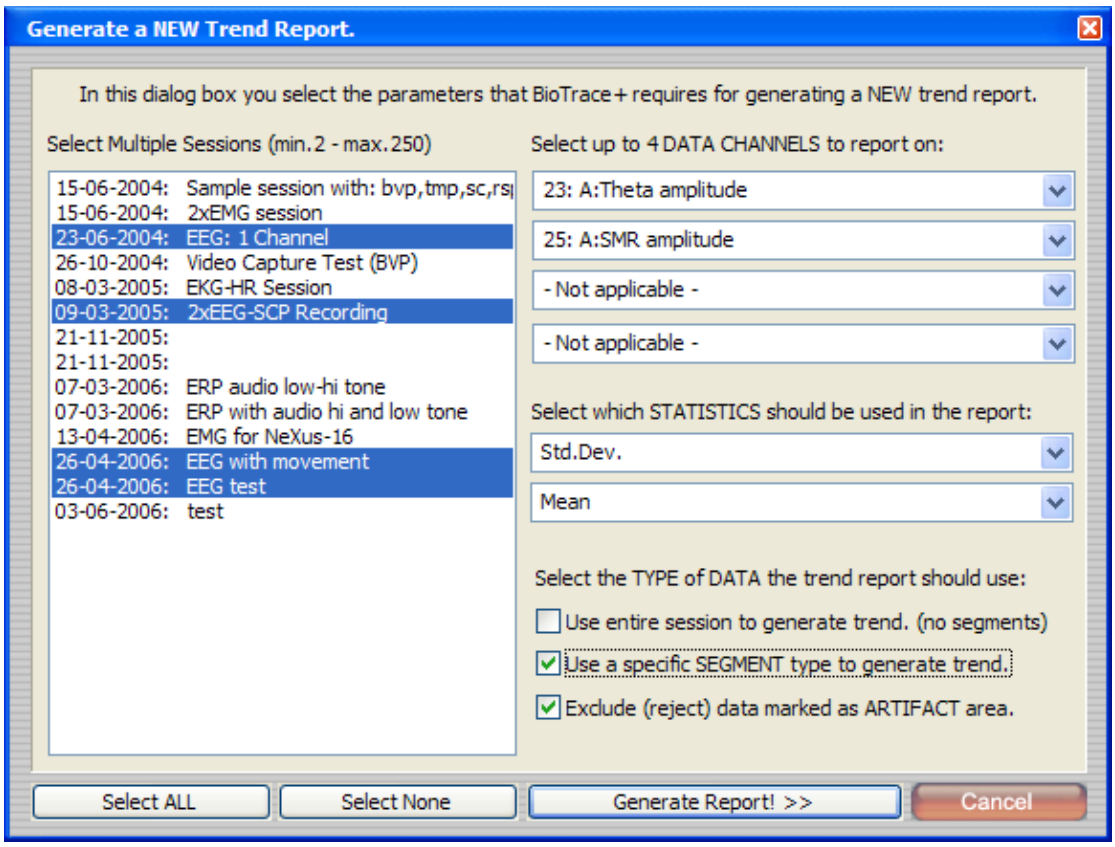
What does a Trend Report show?

A trend report shows the 'trend' or 'progress' of a physiological parameter over a number of sessions. For instance it could be used to show the trend of the EMG level during relaxation sessions, where the goal is to learn to lower muscle tone. By using a trend report, we can plot a graph that shows the mean level of EMG activity, expressed in microvolts, from session to session. In order to reduce the amount of data a trend report is often based on summary statistics that cover a larger span of time. If you observe a decrease of the minimum and mean EMG level from session to session, this could indicate that a specific relaxation training you are using, is making progress.

BioTrace+ leaves it up to you what type of data you want to generate trend reports on. Please note that any data channel in BioTrace+ can be used for generating a trend report.In order to generate a **new** report click the button: '**Create NEW Report!**'.

You now have to select the following items:

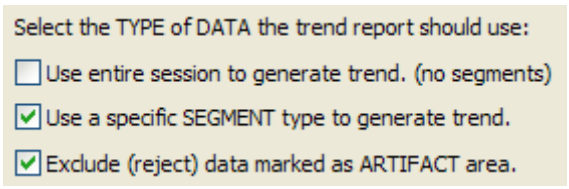
1) **A number of sessions (minimally 2)**
2) **A number of channels (1-4)**
3) **The statistics you want to trend per channel (1 or 2)**



You also need to select whether you want to generate a trend report on all the data of a session (the entire session) or only on a special **segment type** that you selected. BioTrace will then analyze the sessions you want to 'trend' and check with you which type of **Segment** you want trend.

Using Segments in Trend Reports

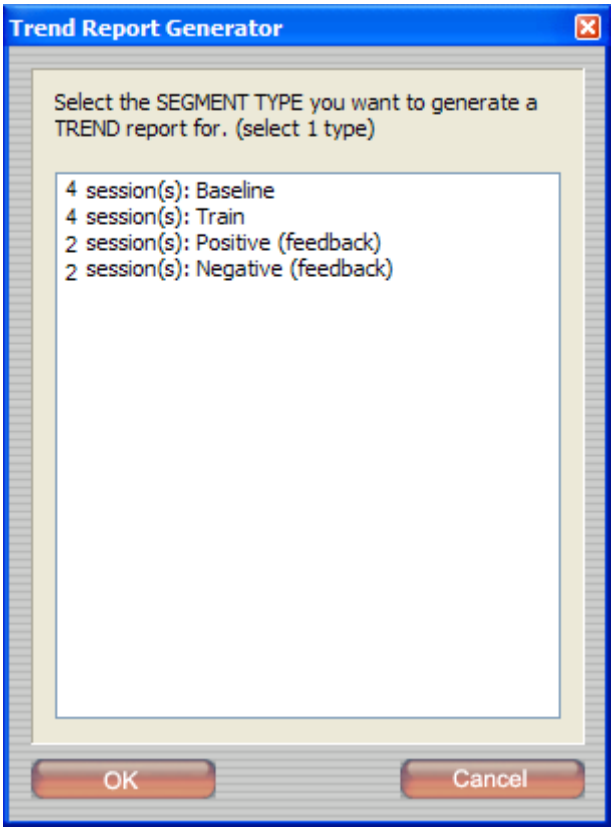
It is of course possible to use the data of an entire session to trend the mean level of a data channel (like Theta Amplitude) but that is not always useful. Frequently you will have sessions where parts are for instance 'baseline' and other parts (segments) may be the parts where the client is actually training or performing a certain task. Those parts in a session can (and should) be marked as being of a specific segment type. In the dialog box you can select this option. (**'Use a specific SEGMENT type to generate trend.**')



The other option that has been selected here, is the artifact rejection. (**'Exclude (reject) data marked as ARTIFACT area'**) When enabled, BioTrace+ will skip the artifact areas when computing statistics.

Next you choose the button **'Generate Report! >>**' to generate the report or press **'Cancel**' to return.

Next, BioTrace will analyze the selected sessions and display a list of segment types that are present in those sessions.



In the example shown, there are 4 sessions with both Baseline and Train segments. For the other segment types, there are only 2 sessions available.

Now you should select the specific type you want to trend. For instance you could select all the '**Train'** segments.

! Note: when the BioTrace+ software generates a new report, it will load ALL the sessions you selected, one by one, and re-compute all the channels and statistics, using the definitions in the current data channel set.

So that means that when you have just changed a data channel, the new trend report will reflect that new setting. For instance when you edit a data channel, say the 'Theta Wave' settings and change the band from 4-8 Hz to 4–7.5 Hz, the trend report will recompute all sessions and base the Theta statistics on these new band pass parameters.

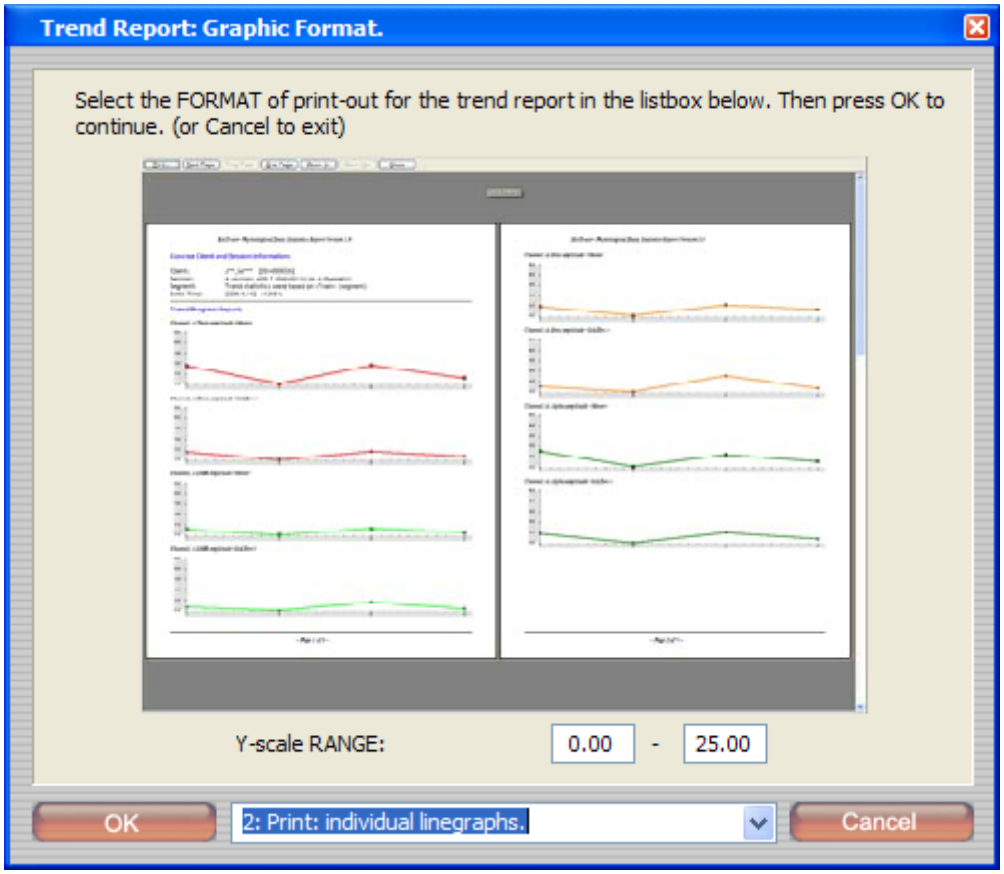
In the same fashion you could add a new data channel (for instance the ratio of the Gamma and Alpha amplitudes) and generate a trend report on this 'new' data channel.

Please note:

Remember: BioTrace+ always stores the plain raw data that was recorded from it's sensors. From that raw data all kinds of data channels can be derived. Since you are always free to build new data channels, this enables you to look at (trend) your sessions in new ways, even years after they have been recorded.

Trend Reports graphic output options

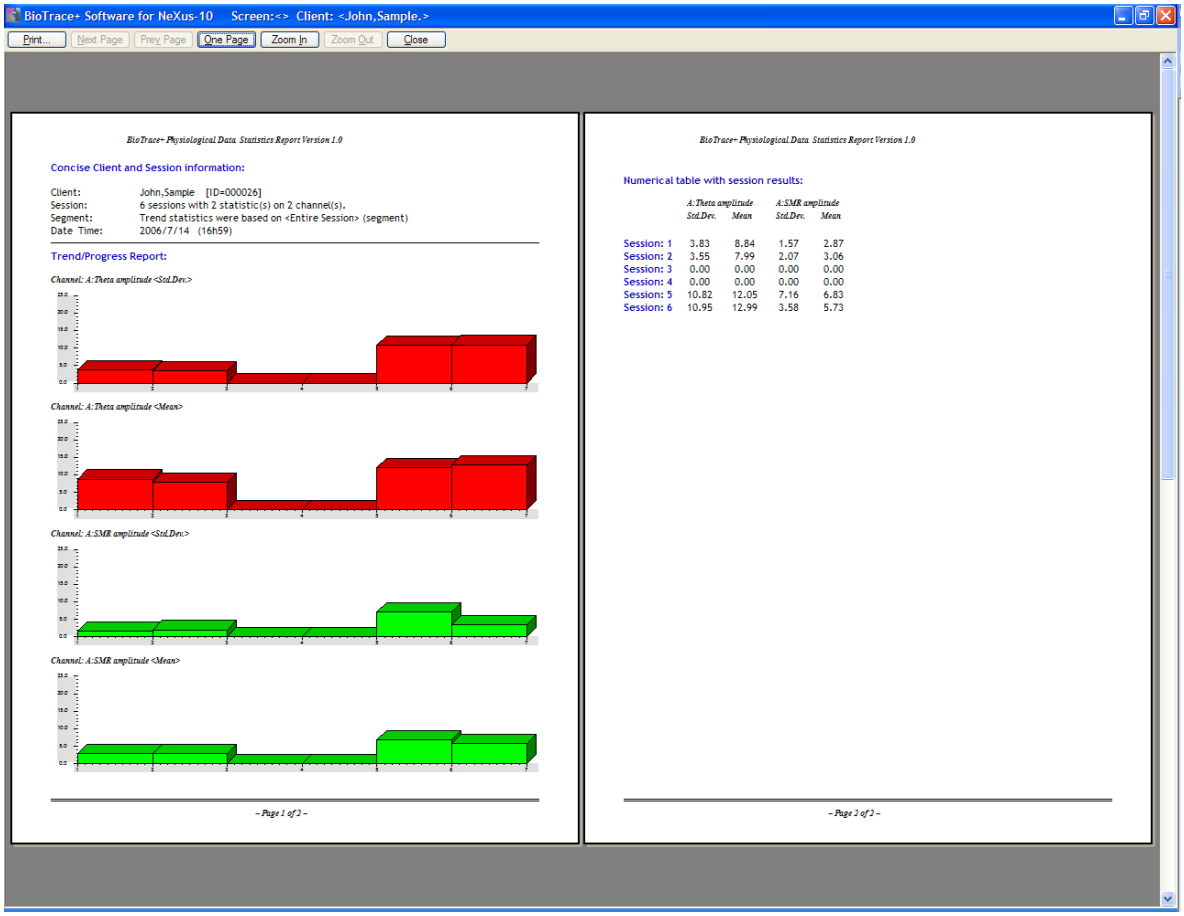
When you view a previously generated report, or view a newly generated report, you will be presented with a dialog box where you can select the graphic formatting of the trend report. This is also the place where you (manually) enter the range of the Y-Scales that are used in the trend report. When you trend a channel like HR, the values will be different from those of Temperature or EMG levels. So y-scale range settings will need to be set differently.



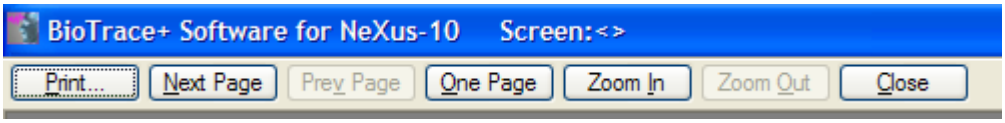
The options are:

1) Print the numerical tables only (just the numbers in a table)
2) Print individual linegraphs. (every linegraph will display one statistic for one channel in a linegraph)
3) Print individual histograms. (every linegraph will display one statistic for one channel in a histogram)
4) Combine statistics in one linegraph. (Example: all the 'Mean' statistics of the 2 EMG channels are combined in one graph and all the Standard deviations are combined in another)
5) Combine the channels in one linegraph. (Statistics are combined in 1 graph)
6) Output the numerical table to a TAB separated ASCII file that you can read or import with a spreadsheet or word processor. This option will prompt you to enter a file name (for instance "trend-data1.txt) and choose the directory where the (txt) file will be saved. By default it will be saved in the EXPORT directory of BioTrace.

After you press the OK button, a print preview will appear. Below an example of the option 3 (print individual histograms) is shown.



Press the **Print..** button on the left top to print the trend report on your default printer.



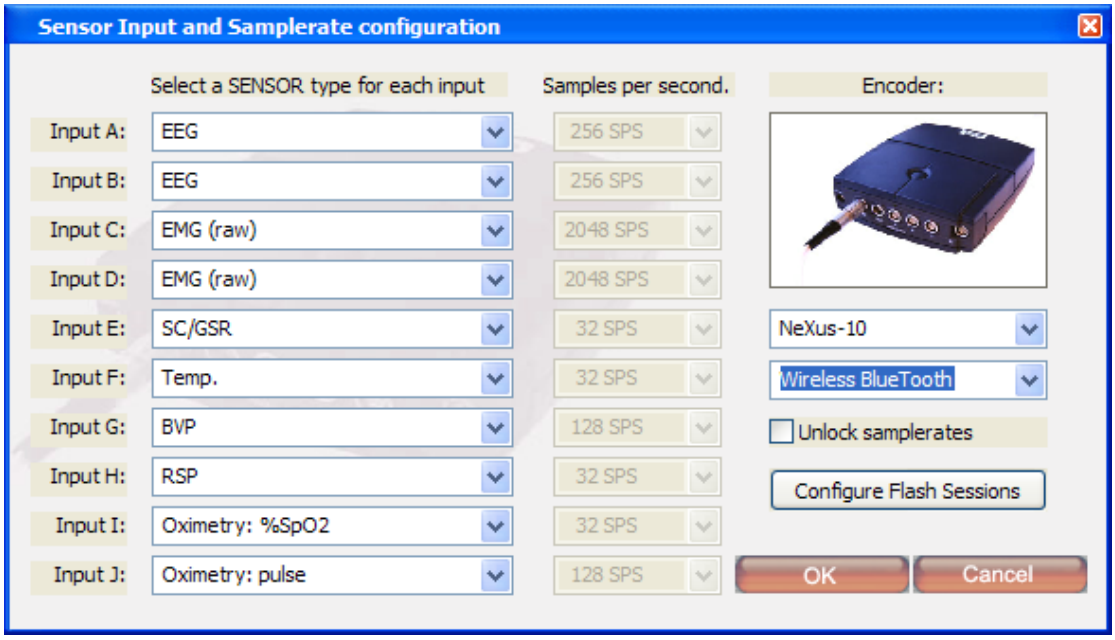
The **Close** button will cancel the printing.

4.6 Sensor Configuration

Sessions consist of sets of data files that contain physiological data and other types of files, such as video, sound, marker information and textual information. The physiological signals are contained by '**Channels**'. In chapter 3.2 you could already read an introduction on them. We will now describe the main user interface that deals with sensors and channels.

BioTrace+ Sensor Configuration

In BioTrace+, all signals are acquired by and derived from the **sensors**. BioTrace+ allows you to change channels and sensor configurations. The place where you can view and change the sensor configuration is here: (press the '**I**' key on your keyboard)



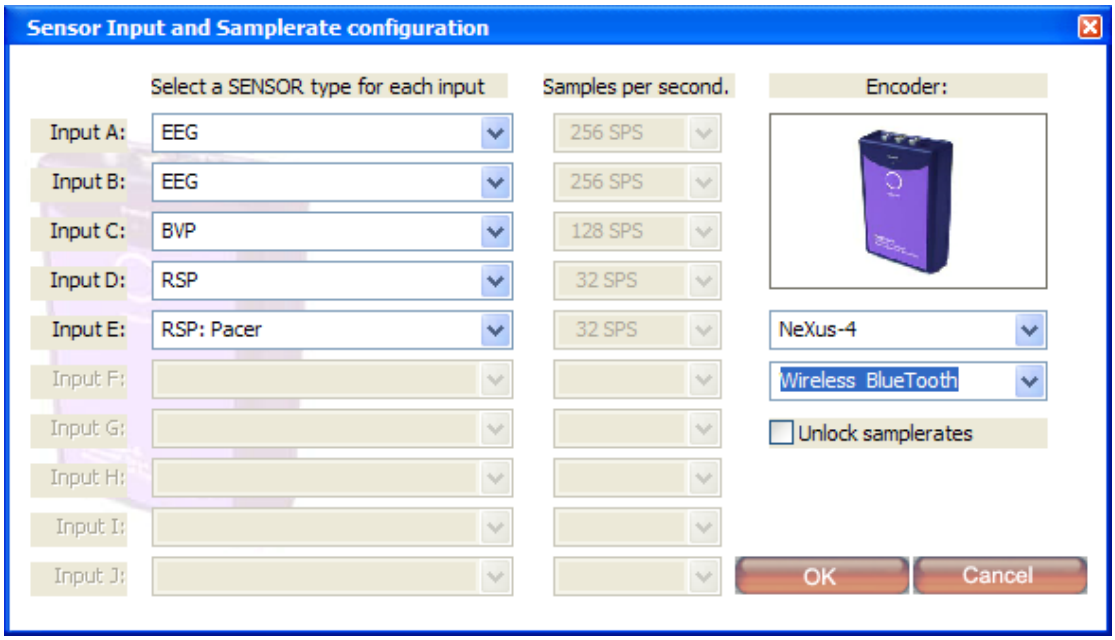
In the dialog box above, the default sensor configuration for the NeXus-10 is shown. You can configure the following:

1) The type of sensor that being used at Inputs A-J.
2) The sample rate of the acquired signal
3) Which sensors are used for storage on a flash card. (Flash Session)

We advise you to only make changes in this dialog box if you have read the chapters in the advanced reference manual. Also we advise you not to change the default channel set, but to create your own channel set or modify a copy of the channel set.

Any change you make in the a sensor configuration or channel set will modify the way the physiological data is represented in all the screens that use this channel set, in case that data channel set is saved. So if you change the default channel set and save it, most of the screens that came bundled with BioTrace+ will be affected.

The default sensor configuration for the NeXus-4 looks like this:



NeXus-10: selecting the type of sensor

Each input allows for a certain number of types of sensors. For NeXus-10, the first 4 inputs **A, B, C and D** can be used for (fast) DC and AC electrophysiological signals in the frequency range from DC to about 800Hz. The following modalities are supported:

Type	Recommended Sample rate (SPS)
1) EEG	256 (or 512)
2) SCP	same as EEG
3) ECG	256-2048
4) EMG	1024 or 2048
5) EOG	256

Please note: since the NeXus has the pre-amplifiers built-in, selecting a different type here, is basically only a matter of changing the labeling of the sensor. If you for instance connect the second input (Input B) to an ECG signal, it is not critical for the signal that the sensor is still labeled as being 'EEG'. The signal of the sensor in that case will not be affected and be just as valid.

If you decide to change all four inputs (A-D) to EEG, you could do so here. In that case you would set the type of all sensors to EEG and set a sample rate of 256 (or 512) samples per second. For 4 channels of (raw) EMG you would change the type to EMG and set a high sample rate of 2048 (or 1024) samples per second.

On inputs **E, F ,G and H** you can connect the peripheral sensors in any combination. Options are:

Type	Recommended Sample rate
6) Skin conductance	32
7) Skin Temperature	32
8) Blood Volume Pulse	128
9) Respiration	32

So if you decide to connect four different people to a single encoder for monitoring Skin Conductance, you would set inputs E-H all to SC/GSR. You would want to set the sample rate to 32 SPS and then save this configuration into a new data channel set.

Finally inputs **I and J** are used for:

10) SpO2 level (relative oxygen saturation)
11) SpO2 pulse waveform **
12) The respiration PACER signal. (which will be stored in a session)

** The SpO2 pulse is quite similar to the pulse waveform from the BVP sensor and can be used to detect HR (heart rate) as well.

NeXus-4: selecting the type of sensor

For NeXus, the first 4 inputs **A, B** can be used for (fast) DC and AC electrophysiological signals in the frequency range from DC to about 500Hz. The following modalities are supported:

Type	Recommended Sample rate (SPS)
1) EEG	256 (or 512)
2) SCP	same as EEG
3) ECG	256-1024
4) EMG	1024 or 1024
5) EOG	256

Please note: since the NeXus has the pre-amplifiers built-in, selecting a different type here, is basically only a matter of changing the labeling of the sensor. If you for instance connect the second input (Input B) to an ECG signal, it is not critical for the signal that the sensor is still labeled as being 'EEG'. The signal of the sensor in that case will not be affected and be just as valid.

If you decide to change all inputs (A+B) to EEG, you could do so here. In that case you would set the type of all sensors to EEG and set a sample rate of 256 (or 512) samples per second. For 2 channels of (raw) EMG you would change the type to EMG and set a high sample rate of 1024 (or 1024) samples per second. Channel Sets supporting EMG at higher samplerates have been included.

On inputs **C and D** you can connect 2 peripheral sensors in any combination. Options are:

Type	Recommended Sample rate
6) Skin conductance	32
7) Skin Temperature	32
8) Blood Volume Pulse	128
9) Respiration	32

Please note that the number of combinations are more limited on the NeXus-4 as it only has two auxiliary inputs. (The NeXus-10 has 4 aux. inputs)

Selecting the sample rate of a sensor

The first 4 inputs of NeXus (**A, B, C and D**) can acquire a signal at a rate of 256, 512, 1024 or 2048 samples per second. Each sample has 24 bit resolution. The way you label the input (EEG, ECG, EMG, EOG and SCP) is only for your reference and does not impact the signal.

On the former page you can see the sample rates that we advise for each type of sensor. There is a reason we have chosen these sample rates. One of the main reasons is the so called **Nyquist frequency**. We advise to use a sample rate that is at least times higher than the highest frequency you want to acquire.

So in case of EEG, we measure signals in a range from DC-64 HZ. Hence a sample rate of 256 samples/sec fulfills this criterion.
In some cases a sample rate of 512 samples/sec (SPS) is used, but for neurofeedback purposes this is not really required.

For raw EMG, we want to measure signal between 10-500Hz, so a sample rate of 2048 SPS will be enough. In some cases the raw EMG is measured only below 200 or 300 Hz. (for instance 100-200Hz). In that case a sample rate of 1024 SPS would be fine to use.

For the other signals (skin conductance, temperature and respiration) we are measuring signals that contain information that is mostly below 4 Hz, so theoretically a sample rate of 16 SPS would be enough. However it can't hurt to have a little more bandwidth. Also the refresh rate where the eye does not perceive individual samples (frames) anymore is above 20 Hz. Therefore we have selected 32 SPS. You could go as high as 128 SPS on those sensors if you want to.

For the BVP sensor this is a little different. Because this sensor is used for heart rate computations, we want that HR data to have a higher resolution. Setting a higher sample rate on the BVP (pulse waveform) will provide a greater precision in computing the distances between individual 'R'-peaks, which are used to compute the HR. So we choose 128 samples per second.

Why powers of 2 on the sample rates?

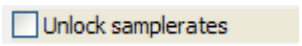
Using a power of 2 based sample rate, has the advantage that you can always divide back the sample rates in integer numbers. (1,2,4,8,16,32 etc.) It also makes it easier to plot an EEG signal sampled at 256 SPS over against a respiration curve that is sampled at 32 SPS. Since monitor screens only come in types that have integer numbers of pixels (for instance 1280x1024) it would not be handy to plot an EEG sampled at 291 SPS over against another signal sampled at 173 SPS.
The last reason is that fast Fourier transformations (fast spectral analysis) works fastest on data that is organized in powers of two.

Use consistent sample rates

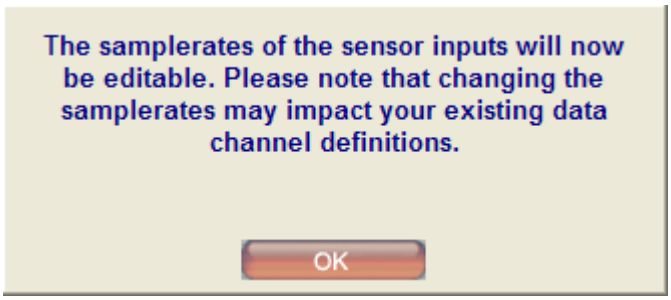
Finally we advise you to use consistent sample rates. For instance, don't use one channel of EEG sampled at 256 SPS and another sampled at 512 SPS. The reason is that when you compute data channels where you want to obtain ratios or differences, (for instance EEG2-EEG1) both channels should have the same sample rate!

Unlocking and changing Sensor Sample rates

In order to protect you from any entering wrong or inconsistent sample rates, you first need to 'unlock' the sample rates. Simply click inside the button and a check mark will appear.



At the same time the software will warn you with a message:



Because the data channel set may contain channels that use two other channels for their input (for instance EMG1 and EMG2) you could enter an 'illegal' sample rate here which would impact an existing channel that computes the ratio of EMG1 and EMG2. Setting sensor EMG1 to a different sample rate as EMG2 will render that channel invalid. Hence all channels that use this ratio channel for input would then also become invalid.

Preparing and using Flash Memory Sessions

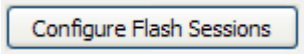
NeXus is capable of not only acquiring 'live' data and sending it in (near) real-time to the computer through a wireless connection, but it can also be used to store physiological data on an internal flash card.

The way it works is like this:

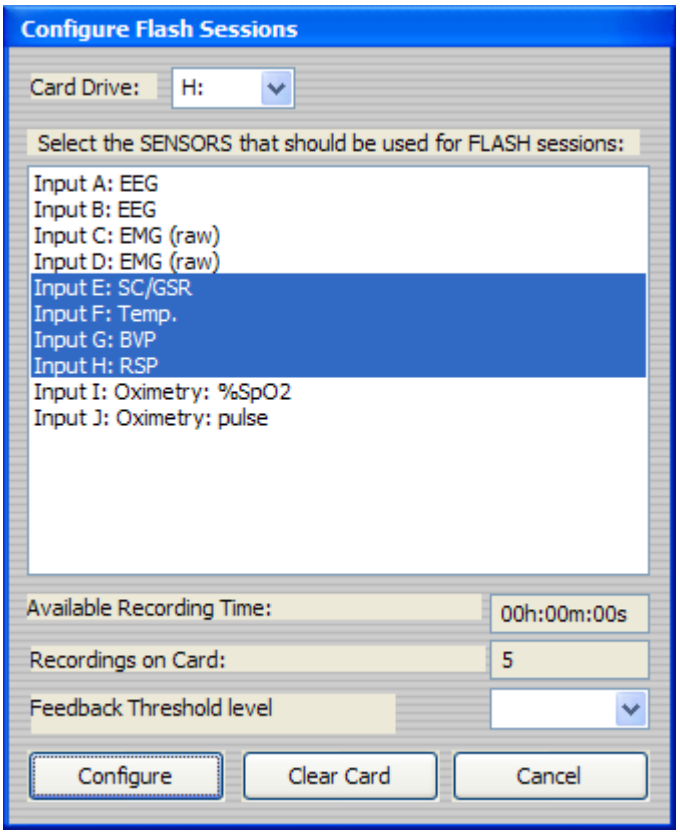
1) You insert the flash card (SD format) into the computer (a flash card reader)
2) You open up the Sensor input configuration box
3) You click on the '**Configure Flash Sessions**' button
4) You select which sensor data you want to store
5) You initialize the flash card
6) You put the flash into the NeXus (see hardware manual)
7) You switch the NeXus on. (hold the power button for 5 seconds)
8) NeXus runs for a few minutes to number of hours
9) You press the power button for 5 seconds to turn the NeXus off.
10) You put the flash card (containing the data) into the PC
11) You import the flash session into BioTrace through the Datebase dialog box. (See chapter 4.5)

Note: in case the NeXus is used in 'ambulatory mode' the wireless data connection is switched off.

So, let's now look at the initialization of a flash session. It is quite easy. Enter a flash card into you PC and click the '**Configure Flash Sessions**' button.



After pressing this button the following dialog box will appear:



You select (highlight) the sensors that you want to store on the flash card. (Remember that all other data channels derived from the sensors are computed by the software). In the example shown above, only channels from input E,F,G, and H are selected. These will be saved on the flash card, using the sample rates that were set earlier in the '**sensor input and sample rate configuration**".

The steps are:

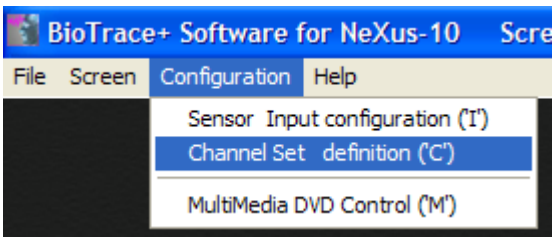
1) Select the correct flash card drive. (the software will try to locate this drive automatically) **
2) Select (highlight) the sensors you want to store
3) Press the '**Configure**' button to save the configuration
4) A message should appear that affirms the flash card has been configured
5) The dialog box will close

** *If you aren't sure which drive letter to choose, insert the flash card into your computer and use the windows explorer to check the available drives. If you have previously initialized the flash card for use with NeXus, it should have a number of '.SMP' and '.INP' files on it.*

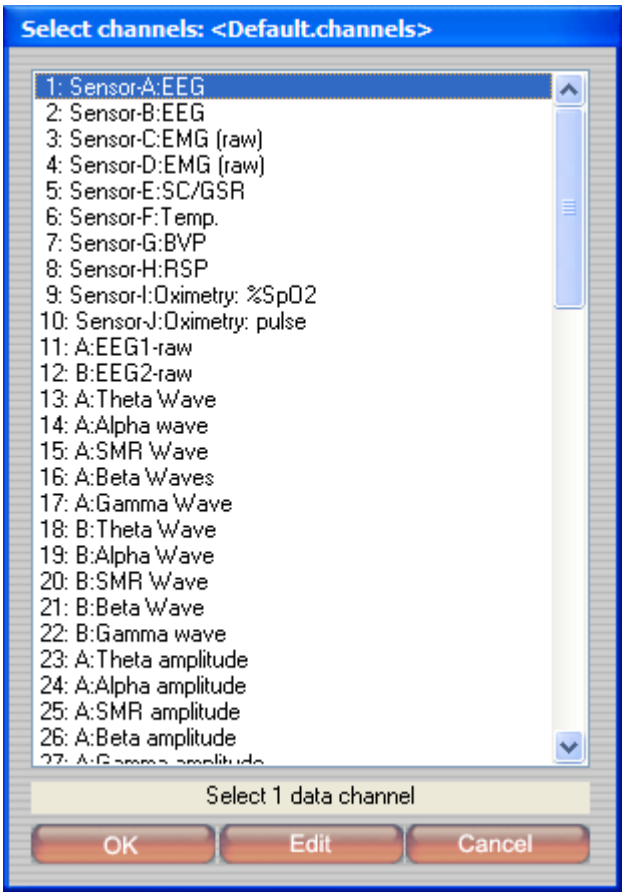
This dialog box will also show you the available recording time that is left on the flash card drive. This will depend on the capacity of the flash card and the selected sensors. If you select the four fast inputs (A,B,C, and D) at a high sample rate, you will have less recording time, then when you select channels with lower sample rates (inputs E,F,G,H,I and J). Please note that NeXus will store the physiological data in a compressed fashion, and BioTrace+ will first need to import (and extract) the session data files from the flash card, before you can use it.

4.7 Channel Sets and Editing Channels

The physiological data channels of BioTrace+ are organized in channel sets. Each set comprises of 80 data channels, of which the first 10 (in case of NeXus) are the sensors. Press the '**C**' key on your or select the menu option '**Channel Set Definition**' from the configuration menu (see below) to open the channel set.



The channel set shown here is the default channel set. The name of the currently loaded channel set can also been found in the caption of this dialog box. The file name of the default channel set is: '**default.channels**'.



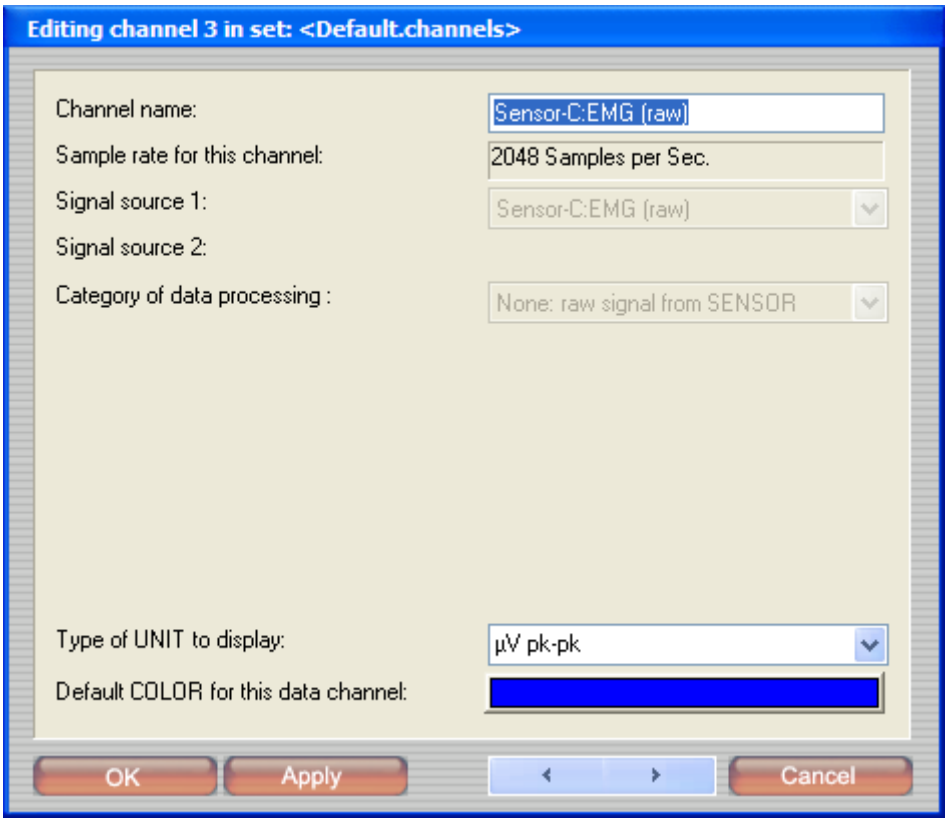
This dialog box also shows the amount of data channels that have been selected (at the bottom). Certain instruments, such as line graphs, can display more than 1 graph, and therefore allow you to select more than 1 channel.

Sensors and (virtual) data channels

The first 10 channels of this channel set (for NeXus) are used to 'channel' the physiological data coming from the sensors. These sensor channels can not be edited, they are simply there. The channels 11-80 are sometimes called 'virtual' data channels. The reason is that they process (compute) data from the sensors and turn it into something else. BioTrace+ computes all virtual data channels on the fly and only stores the raw data from the sensors.

Editing & defining a data channel

Let's take a look at a definition of a sensor channel:

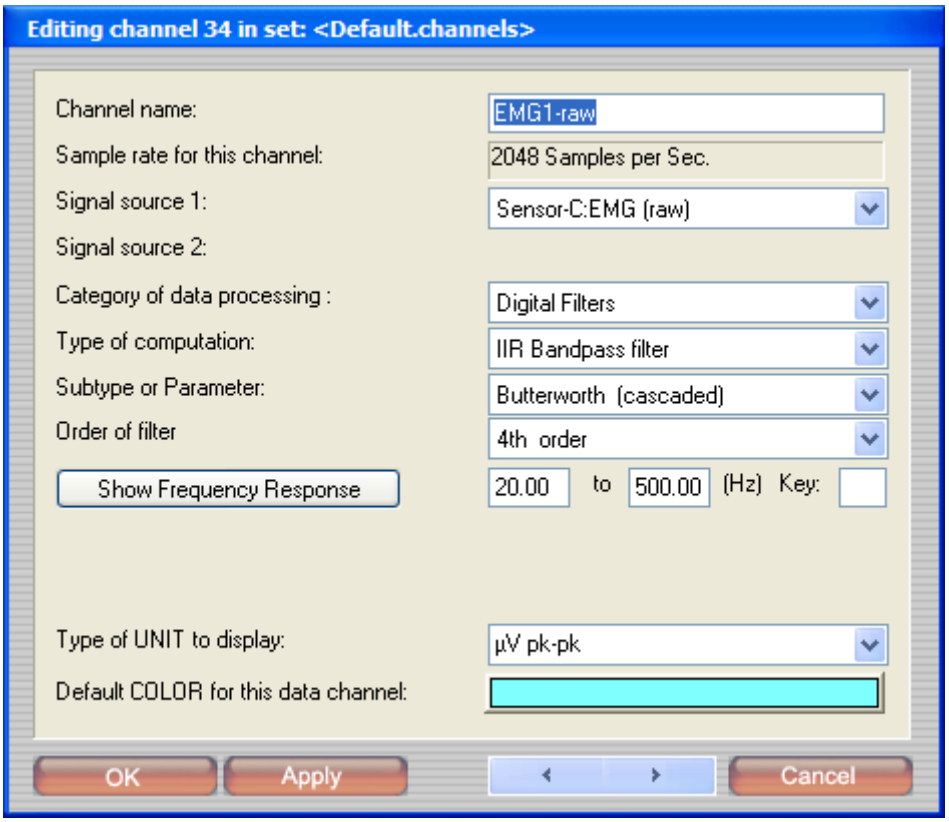


This display the definition of the sensor input C, defined as being the raw EMG signal sampled at 2048 samples per second. There is no category data processing that you can select here. The only options you can change here are:

1) The name of the sensor channel.
2) The type of the UNIT used to display the data.
3) The default color that is used when the data channel is displayed in the session overview screen.

You can use the **left** and **right** arrows at the bottom to navigate through the channels. Once you press '**OK**' the changes you made will be stored and the dialog box will close. When you press apply, the changes are applied, but the dialog box stays open. In most cases you will not change the sensor channel definitions.

Now let's look at the definition of another channel. In this case we look at channel 34.



This data channel defines a 'raw' EMG data channel, containing EMG activity in the range between 20 and 500 Hz. You can edit or change the following parameters here:

1) The name of this channel
2) The source (in this case the source is sensor input A)
3) The data processing category (in this case a digital band pass filter)
4) The type and characteristics of the filter **
5) The frequency range
6) The UNIT of the channel
7) The default color (used in the session overview screen)

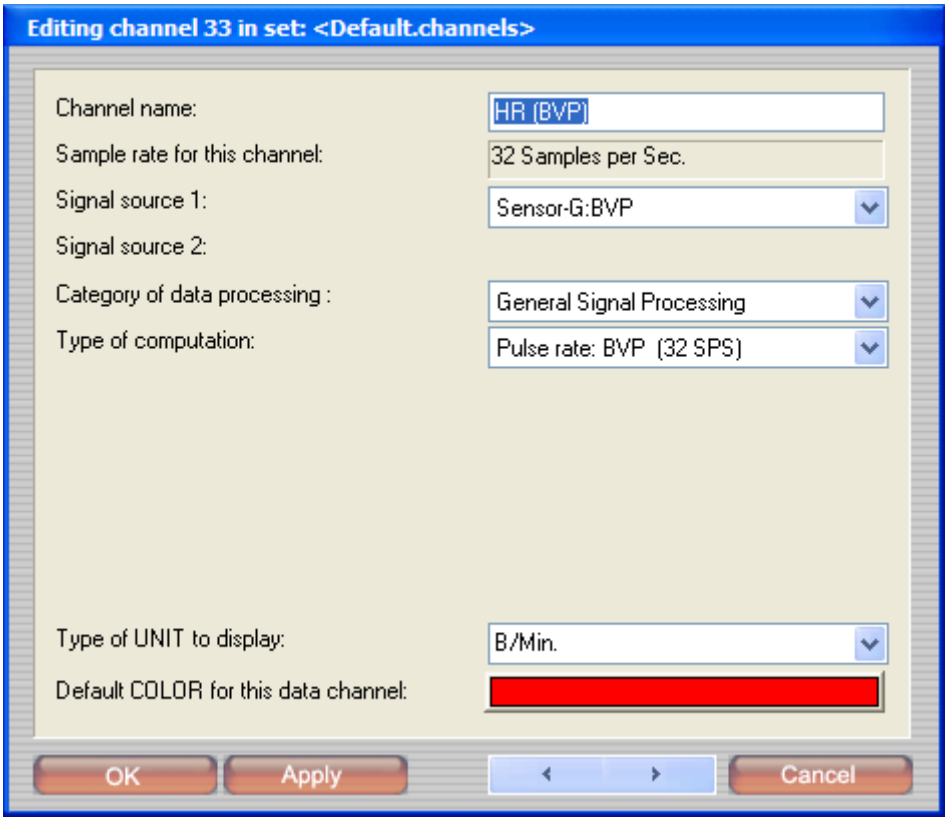
** The order of the digital filter defines how 'strong' the channel filters out signals outside the chosen range. You can view the frequency response under the button marked with '**Show Frequency Response**'.

So you may ask yourself, why define 'another' channel for the raw EMG activity, when we already have the sensor input C: itself? (channel #3) Does it not make more sense to just plainly use Input C?

The answer is that the signal coming from sensor C: contains much more information that we need for a standard EMG. It contains activity in the range from DC (0Hz) to 800Hz. Therefore we create a new channel (#34) which is sampled at 2048 SPS and contains only the activity in this smaller range. (20-500Hz) Note that in this case we do not use the DC contained in this signal.

TIP: in case you want to set a narrower band pass on the raw EMG, for instance to get rid of ECG activity, you could set the frequency range of this channel to 100-500Hz or 100-200Hz.

The next example of a channel is the heart rate (HR) computed from the BVP signal on input G.



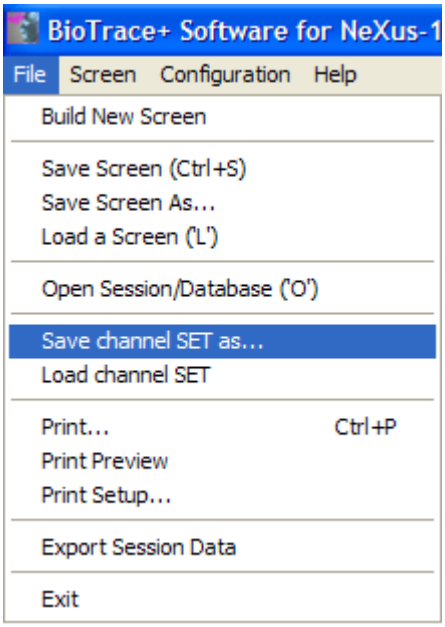
This channel (#33) uses the general signal processing category and the function '**Pulse Rate: BVP**' to compute the HR. The result of this channel is computed and stored 32 times per second. (See the sample rate at the top)

The unit in this case is beats per minute (abbreviated as B/Min) and the default color is red.

In the advanced reference manual, all the different categories of data processing will be explained, so we will not elaborate on the more complex data processing features here. However we will go into the use of data channel sets and how to create, load and save them.

Creating and Saving Channel Sets

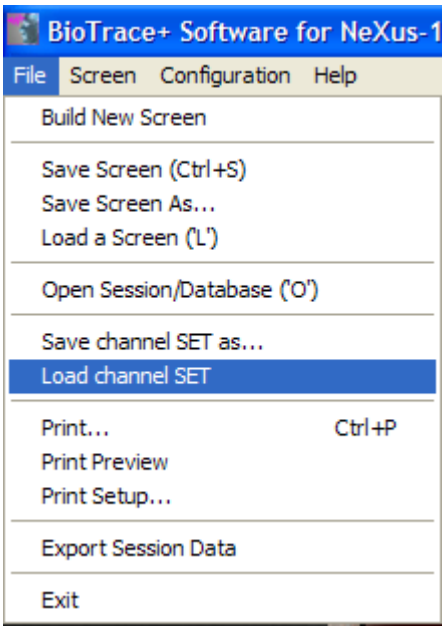
Most of the screens supplied with BioTrace+ for NeXus use the default channel set. If no channel set can be found, the software always loads this channel set by default. So therefore you do not specifically need to load the default set. However if you make changes to a channel set or create a new channel set, you can **save** this set under a new name. Use the option '**Save channel SET as…**'. (see below)



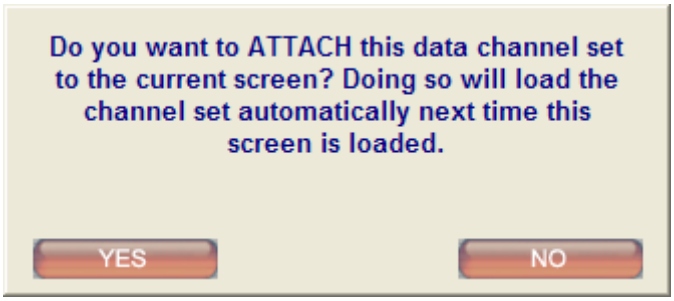
The best way to create a new channel set is starting with a given set, modify it, and then save it under a new name.

Loading Channel Sets & Attaching them to a new Screen

If you want to **load** a channel set, use the following option under the '**File**' menu:



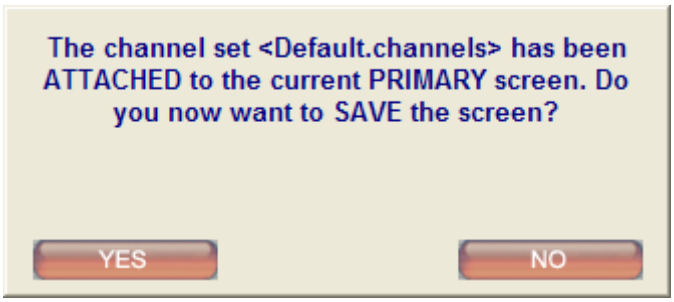
Any time you choose this option, the computer will ask you if you want to '**attach**' this channel set to the current screen.



So what does '**attaching**' a channel set mean?

It simply means that if you click the '**YES**' button in the dialog box above, this screen will **load** this specific channel set each time you load this screen. For instance if you create a channel set that contains your own new channels **AND** you have created a special new screen for it, you do not want this screen to use the default channel set. By **'Attaching'** your new channel set to it, you permanently 'link' them together.

After you have selected the YES button, the computer will ask you one more time if you want to save this screen.



If you choose **YES** again, the 'link' has become permanent.

Changing channel sets during recording

Please note: there is one exception that you should know about. During session recording, you can not change channel sets! So make sure that the screens you use during recording are all using the same channel set.

If you think about it, you will see why it makes sense:

An example*: imagine that you have two channel sets. One that contains 4 channels of EMG on inputs A,B,C and D and another one that uses these same sensor inputs for EEG and ECG. When you record a new session, BioTrace+ assumes that you know what you are doing. In other words, when you connect an ECG sensor to the chest, it assumes you know that you can't record EEG data from it. Now, when you would change from the EMG channel set to the other one, during a recording, the meaning of your signals would suddenly change. So in this example, the EMG signal on input A: would suddenly be interpreted as an EEG signal, with a different sample rate etc.*

So therefore you can not change channel sets during a recording. It would render your signals invalid, because the software would not know how to interpret them.

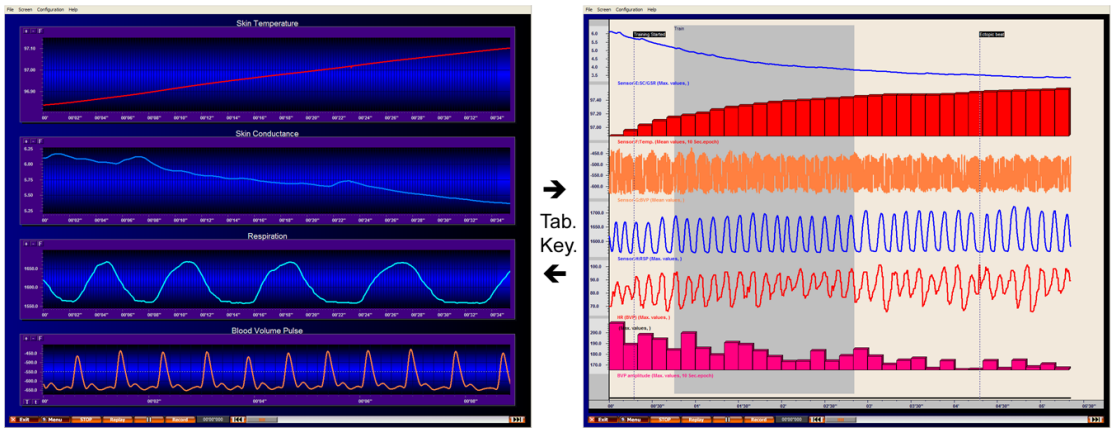
4.8 Screen modes: Real-Time & Overview mode

BioTrace+ screens run in two different '**modes**'. The first (and default) mode is the **real time mode**, the second is the **session overview mode**. Think of them as two sides of the same 'coin'. (the screen you are currently using)

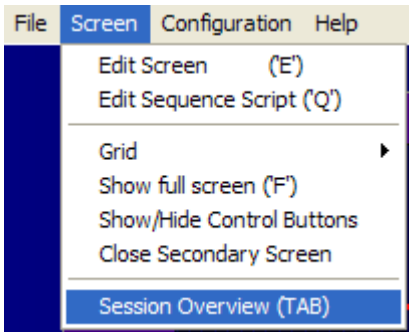
Switching between modes

The quickest way to switch between both screen modes is to use the '**Tab.**' key on your keyboard. On a QWERTY keyboard, you find this just left from the 'Q'.

'Real-time mode' **'Session overview mode'**



The other way to get there is through the following option from the main menu bar:



Note: when you create a new screen, remember that you have to create both the real-time part of the screen and the 'session overview' part of the screen. Both are saved into the same file. A single screen contains both modes.

Real-time mode functions

The real-time mode (also sometimes called the 'feedback' mode) is where you view and use all signals in (near) real-time. In other words when you recording a new session on your PC, this is where you see the 'live' signals.
This is also the screen mode that you use for generating audio-visual 'biofeedback'.

Now follows an overview of what you can do in the real-time screen:

Functions:

1) View live signals
2) Generate audio-visual feedback
3) Change channel definitions on the fly
4) Show videos, texts, images,
5) See real-time signals at full sample rate speed.
6) View frequency analysis and statistics online
7) Change scaling, colors, feedback settings etc.
8) Use step by step protocols
9) Navigate to other screens
10) Enter markers (during recording, use the 'Enter' key)

Restrictions:

11) You can only see a part of the data, up to 50 seconds
12) You can't use the offline special analysis functions

So when you want to get an overview of larger parts of the session data, or want to use the special analysis functions you should use the '**session overview**' mode.

Session overview mode functions

This screen-mode is used to see trends in the data, do statistical analysis, and perform special analysis functions, such as HRV analysis. The advantage is you can see the entire session at once (or parts of it as you zoom in). It is mainly used for offline analysis, but it can be used during live recording as well.

Functions:

1) Provides an overview of the entire session or parts (zooming) of it
2) Shows up to 64 channels on a single time line
3) Shows both raw data signals as well as statistical trends (histograms)
4) Allows you to define segments of data
5) Allows you to mark artifact areas
6) You can enter or edit markers
7) Performs fast statistical analysis
8) Performs special HRV, correlation and averaging analysis.
9) Export parts of the session to other data formats.

Restrictions:

10) Can't be used for biofeedback and other 'real-time' mode functions

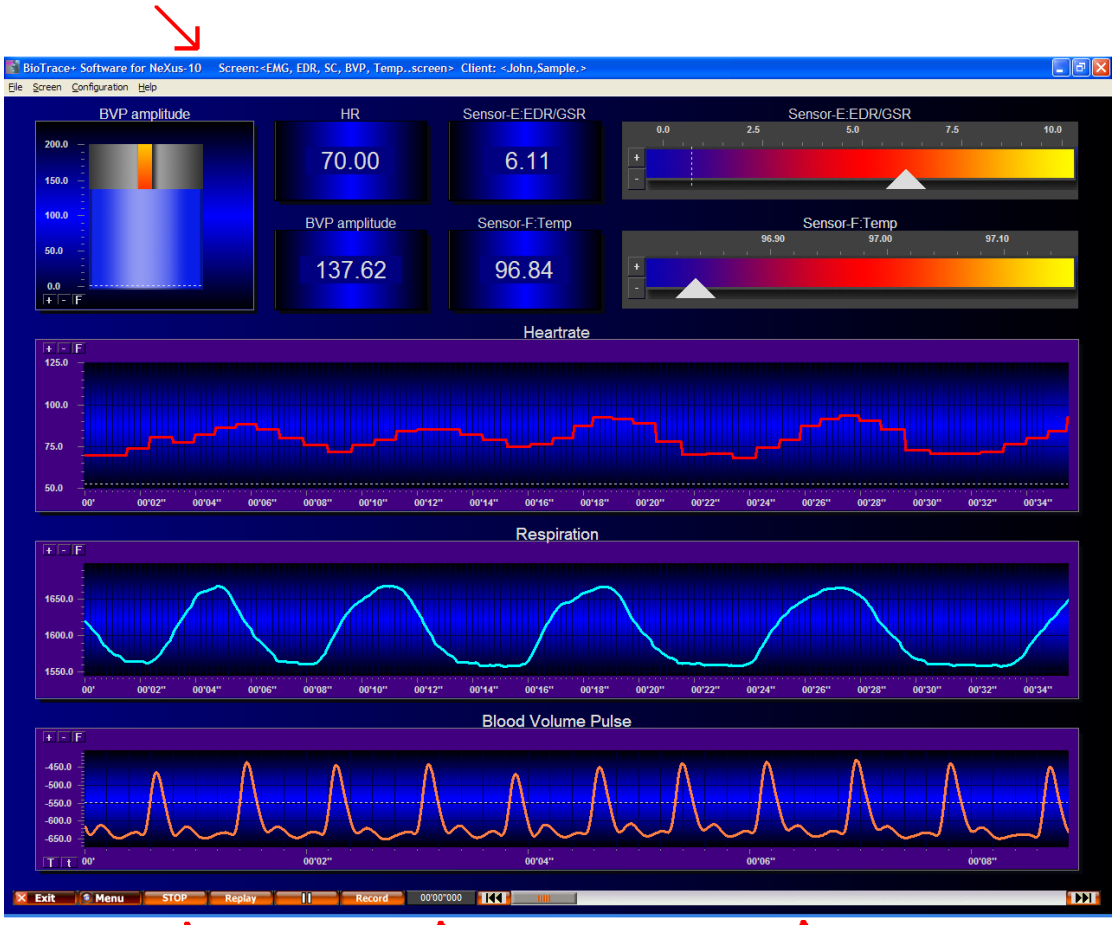
4.9 Real-Time Screen Mode

The real-time screen mode is essentially the mode that you will use when you are observing 'live' signals, use audio-visual feedback and replay old sessions.

The main elements of the screen are:

1) The caption (on top of the window) with the main menu bar.
2) The screen objects and instruments
3) The session control buttons and time-slider.

Screen caption with menu bar.

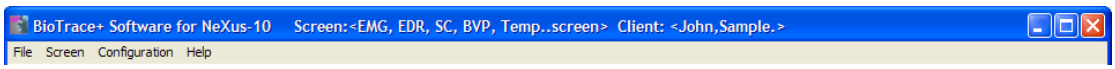


Session control buttons **Time display** **Time slider**

The screen caption and menu bar

The screen caption is used to display information about the software, **the name of the screen** and **client** that are currently selected. When you press the '**F**' key on your keyboard, the screen caption and windows taskbar (at the bottom) will disappear.

The menu bar is used to control the main functions of the software, such as loading and saving screens, opening sessions and configuring data channels and sensors.



The functions of the main menu bar are explained in chapter 4.2.

You can also use the caption to move and resize the main (primary) window. This is a standard windows function.

Use these buttons: to resize the main window.

Full screen mode

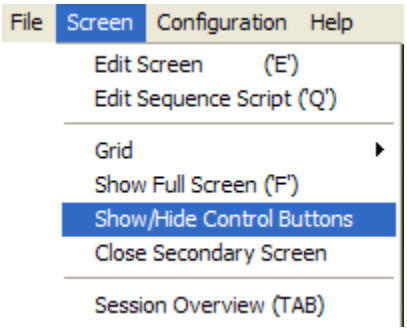
Tip: You can use the '**F**' key on your keyboard to switch to and from '**Full-screen**' mode.

The session control buttons

These buttons are used to:

1) **Exit** the application
2) Switch to the **main menu** (pressing 'Esc.' does the same)
3) **STOP** the session (while recording or replaying)
4) **Replay** a previously stored session
5) **Pause** the session (during recording or replaying)
6) **Record** a new session.

If you want to display a screen 'full screen' and want to **hide** the control buttons, you can use the following function from the main menu bar:



'**Show/Hide Control Buttons**' will show or hide the session control buttons. When the buttons are hidden and you **save** a screen, next time you **load** this screen, it will be shown without the session controls.

The time display & indication of the inhibit state

The time display, displays the current time of the point of the session where we are currently replaying/recording data. It shows hours, minutes, seconds and milliseconds.

Note: the time display will show a dark-red background when the session is recording or replaying data and one of the instruments is setting an **inhibit state**. An inhibit state will temporary stop audio or video feedback. You can use the time display to check whether inhibits are currently active.

The picture above shows the inhibit state by darkening the background of the time display.

The time slider and time key controls

The time slider can be used during review mode only (not while recording) to scroll through the session. Click inside the scrollbar and move the scrollbar while holding (dragging) the scrollbar. This function only works if a session has been loaded.

Another way to step through the session is the session control keys:

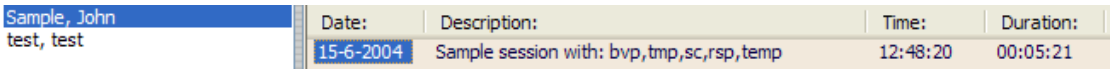
1) Left cursor (arrow) key: steps back 1 second **
2) Right cursor (arrow) key: steps forward 1 second **
3) Page-Down key: steps forward 5 seconds
4) Page-Up key: steps back 5 seconds

** Note: if you hold the '**Ctrl.**' key down while using the cursor keys, you will step through the session in steps of 50 milliseconds. This function can be useful when reviewing physiological data with synchronized video. You can step through the data one video frame at a time.

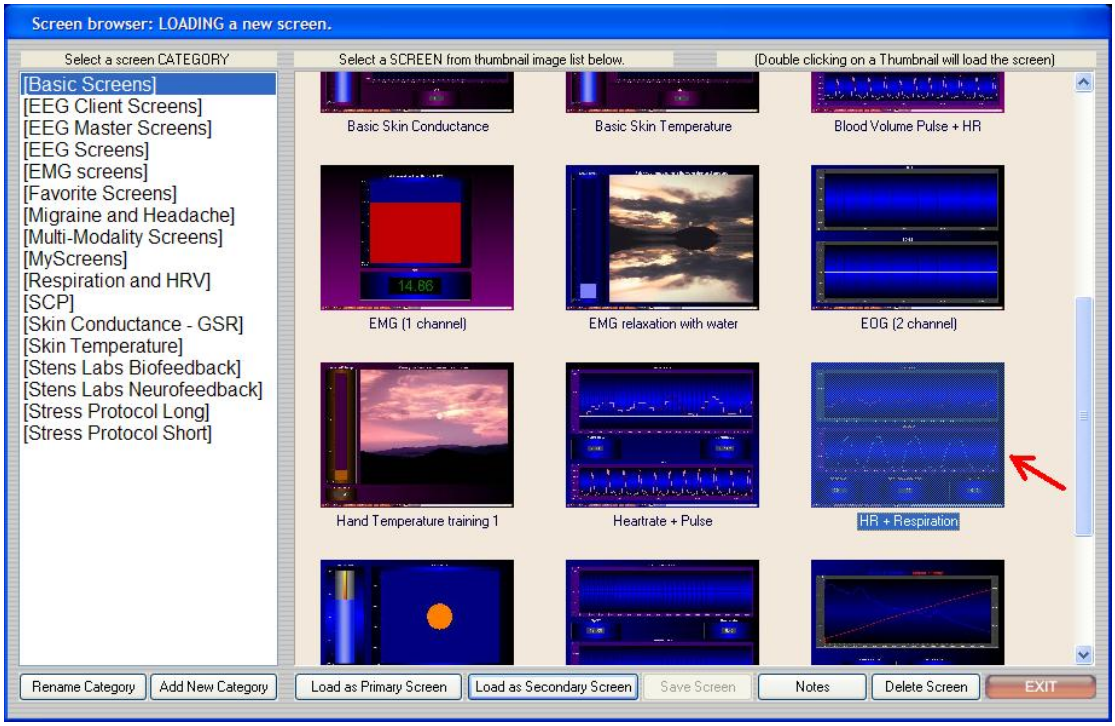
The **Real-Time screen mode** is also the mode that you will use to **Edit** screens, in the screen editor.

4.10 Session Overview Screen Mode

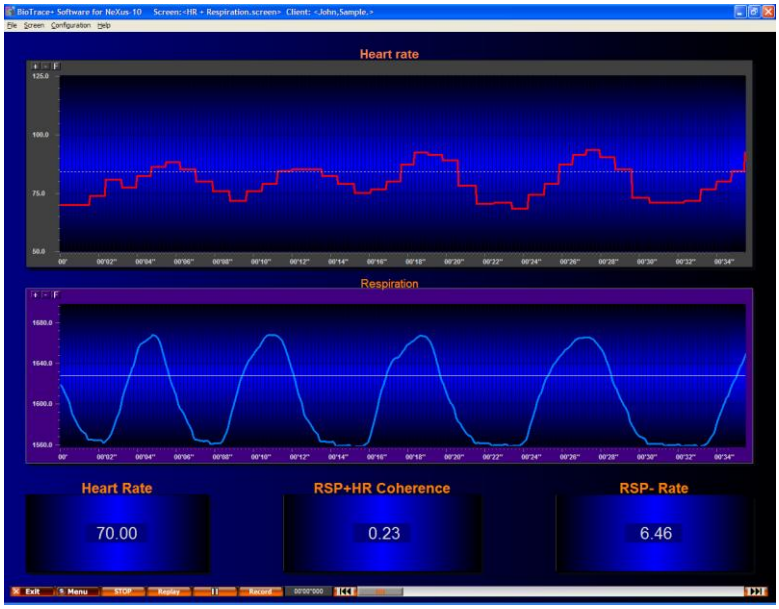
Let's now look deeper into the '**Session Overview Mode**'. In the former chapters we have discussed most of the **'real-time mode**' functions. For this example, we first need to load the 'John Sample' sample session: (Press 'O' on your keyboard)



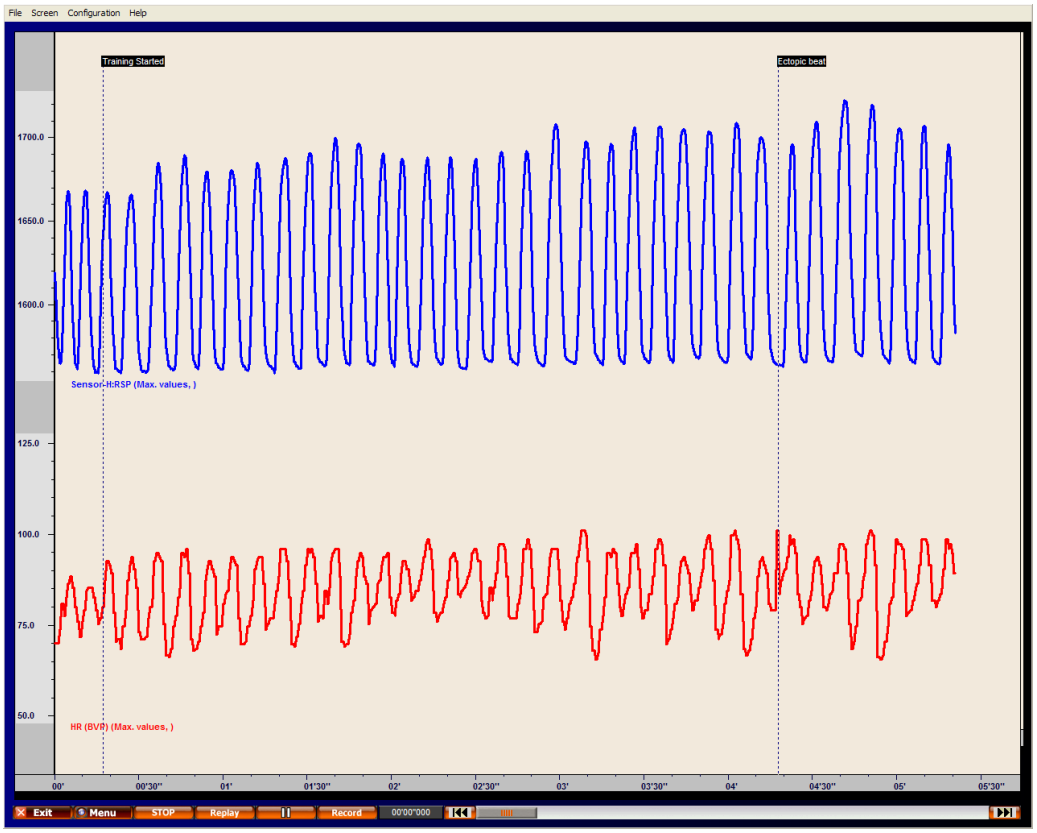
Then load the following screen: '**HR + Respiration**' from the category '**Basic Screens**' in the screen browser. (press 'L' on your keyboard)



When you double click the screen, it should appear on your screen as follows:



Now press the '**Tab.**' Key on your keyboard to switch to the 'session overview' mode. You will now see something like this: *(actual screen display may vary)*



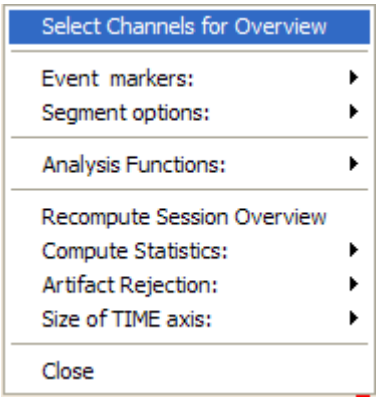
In the '**session overview mode"** this screen will display the entire John Sample session, showing 2 channels, namely

1) Respiration (the blue line)
2) The heart rate (red HR line) derived from the BVP sensor

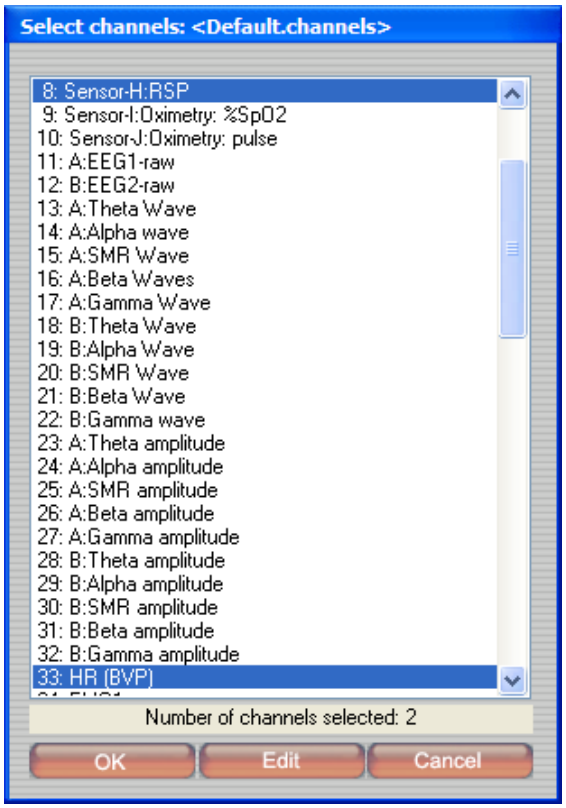
The fact that this screen displays only 2 channels, does not mean that the other signals do not exist! Remember that we got 80 data channels, but are currently only displaying 2 of them. So let's add 1 more channel.

Adding channels to the overview screen:

Right-click the overview screen, and you will see a drop down menu:

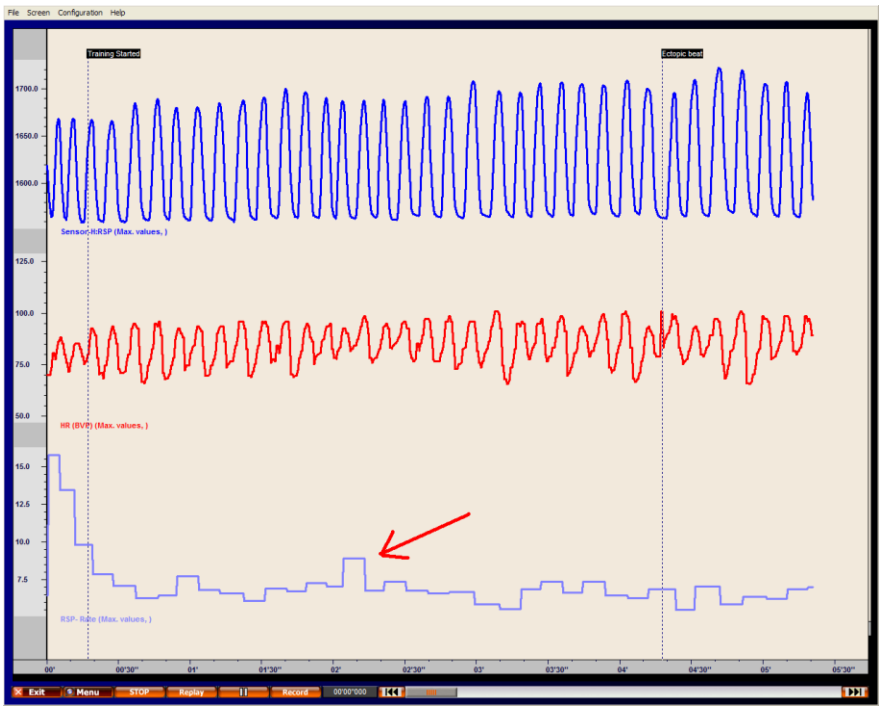


Now select the option '**Select Channels for Overview**' and another dialog box will appear:



Note that in this case, two channels have been selected (indicated at the bottom) namely channel #8 (the respiration sensor) and channel #33 (the computed HR).

We will now add a third one, channel #39 (Respiration rate). Scroll down in the list and highlight channel 39. Then press the **OK** button.

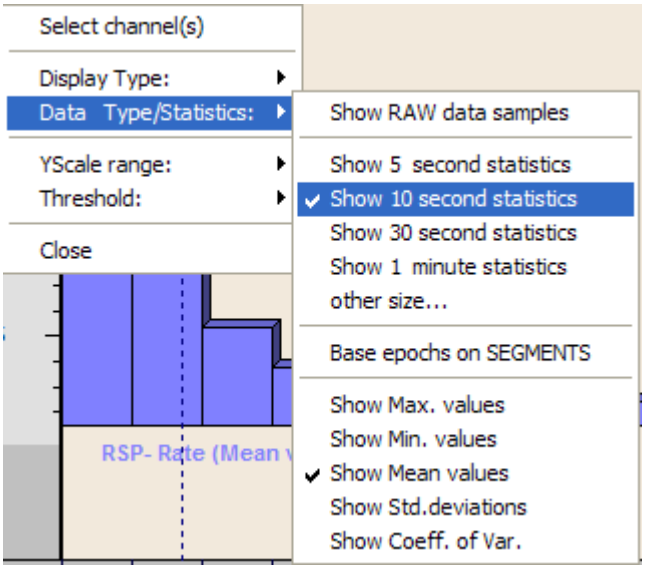


You will now see that at the bottom the channel (#39) has been added.

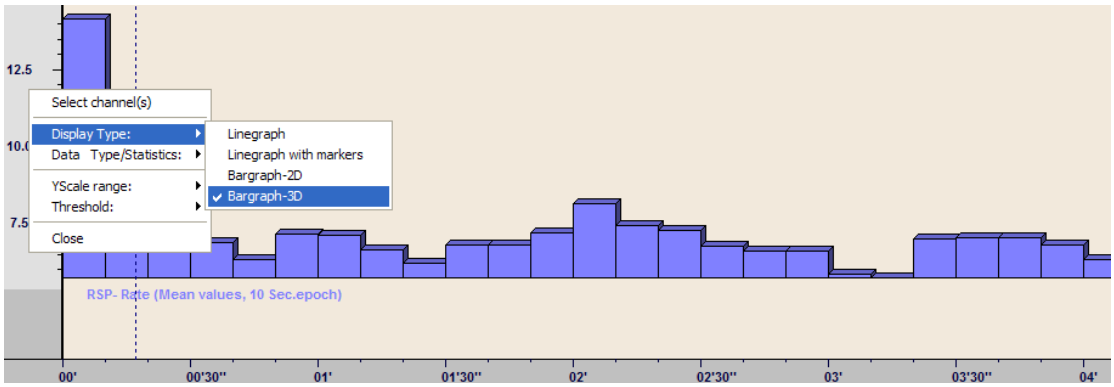
Changing the way a channel is displayed

In some cases you want to see the actual signal (such as respiration) as a line graph. In other cases it may have advantages to display the activity of a channel, over time, in another form, such as in bar graphs. (forming a histogram) The histogram would typically display the mean or maximum level of a signal over time, in steps of 5 or 10 seconds. This way it is far easier to recognize trends.

