

**Welcome to**  
**NeuroScore Version 3.0**  
**Online Help**

[Acknowledgements](#)



## Acknowledgments

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DSI  
119 14th Street NW • Suite 100 • St. Paul, MN 55112  
Telephone (1-651) 481-7400 • (1-800) 262-9687  
Fax: (1-651) 481-7404  
Web Site: <http://www.datasci.com>



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# Introduction

## NeuroScore User Manual

Welcome to the NeuroScore User Manual. This manual is designed to help the user begin using the NeuroScore program. The manual describes the overall architecture of the program, specific features and functions, and includes step-by-step examples of common ways the program is used. To access this online manual within the NeuroScore software, push <F1> and the NeuroScore User Manual will automatically open.

- Who Should Use The Manual?
- Things You Need to Know
- How to Use The Manual
- What is NeuroScore?

## What is NeuroScore?

NeuroScore is a software program that allows the user to analyze physiological signals through various mathematical functions and graphing techniques. It is a modular platform and the optional Rodent Sleep Scoring, Large Animal Sleep Scoring, Seizure Detection, and Video Synchronization modules can easily be added-on to NeuroScore's Core software. The Core software is the foundation of NeuroScore and offers sophisticated graphical and browsing capabilities, derived signals including frequency analysis tools, manual scoring and marking options, and report templates. In addition, the Core software provides the ability to export results into Excel® and other formats.

NeuroScore's Rodent Sleep Scoring Module and Rodent Scoring 2 Module makes sleep scoring easy by providing fast and accurate scorings. These modules assigns a vigilance stage to each epoch based on EEG, EMG, and activity data. Stages include Paradoxical, Slow Wave Sleep (with option to distinguish between SWS-1 and SWS-2), Wake, and Active Wake.

NeuroScore's Large Animal Sleep Scoring Module also automatically assigns a vigilance stage to each epoch. It is intended for use with data from non-human primates and other large animal species and uses EEG, EMG, EOG, and activity signals as inputs to the scoring algorithm. The algorithm used in the detector is based primarily on the AASM standards for human sleep scoring and assigned stages include, Wake, Active Wake, REM, Non-REM (N1, N2, N3)

The Seizure Detection (Spike Train) analysis module scans an EEG signal to detect patterns of repeating spike activity contained within the signal. This detector is primarily based on amplitude thresholds and the user can define spike characteristics and rules for periodicity to help differentiate spike trains from 'normal' EEG.

The Batch Processing feature of NeuroScore allows the design of a study specific workflow that can be run on a group of subjects without having to open and analyze subject data individually. A Workflow can be custom designed to load data, run an analysis, generate reports and export data features of interest.

Video Synchronization allows for recorded video data to be loaded into NeuroScore along with data from other sources, such as telemetry. Once loaded, video data can be reviewed with the associated data, fully synchronized, to complement the analysis process. Video information allows visual assessment of the subject's behavior, confirmation of scoring events, classification of seizure types and more. Video data must be acquired in Dataquest A.R.T. or Ponemah acquisition packages.

**For more information, see the following topics:**

- NeuroScore General Concepts
- NeuroScore Work Environment

## Who Should Use This Manual?

The purpose of the NeuroScore User Manual is to provide assistance through the process of data analysis using the NeuroScore software. It uses simple, easy to understand wording, realistic examples, and sample screen shots to explain how to use the program. The procedures and examples are written in a level of detail appropriate for users who have experience with basic Windows Operating System functions for Windows XP Professional, Windows Vista, and Windows 7. Please refer to Important Things to Know for a more definite list. There are many data types that can be analyzed with the NeuroScore software; however, NeuroScore was designed specifically for the analysis of EEG in regards to sleep and seizure related data. This user manual primarily focuses on those applications.

*Note:* This manual is intended to be a guide to using the program, and should not be used as instructions for sleep scoring or seizure analysis.

## Important Things to Know

There is no need for an individual to be a computer expert to work with the NeuroScore software. To use the software there are only basic Windows® tasks that an individual will need to know to operate the NeuroScore software:

- How to start and shut down Windows®.
- How to use the mouse to point, click and double click on icons, buttons, radio buttons, entry fields, list boxes and check boxes.
- How to access drop-down menus, command choices and online help.
- How to minimize, maximize, and exit dialogs and windows.
- How to enter data at the keyboard.
- Understand the file manipulation terms: open, save, edit, copy, delete and exit.

If familiar with Windows® or other graphical user interfaces that use a mouse to point and click, skip the rest of this section.

The following terms are from the glossary of the Windows® Online Help manual.

<b>Term</b>	<b>Definition</b>
<b>Check Box</b>	A small box in a dialog box or property page that can be selected or cleared. Check boxes represent an option that you can turn on or off. When a check box is selected, a checkmark appears in the box.
<b>Push Button</b>	A rectangular control item on the screen containing text or graphics or both as a push button. Click a button with the mouse and an action will immediately occur, such as accessing another dialog or running a program.
<b>Radio Button</b>	A round button on a window with text or an icon beside it. Radio buttons are combined to show a fixed set of choices from which only one can be selected. Click on a radio button to partially fill or clear it. A partially filled radio button indicates a parameter or device is enabled or selected. An empty radio button indicates a parameter or a device is not selected.
<b>List Box</b>	In a dialog window, a vertical, scrolling list of objects or choices available. For example, a list of all files in a directory.
<b>Double-click</b>	To rapidly press and release a mouse button twice without moving the mouse. Double clicking carries out an action, such as starting an application.
<b>Drag</b>	To move an item on the screen by selecting the item and then pressing and holding down the mouse button while moving the mouse. For example, you can move a window to another location on the screen by dragging its title bar.
<b>Icon</b>	A graphical representation that is associated with a specific item. Within applications, there are also toolbar icons for commands such as cut, copy, paste etc.

<b>Menu</b>	A list of available commands in an application window. Menu names appear on the menu bar located near the top of the window. To open a menu, click the menu name.
<b>Pointer</b>	The arrow-shaped cursor on the screen that follows the movement of a mouse (or other pointing device) and indicates which area of the screen will be affected when the mouse button is pressed. The pointer changes shape during certain tasks.
<b>Toolbar</b>	Area located directly under the menu bar that contains a set of standard controls, otherwise referred to as toolbar icons.

## Structure of Manual

### Manual Organization

Technical terms relating to computer usage or the NeuroScore software are explained in the text or appendices.

#### Example procedure

Program and procedure descriptions are presented in a numbered, step-by-step list as shown in the following example:

#### Exporting the Signal Sheet

The Signal sheet can be exported:

1. Have the signal sheet of interest to export active.
2. Select **File-Export Sheet...**
3. The sheet can be exported as a ".emf" or ".png" file, both of which are image file extensions.
4. Enter the file type and the file name.
5. Click **Save**.

*Note:* The exported sheet will need to be opened from the folder that it was just saved to, it will not automatically launch after it has been saved.

## Conventions

This manual uses the following conventions:

<b>File - Export Sheet...</b>	Menus and command choices are printed in a bold font and are combined in one instruction when possible. For example, the instruction Click on " <b>File - Exports Sheet...</b> " directs the user to click on the <i>File</i> menu, then click on the <i>Export Sheet...</i> command choice to access the appropriate window to complete the task. If the option has a letter underlined, it can be accessed through the keyboard by pressing the <Alt> key and the underlined letter. Each subsequent hyphen (-) in a menu/command choice indicates a sub-command choice.
<b>Bold</b> or <i>Italic</i>	<b>Bold</b> and/or <i>italic</i> text indicates that an item is important enough to call special attention to it. General-purpose headings are in bold and italics.
<Ctrl> + <Esc>	A bold font with < > symbols indicates keyboard keystrokes in the text. For example, the <Ctrl> + <Esc> key sequence (hold the Ctrl key down while pressing the Esc key) in Windows activates the Start menu.
<u>Underlined text</u>	Underlined text indicates a publication name or a heading within a publication.

## How to use the Manual

This manual can be useful using a number of different approaches. The three methods most commonly used to find information about the software are using the search option, navigating through the Table of Contents, or using the context sensitive help in pre-selected windows. The manual can also be accessed while the NeuroScore software is open and the active program. Press <F1> to have the manual launch while in NeuroScore.

# Installation and Maintenance

## System Requirements

The following tables include the recommended hardware requirements needed to operate the NeuroScore application efficiently.

### Minimum System Requirements:

#### 1. Desktop Minimum System Requirements

	Recommended
Operating System	Windows® XP Professional SP3, Windows® Server 2003 SP1, Windows® Vista, or Windows® 7 SP1 - 32 or 64 Bit Compatible
Processor	x86 based AMD or Intel processor
Processor Clock Speed	1.7 GHz or faster
Memory	512 MB or more
Local Hard Drive	100 GB or more
Free Hard Drive Space	At least 500 MB or more
Graphics Resolution	1024x768 or higher

#### 2. Laptop Minimum System Requirements

	Recommended
Operating System	Windows® XP Professional SP2, Windows® Vista, or Windows® 7 SP1 - 32 or 64 Bit Compatible
Processor	x86 based AMD or Intel processor
Processor Clock Speed	1.2 GHz or faster
Memory	512 MB or more
Local Hard Drive	40 GB or more
Free Hard Drive Space	At least 500 MB or more
Graphics Resolution	1024x768 or higher

### Recommended System Requirements:

#### 1. Desktop Recommended System Requirements

	Recommended
Operating System	Windows® XP Professional Service Pack 2, Windows® Server 2003 SP1, Windows® Vista, or Windows® 7 SP1 32 or 64 Bit
Processor	x86 based AMD or Intel processor
Processor Clock Speed	2.0 GHz or faster

Memory	1 GB or more
Local Hard Drive	100 GB or more
Free Hard Drive Space	At least 10 GB or more
Graphics Resolution	1280x1024 or higher

2. Laptop Recommended System Requirements

	Recommended
Operating System	Windows® XP Professional Service Pack 2, Windows® Vista, or Windows® 7 SP1 32 or 64 Bit
Processor	x86 based AMD or Intel processor
Processor Clock Speed	1.5 GHz or faster
Memory	1 GB or more
Local Hard Drive	80 GB or more
Free Hard Drive Space	At least 10 GB or more
Graphics Resolution	1280x1024 or higher

**Prerequisites:**

Before installing the NeuroScore application the following operating system components need to be available and of the correct minimum version.

For Windows® Vista, Windows 7, XP Professional

- Service Pack 2
- .Net Framework 4.0 (included in the installation phase)
- Microsoft Installer 3 (included in the installation phase)
- Sentinel Protection Installer 7.5.1 (included in the installation phase)

For Windows Server 2003

- Service Pack 1
- .Net Framework 4.0 (included in the installation phase)
- Microsoft Installer 3 (included in the installation phase)
- Sentinel Protection Installer 7.5.1 (included in the installation phase)

Installation of the .Net Framework 4.0 and Microsoft Installer 3 are a part of the NeuroScore installation package. The files for the Microsoft Installer 3 are acquired over the internet so if no internet connection is available the files need to be gathered on an internet connected computer and moved over to the installation computer. The service packs and the Microsoft Installer 3 are available from the Microsoft update site at <http://update.microsoft.com/>.

*Note:* The Microsoft update requires the use of Microsoft Internet Explorer to function correctly. The simplest way to activate the Update is to access the **Start** menu and then **All Programs**. At the top of that list is a **Windows Update** start menu item that will open the **Windows Update** in the *Microsoft Internet Explorer*.