Let's modify the display type of the respiration frequency channel. You can access the properties of a channel, by right-clicking on the scale of the channel you want to change. So in this case, right-click on the scale of channel #39 and you will see a drop-down menu appear:

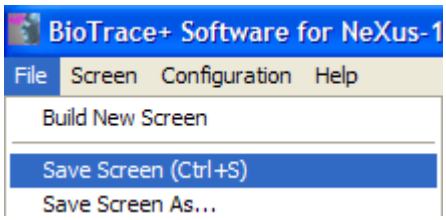


First change the **'Data Type/Statistics**' to 10 second statistics of the type '**Mean values**'. Then change the '**Display Type**' to '**Bargraph 3D**'.



After you make this change you will see a 10 second trend of the mean respiration rate over the entire session, instead of the respiration rate line graph you saw before.

If you want to keep this change, save this screen. (See the FILE menu)

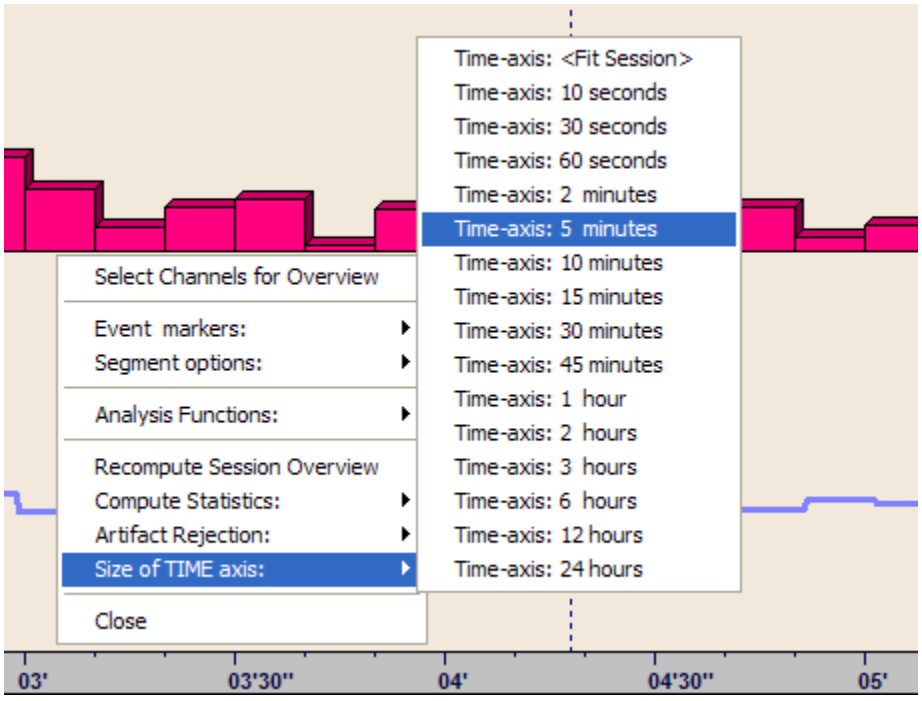


Note: when you SAVE a screen, all screen settings of both the real-time mode AND the overview mode are saved. They are saved in one and the same file.

Setting the size of the Time-Axis

You can set the size of the time-axis by using the '+' and '-' keys on your numerical keyboard. These will expand and contract the time scale by a factor 2.

Another way to set the size of the time-axis is by right clicking the overview screen and choosing the size of the time axis from a drop down menu:



Here you can set the exact size (in time) of the overview screen or choose the option '**<Fit Session**> to fit the entire session data into the screen.

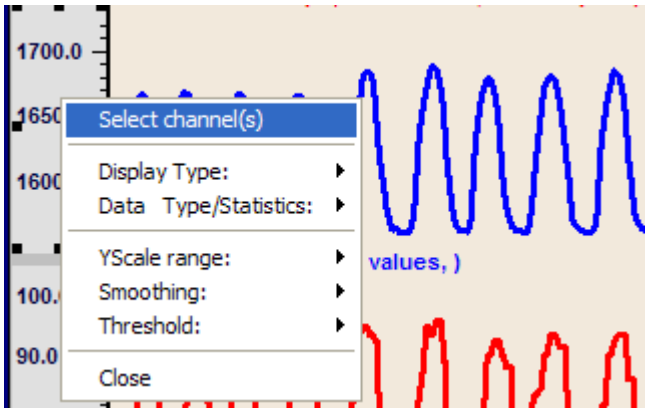
Note: pressing the '**Backspace ←**' key on your keyboard, will set the size of the overview time scale **back** to fit the **entire** session.

When you only want to view a small part, you can select a segment (part) of the session and select: the '**Zoom Selected Data'.**

Overview channel: display options

By right-clicking on the scale of a channel that is shown on the overview screen, we can select from the following options:

1) Select more channels that are to be display on the same scale
2) Select the display type (line graph/bargraph)
3) Select the data type and statistics type
4) Change the Y-scale range settings
5) Change the threshold settings

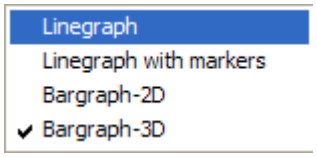


Option 1: Select channels

With this option you can add more channels to the one currently shown on the current y-scale. This way you can for instance choose to combine two or more EMG graphs on the same Y-scale. Each graph will be shown using the default color that has been defined for the channel in the channel editor.

Tip: use this option only to combine channels that are in the same y-range. Overlapping skin temperature and skin conductance will not work very well, since these have different y-ranges. Combining Alpha and Beta EEG activity on the other hand would work fine. Note: this option works only on the line graphs display type.

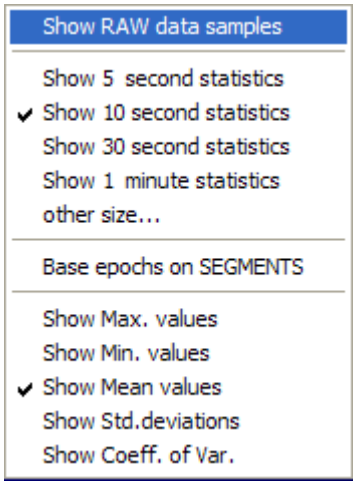
Option 2: Display Type



With this option you select the graphical way the data is displayed. You can choose from line graphs (default), a line graph with marker-points, or bar graphs.

Option 3: Data Type

With this option you select how the data is processed before it is displayed.



'Show **RAW** samples' in this case means that the data is showed without any processing. In the overview screen, this means the data is compacted to 4 samples per second when looking at parts of the session that are greater than 60 second.

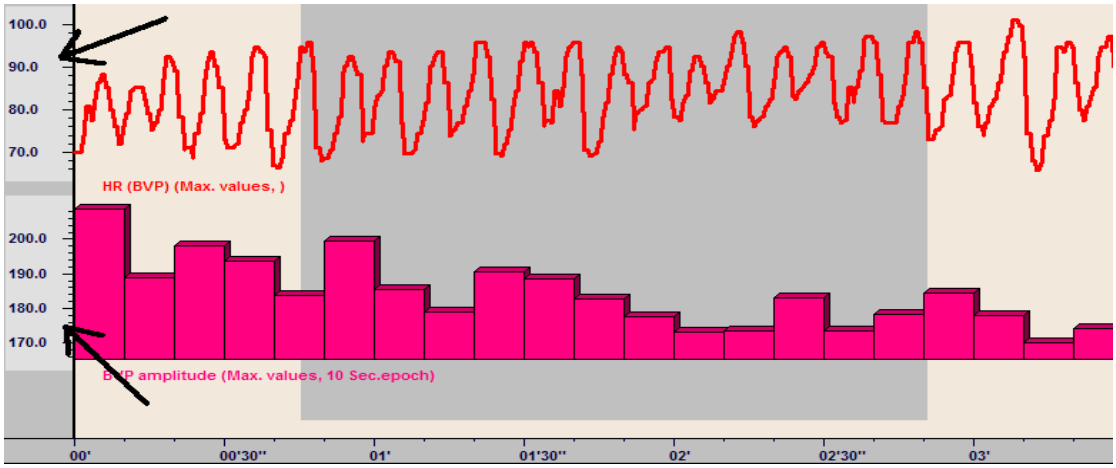
'Show **N second** statistics' means that the data is summarized over segments of 5,10,30 seconds and more. This is the option you want to choose in order to view trends in the data.

'Show **Max/Min/Mean** etc.' indicates what statistic will be used for the summary statistics. Choose 'Max.' in this case will imply that the trend of the maximum levels within an n-second statistic will be shown.

Option 4: Y-Scale Range settings

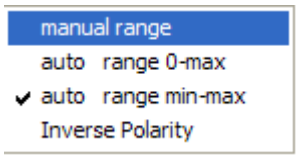
Each channel that is displayed in the overview mode, requires a Y-scale that is shown on the left side of the screen.

In the following picture, the Y-scales are indicated by the arrows. AS with any instrument that displays physiological data, you must set some kind of range, so the signals will be visible and scaled properly.



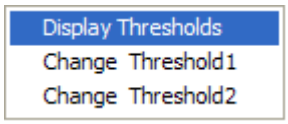
In many cases you will set an automatic range, but in other cases you may want to set a fixed range. A fixed range makes it easier to compare signals to each other. (The auto scale range will change every time you scroll through the session data)

These are the options:



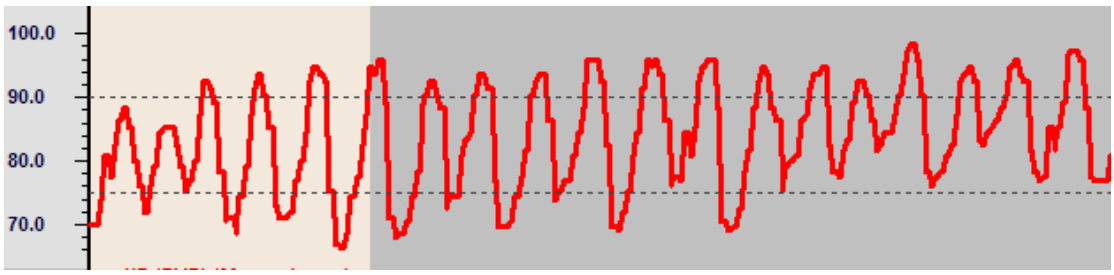
1) Manual range (you need to enter this manually)
2) An automatic range with 0 as the minimum and a floating maximum.
3) An automatic range where both the lower and upper values are set by the software. (min-max)
4) Inverse polarity. This option only inverts the display of line graphs in the Y-direction. This may be useful when displaying SCP signals, where the polarity is inversed. (negative values being plotted as going upwards)

Option 5: threshold settings



You can choose to enable (display) of the thresholds in the overview mode with the first option. ('**Display Thresholds**') The other two options enable you to enter a threshold value which will be displayed as dotted lines in the graph and which will be included in the session statistics.

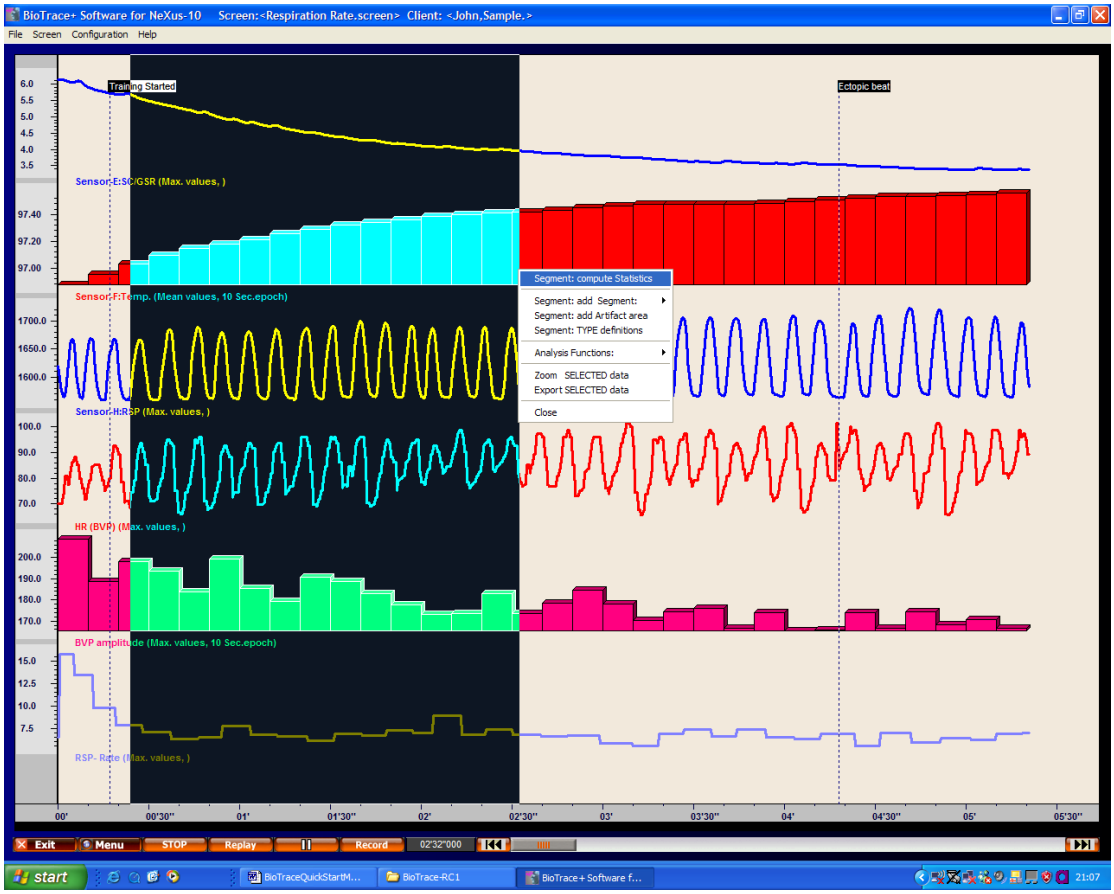
A sample of the threshold lines shown in a HR graph is shown in the next picture.



When computing statistics, the settings of the thresholds will provide an estimated value of the percentage of time the signal was above threshold-1 and below threshold-2.

Selecting and marking Segments

Segments are a way of marking selected areas in a session. A session may consist of different ‘phases’ or ‘activities’ that need to be distinguished from each other. An example is for instance the difference between the beginning (e.g. baseline) and the rest of a session. (E.g. stressor or some type of activity). Often we want to observe what physiological changes occur during different ‘phases’, ‘tasks’ or ‘activities’.



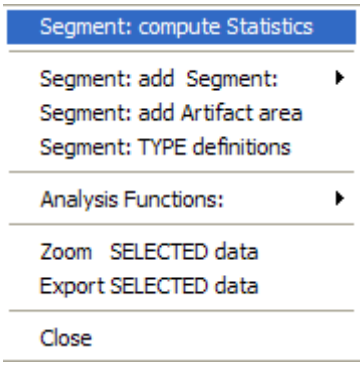
Each activity is ‘marked’ in the session, as being of a certain type. We call such a marked area, a **segment.** A segment may be only seconds long, or last several minutes.

So how do we define segments?

You define a segment by pointing with the mouse to the start of the segment, **clicking** the left mouse button **and dragging the mouse to the right**. This is called ‘selecting a segment’.

The selected segment is highlighted with a black background. When you release the mouse, a drop down menu will appear, presenting several options to you, which you can choose from. The first option is, ‘**Compute Statistics**’.

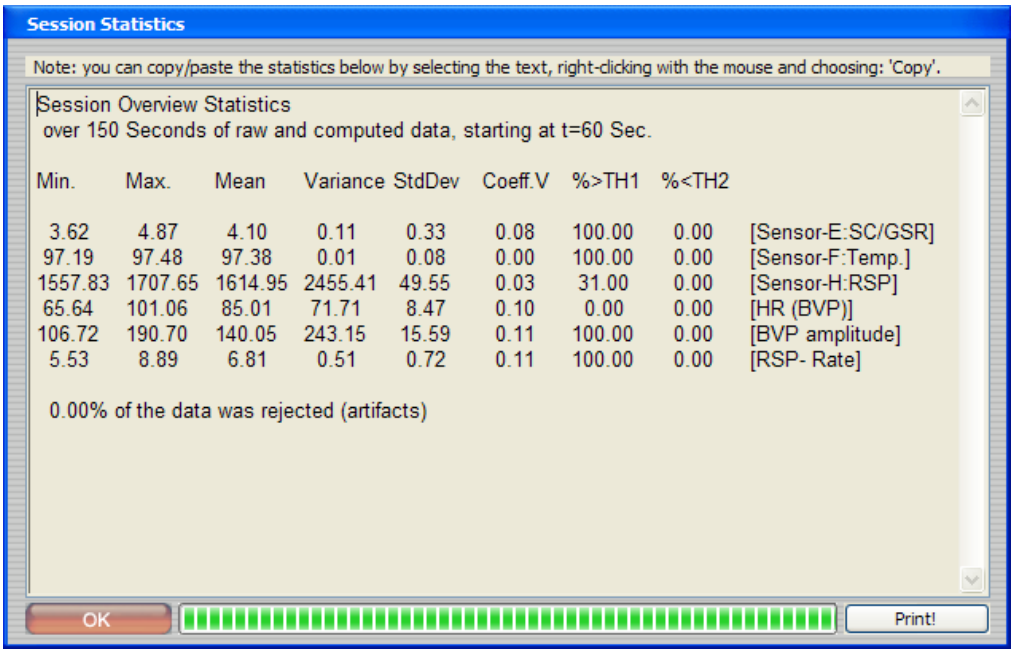
Computing Statistics on a segment



This option will compute a number of basic statistics, but only on the segment of the session that you selected (highlighted). These basic statistics are:

1) **Minimum (lowest) value found**
2) **Maximum (peak) value found**
3) **The mean (average) value of the data with the segment**
4) **The statistical Variance**
5) **The Standard Deviation (StdDev)**
6) **The Coefficient of variability (StdDev. divided by the mean)**
7) **An estimation of the % time above threshold value 1**
8) **An estimation of the % time below threshold value 2**

The following dialog box appears when the statistics have been computed:



The text in this session statistics dialog box shows the basic statistics for each channel that appears on the session overview screen. Of course the actual screen display in your case will different, you will probably use different channels, a different session and a different selection.

Copying/Pasting the statistic texts:

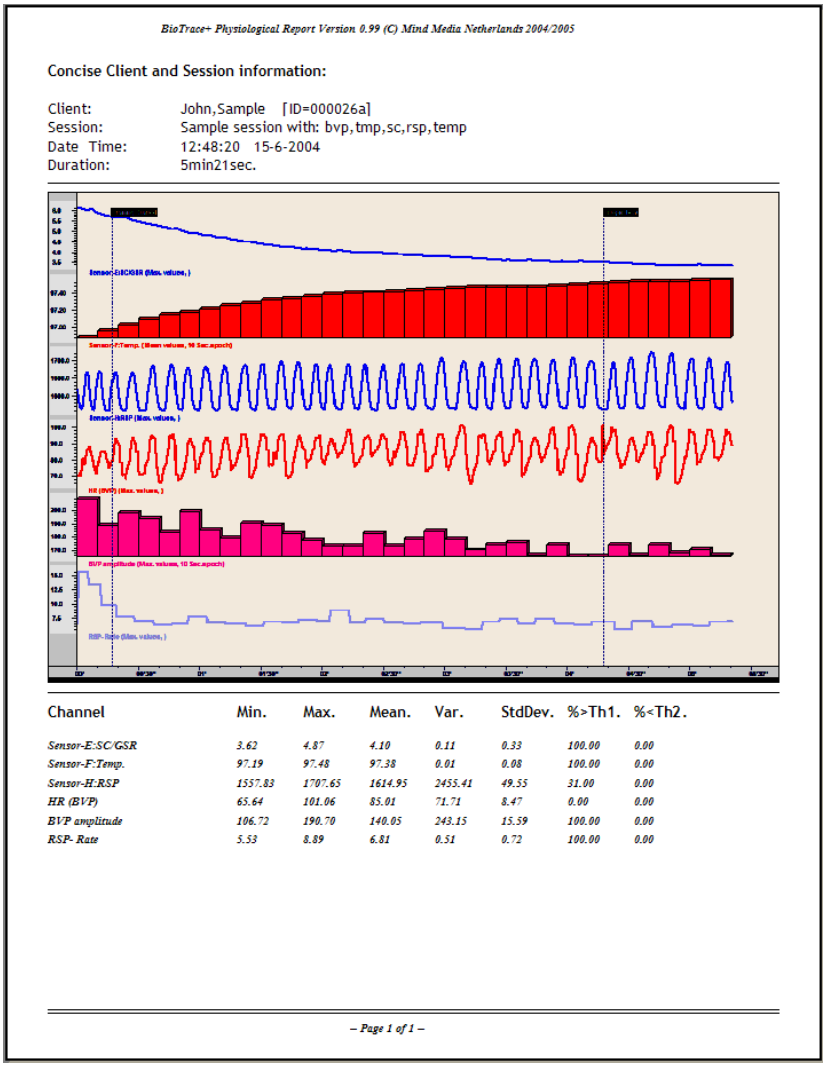
You can select the text in this dialog box by right clicking it and choosing '**Select All**' or by simply left clicking on the text and the dragging the mouse. (The same fashion you select text in a word processor) Then you right click and choose '**Copy**' or by pressing '**Ctrl+C**', which is the Windows ™ convention. Then you choose '**Paste**' in your spread-sheet or word processor, or choose '**Ctrl+V**'.

Artifact rejection:

At the bottom of the text, you find a percentage which indicates how much percent of the data within the segment was found to be within an artifact segment.

Printing the statistics:

If you click in the **'Print!**' button at the bottom of the Session Statistics box, you will be presented with a preview of the graphs, basic client information and the statistics.



BioTrace+ Physiological Report Version 0.99 (C) Mind Media Netherlands 2004/2005

Concise Client and Session information:

Client: John,Sample [ID=000026a]
Session: Sample session with: bvp,tmp,sc,rsp,temp
Date Time: 12:48:20 15-6-2004
Duration: 5min21sec.

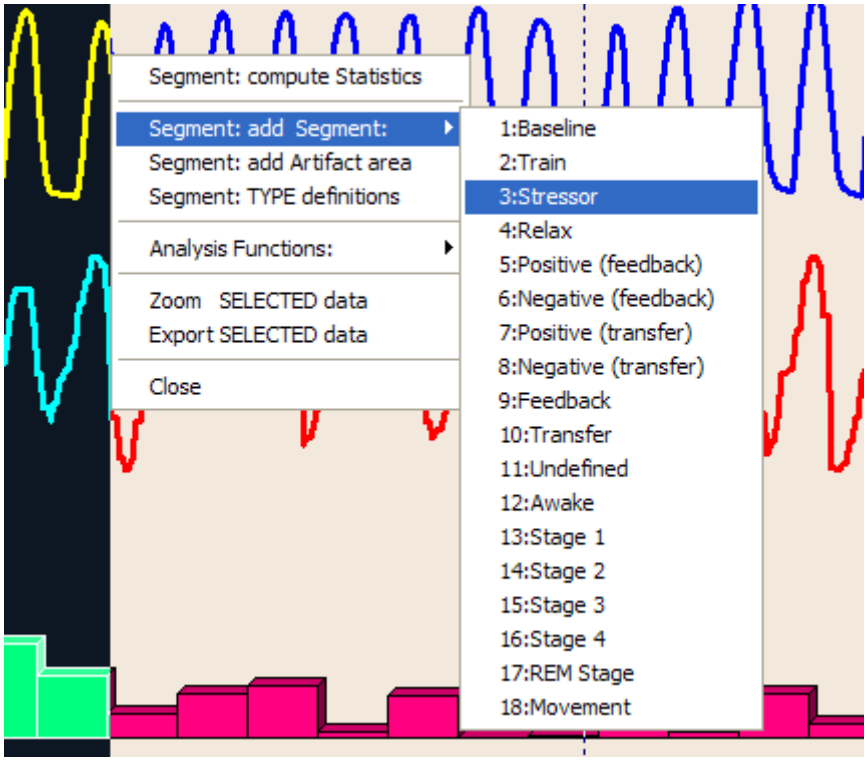
Channel	Min.	Max.	Mean.	Var.	StdDev.	%>Th1.	%<Th2.
Sensor-E:SC/GSR	*3.62*	*4.87*	*4.10*	*0.11*	*0.33*	*100.00*	*0.00*
Sensor-F:Temp.	*97.19*	*97.48*	*97.38*	*0.01*	*0.08*	*100.00*	*0.00*
Sensor-H:RSP	*1557.83*	*1707.65*	*1614.95*	*2455.41*	*49.55*	*31.00*	*0.00*
HR (BVP)	*65.64*	*101.06*	*85.01*	*71.71*	*8.47*	*0.00*	*0.00*
BVP amplitude	*106.72*	*190.70*	*140.05*	*243.15*	*15.59*	*100.00*	*0.00*
RSP- Rate	*5.53*	*8.89*	*6.81*	*0.51*	*0.72*	*100.00*	*0.00*

– Page 1 of 1 –

You can print this preview on your color or monochrome printer. Although by default the 'portrait' orientation is assumed, you may choose 'landscape' as well.

Adding Segments manually

After selecting a segment the next option that will be available, is the '**Add Segment**' option. Through this option you will keep the selected segment and mark it as being of one of the available types. (Yes: you can add your own segment TYPE definitions)

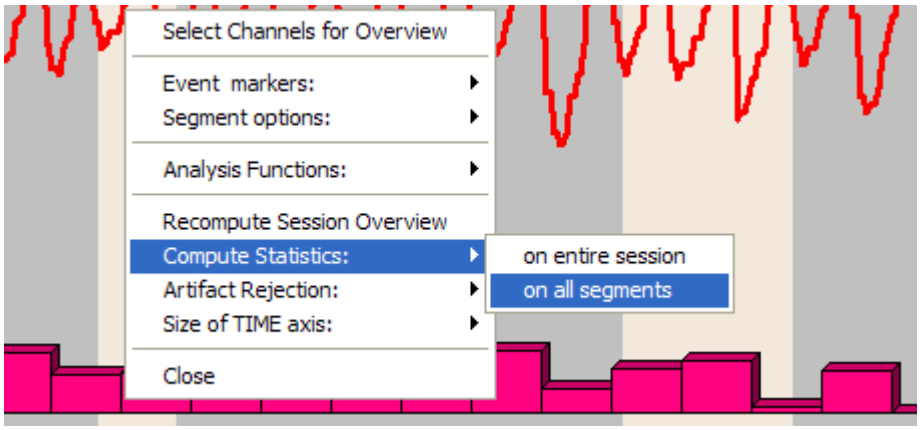


The purpose of segment is to 'mark' data as having a certain meaning.

Example: imagine a session with a 5 minute baseline, 5 minute of different types of stressors, and 5 minutes of relaxation. If you want to compare the results from the different segments, you need to mark these segments and compare the data.

BioTrace+ can compute statistics for each type of segment separately.

Computing statistics on multiple segments



If multiple segment types exist, just right-click the overview screen (without selecting any data) and choose the option **'Compute Statistics -> On all segments**'.

The session statistics box will show up, but now with the basic statistics for each type of segment.

Note: if multiple segments of a certain segment TYPE (say 'stressor') exist, BioTrace+ will summarize the statistics for all these segments in a single set of statistical results.

Adding Segments Automatically.

BioTrace+ can add (or generate) segments automatically through protocols. This is not a function you can access in the session overview mode. When a protocol is running (displaying one screen after the other in a certain sequence and with a given timing) you can define that when a specific screen is shown, it has to generate a new segment of a '**type**' that you define.

The '**sequence editor**' is one of the places where you can define this.

Marking Artifact Areas

Artifact areas, are special types of segments, that mark a part of your session as being 'invalid'. When BioTrace+ computes statistics, these artifact areas will be skipped.

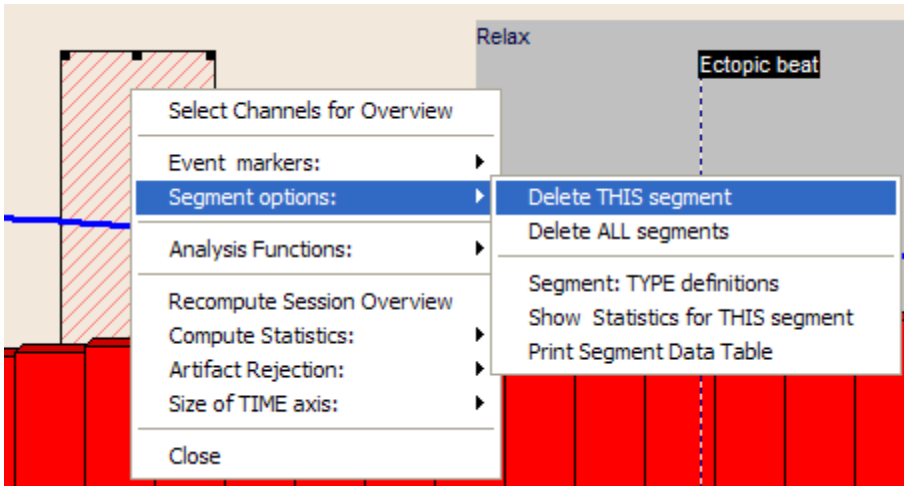
You mark a new artifact area by selecting a segment (left-click and drag) and choosing the '**Segment: add artifact area**' option from the menu that appears when you release the mouse. The Artifact segment will appear as a red cross hatched area.

Note that the data in the artifact area will not be deleted, it is only 'marked' as being artifact. You can remove the artifact segment mark later on if you like.

Deleting Segments

When you want to delete a marked segment, you can simply select the segment by (left) clicking on it.

The segment (in the example below, we selected an artifact area) will now show black 'handles' around it. Next, click the right mouse button and a drop down menu appears:



You can choose now to delete 'THIS' segment, or even all segments. Please note again, that only the segment selections (markings) will be deleted. The actual data itself will remain intact.

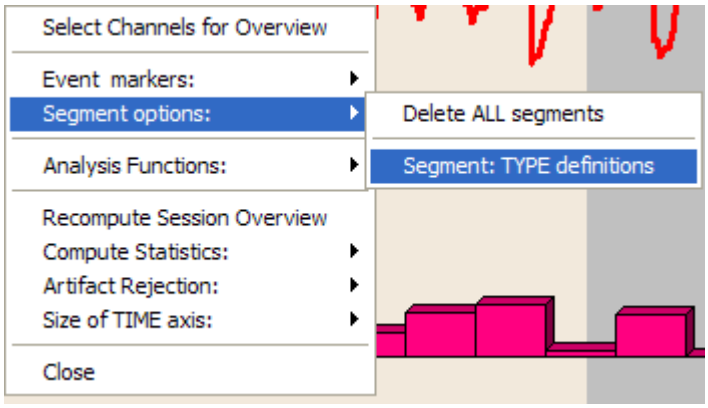
Another way of deleting segments, is even simpler. Simply select a single segment (left click it) and press the '**Delete**' key on your keyboard. A message box will appear that wants you to confirm that you really want to delete it.

Press the '**YES**' button to delete the segment, or '**NO**' to cancel.

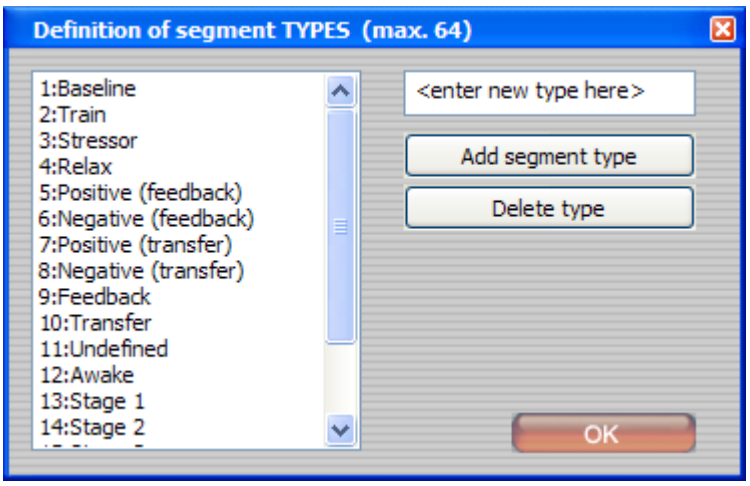
Defining and adding your own Segment Types

BioTrace+ has a number of standard types of segments built-in. But you can add your own type definitions to this list.

Right-click the session overview screen and choose the option **'Segment options: -> Segment: TYPE definitions'**. You do not need to select a segment for this option to work.



After you click this option, the following dialog box will be shown:



You enter the text of a new type in the text field (on the right-top) and then press '**Add segment type**' to add it to the list. The new entry will be placed at the bottom of the list". If you select '**Delete Type**', the segment type at the bottom will be removed.

The **'OK**' buttons leaves and closes the dialog box.

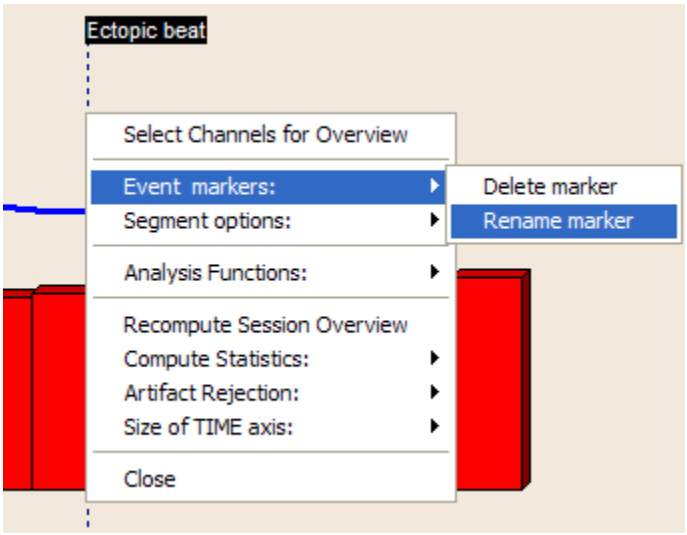
Note: BioTrace+ supports a maximum of 64 different types of segments.

These new segments type definitions will be saved when you close the application, so that next time you start up the application, they will be there.

Defining and Adding Event Markers

Markers are, just like segments, a visual way of 'labeling' your data. An event marker however has no size. It is a single point in time when something is marked. Event markers can be entered manually or automatically. They are stored internally with a 1 millisecond precision.

Event Markers are represented visually by a single vertical dotted line in your session overview. (See sample below)



Selecting a marker:

If you move the mouse over an event marker, the mouse will turn into a double arrow (pointing two ways horizontally ←→) indicating you can move it or edit it.
Right clicking will bring up the drop down menu that you see in the picture above.

You add markers by:

1) Pressing the **ENTER** key during live session recording. (you can enter a text, while the session recording continues)
2) Pressing the **SPACE-Bar** during live session recording. This way you do not enter a text, but an automatic marker text will be generated like 'Marker-1", "Marker-2" for each time you press the space bar.
3) Selecting **automatic marker** generation in your protocols. When a specific screen is shown in a sequence of screens, you can tell the software to set a marker (at the point where the screen becomes visible)

Deleting and Renaming Event markers

By selecting a marker and choose the menu options shown above, you can **rename** or **delete** an event marker.

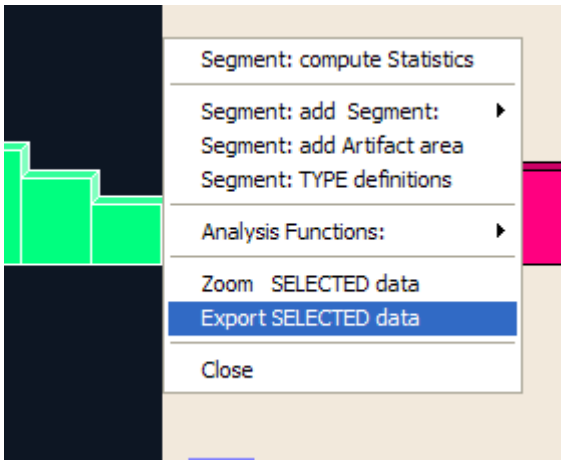
You can also select a marker (←→ symbol will appear) and then press the '**Delete**' key on your keyboard. This will delete the event marker as well.

Exporting Session Data

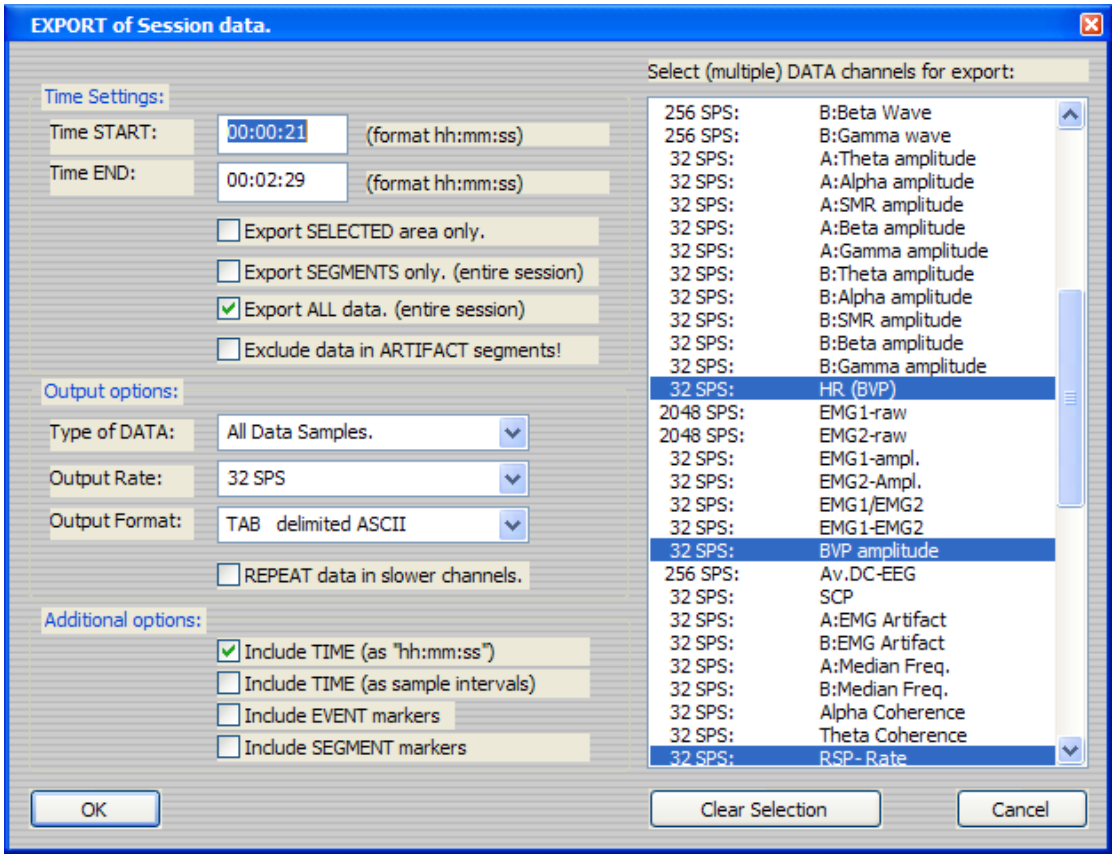
In some cases you will want to export data from the BioTrace+ software to another application for very specific data processing or statistical analysis.

BioTrace+ can export its data to ASCII formatted files that your can read with applications such as SPSS ®, MatLab ® or MS Excel ®.

There are two ways to export data from a session. The first is to go through '**File**' in the main menu bar. The second is to select (highlight) a segment of data in the session overview screen, and then choose '**Export Selected Data**' from the drop down menu:



This option will bring up the Session Export dialog box:



In this dialog box you can make the following selections:

1) The channels you want to export
2) The **start** and **end** of the segment of data you want to export (this is usually already filled out when you have selected export of a selected area)
3) **What** data you want to export. (the selected area, or the entire session)
4) You can exclude artifact segments
5) The output (sample) rate of the data
6) The output format (TAB separated ASCII)
7) Whether you want repeat slower data channels (Example: if you export two channels, one fast at 2048 SPS and one slow at 128 SPS, the '**repeat**' will fill in the gaps between the two
8) What you want to include: time, event markers, segment markers, etc.

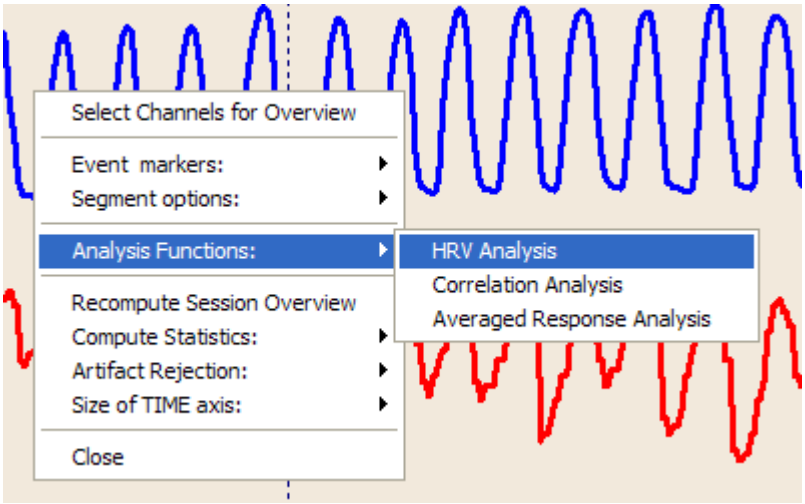
Important: when you select multiple channels that have different sample rates, you may want to select the highest sample rate as your OUTPUT rate. That will mean that your slower data will be '**up-sampled**' or repeated and no data is lost.
When you choose a **slower** sample rate than the fastest channel (say your fastest channel is EEG sampled at 256 SPS and you choose 128 SPS as output-rate), it will mean your faster channel will be '**down-sampled'** and data will be lost.

A short sample of EXPORT output data is shown below, note that slow sensor data is repeated.

```
RAW Data export file (tab separated)


Client:   John,Sample
Session:  Sample session with: bvp,tmp,sc,rsp,temp
Date:     6/15/2004
Time:     12:48:20 PM
Duration: 31   Seconds.
Output rate:   128  Samples/sec.

hh:mm:ss  32 SPS    128 SPS   32 SPS
TIME Sensor-F:Temp  Sensor-G:BVP   HR (BVP)


00:00:29  36.144    -621.474  67.965
00:00:29  36.144    -623.690  67.965
00:00:29  36.144    -626.359  67.965
00:00:29  36.144    -628.380  67.965
00:00:29  36.144    -630.677  67.965
00:00:29  36.144    -633.006  67.965
```

4.11 Session Overview: Analysis Functions

In the session overview (screen) mode, you have access to a number of special functions, beside the statistical functions. The way to get to these functions is by right-clicking the overview screen, and choosing the option: '**Analysis Functions**'.



You can use these functions without selecting a segment. In that case the software will 'select' the entire session and assume the function will apply to the entire session. If you select a segment and then choose the '**Analysis Functions**' the function will only apply to the selected segment.

The functions you can currently ** choose from are:

1) **HRV (heart rate variability) Analysis**
2) **Correlation Analysis**
3) **Averaged Response Analysis**

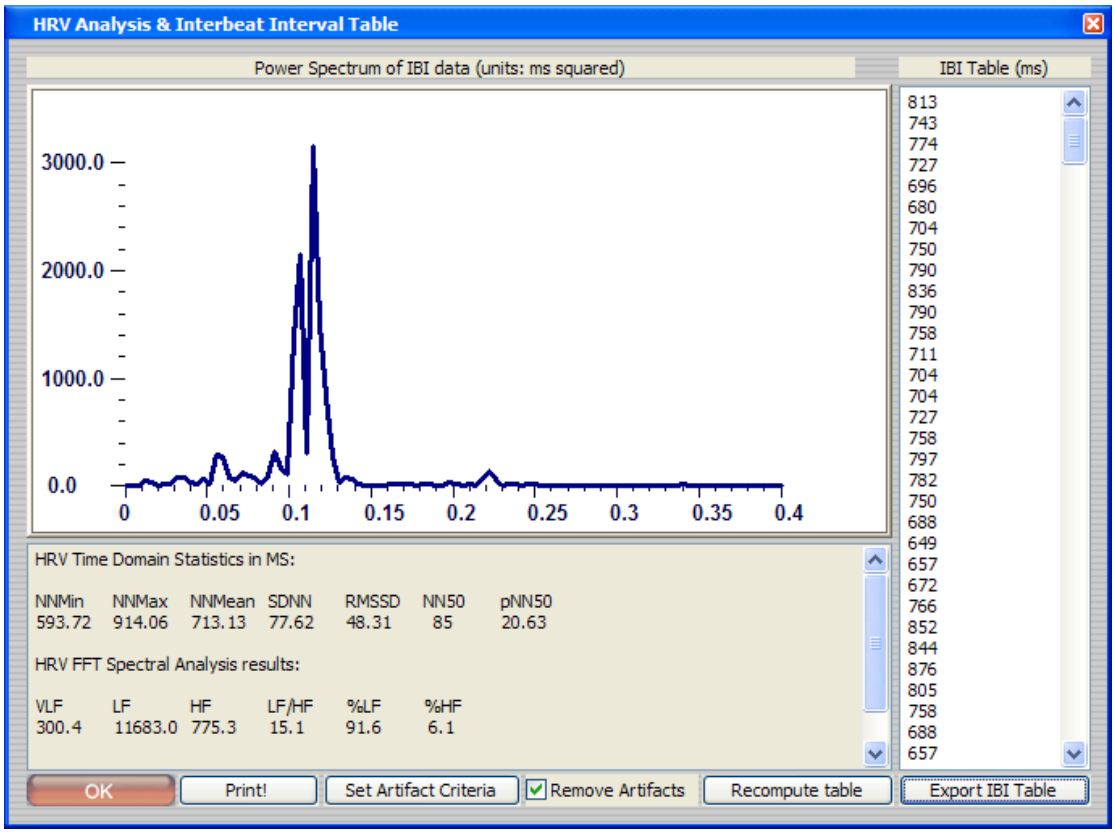
** *More functions will be added to future versions of BioTrace+.*

HRV Analysis Function

This function can only be applied to sessions that contain **HR** (heart rate) data, derived from a BVP sensor or an ECG signal. (electrocardiogram)

Background information: the **heart rate** is computed by BioTrace+ by taking the peak to peak distances between beats (also called the inter-beat interval or IBI). The software uses a function called '**pulse rate**' to compute this data. The resulting HR values are usually expressed in beats per minute. Another measure however, that is commonly used by researchers, is the '**inter-beat interval'** which is expressed in milliseconds. A HR of 60 beats per minute, translates into an interbeat interval of 1000 ms. The original pulse signal (from BVP or ECG) is sampled at a sample rate of 128 to 2048 samples / second. That means that the precision of the IBI interval ranges from about 8 (128 SPS) to 1 millisecond (2048 SPS). For clinical use, the BVP usually provides enough precision. For research we advise to use the ECG signal.
In the session overview, the IBI values are computed and 'sampled' at a rate of 4 times per second. The software generates a table of all the IBIs it found and uses this table to compute the HRV statistics. The IBI table can be exported to other software.

You can either select a segment of data, or simply ‘right-click’ the overview screen and choose the ‘**HRV analysis**’ function straight away. (This means the whole session is used. After computing the statistics, the following dialog box will be shown:



The graph that you see above, shows an estimation of the **power spectrum** of the (de-trended) HR data, using the IBI values (ms) as it’s source. The result therefore is in squared milliseconds. The power spectrum is computed by a 1024 point FFT (fast Fourier transforms) on the IBI data, which is time sampled at 4 SPS.

Below this graph you can find the **standard HRV statistics**. In scientific HRV literature the interbeat interval (IBI) is called a ‘normal to normal’ interval or NN value. The IBI data used for generating the NN statistics has to be ‘de-artifacted’ before the statistics are considered valid. The statistics output is:

NNMin	The smallest interbeat interval (IBI in ms)
NNMax	The largest IBI
NNMean	The average IBI
SDNN	The standard deviation of the IBI table
RMSSD	The square root of the mean of the sum of differences between Subsequent interbeat intervals.
NN50	The number of subsequent pairs that differ more than 50 ms
pNN50	This number expressed as a percentage of the total
VLF	Very low frequency power from 0.0033 to 0.04 Hz
LF	Low frequency power from 0.04 to 0.15 Hz
HF	High frequency power from 0.15 to 0.4 Hz
LF/HF	Ratio of the LF over the HF
%LF	The percent power of the LF (of VLF+LF+HF)
%HF	The percent power of the HF (of VLF+LF+HF)

The IBI table

On the right side of the dialog box, you see the IBI table. This is a text field, holding ASCII data that you can select and **copy/paste** to another application. Alternatively, you can '**Export**' the IBI table to a text file, which you can 'import' from other applications.

IBI Artifact Rejection

Please note that this IBI table contains NN intervals that are de-artifacted by the software in the following ways:

1) The software already rejects unlikely IBIs values during the computation of the HR. It for instance rejects values that are below 40 beats per minute and over 240 beats per minute. It also rejects peaks (beats) that contain too much (EMG) noise or have a difference that is greater than 30 BPM as compared to the last detected beat. You do not have to select this. However this is no guarantee that all IBI data is free of artifacts. **
2) The IBI table can reject beats (IBI values) in segments that you define as being '**artifact areas**'. (you have to select this) **
3) The IBI table can reject beats (IBI values) in segments of the session that fulfill certain **automatic artifact criteria**. (you have to select this) **

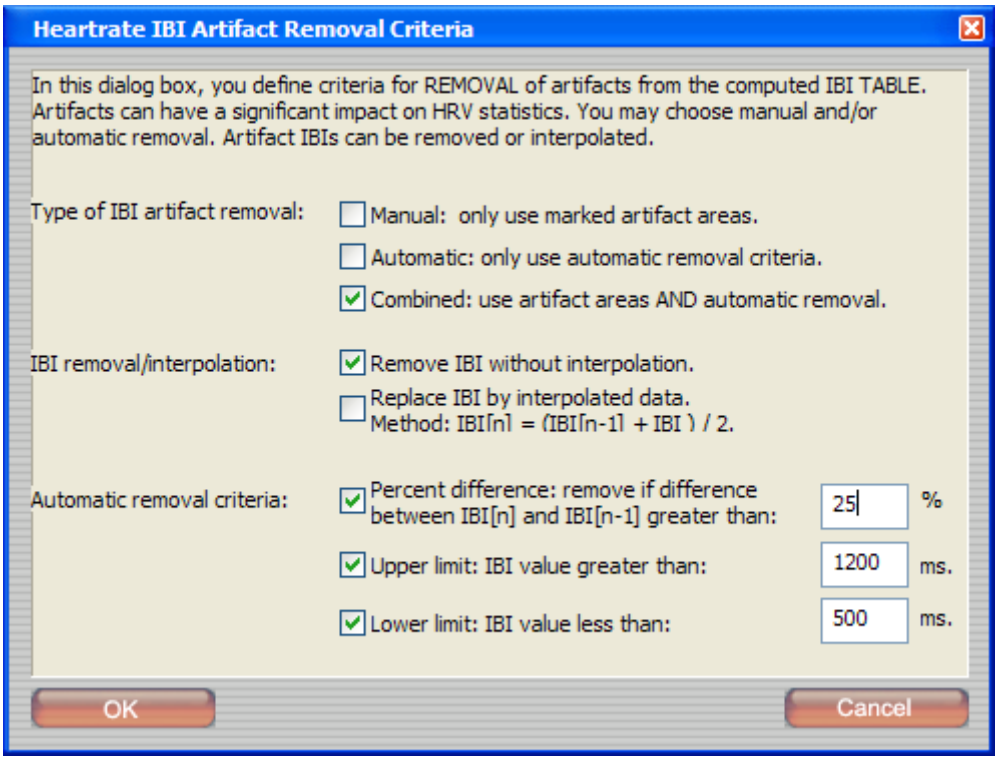
You can check (or uncheck) the check-mark that says '**Remove Artifacts**' in order to set or clear the artifact removal.

Press the button '**Recompute table**' to recompute the IBI using the current (new) artifact settings.

****** Note: visual inspection of the IBI table and the original source signal (such as the BVP or ECG) always remains necessary in order to make sure the IBI tables contains as little artifacts as possible. However, even after artifacting, the IBI table may (and probably will) still contain an unknown number of artifacts.

Definition of Artifact Criteria:

Click the button labeled '**Set Artifact Criteria**' to open the dialog box where you can define how the software should 'filter' the IBI table. The following box appears:



You can choose from the following options:

1) **Manual Artifact removal**. This option only uses the manually marked artifact areas to reject 'bad' IBI data.
2) **Automatic Artifact Removal**. This option will include all IBI table (also those within artifact areas) and only use the '**automatic removal criteria**' to reject 'bad' IBI data.
3) **Combined**. This option combines manual and automatic removal. So it will reject any data within a manually marked '**artifact area**' and data that fulfills the '**automatic removal criteria**'. **

***** *Removal in this case means that these IBI values are being skipped, and thus removed from the IBI table. No session data will be removed.*

Next you need to decide what to do once you reject IBI values. 'Removing bad IBI data' from the IBI table may sometimes mean you are left with a gap. The gap may impact you statistics in a way that you don't want. You can choose from two options:

1) **Remove IBI without interpolation**. This factually, leaves the 'gap' in place. No data is added to 'fill' the gap.
2) **Replace IBI by interpolated data**. This will replace the 'bad' IBI value that will be 'removed' from the IBI table, by the average of its value and the last (valid) value at index-1. In fact this is a solution which doesn't leave a gap but 'smoothes' out the effect of 'bad' IBI data.

Automatic removal criteria:

As the last option, you have to select **how** you want to define 'bad' IBI values. There are 3 options:

1) You define a **percent difference** between subsequent IBI values. If the difference is too big, you assume the IBI data must be 'wrong'. Imagine that someones HR seems to go up, within one beat, from 60 to 120 beats per minute. (equals an IBI difference from 1000 to 500 ms) This is physiologically rather unlikely, so you may define here that you only accept differences up to 25%. **
2) You can set an **upper limit** of what HR data (IBI millisecond value) you want to accept. If you enter a value of for instance 1200 ms here, it equals a HR of 50 bpm. **
3) You can also set a **lower limit** for the HR. Setting a value of 500 here would equal a heart rate of 120 beats per minute. (2 beats per seconds means 0.5 second interbeat interval equals 500 ms) **

** Please note that no absolute or fixed criteria exist for defining what IBI values are artifacts and which are not. The HRV statistics use NN intervals that are based on de-artifacted HR data. You define what artifacts are and what are not. Henceforth the statistics that the software computes are impacted by your definition of what artifacts are. The automatic removal is only a tool for supporting you in de-artifacting the IBI data.

Tip: if you are doing research, you can export the IBI table and compare the (de-artifacted) results of BioTrace+ with other HRV software applications. It may take some tweaking and tuning to get the best results.

Printing a HRV quick report

Press the button labeled '**Print!**' in the HRV statistics dialog box to show a preview of the HRV statistics report. An example of such a report is shown below.
(Actual screen display may vary)

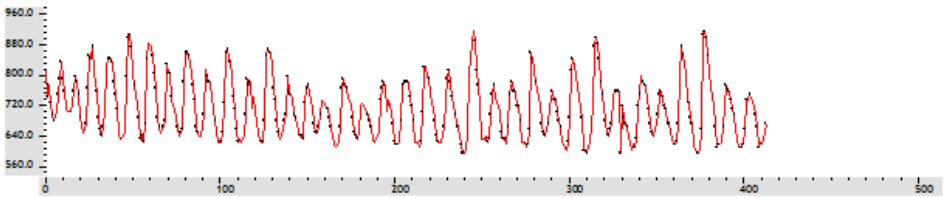
BioTrace+ Physiological Data Statistics Report Version 1.0

Concise Client and Session information:

Client: John,Sample [ID=000026]
Session: Sample session with: bvp,tmp,sc,rsp,temp
Date Time: 12:48:20 15-06-2004
Duration: 5min21sec.

Heart Rate Variability Analysis. *HRV channel 33:HR (BVP). 128 Samples/Sec.*

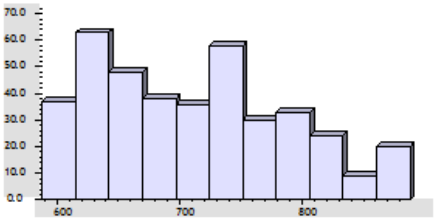
Graphical overview of the RR Intervals (IBI table)



HRV Statistical Results

Statistic	Unit	Value
NNMin	(ms)	594.00
NNMax	(ms)	915.00
NNMean	(ms)	713.61
SDNN	(ms)	77.66
RMSSD	(ms)	48.31
NN50	(count)	85
pNN50	(%)	20.63

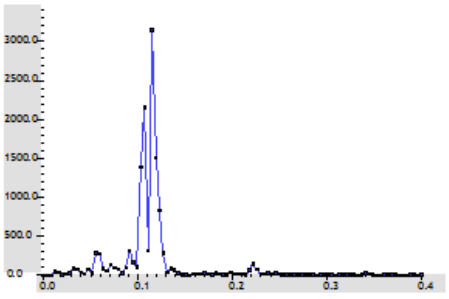
IBI Distribution



HRV FFT Results

Frequency	Unit	Value
VLF power	(ms^2)	300.5
VLF %	(%)	2.35
LF power	(ms^2)	11710.9
LF %	(%)	91.55
HF power	(ms^2)	779.9
HF %	(%)	6.10
LF/HF	(ratio)	15.0

HRV Spectrum



Artifacts: 0.0% of the IBI data (0 beats out of 412) were rejected.
Note: The HRV Spectrum (0-0.4Hz) uses a non parametric FFT (1024 points) on detrended RR intervals, interpolated at 4Hz.

~ Page 1 of 1 ~

Above this preview a number of buttons will be shown. If you press the '**Print**' button you can print the page on the printer of your choice.

If you choose a color printer, the report will be printed in color. If you choose a monochrome printer the printout will be in black and white.

The Correlation Analysis function

The correlation analysis function provides you with an estimate of the linear correlation between two source signals.

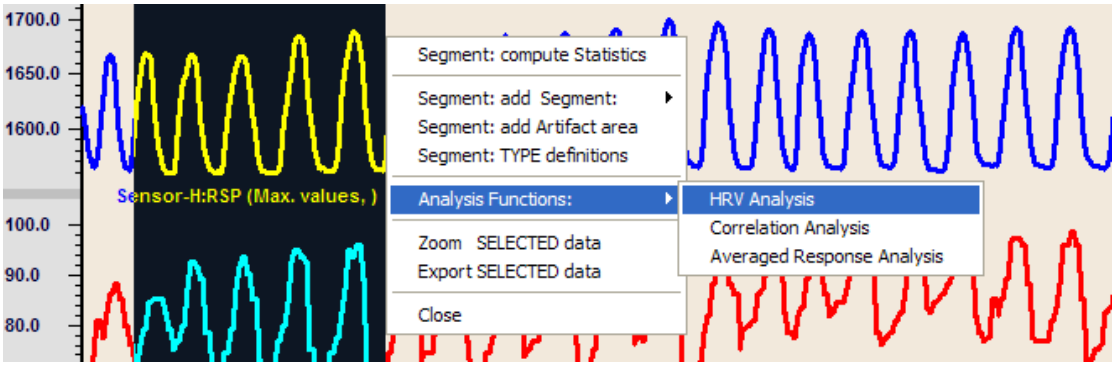
This function uses a Pearson Product Moment on epoch based channel data. Epochs contain summary data and statistics, which are stored 4 times per second. Therefore the correlation function works well on analyzing slow signals or trends over longer time periods. (Greater than 10 seconds) Slow signals in this case mean physiological activity generally below 10 Hz. Examples of some 'slow' signals:

- **The respiration graph and the respiration frequency**
- **Heart rate (HR)**
- **Skin Conductance**
- **Slow Cortical Potentials**
- **Skin Temperature**
- **BVP amplitude (vasoconstriction/vasodilation)**
- **Theta, Alpha and SMR amplitude**

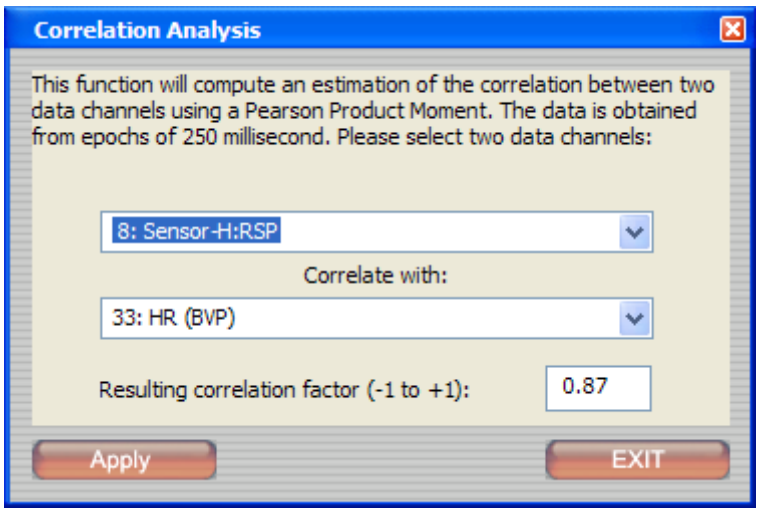
This correlation function will not work well when correlating fast signals such as:

- **raw EEG, ECG or EMG**

This function always needs two source channels. For example, select a segment of session data and choose '**Analysis Functions: → Correlation Analysis**'



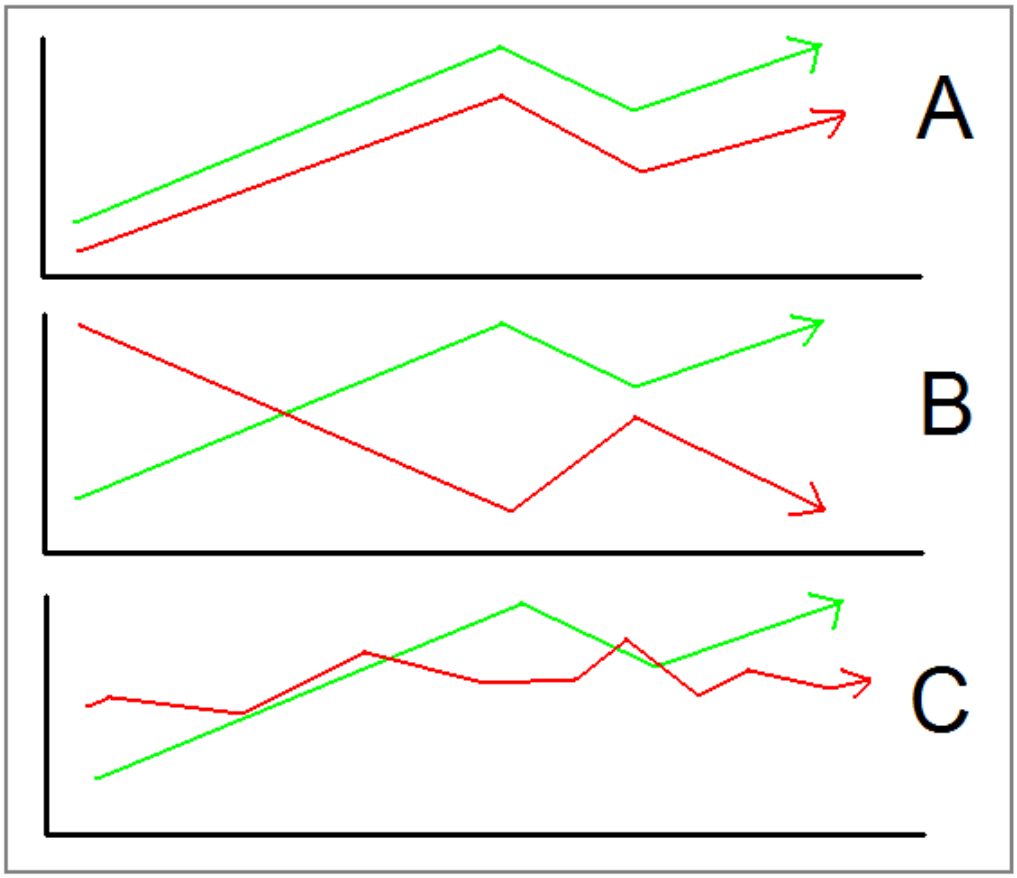
The following dialog box will be shown: (*in this sample we use HR and Respiration)*



In this example we compute the correlation between the computed HR (heart rate) which was derived from the BVP sensor, and the respiration activity. The sample session we analyze contain HR and RSP data acquired during an abdominal breathing exercise. Due to the RSA (respiratory sinus arrhythmia) effect, which increases the HR during inhalation and decreases it during exhalation, we expect to see a positive correlation.

To obtain the estimate of correlation, press the '**Apply**' button. In this example a value appears that is **0.87**, indicating high correlation between the HR and RSP signals.

If two signals correlate positively, it means that they 'move' in the same fashion. So when one signal goes up (or down), the other goes up (or down) as well. This is shown in **sample A**.



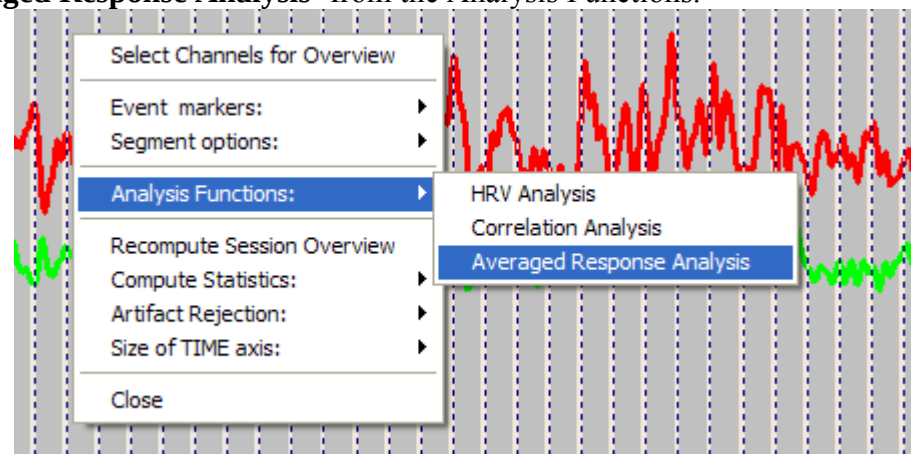
If signals correlate negatively, their 'phases' are inverted. If one signal moves up, the other moves down. A high negative correlation (**see sample B**) can be just a meaningful as a high positive correlation. If there is no correlation between two signals, the result will be a value near zero**. (See sample C**)

Session Overview: Averaged Response Analysis (NeXus-10 only)

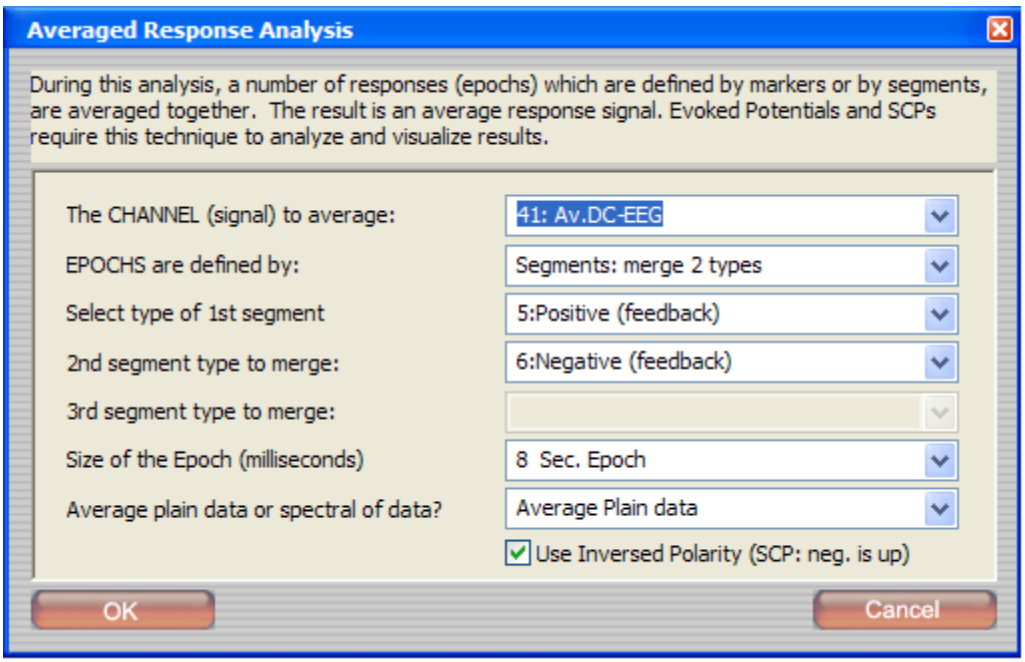
This function computes an 'averaged response' to a number of trials, stimuli or tasks. This technique is for instance used in computing 'evoked potentials', resulting from stimuli. It is also used for obtaining results from SCP (slow cortical potential) training. The averaging technique will 'average out' random effects and noise and will amplify reoccurring patterns. All you need is a repeating task or stimulus, which is time stamped by an event marker or by a segment area plus the physiological data which was sampled at the same time.

Using the averaged response function:

Load a session that contains a series of tasks/stimuli that have generated markers or segments. Switch to the session overview screen, right-click and choose the option: '**Averaged Response Analysis**' from the Analysis Functions.



In the dialog box that pops up, you need to enter the parameters the software will use to compute the 'Averaged Response':



Let's now look at these parameters.

1) The first parameter, is the channel that contains the physiological data you want to run through the averager.
2) Next you need to indicate what type of epochs you want to average. An epoch in this case means a fixed array of data samples, that you will average. You can choose from a) Event Markers, b) 1, 2 or 3 types of segments. Merging them means that for each type of segment a separate line graph will be plotted.
3) Then you need to enter the 1, 2 or 3 types of segments.
4) Next is the (fixed) size of the epochs that must be averaged. Note that the only the start of a segment or event marker is used. You must specify the size here. You can choose from 1,2,4,8,16 and 32 seconds.
5) Last, you enter what type of data is averaged. Default you just take the data samples themselves. The other option is that you average the spectrum of the epochs rather than the plain data itself.
6) For SCP averaged responses you will want to set the inversed polarity where negative values are plotted up. (this is a EEG/SCP convention)

In this example we have chosen to compute an averaged response on the DC-EEG (used during SCP training) on the training segments marked as 'Positive' and 'Negative". One of the goals during SCP training is to cause positive and negative DC shifts in the cortical potentials. The sample picture below shows these 'shifts'.

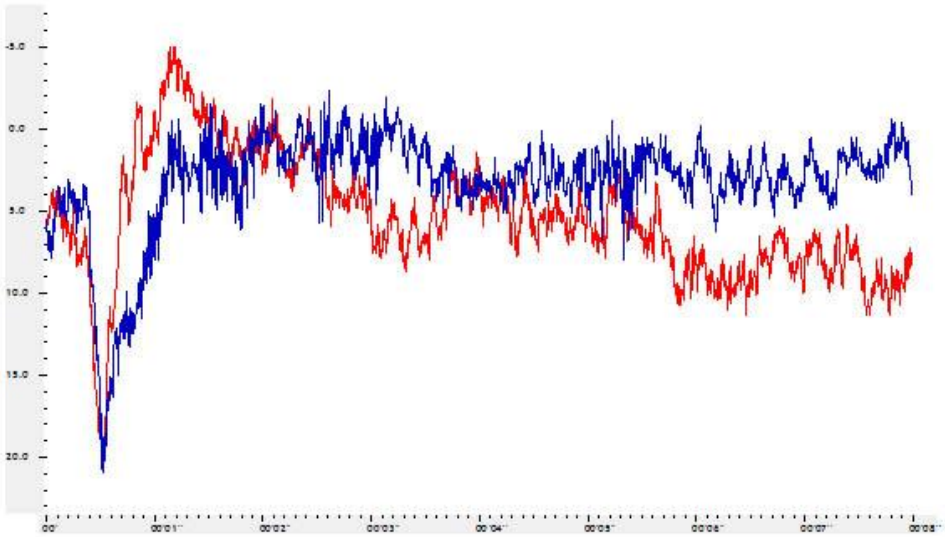
Now we press the button, labeled, '**OK**'. And the software will need some time to compute the results. When it is ready, a 'print preview' will appear showing the averaged data. You can print out this page on your printer.

BioTrace+ Physiological Report Version 0.99 (C) Mind Media Netherlands 2004/2005

Concise Client and Session information:

Client:	test, test [ID=000037]
Session:	SCP session with protocol
Date Time:	11:08:44 PM 9/28/2005
Duration:	11min2sec.

Averaged Response of channel 41: (Av.DC-EEG) over 8 Second Epochs.



2 types of EPOCHS have been found:

EPOCH type 1: Positive (feedback) Total number of Responses: 29.
EPOCH type 2: Negative (feedback) Total number of Responses: 35.

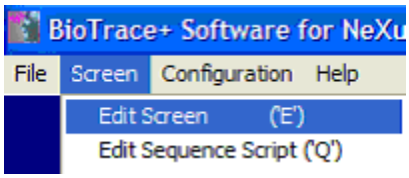
Samplerate of channel 41: 256 samples/sec.

-- Page 1 of 1 --

5.0 The Screen Editor

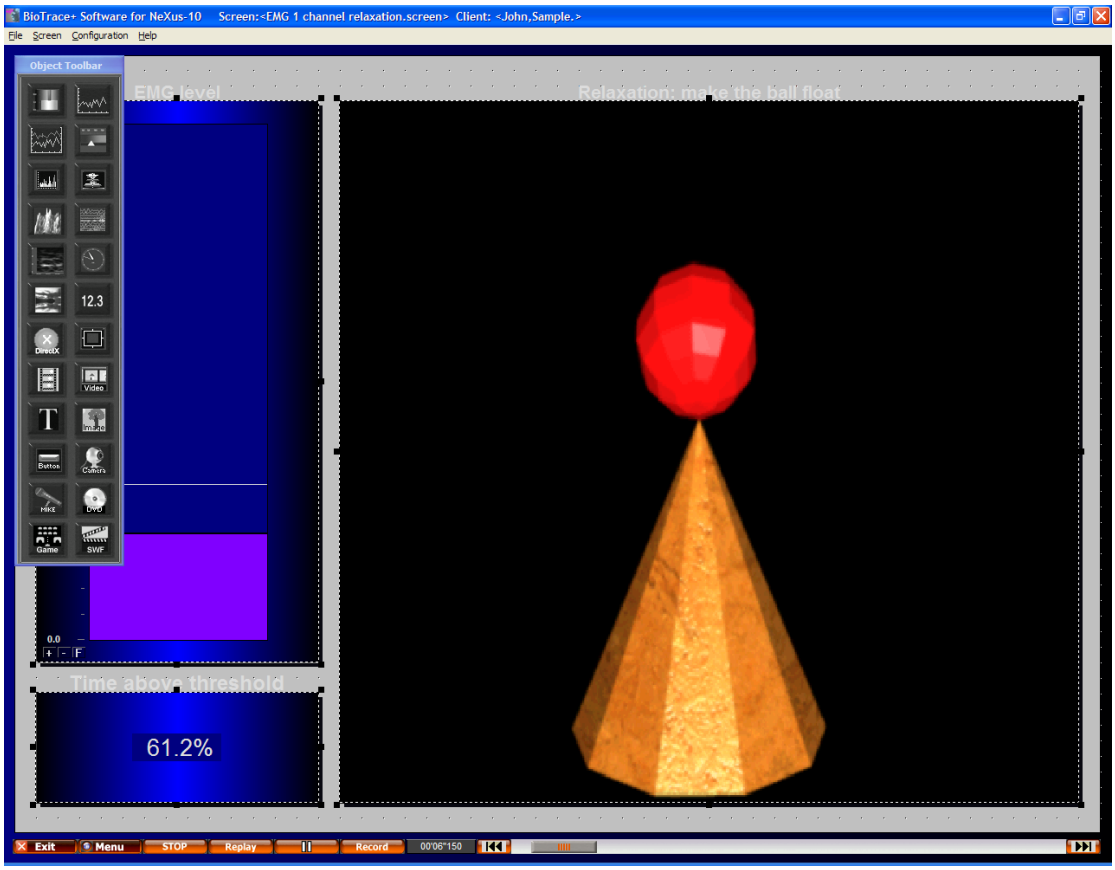
BioTrace+ features a WYSIWYG screen editor that is fully integrated into the software. It is not necessary to pause or stop sessions while using the screen editor.

You enter the screen editor mode, through main menu bar. Under the '**Screen**' item, choose '**Edit Screen**'.



Tip: another quick way to open the screen editor is by pressing the '**E**' key on your keyboard. Pressing the same '**E**' key once more, will exit the **editor mode.**

When you are in the editor mode, your screen will appear a little different, because the background will appear in a grey color, showing a grid and a floating toolbar.

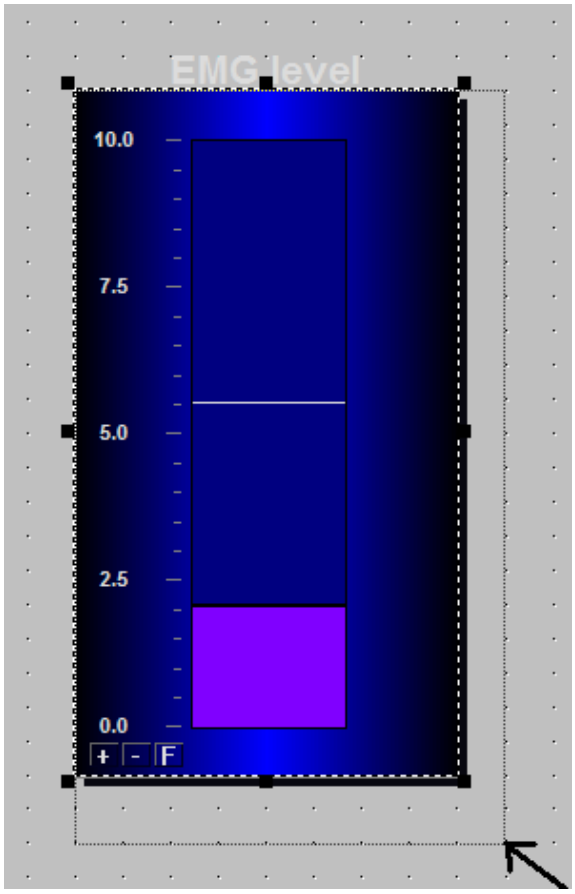


All the objects on the screen now appear with black handles around them, indicating that you can move and size them.

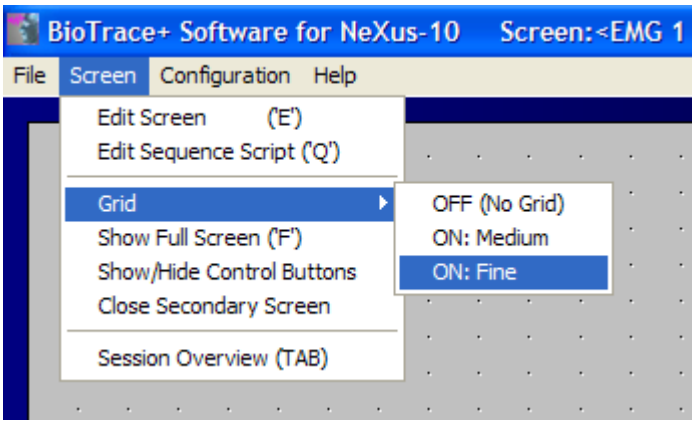
5.1 Modifying object properties

Moving and sizing screen objects

By 'dragging' (left clicking and holding) the handles of the object, you can **size** the object and make it bigger or smaller. If you click on the middle of an object, the mouse will change into a symbol with 4 arrows, indicating you can **move** the object.



While you move the object the objects will snap to the grid, unless you turn the grid '**OFF**'. The grid settings can be found under the '**Screen**' part of the main menu bar.

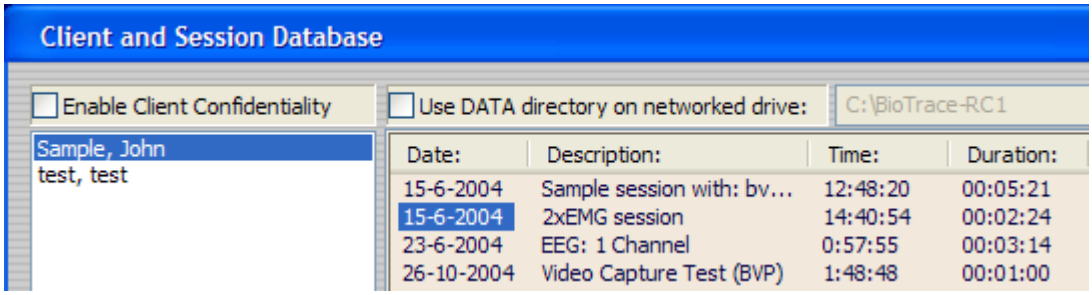


The default grid settings are: '**fine**'.

How to change Object Properties

Open the screen browser and choose the '**EMG screens**' category. Now load the '**EMG 1 channel relaxation'** screen by double clicking on the preview thumbnail.

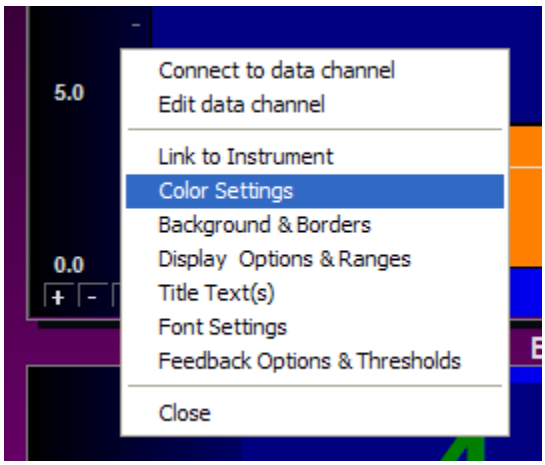
In order to be able to view session data with EMG, press 'O' on your keyboard and open the "2xEMG session" from John Sample.



Please note that you select a session by selecting the **data** in the first column and then double click on the date. While you do this, the mouse pointer will show a pointing hand.

We will now make a change to the 'properties' of the bargraph instrument, in this case we will change the COLOR of the bargraph.

Now **right-click** with your mouse on the bargraph, and a drop-down menu will appear:

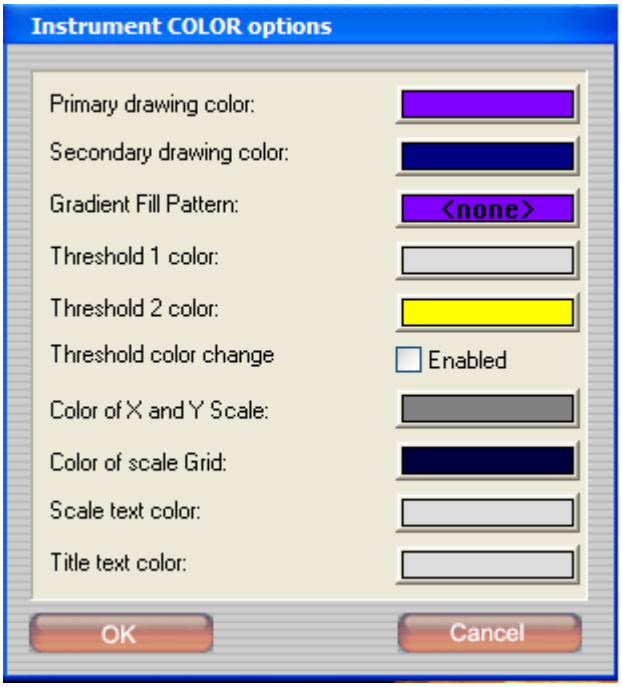


Note: you can change properties of the objects, instruments, scales, and screens by **RIGHT_CLICKING** on them with your mouse!

Now choose the '**Color Settings'** item with the left mouse and click on it.

The color property dialog box will appear:

Properties: The Color Property Dialog box

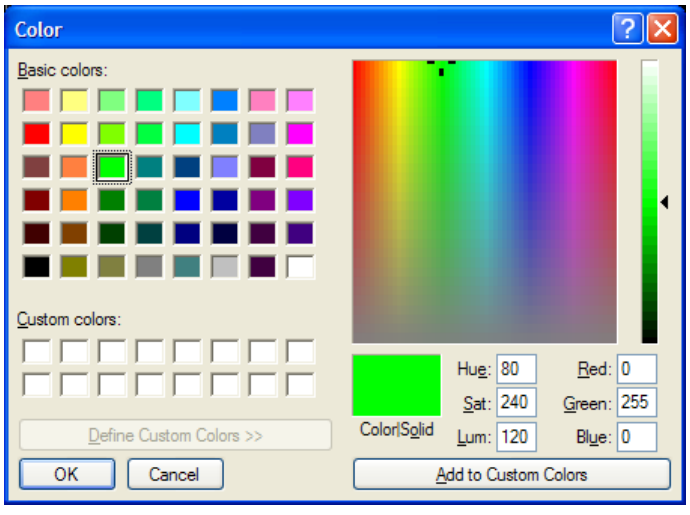


This dialog box contains all the color settings of the objects and instruments that are used to draw:

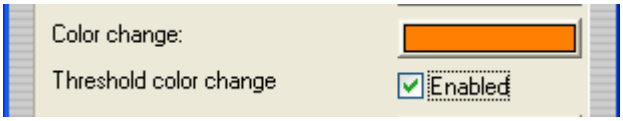
A) The signals
B) The Thresholds
C) The Scales and Grids
D) The Texts with the instruments/objects.

Please note that the background settings are selected by a separate menu item (called "background & borders".

1) Now click on the "primary drawing color". This is the color that the instrument uses to draw the signals. (in this case the foreground color by which the bargraph is drawn) Let's change the color of the bargraph to green:



We will now activate a color **change** that will occur when the signal is getting too high (over threshold).



Enable the **'threshold color change**' and set the **color change** item to orange. This will now cause the color of the bargraph to change from **green** to **orange** when the signal goes over threshold.

That's it. You have now changed the color of the bargraph and enabled a color change when the level goes over threshold.

Overview of Instrument properties

As mentioned before, there are two types of objects on the screen:

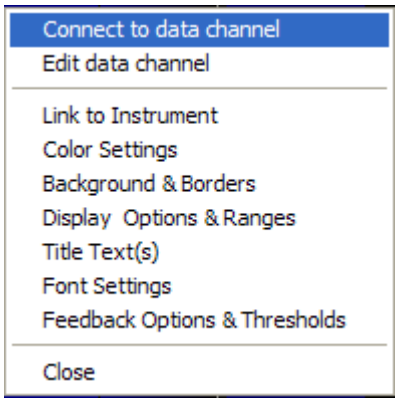
1) Instruments (that display physiological data)
2) Screen Objects (that display images, texts, video etc.)

The instruments have more properties than the screen objects, because they display physiological data. So this means they connect to a data channel, support biofeedback options, etc. Not all instruments support the same features. For instance some instruments do not support thresholds & biofeedback.

Note: you can change most object properties in real-time screen mode and edit mode. Except for size and position. These can only be accessed in the screen editor mode.

Let look at all the different options:

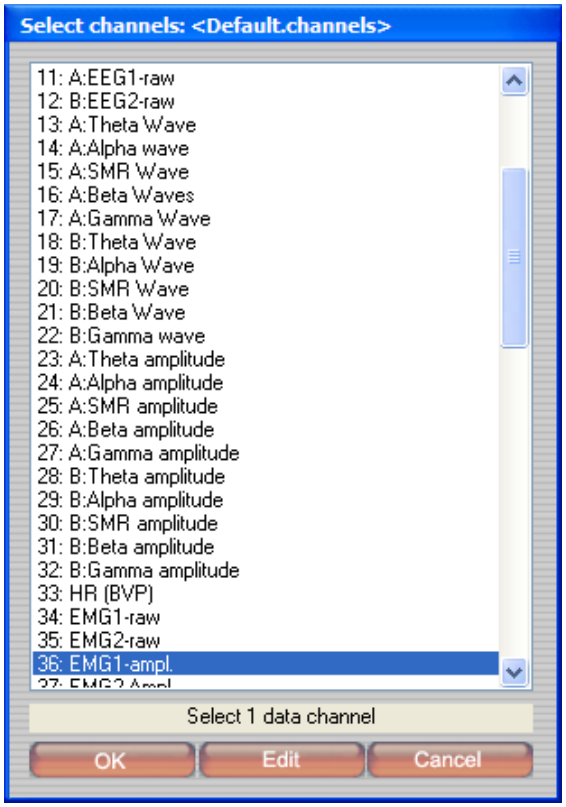
Instrument: connecting a data channel



All instruments must be connected to 1 (or more) data channel(s). For instance if there is a bargraph on your screen, it must 'know' what data should be displayed. If you 'right-click' it, you can choose the data channel it should display.

The channel list box

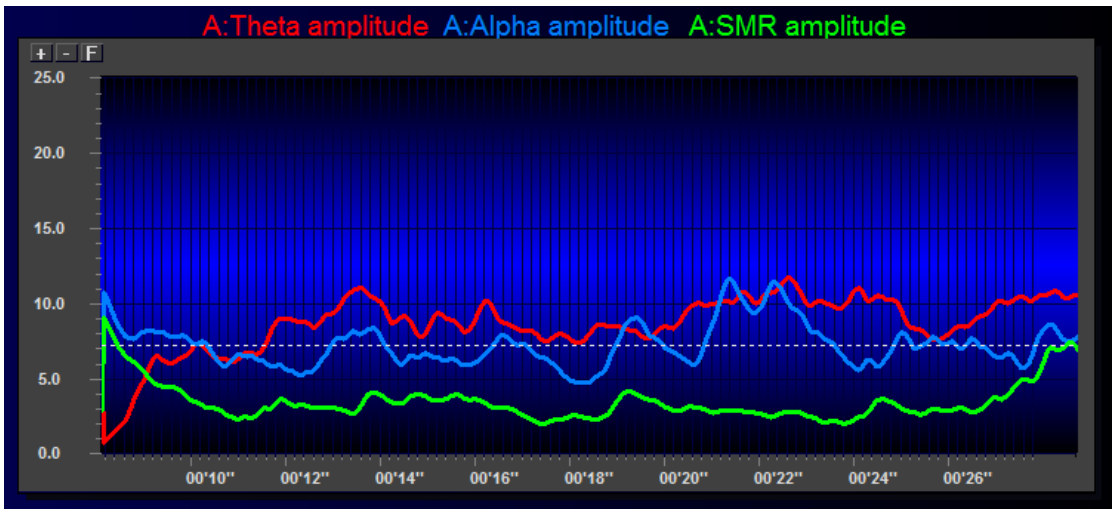
When you connect an instrument to a channel, the channel list box will be shown.



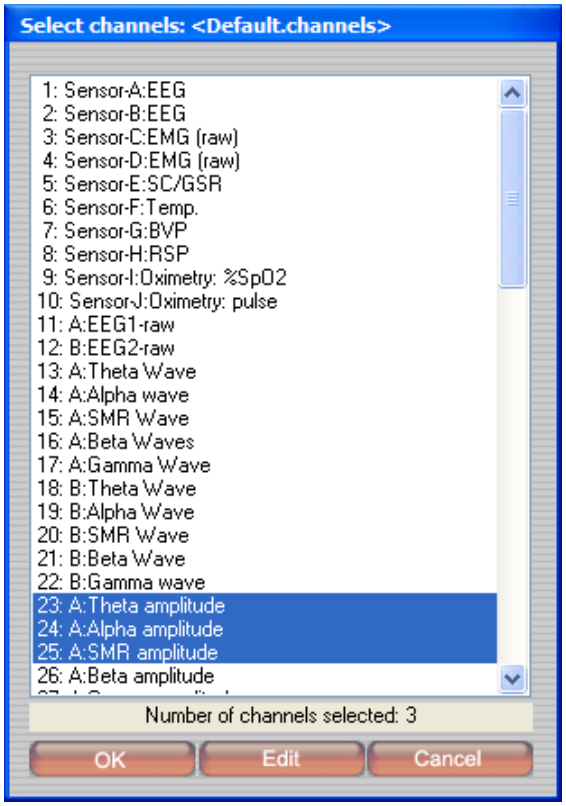
Most instruments only support 1 data channel. Make sure the instrument you connect to a data channel is able to display that channel correctly. For instance it makes little sense to connect a raw EMG signal to a bargraph. In that case you would choose a line graph instrument.

Connecting to multiple data channels

Some instruments can connect to multiple channels. The Line graph instrument is able to do this.



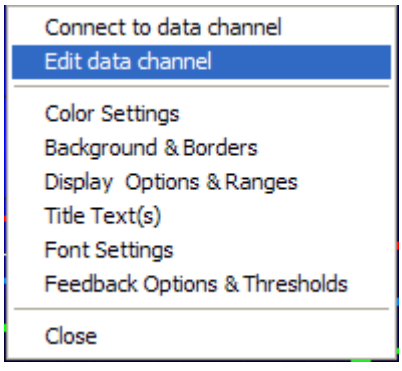
If you select the '**Connect Data Channel**' option on the line graph shown above, the channel list box will allow you to choose up to 4 channels.



Note that the channel list box will indicate the **number** of channel that you selected at the **bottom**. If you press the **'OK**' button, it will use your selection. If you choose '**Cancel**' it will use the last used channel selection.

Properties: Edit a data channel

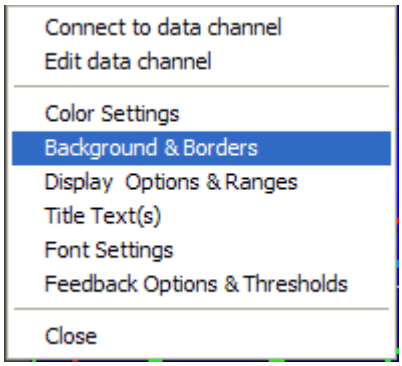
If you choose the '**Edit**' button in the channel list box (shown above) you can edit the data channel definition. You can also 'right-click' the instrument and choose the '**Edit Data Channel**' option directly, as follows:



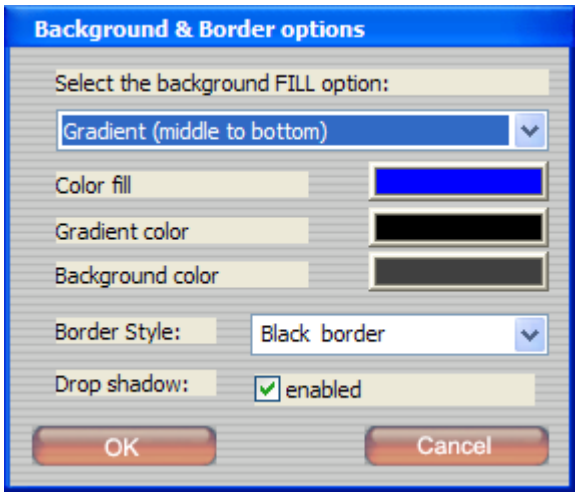
In one of the next chapters, we will discuss the **editing of data channels** in detail, so we will not elaborate on this in here.

Properties: Background & Borders

Each screen object or instrument has background settings. Right-click the object and choose the following option:



This will bring up the following dialog box:



Here you can define the background colors and fills of the object. You can choose from:

1) No background: the instrument/object will use the screen background and seem to be transparent
2) A solid color background
3) Several types of gradient fills. (The gradient uses the **Color fill** and the **Gradient color** to generate the gradient.
4) A number of instrument '**textures**'. These are basically images, stored in the '\BioTrace\Textures' directory.

Border and shadow options:

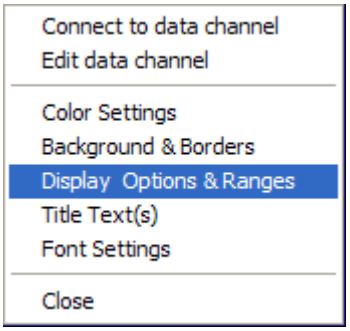
The border style will create a 'rectangle border' in several available colors around the instrument/object. Choose '**No Border**' to switch this option off.

The '**Drop shadow**' option will draw a shadow below the object.

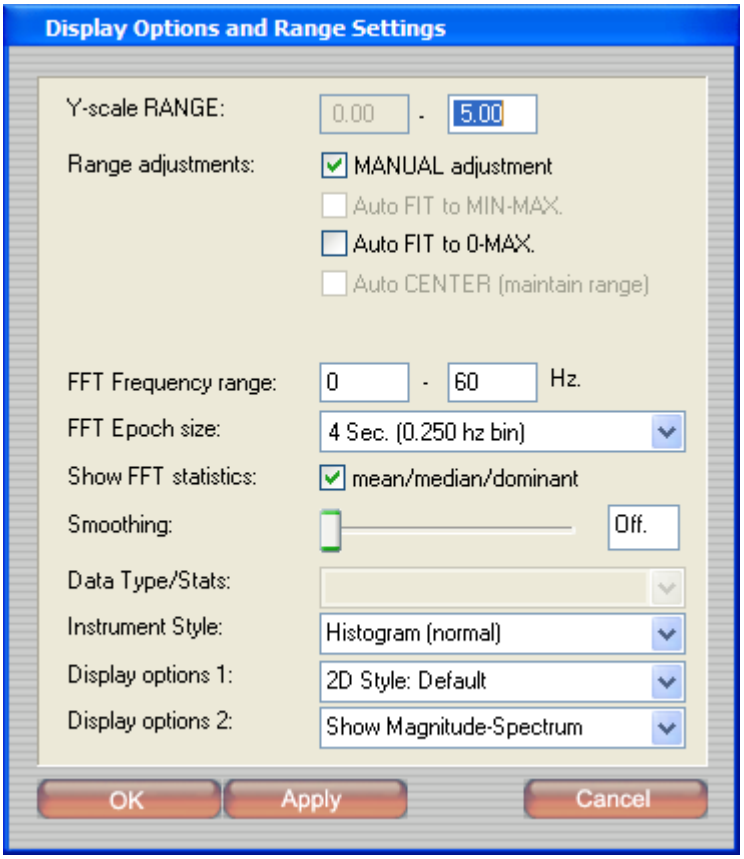
These are simply visual effects that enhance the visual quality of the objects.

Properties: Display Options & Ranges

Right-click an instrument and choose the following option from the drop down menu:



This will bring up the following dialog box:



The first part of this dialog box contains the '**ranges**' fields, where you can enter the **start** and the **end** of the Y-scale range. On a bargraph, the **start** value would be at the bottom, and the **end** value would be shown at the top of the barograph's Y-scale.

Note: the display options vary considerably from instrument to instrument!

Some instruments support frequency range settings as well (as shown above). An example of this is the **'Single FFT Spectrum**' object.

Now follows an overview of all the available display options:

Y-Scale range:

- Here you enter the **start** and **end** of the Y-scale range of an instrument. In cases where an instrument always has a **start** value of 0, the field will not be editable.

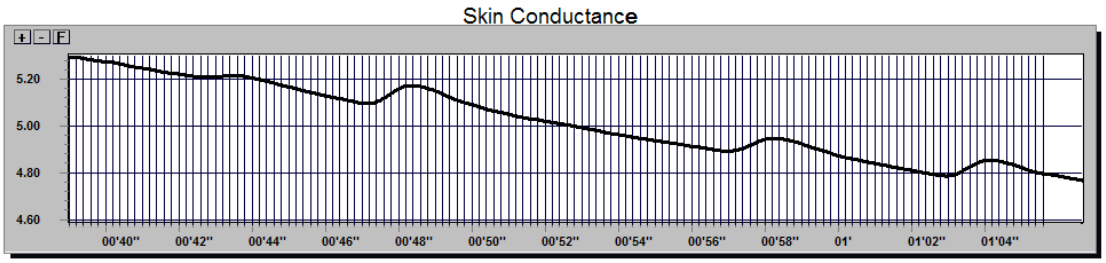
Range Adjustments:

There are 2 types of range adjustments, **manual** and **automatic**. The first option is the **manual** adjustment:

- You can choose '**Manual Adjustment'** which means that you have to enter or change the range manually, and it will not be changed by the instrument.

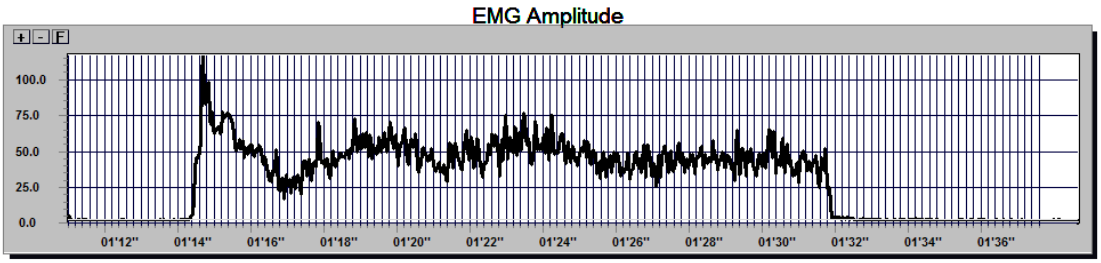
The other options are **auto-ranging** adjustments, the instrument will auto-adjust the range as needed:

- **Auto Fit to MIN-MAX:** will enable the instrument to adjust the scaling while running signals. In this case it will make sure the entire signal will fit inside the range, from its lowest (Min.) level to it highest level. (Max.) The instrument will update its Y-scale range every time a new minimum or maximum value is detected. This type of auto ranging can be used for most signals, but are especially suitable for Line graphs displaying: Respiration, BVP, HR, Temperature and Skin Conductance.

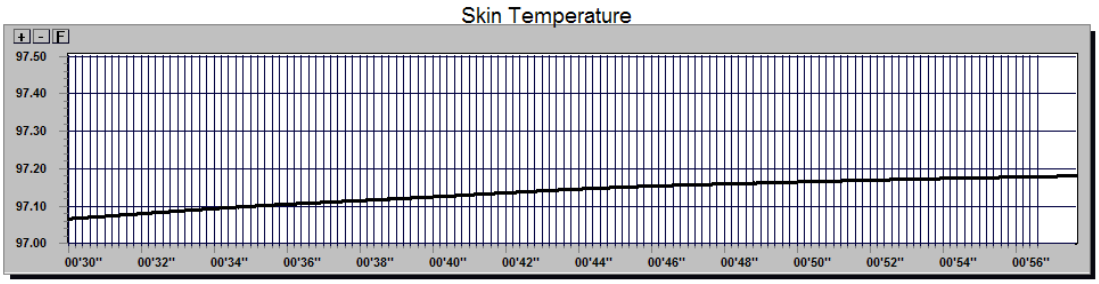


*Example: the picture above shows a line graph displaying skin conductance, with '**Auto Fit to MIN-MAX**' enabled. This will ensure the signal will always 'fit' in the y-scale range and therefore will always remain visible.*

- **Auto Fit to 0-MAX:** this option is very similar to the 'MIN-MAX' except that the MIN level (at the bottom of the Y-scale) will always be zero. This type of auto-ranging is more suitable for signals like EMG and EEG amplitudes. See the example below of an EMG signal using 0-MAX. auto ranging.



- **Auto-CENTER**: this option keeps the manual range that you set (for instance a total range of 0.5 degree of temperature) and makes sure the signal will be displayed within this range. When the signal is getting out of range, the instrument will auto-center the range. Example: if you set a manual range from 0 to 0.5 degrees Fahrenheit on a temperature instrument and the current temperature is 78.5, the range will start from 78.25 and end at 78.75. When the temperature changes and moves outside its range, the auto-center function will place it back in the middle and adjust the scale, for instance by changing the range from 78.5 to 80 degrees Fahrenheit. The 'size' of the range will be maintained. You have to enter a manual range first (in manual adjustment) and then click the AUTO-center, to keep this range.

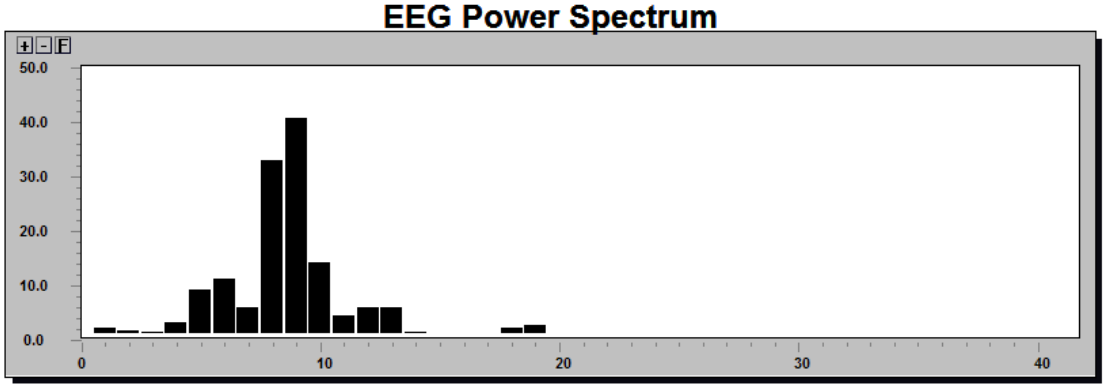


*The example above shows a line graph signal, with the '**Auto-CENTER**' option enabled. The range is set to 0.5 degrees Fahrenheit. The 'size' of this range will be maintained to 0.5, but the start of the range will adjust to wherever the signal requires it to be, so that it is visible.*

- **Line graph: Refresh each sweep**: This option (not displayed in the example) will refresh the range every time a line graph instrument is starting to redraw from the beginning. Refreshing in this case means that the range will be readjusted, even if the signal is not below the MIN or above the MAX.

FFT Frequency Range

FFT Frequency range: this is the place where you enter the **start** and **end** of the frequency range of an instruments that display a power or magnitude spectrum. Examples are: **'Single FFT Spectrum**', the '**Dual FFT Spectrum**' and the '**3D FFT Spectrum**'. The picture below shows a single FFT Spectrum with a (horizontal) **frequency range** setting from 0 to 40 Hz. The vertical Y-Scale range is 0-50 µV.



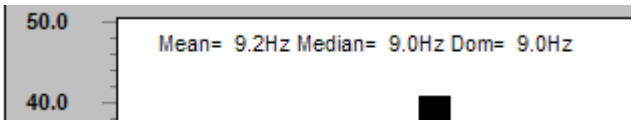
FFT Epoch Size

A fast Fourier based instrument needs to know how many seconds of data have to be analyzed. Default is an **epoch** size of 1 or 2 seconds. Setting a 1 second size will results in each resulting frequency value (called a 'bin') to cover 1 Hz. Setting an **epoch size** of 2 seconds, will result in a bin-size of half a Herz (0.5 Hz). You can choose epoch sizes between 1 and 64 seconds, depending on the sample rate of the source channel.

In the example on the former page, the **epoch-size** of the spectrum is 1 Hz.

Show FFT Statistics

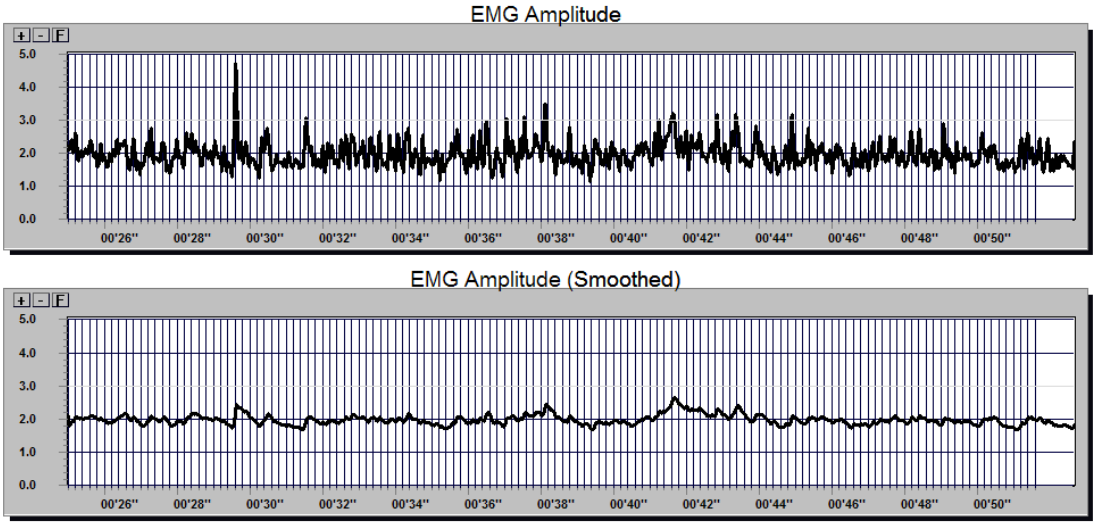
Some of the **FFT** based instruments, like the '**Single FFT Spectrum**' can display the mean, median and dominant frequency as a numerical value. You can enable this option here.



The text will be placed in the left-top of the FFT spectrum display.

Smoothing

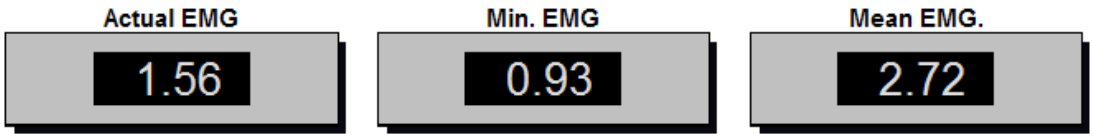
Smoothing is an option that will 'dampen' a signal, in case it is rapidly moving up and down. Example: in case you are feeding back EMG activity on a **bargraph** or **line graph** instrument, the EMG level may appear too fast (or 'jerky') to train on. Setting a smoothing factor greater than 0 (0 means smoothing is off) will slow down the signal by a type of averaging. It is easier too observe **trends** in a smoothed signal, than in an unsmoothed signal.



In the example above an EMG amplitude is shown that is not smoothed (smoothing = 0) and below it a graph with a smoothing factor of 8.

Data Type/Statistics

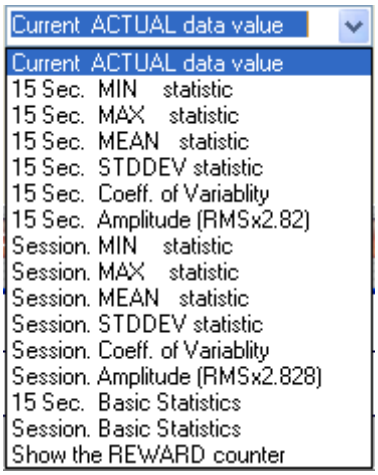
A number of instruments support this features, where you can define what type of data you want an instrument to display. A good instrument to use this feature on, is the **numerical instrument**. Below an example is shown where the first numerical instrument displays the current **actual** EMG level, the 2nd shows the **minimum** EMG level of the last 15 seconds and the last and 3rd instrument shows the **mean** EMG level of the last 15 seconds.



The instruments that support this feature are:

1) The numerical instrument
2) The bargraph
3) The Vernier (ruler) instrument
4) The zoomer instrument
5) The animation instrument

The options that you can choose here are shown in the drop-down list that appears when you click on the button:

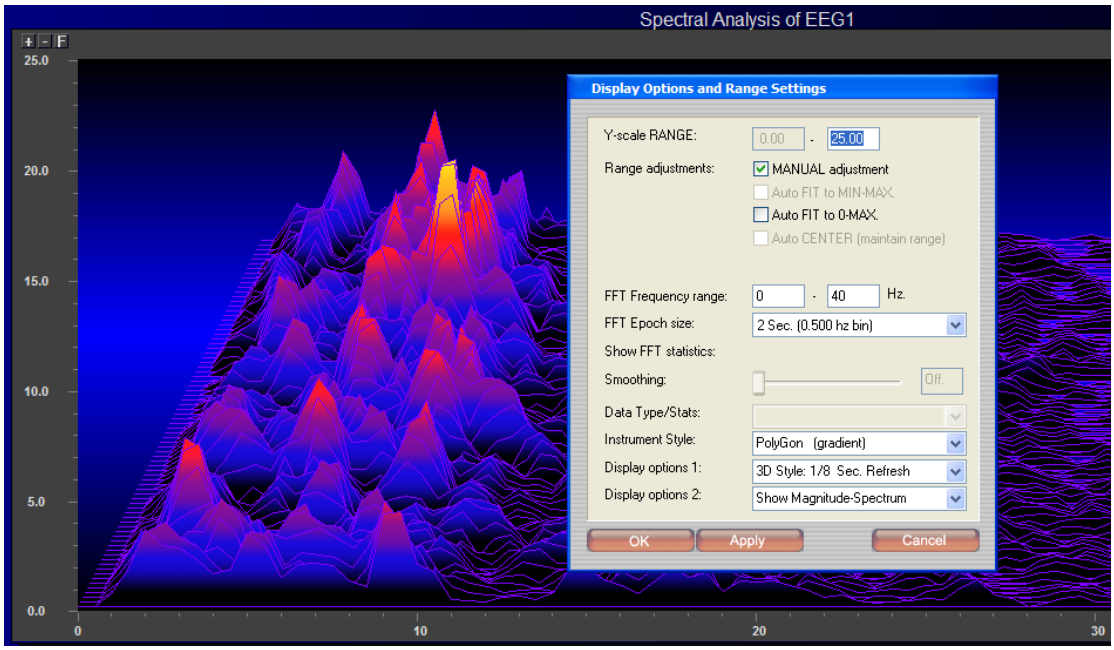


You can choose from:

1) The actual current value (default)
2) The min, max, mean, standard deviation, Coefficient of variability and 'RMS amplitude' of the last 15 seconds.
3) The same values, but now for the whole part of the session leading up to the current sample.
4) A list of all basic statistics for the past 15 seconds or the whole session.
5) The current state of the reward counter. (this counter value can be increased by instruments when they are below or above thresholds) The reward counter is used for scoring the success of biofeedback guided training.

Instrument Style and other Display Options

The instrument style and other display options vary considerably from instrument to instrument. We will give one example:



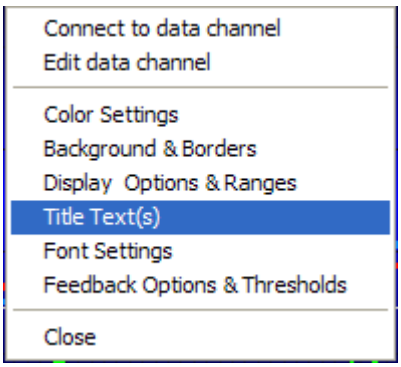
In the picture above, the following special display settings have been chosen for a **3D FFT Spectrum** instrument:

- **Instrument Style:** Polygon (with a gradient in it)
- **Display options 1**: 3D Style with 8 refresh sweeps per second
- **Display options 2:** Magnitude-Spectrum. (instead of power spectrum)

The instrument style and other display options are ways to fine-tune the specifics of how an instrument will display the data.

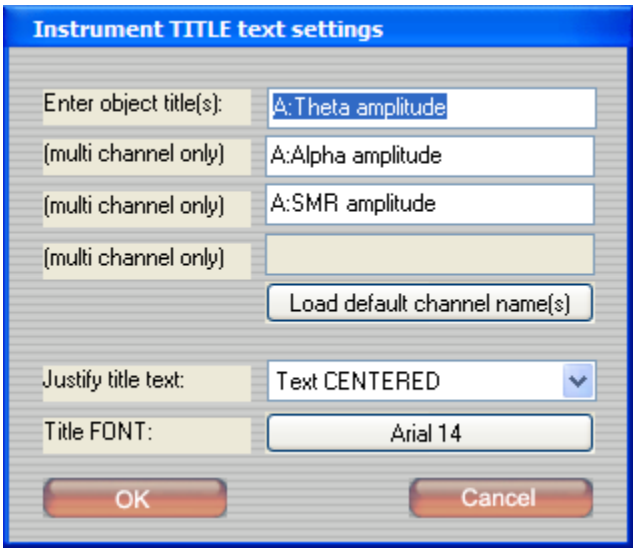
Properties: Title Text

If you want to 'label' an instrument, you can enter a title text by right-clicking the object and choosing '**title text**'.

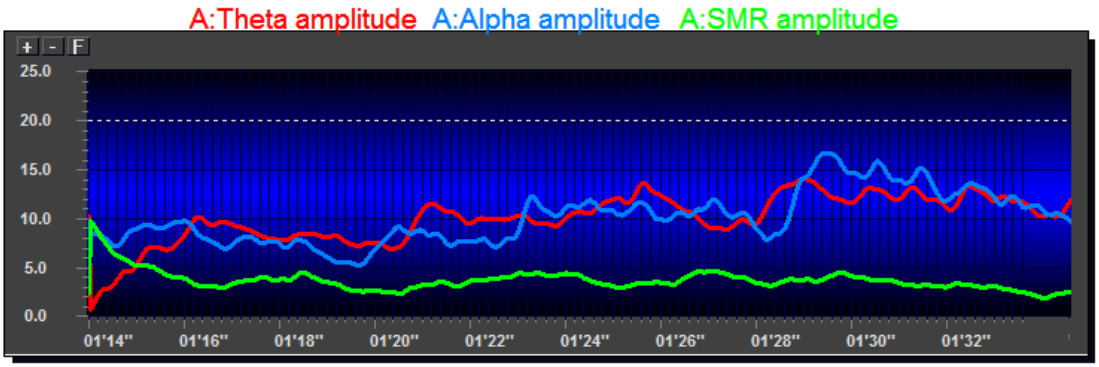


The title of the object/instrument will appear at the top.

The following dialog box will appear: *(actual screen display will vary)*



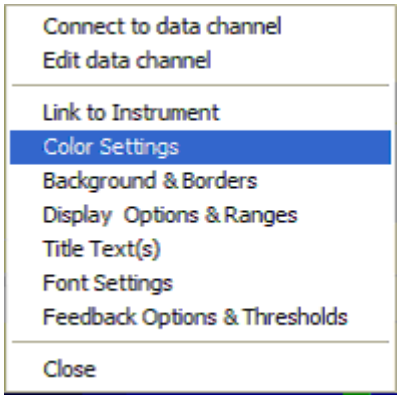
The example shown above, is from a line graph, displaying 3 'multi' channels. You can enter your own choice of text in the text fields, or you can press '**Load default channel name(s)**' which will fill in the title texts by using the channel names.



Next you can choose:

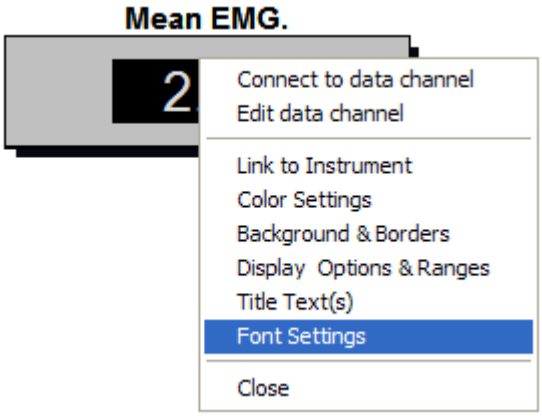
1) The text justification. (left justify, centered or right)
2) The characteristics of the FONT.

When you click on the **Title FONT** button, a standard windows FONT selector box will appear, where you can enter the font, the size and font style. Please note that you select a **title text color**, through the object 'Color' properties dialog box.

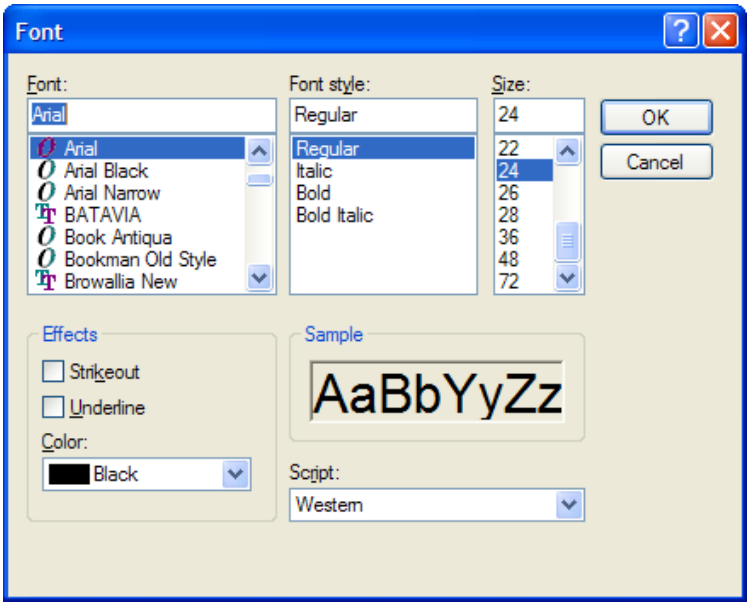


Properties: Font Settings

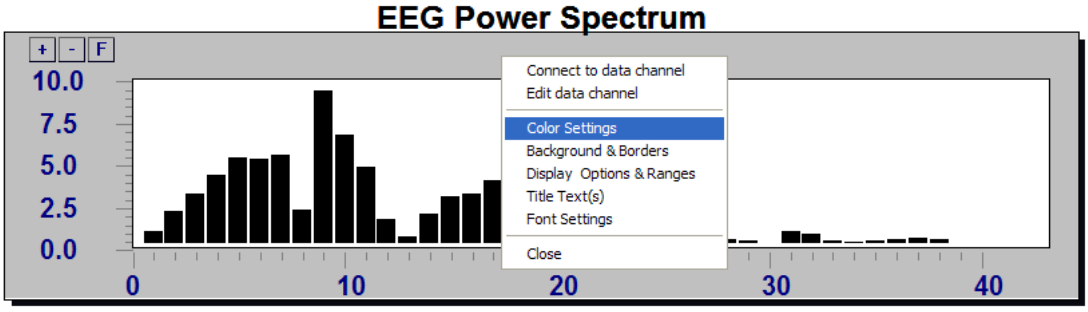
Most instruments have **FONT settings**. The FONT setting applies to the numerical text used in numerical instruments, or to the scale text (Y-scale and Time-Scale) fonts for other instruments.



If you right-click an object and choose '**Font Settings**', Microsoft Windows ™ will open a standard FONT selector box: *(actual screen display may vary)*



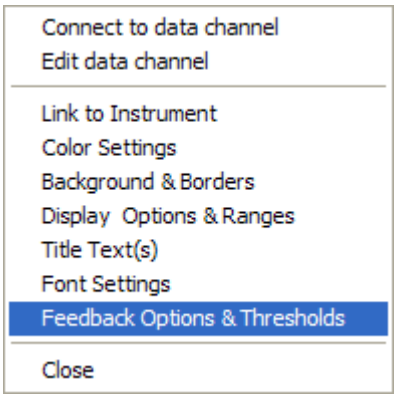
In this box you can select the **Font** itself, the **Style** and **Size** of the Font. Note that the Color that you select here, will impact the colors of the **scales** of the instrument.



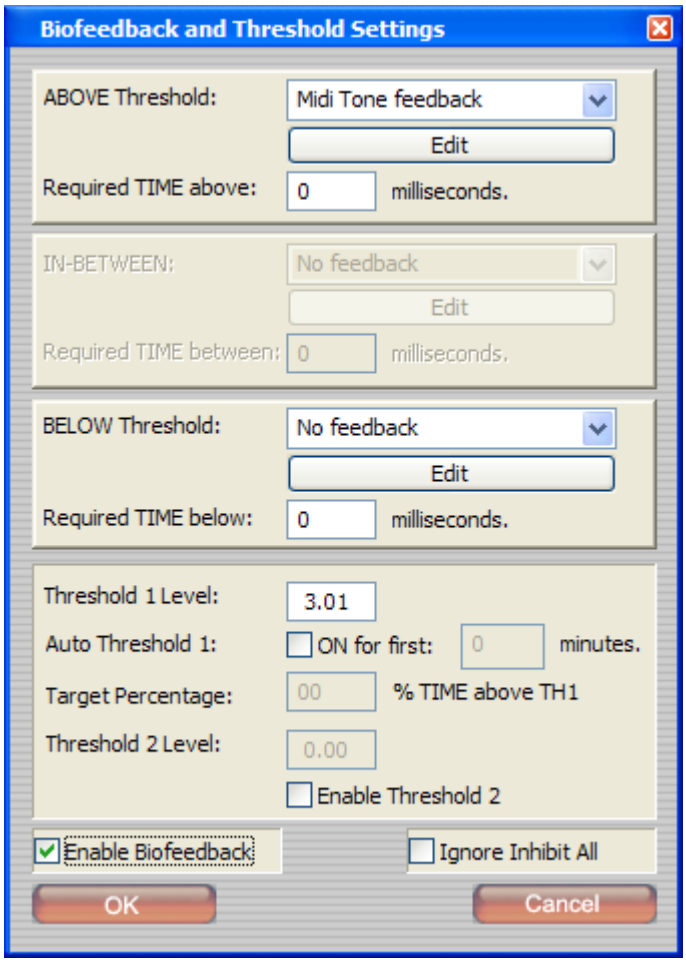
The sample picture above shows a larger **scale-font** on an FFT Spectrum instrument, that has been changed through '**font settings**'.

Properties: Feedback Options & Thresholds

This is the place where you control all biofeedback settings, for those instruments that support a threshold. Examples are: the Line graph, the Bar graph, the Zoomer and the Vernier instruments. Right-click the instrument and choose the '**Feedback Options & Thresholds**' as shown below:



This will bring up the Biofeedback and Threshold settings dialog box:

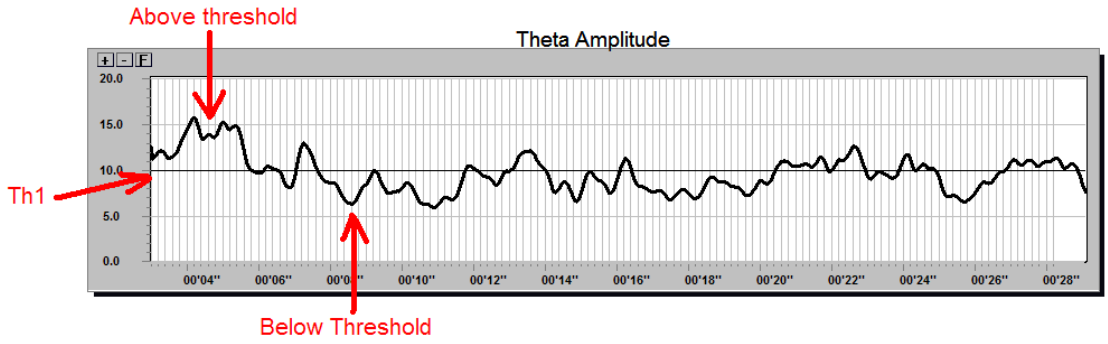


This dialog box controls the following properties:

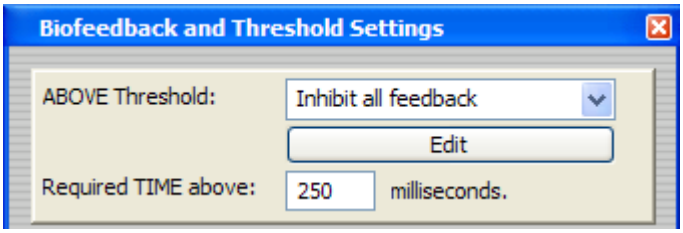
1) **The audio biofeedback settings above, in-between and below thresholds**
2) **The Inhibit settings**
3) **The Threshold levels and auto-thresholding criteria**

The Biofeedback Settings: Above and Below

As you can see in the dialog box on the former page, you can set feedback options for activity **above** and **below** threshold. In that case you are using only one threshold, namely threshold 1.



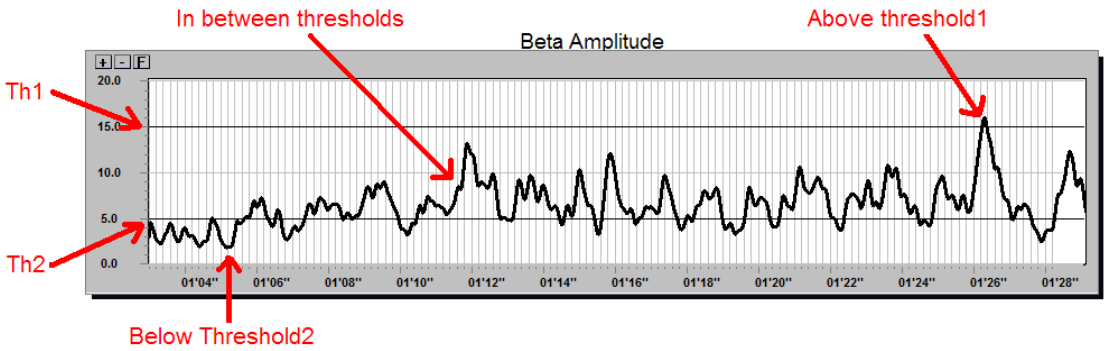
In the example above, the level of **threshold-1** (**Th1**) has been set to 10 microvolt pk-pk. The first part of the Theta activity is taking place **above** threshold-1, then after a few seconds a part of the activity occurs below threshold-1. We could for instance decide that if the Theta amplitude is getting too high (meaning it is above the threshold) for too long (for instance ¼ second) we will inhibit the feedback of the entire screen. (all instruments)



An example of this 'Inhibit' setting is shown above.

Enabling Threshold-2

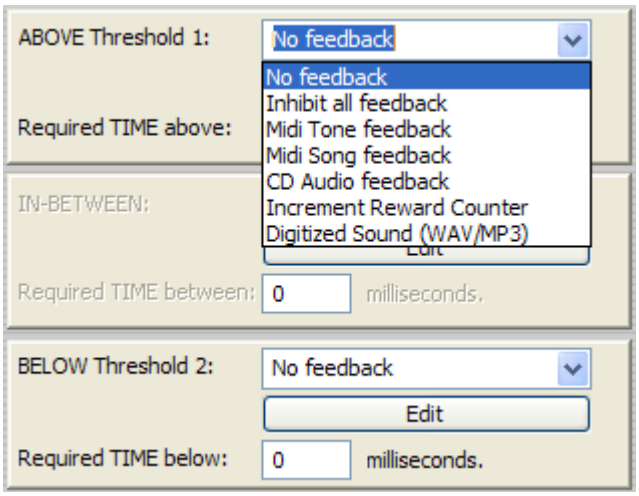
When you enable the second threshold as well, you will have 3 states to choose from: **Above threshold-1, In-Between thresholds** and **Below threshold-2**. An example of this situation is shown in the picture below.



Please note that the 1st threshold (th1) is always the top threshold, and the 2nd threshold (th2) is always the lower threshold.

Biofeedback: Overview of all the options

In each of the three fields of **Above, In-between** and **Below** you can choose from the same list of biofeedback options:



1) **No feedback**: means that no action is taken and in the instrument that you are editing, biofeedback is switched off for that threshold state.
2) **Inhibit all feedback**: means that all feedback (audio and visual) will be temporarily 'paused' until the inhibit state goes away. This goes for all instruments on all screens, unless you specified the 'Ignore Inhibit All' for an instrument.
3) **Midi Tone feedback**: this option will play a tone, a chord or sequence of 'MIDI' tones. BioTrace+ uses DirectX based MIDI instruments which are digitally sampled and generally sound better than standard MIDI tones.
4) **Midi Song feedback**: this option will replay a digital MIDI file.
5) **CD-Audio**: this option will play one or more track on an audio CD.
6) **Increment Reward Counter:** this option will increment the reward counter. This is a counter, reset to 0 at the start of a session, which can be incremented each time a threshold condition has been met. Thus it can be used as a form of scoring.
7) **Digitized Sound**: this option will play a digital file (WAV, MP3 or WMA) containing sound or music.

Required TIME above/below:

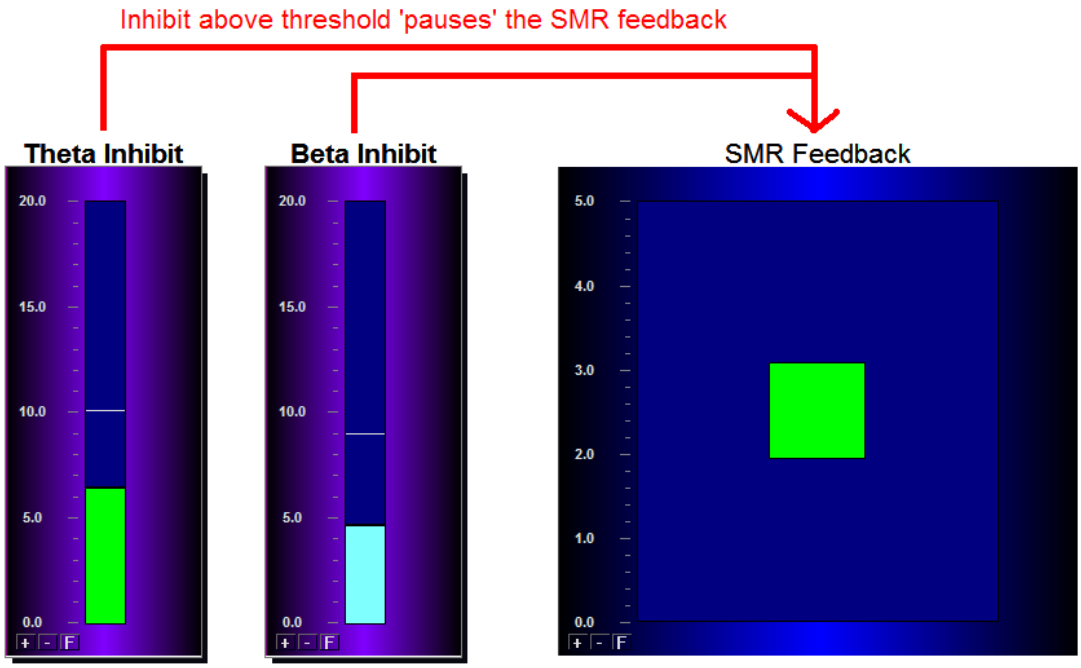
This defines how long a threshold condition should last, before the feedback condition will start. You can also think of it as a feedback 'delay. The default value here is 0 milliseconds. In some cases you will use a 'required TIME' setting.

Example 1: when during neuromuscular training a certain EMG level has been reached, you want this level to last at least 1 second before the 'reward' tone or music is played. In that case you set a required time of 1000. (milliseconds)

Example 2: when doing EEG feedback, you have set an Inhibit condition on Theta. At the same time you are using a DVD video on the secondary screen for 'positive' feedback. You set a required time of 250 milliseconds, so that the DVD will only 'pause' when Theta is too high for this period. Setting a required time of 0 ms, may in some cases start and stop the DVD too frequently.

Biofeedback: Inhibit All feedback

This is the only biofeedback condition that will turn other instrument's biofeedback temporarily off. Note that you can have multiple instruments applying an ***'Inhibit All'***. In the example below you see two instruments that have set an **inhibit** for levels above threshold. The 3rd instrument is producing **midi tone sequence** feedback based on the SMR activity. (*Settings not shown here*)



From the picture above, you can now see that each of the 'inhibit instruments' is able to turn the tone feedback on the SMR instrument off.

> **Note**: it does not matter which screen the inhibit instruments are on. In this example the inhibit instrument could for instance be on the primary screen and the SMR instrument could be on the secondary screen.

The inhibit state is indicated in the '**Time Display**' element in the real time screen:

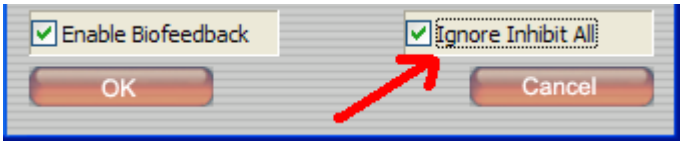
The background of the time display normally is **dark grey**, in case an **inhibit state** in reached by any of the instruments present, the background will turn **dark red**.

This way you can always verify if biofeedback has been turned off (paused) because of an inhibit. If you do not want an instrument to respond to the 'inhibit all', then you can select the 'Ignore' option.

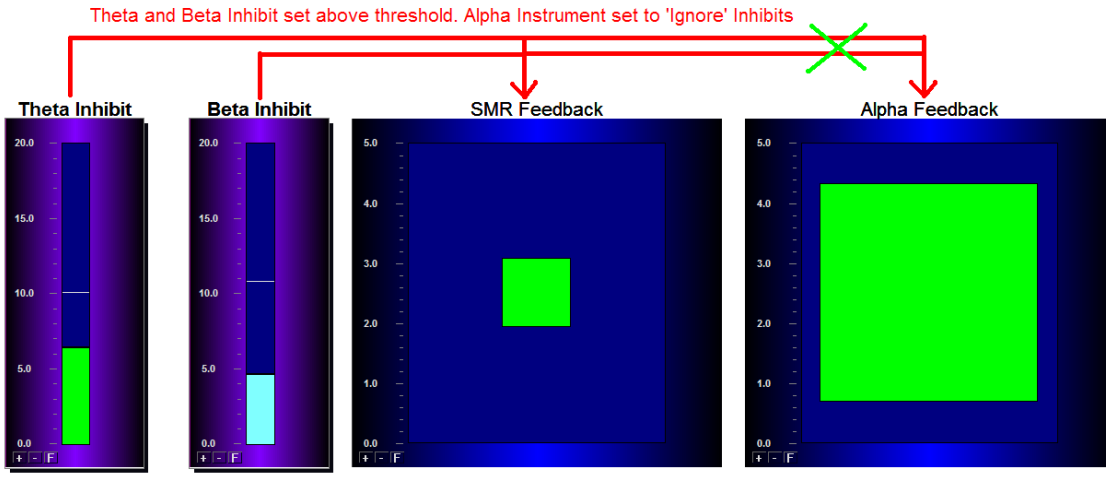
Note: the visual display of the physiological signal of the instrument will always continue, an inhibit will only have an effect on the 'Feedback settings' of an instrument.

Ignore Inhibit All State

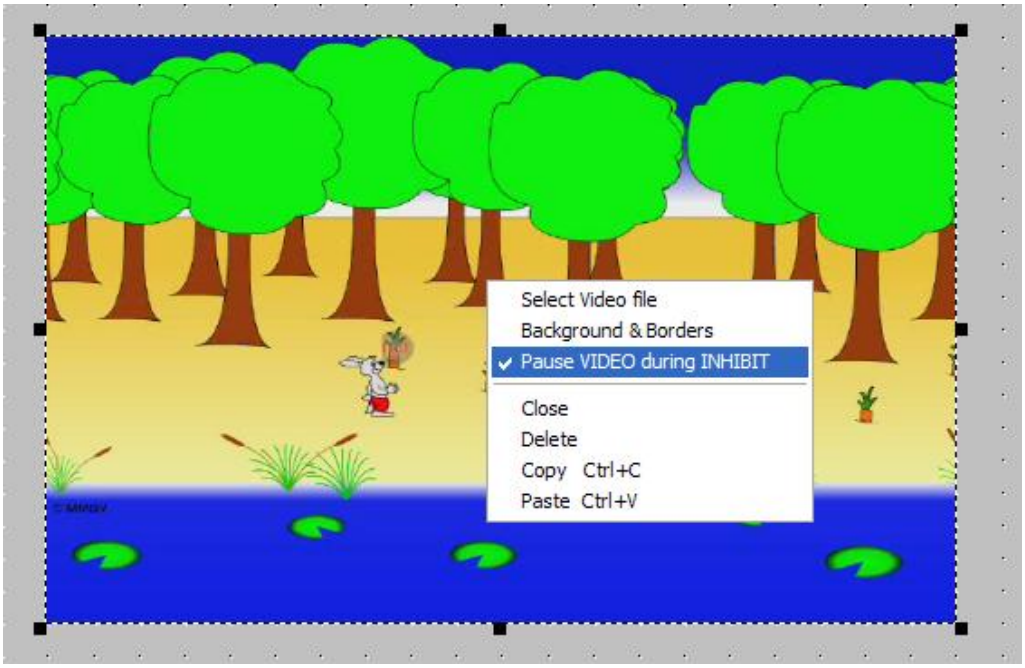
By putting a check-mark in the '**Ignore Inhibit All**' field, you tell the specific instrument that you are editing, to ignore the all inhibits and just continue with generating the biofeedback activity.



An example is shown below:

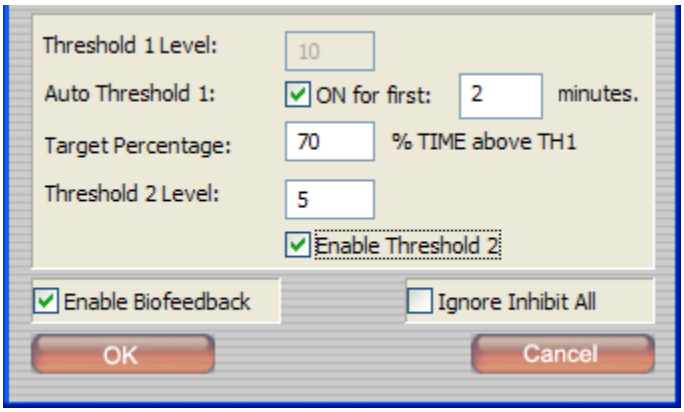


When one of the 'inhibit instruments' (either Theta, or Beta, or both) reaches an **Inhibit state** by going over threshold, the result will be that the SMR feedback instrument will pause its feedback., but the Alpha instrument will continue it's feedback activity. When you want a video instrument to 'ignore' the '**Inhibit All**', you uncheck the '**Pause VIDEO during INHIBIT'** option.



Biofeedback: Threshold levels & Auto-thresholds

In the bottom part of the '**Feedback Options & Thresholds**' property dialog box, you can enter the threshold levels for threshold 1 and threshold 2.



Manual thresholds:

Generally you will set thresholds manually. In that case you simply enter a value in the threshold 1 or 2 level box.

Note: you can only set the threshold 2 level, when you have set a check-mark in the '**Enable Threshold 2**' field.

Automatic threshold:

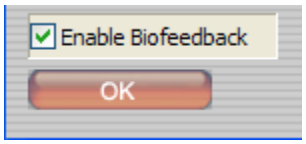
In some cases you will use an automatic threshold for a certain part (normally the beginning) of a session. You have to enter a '**target percentage**' that tells the computer how much the threshold-1 (the auto function does not work on threshold 2) should be adapted so that the physiological signal will be N percent of the time above threshold. Note: this will always be an **approximation**, manual adjustments may be still be required after the period of X minutes that you enter.

Example 1: you define an inhibit state of a Theta level above threshold, and use the **auto-threshold** function. You set the Target percentage to 30%, so the inhibit state will occur 30 % of the time. You set the duration to 5 minutes. This will now mean that the first 5 minutes of the new session, the auto threshold function will be active and attempt to modify the threshold level so that the Theta level will be mostly below threshold (70% of the time) and sometimes (30% of the time) above the threshold. Effectively, then after the 5 minutes, about 30% of the time an inhibit state will be reached.

Example 2: you are doing relaxation training using EMG feedback. In the first 2 minutes of a session you want to set a (low) threshold value which will be the goal to reach. Below this threshold you will reward the (relaxation) level with digitized sound of flowing water. Therefore you set the duration (**ON for first X minutes)** to 2 minutes and set a Target percentage to 50%. On top of that, you set a required time of 1000 ms, so that the reward will only be played if the subject reaches the desired state for 1 second of time or longer.

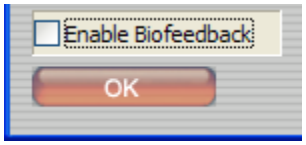
Biofeedback: Enabling/Disabling it on an Instrument

The last option in the '**Feedback Options & Thresholds**' dialog box is the following check mark button:



You use this button to **enable** or **disable** the feedback for the entire instrument. You could alternatively also set all biofeedback conditions (above, in-between, below) to '**No Feedback**' but that has the disadvantage you loose those settings.

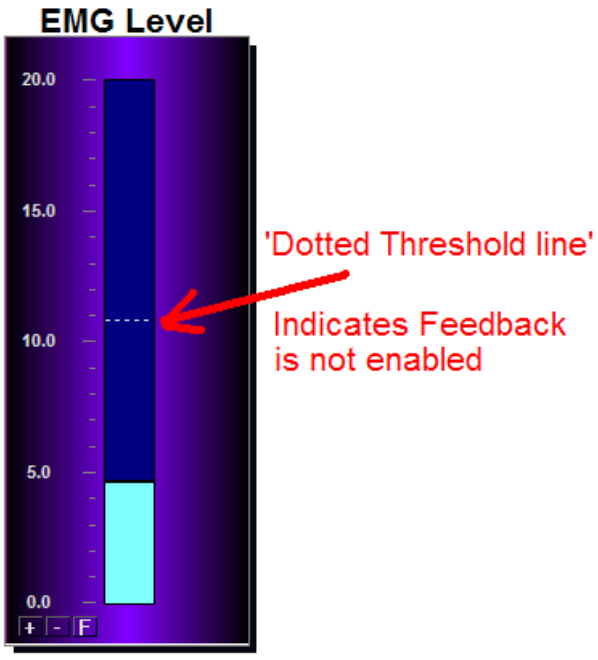
Un-checking this '**Enable Biofeedback**' field will keep all your biofeedback settings, but simply does not use them. So effectively the feedback on that instrument will be switched OFF if the check mark is not set:



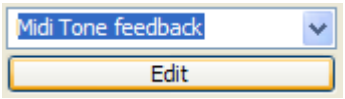
This will disable the biofeedback on this instrument.

Note: if the biofeedback has been **disabled**, the threshold will be shown as a '**dotted**' line. A '**solid**' threshold indicates the Biofeedback is active. (Enabled)

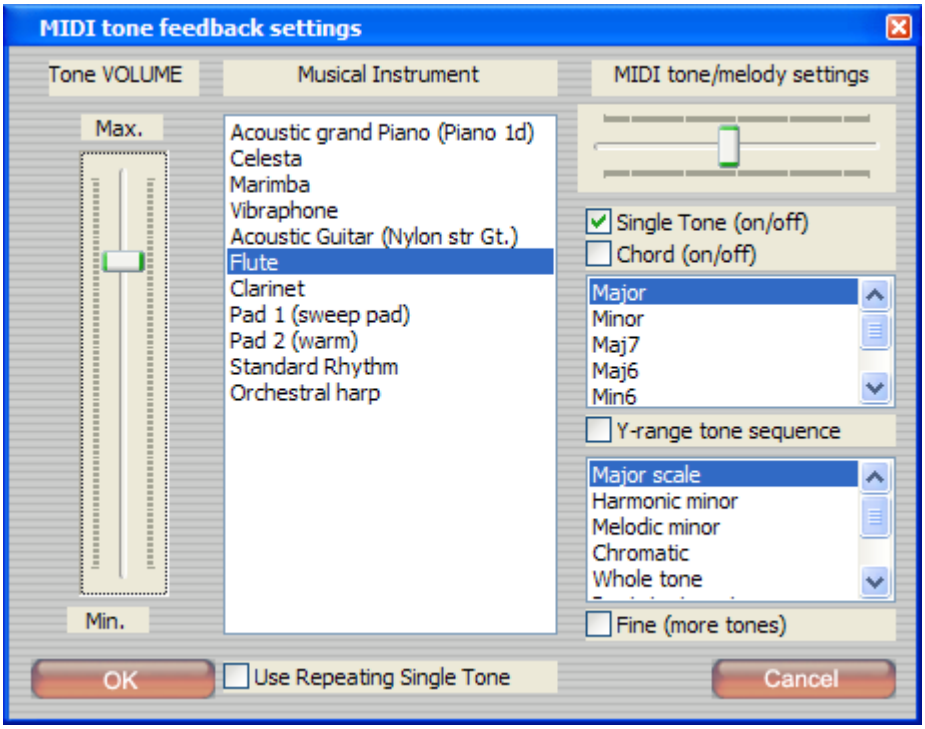
Shortcuts: You can use the ']' key to toggle the **enable** state. The '[' key will **show/hide** the threshold line. Just point the mouse over the instrument and press the key.



Biofeedback: Midi Tone feedback



When you choose the '**Midi Tone feedback**' option in the dialog box and click in the '**Edit**' button, you will see a new dialog box, presenting you with all the tone options:



In this dialog box you can choose the following options:

1) **The volume of the MIDI tone(s) that will be played**
2) **The musical instrument that will play the tone**
3) **The height of the MIDI tone (use the horizontal slider)**
4) **The type of tones you will play: Single tone, Chord or Sequence.**

Volume: Set a volume between min. and max. by moving the slider up and down.

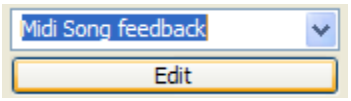
Musical Instrument: select (highlight) one of the instruments in the list

Single Tone: this option will play a single tone only. Note that the tone will stay ON for as long the feedback condition is true. (For as long as the level remains below/above threshold) Some instruments by nature however only play briefly, an example is the piano. A flute instrument has a long sustain.

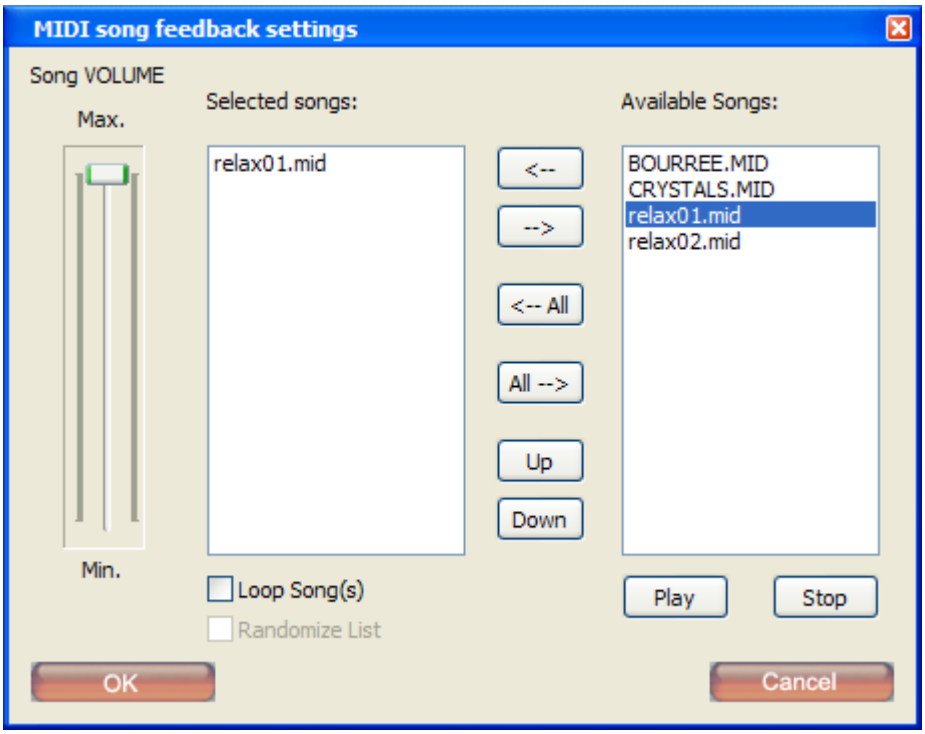
Chord: BioTrace+ will play a number of tones at once, forming a chord of the type that you can pick from the list below.

Y-range tone sequence: this is a form of 'continuous' feedback, where the level above threshold will determine the next tone that will be played. For example the increasing/decreasing level of EMG activity can be made audible in a tone sequence. The **'Fine**' options will add more tones to the sequence.