## NeuroScore Installation

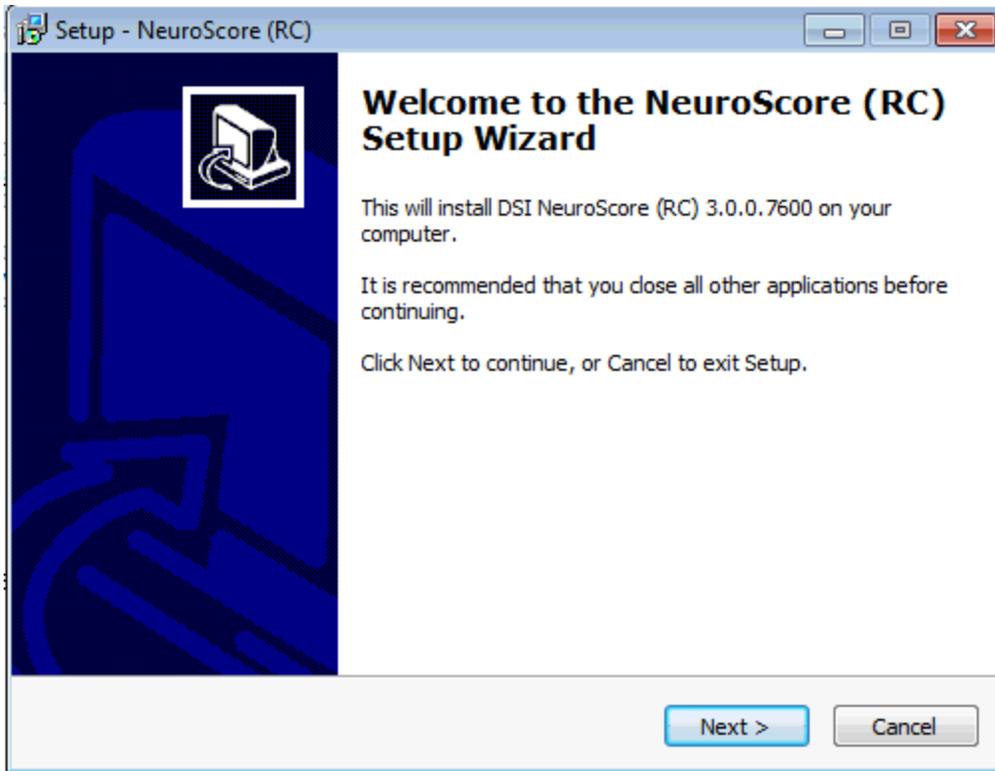
Installing NeuroScore 3.0 includes three components: 1.) The NeuroScore program itself; 2.) the Microsoft .NET 4.0 Framework; and 3.) the Sentinel Protection Installer 7.5.1. The Sentinel Protection Installer is for NeuroScore's security purposes. It allows the USB dongle provided with the program to be recognized by the computer and the corresponding license key code or file to activate it. The licensing process is discussed in the next section.

If any of these components have previously been installed, they will be updated if necessary. To install the NeuroScore application, the user must have administrative privileges. If insufficient privileges are found during the installation, a message will be shown stating that this is the case and the installation will terminate.

Note: The same user should be logged onto the computer when installing the software and activating the license file. If different users are logged on for each situation, there will be access privilege issues.

The following steps are needed to ensure a successful installation:

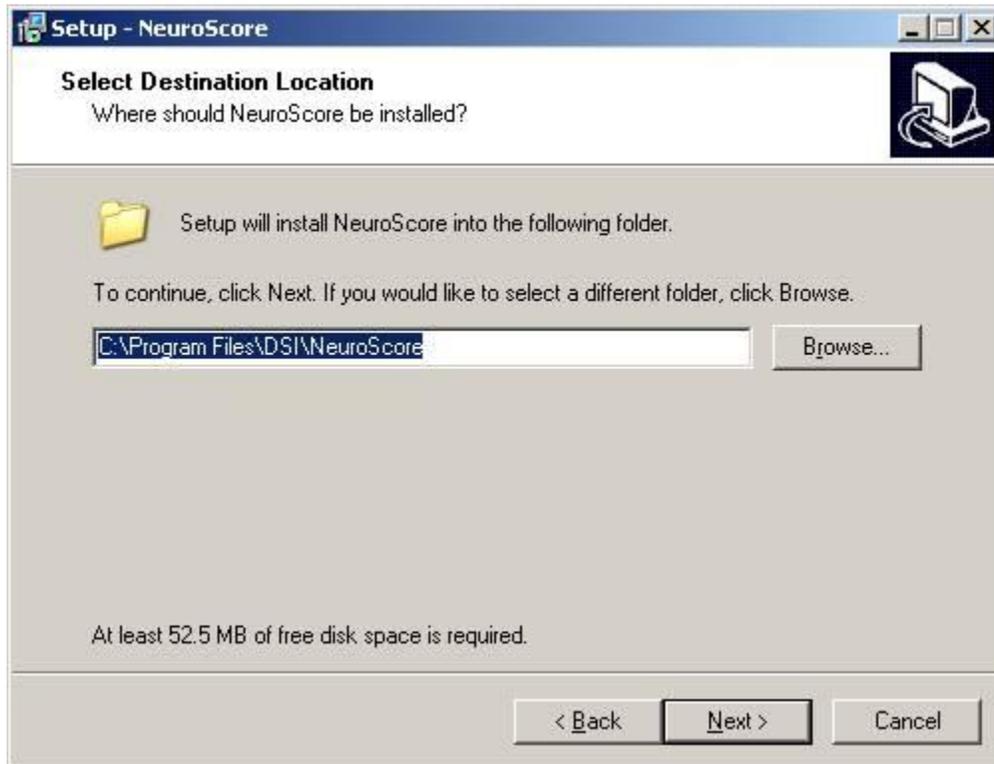
1. Log in as the Administrator on the machine
2. Insert the NeuroScore CD into the CD/DVD drive. The installation should start automatically. If not, browse the CD for the Setup.exe file and double-click it. Keep the CD package as it contains the security key code which will be needed to activate the program.
3. The installation wizard should start with the welcome message.



4. Select **Next**
5. Accept the software license agreement



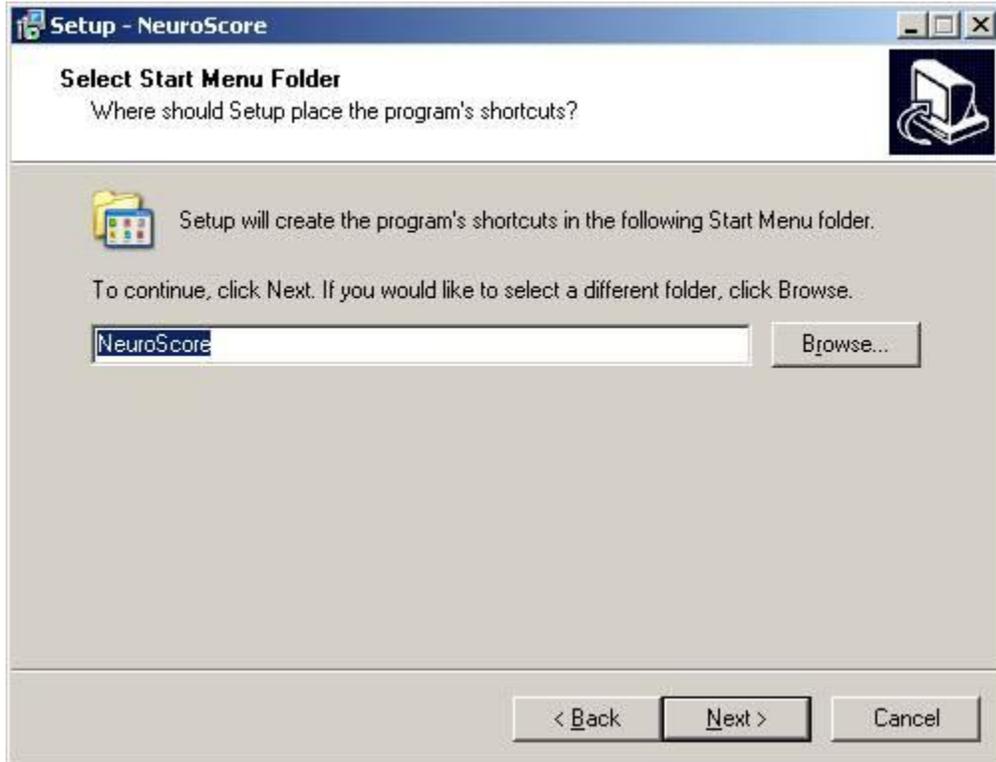
6. Select the Destination Location: Here the default installation location can be changed to a new location.



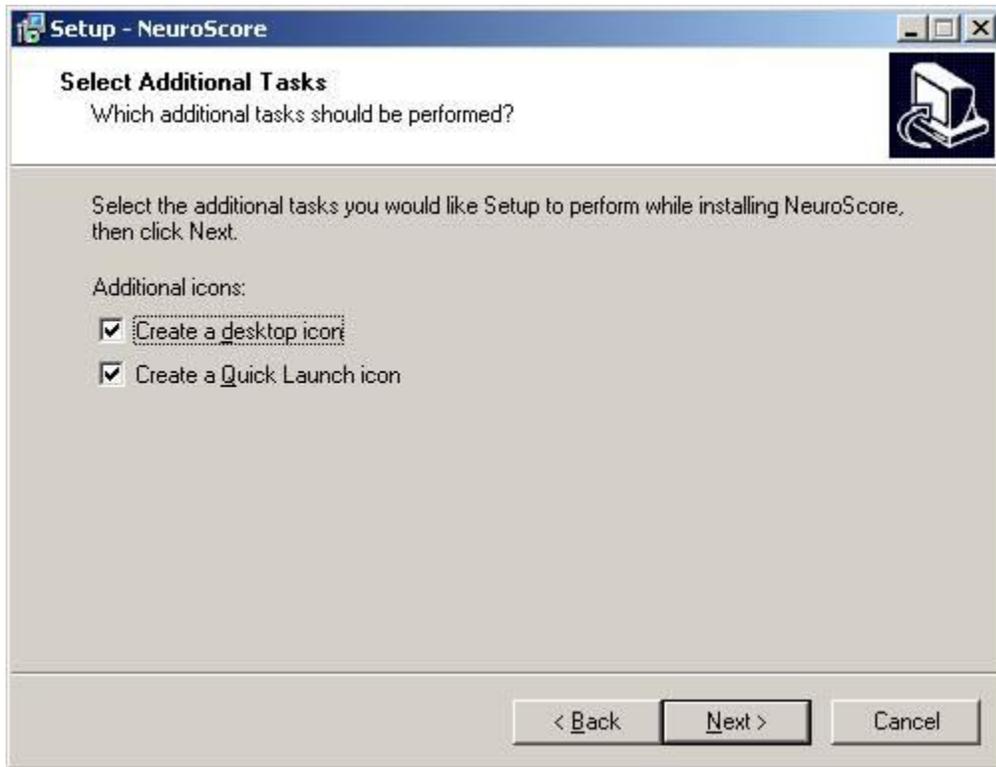
The amount of disk space needed for the installation is displayed. If disk space is insufficient for installation, a warning will be displayed.

7. Click **Next**

8. Select the Start Menu Folder: the location of the application in the Windows Start menu.

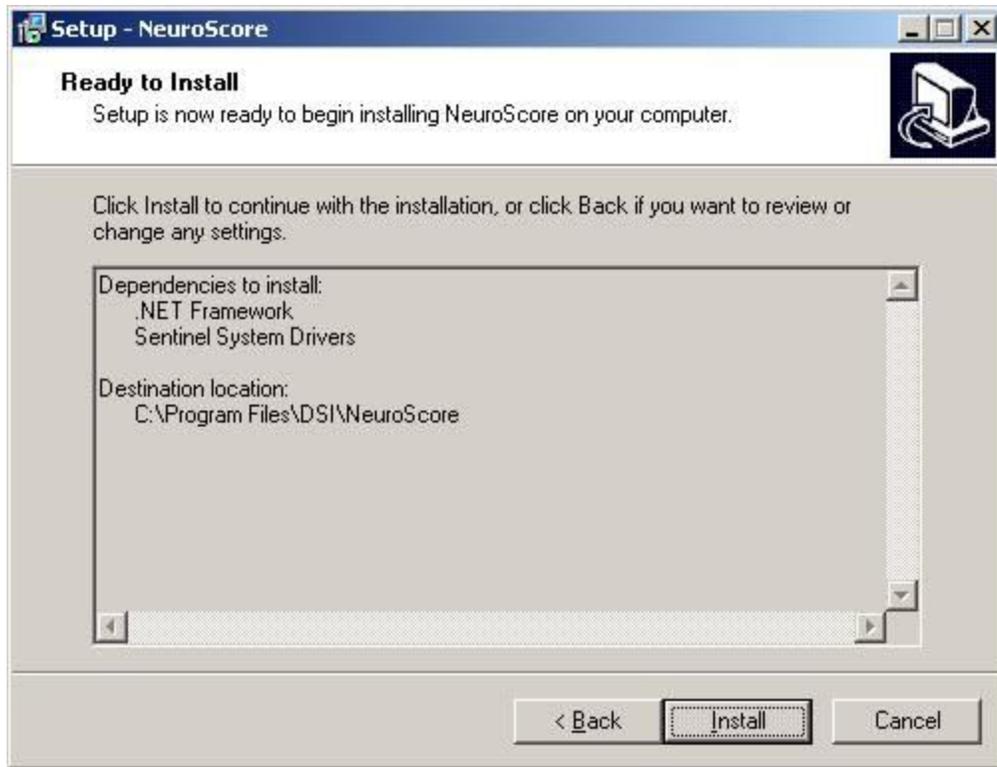


9. Click **Next**
10. Select Additional Tasks: Specify if a desktop icon or an icon in the quick launch bar should be created.