Biofeedback: Midi Song feedback



Selecting this option will bring up the following dialog box:

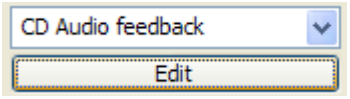


You can choose from the following options:

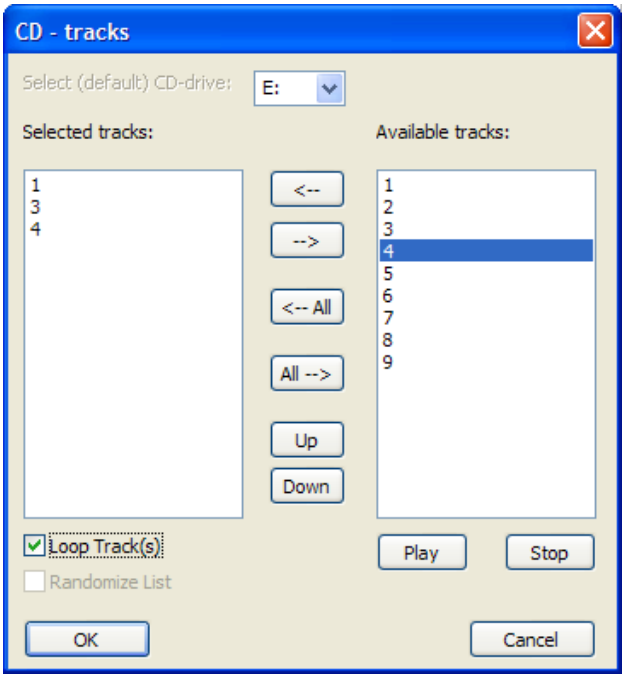
1) **Set the volume of the MIDI song with the vertical slider**
2) **Add songs to the 'Selected Songs' list from the list of available songs on the right. (Use the ← and → buttons.**
3) **The 'Loop Songs' option will loop the song back to the start when it has finished. It will also loop a list of songs**

Note: this feedback option is useful for generating audio feedback, but the sound quality of MIDI songs is generally less than digitized sound/music. So you may want to take a look at that option as well.

Biofeedback: CD Audio feedback



When you choose 'CD Audio feedback' and click the edit button, a dialog box will be shown, where you can choose which track(s) you want to play:



You begin by selecting the CD drive. It is quite common for (desktop) computers to have more than 1 drive, so we first have to tell the computer which drive we will use.

Make sure you have placed a CD in the correct drive, before using this option. You also want to make sure that no other application is currently using or playing this CD, or BioTrace+ would not be able to access the CD. As an alternative you can use the Digitized Sound/Music biofeedback option, which is more flexible and plays digital sound files in the WAV, WMA and MP3 formats.

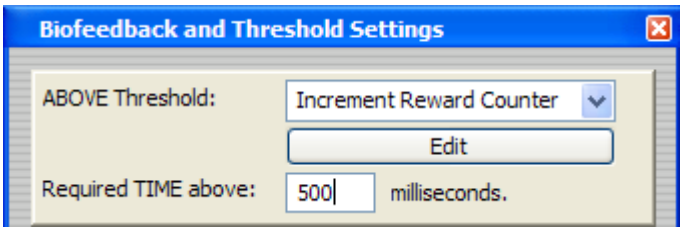
After you have selected the CD drive, a list with available tracks will be shown.
By clicking in the '←' and '→' buttons you can now add or delete tracks from the list box.

The CD feedback works simply by playing the selected tracks (one by one) for as long as the feedback criterion is true. In case you have selected the CD Audio feedback above threshold, it will automatically pause playing when the signal reaches at state below threshold . No matter what the feedback setting for below threshold is.

Please note: only place the CD Audio feedback on one of the criteria: **Above**, **In-Between** or **Below**. You should not place CD Audio feedback on more than one criterion or on more than 1 instrument.

Biofeedback: Increment Reward Counter

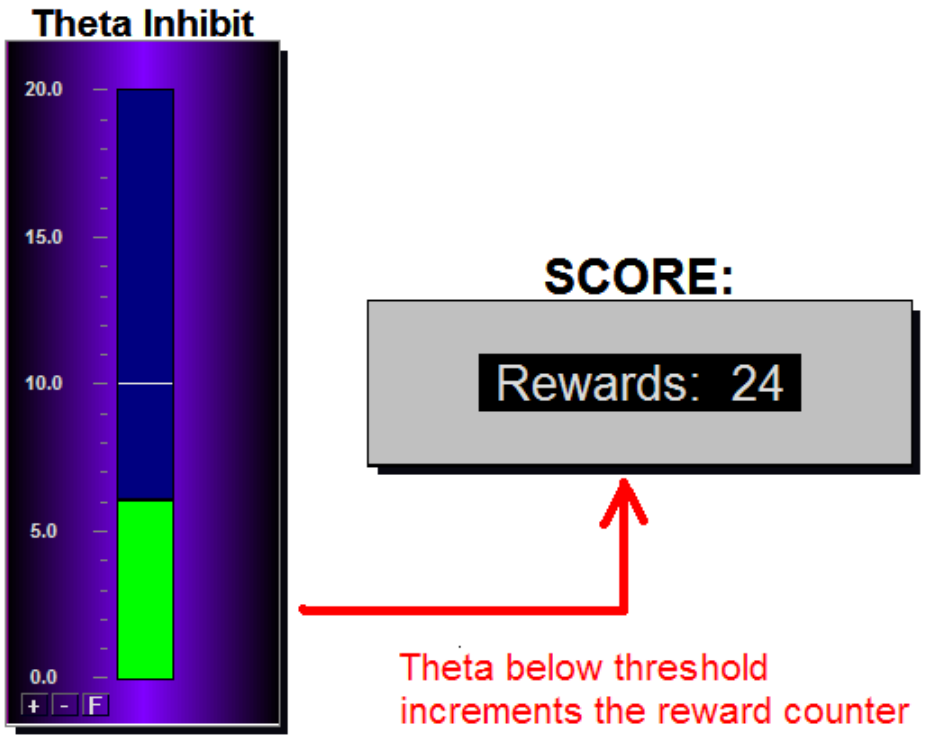
Selecting this option, will increment the '**Reward Counter**' by 1 when the signal goes over (or below) threshold and there is no '**Inhibit**' from another instrument. The purpose of the reward counter is to 'score' the training result. It is a way to observe progress during a session. At the start of a session, the reward counter is always reset to 0. An example of an increment above threshold is shown below:



We advise to set a '**Required Time**' of at least 100 ms, or the counter will run very fast. For instance, setting it to 500 ms would mean that for every second that the criterion has been met (and there are no inhibits) the counter would be incremented twice.

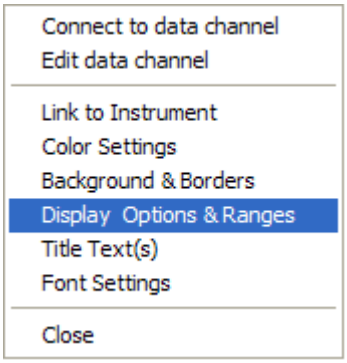
How to display the reward counter:

So how do we use and display the **reward counter**? Take a look at the following example:

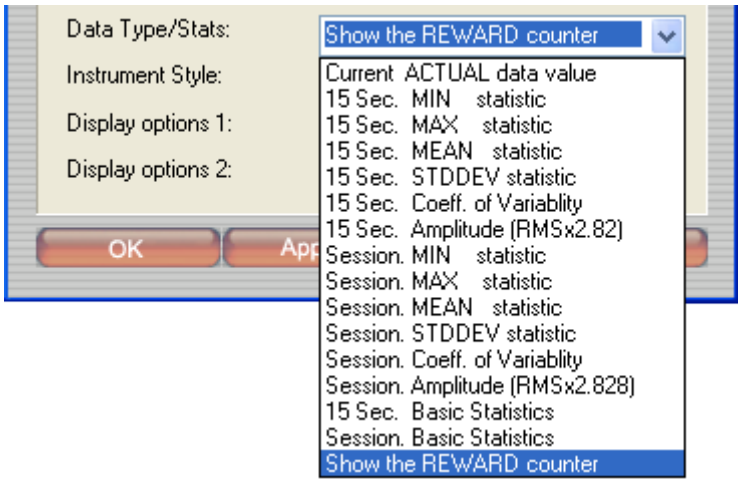


In this example the reward counter will be incremented when Theta activity is below threshold. A numerical instrument is used to display the counter. Other instruments that could be used as well are the Bargraph, Vernier and Zoomer instrument.

Change the display options property of these instruments so they will show the reward counter rather than a data channel. To open the display options, right-click the instrument and choose:



In the display options dialog box, click on the '**Data Type/Stats**' option and choose '**Show the REWARD counter**'.



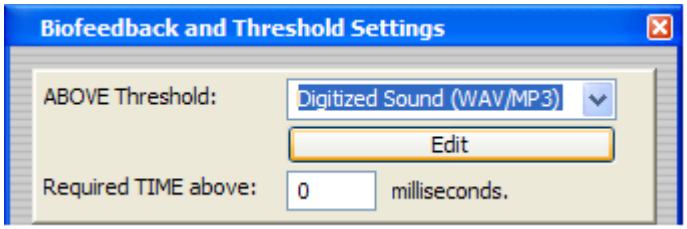
Now follow two more examples of how you could use a reward counter:

Example 1: a bargraph instrument is connected to EMG with an '**Increment Reward Counter**' above a threshold of 50 microvolt and a 'required time above' of 500 ms. The training consist of 10 cycles of 5 seconds of relaxation + 5 seconds of contraction, where the goal is to contract at levels above 50 microvolt. At the end of the 10 cycles the reward counter shows a value of 40. You enter the value of the reward counter in the session notes. (See database functions) One week later the same training is repeated, and the reward counter shows 48 at the end of the session.
The reward counter can now be used as an indicator that the 2nd training has been more successful than the 1st.

Example 2: during Theta inhibition training, a reward counter is incremented when the Theta level is below 10 microvolts for longer than 250 ms. In a former session that took 5 minutes, a 'score' of 700 'points' was reached. For the next session we can now use the same 'scoring' mechanism by setting a goal of 750 points.
If a better counter 'score' has been reached, we know that effectively the theta level has been below threshold for a longer period.

Biofeedback: Digitized Sound and Music (WAV/MP3)

This option plays digital sound and music files in the WAV, MP3 and WMA formats.

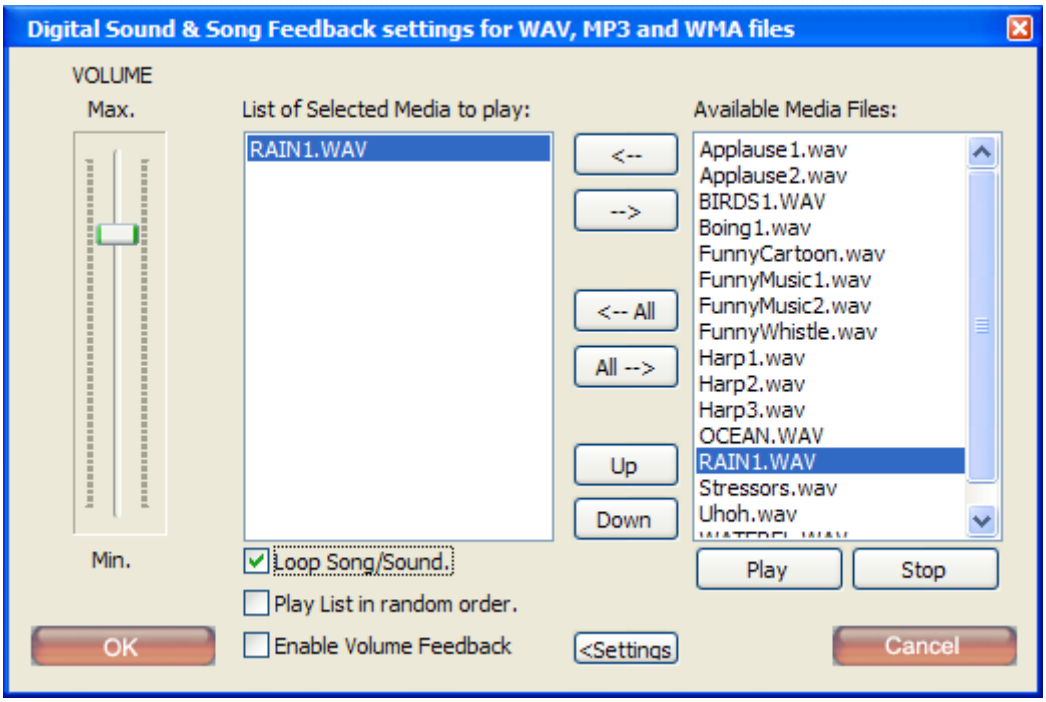


The advantage of digitized sound is that you can use it for multiple conditions and in multiple instruments. For instance one instrument will play some digitally recorded flute music when the EMG is below threshold, while another instrument plays the digitized sound of wind and water when the skin conductance is below another threshold (on another instrument).

In others words: you can mix as many sounds in as many instruments as you like.

Note that this feature has a clear advantage over some of the other media used for biofeedback, such as MIDI songs and the CD player. In those cases you can only run one instance. (You can't play 2 tracks at once, from the same CD)

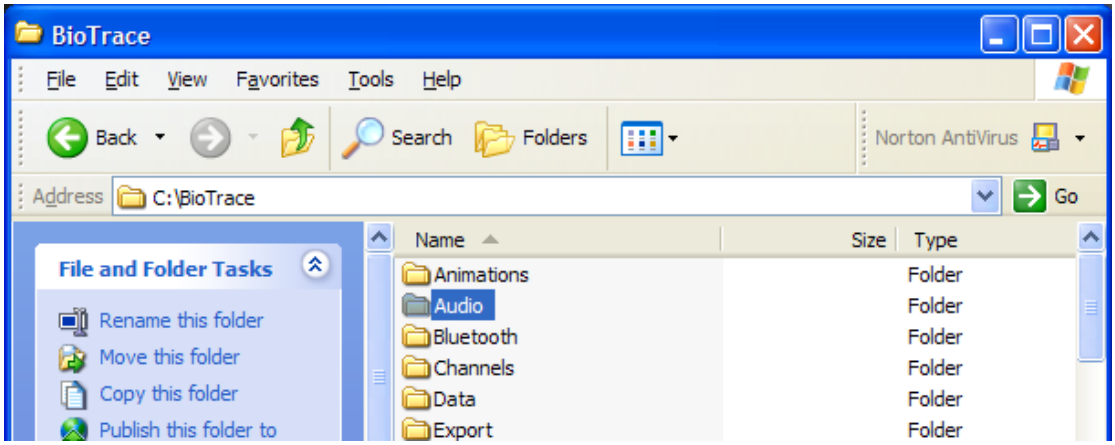
When you click on the '**Edit**' button, the following dialog box appears:



In this dialog box you can choose a number of sound/music files form the list on the right and place them in the list on the left (to play) by using the '←' and '→' buttons.

You may choose 1 sound file (in the example shown this is 'RAIN1.WAV) or you may choose list of sound files that will be played one by one.

You can put your own WAV/WMA or MP3 files in the \BioTrace\Audio directory so the software can use them.



If you choose to play a **single file**, you could choose to '**Loop**' the sound. This is particularly useful if you want to use the sound for a background sound. Rather than using a digital file that has recorded 45 minutes of ocean waves, you can now use a 1 minute sample and loop it.

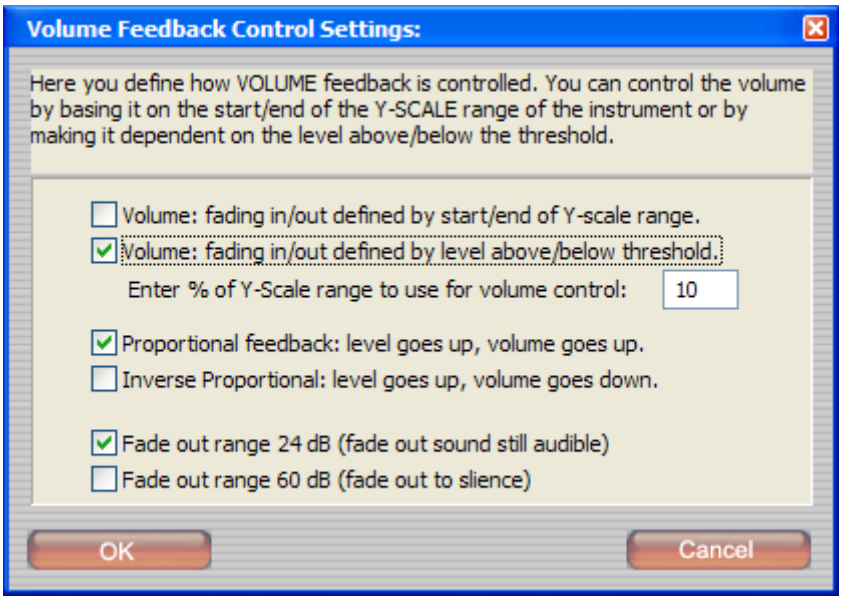
If you choose **list of files**, you can choose to play them in random order.

The **Volume** that you choose (with the vertical slider) will be applied to any of the sound files that will be played.

Digitized sound: Volume Feedback

This is a special option that uses '**fading in and out**' control on your sound files. In this case the signal displayed in your instrument will control the 'fader'.

Choose the '**< Settings**' button at the bottom, to open up the control dialog box:



In the example below, a respiration signal is used with a digitized sound above threshold and volume feedback enabled.

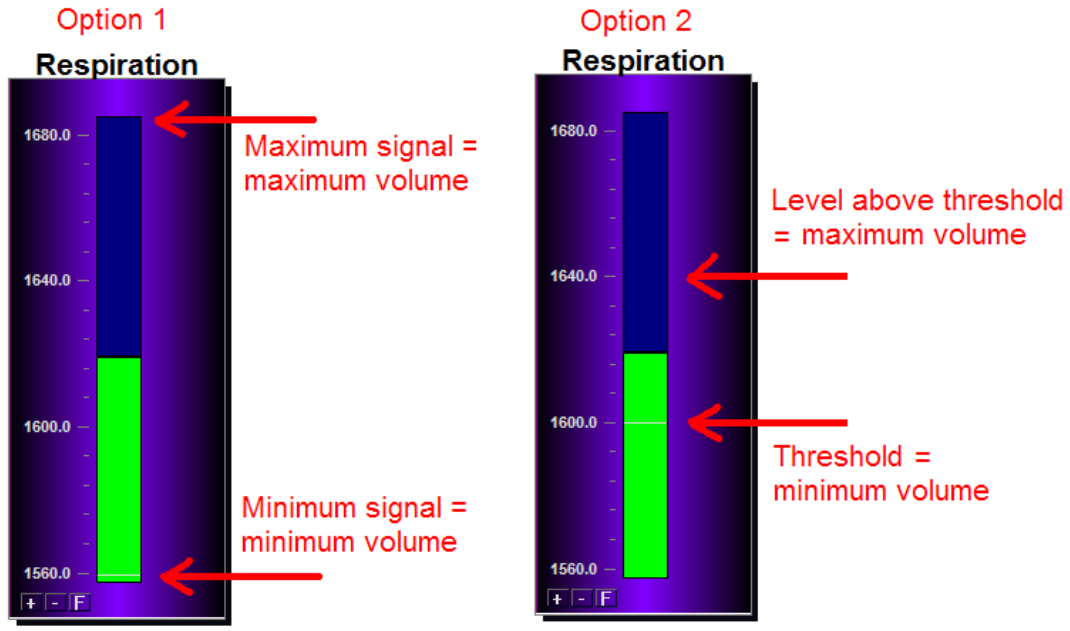
You can choose from a number of options in the volume feedback control:

1-Volume:Fading in/out defined by start/end of Y-scale range

This will set the **minimum** volume at the bottom of the Y-Scale of your signal. So this is where the signal will be completely faded out. At the **top** of the bargraph (Y-scale) the volume will reach its **maximum**. So effectively the signal displayed in the bargraph will 'equal' a volume fader (slider). There is one catch though. The sound will only play **above threshold** so make sure the threshold is towards or below the beginning of the Y-scale at the bottom of the bargraph. (You may set it at 0)

2-Volume:Fading in/out defined by level above/below threshold

This will set the **minimum** volume at the threshold and the maximum volume at a certain level (as a percentage of the total range) above threshold. (or below) You enter this range as a percentage of the total range. If you set 100% you will get the same range as in the first option, but now starting from the threshold rather than from the bottom of the bargraph. Both options are shown graphically below:



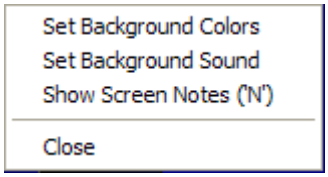
Please note that this example is for a case of feedback **above threshold**. In case of feedback below threshold, the maximum volume of option 2 would be reached at a given level **below** threshold.

Proportional feedback: this option sets the response of the volume. You could decide for instance to get the maximum level at the bottom and the minimum at the top of the bargraph. In that case you would choose **'Inverse Proportional**'.

Fade Out Range: this defines what volume level you reach when faded out. This can be total silence **(60 dB)** or a soft but still audible level (**24 dB)**.

5.2 Modifying Screen Properties

Apart from the screen objects that you can edit and modify, the screen itself also has a few properties. To access these properties, simply right-click somewhere on the screen, outside the objects.



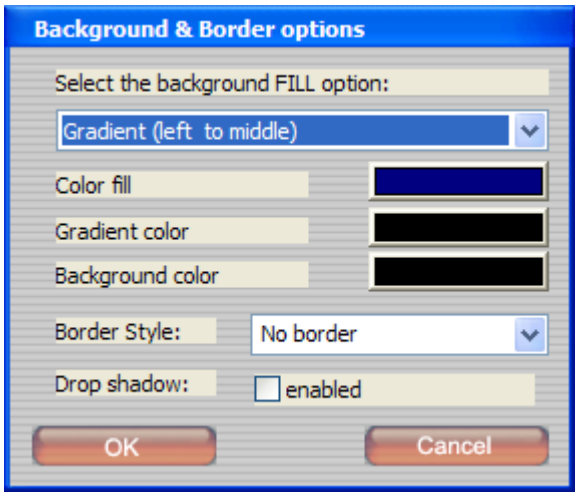
From this menu you can edit the three screen properties

1) The background colors
2) The background sound
3) The screen notes

Let's first look at the background colors option:

Screen: background colors

This option will open up the following dialog box:

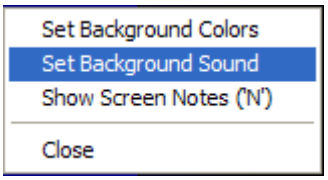


In this dialog box you can choose the type of background, solid fill, gradient fill etc. The border style and drop shadow are not used.

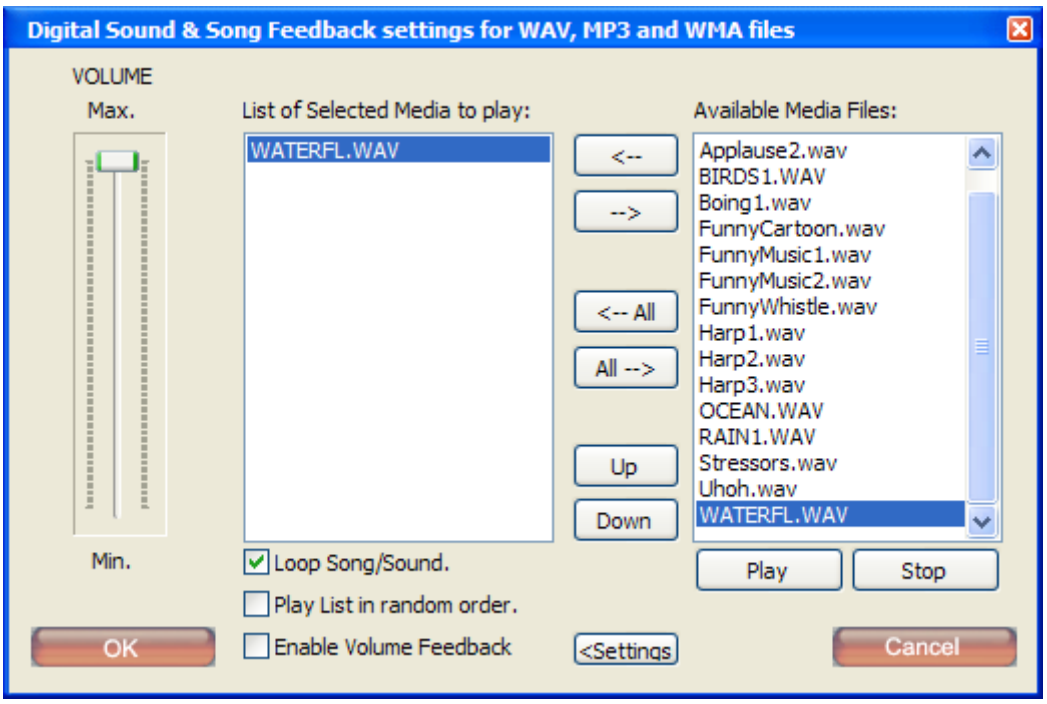
These settings are saved when you save the screen.

Screen: background sound

Right-click the screen background and choose '**Set Background Sound**' from the drop down menu.



Next the following dialog box will appear:



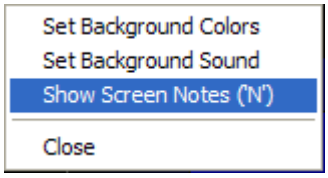
Generally you choose a single sound file here that will be played instantly when the screen is loaded. This way you can for instance attach a spoken (voice) instruction to a screen when it is shown. Or you can start some background music.

The '**Loop Songs**' option will replay the sound for as long as the screen is shown.

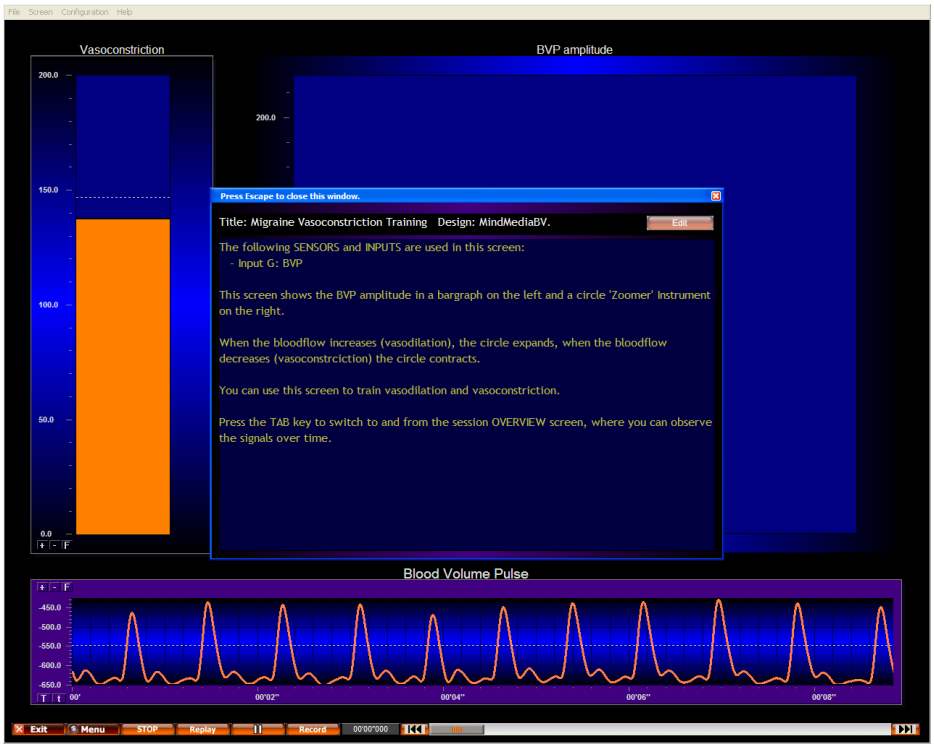
When the next screen is loaded, the background music/sound will stop.

Screen: screen notes

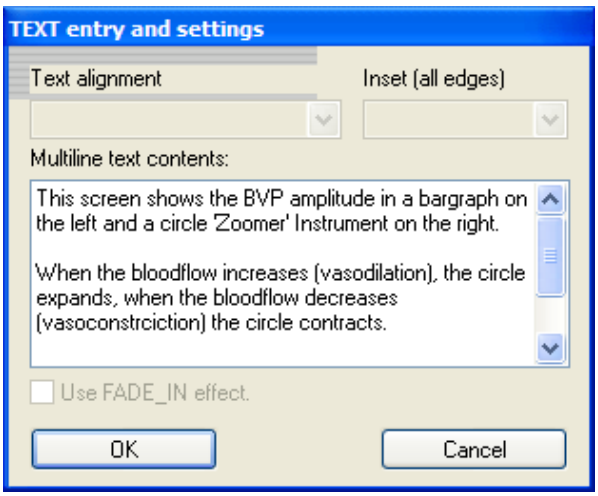
Right-click the screen background and choose '**Show Screen Notes**':



This will bring up an information box containing text that describes the function of the screen. The designer of the screen is responsible for adding this information.



When you are editing your own screens you can press the button labeled with '**Edit**' and enter your own text description. The software will add some basic information regarding the inputs and session overview mode to the screen notes.

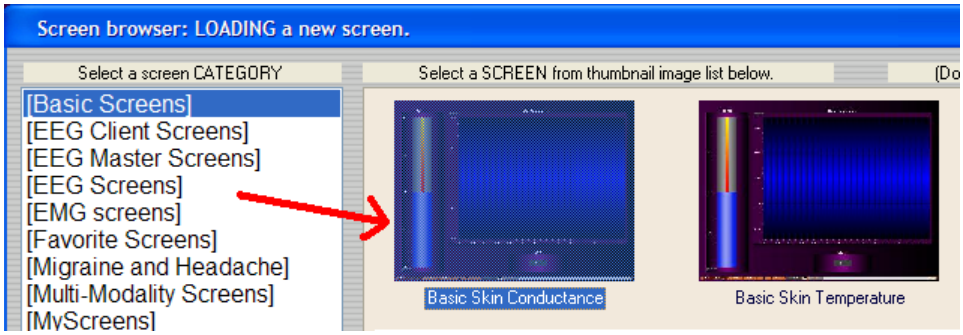


5.3 Overview of Screen Objects and Instruments

There are two ways to create a new screen:

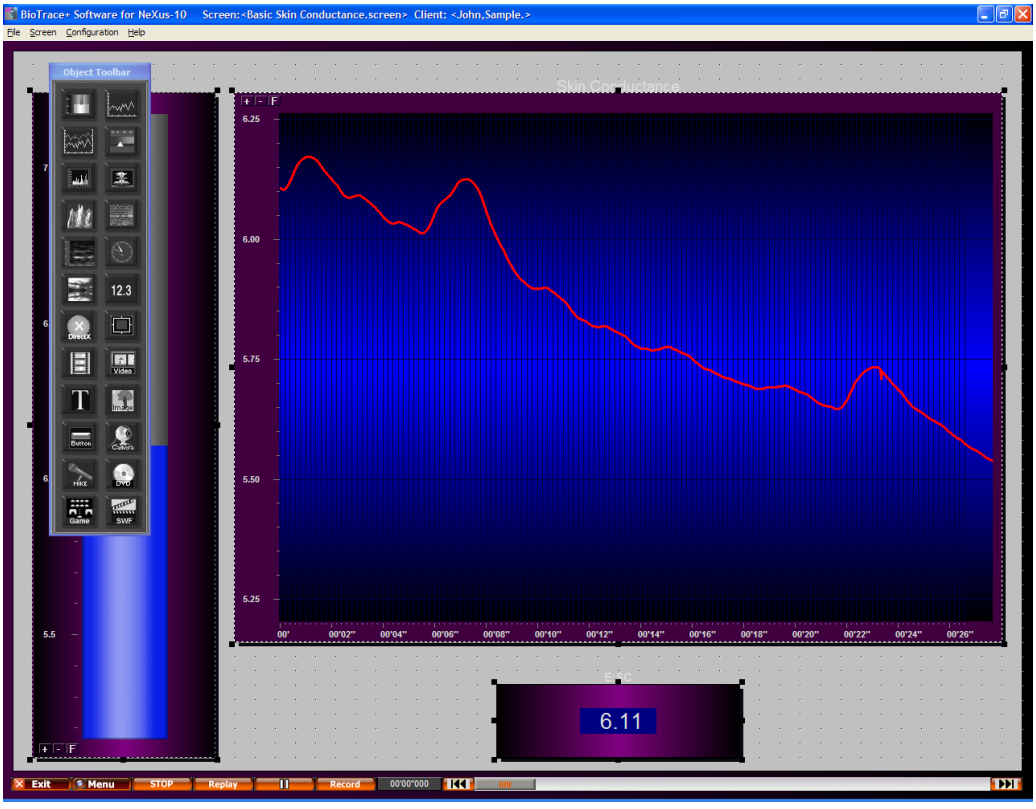
1) You modify an existing screen.
2) You start from scratch

The first method has the advantage that you could use a sample or 'template' screen that contains preset backgrounds, colors and instruments. That screen could also already have been connected to the data channel set of your choice.
To edit a screen, you first need to load a screen and a session. For instance load the '**Basic Skin Conductance**' screen from the Basic Screens category:



Switching to the Editor Mode

After the screen has loaded, you can press the '**E**' key on your keyboard to enter the screen editor mode. You will then see the screen canvas (with grid) and the object tool bar. You can only edit a screen that is loaded as a **primary screen**.

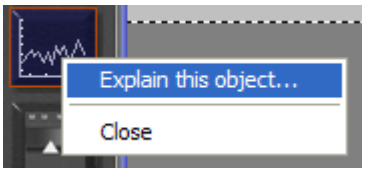


The Object/Instrument Toolbar

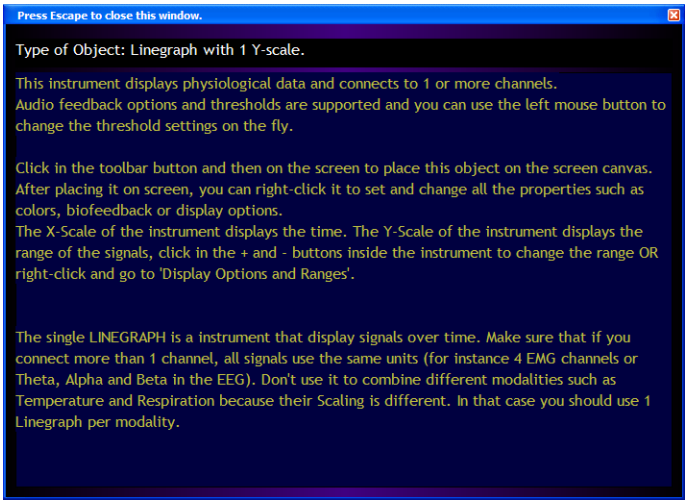
Once you are in the screen editor mode, you use the **object toolbar** to add new instruments or objects to your screen.

You can move the floating toolbar around to any location within the primary screen and pick and choose instruments and objects from it. You do this by (left) clicking on the object that you want to '**add**', then release the mouse button and click again somewhere on the screen canvas, where you want to place the object.

If you **right-click** the object, a drop down menu appears and you can choose the option '**Explain this object…**'

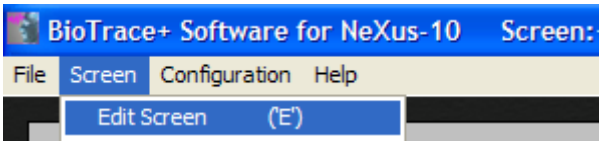


The option will show a text box with information about the selected type of instrument/object:



Note that the first 15 items on the toolbar are the (virtual) instruments which can display physiological information. (Bargraph up to the Animation instrument)
The next 9 items are 'screen objects' which display information, text, graphics, video or capture sound and video. A special case is the '**Game**' object, which we will describe further down the manual.

If you want to leave the screen editor mode again, simply press the '**E**' key once more, or select the following option from the main menu:



Instruments: Overview & Functions

On the toolbar you find the following instruments and objects:

Number	Name	Feedback	Function
1	**Bargraph**	Yes	Displays 1 channel of data on a vertical graph
2	**Single Line graph**	Yes	Displays up to 4 channels on 1 Y-scale
3	**Dual Line graph Vernier**	Yes	Display 2 channels on 2 Y-scales
4	**Instrument**	Yes	Displays 1 channel of data on a horizontal graph
5	**Single Spectrum**	No	Display a power spectrum of 1 channel
6	**Dual Spectrum**	No	Displays a power spectrum of 2 channels
7	**3D FFT Spectrum**	No	Displays a spectral array of 1 channel
8	**Poly-Line graph**	No	Displays up to 32 channels on 1 time scale
9	**Spectrogram**	No	Displays a horizontal spectrum using color for intensity
10	**Clock Instrument**	Yes	Counts small increments of channel data
11	**Water Effect Instr.**	No	Translates physiological signals into water ripples
12	**Numerical Instr.**	No	Displays numerical data of a channel
13	**Direct-X plug-in**	Yes	Uses special DirectX effect to visualize signals
14	**Zoomer instr.**	Yes	Displays expanding-contracting graphs
15	**Animation Instr.**	No	Uses bitmapped animations to visualize signals
16	**Video Replay Obj.**	No	Plays video files in a window.
17	**Text Object**	No	Displays 1 or more lines of text
18	**Image Object**	No	Displays static images (jpg/bmp)
19	**Button Control**	No	Displays a button that can execute commands and navigate to other screens
20	**Video Capture**	No	Captures Video from a digital video camera
21	**Audio Capture**	No	Captures Sound from a microphone or audio source
22	**DVD replay**	No	Plays a DVD movie in a window.
23	**Game Object**	Yes	Displays biofeedback driven games
24	**Flash Animation**	No	Plays Macromedia Flash Animations

Maximum number of objects in a screen:

In total you can place 64 instruments or objects on a screen. Most of the instruments can be repeated on a screen. So it is no problem if you decide to place 10 bar graphs, 5 line graphs and 3 text controls on a single screen. There are some exceptions though:

Object/Instrument restrictions:

The following objects/instruments can only be used once on the primary or secondary screen:

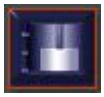
- **The Video and Audio capture**
- **The DVD replay instrument**
- **The Direct-X plug-in instrument**

(Only 1 instance may exist at any time)

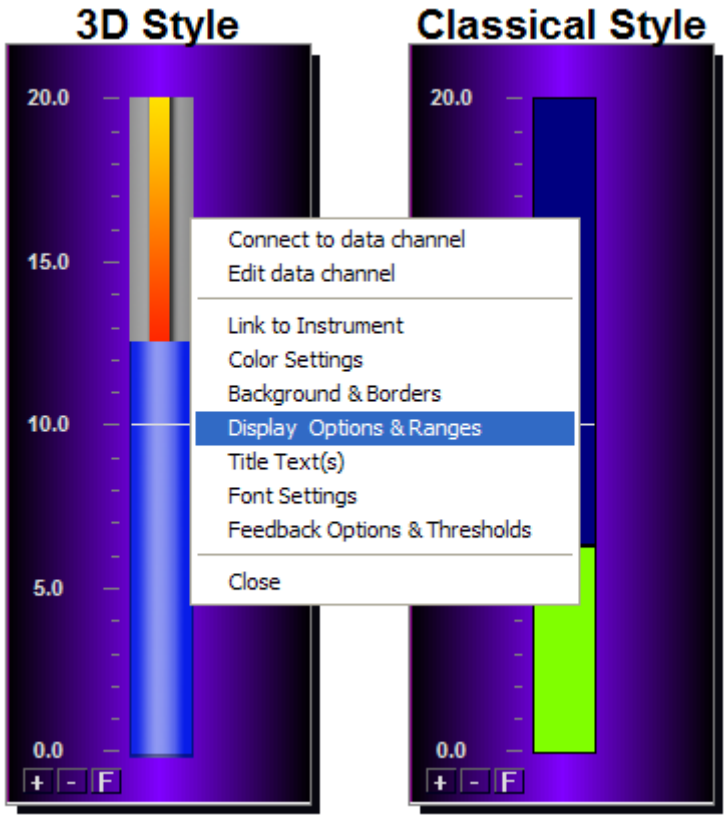
5.4 Screen Instruments

Instruments: the Bargraph

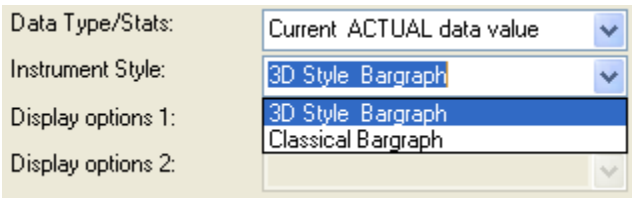
The first object on the toolbar is the **Bargraph**:



This is a multi-purpose instrument capable of displaying 1 channel. It supports most of the standard instruments features, including biofeedback. The Instrument specific display options can be found under the option '**Display Options & Ranges**'.



One of these options is the '**Instrument Style'** of the instrument, which can be set to '3D Style' or 'Classical Bargraph':

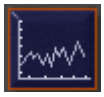


You change the threshold on this instrument by left clicking in the part where the bar is drawn and moving the mouse up and down.

The '+' and '-' button increase and decrease the scale, the 'F' button fits the range, to the signal being displayed.

Instruments: the Single Y-Scale Line graph

The 2nd object on the toolbar is the **Single Y-Scale Line graph**:

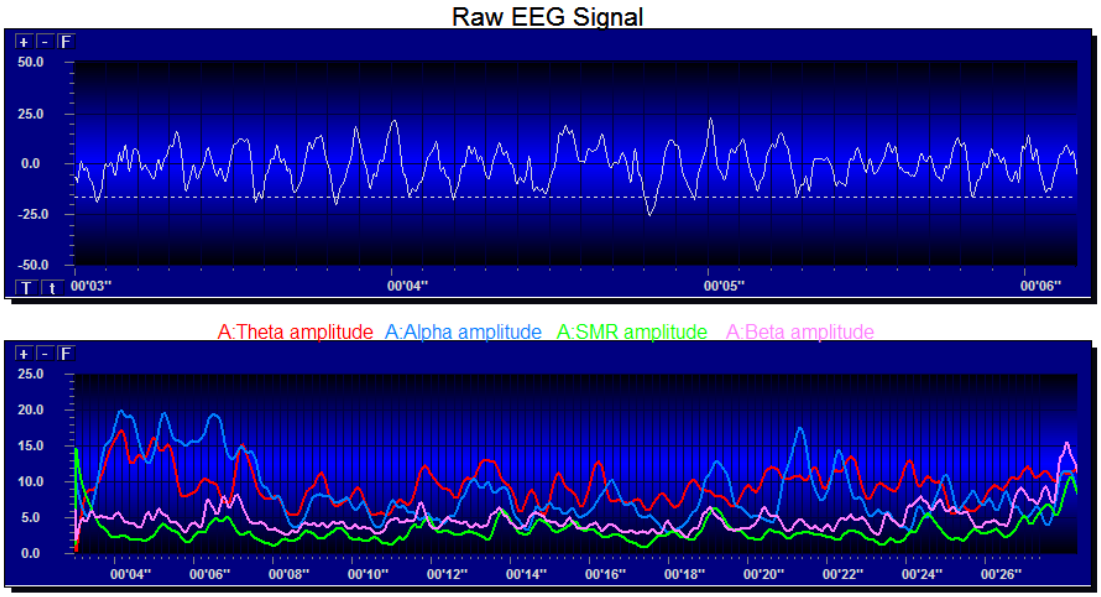


This is a multi-purpose instrument capable of displaying of up to 4 channels simultaneously. In case more than 1 channel is connected, please make sure all channels are using the same units or have the same modality!

Explanation: it is fine to combine 1-4 EMG amplitudes, EEG signals (Theta, Alpha, Beta) but you should, for instance, not combine temperature and heart-rate on a single Y-Scale line graph. The units and ranges of Skin Temperature and heart rate are just too different. Therefore you would never get a good resolution on both channels at the same time. If the range would be good for the heart rate (e.g. 50-100 beats per minute) the temperature would show (almost) as a flat line. For such a combination of channels you would be better off choosing the dual Y-Scale Line graph instrument.

This instrument supports most of the standard instruments features, including audio feedback options and inhibits. The instrument can be used to display fast (2048 SPS) and slow signals (32 SPS). The maximum time range the line graph instrument can display is about 50 seconds.

The picture below shows an example of this instrument connected to **1 raw EEG** signal (top). At the bottom the same instrument is now connected to **4 channels of EEG** band pass filtered activity (Theta, Alpha, SMR and Beta)

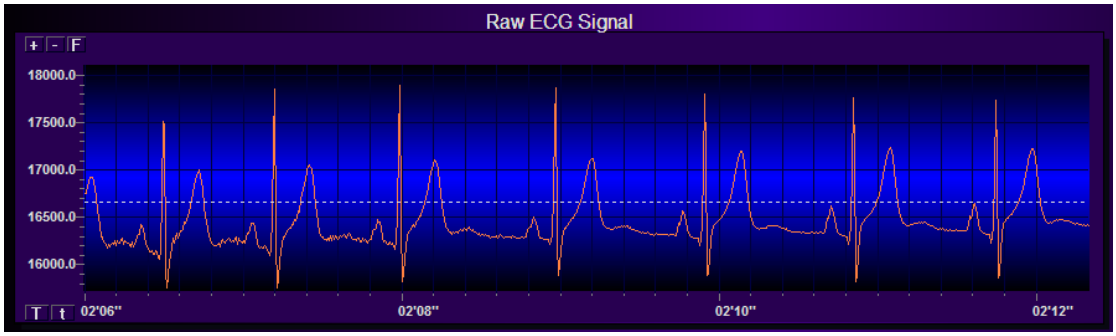


Notice that you can set different colors and border styles on this instrument. Also notice that the top line graph has a different time scale (it displays roughly 3 seconds while the bottom instrument displays about 24 seconds)

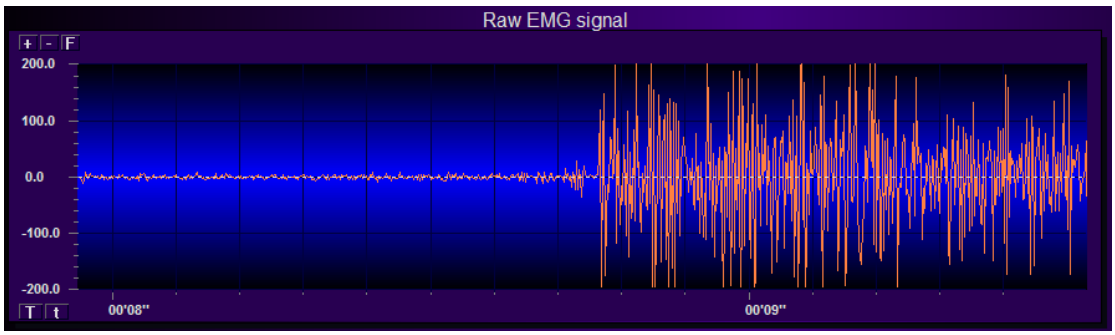
Each instrument can be set to have its own colors, time scales, smoothing factor and display option properties.

More examples of the Single Y-Scale Line graph:

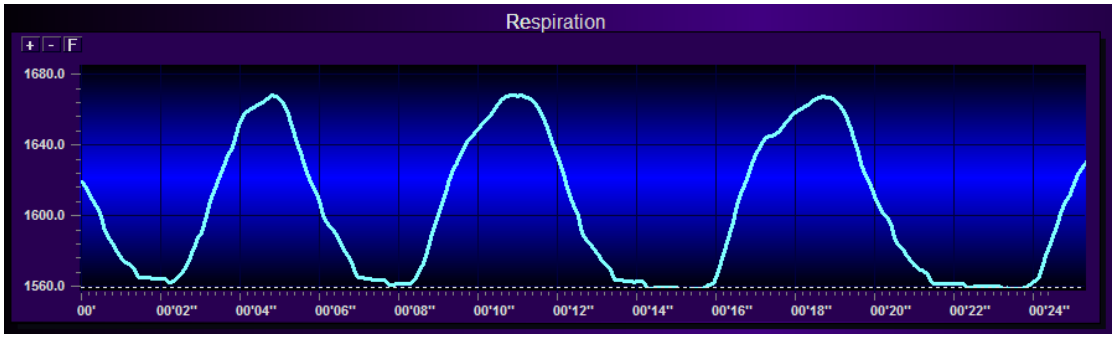
The line graph below shows an **ECG signal**, sampled at 256 SPS.



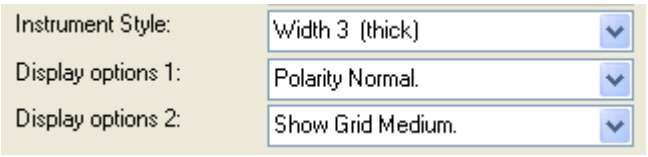
The line graph below shows a **raw EMG signal** sampled at 2048 samples per second, the first part shows the EMG activity during relaxation, the second part shows the EMG activity during a contraction. The range is –200 to +200 microvolts pk-pk.



The last line graph shows **Respiration** activity, sampled at 32 samples per second. Inhalation is **Up** and exhalation is **Down.** Notice the different time scaling.



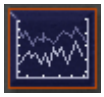
Note that on the last line graph the **width** of the line graph was set to 3 and the **grid size** was set to medium. You can edit these properties under '**Display Options & Ranges**' when you right-click the instrument.



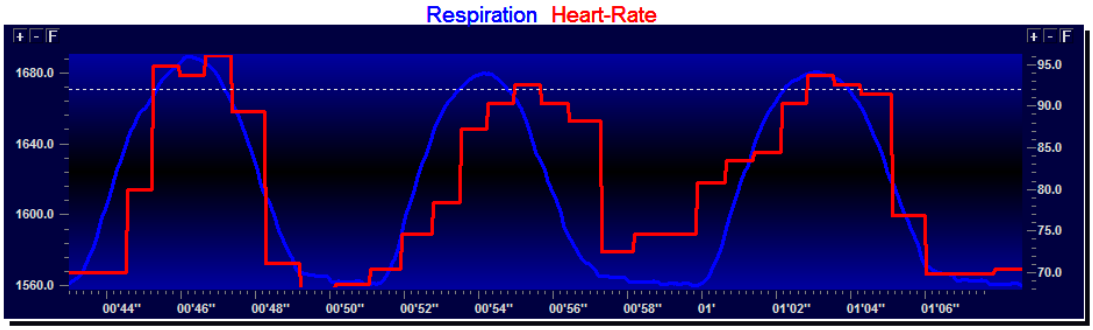
The **Polarity** setting defines whether a positive value is plotted as going **Up** or **Down** on the Y-scale of the line graph. For SCP signals, the polarity is sometimes inversed.

Instruments: the Dual Y-Scale Line graph

The 3rd object on the toolbar is the **Dual Y-Scale Line graph**:

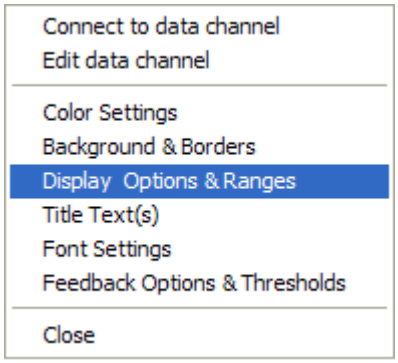


This instrument is quite similar to the other Line graph instrument, except that it has two Y-Scales, rather than one Y-Scale. This means that you can now combine two different modalities in the same instrument. An example of a combined display of respiration (blue) and heart rate (red) is shown below:

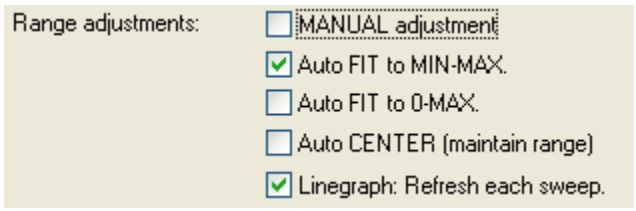


The ranges of HR (70 to 95) and respiration (1560 to 1650) are very different, but by using the dual Y-scale Line graph you can combine then in a single graph, and overlap the graphs.

We advise you go to the '**Display Options & Ranges'** setting for this instrument:



Then set the '**Auto FIT to MIN-MAX**' and '**Line graph: Refresh each sweep**' options.



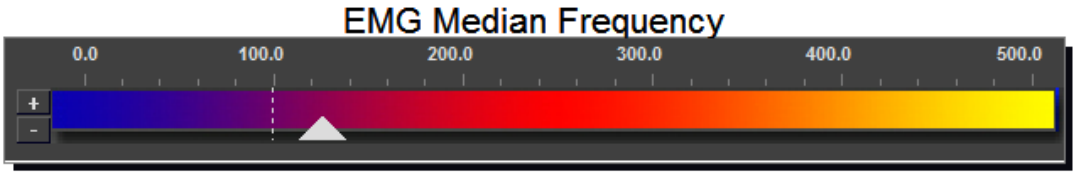
Using the **Min**-Max auto range adjustment will take care that the range settings of both channels are made to 'fit the signals and thus both channels will remain visible.

Instruments: the Vernier Instrument

The 4th object on the toolbar is the **Vernier Instrument**:

This instrument is rather similar to the bargraph, except that it displays signals **horizontally**.

Below an example is shown where the Vernier Instrument displays the median frequency of a raw EMG signal in the range from 0 to 500 Hz.

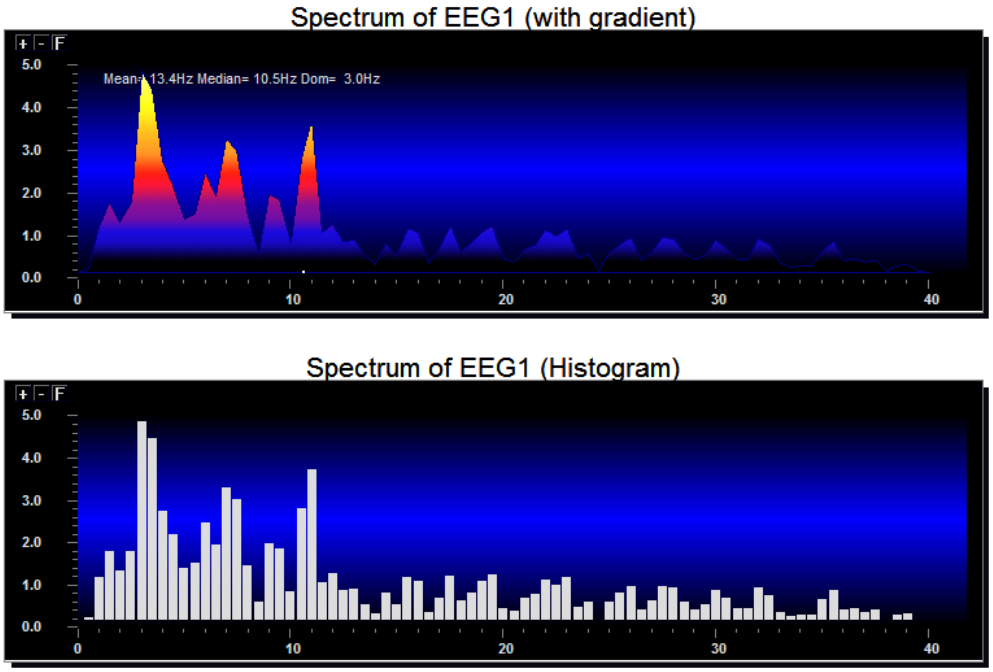


The Vernier instrument supports Biofeedback and most other display options.

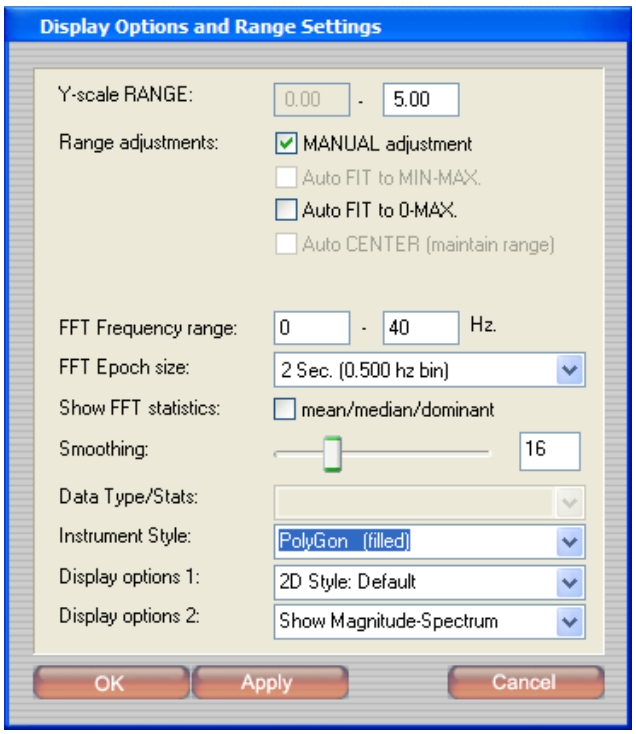
Instruments: the Single FFT Spectrum

The 5th object on the toolbar is the **Single FFT Spectrum**:

This instrument computes and displays a spectral analysis of any time sampled signal. It is based on the fast Fourier transform (FFT). Below a sample is shown of a spectral analysis of an EEG signal using two different **Instrument Styles**.

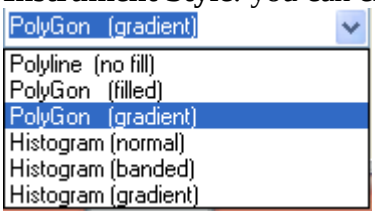


You can change these Styles under the '**Display Options & Ranges**' property:



Through the **Display Options Dialog Box** you can set the following options:

1) **The Y-Scale range:** This can be any positive value. It defines the height of the graphs being displayed.
2) **The FFT Frequency range**: The maximum frequency you can enter here is half the sampling frequency. (so for EMG sampled at 2048 SPS, you can enter values up to 1000 Hertz)
3) **The Epoch Size** of the FFT. The Fast Fourier computes a spectrum on discrete portions of a signal. These are called **Epochs**. The maximum size of the Epoch in samples that the FFT can process is 2048 points. That means that for a medium fast signal like EEG, you can choose from an **epoch size** of 1 to 8 seconds. (1 second = 256 points, 8 seconds = 2048 points)
4) **Show FFT Statistics**: you can enable the display of the numerical values of the mean/median and dominant frequencies here.
5) **Smoothing**: like most instruments, you can set a smoothing factor on the FFT. High smoothing factors will have the effect that you can observe trends in the signal better, but the response of the FFT will slow down and you will not see the current activity. You can solve that problem by placing two identical FFT instruments below each other. One with no smoothing and one with high smoothing.
6) **Instrument Style**: you can choose from 6 different instrument styles:

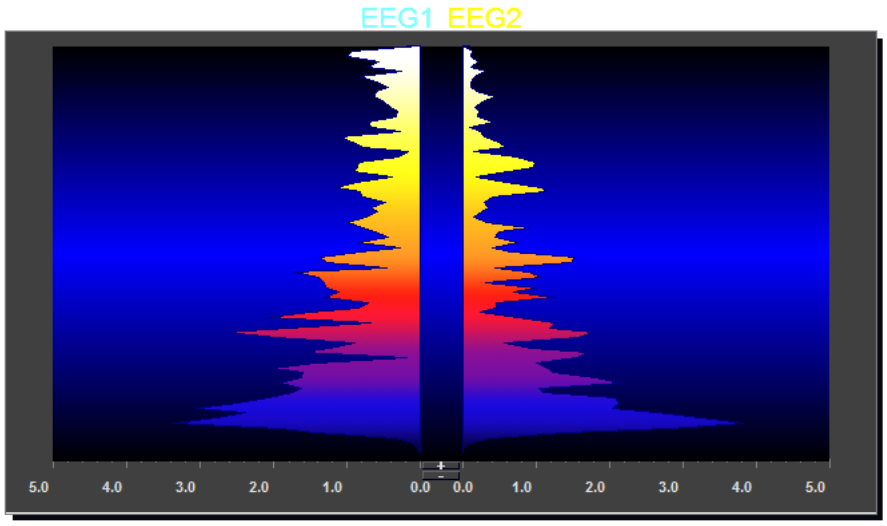


7) **Options 1**: The 2D style is, at present, the only option you can set here.
8) **Options 2:** here you can choose whether to look at the **magnitude-** or at the **power-spectrum**. The magnitude spectrum contains the square-root values of the power spectrum.

Instruments: the Dual FFT Spectrum

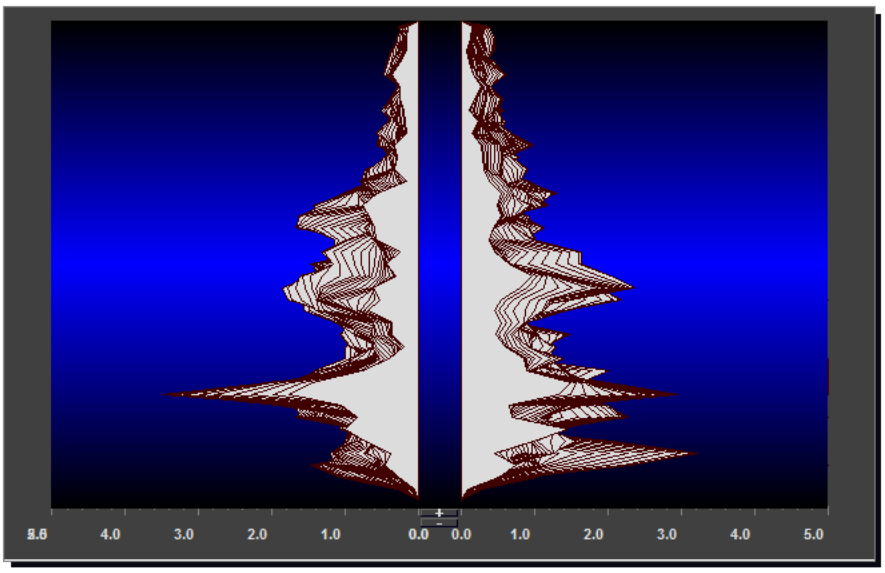
The 6th object on the toolbar is the **Dual FFT Spectrum**:

This instrument is very similar to the former instrument (**Single FFT Spectrum**) except that this instrument displays the spectrum of two channels of data. The display of the spectrum is shown in a horizontal fashion, where the first channel is shown to the left and the second channel is shown to the right.



The **Display Options** for this instrument are similar to the **Single FFT Spectrum**. Please refer to the description of the display options for that instrument (1 page back)

Note: you can turn the **'Refresh OFF**' under the 'Display Options 1'. A sample of the effect that this generates, is shown in the picture below:



Instruments: the 3D FFT Spectrum

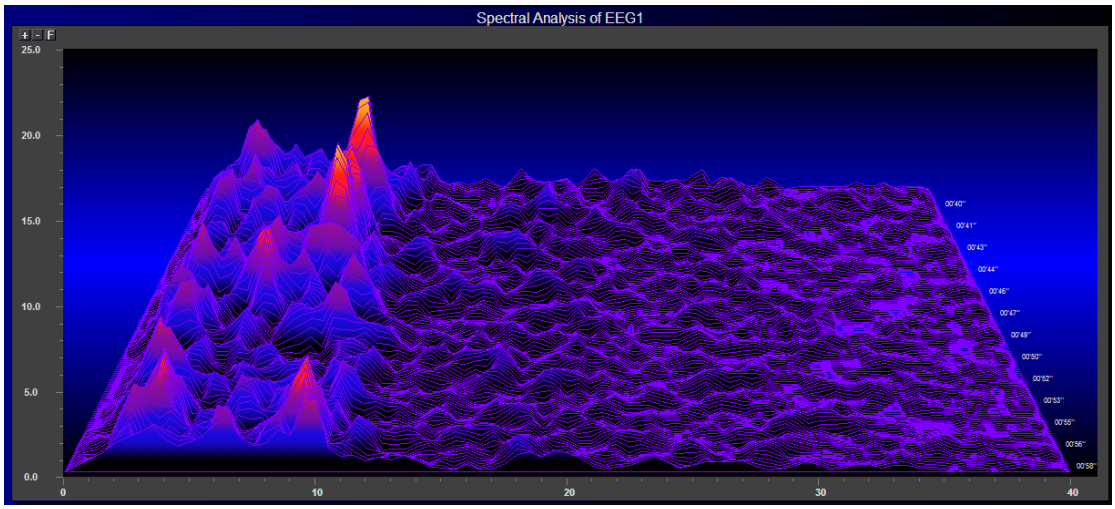
The 7th object on the toolbar is the **3D FFT Spectrum**:

This instrument is sometimes called a spectral 'Waterfall' or 'Compressed Spectral Array'. In our first 2 channel neurofeedback system (The BrainTracer) that we introduced in 1992, we called this type of display a 'BrainScape' when it was applied to the EEG signal.

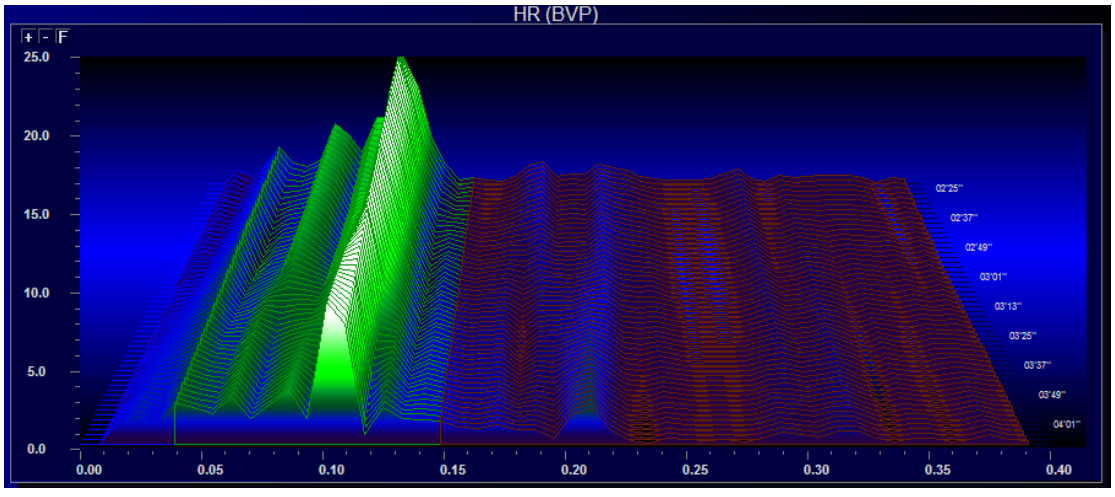
You can think of the **3D FFT Spectrum** as a spectral analysis over time, where there are three axes:

1) The Y axis, showing the amplitude of the signal
2) The X axis, showing the frequencies
3) The Z axis, showing the progress of time

A sample of this instrument analyzing EEG between 0-40Hz is shown below:

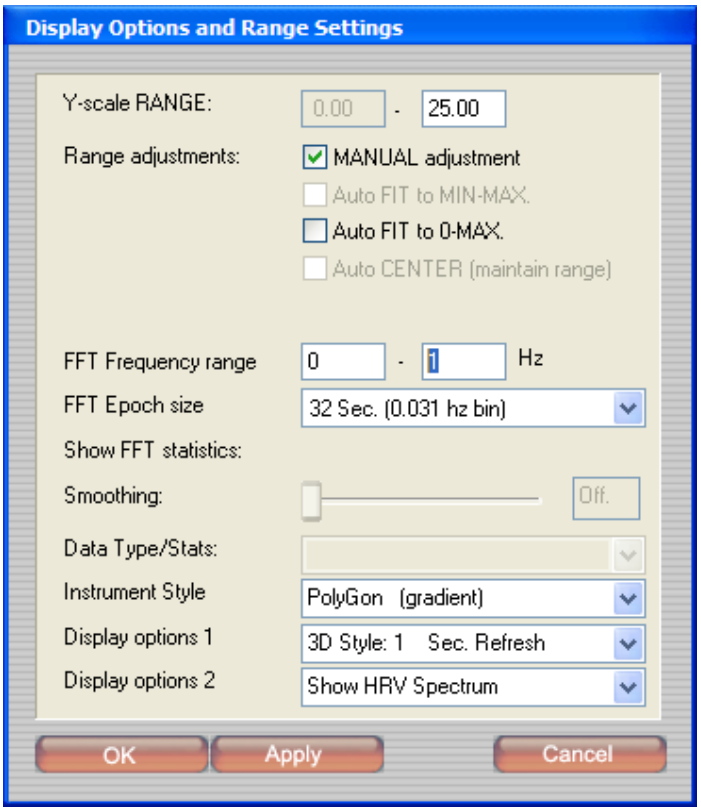


Another example of the same instrument showing a spectral analysis of the HR (heart rate) activity, with a frequency range setting from 0–0.4 Hz is shown below:



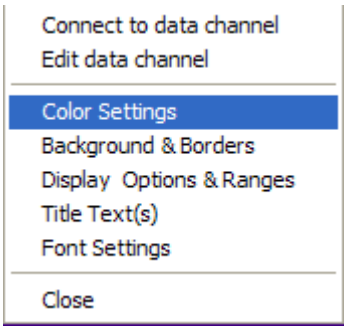
Display options:

The same display options apply, as those that are used in the '**Single FFT Instrument**'. A sample (for HRV analysis) is shown below:

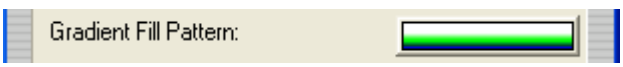


Note that for slow signals (such as heart rate, respiration, and skin conductance) you can set much greater **FFT Epoch sizes**. The reason is that the sample rates of those signals are lower. Choose **'Show HRV Spectrum'** for a 0-0.4 Hz range setting.

No smoothing is supported on this instrument. The **Display Options 1** set the refresh rate of the instrument. The type of gradient can be selected from the **Color** properties.



In the **Color Dialog Box** that will open, you click on the '**Gradient Fill Pattern**' button. Then you can pick a gradient from a list of gradients.

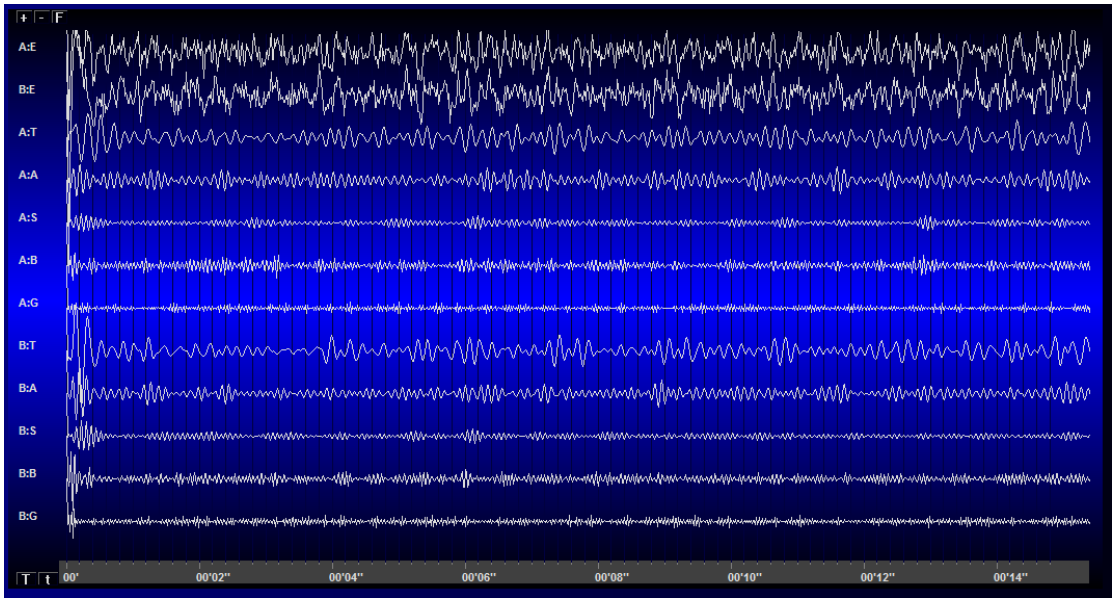


Instruments: the Polygraph Instrument

The 8th object on the toolbar is the **Polygraph Instrument.**

This instrument does not (unlike the other line graph instruments) support feedback options, but does allow combining up to 32 channels of line graphs, on a single time scale. This way you get an overview of the activity of the all these channels, during a live recording. The session overview mode could display the same amount of channels, but in that case the signals would be static.

The sample picture below shows 11 EEG channels consisting of the raw EEG signals and their band-pass filtered derived channels.



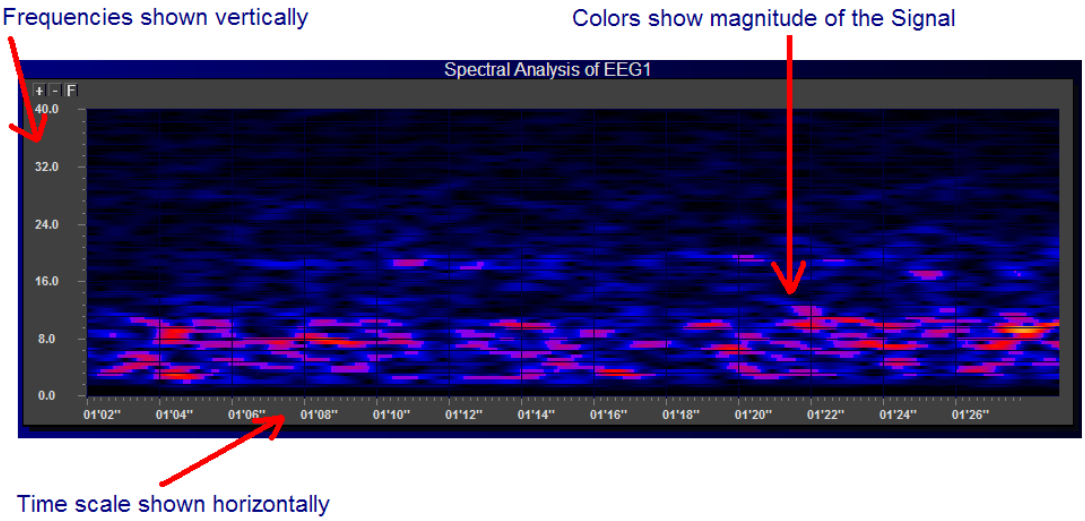
The instrument auto-scales the signals, so the signal will always fit.

The main use for this instrument is get a '**Live Overview**' of multiple channels, in a single instrument.

Instruments: the Spectrogram

The 9th object on the toolbar is the **Spectrogram Instrument.**

This instrument displays a spectral analysis of a channel in a different way than a regular FFT Spectrum. The Frequencies are displayed vertically, the time is displayed horizontally and the magnitude of the activity is shown by the intensity of a color. The main use for the Spectrogram is to provide a visual overview of spectral activity over time.

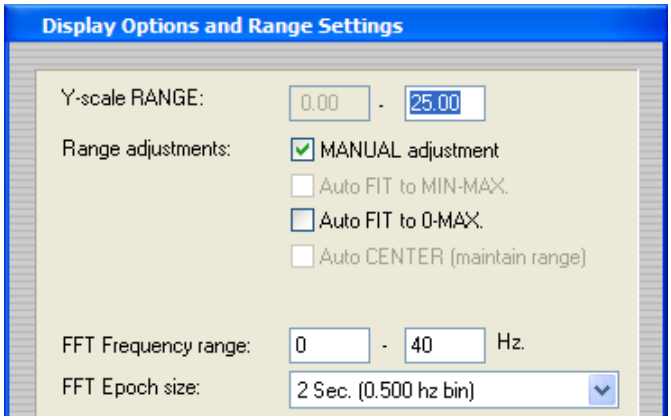


In the example above a **Spectrogram** of an EEG is shown between 0-40 Hz over 24 seconds of time. In the beginning of the graph we can see some Alpha activity (around 01'04'') and low Theta activity which are both shown in the color red, indicating a higher level. Blue or dark colors indicate low level activity. Red, yellow and white colors indicate medium and higher levels.