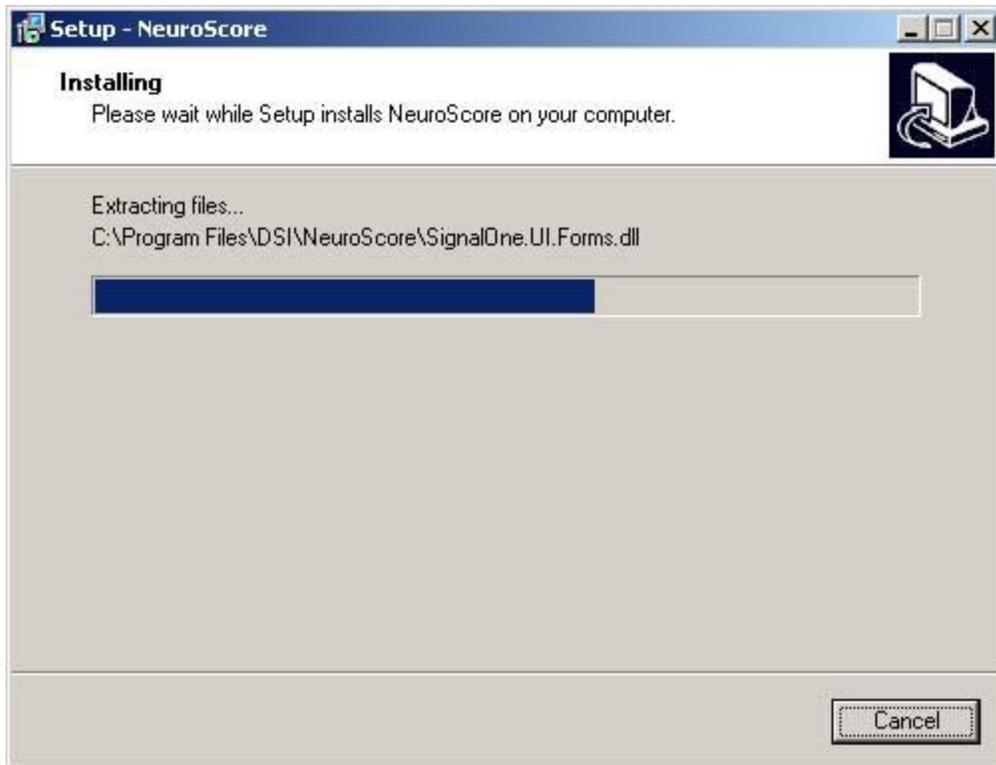
11. Click **Next**

12. *Ready to Install.* This window will indicate if the .NET Framework and/or Sentinel System Drivers need to be installed prior to the NeuroScore installation.

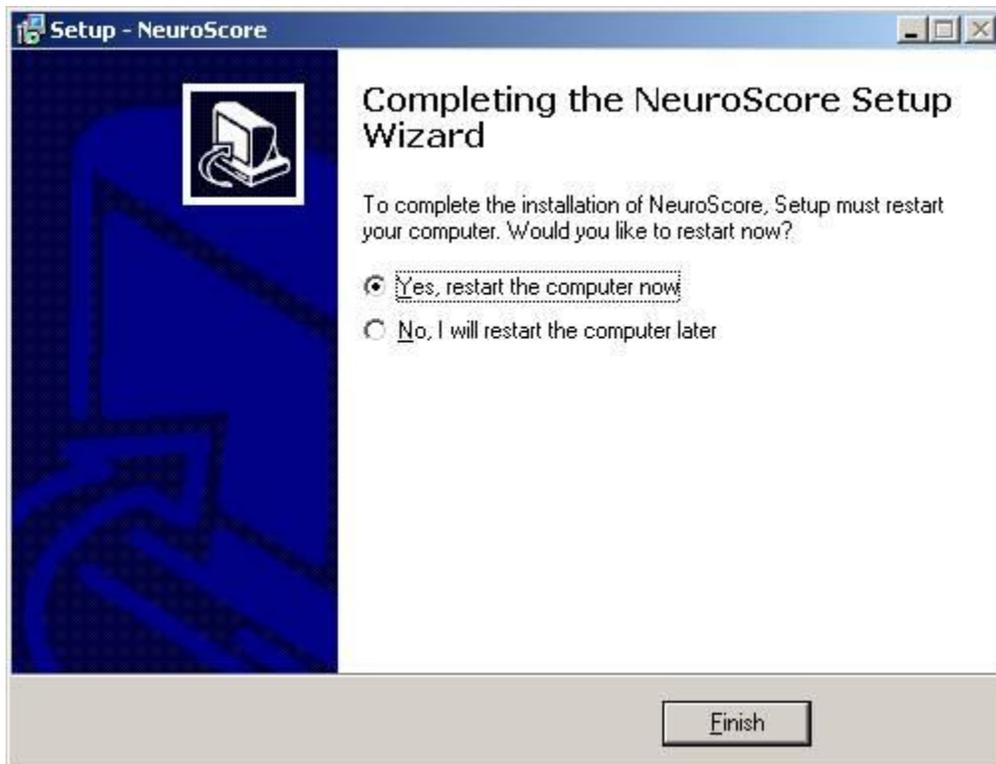


13. Select **Install**

14. See .NET Framework Version 4.0 and [Sentinel Protection Installer 7.5.1](#) sections for important wizard steps. After these components are finished, you may be prompted to restart the computer. Please press No in order to restart at a later time. Continue through the wizard steps and NeuroScore will begin to install.



15. Select Yes to restart the computer after NeuroScore is finished installing.



16. Plug in the USB dongle provided with the software before opening the program. See [NeuroScore License File Procedures](#) to activate the program.

*Note:* If NeuroScore is being upgraded from a previous version, use the USB dongle that came with the original NeuroScore shipment.

## **Maintenance**

The NeuroScore application architecture is simple and it is not necessary to perform extravagant maintenance routines. The only option the user has is to remove the application from the computer.

To remove the installed NeuroScore Application:

1. Open the *Add or Remove Programs* dialog.
  - a. Click on the **Start** menu
  - b. Select **Control Panel**
  - c. **Double-click** the **Add or Remove Programs** icon.
2. Located and select the NeuroScore application
3. A **Remove** button should be available.
4. Click the **Remove** button.

## NeuroScore License File Procedures

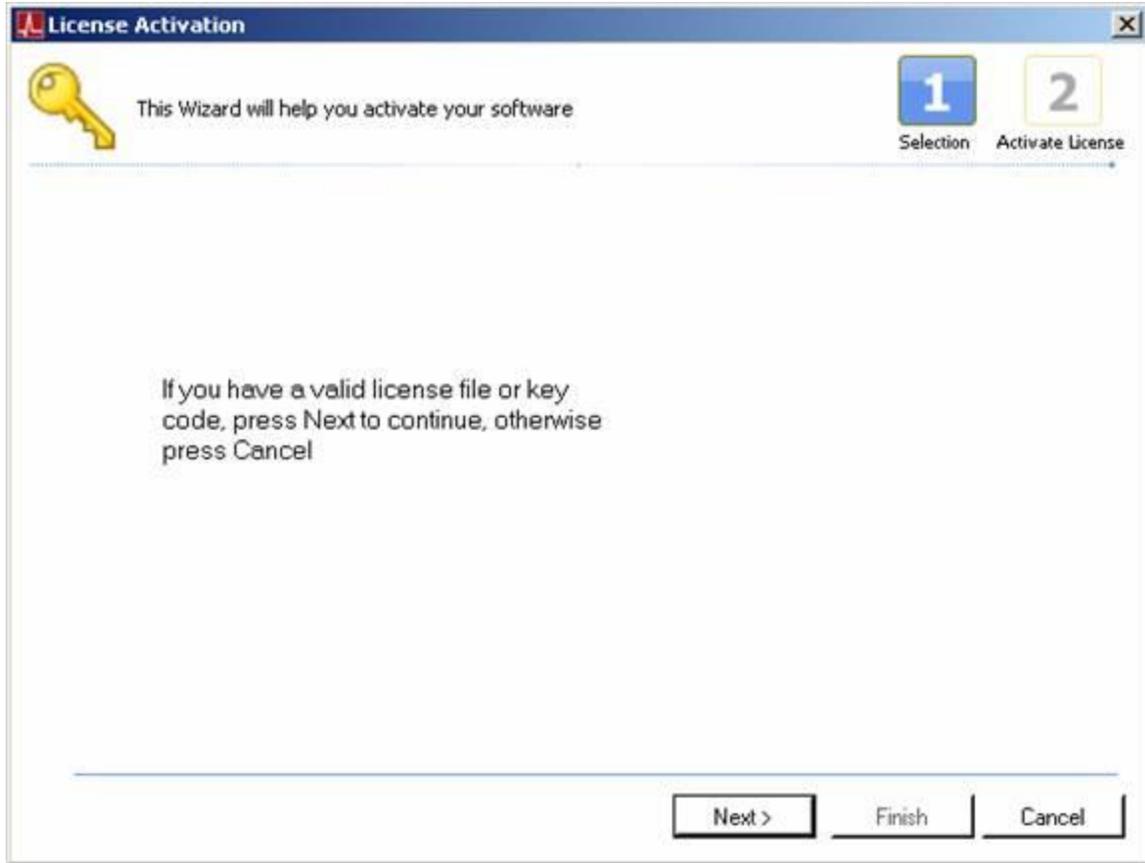
A license key code or file is required to activate the NeuroScore program following installation. This license file is keyed to the USB dongle provided with the software. The licensing process varies depending on what version of NeuroScore is being installed for the first time, if NeuroScore is being upgraded from a previous version, or if a new module is being added to an existing NeuroScore system.

In addition, the licensing process has changed with version 2.0 and higher compared with previous versions. Instead of retrieving a license file from DSI's FTP site, the program now ships with a key code found on a label on the CD package. The key code is used to retrieve a license file from a web server and internet access is required. If internet access cannot be available, please contact [DSI Technical Support](#) to receive your license file.

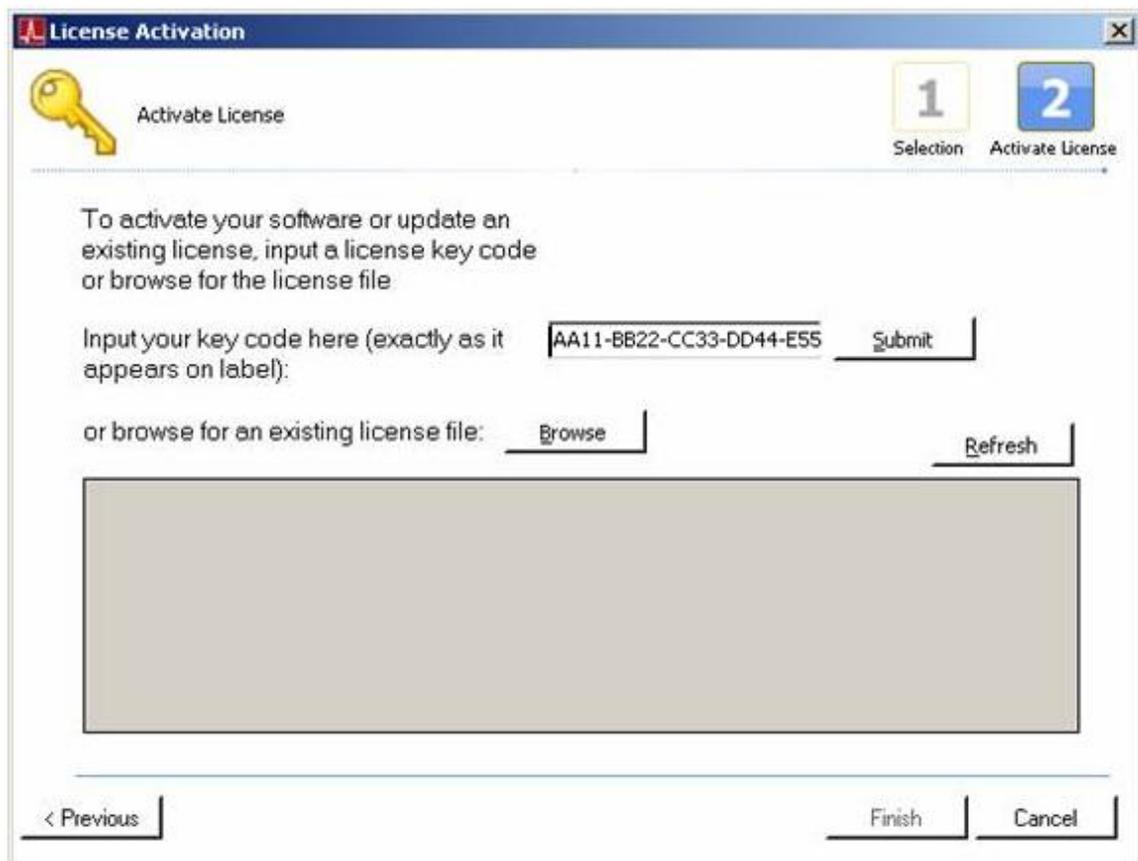
After installing NeuroScore following the steps in the [Installation](#) section, follow the steps below for the appropriate scenario:

### Activating NeuroScore for the first time:

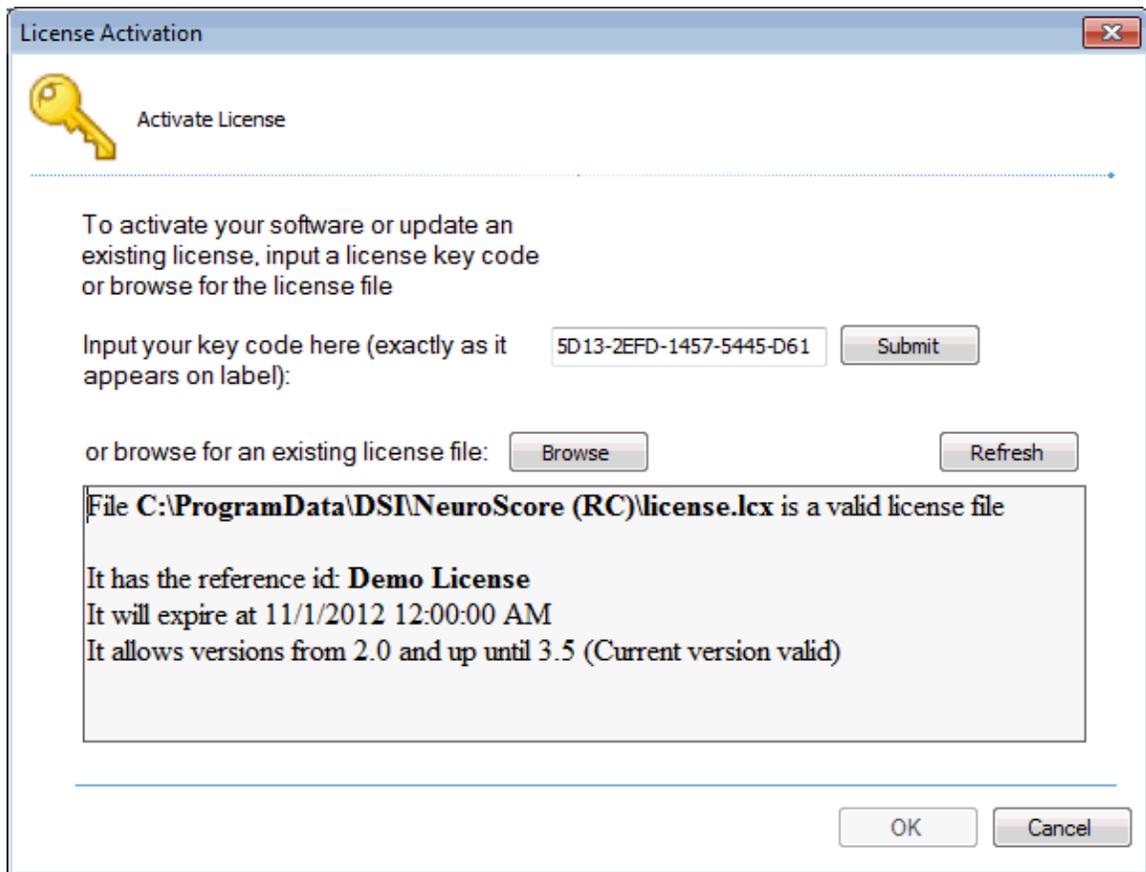
1. Install NeuroScore v3.0 following the steps in the [Installation](#) section.
2. Insert the USB dongle and **Open** NeuroScore
3. The *License Activation* window will automatically appear.



4. Click **Next**
5. Locate the license key code found on the NeuroScore v3.0 CD package. Enter the license key code exactly as it appears on the label (include the dashes). The submit button will not be available if the code is typed incorrectly.



6. Click **Submit**. It may take a few moments for the program to contact the server and retrieve the actual license file. A message will appear indicating the license file is valid and the dongle is connected.

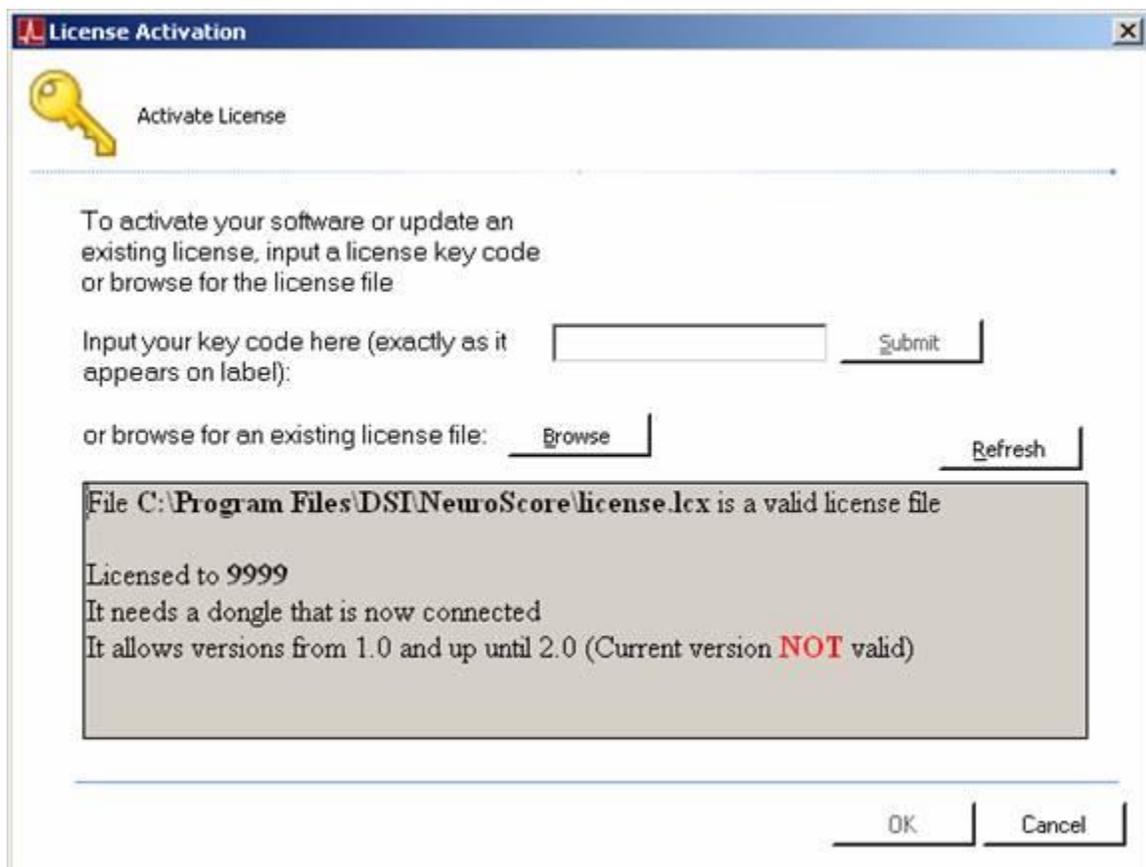


7. Click **Finish**. NeuroScore will launch.

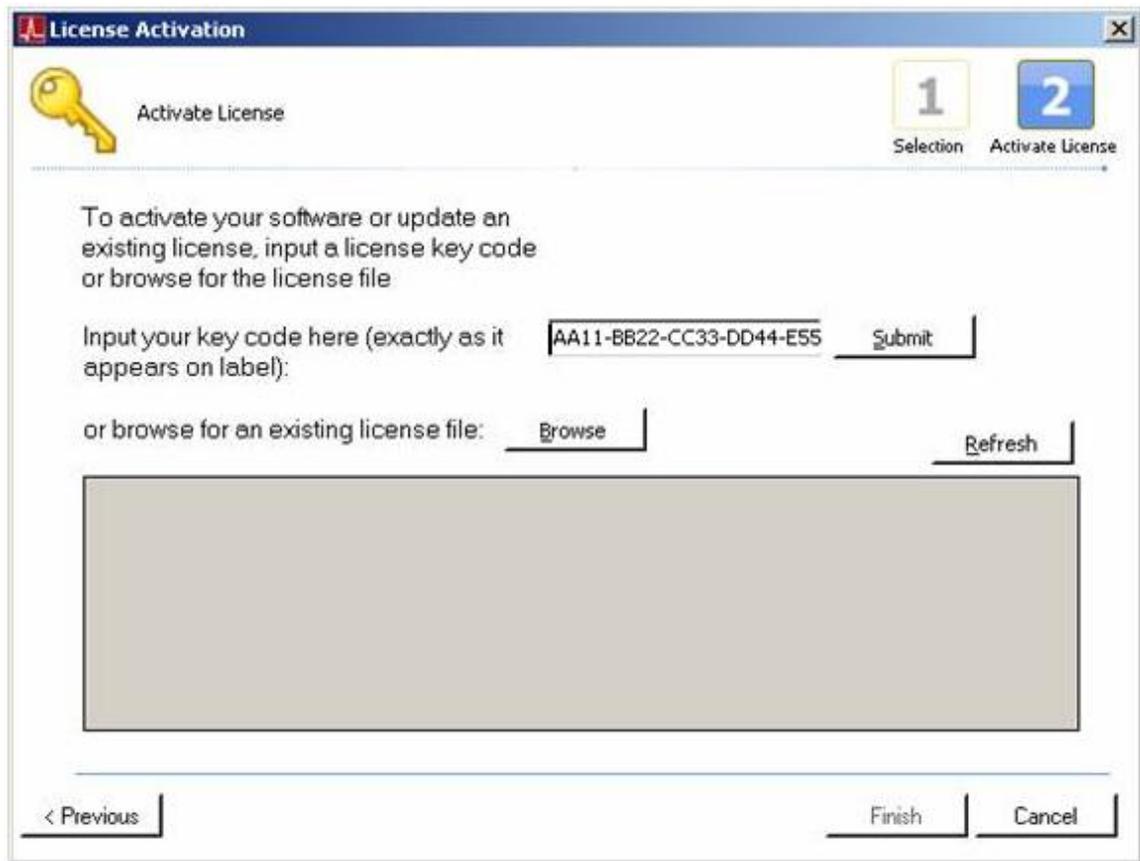
*Note:* If internet access is not available, please contact [DSI Technical Support](#) to obtain the license file.