Low level Medium Level High Level

The (Y-Scale) range of the magnitude being displayed can be changed by the range controls at the left top of the instrument:

Under the '**Display Options & Ranges**' you can also manually enter the Y-scale range, Frequency Range and FFT Epoch size:

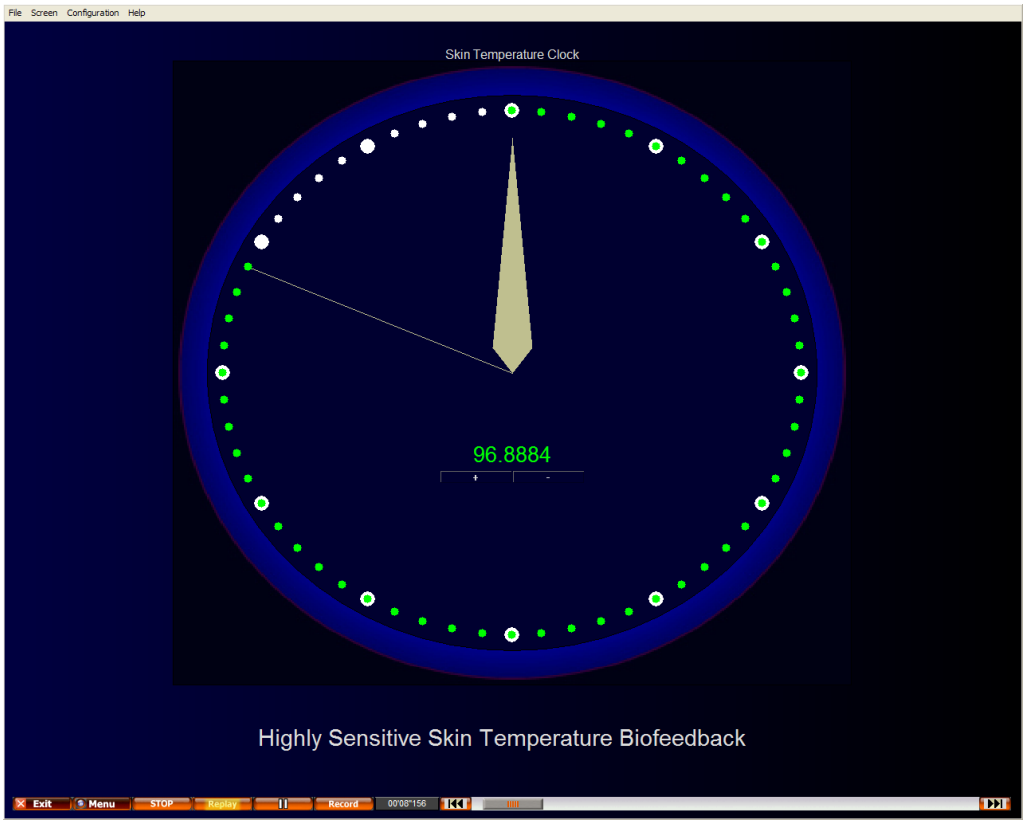


Instruments: the Clock Counter Instrument

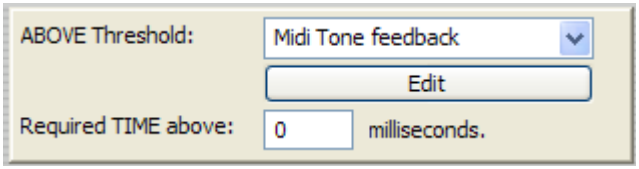
The 10th object on the toolbar is the **Clock Counter Instrument.**

This instrument can be used to feed-back very small increments or decrements of physiological signals. Examples are Skin Temperature, Skin Conductance and EMG amplitude levels. The step size of the increment/decrement can be defined from very small (0.0001) to large (1000) by clicking the '+' and '-' buttons in the middle.

An example of the clock instrument feeding back very small temperature changes (of 1 thousandth of a degree Fahrenheit) is shown below.



Every time the pointer advances one 'tick' the 'Above Threshold' feedback sound is played. When stepping backwards, the 'Below Threshold' feedback sound is played. You can edit these changes by right-clicking the instrument and choosing '**Feedback Options and Thresholds**'. Below a sample of the 'ABOVE' feedback is shown:



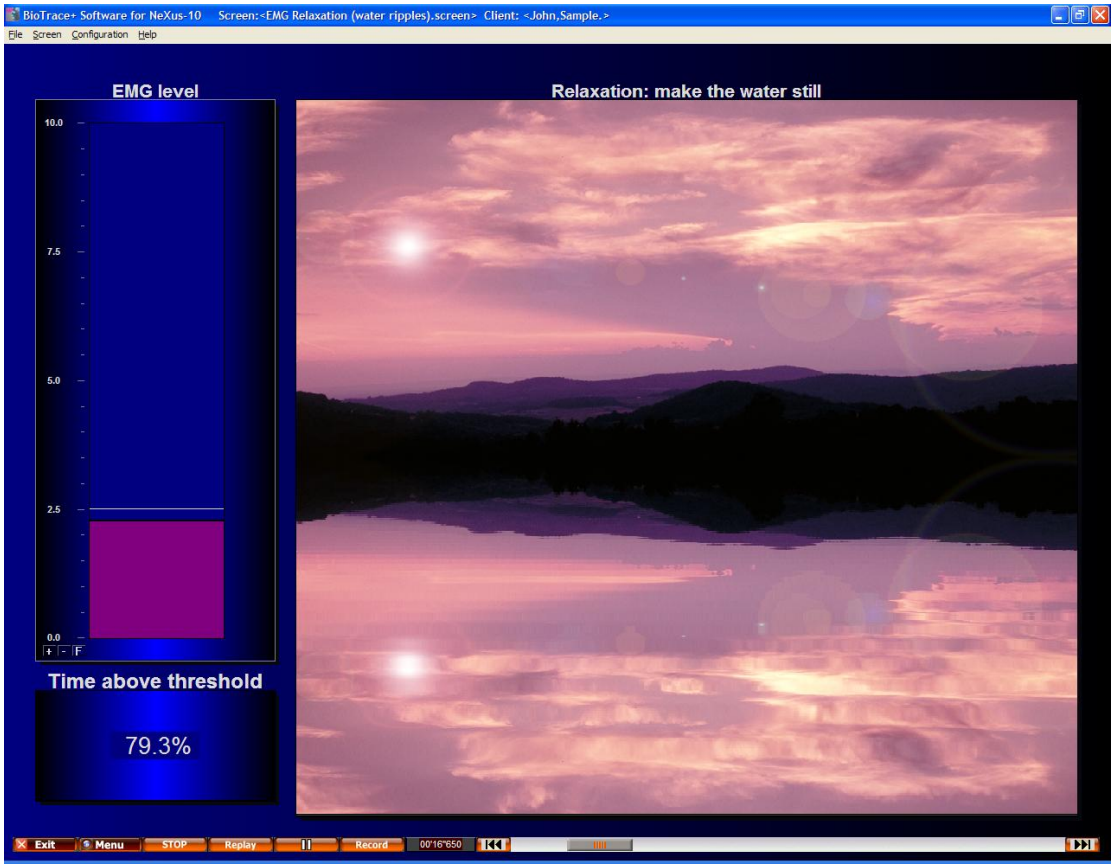
TIP: you can use higher smoothing factors to dampen the response of the instrument *(put the mouse over the instrument and press 'S' or shift + 'S')*

Instruments: the Water Effect Instrument

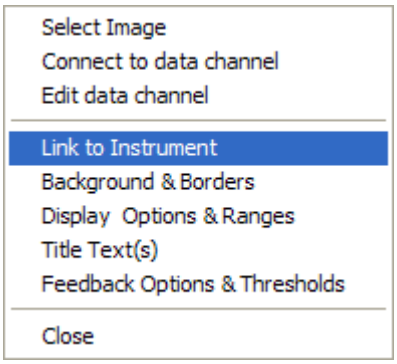
The 11th object on the toolbar is the **Water Effect Instrument.**

The Water Effect Instrument uses a special digital effect that is computed on the fly. It shows a water ripple effect where the height of the ripples reflects the magnitude of the attached physiological signal. *(The maximum ripple level is at the top of the range)*

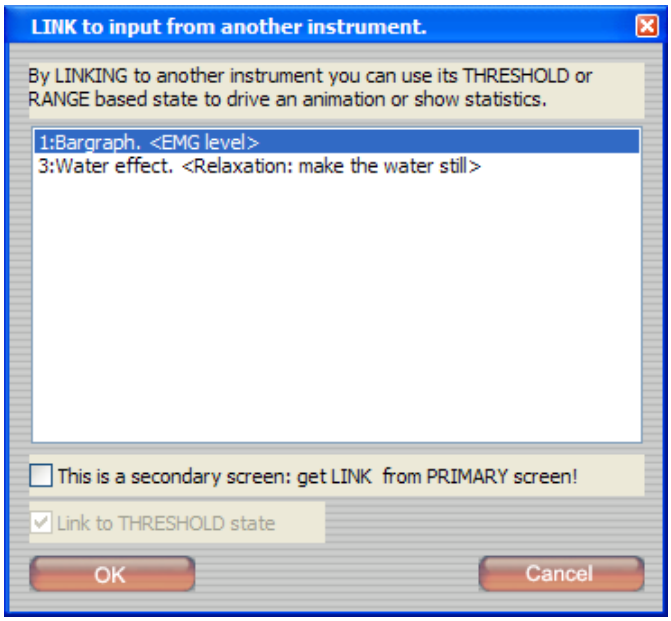
In the example below, you see the water effect reflecting the EMG amplitude level during a relaxation session. The lower the EMG level, the less ripples will be visible:



This instrument is either '**Connected**' to a data directly or '**Linked**' to another instrument. If the Water Effect Instrument is connected to a data channel directly, you need to set a manual range. (Under '**Display Options & Ranges**)

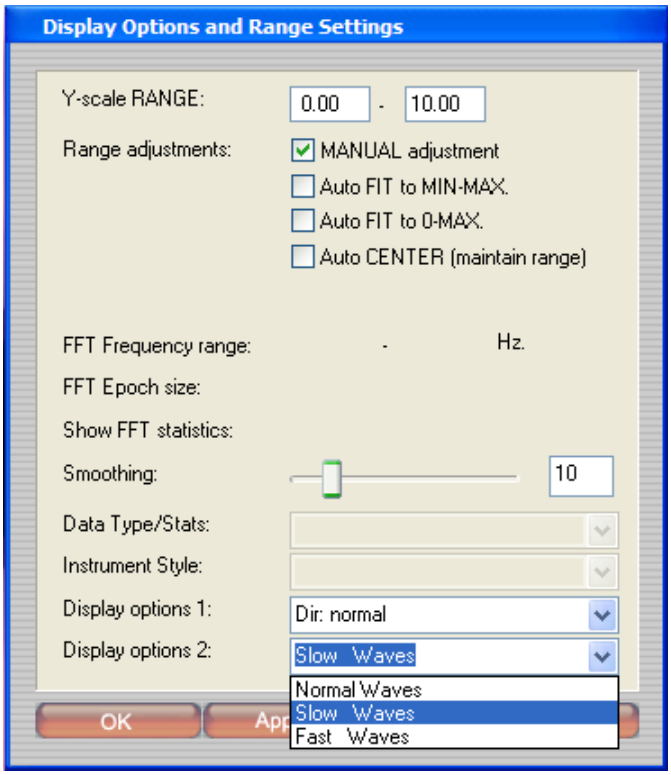


The advantage of choosing '**Link to Instrument**' is that the Water Effect Instrument will use the range settings of the other instrument. In the example on the former page, you could link the instrument to the bargraph. Automatically then, it would use the range from 0-10 microvolt that this bargraph is currently using.



When you change the range on the bargraph (by clicking in the

control buttons, this change would immediately apply to the Water Effect Instrument as well.

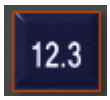


Other options you can set on this instrument:

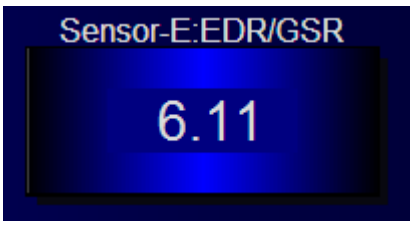
- **Smoothing** (dampens sudden changes in the signal & ripples)
- **1:Direction:** when inversed the ripples slow down when the level goes up.
- **2:Wave Speed:** sets the 'waving' speed of the water ripples.

Instruments: the Numerical Instrument

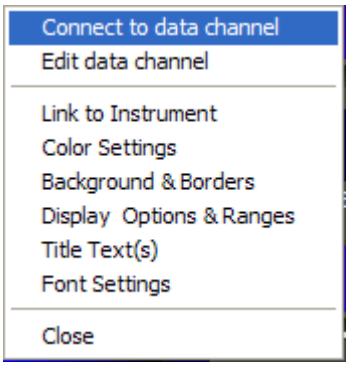
The 12th object on the toolbar is the **Numerical Instrument.**



In the simplest case, this instrument displays the current value of a data channel:



The instrument updates once every second. When you right-click the instrument, you can choose a number of options:

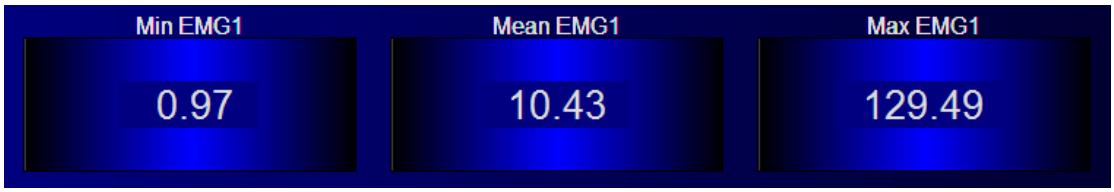


1) **Connect to data channel**: tells the instrument to display channel data.
2) **Edit data channel**: edits the data channel settings.
3) **Link to Instrument**: tells the instrument to display the percentage above or below the threshold of the other instrument
4) **Color settings**: changes the color of the text and text background
5) **Display options and ranges**: changes the instrument '**Style**'
6) **Title text**: sets the text show on top of the instrument.
7) **Font Settings**: changes the FONT of the instrument.

Most of these options are common to the other instruments and have been discussed in the earlier chapters. Let's look at the special features of this instrument:

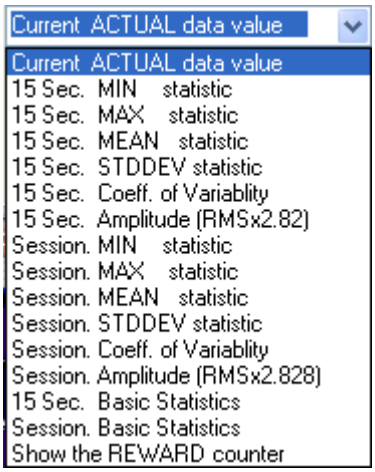
Displaying Statistics:

When the numerical instrument is connected to a data channel, it can display the current '**Actual Value**' or it could display a statistic:

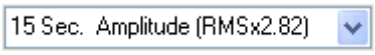


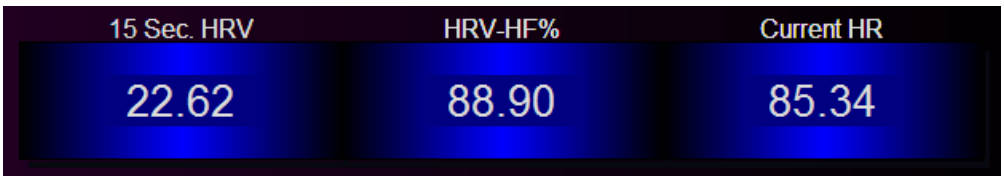
In the example three numerical instruments are shown, all connected to EMG amplitude channel 1. The first instruments shows the minimum level, the second the mean level and the last the maximum level of the last 15 seconds. During a session recording (or replay) it takes 15 seconds before these data values appear.

You can change these settings under the '**Display Options & Ranges**' right of the '**Data Type/Stats**' option:



A special case of these statistics is the'**15 Sec. Amplitude (RMSx2.82**)'. This option can be used to measure the peak-peak level of variability of a signal. This is particularly useful for displaying the level of heart rate variability, online. In the example below, the first numerical instrument on the left uses this specific setting:

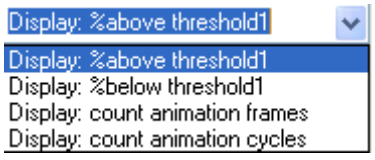




Effectively this displays the distance (or difference) between HR_{max}. and HR_{min}. within the last 15 second cycle. This statistic reflects the HR variability very well. The advantage of this method is that is continuously updates the HRV, rather than once every cycle of 10-15 seconds like the older HR_{max}-HR_{min} methods typically do

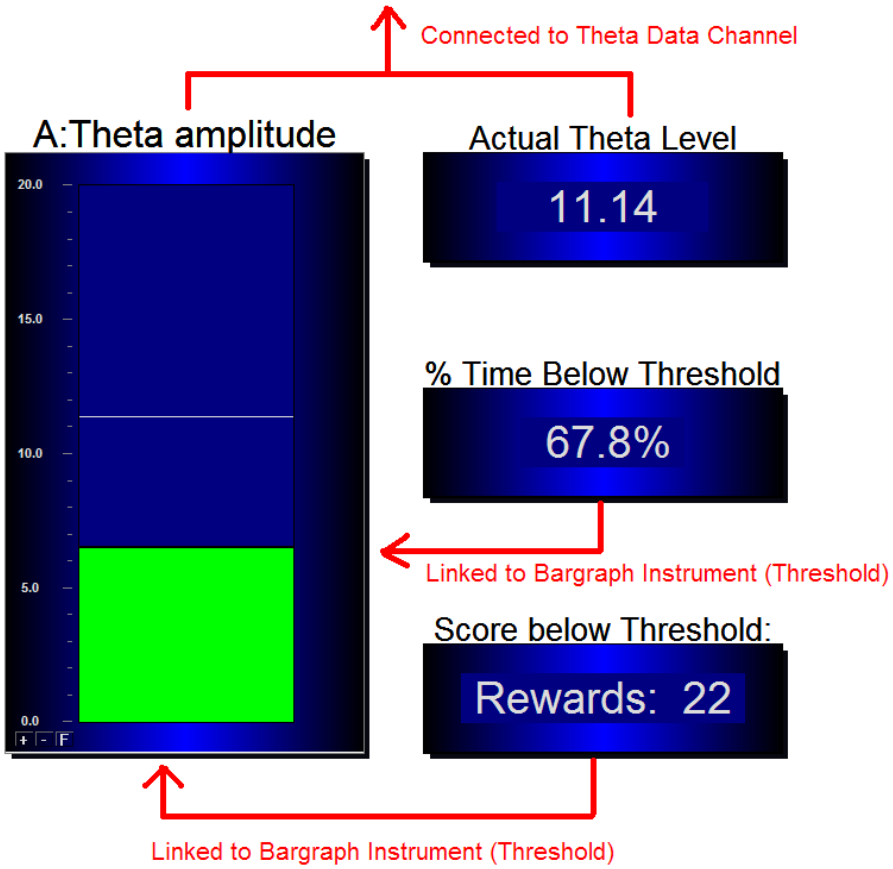
A linked Numerical Instrument:

When the instrument is '**linked**' to another instrument, it starts to function differently. It will change into a 'threshold counter' or 'animation frame counter'. You can set these options under the '**Display Options & Ranges**' right of the '**Data Type/Stats**' option:

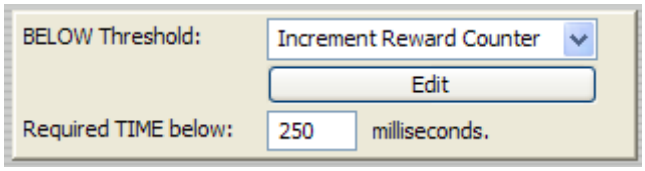


The numerical instrument can also be used to display the '**Reward Counter**'
(Note: for this option to be available the instrument should be connected to a data channel rather than being 'linked')

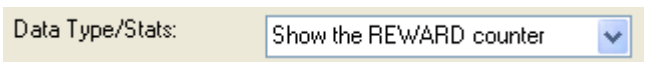
Example: below an example is shown for a design of 4 instruments. The Bargraph, the first and third Numerical instruments are **connected to** the **Theta** data channel. The numerical instrument in the middle is '**linked to**' the bargraph instrument.



The Theta Bargraph instrument has a feedback setting that is '**Increment Reward Counter**' below threshold when the signal stays there for another 250 ms.



Every time the Theta level is below threshold for 250 ms, the counter will be incremented. The numerical instrument at the bottom is connected to Theta, but shows the Reward Counter, because of its '**Data Type/Stats**' setting.



So you see from these examples, that the numerical instrument can be used in many ways.

Instruments: the DirectX Plug-in Instrument

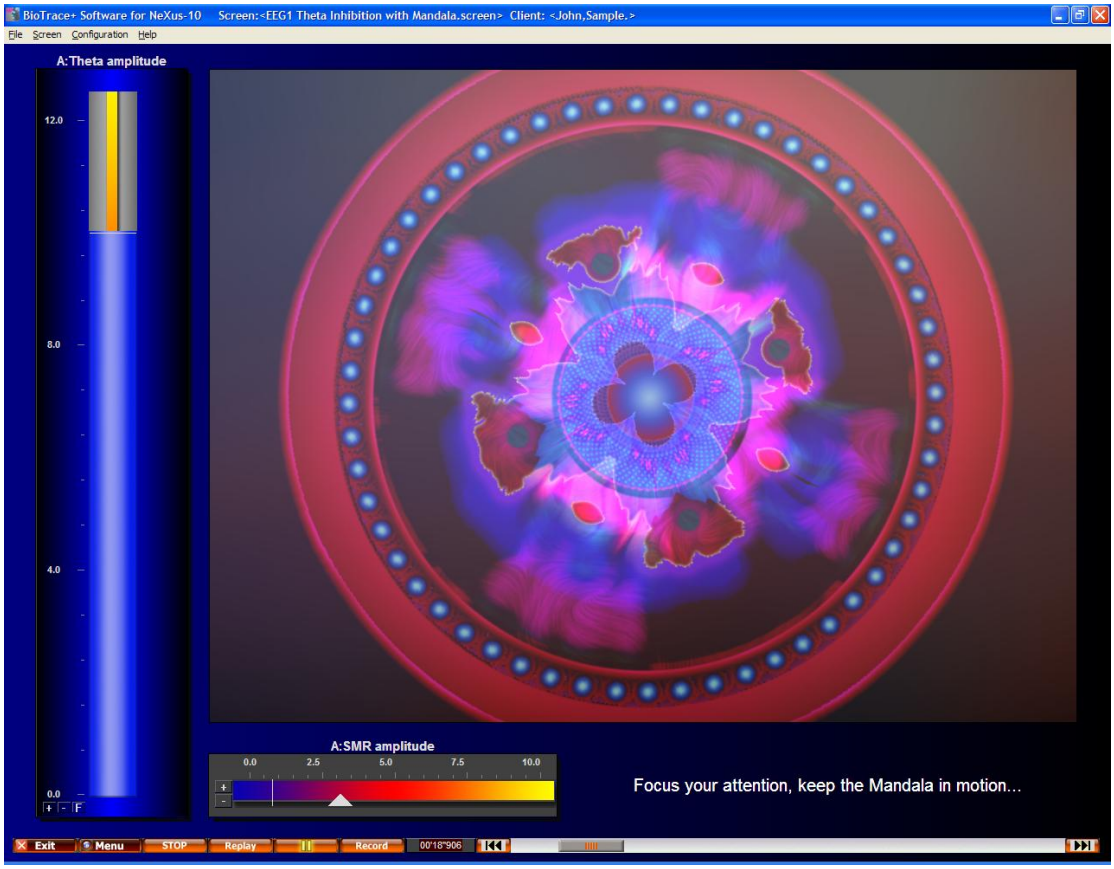
The 13th object on the toolbar is the **DirectX Plug-In Instrument.**

Plug-In instruments are ways to expand BioTrace+ with new powerful Graphics and Instruments, without having to change the Software. As new software technology becomes available, you can add these Plug-Ins to your system. These plug-ins will be available from Mind Media, but also from other developers.

The main purpose of Plug-In instruments is to offer new interesting Graphics and Special Effects that offer alternative ways to visualize the Physiological Signals.

Each of these plug-ins will have their own specific properties and settings, so we can't discuss those here, but we will now take a look at the default Plug-In that comes standard with BioTrace+: **The Mandala Plug-In**.

A sample screenshot is shown below.



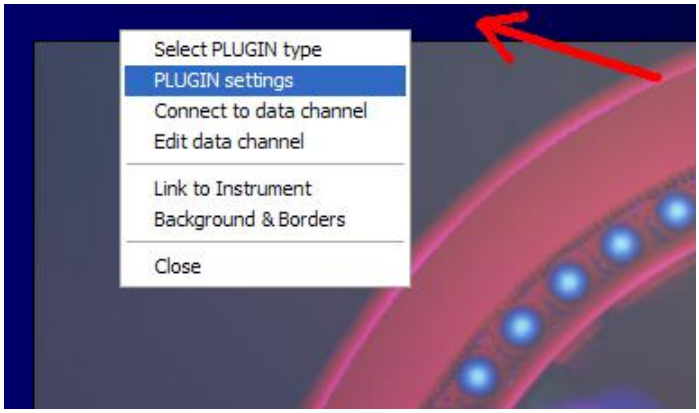
The **Mandala Plug-In** expands BioTrace+ with an instrument that rotates colored Mandalas in a 3D space.

The Mandalas are layered on top of each other and their **Size**, **Brightness** and **Rotation** can be driven by Biofeedback and Physiological signals.

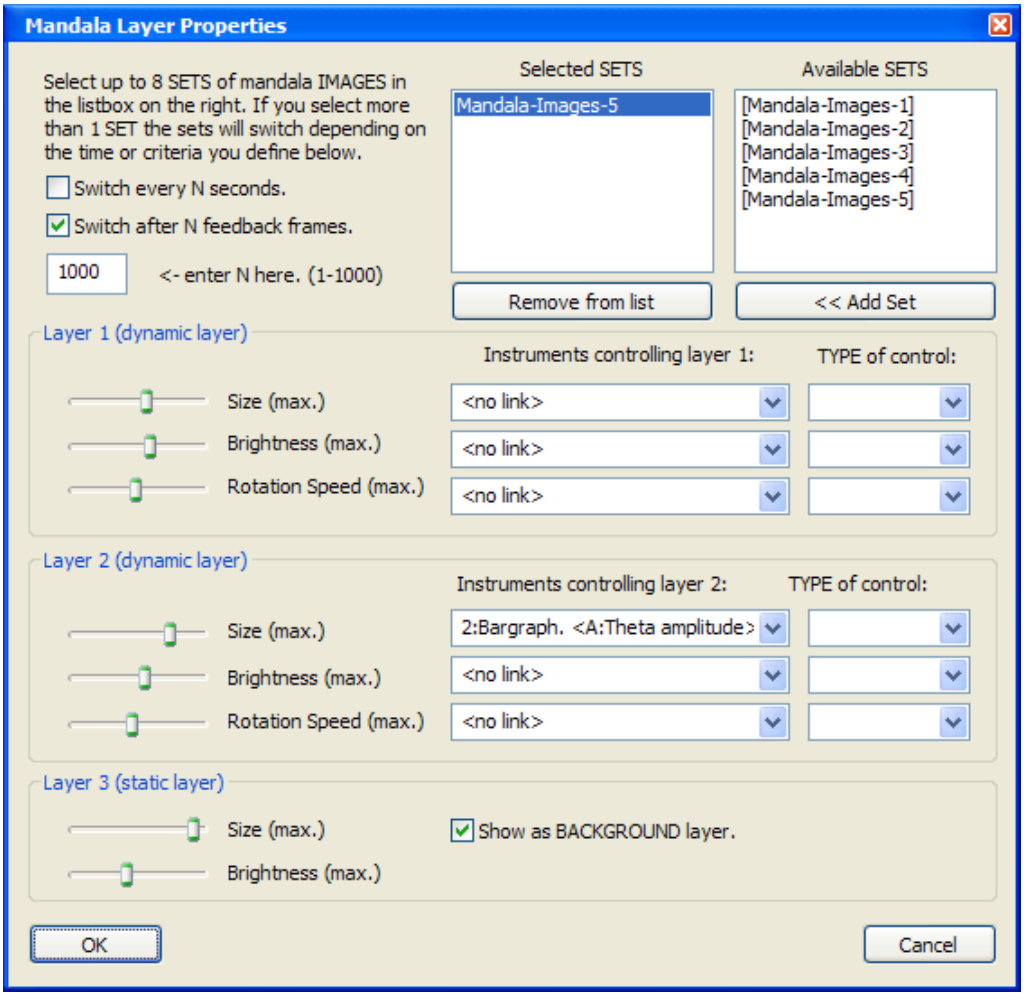
The Mandala Plug-In Settings

In order to **open the Plug-in Settings** you need to right-click just outside the border of the Instrument. (As indicated by the arrow in the picture below) This is different from the other Instrument that accepts right-clicking everywhere inside the Instrument.

Example: right-click just outside the border to open the drop-down menu:



After you have selected the '**PLUGIN settings**', the following dialog box will appear:



In this dialog box you can edit and modify all the settings for this plug in. Please note that the dialog box and settings for other plug-ins will be and look (very) different. The Mandala uses **'Sets of Images**'. Each set consists of three images, for each of the three **layers**. These layers are projected into 3D space and made to respond to the physiological activity.

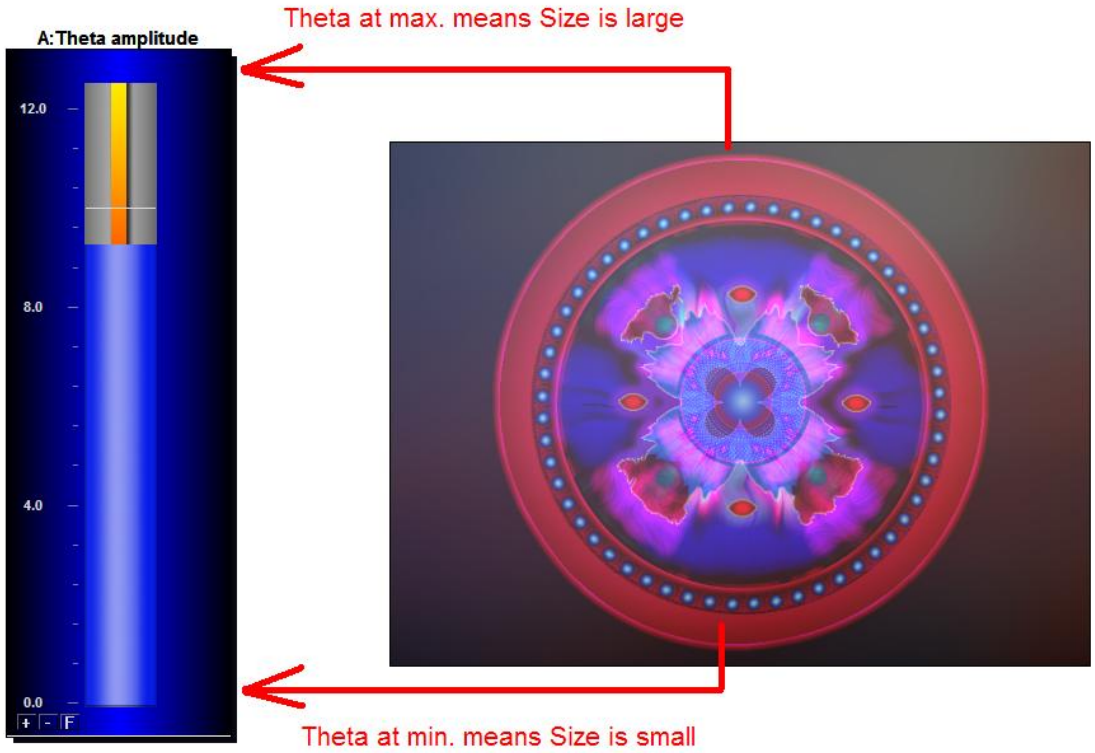
The Mandala plug-in has three layers:

1) Layer 1, which is a dynamic layer that can change its size, brightness and rotation speed using input from another instrument
2) Layer 2, which is a another dynamic layer that can change its size, brightness and rotation speed using input from another instrument
3) Layer 3, which is a static layer that functions as a background layer.

You can choose up to 8 sets of Mandala to appear, in sequence, in your DirectX Plug-In instrument. You do so by selecting a set and clicking the '<< **Add Set**' button.

The next step is that you should select one or more instruments that **control the layers**. This means that the screen displaying the Mandala should contain one or more instruments that use 1 channel and have a Y-Scale range. The following Instrument can be used: Bar graphs, Vernier Instruments, Zoomer Instruments and Line graph Instruments.

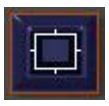
You will then '**link**' one or more of these Instruments to the properties of the **layers.** The level of the signal displayed in the Y-Scale range of the linked Instrument will then **drive** the Layer property. In the example on the former page, the Theta Amplitude is driving the **size** of Layer 2. So when Theta has reached the maximum range of the Instrument, Layer 2 will have the largest size. See the example below:



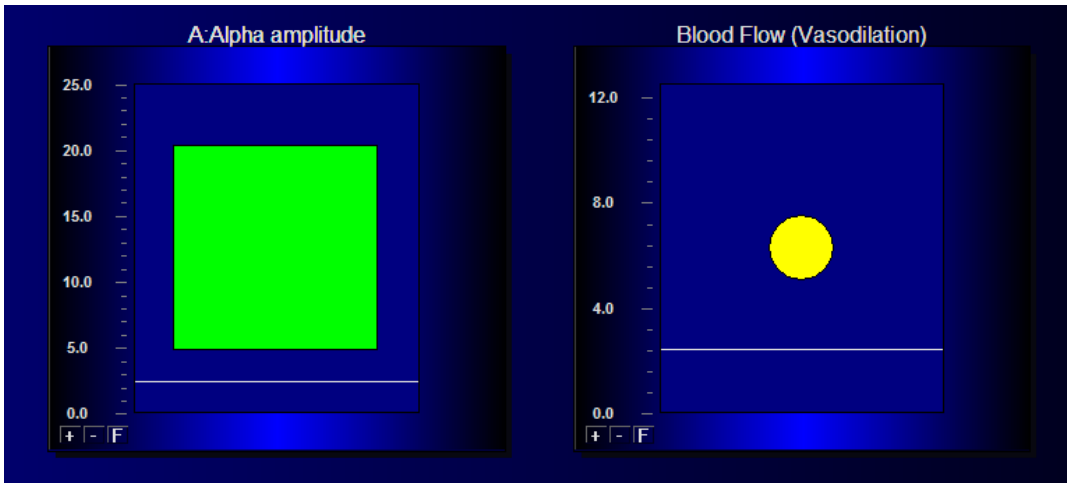
So effectively the position of the signal level within the range of an Instrument is used to '**drive'** the Size, Brightness or Rotation speed of the Mandala layer. Make sure that after you are ready making changes to the Mandala, you **save the screen**.

Instruments: the Zoomer Instrument

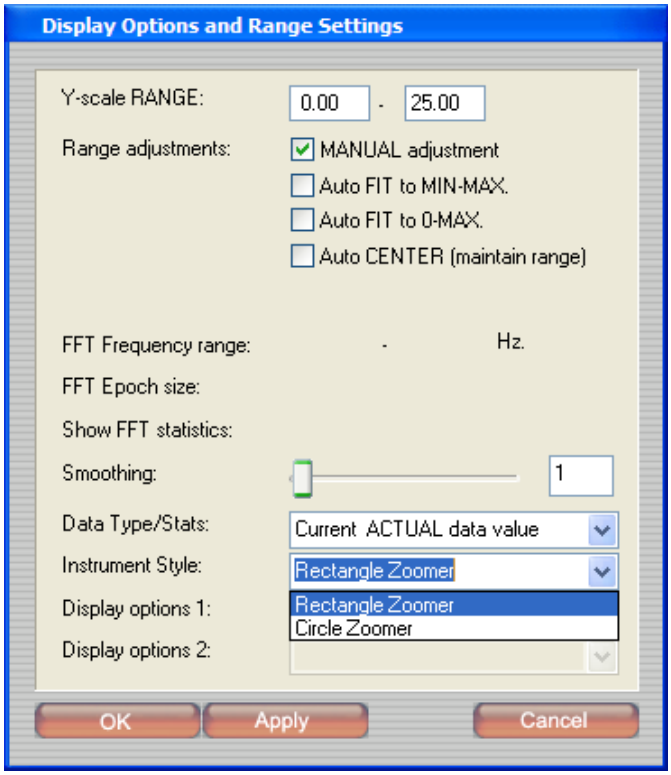
The 14th object on the toolbar is the **Zoomer Instrument.**



This instrument display an expanding **rectangle** or **circle**, rather like the way a bargraph shows a vertical bar that moves up and down. The graph of the Zoomer instrument moves (expands/contracts) in all directions.
Below an example is shown of a rectangle Zoomer displaying the Alpha Amplitude and another Zoomer instrument (with circle) displaying the relative blood flow.



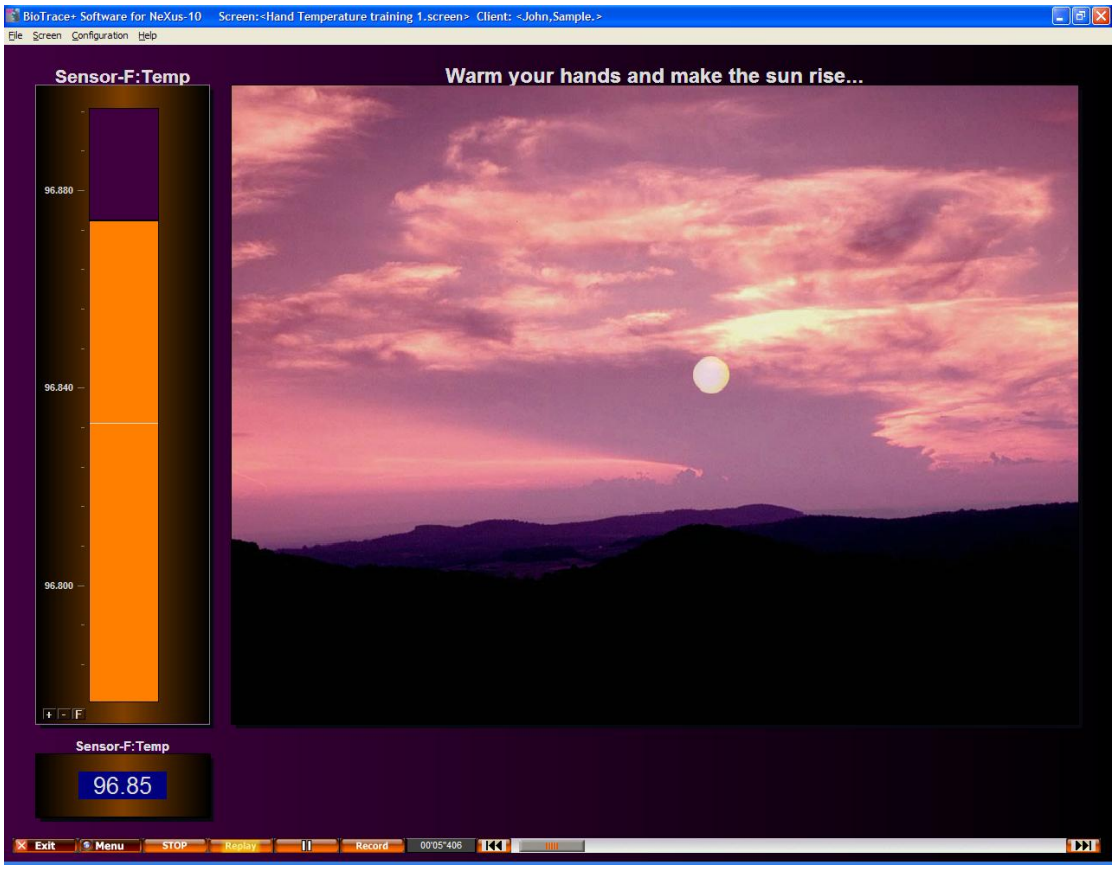
The Biofeedback and Display options are very similar to those of the Bargraph, so we refer you to the description of the Bargraph for those. The **Display Option** that is specific for the Zoomer Instrument, is the Instrument **Style**:



Instruments: the Animation Instrument

The 15th object on the toolbar is the **Animation Instrument.**

This instrument uses an ‘animated’ series of images (bitmap or jpg file) that start in one position and end in another. When the bitmaps are played in sequence (backwards or forwards) usually objects showed in the animation change, move, expand etc. Below an example is shown of an animation of a ‘Sun-set / Sun–rise’ where the sun will ‘rise’ when the hand temperature rises.

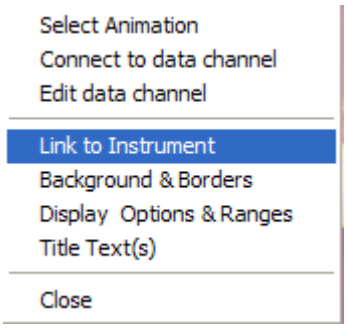


The Animation Instrument can be used in three modes:

1) **Connected to a data channel**
2) **Linked to another Instrument range and data channel.**
3) **Linked to another Instrument Threshold**

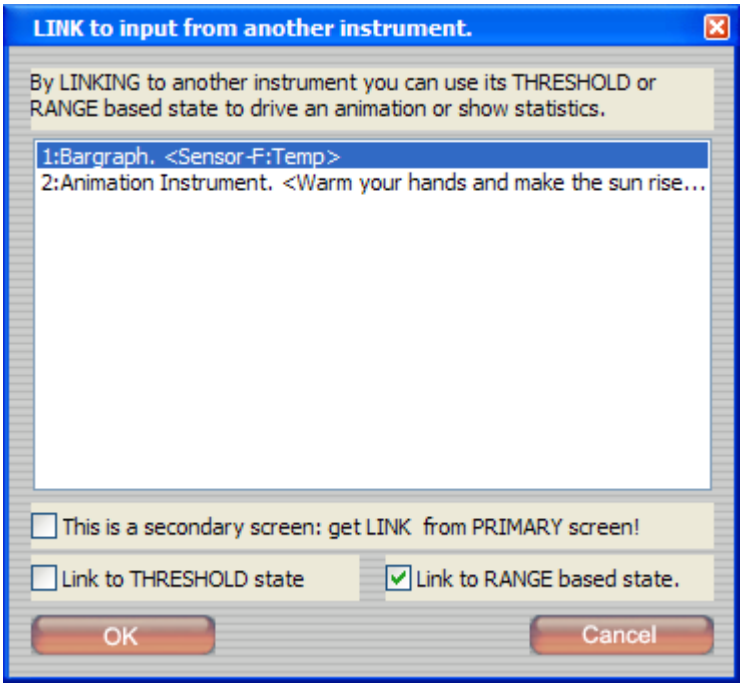
In the first mode the animation instrument is simply connected to its own data channel and plays the frames from start to end, according to the range settings you can manually enter under the ‘**Display Options & Ranges**’ The first frame will be played when the signal is at the at the bottom of the range, the last frame will be played when the signal is at the end of the range. All frames in between will be divided over the range. In case of the sunset animation, there are 100 images. (In JPG format).
*Note: the drawback of this method, is that you have to know the exact range you want to use, and have to set this range manually in the ‘**Display Options’.***
Mode 2: linked to another instrument’s range:

This mode still uses a data channel to display the animation, but now it uses the **data channel** and **range** of another instrument. Right click the instrument and choose the option ‘**Link to Instrument**’.



In the dialog box you choose the **Instrument** you want to **Link to**. (In this case the Bargraph has been selected) You can choose an instrument from the PRIMARY screen if you are editing a secondary screen. (Check the first checkmark button)

Next you select whether you want to link to a **threshold** or a **range**.

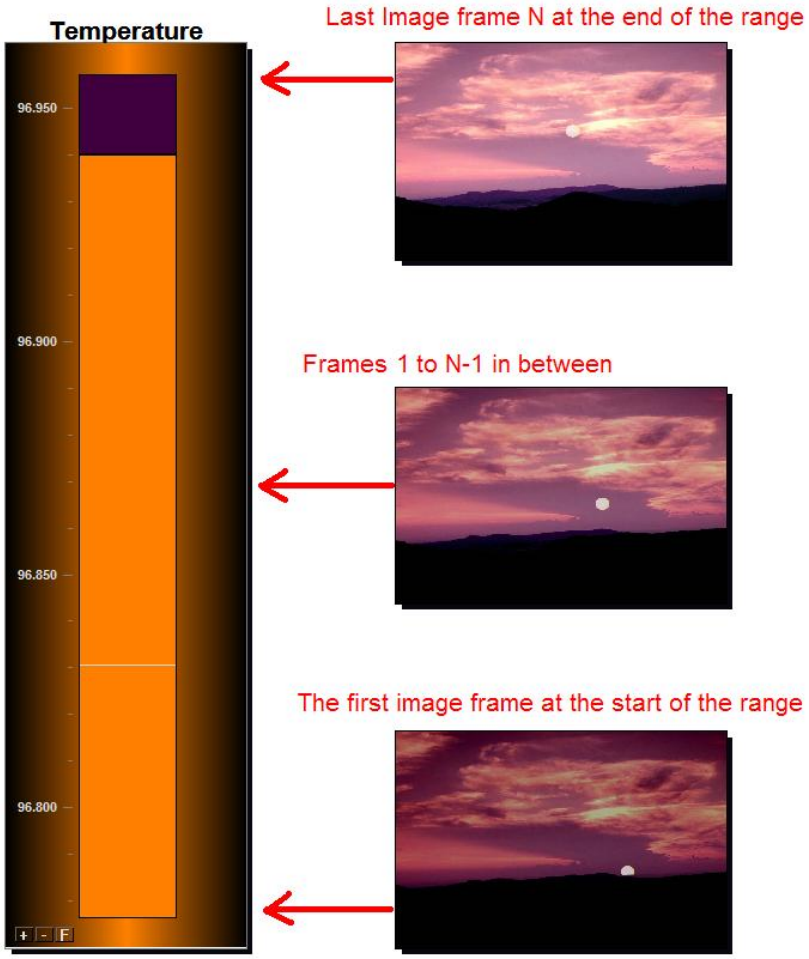


For **mode 2** you select: '**Link to Range based state**'. In case you want to use the other mode (**mode 3)** you select: '**Link to Threshold state**'

Mode 3: linking to a threshold

When you link to a threshold of another instrument, this will **play the animation** sequence **forwards** or **backwards** depending whether the signal of the linked instrument is above or below threshold. In mode 3 there is no relationship anymore between where the signal is and the range of the instrument.

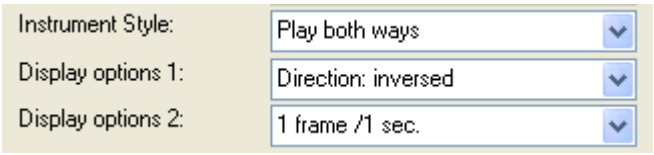
Let's now take a graphical example of **mode 2**, so you get an idea of how that works:



Mode 2: In this example you see how the first image in the sequence is shown at the bottom of the bargraph range (when the temperature is lower) and the last image is shown when the temperature has reached the top of the bargraph.

Other settings:

In the '**Display Options**' of the Animation Instrument you can edit the following settings:



- **Instrument Style**: how the animation plays. (one way, both way, whether it cycles, etc.) Cycling means that an animation will start all over again when it has reached the end.
- **Display Options 1:** the direction of the sequence. Does the Animation begin at the **start** or at the **end** of the sequence?
- **Display Options 2:** when **'linked to a threshold**' you can set the speed (frames/sec) of the animation at which it will play forward/backward.

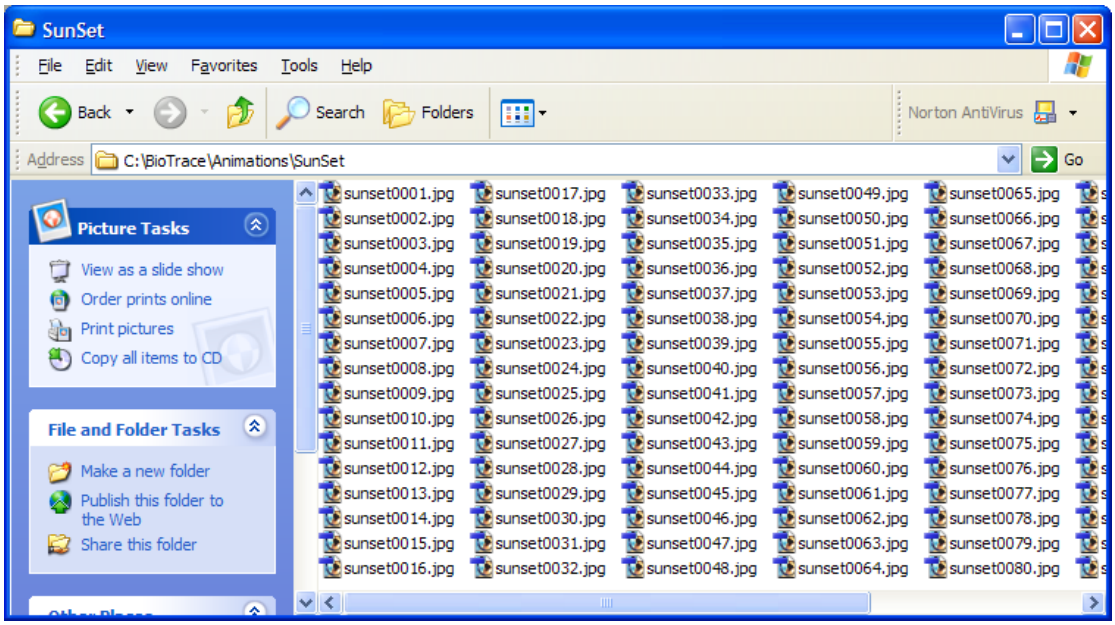
Adding your own animations to BioTrace+

You can add your own animations to BioTrace+.

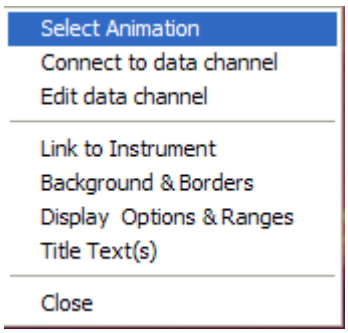
The image format of an animation is either **'.bmp'** or **'.jpg**'. The compressed JPG images are (much) smaller than the BMP images, but take a little more time to load. The BMP files are large, but load fast, because they are not compressed.

Files in an animation sequence always start with some **alphanumerical characters** followed by a **number** (index). In case of the sunset animation they are: "sunset0001.jpg", "sunset0002.jpg", etc. up to "sunset0100.jpg" for the last image file. A maximum of 9999 images are supported. Most animations only need 20-100 images though.

The animation files are placed in the "**\BioTrace\Animations**" directory, in their own subdirectory. This subdirectory uses the same alphanumerical text, so in this case the full directory would be: "**\BioTrace\Animations\SunSet**". The file names are not case sensitive. An example is shown below:



So when you place your animation files in this directory, BioTrace+ will be able to find and use them. Right-click the animation instrument and choose:



You will then be presented with another dialog box where you can select the animation that you have just added to BioTrace+.

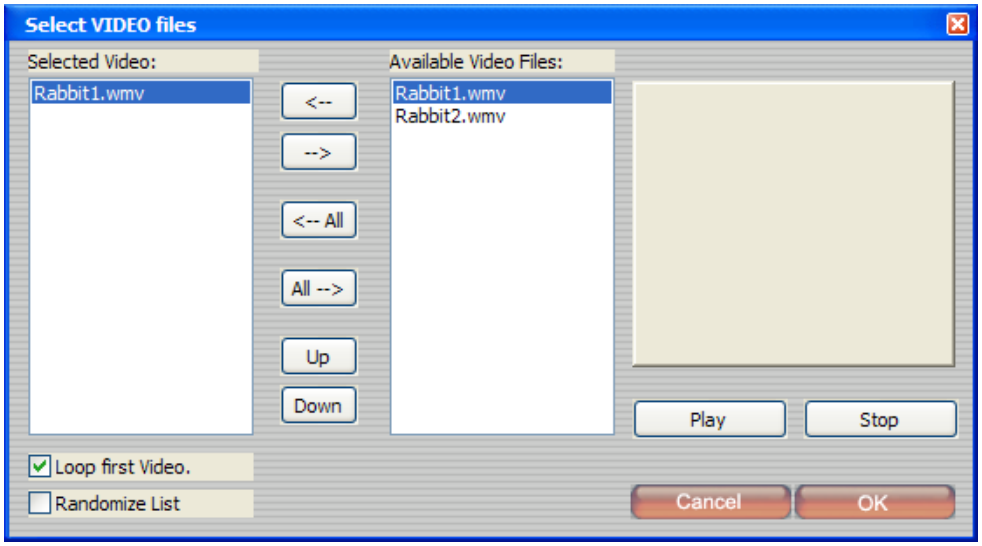
5.5 Screen Objects

Objects: the Video Replay Object

The 16th object on the toolbar is the **Video Replay Object.**

This object does not display Physiological data, but replays video files. The video file can be used for instruction or for feedback purposes. An **Inhibit** state can temporarily **pause** the video. The video file is replayed in a window and will play only when the session is running in **record** or **replay** mode. You can put up to 4 video objects in a screen. When the session is not running or **paused**, the video file will not play. The video object has a number of properties that you can access by right clicking the video object:

The first option is '**Select Video File**'. This option will show the dialog box where you can select the video file(s) that should be played.



Note that you can select more than 1 video file. In that case the video files will be played one by one, in a sequence.

Another option is that you can '**Loop**' the first video file. That implies that the first video in the selected list will immediately wind back to the beginning and start replaying when the video has ended.

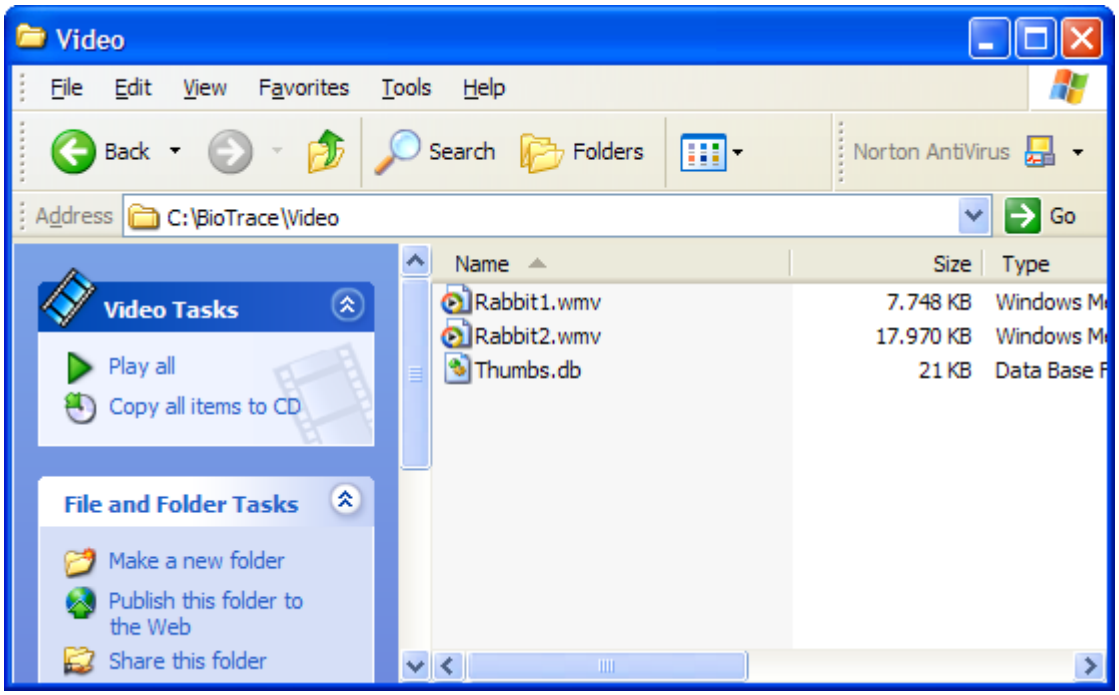
Adding Video files to BioTrace+

On the internet there are thousands of video files available, but since they usually are protected by some form of copyright or because they are not for sale, we can not include these video files with BioTrace+. Fortunately it is very easy to download such video files and **add** them to BioTrace+.

The following video file formats are supported:

- **AVI**
- **MPG (mpeg)**
- **WMV**
- **ASF**
- **Divx** *(only works when the Divx encoder has been installed)*

When you download the video files from Internet or copy them from a CD or DVD that contains video files, you should copy the file(s) to the \BioTrace\Video directory. An example of this video directory is shown below.



Video used for feedback purposes:

The Video object by default responds to the **inhibit state**. So if any instrument sets the **inhibit**, the video will be **paused**. You can switch this option off, so that the video file will always play, even if there are inhibits.

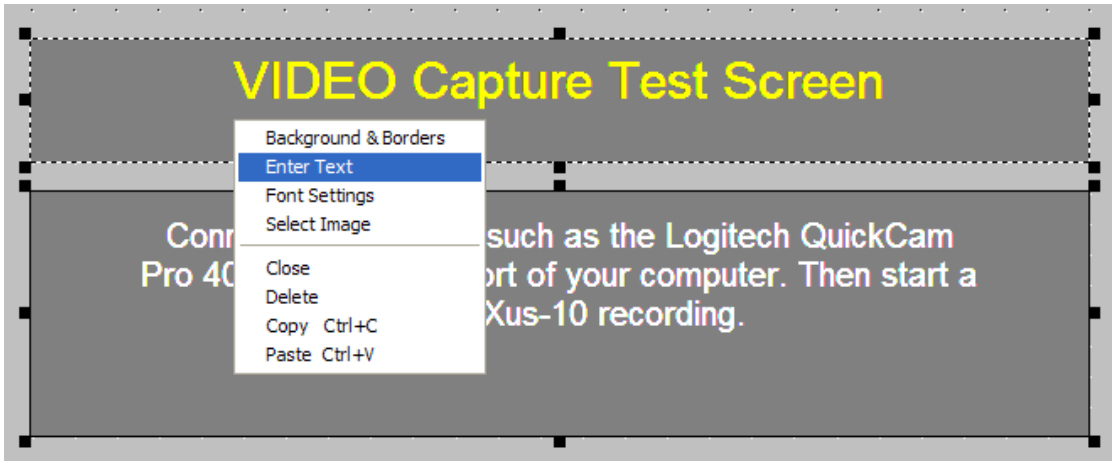
To do this, right click the video object and un-check the '**Pause VIDEO during Inhibit**' option. Selecting this option again will put back the check mark.

Objects: the Text Object

The 17th object on the toolbar is the **Text Object.**

This object does not display physiological data. If you want to show physiological data in numerical form, please choose the **numerical instrument** instead.

The Text Object properties can be opened by **right-clicking** the object:

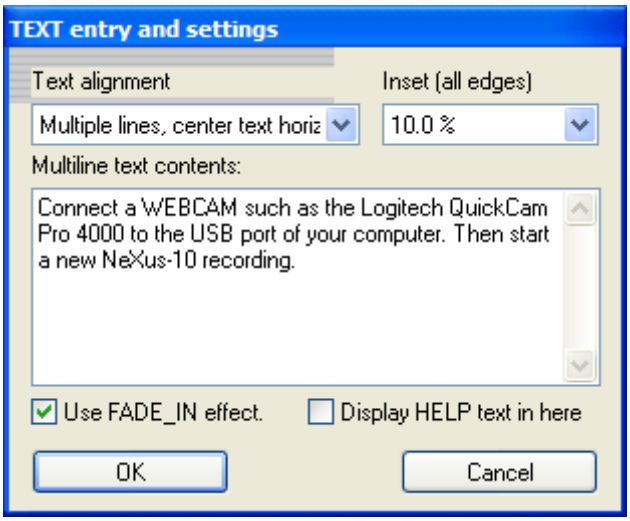


Beside the standard properties that most object use, you can:

1) **Enter the text of the object**
2) **Define the Font size, style and color**

Entering Text:

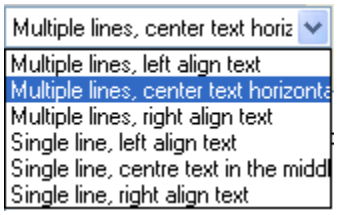
Choose the '**Enter Text**' option from the property menu. The following dialog box will appear:



In this dialog box you can enter up to 2500 text characters.

Text Alignment:

The alignment of the text (also called justification) defines how the text lines will be displayed. You can choose from **multiple** or **single** lines and from **left**, **centered** or **right** alignment.



Text Inset:

The **Inset** defines how much space there is around the edges of the text. 10% can be used as a good default.

Text Scaling:

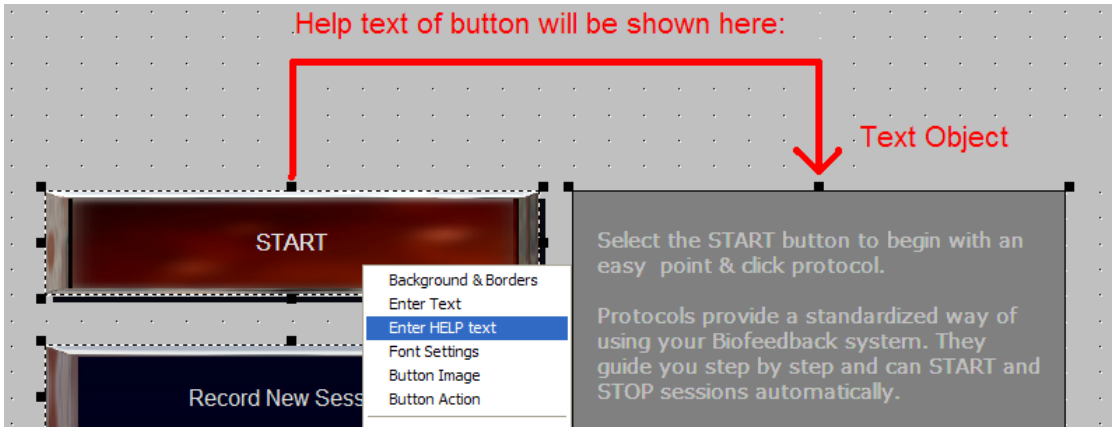
Please note that all text instruments and objects are scaled to the size of the monitor they are displayed on. That means that a screen will adapt the size of the object such that the screen 'fits' on a 1024x768 as well as on a 1280x1024 monitor. The size of the **Font** of the text will be scaled as well.

Fade IN effect:

The **fade in effect** will initially display the text in black and then slowly fade in the text to the color that you have selected under the FONT options.

Display HELP text:

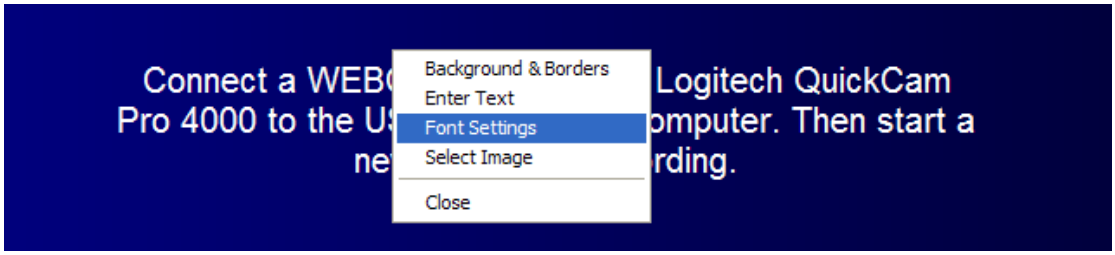
This option will tell a text object that it should display the '**help text'** of buttons on the screen, when the mouse moves over these buttons. You define this 'help text' under the properties of a **Button Object**. A sample is shown below:



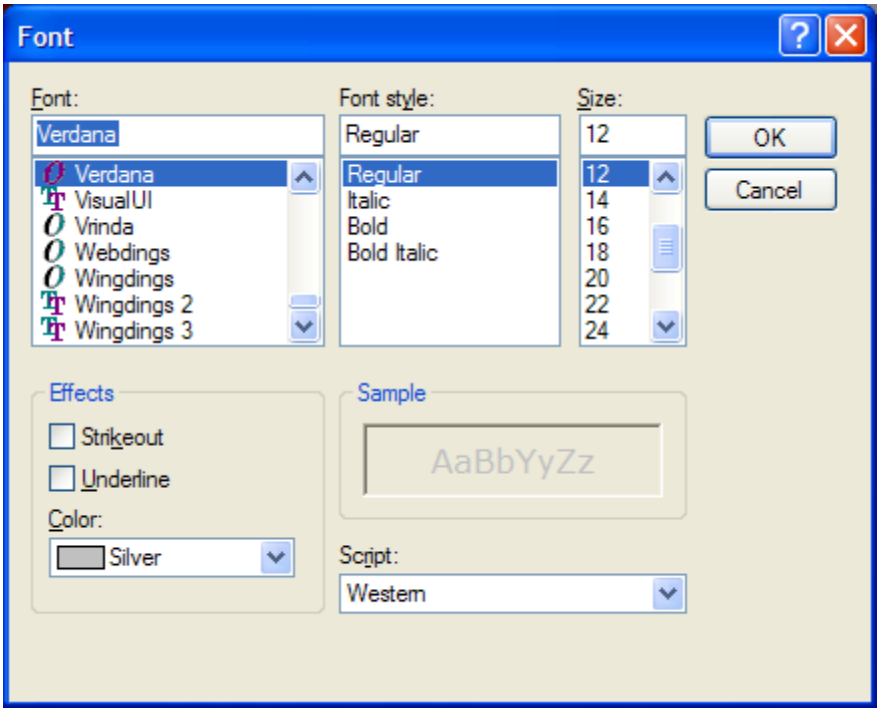
The 'help text' is basically an instruction to the user, telling him what the button will do when it is selected. The **Button Object** is described in this same chapter.

Selecting the Font style, size and color:

When you right-click the text object, you can select the font settings of the objects:



Note that you can select the font in the screen editor mode, but also in the normal mode. (Real-time mode) The following (standard) Windows Font selector box will be shown on the screen:



From this box you can select:

1) **The Type of Font**
2) **The Style of the Font (Regular, Bold, etc)**
3) **The Size of the Font**
4) **The Color of the Font.**

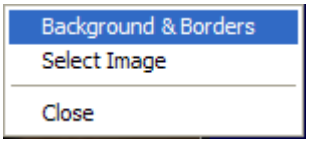
Note: the font **size** will be scaled, when the window that contains the screen is sized.

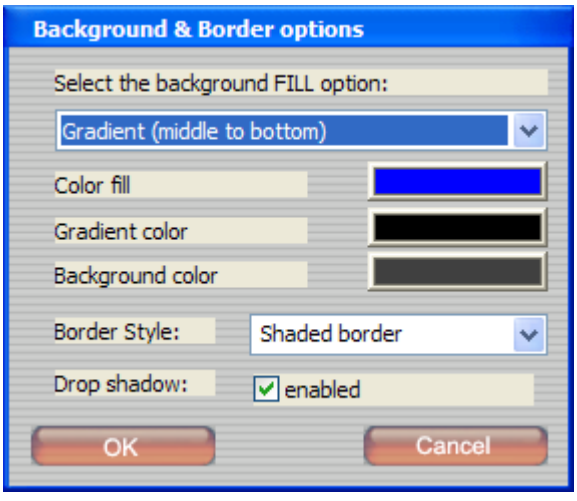
Objects: the Image Object

The 18th object on the toolbar is the **Image Object.**

This object does not display physiological data. It displays a static image that can be used for instruction, as information or as a background image. An example of a screen containing two image objects is shown below:

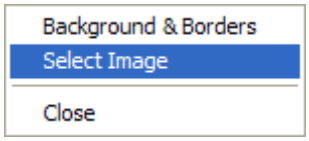
You can select a **border** and **shadow** style by right-clicking the image and choosing:



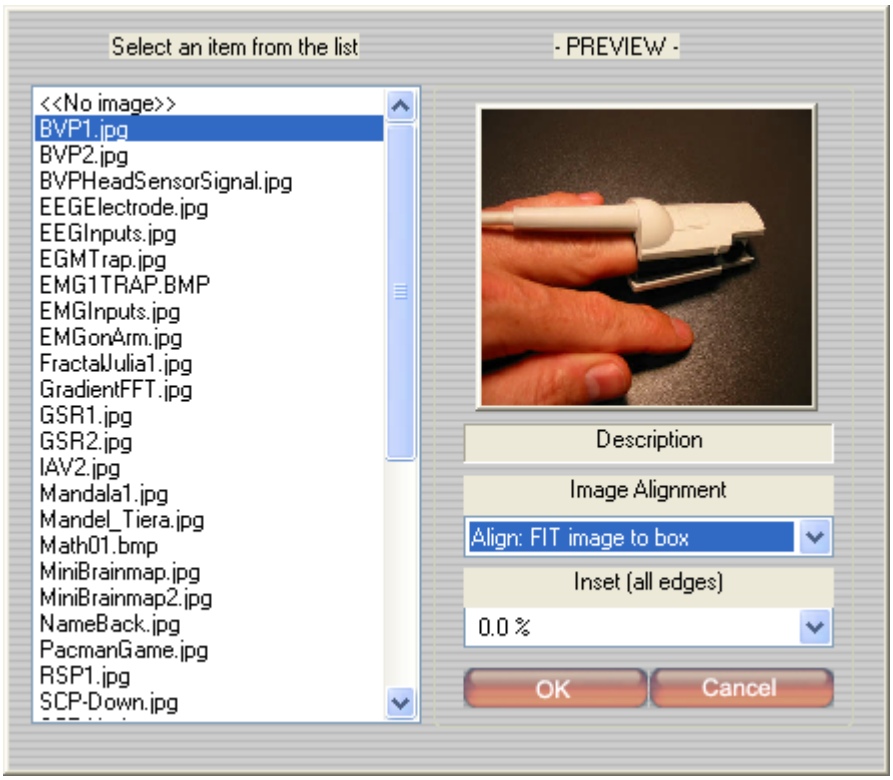


Selecting an Image file:

Right-click the object and choose:



This will show the **image** selection dialog box:



You can select 1 image file from the list on the left and set the following properties:

1) **Image Alignment**: this defines how the image will be placed or stretched inside the image object box. Default is '**Fit Image to Box'**.
2) **Image Inset**: when you select '**Center Image**' under the Image Alignment property. You can choose the **Inset**. This defines how much (empty) space there will be around the image.

Adding Images Files to BioTrace+

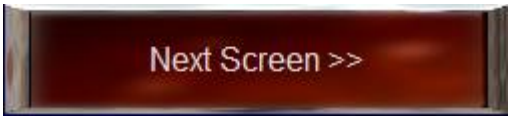
You can add your own **Image Files** to BioTrace+ by copying them into the '**Biotrace\Images**' directory.

Both the **BMP** and **JPG** file formats are supported. Generally we advise to use **JPG**, because these files are compressed and much smaller than the BMP format.

Objects: the Button Control Object

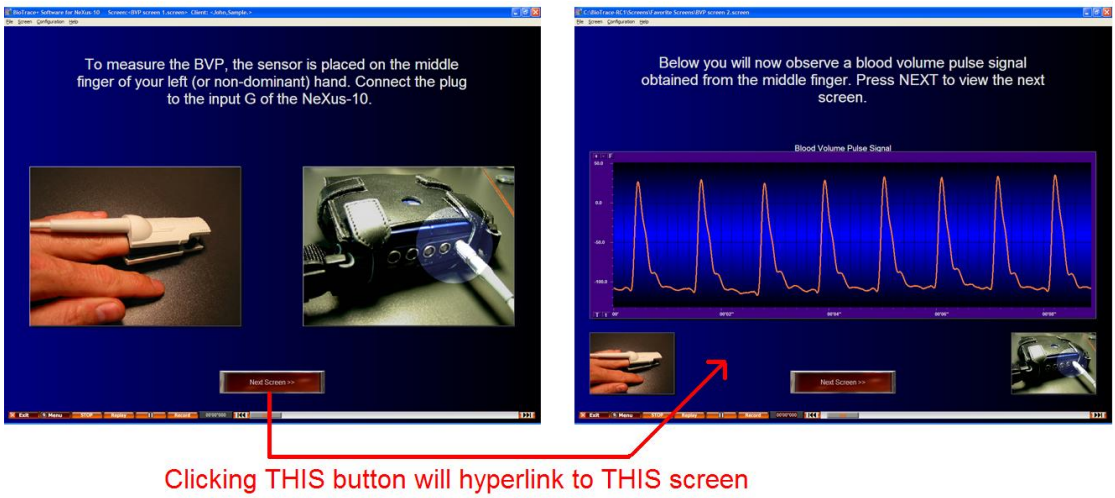
The 19th object on the toolbar is the **Button Control Object.**

This object does not display any data, but is a versatile and powerful **control object** that you can use to make your screen 'do things'.



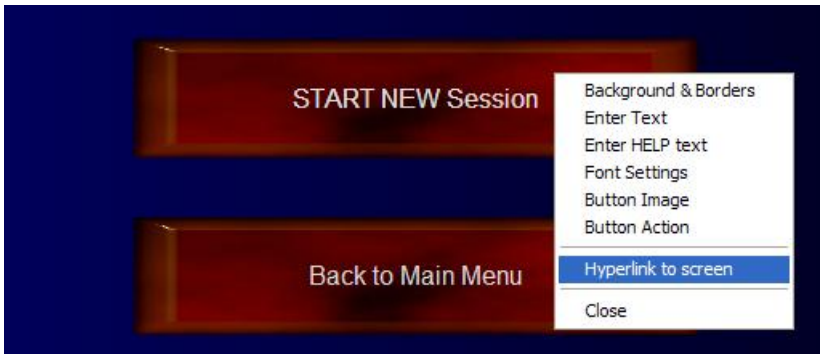
When the user clicks a button, you define what **Button Action** the button will execute.

A simple example is for instance the use of a button for **navigation** by turning the button into a **hyperlink** to another screen.

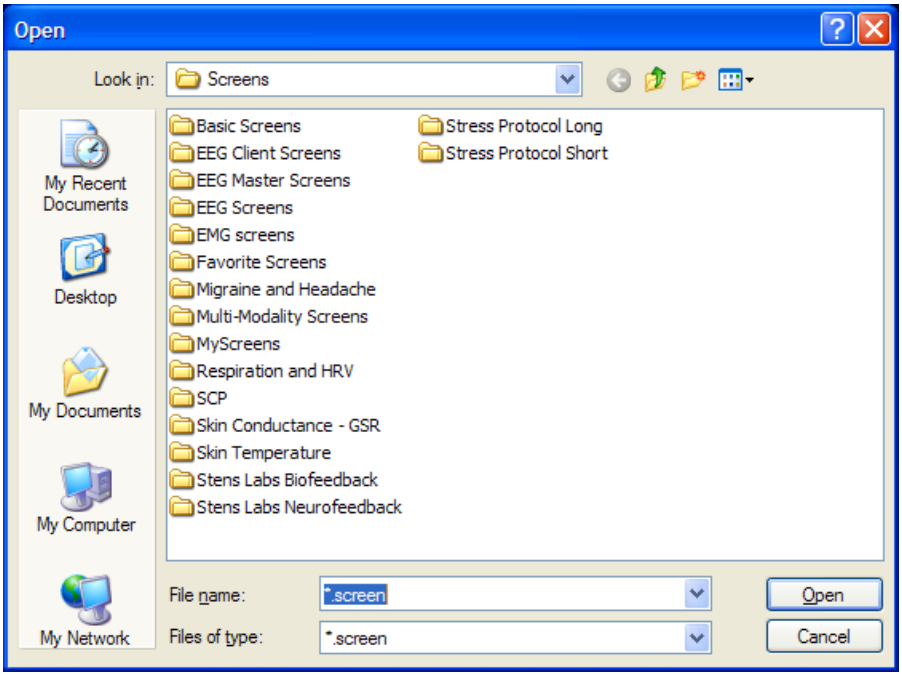


A **Hyperlink** will load the screen that has been programmed under the button and replace the current screen. This way you can navigate between screens by clicking buttons. When you build your own protocols and screens, you will probably find this to be an easy and simple way for users to use your protocols.