### **To upgrade a previous version of NeuroScore to v3.0**

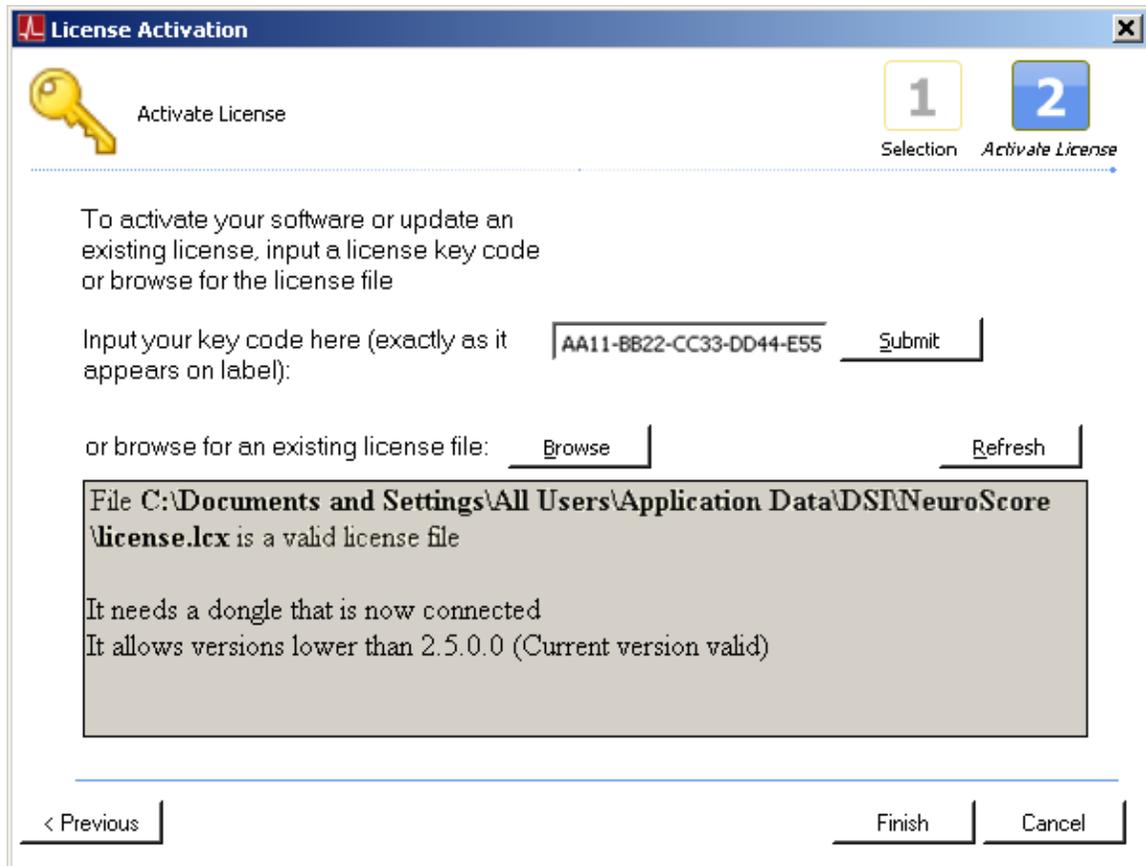
1. Install NeuroScore v3.0 following the steps in the [Installation](#) section.
2. Insert the USB dongle and **Open** NeuroScore
3. NeuroScore will automatically locate your previous license file which will be expired and a message will appear in the License Activation window.



4. Locate the license key code found on the NeuroScore v3.0 CD package. In the License Activation window, enter the license key code exactly as it appears on the label (include the dashes). The submit button will not be available if the code is typed incorrectly.



5. Click **Submit**. It may take a few moments for the program to contact the server and retrieve the actual license file. A message will appear indicating the license file is valid and the dongle is connected.



6. Click **Finish**. NeuroScore will launch.

*Note:* If internet access is not available, please contact [DSI Technical Support](#) to obtain the license file.

### To add a module to an existing NeuroScore v3.0 system

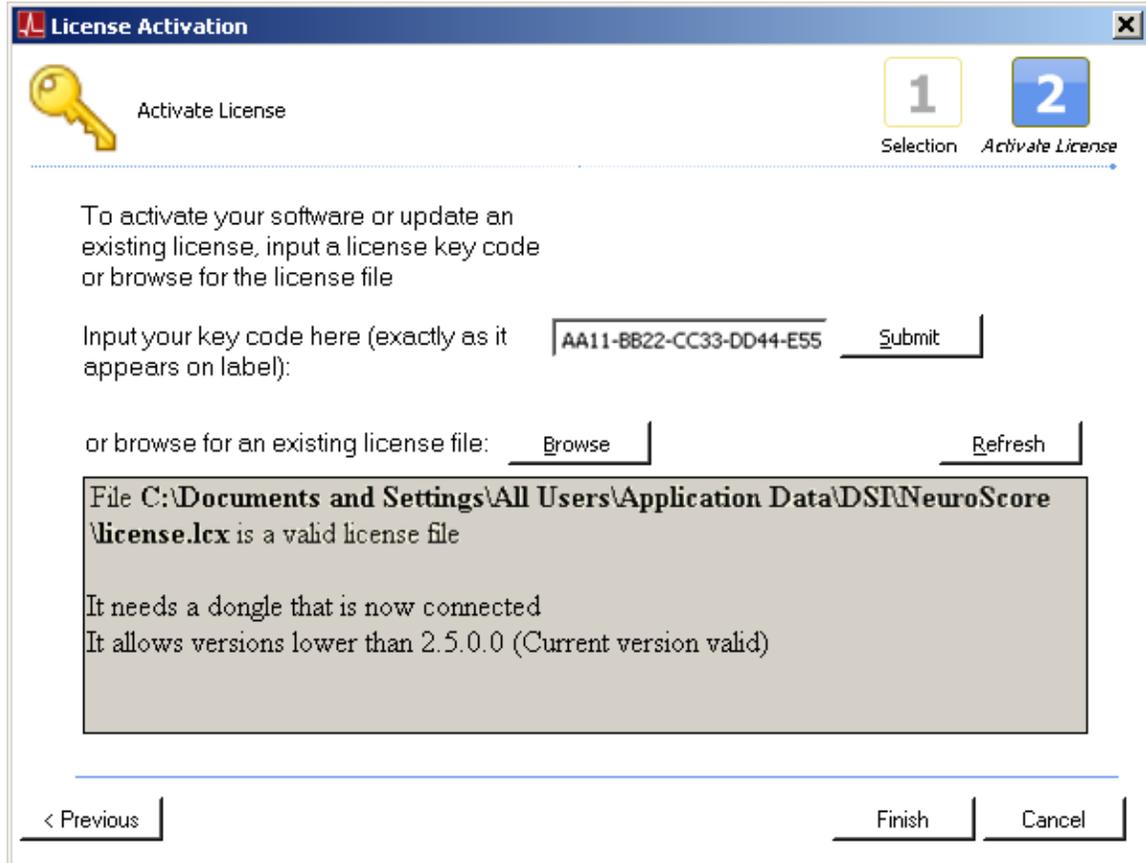
This scenario applies if NeuroScore v3.0 has already been installed and the user decides to add an optional analysis module at a later time. The program will need to retrieve an updated license file from the web server.

1. With the USB Dongle inserted, **Open** NeuroScore

2. Select **Help – About Application...**



- Click **Update License**. The existing license information will appear.



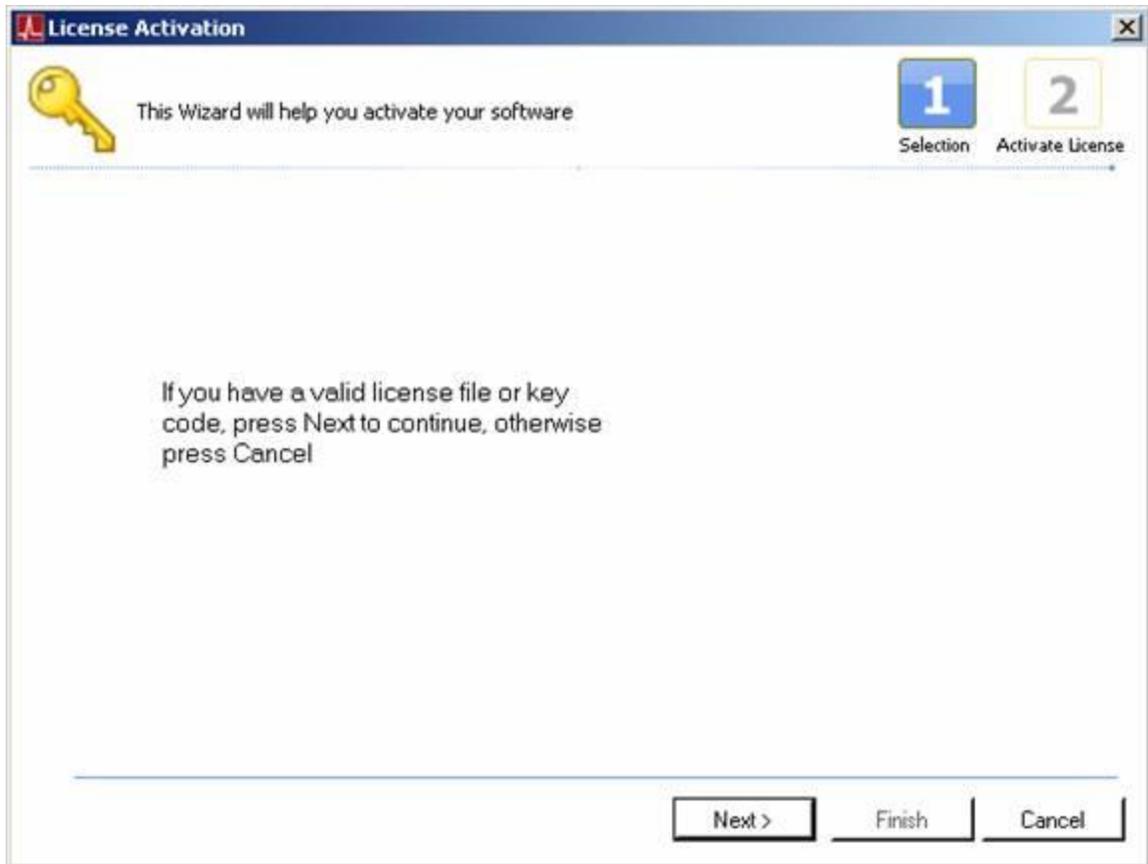
- Leave everything exactly as it appears and simply click **Submit**. The program will retrieve the updated license file from the server. No change to the message will appear.
- Click **OK**.

*Note:* If internet access is not available, please contact [DSI Technical Support](#) to obtain the license file.

### To activate the program using a license file instead of a key code

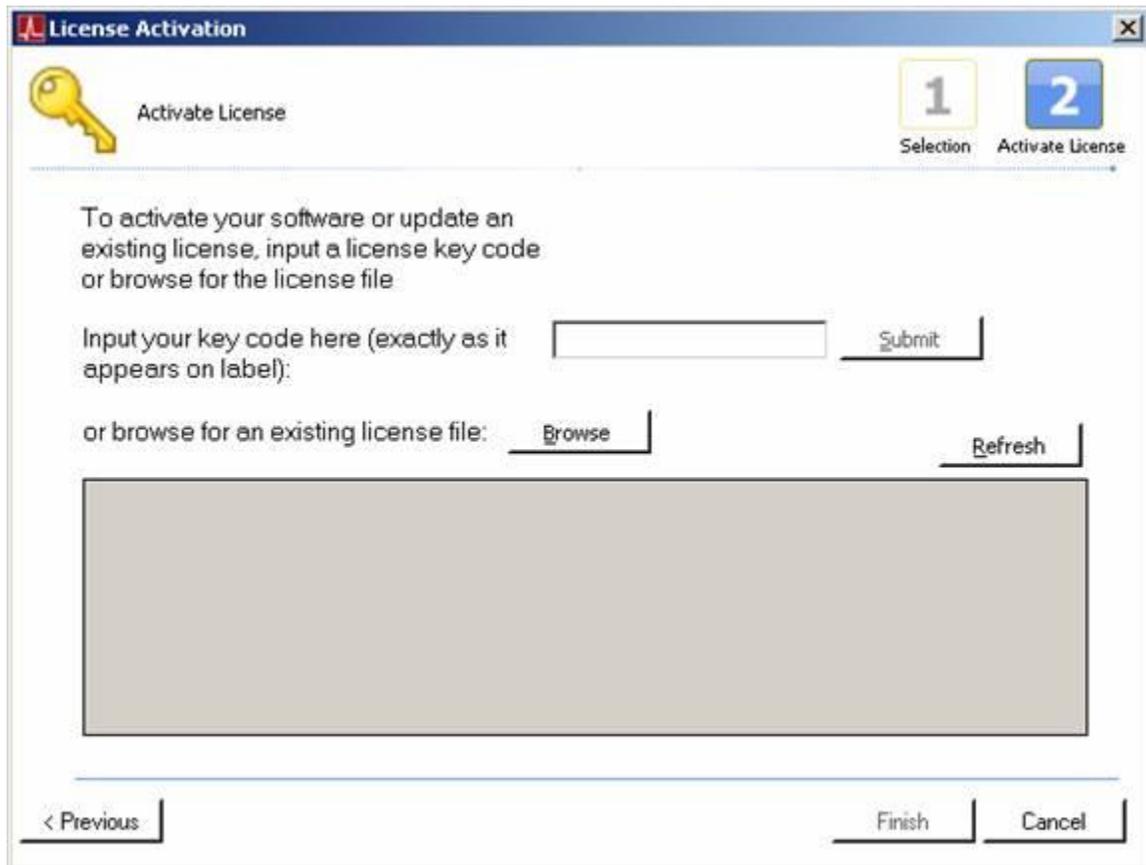
This scenario applies if internet access is not available. Technical Support will provide a license file (.lcx). Save the file in a known location on the computer where NeuroScore is installed.

- Install NeuroScore v3.0 following the steps in the [Installation](#) section.
- With the USB dongle inserted, **Open** NeuroScore
- The *License Activation* window will automatically appear.

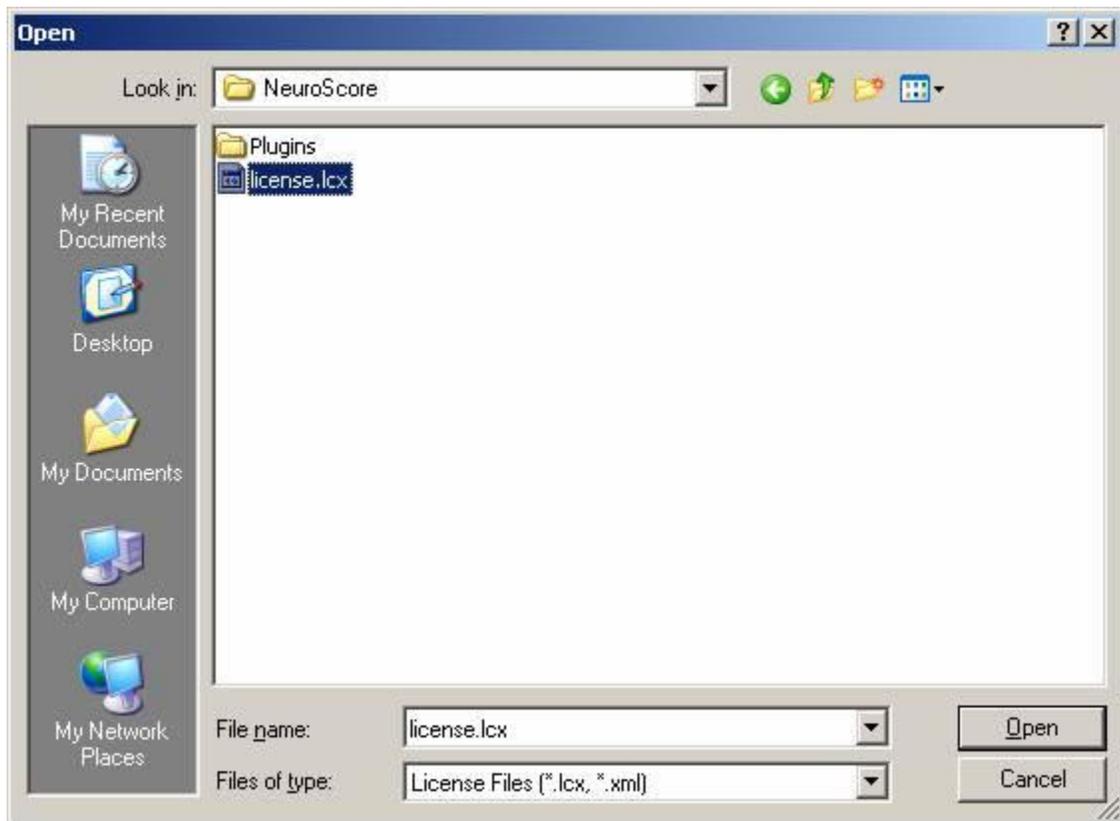


4. Click **Next**

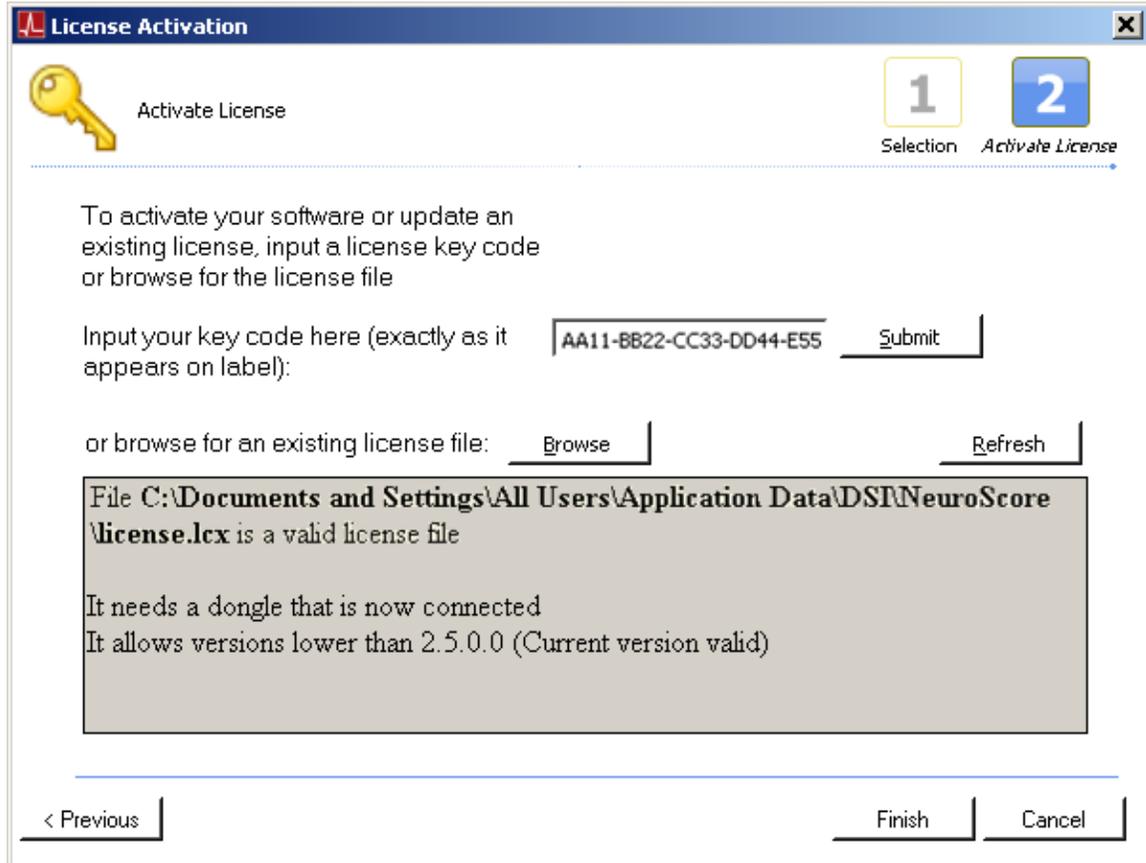
5. In the Activate License window, choose **Browse**.



6. Navigate to the location where the license file (.lcx) provided by Technical Support is located on the computer. Select **Open**.



7. A message will appear indicating the license file is valid and the dongle is connected.



8. Click **Finish**. NeuroScore will launch.

# Software License Agreement

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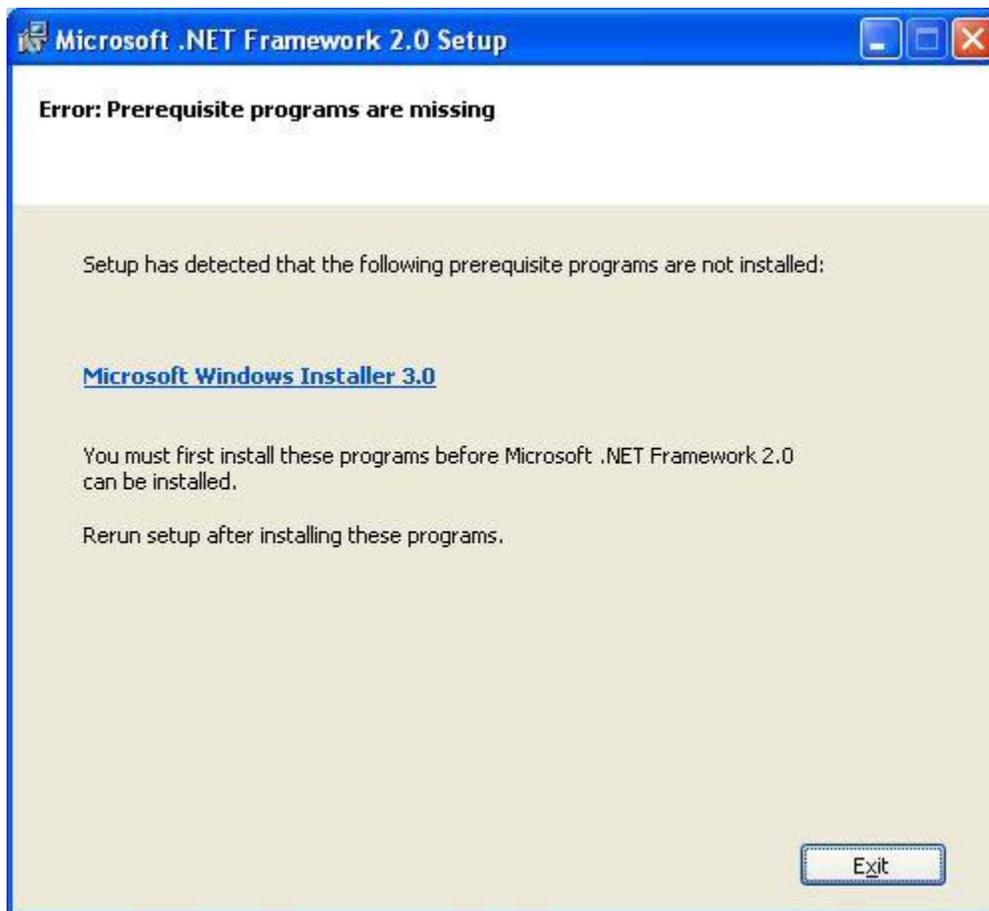
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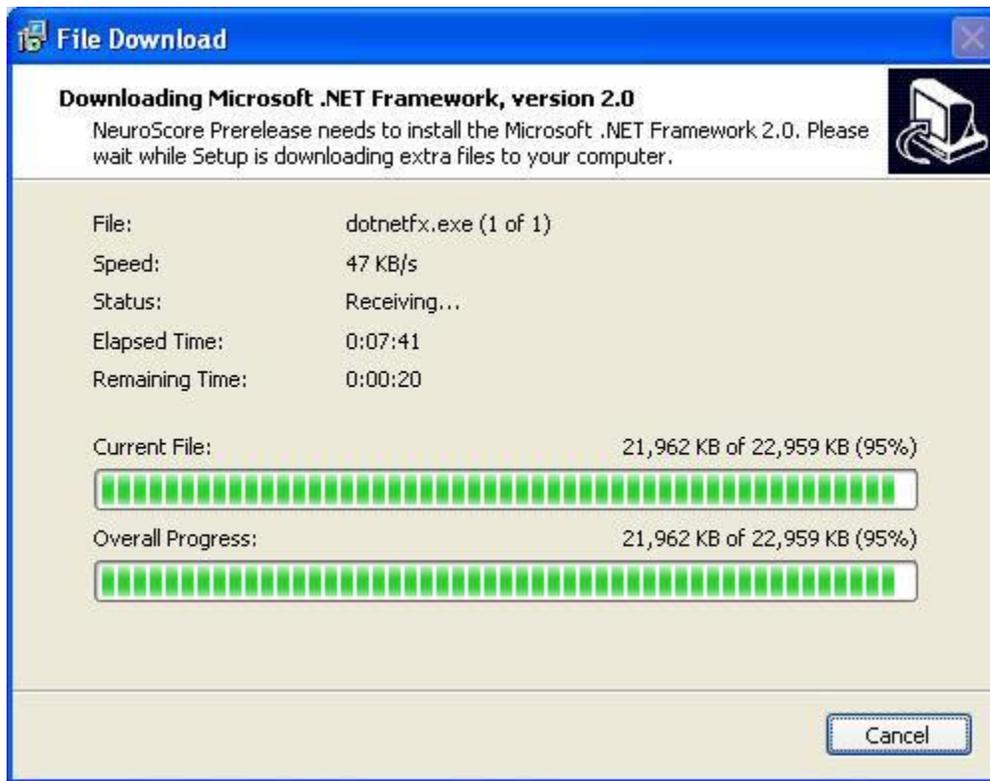
## Install .NET Framework Version 4.0

This program is needed for NeuroScore to operate successfully. Below is the outline of the wizard.