The action that a button performs when clicked, is called the '**Button Action**'.
You can directly choose **'Hyperlink to screen**' with a right-click:

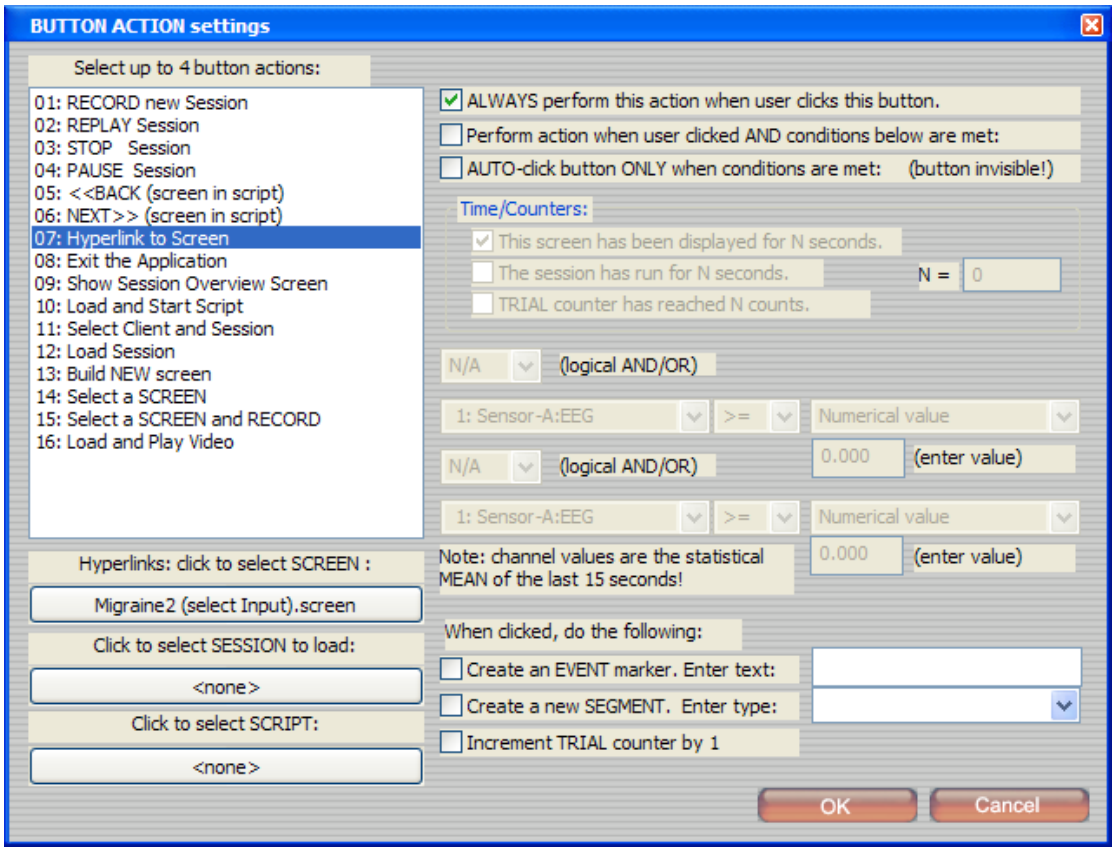


This will bring up the Windows File selector dialog box where you can choose the directory (= screen category) and name of the screen you want to 'jump' to:



Programming Button Actions

Apart from the basic **Hyperlink** action, you choose many other **Button Actions**. Right-click the button and choose '**Button Action**' from the property menu. This will show the Button Action Settings dialog box:



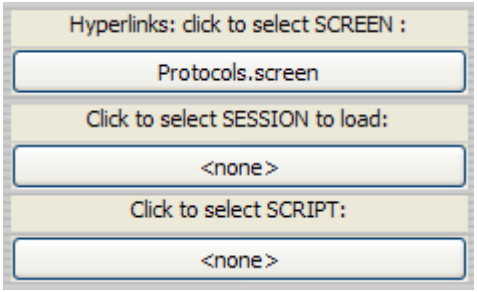
The following button actions can be programmed:

1) **Record new Session**: this button action has the same effect as pressing the record button in the session controls.

It will ask the user to select a client and then start a new session.
2) **Replay Session:** this button action has the same effect as pressing the **'Replay**' button. It will replay a previously loaded session.
3) **Stop Session:** this button action has the same effect as pressing the '**Stop**' button. When a session is recording it will ask the user if they want to save the session.
4) **Pause Session:** this button action has the same effect as pressing the **'Pause'** button in the session controls.
5) **<< Back (in script):** when a protocol screen sequence script has been loaded (a list of screens to be shown one after the other, like as slide show) this button action will step one screen back in the sequence.
6) **Next >> (in script):** when a protocol screen sequence script has been loaded this button action will advance to the next screen in the sequence.
7) **Hyperlink**: this button action jump to (load) a next screen.
8) **Exit the Application**: this will end the BioTrace+ application.
9) **Show Session Overview**: this will switch to the session overview screen mode. (same as pressing the '**Tab.**' Key on your keyboard)
10) **Load and Start Script**: this button action will load a sequence script and load and show the first screen of this sequence. Sequence Scripts are **always** started by use of a button action!
11) **Select Client and Session**: this button action will open up the client/session database dialog box, so the user can select and load a session.
12) **Load Session**: same as above
13) **Build NEW screen**: this will clear the current screen and enter the **screen editor** mode.
14) **Select a screen**: this button action will open up the screen browser, so the user can select and load a new screen.
15) **Select a screen and record**: this button action will open up the screen browser, where the user can select and load a new screen. Immediately after that it will start the recording mode, ask for a client, and start a new session.
16) **Load and Play Video**: this button action will load and play a video file.

Note: you can select more than 1 button action to a button. For instance you could combine the **Record Session** with a **Hyperlink** to a new screen. Not all combinations will be valid though. Obviously it does not make sense to combine the option **Record Session** with the action **Stop Session**. In most cases you will use 1 button action.

Selecting Screens, Sessions and Script files:

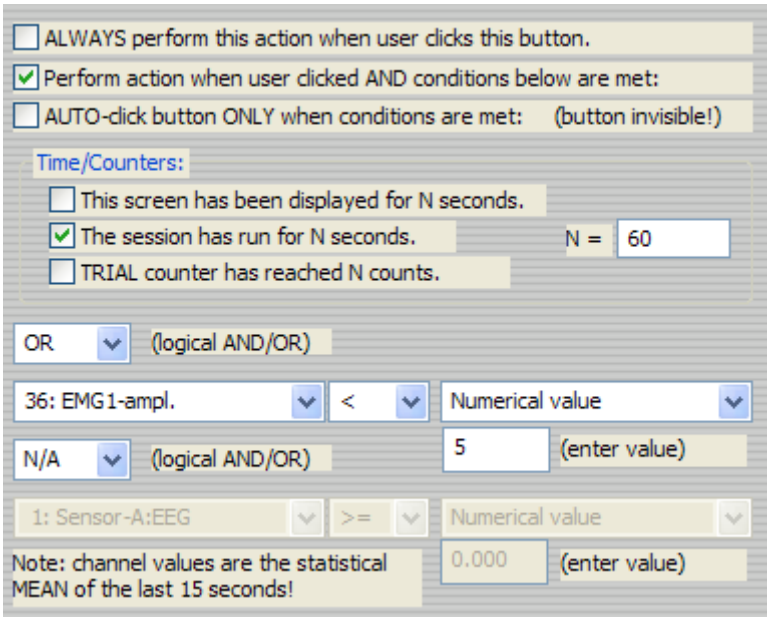


Use the buttons (shown on the former page) to select:

1) The screen file to load when hyper linking
2) The Session to load when choosing '**Load Session**' as the button action.
3) The Script file when choosing '**Load and Start Script**' as the button action.

Conditional Button Actions:

This is a more advanced option. The simplest condition is that the **Button Action** will always be executed. In some cases though you want to set **special conditions**. The example below shows a button action that is executed when the session has run for 60 seconds OR the mean level of the EMG amplitude **over the last 15 seconds** is less than 5 microvolts:



You can combine up to 2 **Boolean** criteria with a logical **AND** or **OR** function.

Other options are:

1) The screen has been shown for certain time (N seconds)
2) The session has run for a certain time. (N seconds)
3) The trial counter has reached a certain level. The trial counter can be incremented by this or other buttons. It starts at 0 at the beginning of a new session.

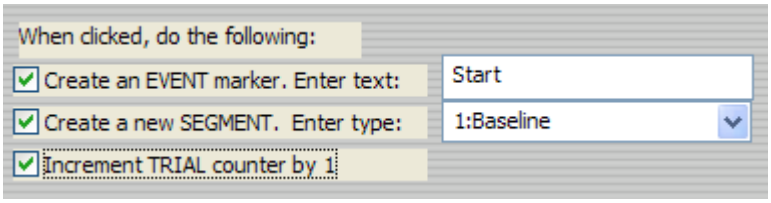
Note: when you choose criteria based on the channel data (physiological signals), please note that this channel value will not be the current data value but rather it will be the **mean value** of this data channel over the last 15 seconds.

Automatic Segments, Markers and the Trial Counter:

When a button is clicked (or auto-clicked by a criterion) you can define a number of click-actions:

1) Generate an EVENT marker
2) Create a new SEGMENT
3) Increment the TRIAL counter

An example of these settings is shown below:

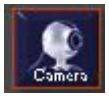


In this example, at the time the button is 'clicked' this screen will create an '**Event Marker**' with the text description of 'Start'. It will also create a new segment of the type '**Baseline**' and it will increment the '**Trial Counter**' by a value one.

Note: the segment will cover the period from the 'click time' of the button, to the moment that a new segment is created.

Objects: the Video Capture Object

The 20th object on the toolbar is the **Video Capture Object.**

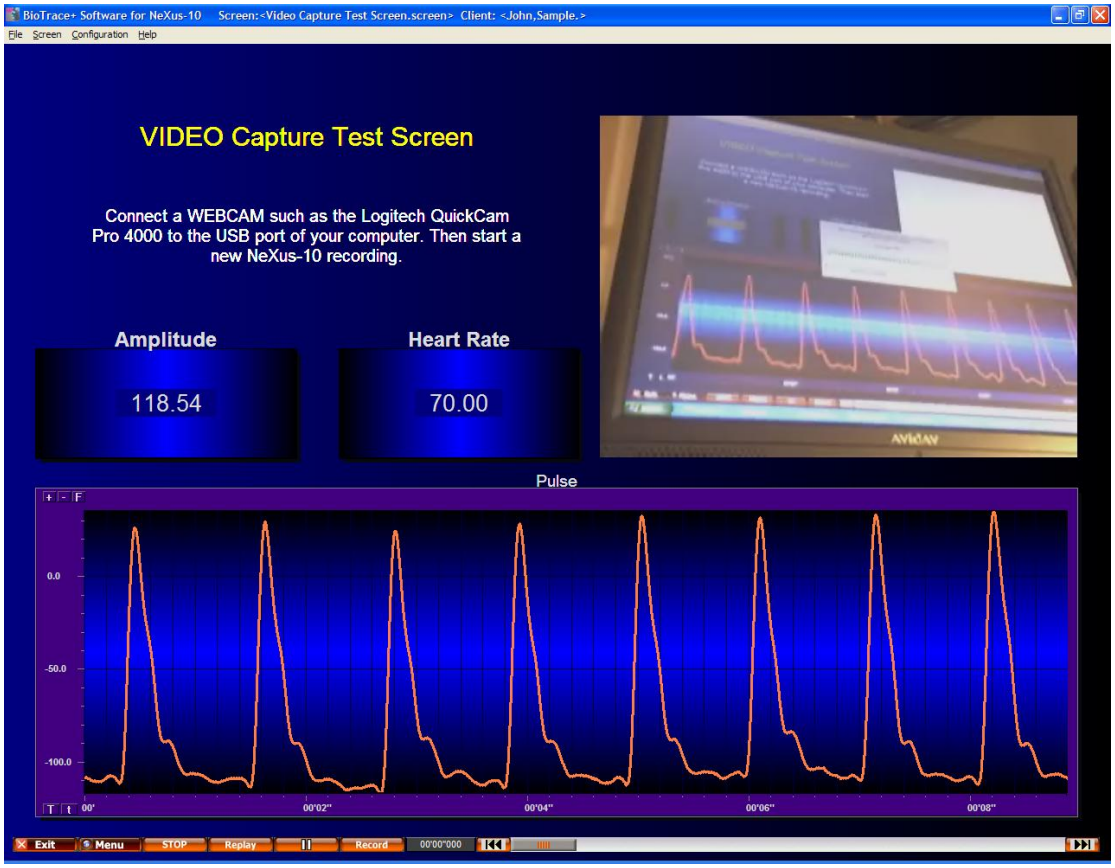


This object captures video from a digital camera or webcam, during a live session.

When the session is replayed, the video signal will be in '**sync**' with the physiological data stream with a precision of about 50-100 milliseconds. That means that generally you can look at the relationship with the video images (and sound) and the physiological data on a frame by frame basis.

Note: you must install the drivers of the video camera or webcam before you can use this function. Connect the camera before starting BioTrace+.

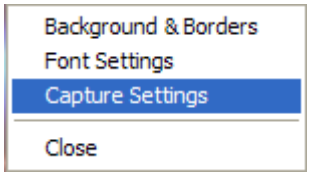
Below a screenshot is shown of a sample video capture screen (from the Basic Screens category)



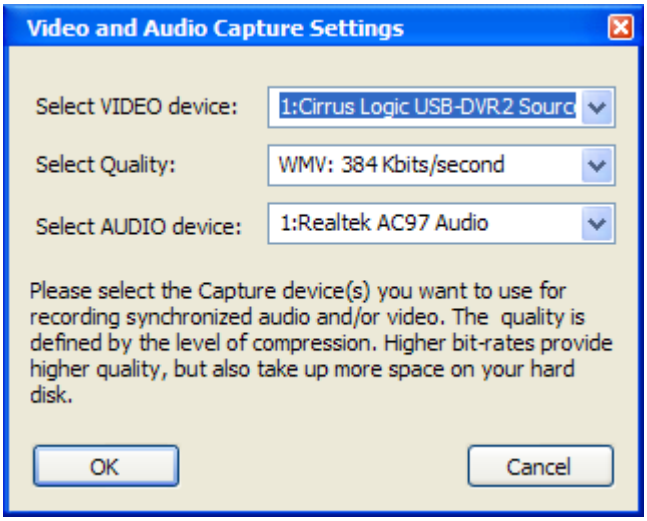
You can only use 1 video capture object on the primary or secondary screen.
During the session the video capture object will show a preview of the video.
Note: sometimes you may observe some 'dropped frames' in the preview window. However this does not always mean that the frames are lost in the session.

Video Capture Settings:

When you right-click the video capture object, you will see the property menu.

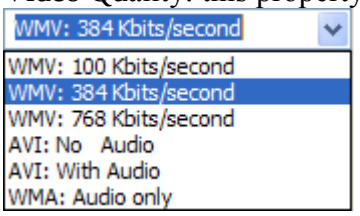


Choose the option: '**Capture Settings**'. Then the following dialog box will be shown where you can configure the video capture:



You can set the following properties:

1) The Video Device: attach the video camera or webcam to your computer and make sure the drivers have been installed properly. Then select the device from this list. Best is to connect the video camera before you startup the BioTrace+ application.
2) Video Quality: this property defines how 'good' the image quality will be.



3) Audio Device: normally when you use a webcam, this will have a built-in microphone. Then you will choose that same device for Audio. In other cases you could use an external microphone or select another audio source.

Video Quality:

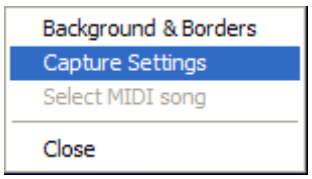
You can choose 100 (low) 384 (medium) and 768 (high) quality compressed video stored in WMV files. WMV:384 is default. If you need higher quality you could choose the AVI option. This will however generate very big files on your hard disk and is only recommended for short sessions of less than 2 minutes. After the session has been stored, the AVI will be compressed.

Objects: the Audio Capture Object

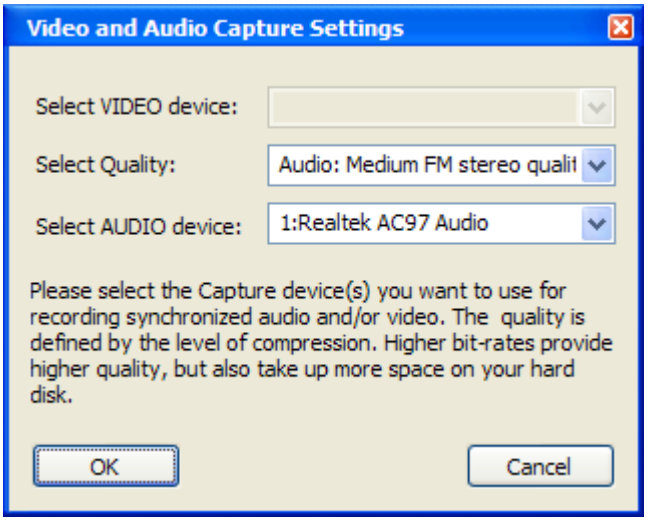
The 21st object on the toolbar is the **Audio Capture Object.**

This object only captures audio. Typically it will use a microphone to store the sounds or voice during a live session.

When you right-click the audio object, you set the properties:

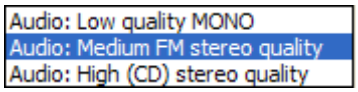


This will open the Audio Capture Settings Dialog box:



In this dialog box you select the audio device (usually the soundcard) that connects to your audio source. (Usually a microphone).

The Audio quality defines the quality of the sounds:



Low MONO quality is sufficient for basic voice sounds. It produces the smallest files. Medium is a good general purpose setting and produces very good results for voice recordings. CD quality is best when recording music or very high quality voice.

In all cases the voice files are compressed on the fly and stored in an MP3/WMA compatible format.

Note: *you can NOT combine this audio Capture object with Video Capture. Video Capture already captures the sounds (microphone) including the video signals.*

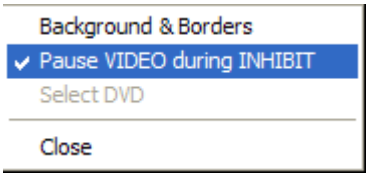
Objects: the DVD Object

The 22nd object on the toolbar is the **DVD replay Object.**

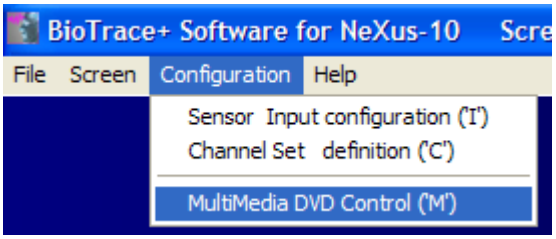
This objects replays video, rather like the Video Objects replays video from stored video files. The difference is that the video source this time comes from a DVD disk, which has to be put inside the drive before the video can be replayed.

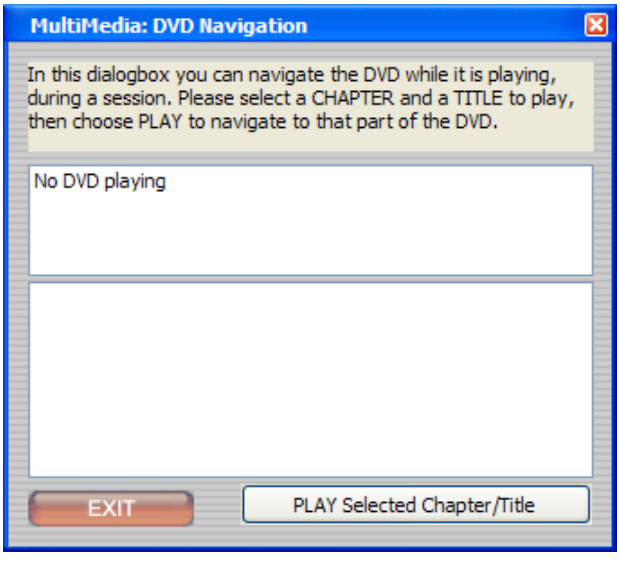
You can only play 1 DVD video object on the primary or secondary screen. The DVD video will only play when a session is running. (Replaying or recording).

The Inhibit state will temporarily '**pause**' the DVD video, unless you 'uncheck' the '**Pause VIDEO during Inhibit**' option.



When you the DVD begins to play, you have to select the title/chapter you want to play form the main menu appearing in the DVD screen. When the DVD is playing you can also use the '**MultiMedia DVD Control**' option from the main menu bar to navigate the DVD. This will option a dialog box where you can select chapters and titles.





Objects: the Game Object

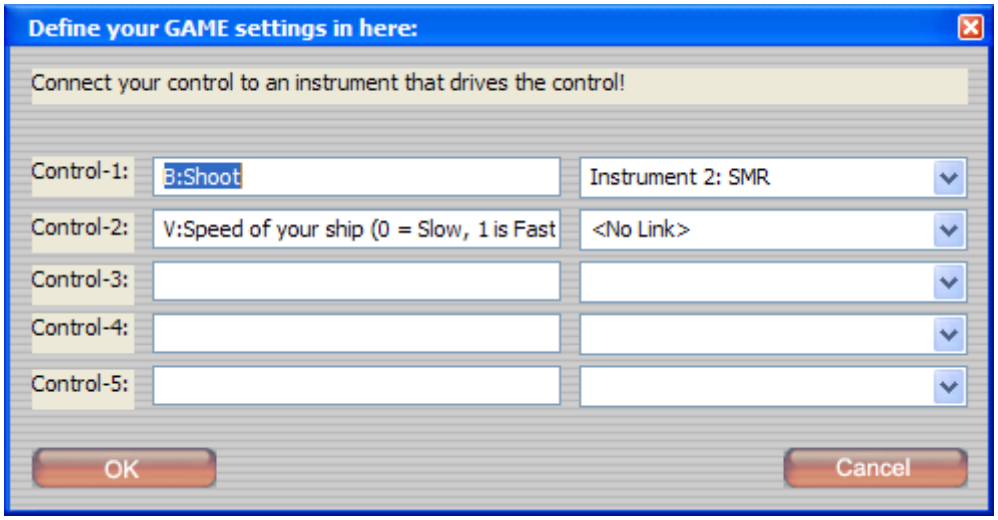
The 23rd object on the toolbar is the **Biofeedback driven GAME Object.**

The game object shows and plays a game within a window, which will be part of the screen. The game parameters can be controlled/driven by biofeedback of physiological signals. In some cases the user can also control the game with the keyboard, like 'shooting' by pressing the space bar. An example of a 'Space Invader' game is shown below:

Note: in case you use keyboard controls in the game, before you use the keyboard, click inside the game window, so it has the 'focus' and receives the key presses.

When you want to edit the game settings, you should right-click the object, just outside the border of the game.

After right-clicking just outside the border, a dialog box will appear where you can edit the settings of the game.



In the case of the space invader game, there are only two '**controls**'.

1) **Control-1** fires (shoots) the laser gun at the bottom when the instrument is over threshold
2) **Control-2** sets the speed of the laser gun (ship) at the bottom. It will use the range of the linked instrument. When the level is at the bottom of the range the speed will be slow, when the level is toward the end of the range, the speed will be fast.

Boolean and Variable controls:

The '**B:**' in front of a control description means it is a **Boolean** control, which is either **true** (above threshold) or **false** (below threshold).

The '**V:**' in front of a control description means it is a **Variable** control, defined by the level of the signal within the range of the linked instrument.

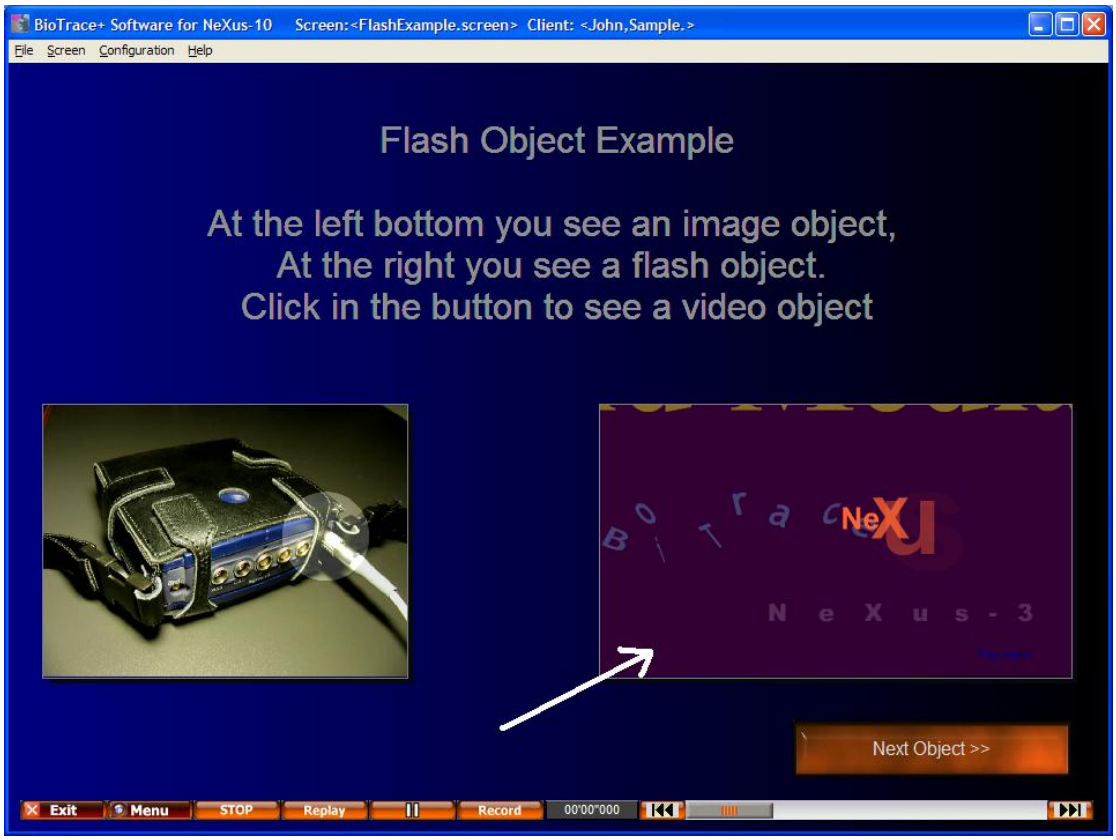
Objects: the Flash Animation Object

The 24th and last object on the toolbar is the **Flash Animation Object.**

BioTrace+ utilizes macromedia shockwave ™ technology. This is the same technology that is used frequently in website technology. Macromedia shockwave is a very powerful technology that supports many animation techniques and even video files in the SWF format. (Shockwave flash format)

You can embed '**.SWF**' file based animations in the BioTrace+ screens and use them for instructions or information purposes. When an SWF file contains a lot of information or is big, it may take some time to load.

The SWF files are stored in the '**\BioTrace\SWF**' directory. You can put your own SWF files in here to enrich the BioTrace+ screens and protocols.



6.0 Building and Creating new Screens

There are two ways to create a new screen:

1) You modify an existing screen.
2) You start from scratch

The first method has the advantage that you could use a sample or 'template' screen that contains preset backgrounds, colors and instruments. Such a template screen would also be connected to a channel set of your choice. The second method (building from scratch) involves more work, but gets you there just as well.

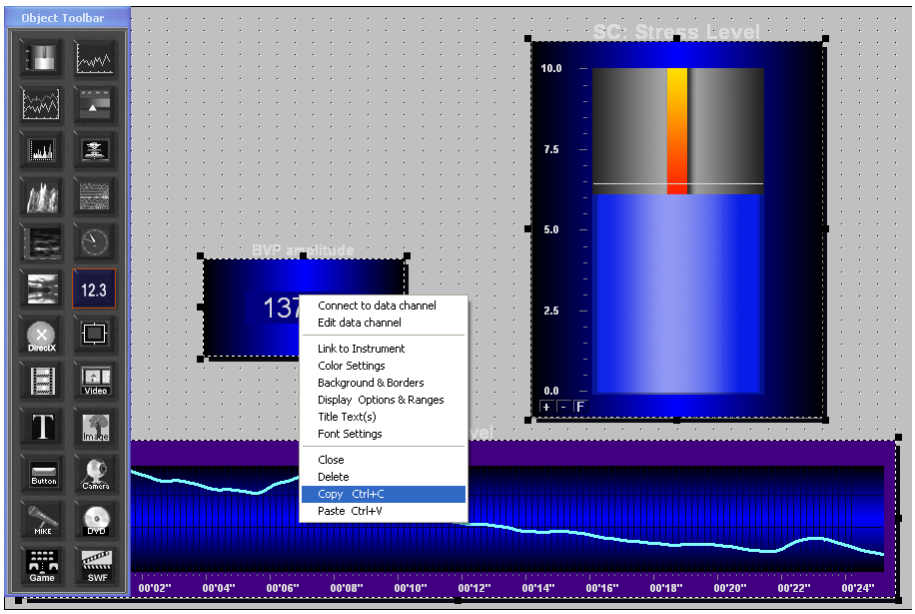
Let's summarize what screen building involves:

- enter the screen editor mode by pressing 'E' on the keyboard
- place objects and instruments on the screen canvas
- load and attach the specific channel set, that you want to use. (otherwise the default channel set is usually loaded anyway)
- connect instruments to data channels or link them to other instruments
- set the feedback properties of the instruments and the set the inhibits
- define the contents of your other objects, texts, images, backgrounds etc.
- switch to the session overview mode by pressing the 'Tab.' key.
- define which channels you want to see in the overview mode and choose the display type (line graphs, bar graphs)
- switch back to the real time screen mode (press 'Tab')
- save the screen you just built

6.1 Basic Principles

Placing objects and using Copy and Paste

Switch to the editor (press 'E') and left-click in the toolbar to select an object. Then move your mouse to the screen canvas and left-click again.



This will place the object on the screen. In case the object is an instrument (capable of displaying signals) the software will show you a list of the current data channels that you can connect the instrument to. After that you will need to set all the other parameters such as colors, background, etc.

Another way to create a new object, is to use an existing object and simply copy it. The copy will have the exact same size and properties as the original. So in case you want to put a number of similar size instruments (bar graphs, linegraphs etc.) on screen, you can use this option.

To use it: Right-click the object you want to copy, choose '**Copy**'. Now right-click the object again and choose **"Paste**". This will now create a copy of the object at the same position, but with a slight offset.

Deleting Objects

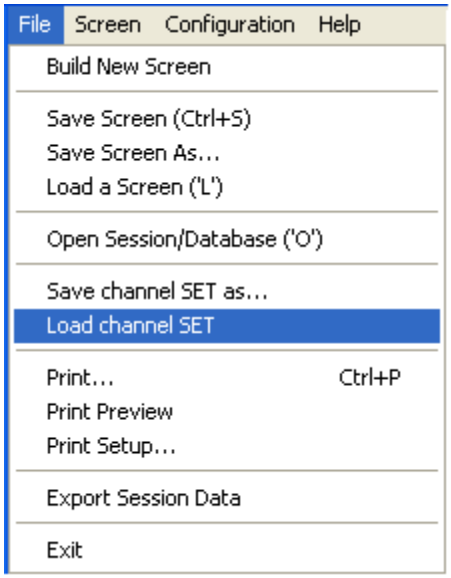
You can delete an object by right clicking the object and shooing '**Delete**'. Alternatively, you can also simply point the mouse over the object (in screen editor mode) and press the **Delete Key** on your keyboard.

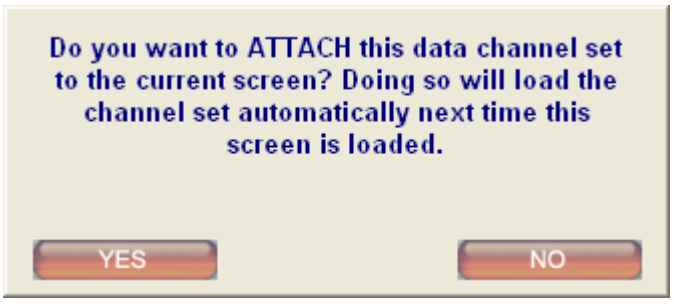
Using the Undo function (Ctrl-Z)

In case you make a mistake or, delete the wrong object, you can use the **Undo** function by pressing **Ctrl-Z** on your keyboard. There are 5 undo levels.

Loading and attaching a channel set

When you want to use a specific channel set for your new screen, you can do so by choosing **"Load Channel Set**" from the main menu bar.





After you select a channel set, the software will ask you, if you want to **attach** this channel set to the screen. If you say **YES** it will attach this channel set and ask you to save the screen. After the screen has been saved, the attachment has been saved to.

So next time you load this screen, this channel set will be automatically loaded.

Note there is one exception here: once you have started a recording, the channel set you have loaded with the current or first screen of a sequence of screen, will remain in place and can not change anymore. If you think about it, it makes sense. Imagine you start of with the default channel set where channel 33 is a HR (heart rate) channel and suddenly change the entire channel set (in the middle of a session) to another, where channel 33 is some kind of EEG activity. That clearly would not be possible, because it would completely change the meaning of this channel and the sensor it would be connected to. That would render your session data, statistics and overview, useless.

In other words: during the recording of a live session you can change screens, but the channel set you have selected can not change.

Connecting and Linking Instruments

In most cases an instrument (like a bargraph or line graph) is simply **connected** to a data channel. In that case the instrument will show the data of that channel.

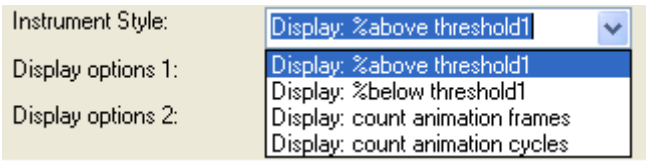
Some instruments though can be **linked** to another instrument. This means that it will use the **threshold state** or **data and scale range** of the other instrument.

Examples are:

1) The Numerical Instrument
2) The Animation Instrument
3) The Water Effect Instrument
4) The Game Instrument

Numerical Instrument:

When you **link** the numerical instrument, you can make it display the percent time above/below threshold. Or when linked to an animation, you can make it display the amount of frames or cycles that the animation has played.



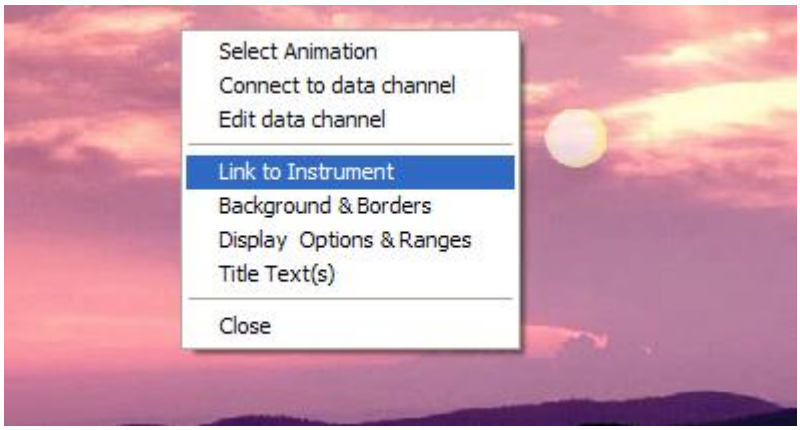
You may use these as a form of **reward** to the client.

The Animation Instrument

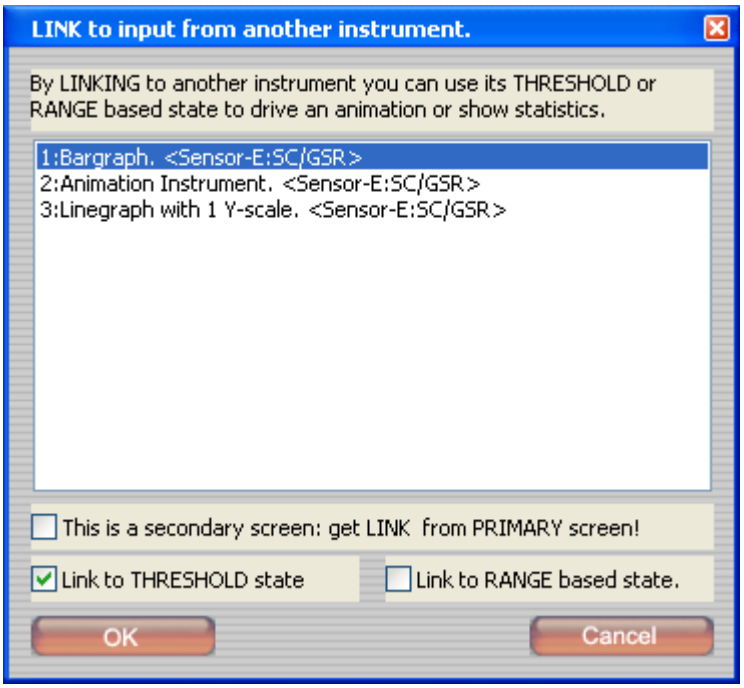
The Animation Instrument can be connected to a data channel directly, but much more often you will use it where it is driven by threshold states of other instruments. This requires **linking** the animation to another instrument.

An example is where an animation of a **sunset/sunrise** is linked to a bargraph that displays temperature. The animation can now be made to play in one or the other direction when the temperature is above or below threshold in the bargraph.

Right-click the animation and choose: "**Link to Instrument.**"



This will bring up the following dialog box:



In this dialog box you need to select 1 instrument. Then you need to choose if you want to link to the **threshold state**' or the **range based state**.

Linking to the **threshold state** will advance the animation one frame every time the signal in the bargraph (in this example) goes over or below threshold.

For example, this way you can make a flower animation open the flower for as long as the EMG level is below 2 microvolts.

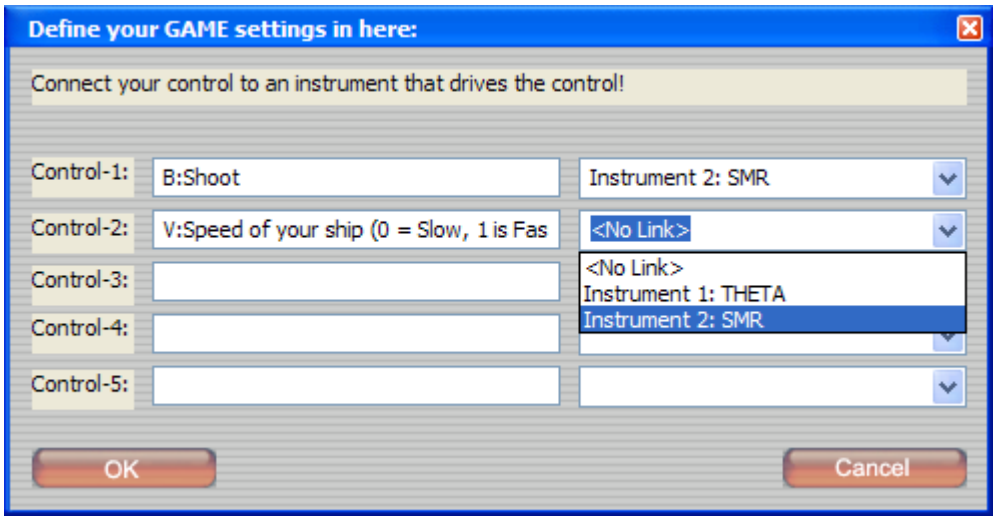
Linking to a **range based state** will make the animation respond in a different way. It will now show the first frame when the bargraph (example) level is at the lowest range and the last frame when at its highest level. All the levels in between will also be indicated by the corresponding frames.

The Water Effect Instrument

Linking the Water Effect instrument to another instrument will have the effect, that it will use the data and range from the 'linked' instrument. So if you link to a bargraph that is displaying the EMG from 0 to 20 microvolts, at the lower end of the bargraph scale (below 5 microvolts or so) the water ripples will almost disappear. At the higher end, the ripples will be stronger. Linking the water effect instrument to another instrument, provides you with more control over the range and sensitivity of the ripple effect.

The Game Instrument

The game instrument usually needs to be linked to a number of instruments so you can use the signals from those instruments. Below example settings from the 'Space Invaders Game" are shown.



The **Boolean** settings of a game (controls starting with 'B:') respond to a signal being over threshold. The **Variable** settings of a game (starting with a 'V:') respond to the signal level of an instrument, within the range of that instrument. The entire scale range is taken as being 100%, and the position of the signal within that scale is then a percentage between 0-100. In case of the space invader game, you can change the speed of your laser-ship, by linking it to an instrument.

Biofeedback Options and Inhibits

It is very important to understand these options, before you start building screens that use biofeedback.

The main concepts are:

- Digital Biofeedback
- Analog (continuous) feedback
- Inhibits

Digital feedback is where an event (sound, music, video, color) is switched ON or OFF depending on a level being over or below a **threshold**. Example: when the Beta level of the EEG is over a threshold, a single tone is played.

Analog feedback is where sound or graphics continuously respond (visually/audibly) to the state of a signal. Example: the level of EMG can be used to control the Volume of an MP3 songs that is played by BioTrace.

Inhibits are another form of digital feedback, except that they are able to turn things OFF. Important to know is that you can 'add' as many inhibits to a screen as you like.

Usually you will put Inhibits mostly on your 'Master' (Clinician) screen. Inhibits switch tone feedback, videos, DVD's, etc off while playing. When there are no inhibits active, those will normally play.

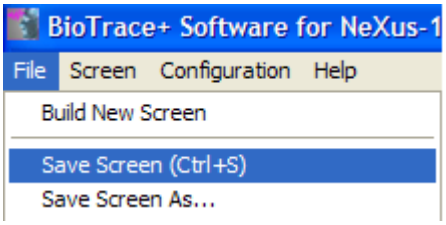
Example: you can use multiple Inhibits on instruments to turn off a DVD. However when none of the Inhibits are active, the DVD will play. So for instance you may have an EMG inhibit, combined with a Theta Inhibit and Eye Blink Inhibit. When any of those occur (for instance Theta is over a threshold of 10 microvolt) the DVD move will stop.

Session Overview Settings

Remember that the screen that you are building always has the 'overview mode' built-in. When you pres tab to switch to that mode, you should manually add the channels you want to visualize on the overview mode.

Saving the screen

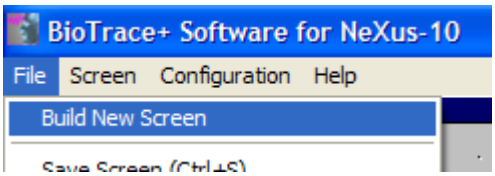
When you are done creating a screen, you should save it by choosing either: '**Save Screen**' or '**Save Screen As…**"



'Save Screen' will overwrite the existing screen. 'Save as…" will create a new screen file.

6.2 Example 1: building an EMG screen

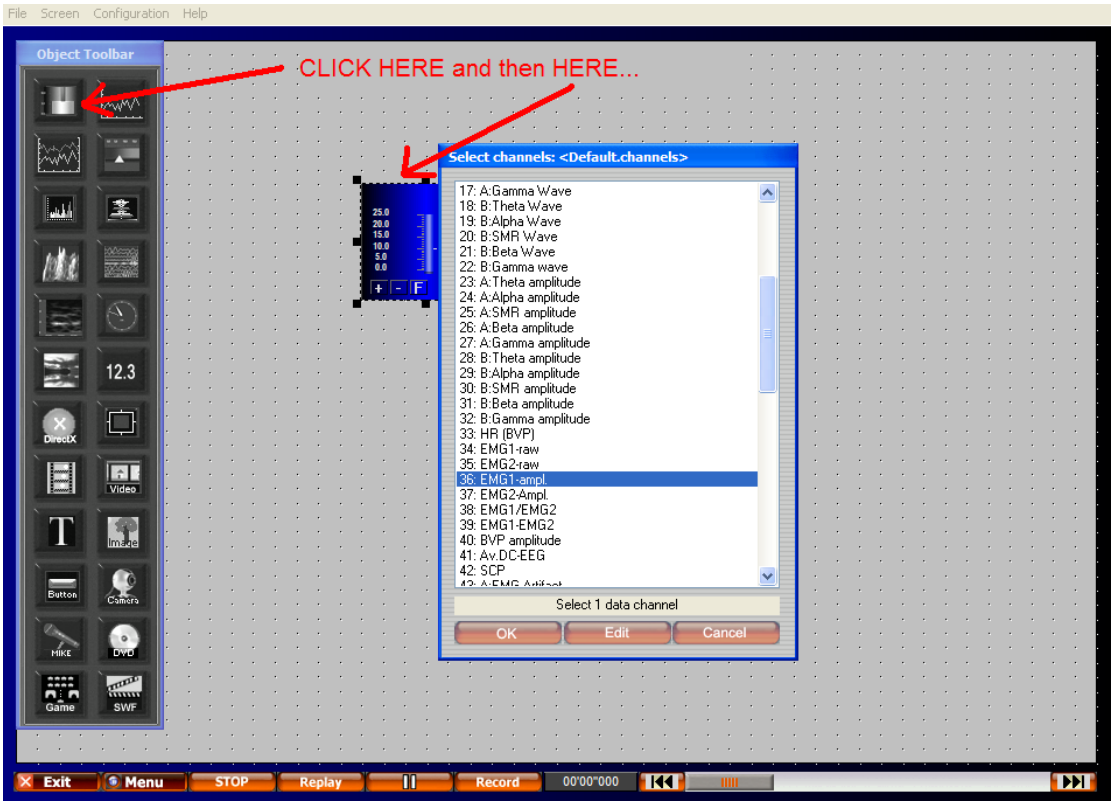
We will now build a simple EMG screen, from scratch. Go to the main menu bar and choose: '**Build New Screen**'.



The software will ask you if you want to delete all current instrument/objects and enter the edit mode. Confirm by clicking in the '**OK**' button.

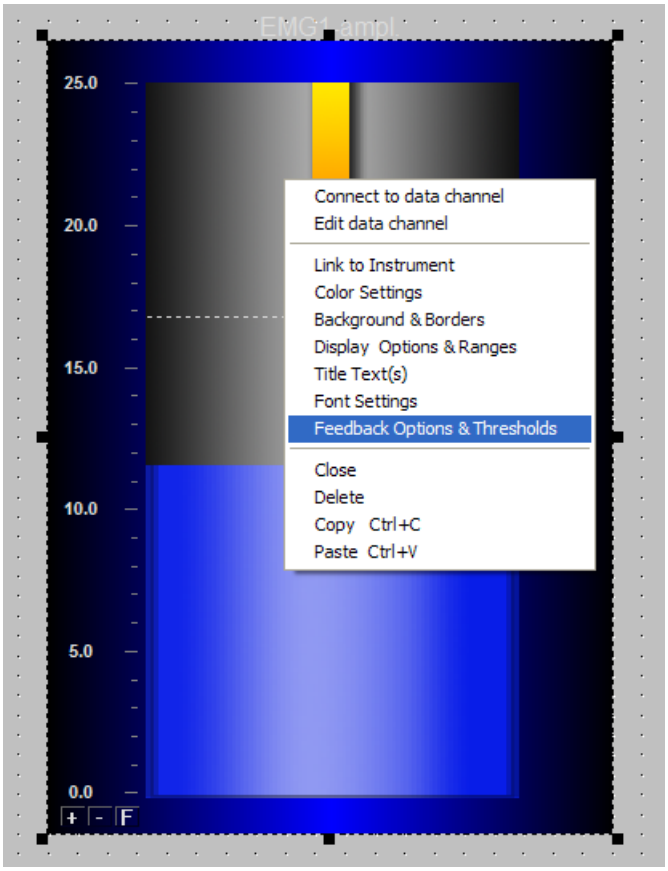
Now you will be asked to enter the **name** of the new screen and choose a screen category. This is the place where your new screen will be saved. Choose the **'EMG Screens**" category.

Now click in the editor and click in Toolbar on the '**Bargraph**' object in the upper left corner. Then move the mouse to a place somewhere in the screen and click again.

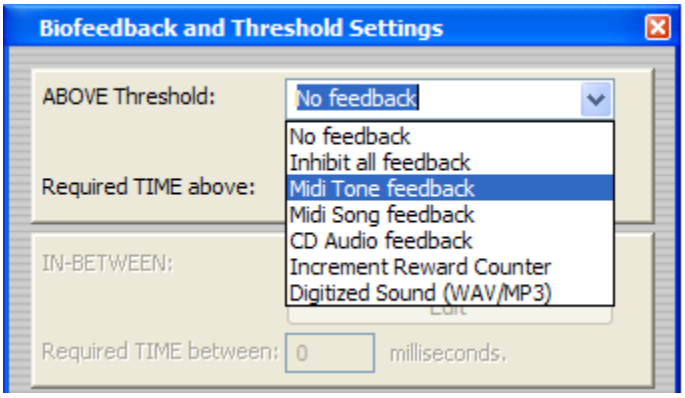


Next, the software will ask you to connect a data channel to the instrument. Select channel "**36:EMG1 Amplitude**".

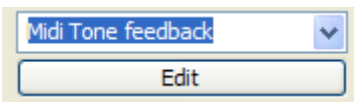
After that press the **'O' key**, on your keyboard, to open the session database. Load the 2xEMG session from John Sample (double click on the date Column) so we will be able to display some data. Now we will need to size the instrument a little. Click in the right-bottom handle and '**size**' the instrument by dragging the black 'handle'.



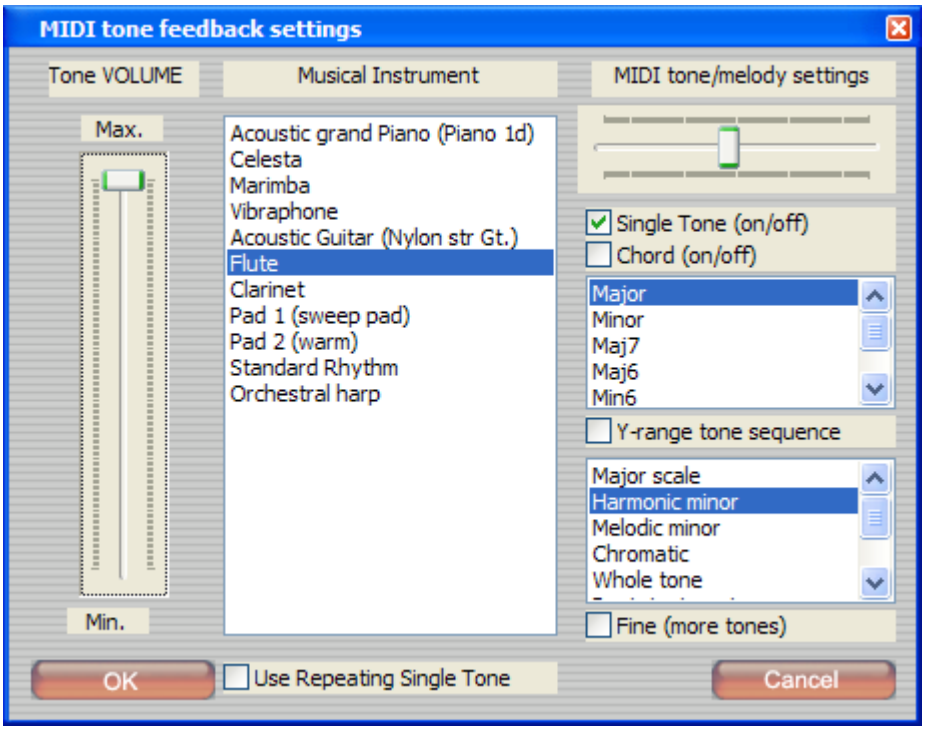
After sizing the instrument, right-click it and select the '**Feedback Options & Thresholds**'. In the dialog box that pops-up, we will now select a feedback tone, when the level is '**Above**' the threshold that we will set. Choose '**Midi Tone feedback'.**



Then click the **'Edit**' button, shown just below the selection you just made.



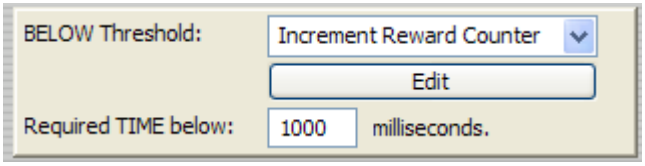
Now you select a simple **'Single**' tone from the Flute as shown below.



Then press OK and close all dialog boxes. Press the '**Replay**' button at the bottom of the screen and the session you just loaded will start to play.

Every time the EMG amplitude goes over threshold, you will hear a single flute tone which will stay for as long as the level is above threshold. When the signal goes below threshold, the tone will disappear. The reason is that you did not set any sound at the '**Below Threshold**' option.

Right-click the bargraph again and choose '**Feedback Options**'. Then select 'Increment Reward Counter' for the option below threshold. Enter a required time below threshold of '1000 ms.

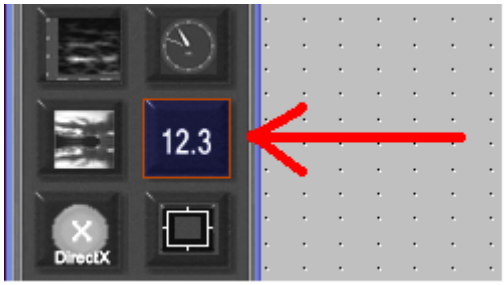


For each block of 1 second of time that the EMG level is below threshold, the reward counter will now be incremented by one.

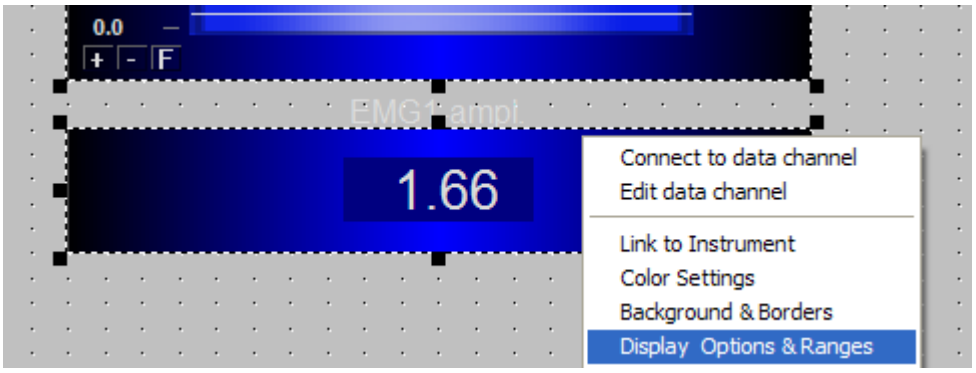
Displaying the reward counter

In this example shown above (1 single bar graph incrementing the reward counter below threshold) we will use a numerical instrument to display the counter. Note that we could also use another bargraph or Vernier instrument to display this counter value.

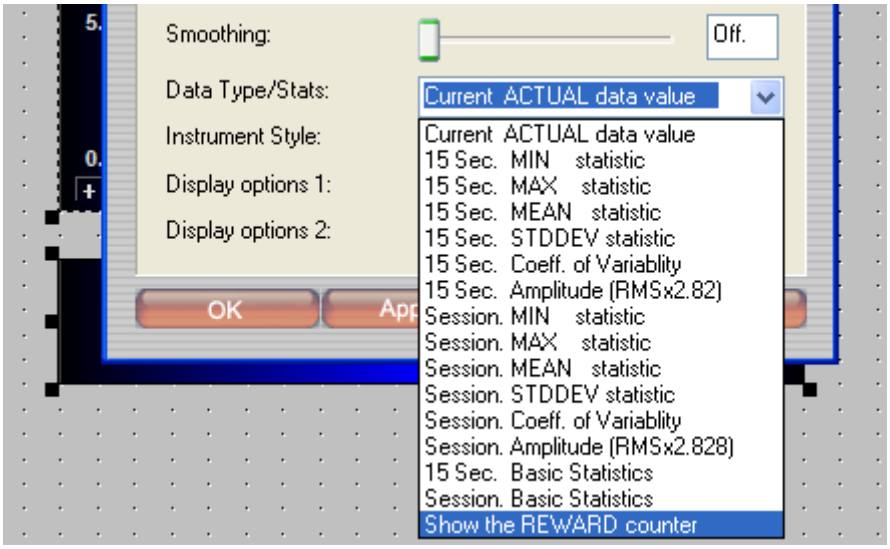
Place a numerical instrument at the bottom of the Bargraph by clicking in the Toolbar on the Numerical Instrument and then clicking somewhere below the bargraph instrument.



The software will now ask you to connect the numerical instrument to a channel. Choose channel '36:EMG1 Amplitude' again. Size the instrument so it fits nicely below the bargraph and right-click the numerical instrument. Then choose '**Display Option & Ranges".**



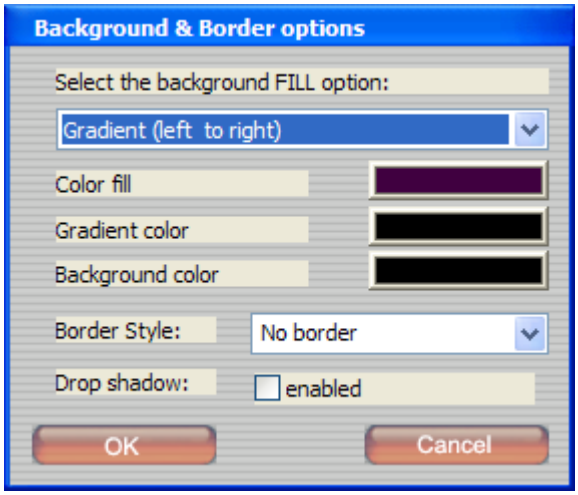
We can now change what the numerical instrument displays from the actual value of the data channel, to the reward counter. Change the setting of the '**Data Type/Stats**' to the reward counter.



Press OK to close the dialog box.

We will now finalize this screen by settings the screen background. Right click anywhere on the screen canvas and select: '**Set Background Colors**'.

Choose some gradient colors and choose '**Gradient (left to right)**' or another gradient option.



Press OK to close the dialog box. You should now have the complete screen on your monitor. Set the threshold of the bargraph to 5 microvolt, by left-clicking in the bargraph around the scale number 5.0.

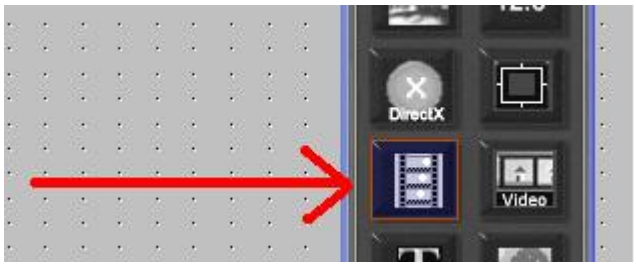
Then play the session by pressing the '**REPLAY**' button. You should now hear a flute tone when the level is above threshold and see the reward counter increment when the level is below threshold for longer than 1 second.

Did it work? If it did, now is a good time to save the screen by choosing '**Save Screen**'. It will use the screen file name and category that you selected earlier.

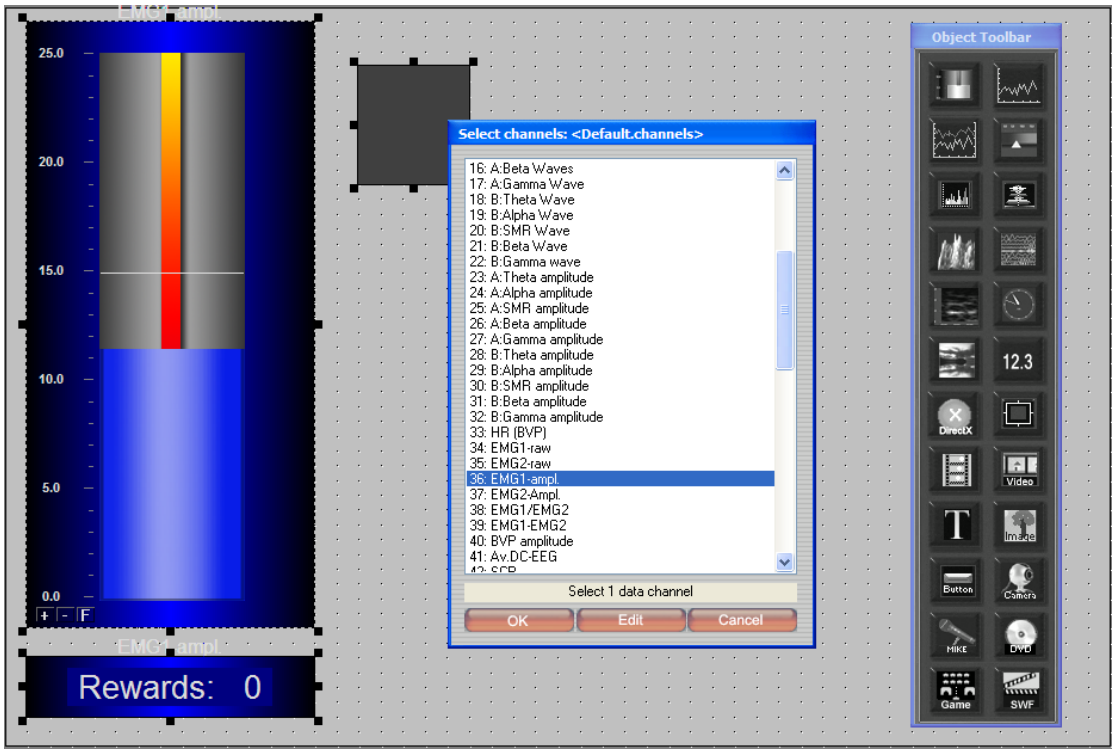
6.3 Example 2: building a Screen with an Animation

We will now build a basic Animation Screen. As you have read earlier, animations are usually driven by thresholds of 'linked' instruments. We will not start from scratch, but instead modify the EMG screen we just made. Press **'E'** on your keyboard to enter the screen editor mode.

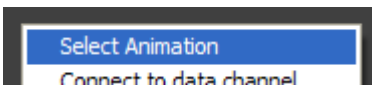
Now move the toolbar to the right of the screen, by dragging it (using the caption) . Then select the Animation Instrument and place it on the screen.



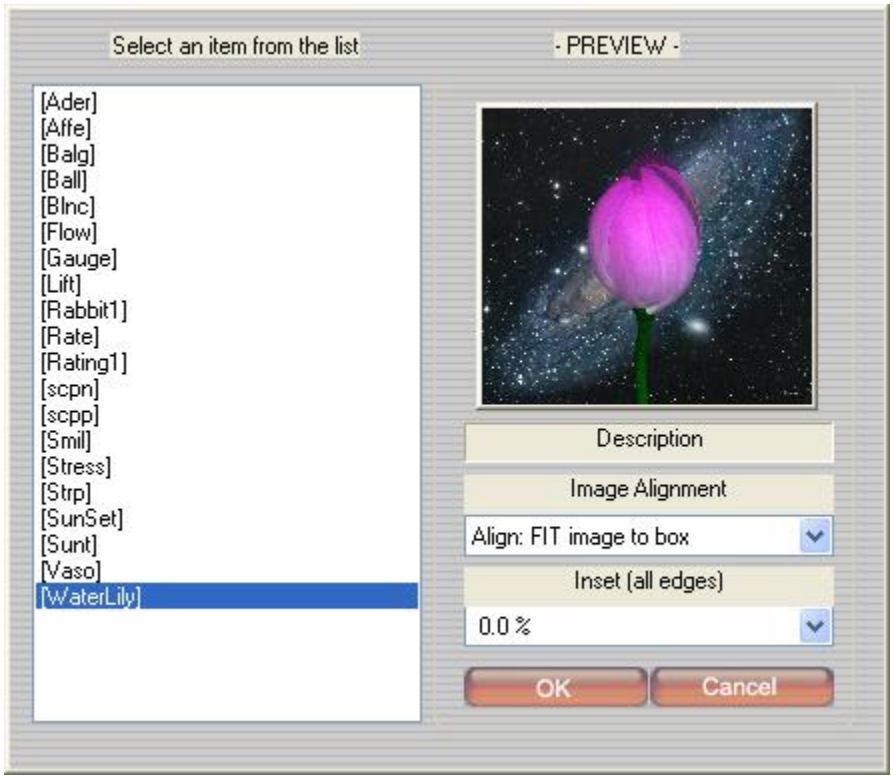
Move the bargraph and numerical instruments to the left. Your screen should now look something like this:



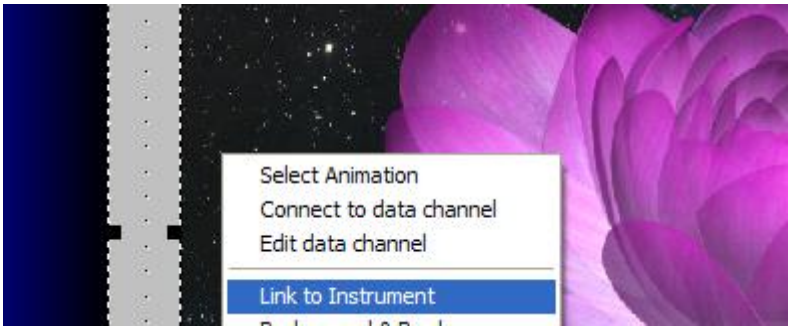
The software will ask you to connect a data channel to the animation instrument. Choose channel 36. (Even though we will not use it at this point). Size the animation to make it bigger. Then right-click it and choose Select Animation.



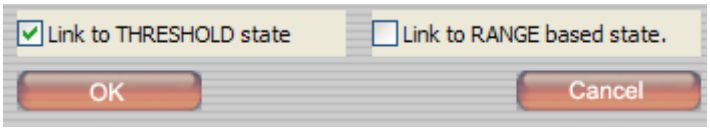
From the dialog box select the **"Water Lily"** by left clicking it in the list on the left.



Then choose the '**OK**' button and wait for the animation to appear.
The next step is that we now must **'Link'** the animation to the bargraph instrument. Right-click the animation instrument and select '**Link to Instrument**'.

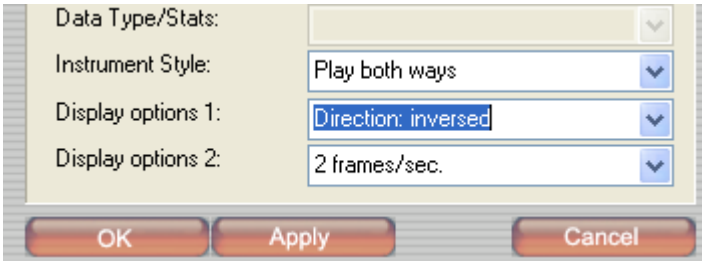


Select the bargraph instrument (in the list box) and also make sure a check-mark is set at the **"Link to Threshold state**" button at the left bottom of the dialog box. Then choose **'OK**'.



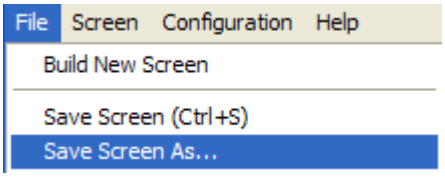
Now the animation is linked. Our goal is to make the lily flower **open** when the EMG is below threshold. (Indicating a certain relaxation level). Right-click the animation instrument and choose the **'Display Options and Ranges**" option.

In the dialog box that will appear, we will now need to choose the '**Direction: Inversed"** settings:

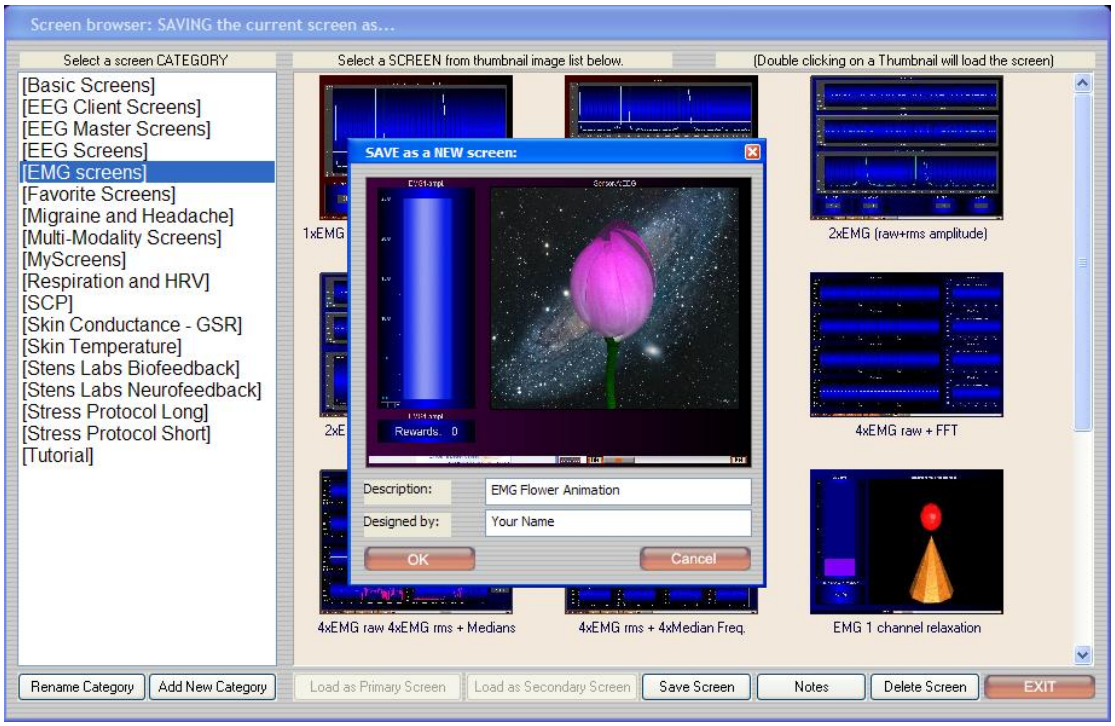


You can set other two display options as shown above. (Play both ways and a speed of 2 frames per second). Click in the **OK** button now to close the dialog box.

Actually we are done now. When you press the '**E**' key on your key to leave the screen editor mode. You can save the screen. Let's save it as a new screen.



This will open the screen browser window:



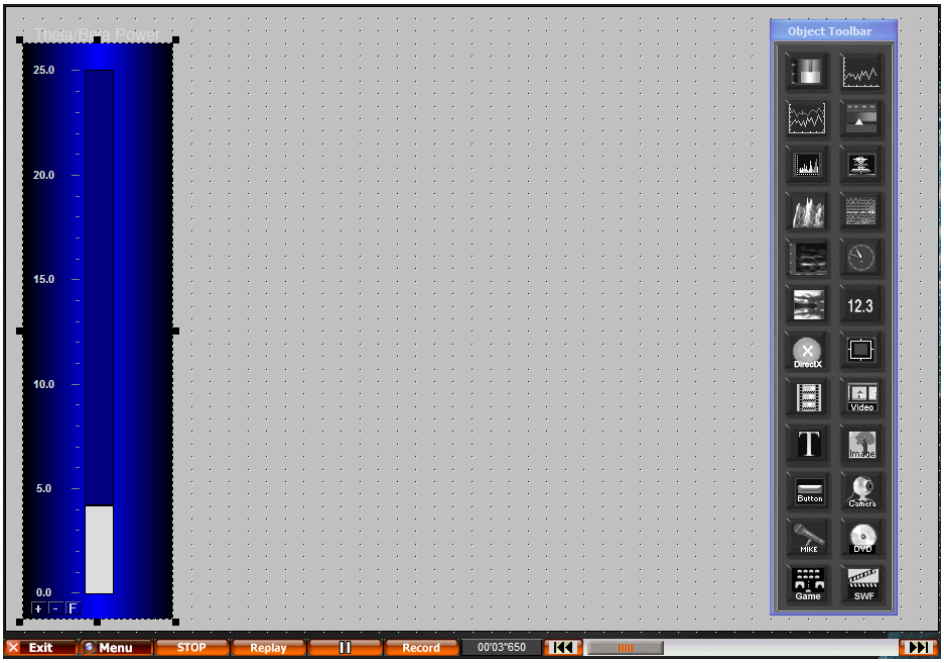
Click in the **'Save Screen**' button and fill in the name of your screen and your own name. (Since you designed it, right?).

That finishes the second screen building example.

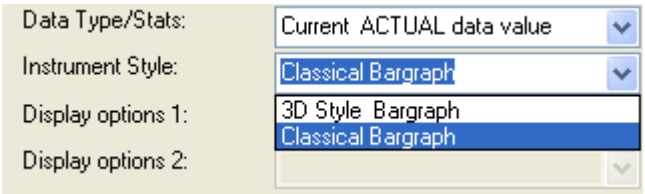
6.4 Example 3: building a Screen with Inhibits

We will now build a screen that uses a number of inhibits. Load the John Sample '**EEG: 1 channel**' session. We start from scratch. Select the '**Build New Screen**' option from the main menu bar at the top. Enter the screen name and select the screen category when asked by the software.

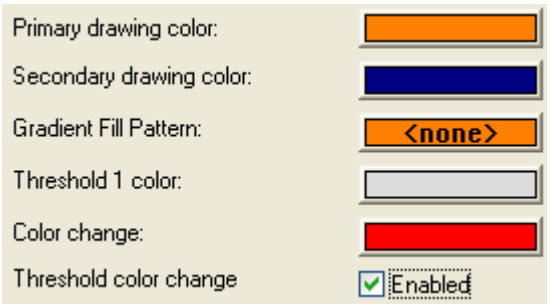
Place a bargraph on the screen as shown below. Connect the bargraph to the Theta/Beta ratio channel number 74 (default channel set).



Then right click the bargraph and choose '**Display Options & Ranges**'.

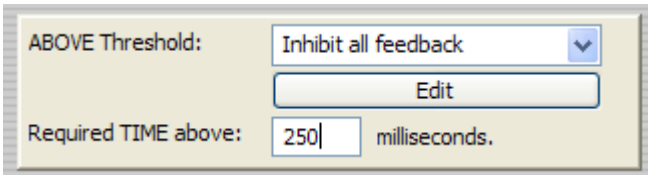


This will change the bargraph '**Style**' to the good old bargraph. Set the Y-Scale range to 0-10. Next :'right-click' the bargraph and select '**Color Settings**'.



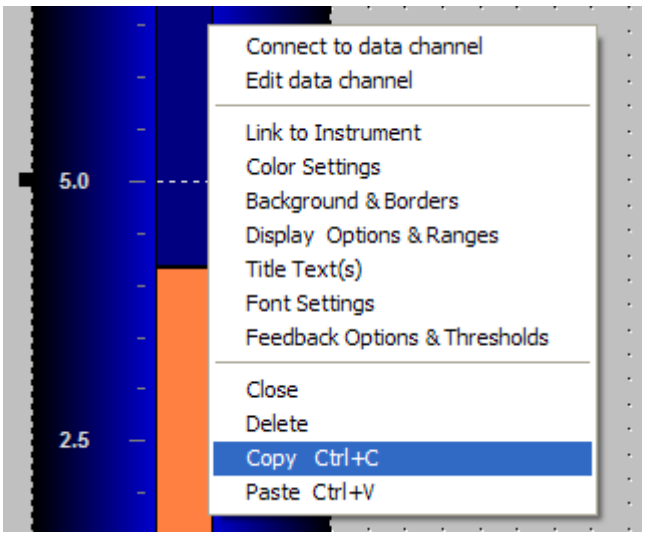
Choose a primary color (for instance Orange). Then click the 'Threshold color change' button and select the color red for the '**color change'** option. This will now mean that when the theta/beta level is higher than the threshold, the color of the bargraph will change to red.

Next: right-click the bargraph and select '**Feedback Options & Thresholds**'. Now select an **Inhibit** state above threshold.



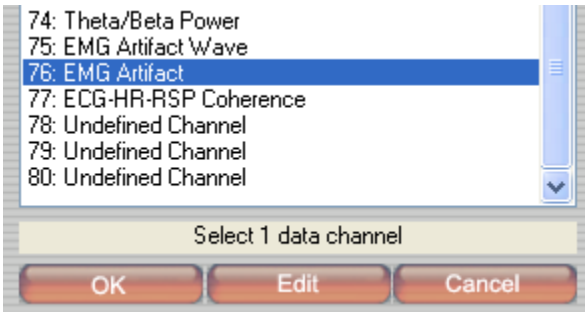
Set a required time of 250 milliseconds.

As a next step, we will make a copy of the bargraph instrument and connect it to the EMG artifact channel. Right-click the bar graph and choose '**Copy Ctrl+C**'.



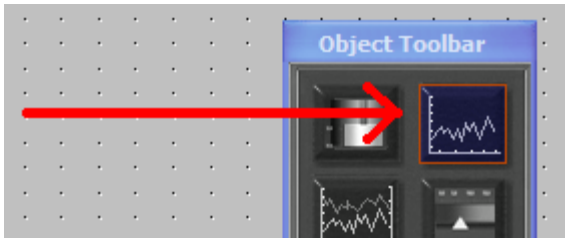
Then right click and choose paste, or simply use your keyboard and press '**Ctrl' and the 'V' key.** This will paste a copy of the bargraph to your screen.

Move the second bargraph to the right side of the first and connect it to channel 76 (EMG artifact) by right clicking and choosing '**Connect to data channel**'.