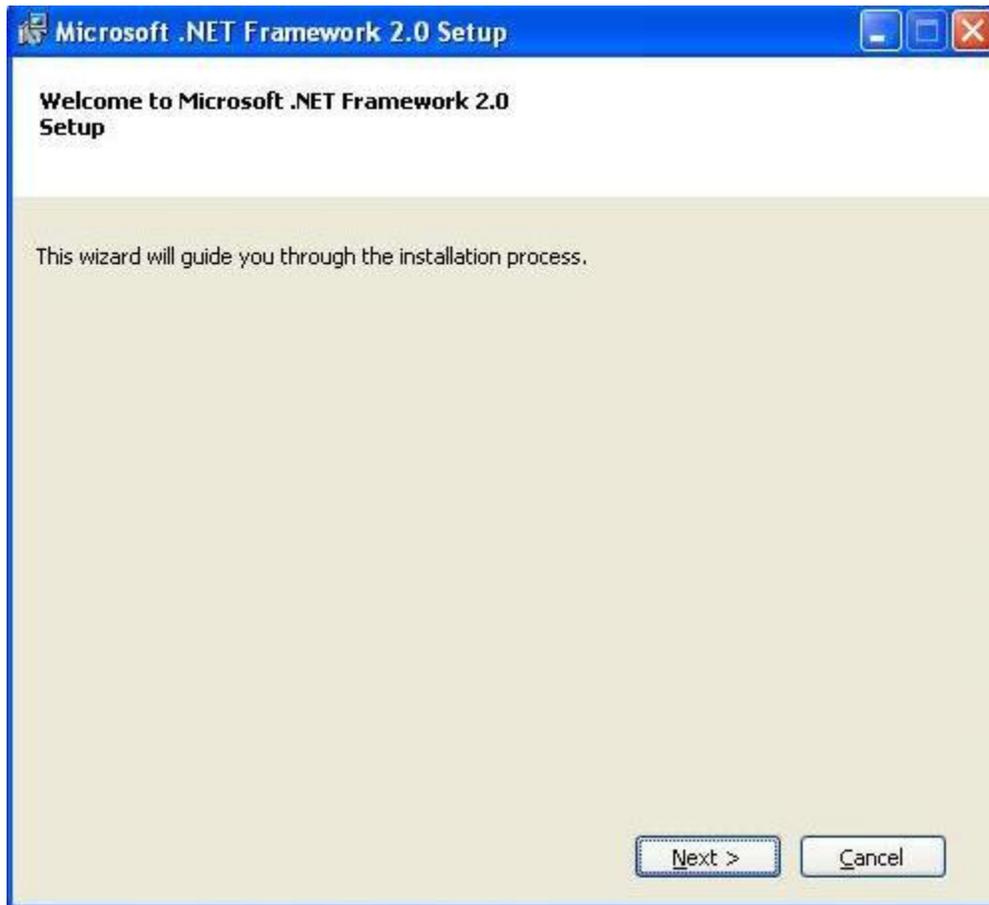
1. During the NeuroScore installation process, an error may come up indicating that the need to install this program in order to continue with the NeuroScore install. If this window comes up, click on the **Microsoft Windows Installer 3.0** link to navigate to the website to download the program at no charge.



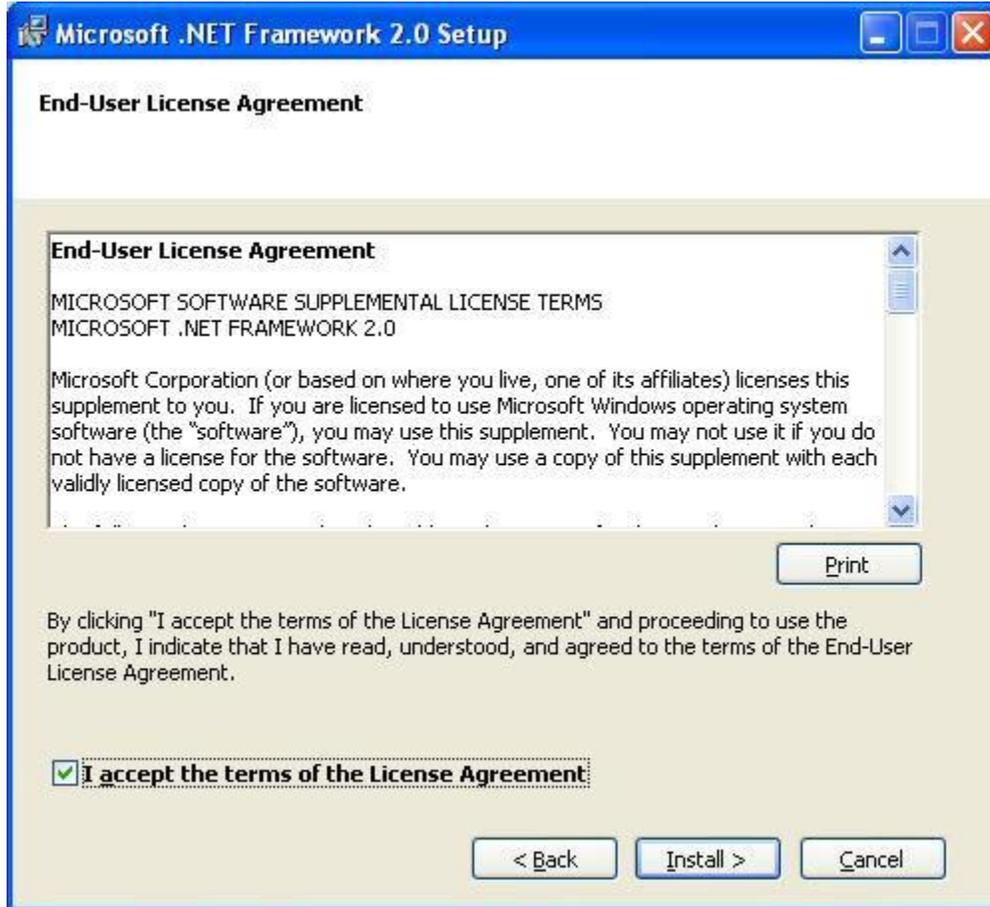
2. The files needed for this program will first need to be loaded. It will take a short time period for this to finish.



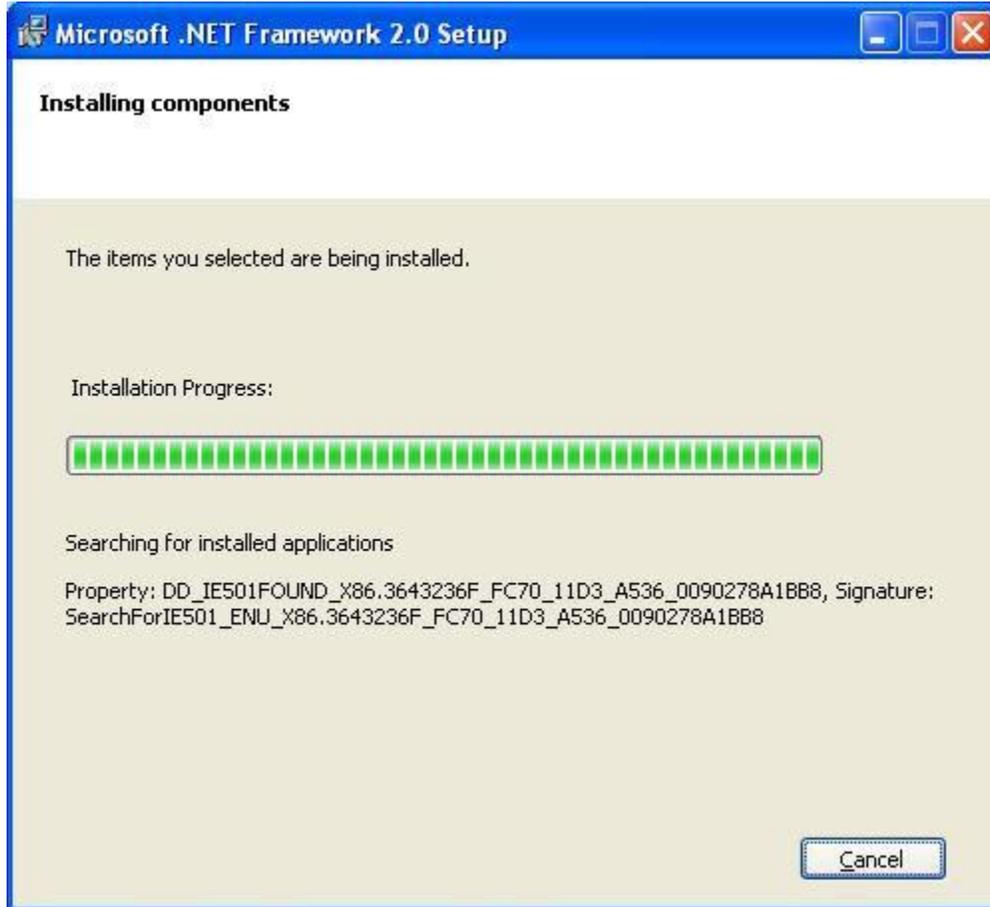
3. Follow the steps provided by the .NET Framework Wizard. Click **Next** to continue.



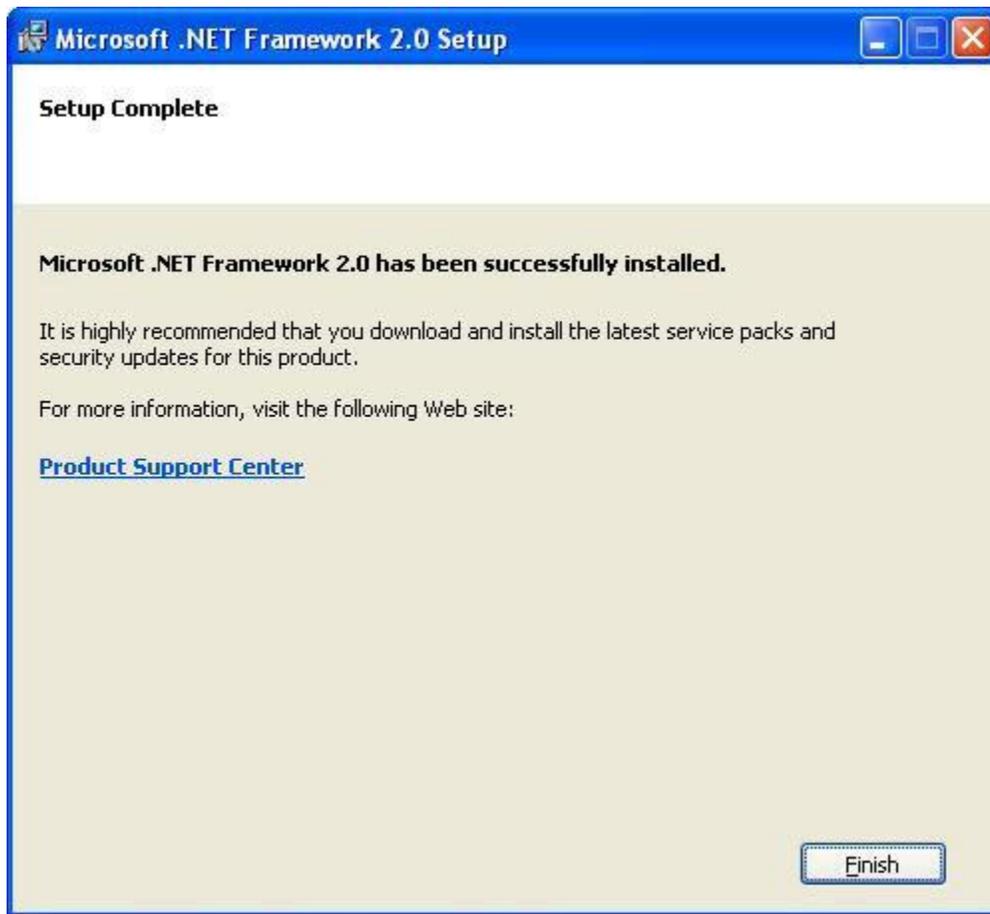
4. Click on the check box to accept the *License Agreement* and click **Install** to continue.



5. The .NET Framework will begin to install automatically.



6. Continue with the NeuroScore install by clicking the **Finish** button. It is not necessary to download and install the latest service packs and security updates for this product to finish installing the NeuroScore software.