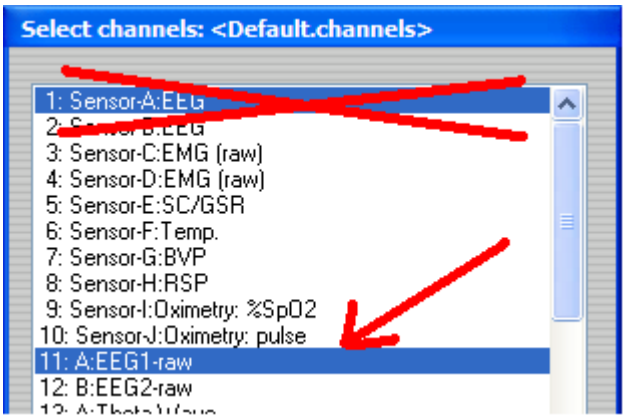


Press the '**R**' key to refresh the screen and wipe out any remaining overlapping texts.

Now size the two bargraph and make them a bit smaller. (Decrease their height) We will place a line graph instrument on the screen.

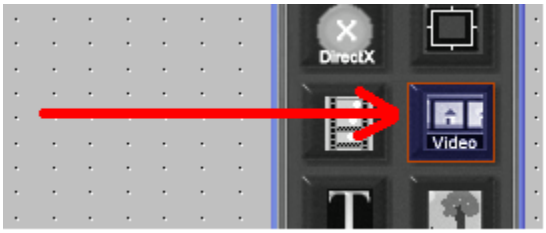


Place the line graph at the top of the screen and connect it to the data channel 11 which is labeled '**A:EEG1-raw**'. Notice that perhaps two channels may now be selected.

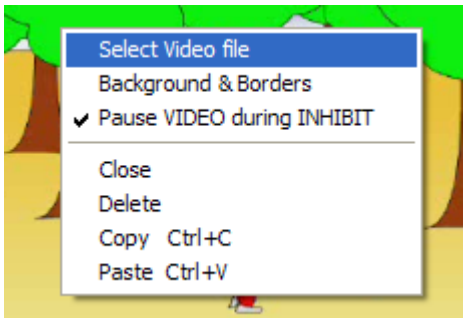


The reason is that linegraphs can be connected to more than 1 channel. In this case we do not want that. So unselect the other channel, and only select channel 11. The number of selected channels is shown at the bottom of the box.

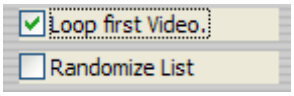
Close this dialog box by pressing '**OK**'. The next step is that we will add a video (animation) to the screen. Choose the **'Video Object**'.



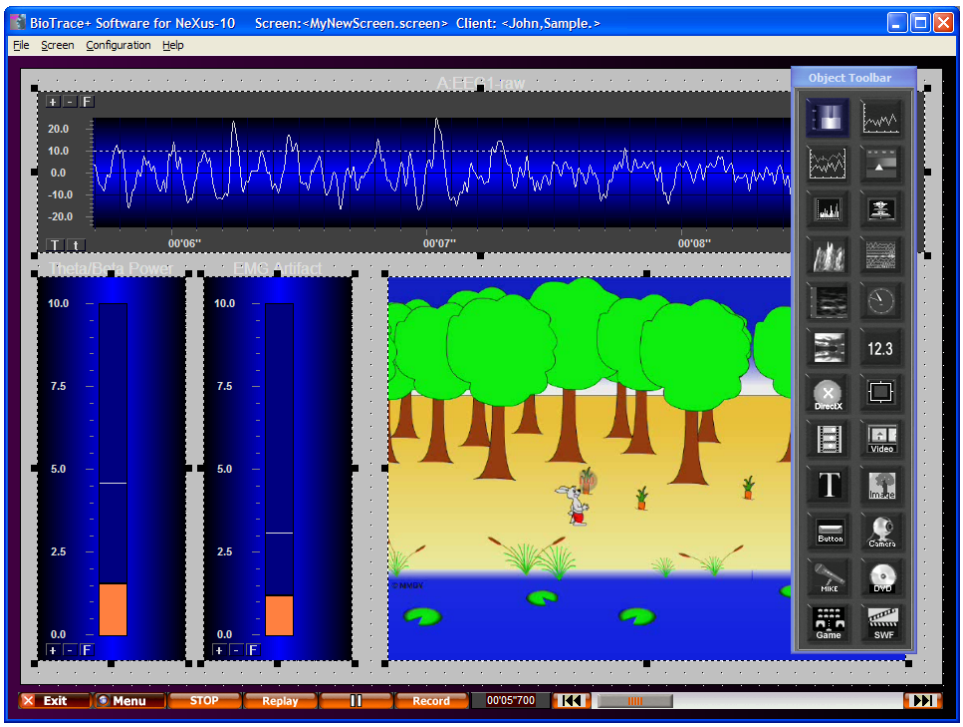
Place it on the screen below the line graph. Stretch and move the Video object so it will use of the space between and below the instruments. Right-click the video object and choose the '**Rabbit1.wmv**' video file. (double click it)



Make sure that you have set the '**Loop first video**' option, so it will keep playing the video animation over and over.



Close the dialog box. Right click somewhere the screen between the instruments and set a background color on the screen ('**Set background Colors**' option). On your screen you should now see something like this:



Press the 'E' key to go out of the edit mode and choose the '**Save Screen**' option from the main menu bar. Do not press the '**Escape**' button as that will leave the screen you are building and return to the main menu.

When you will **'Replay**' the session you will see that both the Theta/Beta power and EMG artifact bargraph will inhibit (pause) the video animation. When you would have loaded a secondary screen that displays a video (or DVD, Game or Animation object), it would work the same way. The instruments on the primary (master) screen would inhibit (pause) the video objects or other instruments just as well.

This ends the third example of screen building.

6.5 Screen Building tips

The screen editor and screen building features of BioTrace+ go pretty deep. In order to help you further along the way, here are a few more tips:

Tip 1: when creating clients screen (for the secondary screen) use a master screen that controls the inhibit factors. Only place a few simple objects on the client screen, such as a video file (WMV/MPEG/AVI etc.) and perhaps a scoring instrument displaying the reward counter.

Tip 2: when building a protocol (script), first build all the screens in the protocol and name them in a structured way. Then start building the '**hyperlinks** (buttons) or the scripted **sequence**, using these screens.

Tip 3: don't be afraid to use multiple inhibits. You can set individual instruments to accept or **ignore** the inhibits in the 'Feedback Options and Threshold" settings.

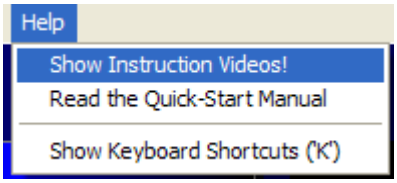
Tip 4: get video files (wmv/mpeg/avi) from the Internet and download them into the '\BioTrace\Video' directory. Because of copyright limitations there are only a few video files included on the software setup CD. Same for MP3 files. You can get them from many places on the internet or copy them from your own CD's. *

Tip 5: use mp3 digitized sounds rather than CD sounds and music. When using a CD you can only play a single track at once. When using MP3/WMA files, you can play many (up to 64) sounds at once, mix them and do volume feedback control on them. *

Note: please observe the copyright limitations that may exist on video and audio materials

Tip 6: you may want to enter **screen notes**. When editing/building a screen, you can press the '**N**' key. This will show the screen notes. When you click the **Edit** button, you can enter your own notes. Save the screen after entering the notes.

Tip 7: use the Video files! Complementary to this manual, you can find information about using BioTrace+ and building screens under the '**Help**' option from the main menu bar.



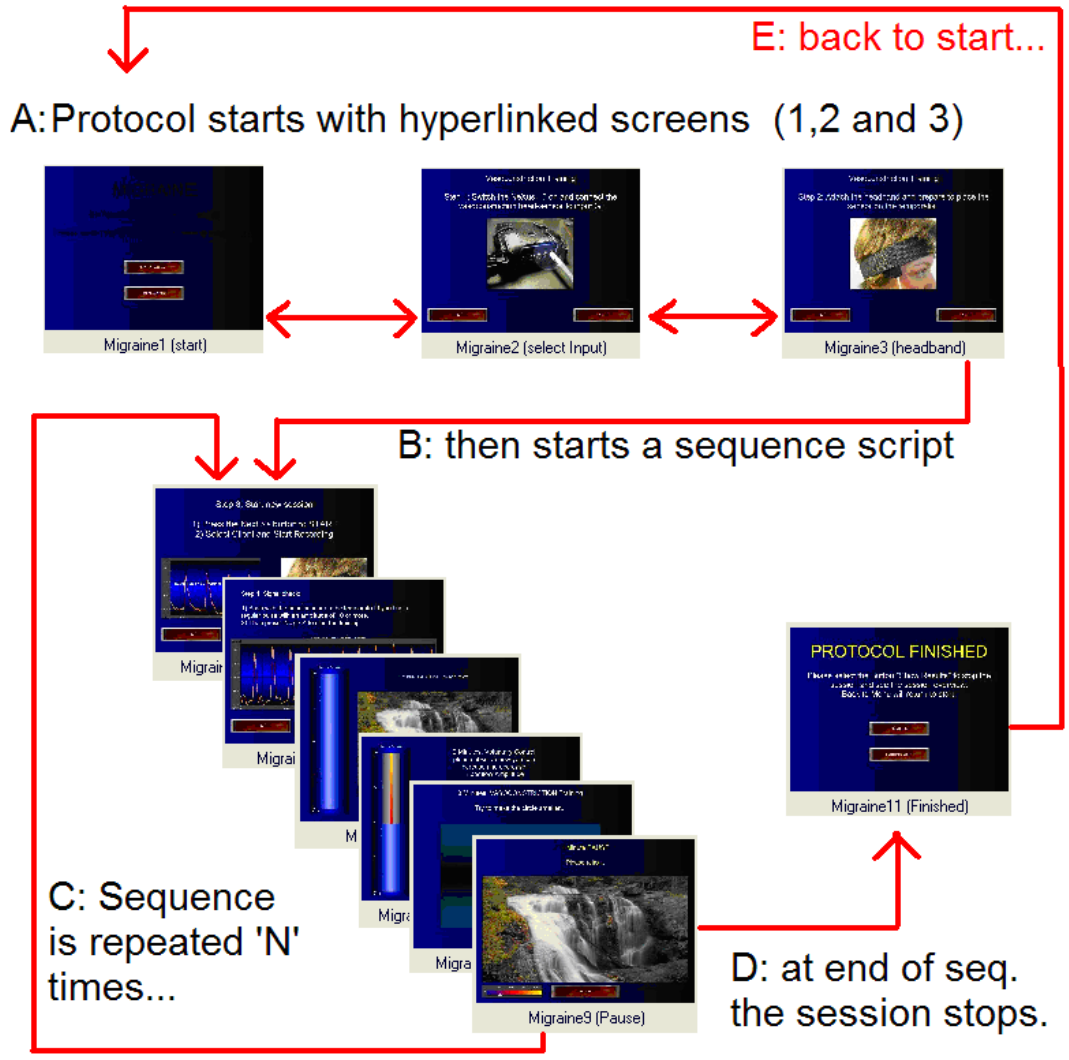
In the video category number 6, you will find more video information and examples on this object.

Tip 8: use the Internet! In September 2005 a user group was started on the NeXus/Biotrace+ Check here: '**http://health.groups.yahoo.com/group/Nexus10/'** If you have a question, you may find the answer there!

6.6 Building Protocols

Building a protocol is nothing but a creating a series of screens that are connected (linked) in one or another fashion and will 'play' in a certain sequence.

Think of it as a pre-programmed slide-show, where the BioTrace+ screens are the slides. The trick is in the way that the screens are connected and how and when the next screen is displayed. Often you will use a combination of 'hyperlinked' screens and a scripted sequence. Take a look at the example below:



To create something like this may look like a daunting task at first, but in fact it is not so complicated as it seems. There are two steps to build a protocol:

1) You begin by creating ALL the screens (slides) that you will use in your protocol (slide show). This may include creating some images, videos and sounds you will use in your protocol.

2) Then you set up the links between the screen and save the screens and the scripts if you created any.

In the protocol example on the former page, the first 3 screens (1,2 and 3) contains buttons that are labeled **'<< back**' and '**next>>**'. For instance the **back** in screen 2 will jump (hyperlink) back to screen 1 if the user clicks in it. The **next** button will jump to screen 3 if the user clicks in it. Note that you have to label the buttons this way yourself and you also have to define the '**Button action**' of those buttons.

Button based (hyperlinked) protocols

Summary: Buttons are objects that you can place on a screen and can 'do' something when you click in them, such as load another screen. This is called hyperlinking (jumping to a screen) Using buttons is a simple and effective way to create a protocol. However each step in the protocol needs a button and you must make sure it loads the right screen.

Advantages:

- you can place as many buttons as you wish on a screen and jump from that screen to a number of other screens. That way such a screen could serve as a menu.
- You can make the link to the other screens conditional. For instance you only hyperlink (jump) to the other screen when the screen (slide) has been shown for at least 10 seconds, or the EMG level is below 2 microvolts.

Disadvantages:

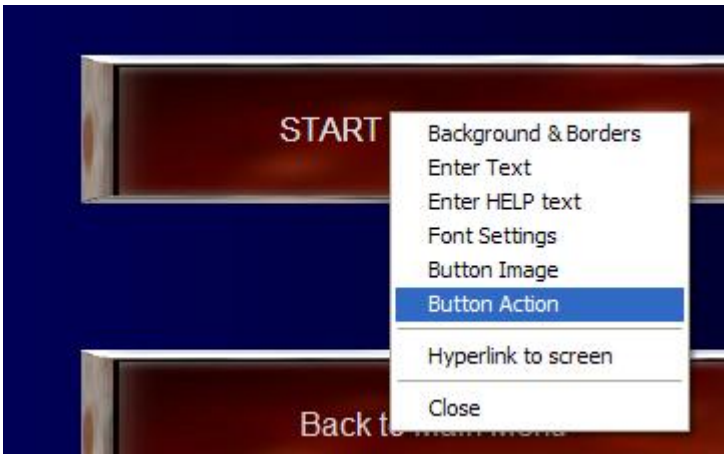
- It is rather laborious and requires each button action to be programmed.
- Removing one screen (slide) from the button linked sequence will break the sequence.
- It is harder to program 'loops' of screens

In the protocol example you can see that a combination of hyperlinked (button based) and sequence based screens are used.

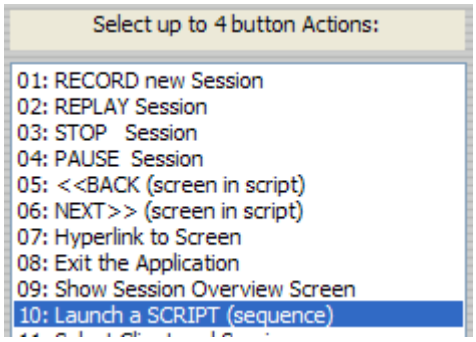
Sequence Script based protocols

Screens that are put in a script, are always played in a fixed sequence. You launch a script by clicking in a button which has a button action set to: '**Launch a SCRIPT'**.

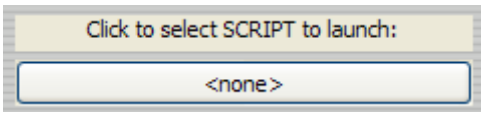
You can find this definition in the button action of a button:



Then you select the '**Launch a script' option** in the button action dialog box:



Next you need to enter the name of the script this button will launch.



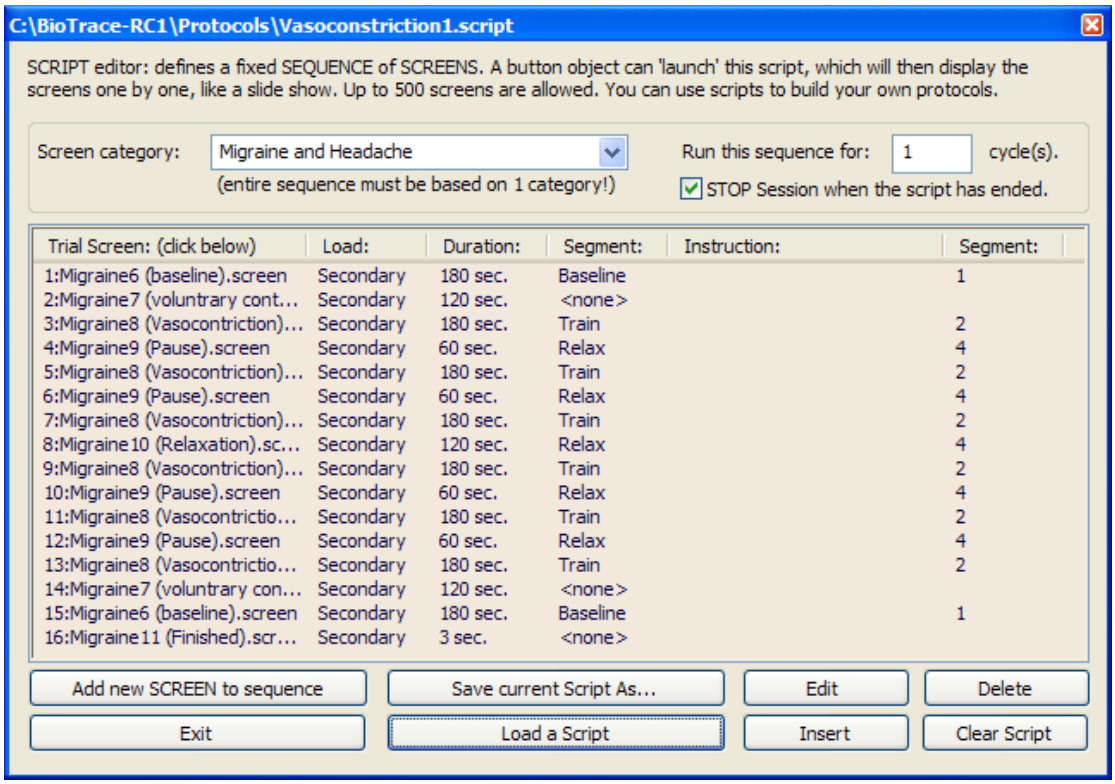
The script file itself is something that you will define in the sequence editor. A short-cut to open this is the 'Q' key on your keyboard.

In the script you define a sequence of screens, where each screen has a certain '**duration**' which defines how long the screen will be visible until the next screen is shown. When a screen is displayed you can make it create markers or segments in your sessions.

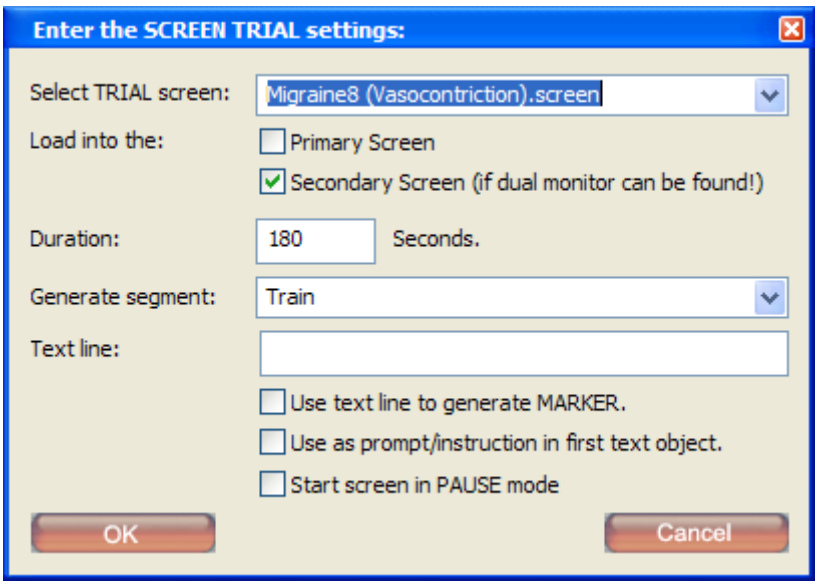
On the next page you will see an example of a script in the script editor.

The protocol SCRIPT editor

This example (actual screen display may vary) shows a list of screens in the script editor, also called a 'sequence', where each screen has a duration and some actions to perform. Think of it as your slide show list. Each slide is shown for a certain time.



With the buttons at the bottom you can **add** and **delete** screens to the sequence.
When you **double click** on one of the screens in this list, you can view its properties:



In this case you can see that '**Screen-8**' is displayed for 180 seconds, as a secondary screen (on your secondary monitor) and it will generate a segment of the type '**Train**' while this screen is running. This segment will last until another screen creates another segment.

The options of the screens in a sequence

You can set the following options here:

1) whether it is displayed in the primary or secondary screen
2) How long (duration) the screen will be displayed
3) What segment it will create. (segments starts immediately after screen is loaded)
4) What text line you want to have appear in a text object or marker.
5) Whether or not you also want to generate a marker (using the text of point 4)
6) Whether this screen should be shown in PAUSE mode. You will need to un-pause the session manually, for the protocol to continue.

Advantages of the sequence based protocol:

- You can exactly define the duration of screens and when they will be shown
- The screen sequence is always the same
- You can loop a sequence (repeat it X times)

Disadvantages:

- You can not navigate away from a sequence. It will keep running in the background and always play the next screen (slide) unless you load another script that overrides it or stop the session.
- You can't set conditions that define when and how the next screen will be shown. (buttons actions can do this)

So practically you will normally use a combination of button based screens that you can use create a menu of your protocol and which can navigate, and one or more sequence scripts that will be launched by another button.

Note: you may create a series of small scripted sequences and launch those with the buttons in your protocol screens.

Making protocols available to others

When making protocols available to others, we advise you **ZIP** all the files. *(right click files and choose: send to compressed zipped folder in Windows Explorer)*

We advise you to do this by copying (through windows explorer) all the screens, images, scripts etc. to a temporary folder, where you have created the same directories, so for instance '\protocol1\screens', 'protocol1\protocols', 'protocol1\audio' etc. Then fill those directories with only those files that you use in your protocols. Then right click the 'protocol1' folder and choose 'Send to compressed (zipped) folder). Now all your protocol files with be in the right directories and you can send the entire protocol as one file to another person by email. That person then just needs to open the compressed ZIP file and copy the contents to their '\Biotrace' directory.

Difficult? Yes, we understand it if you think this is not so easy. It indeed requires laborious manual copying and pasting of files in Windows Explorer. In the future an automated function may become available which will make your life easier.

6.7 Protocol Building tips

Protocol building resembles creating a slide show, except that you now have many more options to jump from slide to slide and even have the user navigate between screens at will or have screens popup only when certain (physiological) conditions are fulfilled. It is outside the scope of this manual to discuss all the possible combinations of screens, scripts and protocols you could possibly build with BioTrace+, but we do hereby provide you with some tips:

Tip 1: when creating a protocol always put all the screens belonging to your protocol in a single screen category. Give that screen category a recognizable name, for instance "Relaxation Protocol1"

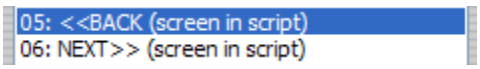
Tip 2: first create all the screens, images, sounds and materials you need for your protocol, only then start creating the links and sequence script.

Tip 3: Start building your first protocol with just three 'hyperlinked' screen. The start screen, the middle screen and the end screen. Put a <<back and next>> button on each screen.

Tip 4: Create a screen 'template' with the buttons and images in place, if many of your screens are similar. Then save that template screen under the name screen1, screen2, screen3 etc. Then load each screen (1,2,3 etc.) and set the buttons action (hyperlinks) on the buttons. This saves you time!

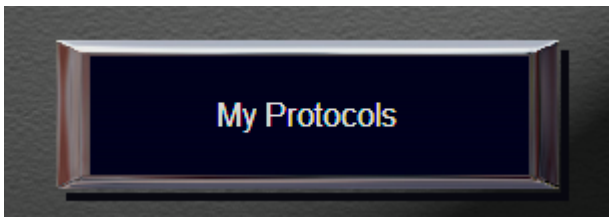
Tip 5: start simple, then expand your protocol one step at a time.

Tip 6: for testing a protocol screen sequence you can place buttons in a screen (for instance on your primary monitor) which contain a button action that will step back or step forward 1 screen in the current sequence.



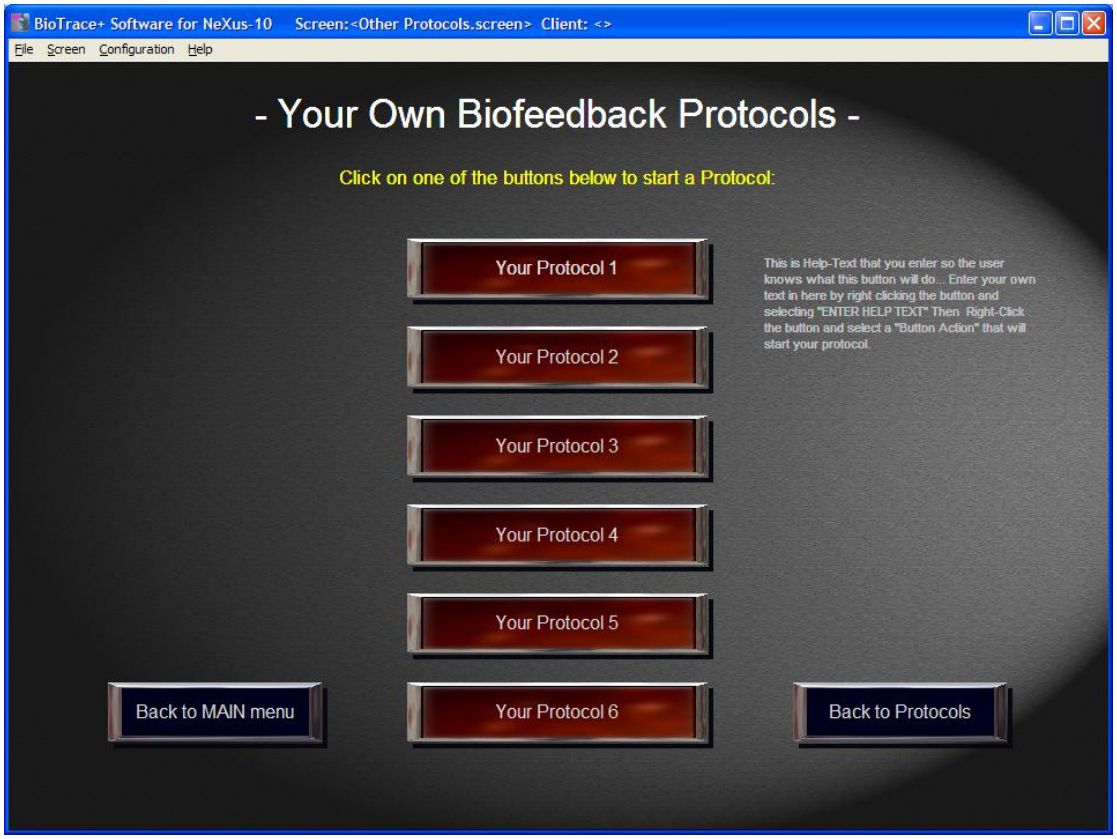
Tip 7: for testing hyperlinked screens you can simply load an existing session and click in the buttons as if you were doing an actual recording. You do not need to record a new session to test your protocols.

Tip 8: If you ask yourself, where shall I place my protocols, so that they are easily accessible from the start menu of BioTrace+? The answer is: click the **START button** on the main menu. Now the **protocol** screen will be shown. At the left bottom of this screen, you will see a button that says: "**My Protocols**":

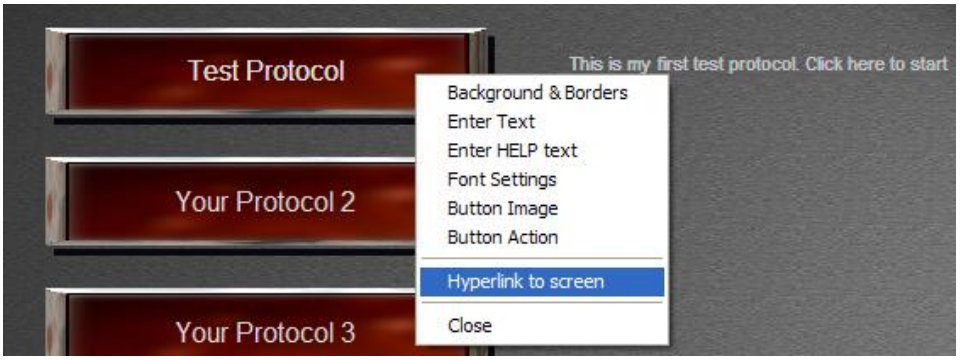


If you click this button you will open up a screen where a list of buttons appears. Each button can be assigned to open your own protocol (script) or navigate to other screens.

You can right-click these buttons and change the text, the button actions and the help text that appears when the mouse moves over the button.



After you made these changes and linked you buttons to your protocols, you save the screen. (**File: Save Screen)** Try to experiment on the first button labeled "**Your Protocol 1**" and link it to another screen by choosing: '**Hyperlink to screen**".



From the same submenu you can select a '**Button Action**' that would load and launch a protocol script.

Note: Remember that a protocol script is always started by a button action. The user has to click in a button to 'launch' the script.

7.0 Data Processing & Analysis Functions

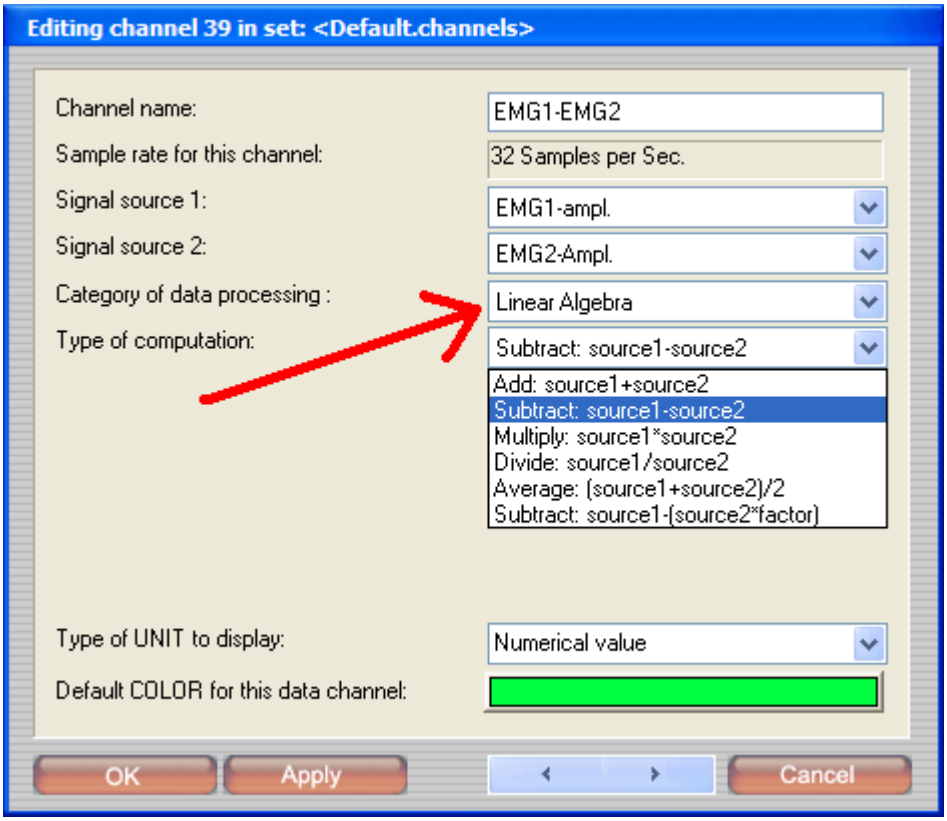
BioTrace+ features a wide range of data processing and analysis functions for online and offline use. You can use these functions to build **data channels**.

Categories of Data Processing:

The data processing functions of BioTrace+ are organized in 5 categories:

1) **Linear Algebra**
2) **Coherence and Correlation functions**
3) **Digital Filters**
4) **General Signal Processing**
5) **Frequency Analysis functions**

When you open the **Channel Editor **** in order to enter a new data channel, you always have to select the **category** of data processing before you enter the other properties. An example where **Linear Algebra** is selected, is shown below:



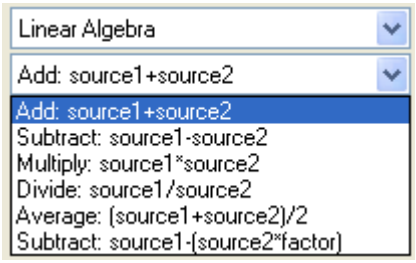
This manual assumes that you are familiar with the basics of physiological signals, data processing and statistics. For instance it will not explain to you what it means to compute the '**mean value**' of a set of data.

*** Since the user interface of the **Data Channel Editor** has been described in chapter **4.7** we will not repeat that information here.*

In the following pages, we will describe all data processing categories, one by one.

7.1 Linear Algebra Functions

When you choose **Linear Algebra** you can choose from a number of functions:



All these functions require that you select **2 signal sources**. A signal source is simply another data channel.

You can choose:

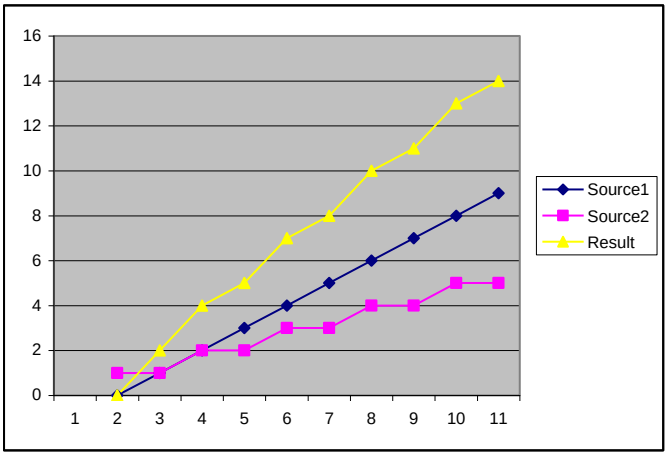
Addition

The function "**Add: source1+source2**" computes the sum of the signal values from source1 and source2 and puts the results back in the resulting channel. Note that it repeats this function for each value in the array of data values that a signal holds.

Result[n] = Source1[n] + Source2[n]

Example:

Source1	Source2	Result
0	1	0
1	1	2
2	2	4
3	2	5
4	3	7
5	3	8
6	4	10
7	4	11
8	5	13
9	5	14



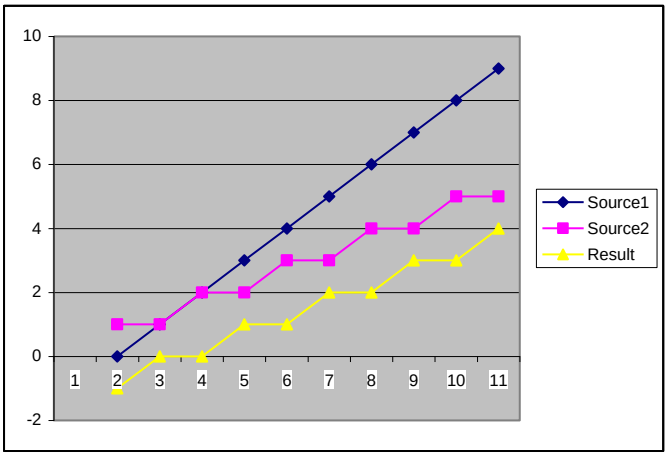
Subtraction

The function "**Subtract: source1-source2**" computes the difference of the signal values from source1 and source2 and puts the results back in the resulting channel. It repeats this function for each value in the array of data values that a signal holds.

Result[n] = Source1[n] - Source2[n]

Example:

Source1	Source2	Result
0	1	-1
1	1	0
2	2	0
3	2	1
4	3	1
5	3	2
6	4	2
7	4	3
8	5	3
9	5	4



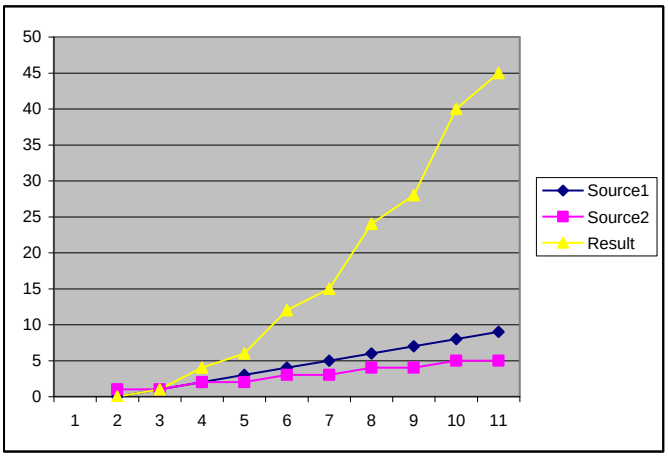
Multiplication

The function "**Multiply: source1*source2**" computes the product of the signal values from source1 and source2 and puts the results back in the resulting channel.
It repeats this function for each value in the array of data values that a signal holds.

Result[n] = Source1[n] * Source2[n]

Example:

Source1	Source2	Result
0	1	0
1	1	1
2	2	4
3	2	6
4	3	12
5	3	15
6	4	24
7	4	28
8	5	40
9	5	45



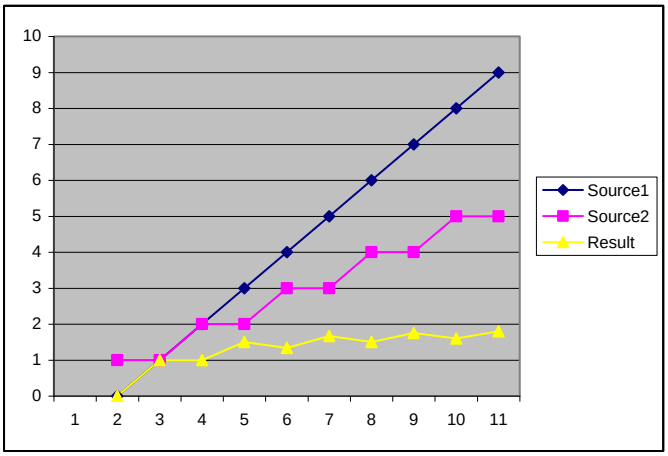
Division

The function "**Division: source1/source2**" computes the ratio of the signal values from source1 and source2 and puts the results back in the resulting channel.
It repeats this function for each value in the array of data values that a signal holds.

Result[n] = Source1[n] / Source2[n]

Example:

Source1	Source2	Result
0	1	0
1	1	1
2	2	1
3	2	1.5
4	3	1.3333
5	3	1.6667
6	4	1.5
7	4	1.75
8	5	1.6
9	5	1.8



*Note: a division by zero will not be allowed and will produce a **ZERO** result value.*

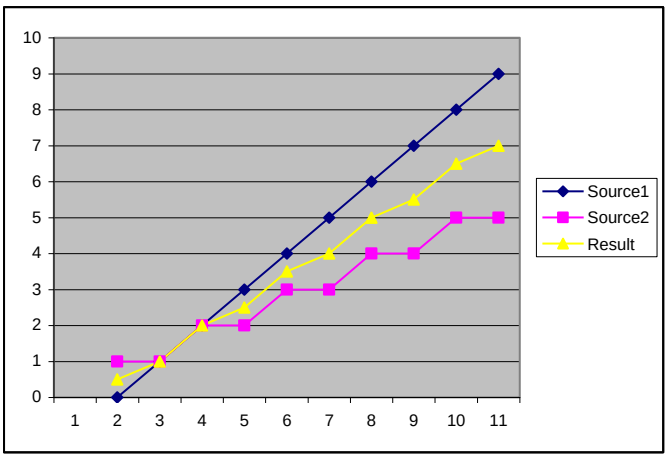
Average

The function "**Average: (source1+source2)/2**" computes the mean of the signal values from source1 and source2 and puts the results back in the resulting channel.
It repeats this function for each value in the array of data values that a signal holds.

Result[n] = (Source1[n] + Source2[n]) / 2

Example:

Source1	Source2	Result
0	1	0.5
1	1	1
2	2	2
3	2	2.5
4	3	3.5
5	3	4
6	4	5
7	4	5.5
8	5	6.5
9	5	7



Subtraction with factor

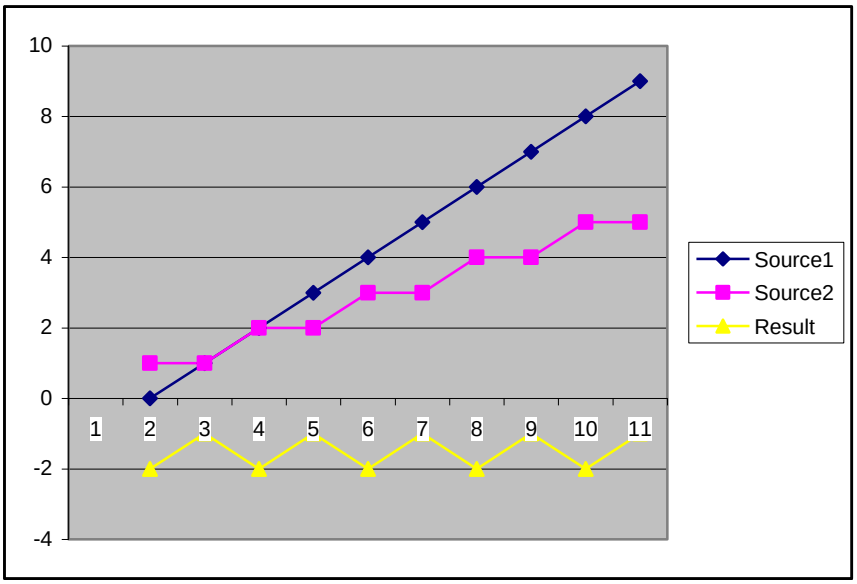
The function "**Subtract: source1-(source2*factor)**" computes the difference of the signal values from source1 and source2 times a factor X and puts the results back in the resulting channel. It repeats this function for each value in the array of data values that a signal holds.

Result[n] = Source1[n] - (Source2[n] * factor)

Example:

factor = 2

Source1	Source2	Result
0	1	-2
1	1	-1
2	2	-2
3	2	-1
4	3	-2
5	3	-1
6	4	-2
7	4	-1
8	5	-2
9	5	-1

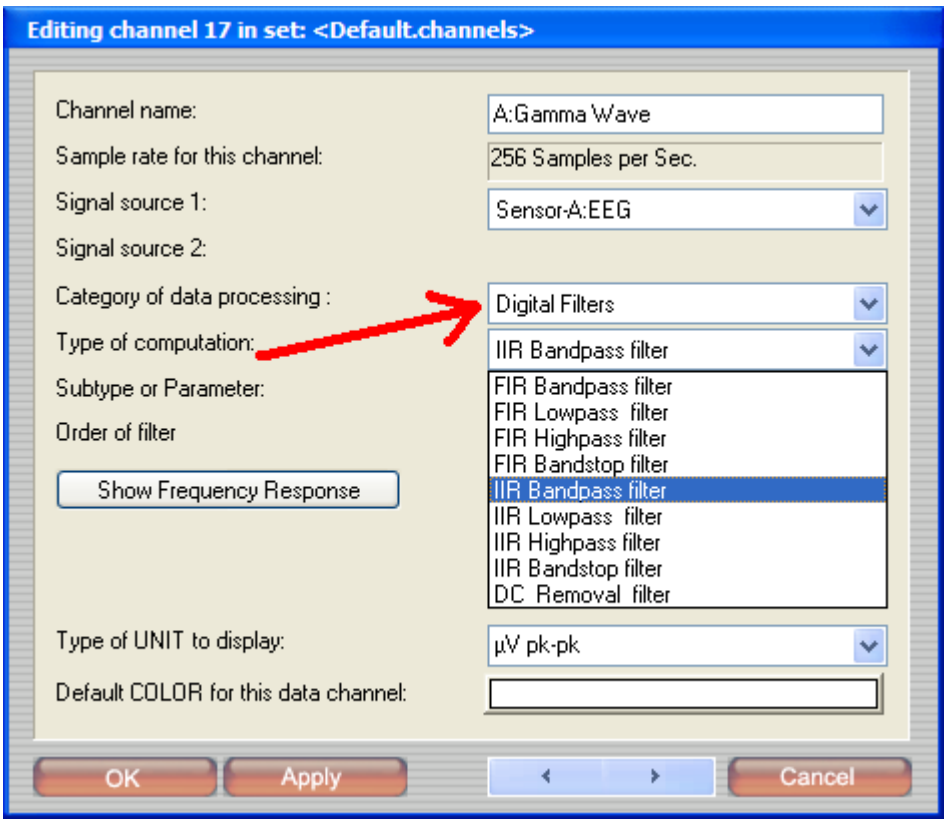


Please note that you can enter the **factor** number in the **Channel Editor Box**:

The purpose of this function is for instance for on-line artifact reduction where a percentage of another signal (for instance the ECG or EOG) is subtracted from another source signal (for instance the EEG or raw EMG). The factor has to be set manually. If an DC-EEG is for instance contained with 10% eye activity, the factor EOG that should be subtracted, should be set to 0.1 (equals 10%)

7.2 Digital Filters

When you choose **Digital Filters** you can choose from several of types of digital filters:



You will first have to decide what type of filter you want to apply:

Types of filters:

- **Band pass filter**: This is the most frequently used filter type. It only passes the frequencies in a predefined band. For example Beta frequencies in the EEG.
- **Low pass filter**: filters out high frequencies, low frequencies are passed
- **High pass filter**: filters out low frequencies, high frequencies are passed
- **Band stop filter**: filters out only a (narrow) band of frequencies. The rest is passed.
- **DC removal filter**: this is a simple trend removal filter, much like a high pass filter, but simpler. It can be used to neutralize the DC offset of a signal. (such as in an ECG)

Digital filters are very flexible compared to the normal analog filters used in electronic equipment. Whereas in hardware the filter usually is fixed, in software we can define and change the filter almost any way we like.

So let's take a deeper look at these digital filters. We will now provide you with some basic background information on filters, frequency analysis, waves and amplitudes. Most of the information here is focused on their use for EEG signals.

IIR and FIR filters:

IIR filters are somewhat comparable to the analog filters found in hardware. FIR filters are more 'digital' by nature.

IIR stands for 'Infinite Impulse Response" because there is 'feedback' in the filter and it takes a long time for the filter to reset to zero when an **impulse** (a '1') is run through it.

FIR stands for 'Finite Impulse Response'. There is no 'feedback' in the filter and after a certain fixed time the filter will reset to zero when an impulse (a '1') is run through it.

Choosing digital filters always means you have to find the right 'trade-off' between all the filter characteristics. Both filters have advantages and disadvantages. The main ones are listed below:

IIR advantages:

The IIR filters require relatively few memory locations and calculations compared to FIR filters, in order to achieve the same result. This means that is some cases (depending on the **order** of the filter) they are **faster** than FIR based filters. IIR filters are usually the best choice for biofeedback/neurofeedback purposes. An IIR filter can cope very well with high DC offsets: a high pass or band pass IIR filter will compute the DC offset away.

IIR disadvantages:

The IIR filters introduce non-linear phase characteristics. That means that the waveform of a signal (like the EEG) will look different than the original when looking at the same frequencies. So an IIR filter introduces 'distortions' in the wave form. This will have little or no impact on the amplitudes in the signal. So when computing the Alpha amplitude, the result will nearly be the same for an IIR and for an FIR filter.
An IIR filter introduces a small delay which depends mostly on the **order** of the filter. Greater orders mean greater delays and more phase distortion, but better filtering!

FIR advantages:

The FIR filter has the advantage that it has a linear phase characteristic. That means that the signal will not be distorted. FIR filters are usually a better choice when waveforms in a filtered signal (like the EEG) should be recognized. When de-artifacting filtered EEG signals, it is recommended to use FIR based filters.

FIR disadvantages:

A FIR needs more computations than an IIR to achieve the same effect and always introduces a fixed delay. This delay or latency gets to be greater when the order of the filter, defined by the number of 'coefficients' is greater. Example: when a signal is sampled at 256 samples per second and an FIR filter is used that uses 128 coefficients, the delay will be half the size of the coefficients: thus 64 samples. This equals a delay in time of 250 milliseconds.

Therefore the FIR filter is more suitable for reviewing signals. More coefficients will provide better filtering, but also greater delays. FIR filters can not compute DC offsets away as well as IIR filters. In that case a DC Removal filter may be required.

Some frequently asked questions

So what is the BEST filter?

The BioTrace+ software comes standard with default channel and filter settings, which are already optimized. In case you want to design your own digital filters, BioTrace+ can show you the resulting filter characteristics while you design your filters. (you press the button labeled '**Show Frequency Response'**)

There is no 'best digital filter'. It all depends on your wish list. Do you want the filter to be 'fast' (causing a small delay only) or do you want the filter to be 'precise'? Do you care about phase or not? Do you filter a signal online or offline (for review). During review the delay is not important, because you are not using the filter for client-feedback. On-line (in 'real-time' sessions) the delay is important.

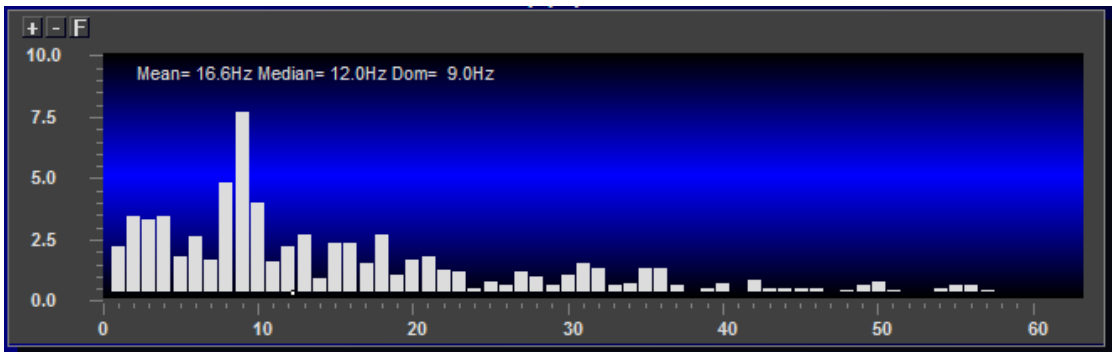
Generally we advise **low-order IIR filters** for use in (biofeedback) training; they are relatively fast and still provide reasonably 'sharp' filtering.

For **review** of signals, we generally advise to use **FIR filters**.

What is the difference between a digital filter and the FFT?

The result (output) of an FFT (fast Fourier transform) is an array of data values which are used for displaying the **spectral analysis** of a signal.

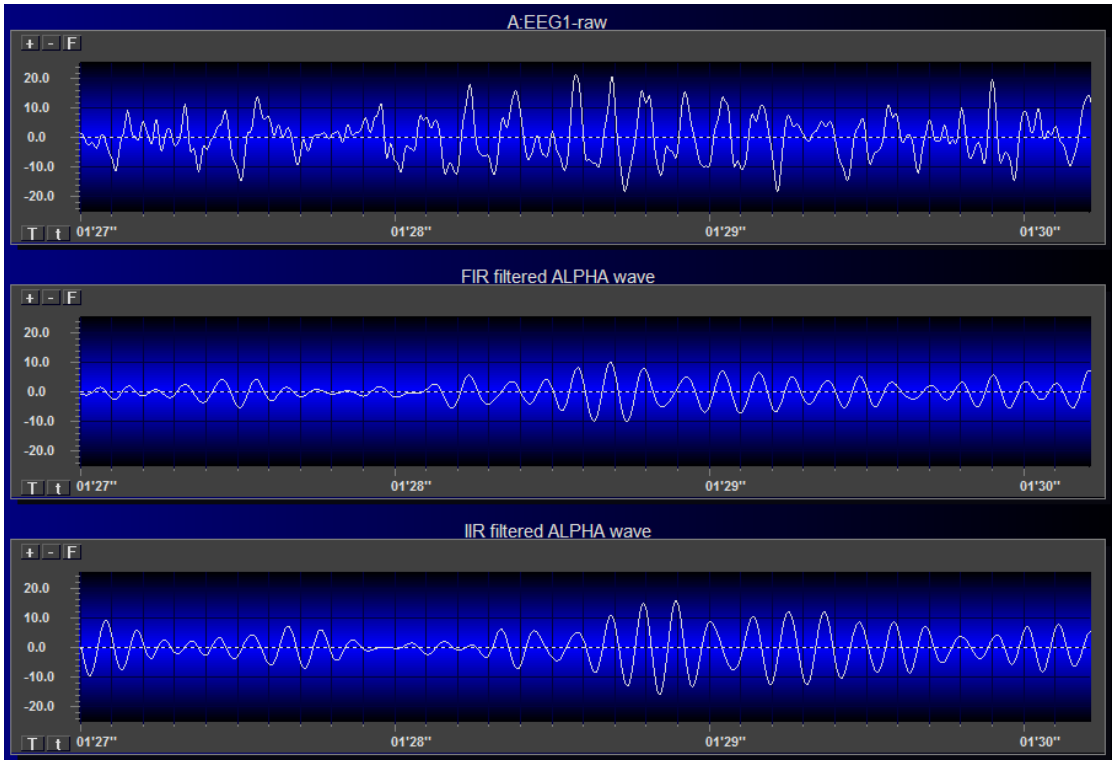
Each frequency is displayed by 1 one more 'bins' in a **histogram**. If you compute an FFT over 1 second of time, the FFT bins will each be 1 Hz in size. An example of an FFT of an EEG signal from 1 to 60 Hz is shown in the histogram below:



However, it will also take the FFT one complete second to compute the result and obtain the entire magnitude/amplitude of that signal within the entire 1 second of data. That means that generally an FFT is much slower when compared to an IIR based filter. Some say that for biofeedback / neurofeedback the FFT is too slow.

The advantage of the FFT over an IIR or FIR digital filters is that is shows an overview of all the frequencies at once. Although this is always an approximation of what is going on in the EEG, it does provide an insight into the total signal.

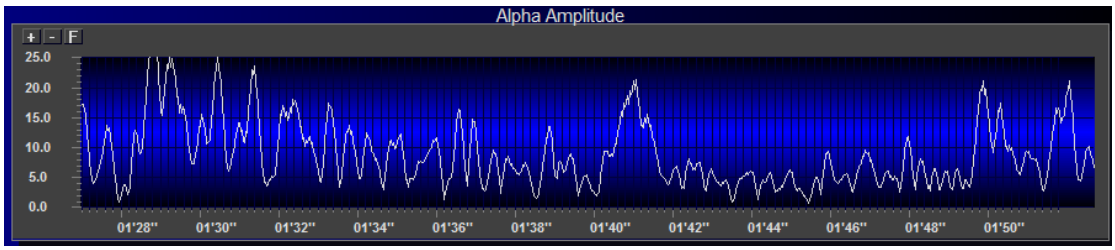
The result of IIR and FIR digital is always another signal or waveform. (See the example below)



In this example the result of filtering the 'raw EEG' with an FIR based Alpha band pass filter (middle) and an IIR based Alpha filter (bottom) is shown. This example was computed in review mode. The experts will note here that the phase of the FIR based Alpha wave is the same as that of the original 'raw' signal at the top. The IIR filter based Alpha shows a delay and some phase distortion.

What does Alpha, Beta etc. Amplitude mean?

The 'amplitude' of a wave can be used for biofeedback. Usually an RMS amplitude of a waveform (like the Alpha wave shown above) is computed on small portions of the wave. When for instance 1/8th of a second of the Alpha wave is used to compute the amplitude, it will update fast enough and display all activity above 8Hz correctly.

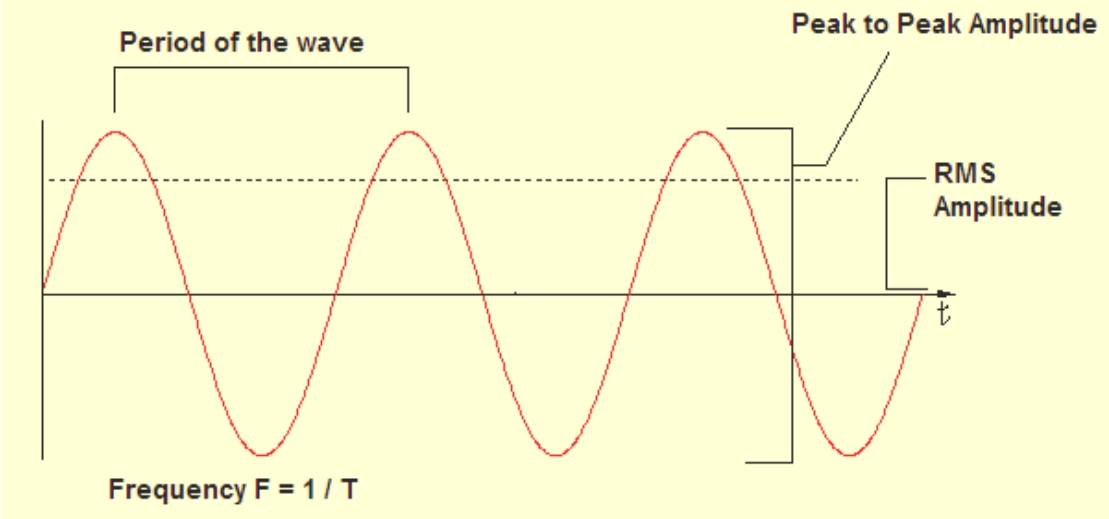


The Alpha amplitude could also be derived from the FFT (through an FFT band pass amplitude) but it would be much slower (causing larger delays) and when it would be based on a 1 second FFT it would also not be as 'precise'. (Spectral leaking)

Quite often though in scientific research, amplitude and ratios (such as the ratio between theta and Beta) are computed from the power spectrum of an FFT. In that case it is important to know that these values are expressed in **microvolts squared**, where the rms based amplitudes are expressed in **microvolts**.

What is the difference between microvolts pk-pk and RMS?

When we observe a wave (in this case a perfect sine wave) we can see its **period**, which defines the frequency, and the **height** of the waves, which defines the amplitude. However what do we mean by height? We can look at the vertical distance between the bottom of the wave and the top of the wave. This is called the peak-peak amplitude. We can also look at the effective 'power' of the signal. This is the level where an AC signal delivers the same average power as a comparable DC signal. This level is lower than the pk-pk amplitude and is called the RMS (root mean square) amplitude.



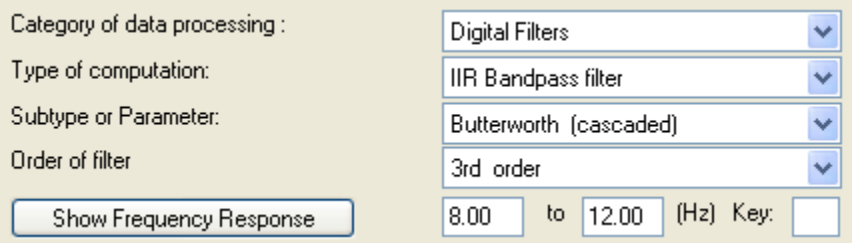
In **EMG** publications, EMG amplitudes are generally expressed in microvolts rms.

In **EEG** the amplitudes are generally expressed in microvolts peak to peak (pk-pk) or microvolts squared.

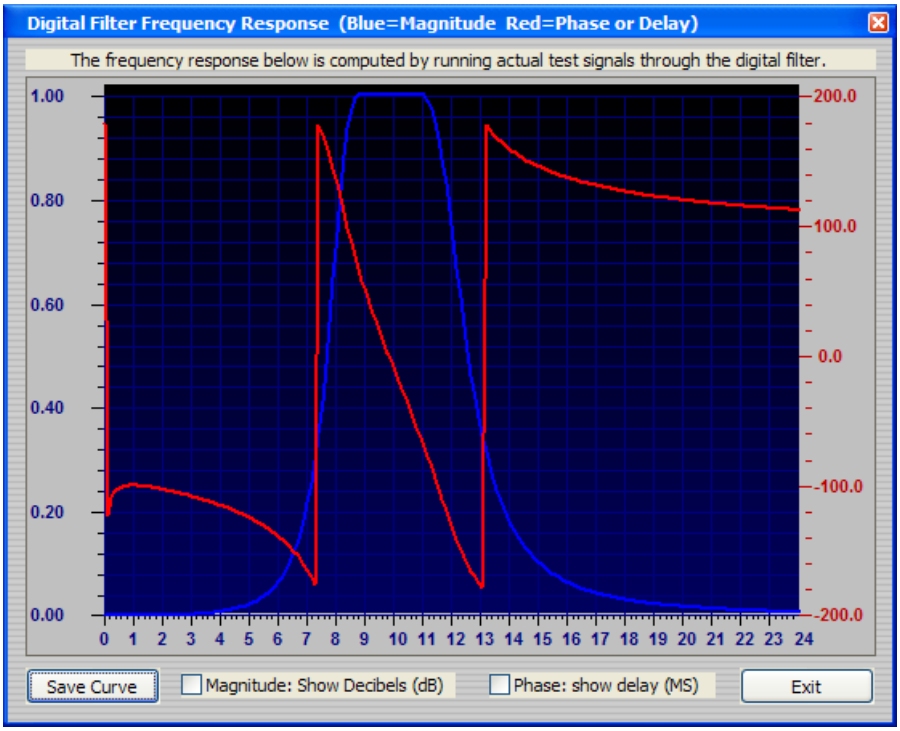
For more information, we advise you to read the professional literature on this subject. You may also find a lot of information about this topic on the internet.

Displaying the Filter Frequency Response

When we want to see the characteristics of a digital filter, BioTrace+ can display the frequency response. You can only compute a frequency response on a digitally filtered **WAVE**. So the IIR filtered Alpha **wave** can be analyzed. The Alpha **amplitude** which is derived from the wave, has no frequency response.
When you open the channel editor for (default channel set) channel #14, you will see a definition of the Alpha Wave, for instance:



Now press the button 'Show Frequency Response':



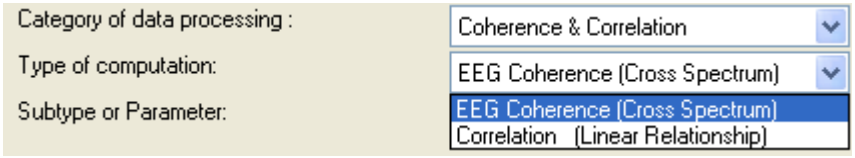
This graph will show you the amplitude (power) of the signal at a given frequency (shown horizontally at the bottom, in this case between 0-24 Hz) in the color blue.

The phase response will be shown in red and is expressed in degrees (-180 to +180).

From the graph, you can see that at exactly 8 Hz, the amplitude is already somewhat less than 100% (1.0), in this case you can read it is about 80% (0.8). Most filters behave this way. The 8 Hz and 12 Hz here are points where the amplitude is already attenuated by -3dB. You can choose whether you want to display the amplitude in magnitude (between 0 and 1) or decibels. The red line can show phase or delay. Phase is expressed in degrees (between -180 and +180). Delay is expressed in milliseconds (MS) and defines the inherent latency introduced by the digital (IIR) filter because of the phase shift.

7.3 Coherence and Correlation Functions

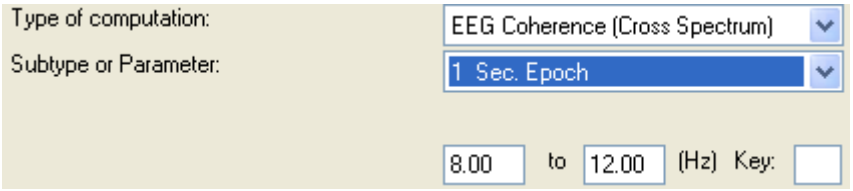
When you choose **Coherence and Correlation** you can choose from the following functions:



EEG Coherence:

Coherence is a measure of cross-correlation between two signals in the frequency domain. For EEG signals, a high coherence suggests that signals are either driving each other, do mutual driving or are driven by a common input. There are several ways to compute coherence. This software computes the coherence of two EEG signal sources, by computing the ratio of the auto-spectra of the two channels and their cross spectra.

You can set the following parameters:



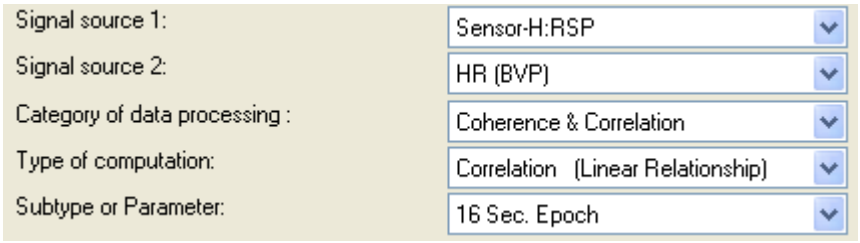
1) **The signal sources.**
2) **The size of the FFT Epoch**: 1, 2, 4, 8 or more seconds. This depends on the sample rate of the signal source. For EEG the sample rate normally is 256 SPS.
3) **The frequency range**. In the example above 8-12 Hz (Alpha) has been selected.

Please note that you should select at least a range of 4 Hertz when using 1 second epochs, or 2 Hz when using 2 second epochs.

Correlation:

This function uses a Pearson product-moment to compute the linear correlation between two signals. The signals must have the same sample rate.
A good example for the use of this function is the measure of correlation (synchrony) between the respiratory activity and the heart rate.

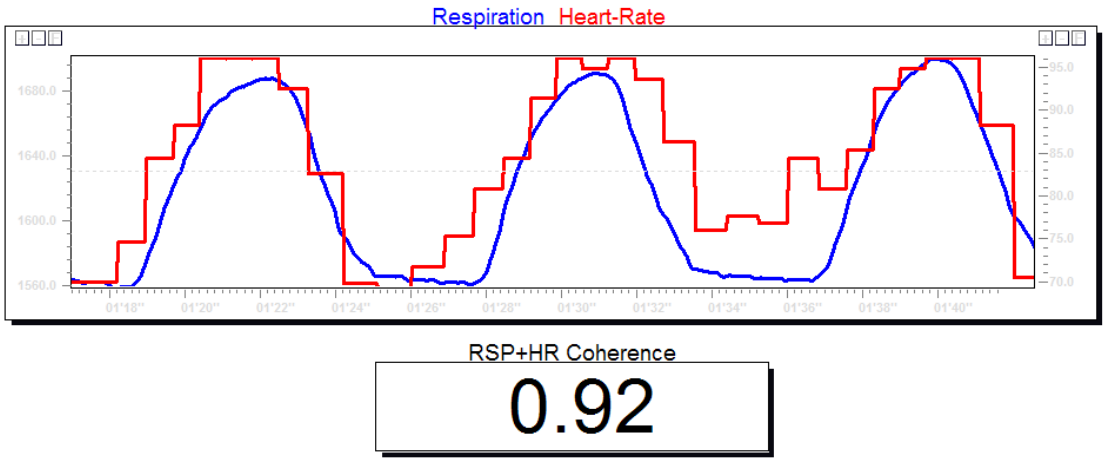
An example of the correlation settings for RSP and HR activity:



The parameters you can set are:

1) **Signal source 1 and 2**. (must have the same sample rate)
2) **The size in seconds** of the samples that should be analyzed. If the sample rate is for instance 32 SPS, setting a 16 seconds epoch means that 512 points of data will be analyzed.

Below the overlapping graphs of the respiration and HR signals are displayed. The numerical instrument at the bottom show the level of correlation (which also may be called synchrony or coherence in this case)

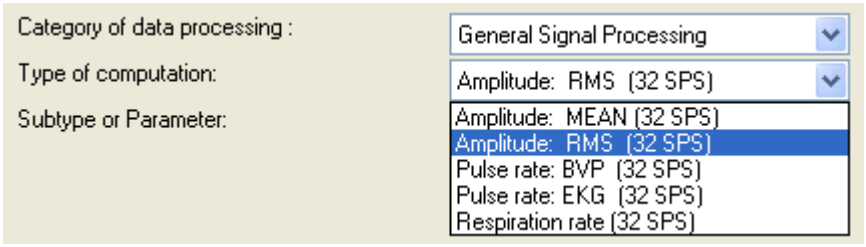


In this example the correlation factor is very high: 0.92.

Note: correlation may result in a value between -1 (negative linear correlation) 0 (no correlation) and +1 (positive correlation). Negative values may occur when signals are out of phase. (one signal goes up, while the other signal goes down)

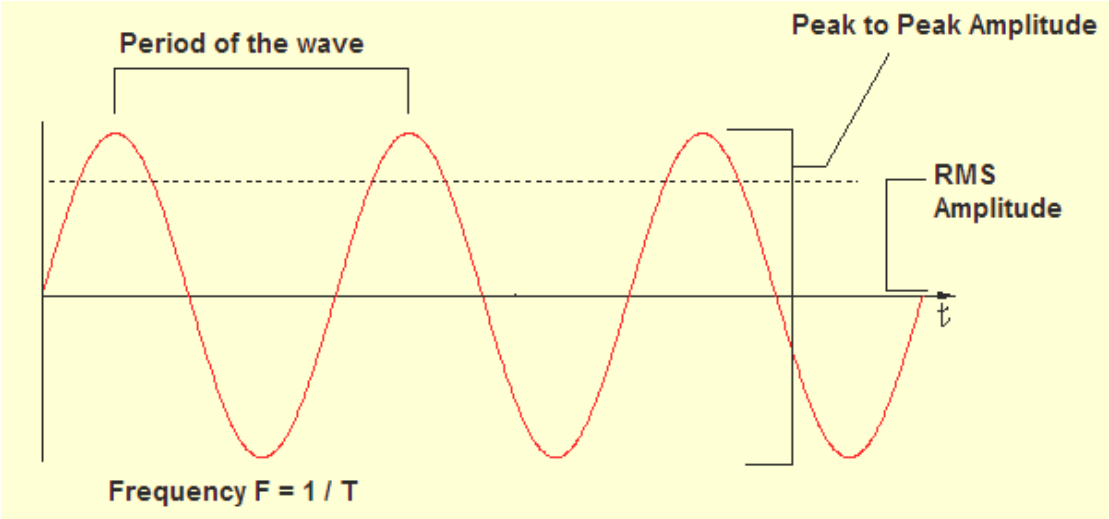
7.4 General Signal Processing

When you choose **General Signal Processing** you can choose from the following functions:



RMS Amplitude

This function computes the root-mean-square of a signal (unbiased = corrected for DC offset). This function is used for computing the 'amplitude' or level of activity of EMG, EEG, BVP and other signals. When computing the level of EMG amplitude, usually a microvolt RMS level is used. When computing the level of EEG 'wavebands' such as Theta, Alpha and Beta, the same RMS function is used, but the unit is converted to microvolt peak to peak. This peak-peak (pk-pk) microvolt level is computed by taking the RMS and multiplying it with a factor of 2 times the square root of 2.

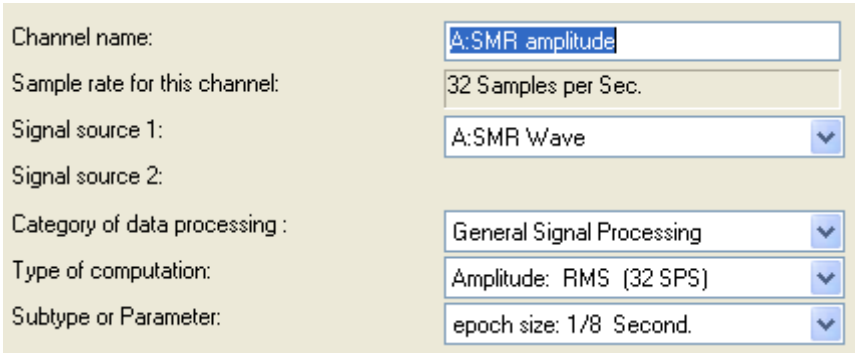


Parameter: size of epoch.

The only parameter you can set, is the **size** of the epoch used to compute the RMS amplitude. As can be seen from the picture above, a complete cycle of a wave is called the **period** of the wave. We advise to set the **epoch size** of the RMS function such that at least one complete cycle of the slowest wave in a frequency band is available to compute the RMS. Taking less than 1 cycle would result in an 'oscillating' result.

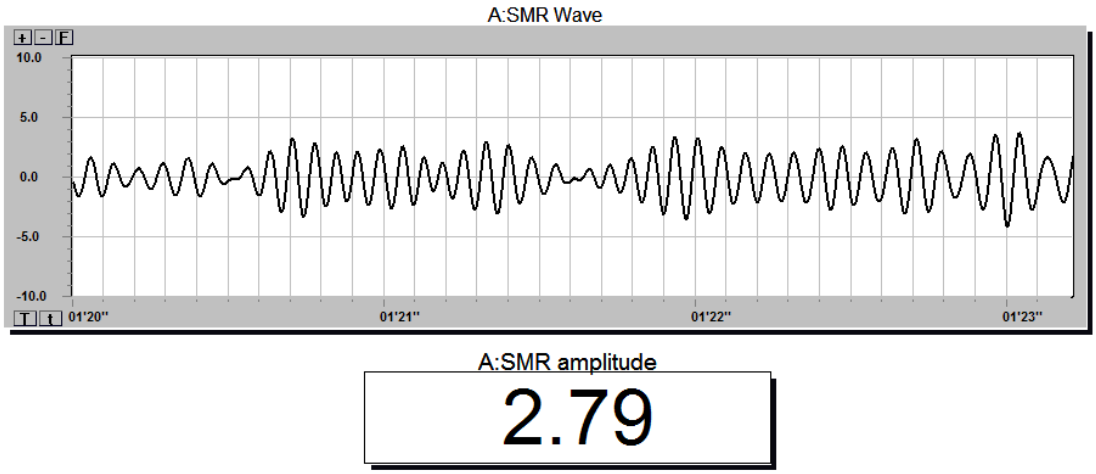
Take a look at the example of the SMR amplitude on the next page:

Computation of the SMR amplitude:



Notice that the **input** or **signal source** of the amplitude always needs to be a **wave**.

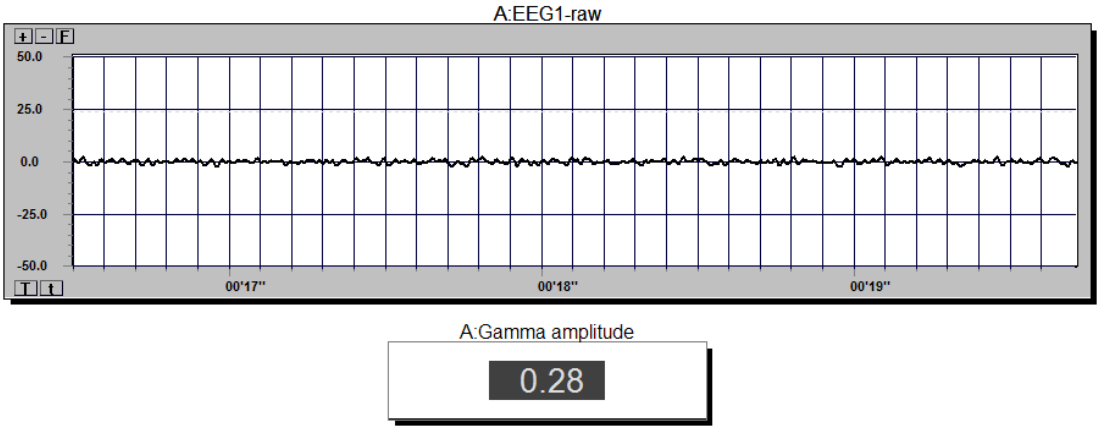
The RMS amplitude of a flat line would always be zero. In this case the SMR wave is used. An example of an SMR wave and it's computed amplitude is shown below:



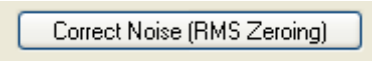
Note that the amplitude shown here, is in microvolts pk-pk:

Correcting noise / RMS Zeroing

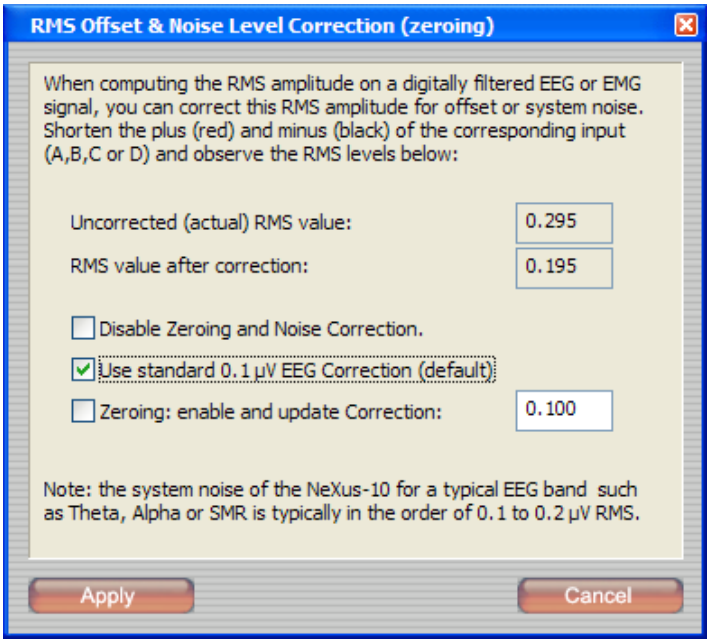
Any RMS amplitude derived from a bio-potential signal containing activity in the frequency range between 0 and 1000 Hz, will contain an 'offset' caused by the electrical noise in that frequency band. This electrical noise is generated by a combination of the electrical properties of the amplifiers, the impedance level of the electrodes and environmental influences.



In the picture above, an example is shown of an EEG signal, which shorted inputs, in the frequency range from 2 – 45 Hertz. In this case, in the gamma amplitude band (35-45 Hertz) an electrical noise of 0.28 microvolt pk-pk is displayed. We may now correct the RMS amplitude by pressing the following button:



The following dialog box will be shown:



In this dialog box we can now set the amount of 'noise' correction. By default for an EEG based signal (band pass filtered) you could choose a 0.1 microvolt correction, or choose to disable the 'zeroing'.

By clicking the '**enable and update**' button the software takes the mean noise level from the signal and subtracts that from the RMS. That means that the total noise in that band, will now be subtracted from the RMS. The minimum microvolt RMS level will be 0.1.

Zeroing EMG rms amplitudes

System Noise levels in the EMG bands (10-500Hz) are generally higher than in the EEG bands. Any instrumentation amplifier will always generate some level of noise. The greater the size of the frequency band is, the greater the noise level will be.

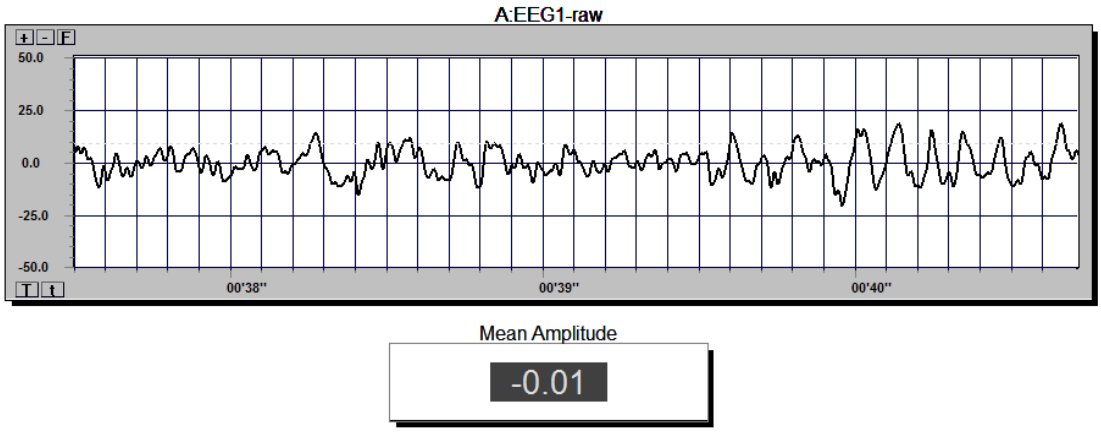
If you want, you can correct the EMG RMS levels for this noise. This process is sometimes referred to as '**zeroing**'.

Example: in case you want to measure the low levels of EMG activity on the frontalis during relaxation (which are typically less than 2 microvolts RMS) you may want to correct the RMS amplitude for the noise levels. In that case you shorten all EMG electrodes (plus, minus and ground) of the relevant input and choose the **zeroing: enable and update** function. This will obtain the average RMS noise level and subtract it from the RMS level being computed/displayed. Note that the raw EMG signals will never be affected and the RMS zeroing can always be undone.

Note: A computed RMS amplitude will never be less than 0.1 microvolt. This is the lower limit of the RMS levels computed by the software.

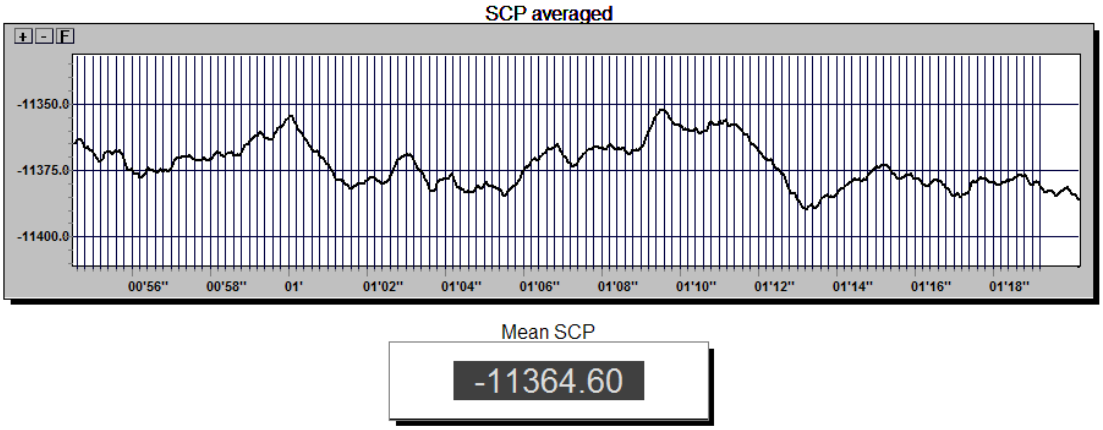
Mean Amplitude

The mean amplitude simply adds up all the sample values and divides the result by the number (N) of samples.

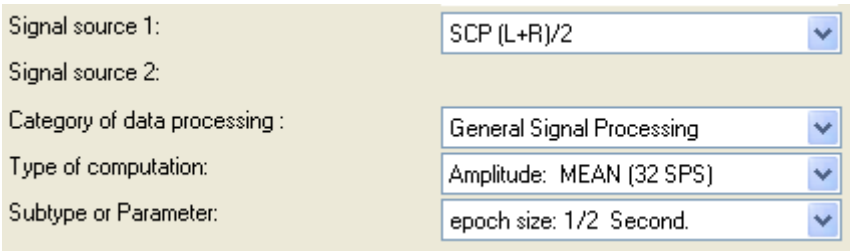


Note that the mean amplitude of an AC type of signal (like the raw EEG) will be close to zero and may even be negative. (See the picture above)

The **mean amplitude** function is however useful to compute the average data value over a certain time period, such as in the case of slow cortical potentials:



In this case the mean value of the SCP is computed by taking a 500 millisecond average (1/2 second) of the average value of the DC-EEG1 and DC-EEG2. This mean value is computed 32 times per second.

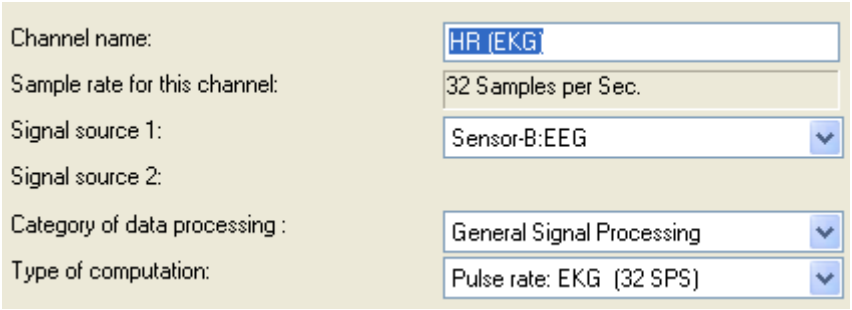


Note that the signal displayed above, has a DC offset of about -11375 microvolts pk-pk.

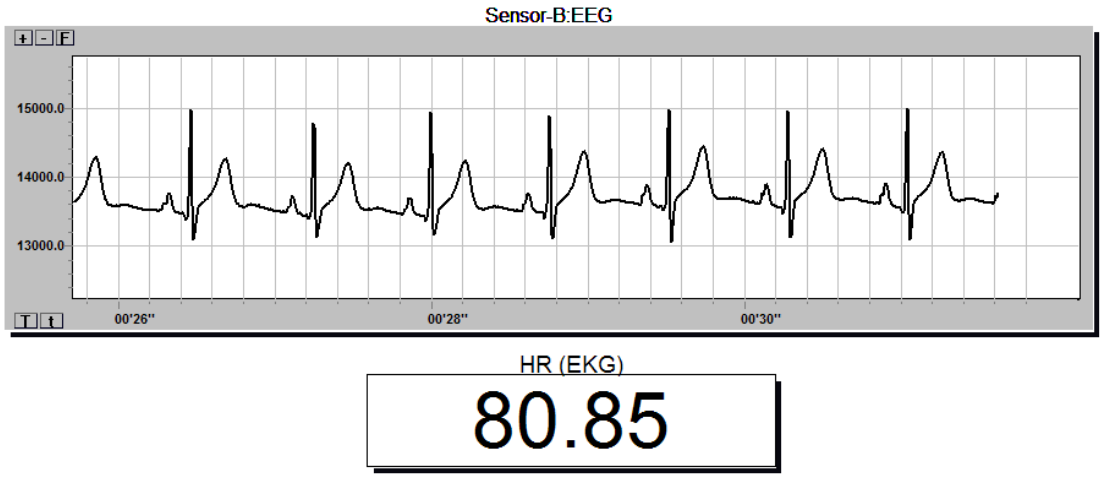
Pulse Rate functions (BVP and EKG)

These functions are generally used to compute the heart rate from a BVP (blood volume pulse) signal or a ECG (electrocardiogram) signal. Since the wave forms of the BVP and ECG are different, you need to select the BVP and EKG pulse rate.

An example of the heart rate derived from the ECG is shown below.



A sample EKG and derived heart rate is shown below:

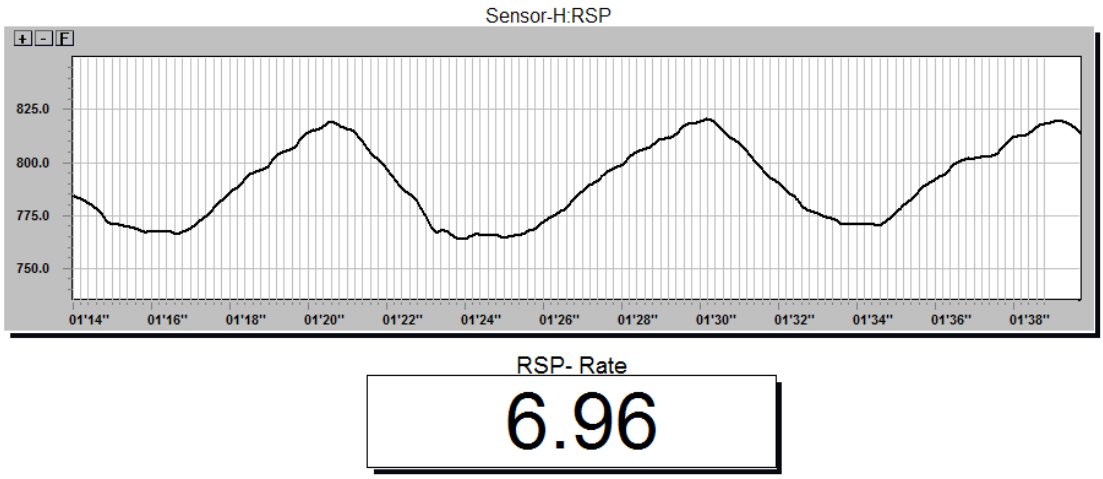


Please note: this ECG signal is displayed within the full bandwidth of DC to 100Hz, and the signal happens to have an offset of about 14 mill volt.

Respiration Rate Function

This function is used to compute the respiration rate based on the input of the respiration sensor.

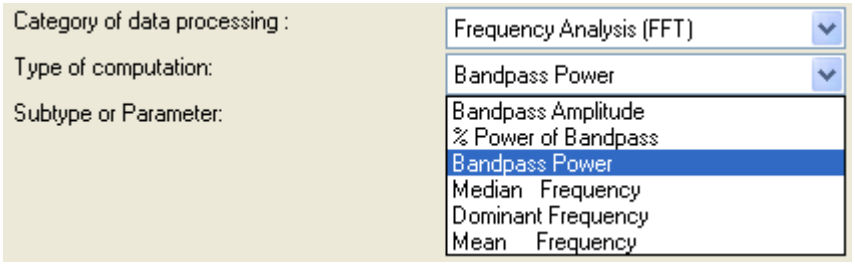
The example below shows a signal obtained from the abdominal area:



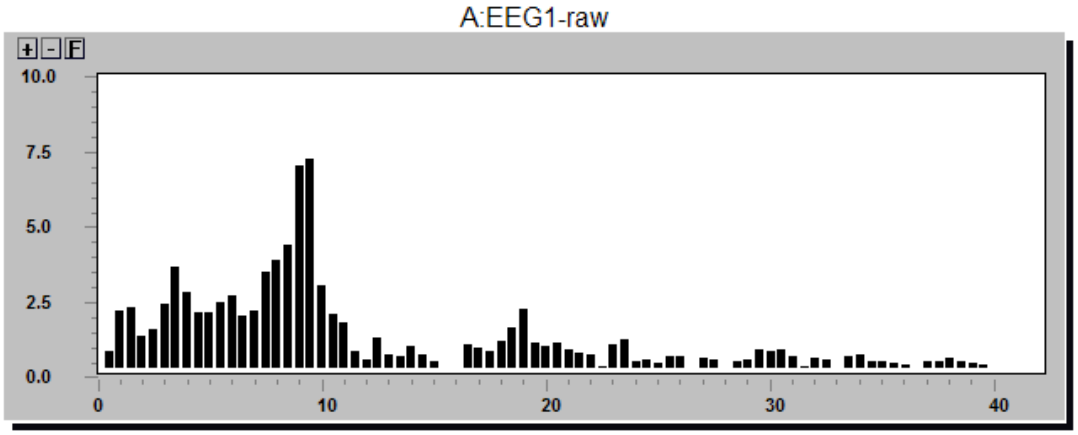
Note: A respiration rate of 6 would mean 6 inhalation-exhalation cycles per minute, or 10 seconds per cycle. When this type of breathing would generate an RSA effect (respiratory sinus arrhythmia) a peak would probably be visible in the HRV frequency analysis around the 0.1 Hz. (equals 10 seconds per cycle)

7.4 Frequency Analysis Functions

These functions are based on spectral analysis (FFT). You can choose from the following functions:



When computing spectral analysis using an FFT (fast Fourier transformation) the result will usually be an array of **'bins**' for each frequency which indicate the power or magnitude of the signal at that frequency. An example for the EEG is shown below:

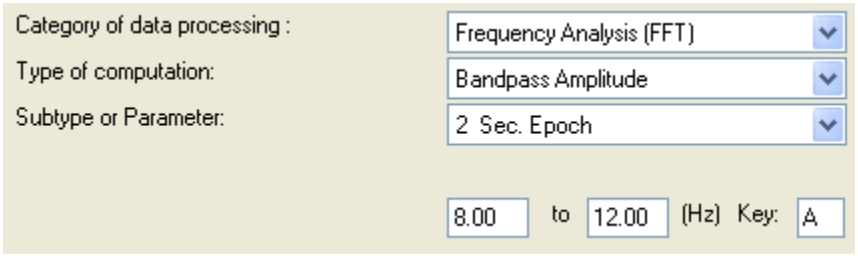


Band pass Amplitude

This function computes the amplitude (= magnitude) of a signal in the given band width. (Band pass results in pk-pk). An example for the Alpha band is shown below.

Note: in this case, the band pass amplitude is comparable to the RMS amplitude computed on the Alpha band (units in microvolt pk-pk). But yet the results will be different because of the 'spectral leaking' of the FFT and the fact that the epoch of the FFT (1 or 2 seconds) is far greater than the epoch of the Alpha RMS. ($1/8^{th}$ of a second)

An example of the Alpha FFT band pass amplitude setting is shown below:



Note: the short-cut key will increase or decrease the band pass settings in discrete steps of 0.25/0.5 Hertz steps.

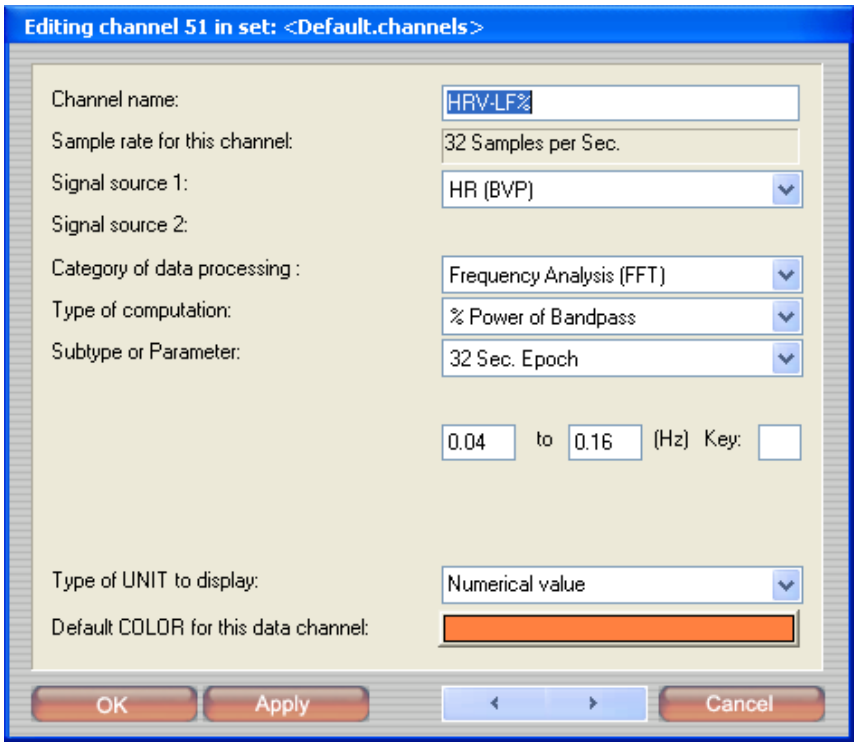
Percent Power of Band pass

This function computes the **percentage** of activity within a certain frequency band, compared to the total power of the signal. The total frequency range of a signal is limited by the sample rate of that signal. BioTrace defines this as follows:

Total bandwidth = sample rate / 4

- for EEG the total bandwidth would be 256 / 4 = 64 Hz.
- for EMG sampled at 2048, this would be 2048 / 4 = 512 Hz
- for HR data re-sampled at 4Hz this would be 4 / 4 = 1 Hz.

The example below shows the percent power of the LF (low frequency) range as used in HRV statistical analysis:



In case of the EEG taking percent power of Alpha (8-12Hz) would compute the percentage of the power from 8-12Hz (microvolts squared) compared to the entire range of 1-64Hz. (DC at 0Hz is not used)

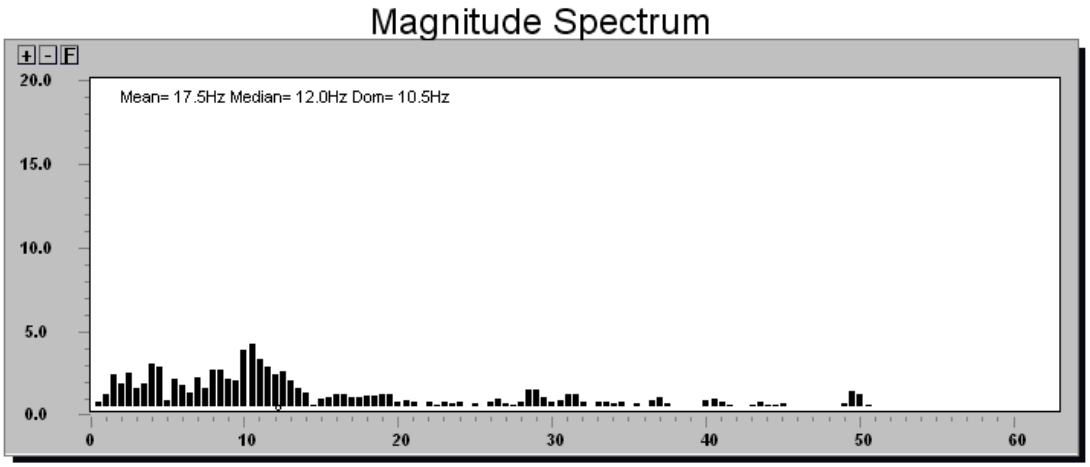
Band pass Power

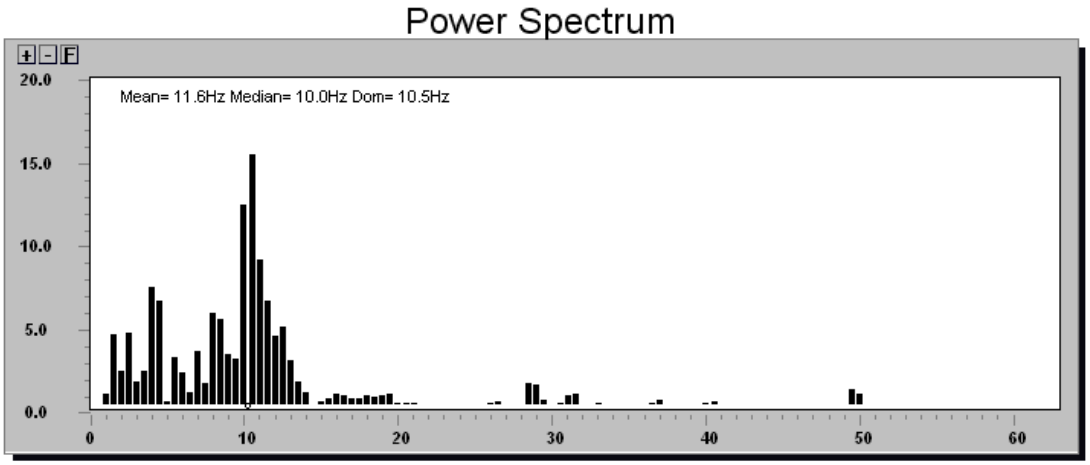
This function computes the **power** of a signal in the given band width. (band pass results in microvolts squared).

That means that when the FFT based **band pass amplitude** (amplitude = magnitude) generates a result of 10 microvolts pk-pk, for the same bandwidth, the band pass power would result in 100 microvolts squared.

In many research articles the results from the power spectrum are published in microvolts squared. By using this option, you can obtain data expressed in the same units.

Results expressed in power show the differences between the 'bins' of the FFT more dramatically. An example of spectral analysis on 2 seconds of EEG data is shown below in both magnitude and power.

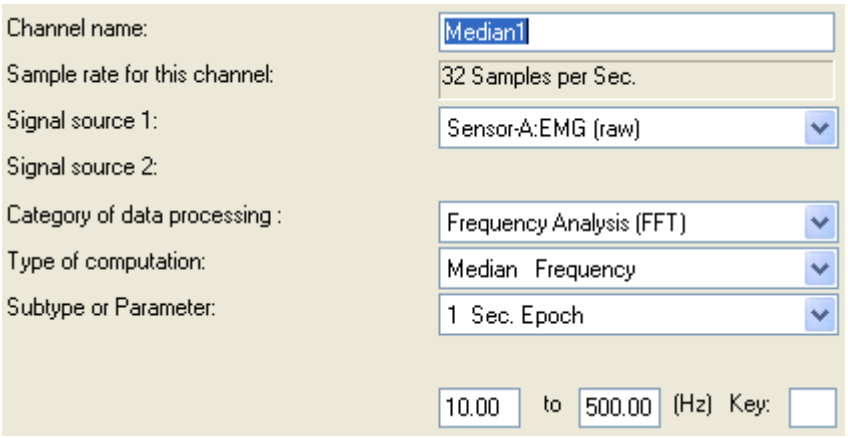




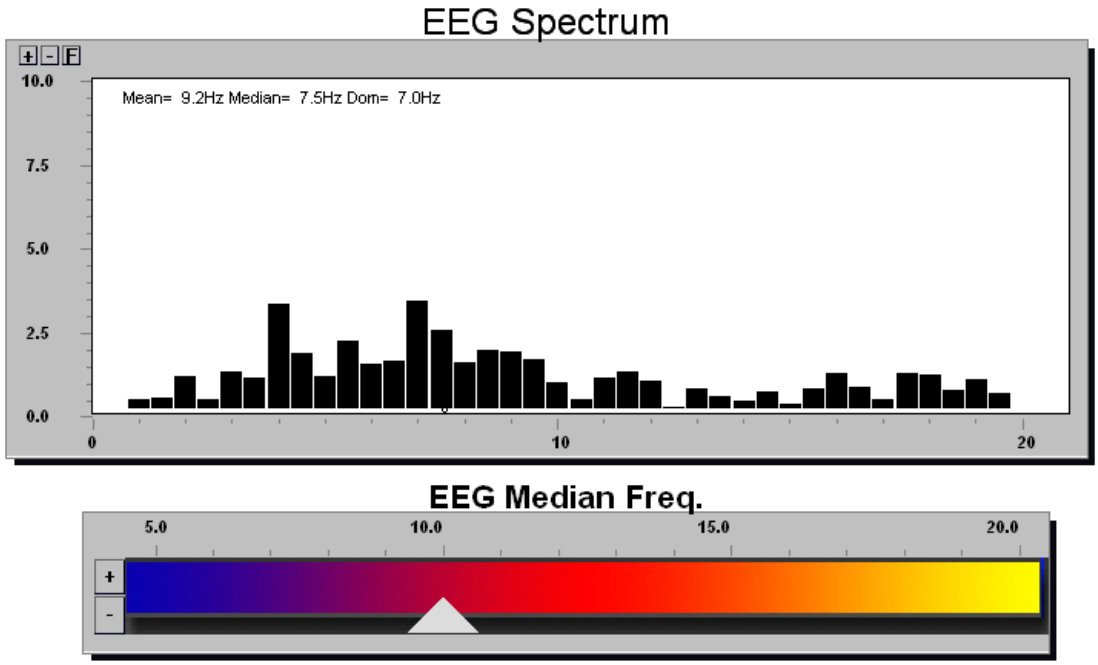
Median Frequency

This function computes the **median frequency** of a signal in the provided frequency band. The use of the shift in the median frequency of the surface EMG power spectrum is a well known method of assessing muscle fatigue.

An example is shown below, where the median frequency of a raw EMG signal (sampled at 2048 SPS) is computed between 10 and 500Hz.



When median (or mean) frequency is used for EEG, it can be used to visualize 'slowing' of the EEG.



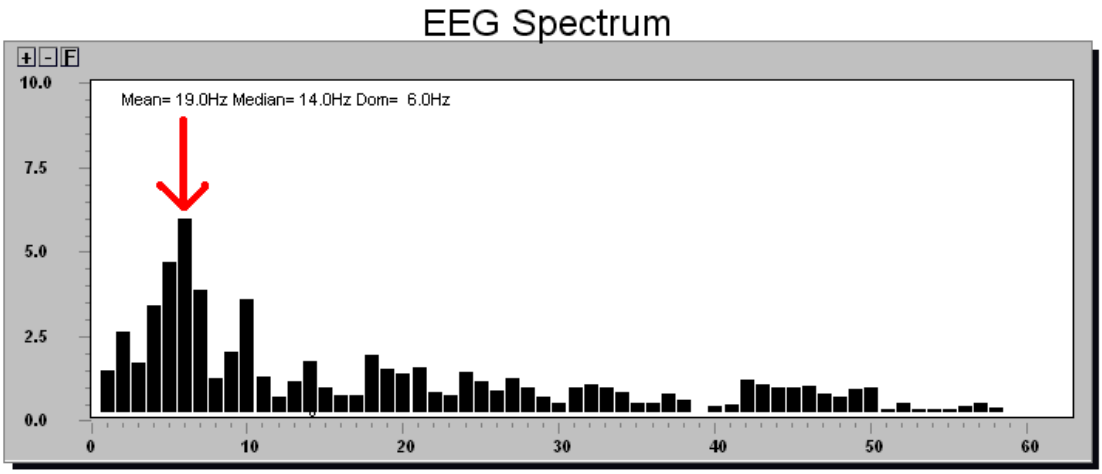
The 'Vernier' Instrument above shows the median frequency between 5 and 20Hz, which is currently around 10Hz. When the EEG slowing occurs, the arrow would move to the left towards the Theta range.

Note: the Spectrum above also shows the median frequency as a numerical value, but now in range from 0-20Hz. Note that you have to set the range within which the median frequency will be computed.

Dominant Frequency

This function computes the **dominant (or peak) frequency** of a signal in the provided frequency band. This simply finds the Hz value in the Spectrum that has the highest **peak**.

The dominant frequency is much less ‘stable’ than the mean or median frequency. The dominant frequency tends to hop back and forth between lower and higher frequencies.



Mean Frequency

This function computes the **mean frequency** of a signal in the provided frequency band. The mean and median frequency usually behave in much the same way.

The difference is that the mean frequency uses a weighted method where each frequency bin is multiplied with the value (magnitude or power) of that bin.

If a spectrum would have a normal distribution, the Median and Mean frequencies would be identical.

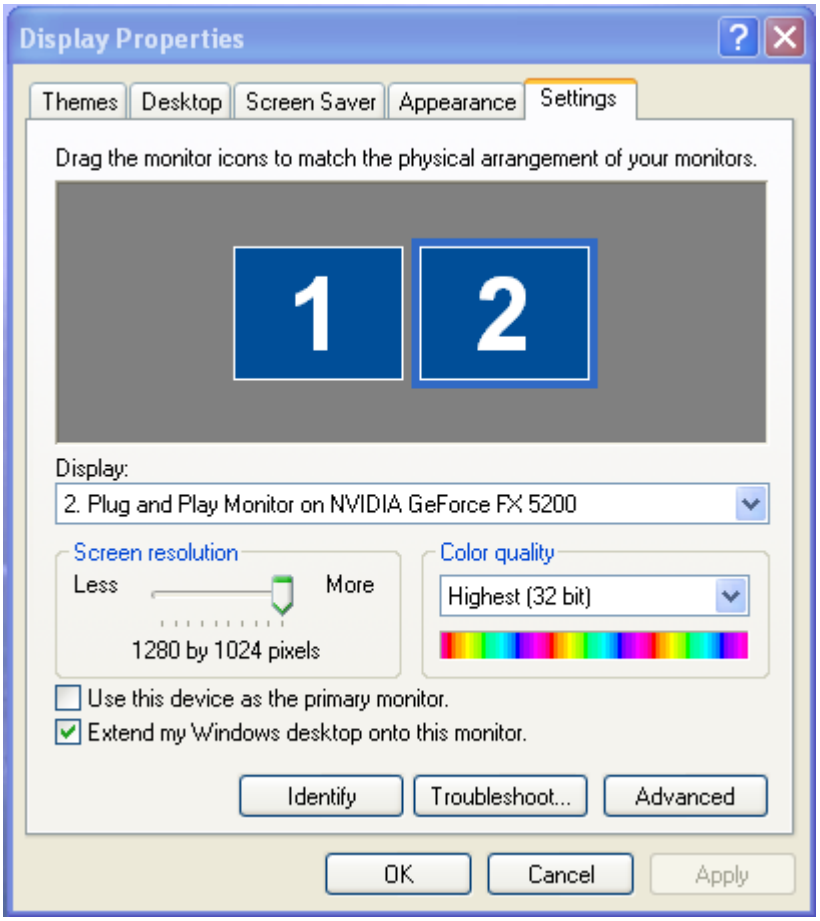
8.0 Advanced Computer Configuration

The BioTrace+ Software uses multi-media features such as dual monitor support, fast hardware accelerated (DirectX) graphics, digitized sound and real-time video capture. In this chapter we describe how you can configure your computer so it will optimally support these features.

8.1 Dual Monitor Functions and your Graphics Card

BioTrace offers full support for a **dual monitor** setup on a **single** computer.

That means that each monitor will display its own independent screen.
Before you can use this function, you need to set up your dual monitor configuration in Windows XP by going to the display properties (right click somewhere on your desktop and select **properties**) then select the TAB called **Settings.** The following dialog box will be shown: *(actual screen display may vary)*



Make sure you have plugged in a second monitor into the Video Graphics Card and switch it on. Now click on the secondary monitor in the dialog box shown above and enable it by clicking on the option: **Extend my Windows desktop onto this monitor.** That is all.
On the **primary** monitor (that is the monitor that you use when you have only 1 monitor) you will see the usual desktop and all the windows controls. On the **secondary** monitor, you will see only the desktop image and no controls or icons.

Please note: the primary and secondary monitor are allowed to have different resolutions. So you could for instance set up the primary monitor to 1280x1024 pixels and the secondary monitor to 1024x768 pixels.

The idea is that the primary monitor will show your '**clinician-screen',** whereas the secondary screen will show the '**client-screen'**. This client screen may for instance only show a single instrument, or a single animation or biofeedback driven computer game. Most often the secondary screen is used for training only. Sometimes it is displayed on a beamer or LCD projector instead of a monitor.

When the secondary screen is mainly used to display animations, video or games, using a lower resolution on the secondary monitor is even recommended because it will run faster.

Recommendations for graphics cards and monitors:

1) We recommended that you get a good graphics accelerator card, such as from NVIDIA or ATI. Get the latest drivers from the Internet.
2) Use 24 bit or 32 bit (true color) modes.
3) Make sure the card supports dual screen mode.
4) For the primary screen, we advise a high resolution. 1024x768 is the absolute minimum, better is 1280x1024
5) For the secondary screen, 800x600 is the minimum. Better is 1024x768.
6) Install the latest version of DirectX. We advise version 9.0C or newer.
7) We advise to use a 17 Inch or greater flat screen monitor for the primary screen. A fast response time (less than 20 ms) is nice to have.

Note: DVD, Video or animations need more processing power on the secondary screen than on the primary screen. If you plan to use them extensively, you have an extra reason to get a good graphics card.

Notebooks and graphic cards

Most notebooks support dual monitors. However the graphics on notebooks are usually slower than on desktop computers. An accelerator card is a **must-have** on a notebook, or the BioTrace+ graphics may not be optimal, particularly on the secondary monitor. Nowadays almost all computers, even standard computers are supplied with fast graphics cards.

Primary and secondary screens

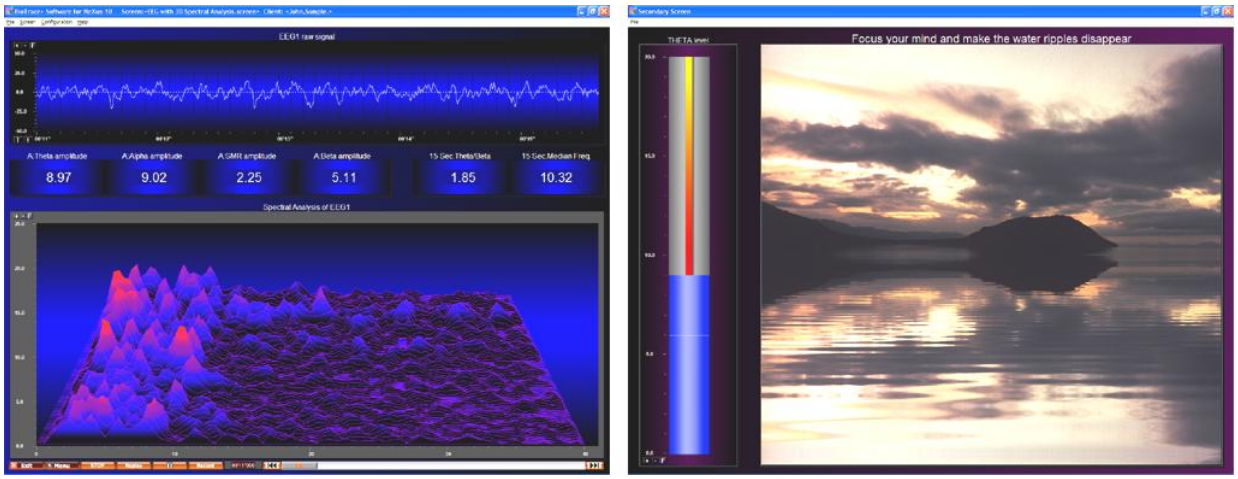
You may already have noticed that in the screen browser box that you can select screens as **PRIMARY Screen** and as **SECONDARY Screen.** The primary screen will be shown on the primary monitor and the secondary screen will be shown on the secondary monitor. You can create shortcuts for loading screens by using the functions keys F1-F12. By pressing them a screen will be loaded in the primary screen. By pressing the **CONTROL** key at the same time, those same screens will be shown in the secondary monitor. You can use these keys on the fly and quickly switch between screens. We will explain this in depth in the shortcuts chapter.

The **PRIMARY** screen is where you have all options to your disposal. You create and **edit** your screens here, you control the session, select clients, etc. The **PRIMARY screen** could also be called the master screen. This is where you change all settings and control everything.

The **SECONDARY** screen could be called a slave screen. It is controlled from the primary screen and its main purpose is to show training screens to the **client**.
You can not **edit** the secondary screen, like you can in the primary screen, but you can make changes there and even save those changes from its menu bar.

A sample of a dual screen setup is shown below:

Primary screen: **Secondary screen:**



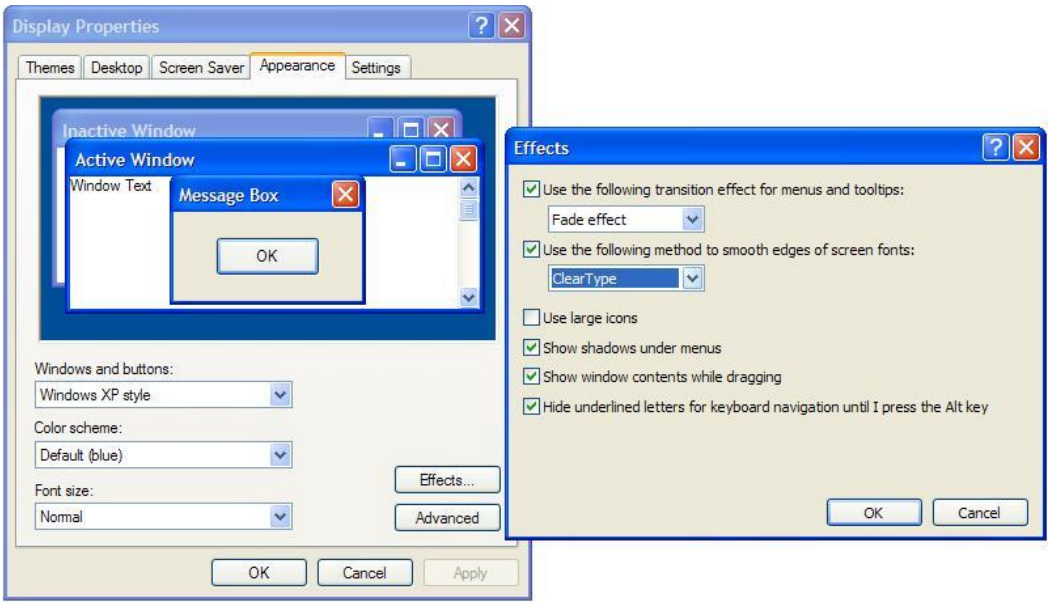
In this setup, the primary screen is used to observe the raw EEG signal as well as a variety of parameters in the EEG. The secondary screen, observed by the client on the right only displays the digital water effect and a bargraph. When the client decreases the level of Theta amplitude, the ripples on the water will disappear and thus the water will become quieter.

Please note that BioTrace+ supports true dual screen mode and allows you to make any combination of primary and secondary screens.

Optimal font settings:

For optimal display of text, we advise you to select the 'clear type' font setting as supported by Windows XP.

To select this, double click on the desktop window and open the display properties, then select the **appearance** tab, and click on the **Effects…** button. A new dialog box will open where you can select the **smoothing** of the font. Select the C**learType** as shown in the example below:



8.2 Configuring your computer for Sound

Because BioTrace support features such as video and sound capture (fully synchronized with the physiological data), but also DVD and CD audio playback, MIDI sounds and digitized sound feedback, the sound capabilities and storage capabilities or your computer need to match certain minimal requirements.

Recommendations for Sound:

Virtually all computers support 16-bit stereo sound and such a soundcard is not really required. 24-bit sound is not required either. For optimal sound playback however, we can suggest the following:

1) If you get a new sound card, get a Creative Labs card.
2) Get good speakers or a good headphone
3) 5.1 Audio output is not required but nice to have.
4) Get a drive that can play DVD and CD. Both are supported in BioTrace+.
5) Install the most recent drivers for your sound card. (from the internet)
6) For recording sound or voice input, get an external microphone.

8.3 Configuring your computer for Video Capture

BioTrace+ supports real time video capture while recording physiological signals.

The captured video can be played back, **synchronized** with the physiological signals and offers a precision of up to a single frame (about 50 milliseconds). When you have recorded a video capture, you can replay the session, or step through it with the cursor keys. You can set markers (offline) based on the video image currently displayed, while stepping through the data using the cursor keys. When you hold the **Ctrl** key, the cursor keys will advance 50 ms for each step.

You will need the following minimal requirements to capture video:

1) A Webcam connected a free USB port, supporting a minimum resolution of 320x240 and a built in microphone. (Logitech has good Webcams)
2) You should not forget to install the Webcam software and drivers.
3) There should be enough free hard disk space to store the captured video. (10GB or more free space is recommended)

Alternatively you can use a firewire connection or a video capture card (PCI) or capture device (USB) that you connect to an external (analog or digital) video camera. When you capture video, the files will be compressed by BioTrace+, but still may become quite large. Typically they use 1 to 2 Mb per minute.

Because video capture uses a lot of hard disk space and it puts a lot of **processing load** on the CPU, we advise the following:

4) Use the default 320x240 resolution. This is sufficient for most purposes.
5) Use the 384 Kbit/sec video quality, which is suitable for most purposes.
6) Get a webcam with built-in microphone or connect an external microphone.

8.4 Configuring your computer for Storage & Backup

The data files that BioTrace produces are stored in high 24 bit resolution. Each data sample will take up 4 bytes of space on your hard disk, therefore your data files may get quite large. For example, storing a single channel of EEG, acquired at 256 SPS, will use about 60 Kilobytes per minute. Video capture files need even more space, although they are compressed and typically 'only' need about 1-2 megabytes per minute. So in other words, it can be a real advantage to have a **large** hard disk.

Recommendations for data Storage

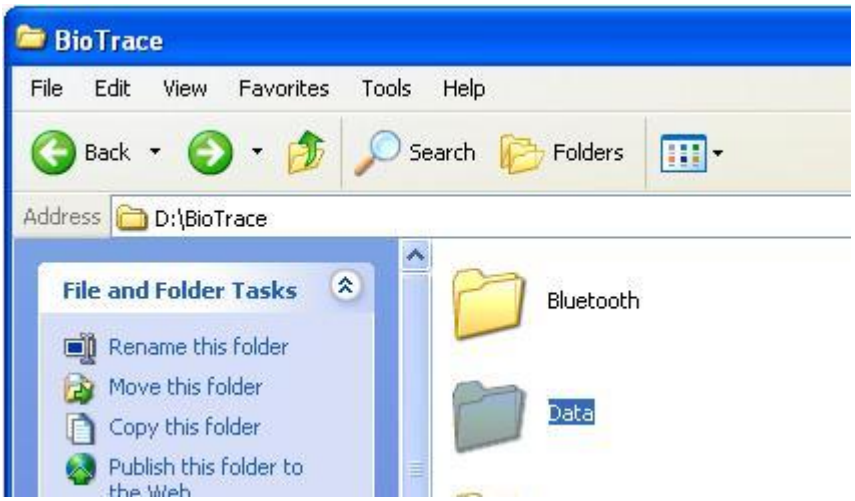
1) Get a large hard disk, as a minimum we advise 80 Gigabyte.
2) For the advanced user (on a desktop computer): if you want a really fast storage system, you can use two hard disks in a RAID configuration. This will double your storage capacity and make it faster as well.
3) Get an external hard disk for backup purposes or a DVD writer.

Backup recommendations

Hard disks, like computers in general may work flawlessly for years and then one day, they might not. This means **you could loose all your data** in an instant! If the data that you store with BioTrace+ is important to you, we advise you to make backups.

Please note: the BioTrace+ software does not make backups of your data. **You** as the user are responsible for making backups. We advise you to do this weekly, or at least monthly. Keep backups in separate physical locations.

All the **client and session data** that BioTrace stores, is stored in a single directory. This directory is called \BioTrace\Data. See the picture below for a sample:



So if you save this **DATA** directory to a backup medium, this means you will have made a backup of:

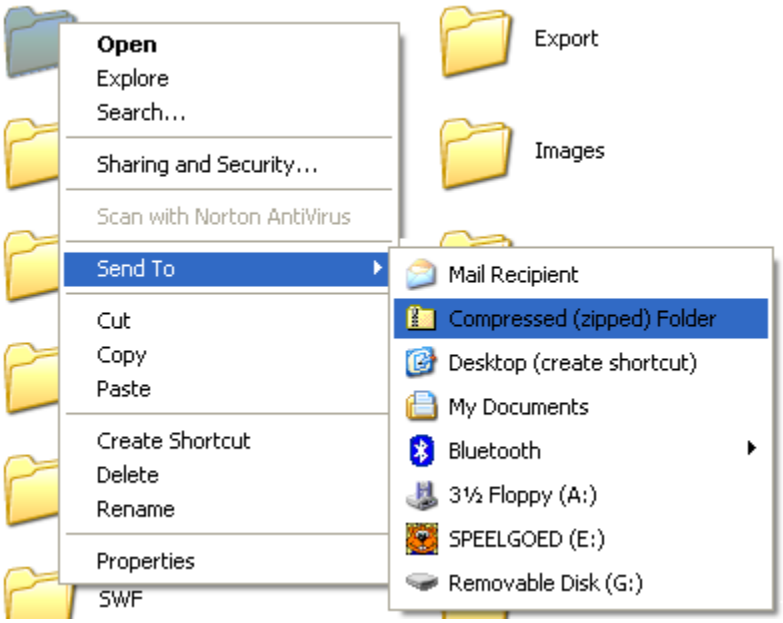
2) **All the stored physiological session data (all the signals)**
3) **The entire client database and all client data and report files**
4) **All the recorded/captured video and audio files**

You make a backup of this directory by:

1) Writing/Burning this directory to a CD or better to a DVD.
2) Writing it to an external hard disk (a faster method)
3) Writing it to an external server through a fast network

An option that you have is to compress this data directory to a ZIP file before you back it up. This can be a really **time consuming process**, but does reduce the size of the backup. The other advantage is that it keeps the state of all the files intact. When you burn the data directory straight to a **read only** device such as a CDROM, it will change the attributes of all the files to **read-only** which may cause the software to be unable to change those files once they are restored from such a backup medium! In that case you will have to clear the **read-only** attributes manually.

Now an example is shown how you compress an entire directory to ZIP file.



The resulting ZIP file will be called **DATA.ZIP** and can be opened like any other directory. However, if there is a lot of data in it, opening it may be slow and take several minutes.

Restoring a backup

The restoring process is nothing but simply **copying back** the contents of the **data directory** to the \BioTrace main directory. You only need to do this in case something bad happened to your data, such as a hard disk failure. In that case you will usually need to reinstall the BioTrace+ software and copy the data directory to the \BioTrace directory (overwriting the old data directory)

Other directories you may want to make a backup of are:

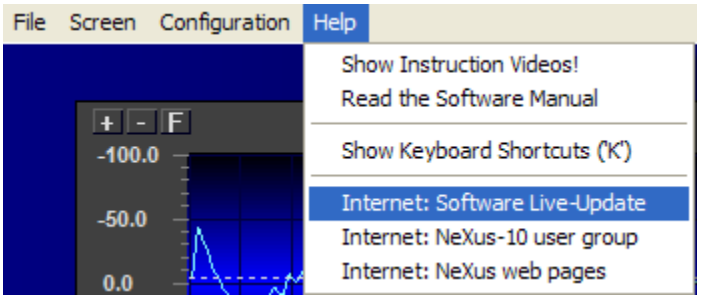
1) The **SCREENS** subdirectory. This contains all the screens and protocols. If you have created, or bought, a number of screens or screen sets, you may want to make backups of these as well.
2) The **CHANNELS** subdirectory. This contains the data channel definitions. If you created you own data channel sets or made significant changes to the default channels sets, you may want to back them up.

8.5 LiveUpdate: Updating BioTrace+ over the Internet

BioTrace+ contains a **'Live Update**' function that will check, via the Internet, if a new version of Biotrace+ and the system files is available. Your computer must be online for this function to work. If you have no online connection, you may also update BioTrace+ from a CD that your reseller can supply you.

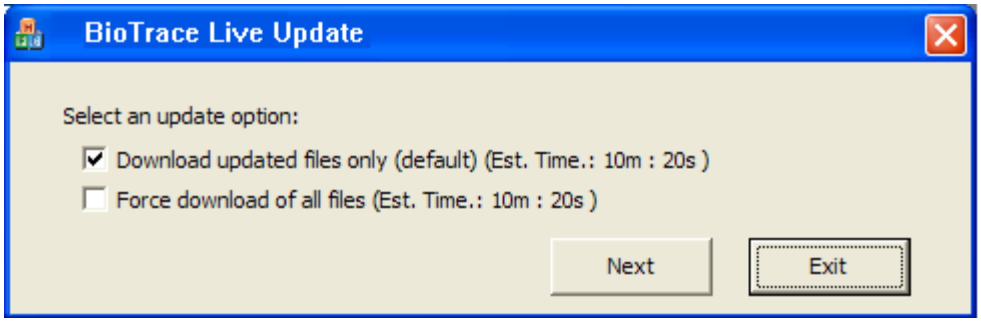
Typically the files that will be updated are in the order of magnitude of 1-5 Mega-bytes. A slow internet connection therefore will in most cases still be sufficient.

You access the **'Live Update'** function under the **'Help**' menu found at the menu bar at the left top:



Notice that you can not run this update function when you are running a session.

When this function is activated, it will close the BioTrace+ application and start a special update application. Please follow the instructions of this update application. (actual screen display may vary)

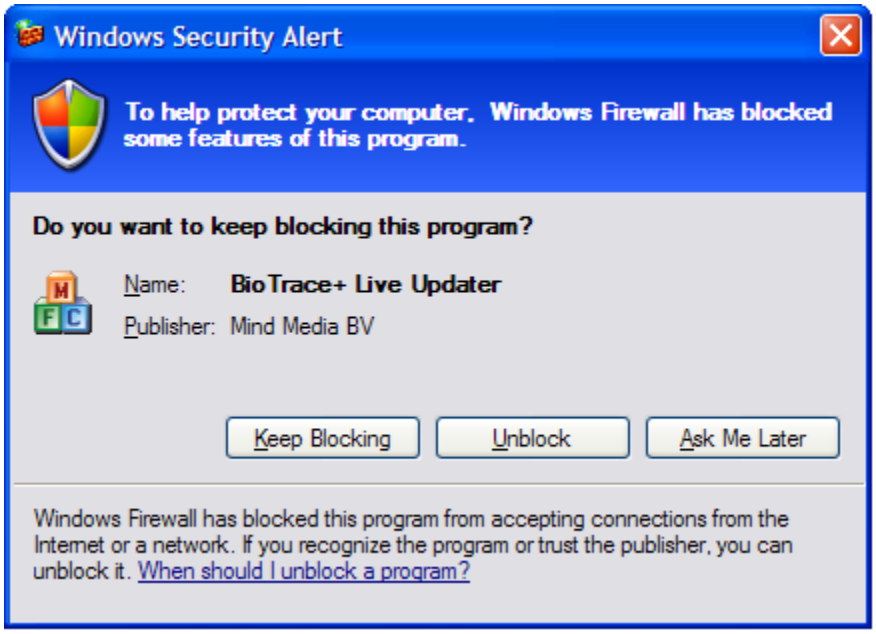


After Live Update has contacted the Mind Media Internet Servers, it will present you with some options.

1) Download updated files only: this will do the minimal update and only add or replace new system files to your system. This is the default option.
2) Force download of all files. Only use this option when you want to refresh all required system and program files, for instance because system settings have been lost or incorrect. This option will take much longer to download.

Press **EXIT** to quit the program.

In some cases when you run this LiveUpdate application, Windows may try to block it, because it thinks the program is illegally accessing the internet. Choose: ‘Unblock’ to allow the LiveUpdate application to continue.



In other cases it may happen that anti-virus software, such as Norton, may want to block the LiveUpdate software. In that case you may need to choose a similar option as the ‘unblock’ option just mentioned.

After the LiveUpdate has finished it may sometimes be required to restart your Windows Computer. In that case you may want to save whatever file you are working on, first.

8.6 Installing the 'Old' Bluetooth drivers

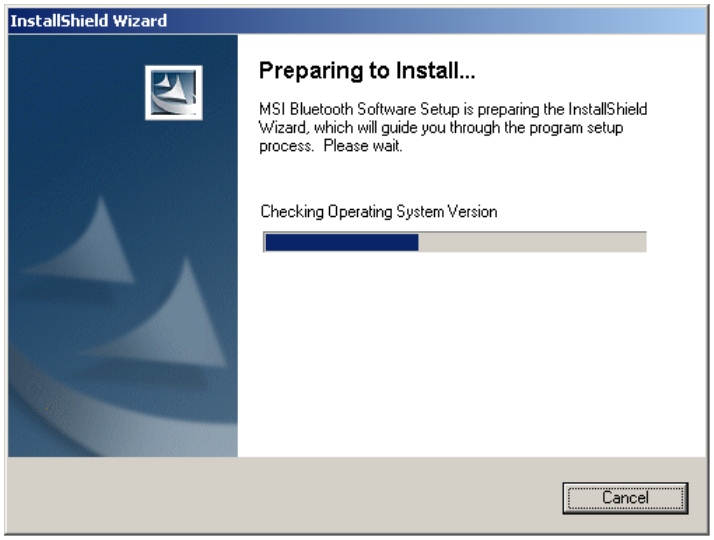
Please be advised that we **recommend strongly** that you upgrade your computer to Windows XP service pack 2 or newer. We cannot support any other configuration with surety;

In case this is not possible and your computer has XP with SP1 or Windows 2000 (with SP4 or newer), you need to install Bluetooth with the old Bluetooth drivers. A copy of these is located on the BioTrace+ setup CD. **They can ONLY be used for the MSI Bluetooth dongle!**

1) Please open the directory: \BioTrace\BlueTooth\Win2000_WinXPSP1 on your hard disk C: or D: (or the drive where you installed the BioTrace Software).

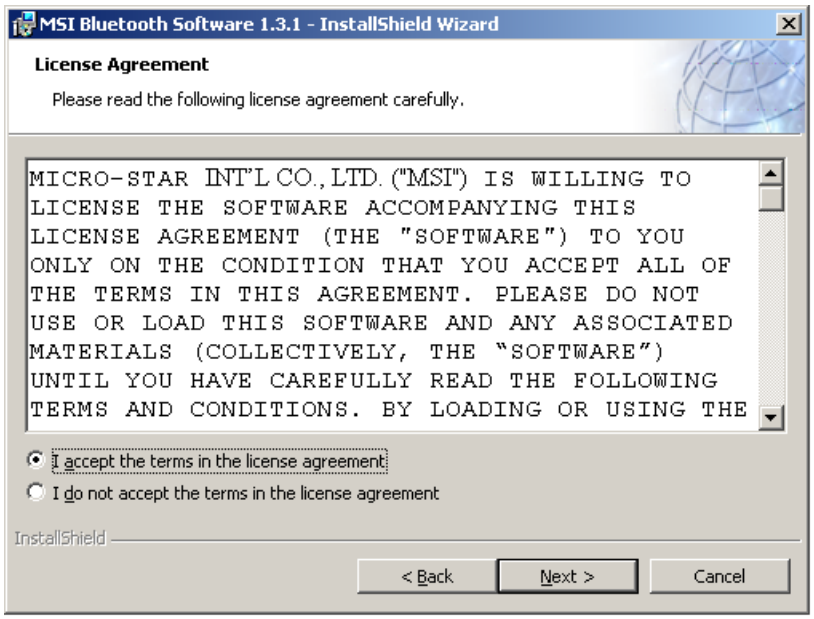
2) Start the SETUP.EXE application located in that directory.

After doing this, you will see the following Dialog Box:

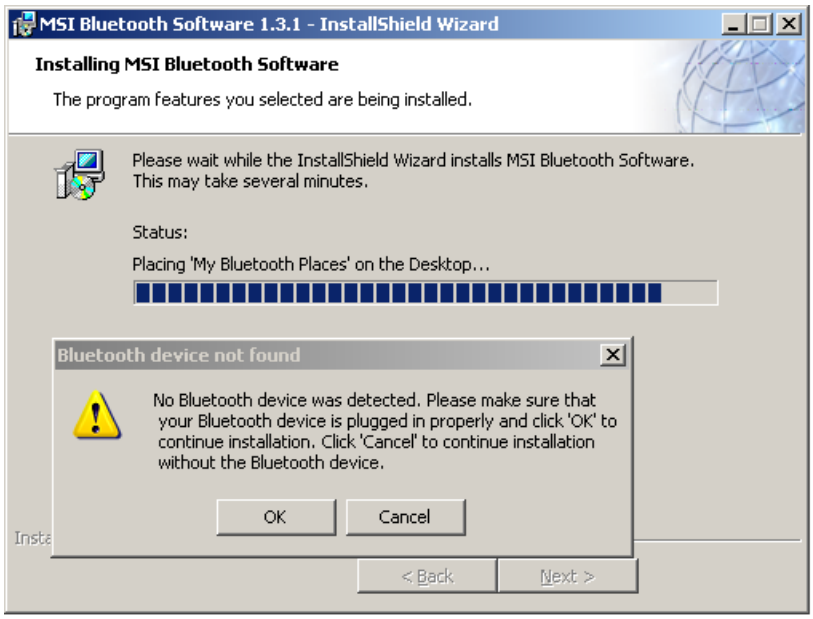


Please wait for this to finish and the next dialog box is shown:

Now press NEXT and follow the instructions.



Continue pressing NEXT until you are shown the following dialog box:

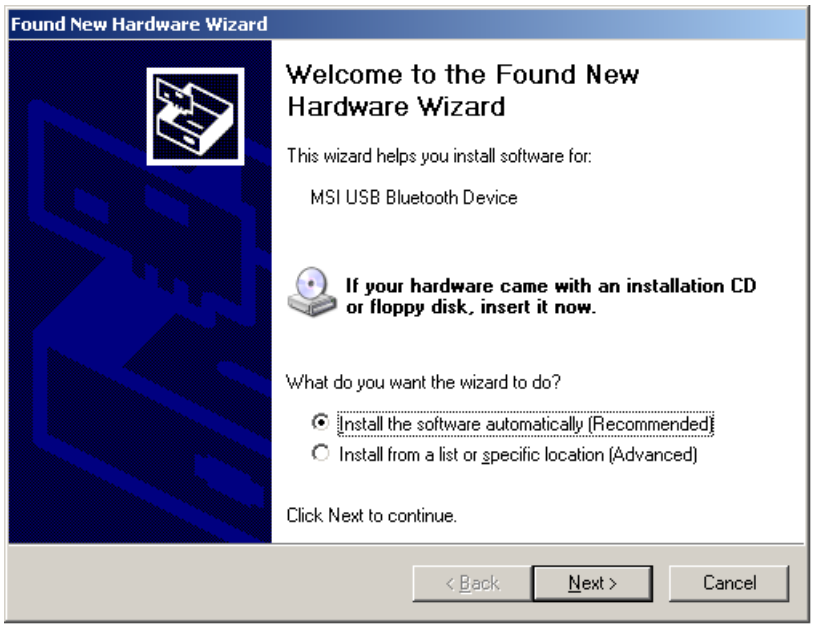


After this dialog box has popped up, **put the MSI Bluetooth 'PC2PC' in a free USB port.**

From now on we advise you to always use this same USB port for the Bluetooth PC2PC stick, so you may want to make a note which USB port you used.

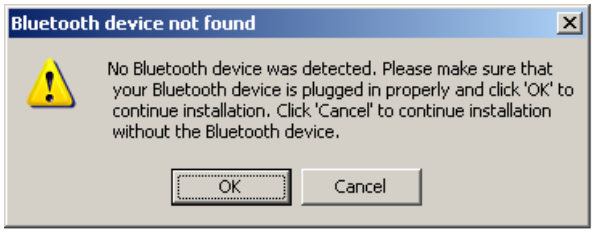
In case you are using a Notebook (portable) computer, we advise you to use the short extender cable. (See picture below)

When the Bluetooth USB stick has been detected, the SETUP software will continue and show the following dialog box: (press NEXT)



After pressing NEXT, the setup process will continue and at the end show the following dialog box:

Confirm by pressing FINISH. And press OK in the dialog box below:

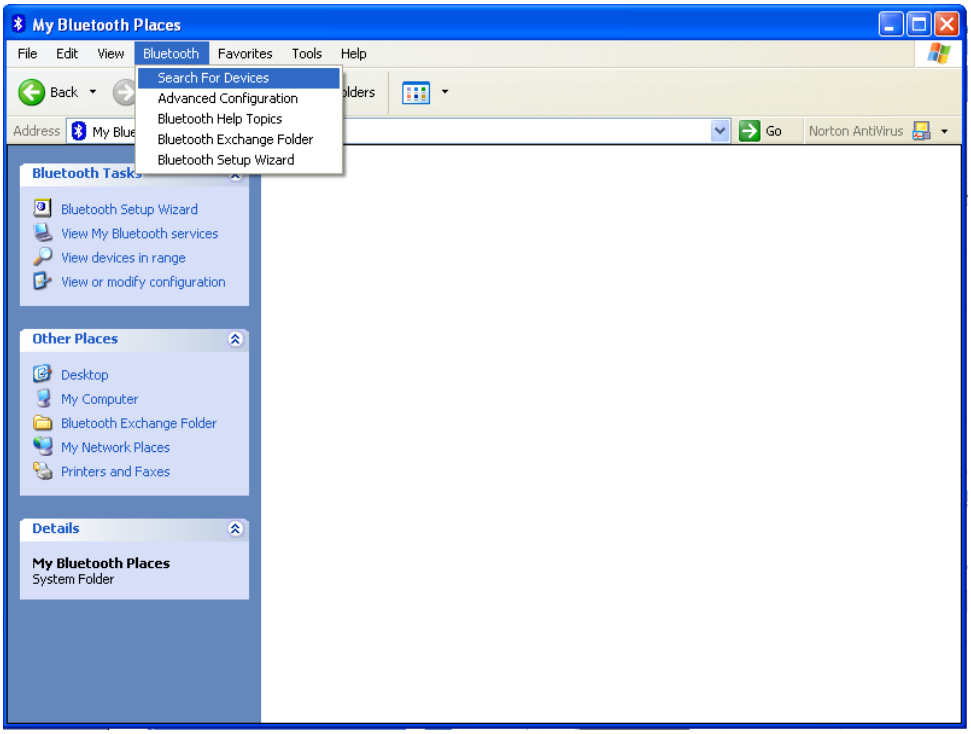


Now that the Bluetooth drivers are installed, you need to ‘pair’ the NeXus to your computer and enter a pin code. You only need to go through this procedure once, unless you connect your NeXus to other computers as well.

The first time you use your NeXus system, the computer must be informed about the **pin code** of the NeXus. The reason is, that Bluetooth is a protected wireless protocol. Not everybody should be allowed to simply connect to your NeXus and receive data from it. Therefore you are requested to fill in the **PIN-CODE**.

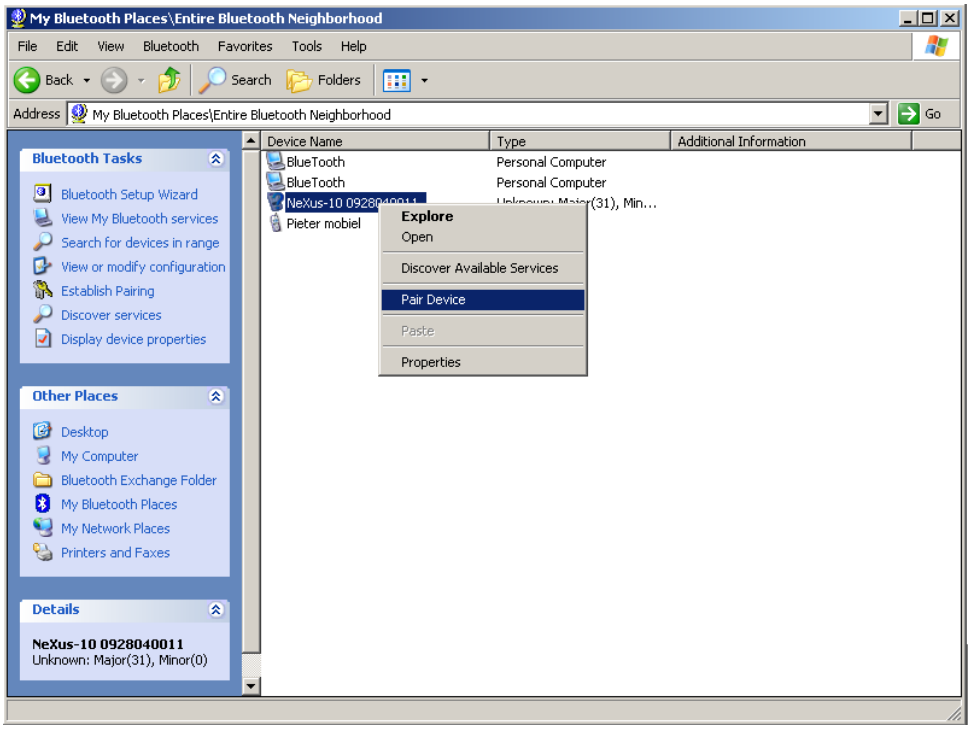
Please note the Bluetooth environment symbol (color blue) at the right bottom part of your computer screen. Please double click on this symbol to open the Bluetooth network environment:

The ‘My Bluetooth places’ window will now open. Turn ON your NeXus and select the **search for devices** option as shown below. This will search for your NeXus device, so you can ‘PAIR’ the device. Pairing is a one-time process whereby you connect and authorize the computer and the NeXus. After pairing, both know about each other and can freely connect.



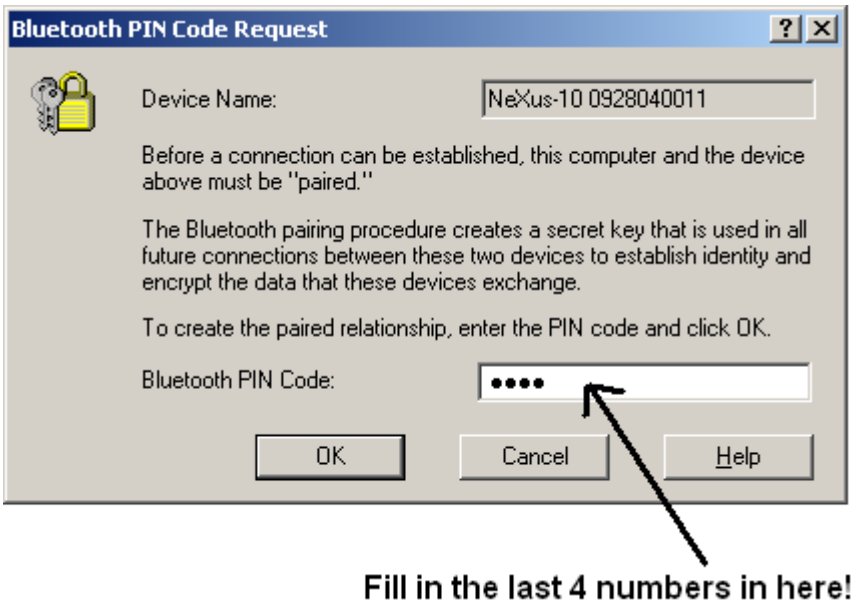
After your NeXus has been found, it will be shown as an ICON which you will need to **right-click** once, so you can **'pair'** the NeXus with the computer.

See the example below:



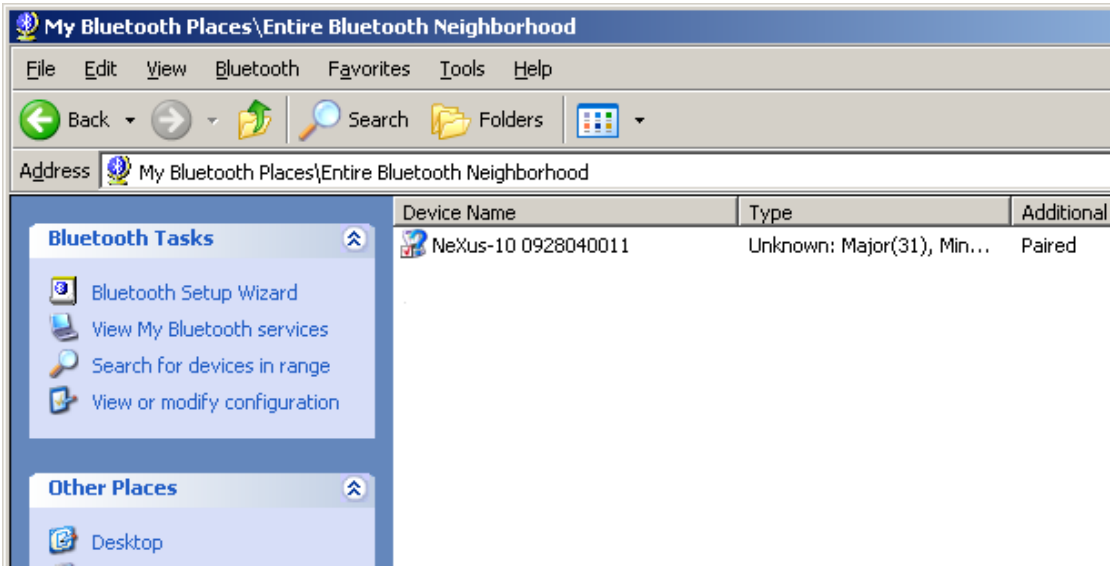
Once the computer has connected to the NeXus, you are requested to fill in the PIN code. You only need to fill in this PIN code once. The PIN code consists of the last 4 number of the serial code shown in the name.

In this example that means "NeXus 0928040011", so you fill in the last part which is: "**0011**". Note: in your case the last 4 numbers will be different.

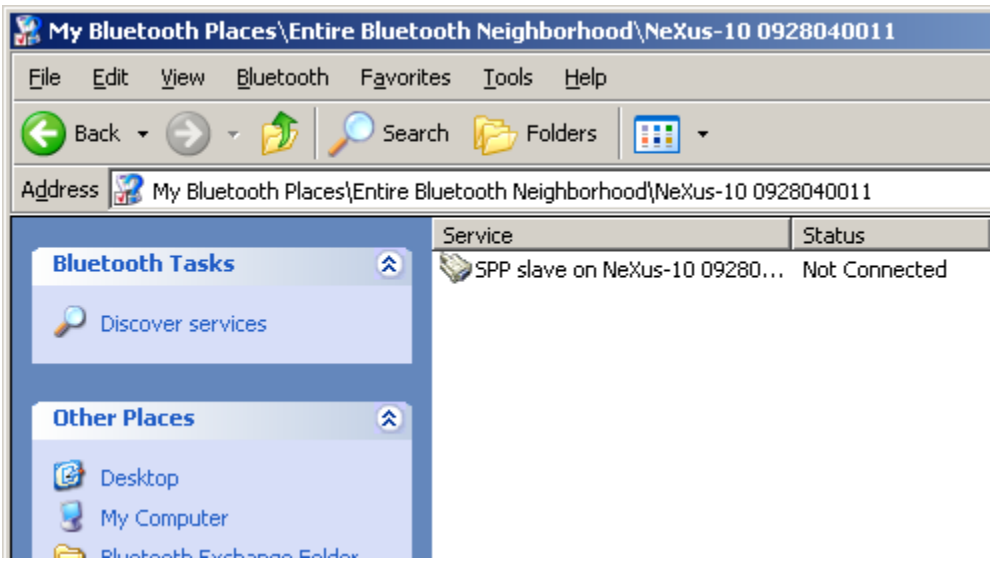


After you have filled in the PIN code, you are ready to make the first connection to the NeXus. The first time you do this by hand. After that, the BioTrace+ software will handle everything.

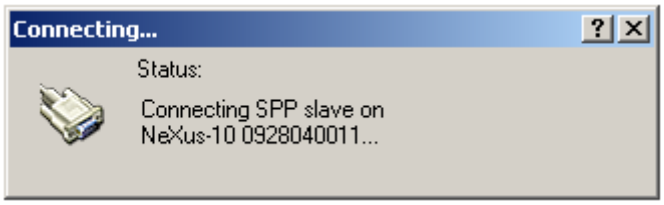
Double click on the NeXus ICON to connect…. (See example below)



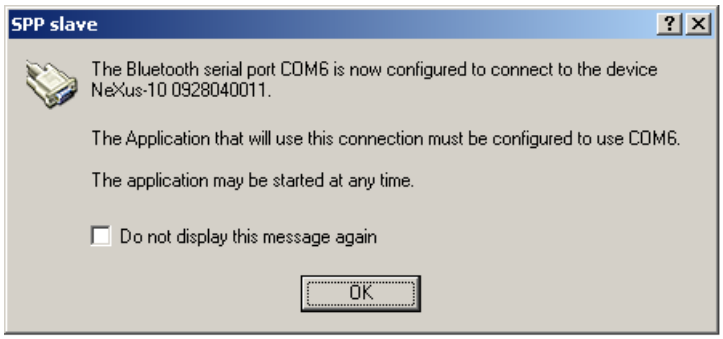
After a few seconds, the following symbol will show:



Now you can connect by hand. Double click on the "**SPP Slave Icon**" to connect. The following Dialog Box will show:



When the system has connected, it will show a dialog box as below.



Usually a COM port of 4, 5 or 6 is selected. Please note that in case the COM port shown is higher then COM9 a problem may have occurred and you may need to manually set the COM port to a lower value through the Windows Device manager.

Note: we advise to use a COM port setting in the range from COM3-COM9.

Important: in case the NeXus does not connect to the computer, it may have 'forgotten' its pin code. In that case you first need to **pair the NeXus again** before the BioTrace+ software can connect to it.

Solutions, in case Bluetooth does not connect:

1) In case it has forgotten the pin code, sometimes you need to **restart** the computer, switch the NeXus on, un-pair it and then pair it before it will be detected. This may happen if you have an older version of Windows XP (without Service pack 2)
2) Check which USB port you have put the Bluetooth dongle into. Preferably always use the same port. If you use another USB port, it may reinstall the drivers for it and need **pairing** before it will work.
3) When you manually connected the NeXus through **pairing** for the first time, restarting the computer (while it is connected and switched on) may help to force the computer to store the right **pin code**.

Bluetooth: Answers to frequently asked questions:

Q1) Can I use multiple NeXus systems in a single location?
A1) Yes, you can, but we advise to keep the number below 6 units in a single room.

Q2) Does Bluetooth interfere with other devices?
A2) This is very unlikely. The power it transmits is 100 to 1000 times less than a mobile phone. Bluetooth has been developed by leading technology companies and has been thoroughly tested.

Q3) Do other devices interfere with the NeXus Bluetooth?
A3) Very unlikely, but possible in extreme situations. For instance when there are many WiFi stations within range of the Bluetooth dongle, they may slow down the communication.

Q4) Do I need to update my Bluetooth drivers regularly?
A4) We do **not** advise to update the drivers supplied with NeXus, if they work as required. We do advise strongly to use Windows XP SP2 (or newer) and use the supplied SP2 drivers.

Q5) Why doesn't the NeXus have a USB cable as a backup connection?
A5) Well, does you mobile phone have a backup cable? Millions of users are relying on wireless technology like Bluetooth and WiFi everyday and find a cable is really not required anymore.

Q6) What if my computer already comes with already comes with Bluetooth technology and a Bluetooth interface?
A6) In that case, do not install the Bluetooth drivers from the BioTrace software package and do not use the Nexus Bluetooth dongle. Your system should recognize the NeXus as a Bluetooth device.

Only in case your built-in Bluetooth would not work: disable it and use the supplied USB dongle and SP2 drivers. In that case you need to have at least Windows XP SP2 (service pack 2)