7. The NeuroScore installation may need to be restarted. Do this by either ejecting the NeuroScore install CD and inserting it again or find the Setup.exe file on the CD by browsing the CD. The Sentinel Protection Driver may need to be installed before continuing with the NeuroScore installation.

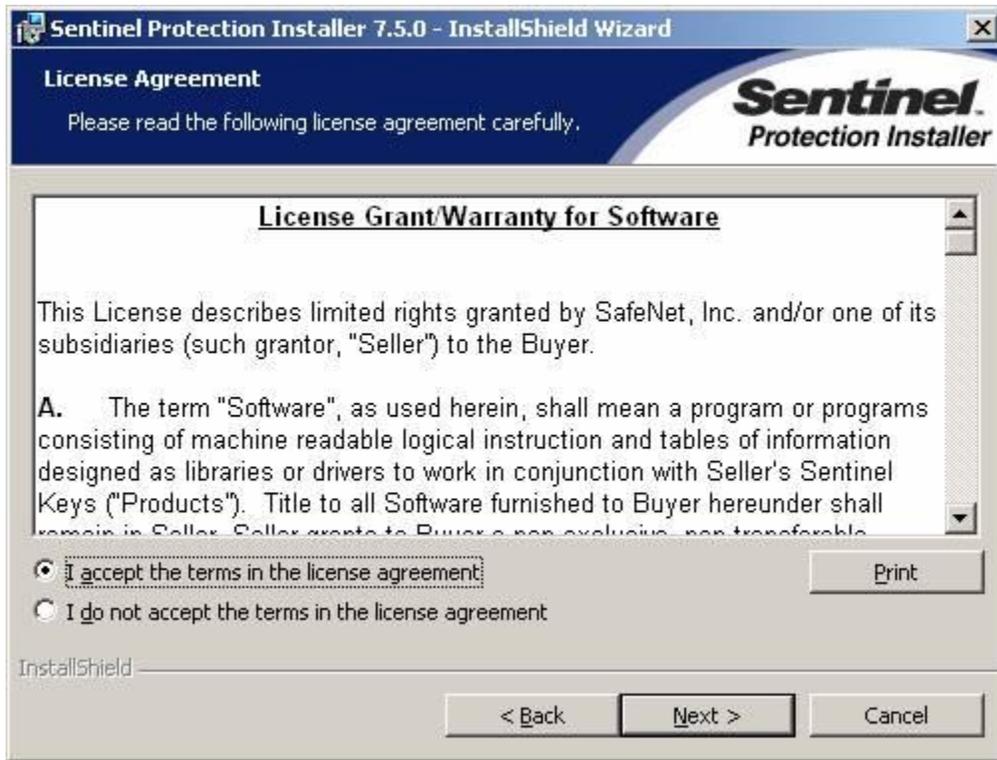
## Sentinel Protection Installer 7.5.1

A Sentinel System Driver needs to be installed before NeuroScore can be run using the SafeNet USB security dongle provided. The Sentinel Protection Installer is the software that will recognize the USB dongle and will treat it like a driver. A license key code or file that matches the dongle is provided with the software and will activate the program (see [NeuroScore License File Procedure](#)).

1. A message may populate indicating that the system contains an older version of the Sentinel System Driver or that the software is not installed. In either case, click **Upgrade** or the appropriate button.



2. The installation wizard will populate. Click **Next** to continue.
3. Agree to the License Grant/Warranty for the Software by clicking the appropriate radio button. Click **Next** to continue.



4. Choose the type of setup to run. The Complete setup is recommended; however, if there is a need to run a Custom setup, click on the appropriate radio button. Then click **Next**.



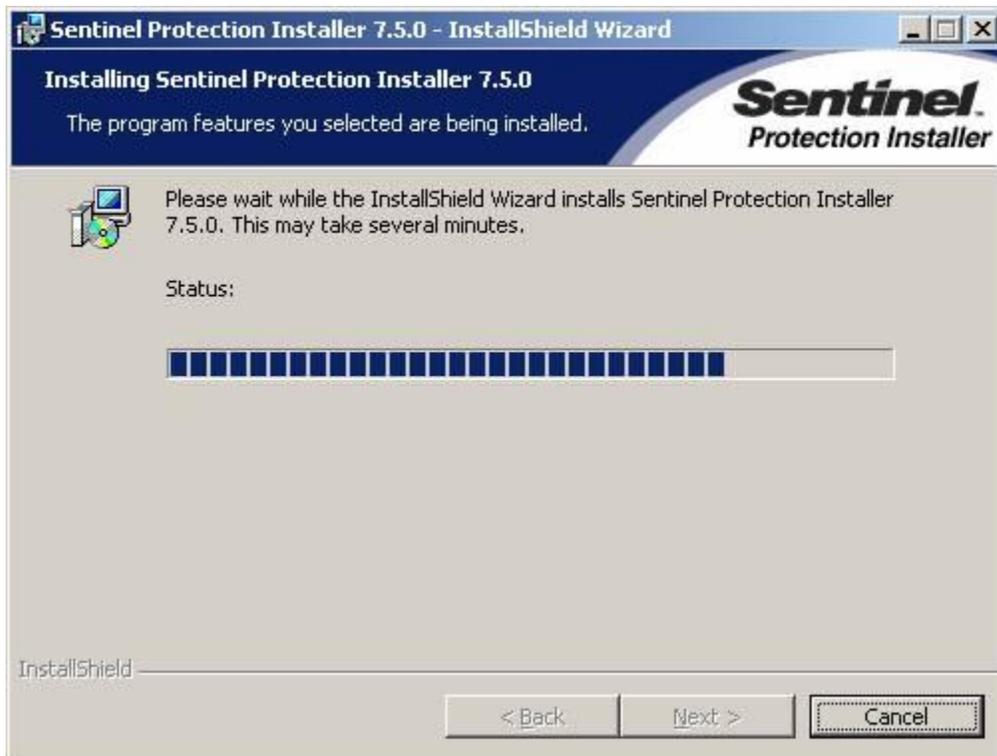
5. Select **Install**.



6. The following message may be encountered upon the beginning of the software installation. Choose to **Yes** to enable the settings so NeuroScore will have the ability to run correctly.



7. The wizard will now install the software. It may take a few moments for this to complete.



8. Select **Finish**. If prompted to restart the computer, press *No to restart at a later time* after NeuroScore is finished installing.



## Obtaining DSI Technical Services

Contact DSI Technical Services for help if questions arise with any part of the NeuroScore system.

### **Before contacting DSI Technical Services:**

- Check that the procedures that correspond to the problem have been correctly followed.
- Locate the assigned customer number. Whenever contacting DSI Technical Services, please provide:
  - Name
  - Company name
  - Phone number
  - DSI customer number

### **To obtain system installation or software-related assistance:**

Provide the following information:

- A printed copy or the exact error message including the error code number.
- The version of the software being used.
- The computer's operating system.
- The computer brand.
- Name, DSI customer number, company name, phone number, email address, and fax number.

### **DSI Technical Services Contact Information:**

#### **United States and Canada**

**Email:** support@datasci.com

**Phone:** 1-651-481-7400

**Phone:** 1-800-262-9687 (U.S. and Canada)

#### **European Services Information:**

**Email:** Europe-Support@datasci.com

**Phone:** 44(0)1359 259400

For more information about DSI, please visit our web site at [www.datasci.com](http://www.datasci.com).

# Getting Started

## Getting Started

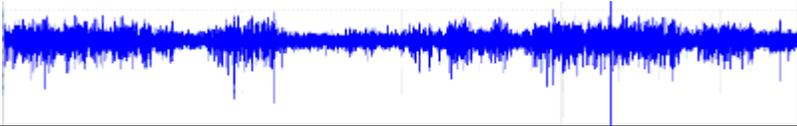
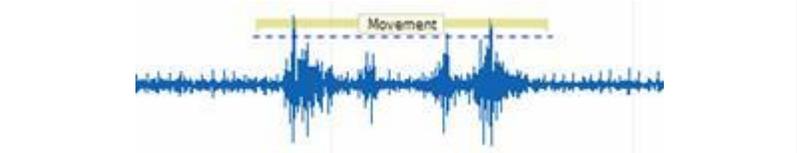
The general process of using NeuroScore is to load physiological data, analyze the data using various mathematic functions, and then save the process used as a layout. Saving processes as layouts provides the ability to open any similar data set and analyze it using equivalent processes and algorithms. NeuroScore also provides a number of different capabilities of reporting experimental results. Reports can be generated from analyzed data to display a variety of sleep scoring parameter and statistical information in a layout that is easy to understand and follow.

Before analyzing data, it is helpful to go through what each menu has to offer, as well as learn how to load recordings of data.

- Working with Recordings
- NeuroScore Menus

## NeuroScore General Concepts

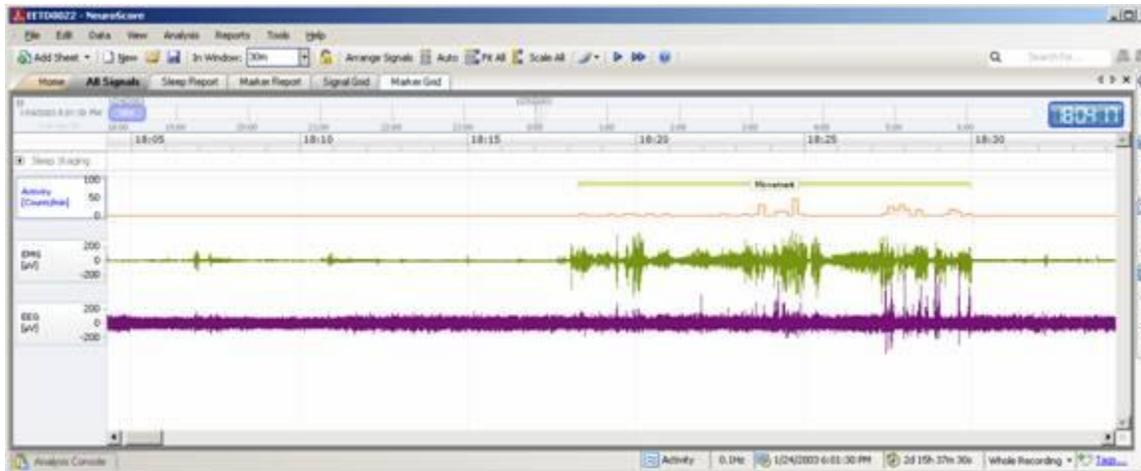
Below are a list of terms that are used in the manual and the software. Please note that some of the terms used in other DSI software are defined slightly different for NeuroScore.

Concept	Description
Recording	<p>A data set consisting of a compilation of signals recorded from a subject is called a recording. A recording can consist of one or more files of the following type: DSI, Ponemah, Embla, BioPac, Spike 2, EDF/EDF+, and Signal One recordings. For addition information, please see Working with Recordings.</p>
Signal	<p>Each recording can have one or more signals associated with it. A Signal is a continuous data stream which has an explicit start time, duration and sampling rate. The NeuroScore application supports any number of signals within a single recording with sampling rates ranging from 0.0001Hz to 10MHz.</p> <p>An example of a signal is an EEG signal recorded at 250 Hz for 10 minutes, see below.</p> 
Marker	<p>A marker is used to identify areas of interest in a signal. A marker has a start and stop time and an identifier used to classify it. Markers can be used for many different reasons, e.g. markers are used when scoring sleep and markers can be used to mark areas of high activity or an area of seizure activity. See the Markers, Bouts and Trimming section for further explanation on how these markers are calculated.</p> 

Bouts	A group of consecutive markers of the same type is referred to as a bout. For example, an episode of wakefulness that spans more than 1 epoch would be considered a bout. Bouts are only used for sleep scoring markers. The Markers, Bouts and Trimming section can be helpful if you are interested in using bouts.
Scoring	A collection of markers can be saved as a scoring. Multiple scorings can be associated with a signal recording; although, only one can be active at any given time. Scorings can be edited and renamed for convenience. For more information, please see Working with Scorings.
Sheet	A sheet is a window docked inside the main application window and represents a view of the recording. Many different views can be expressed, such as a graphical representation of signals and numerical representation of signals. Some sheets are static, meaning that they always exist, such as the startup sheet which contains a user interface that simplifies working with data. Most sheets allow multiple instances, such as signal view sheet which is used to work view signals in a graphical manner. Reports are also sheets and many general purpose sheets are available. For more information, please see Sheets and Sheet Layouts.
Period	A period is a way to work with data in a more simplified manner. Many DSI and Ponemah recordings span days even weeks, which can be difficult to manage in a single session. The periods allow the data to be split up into logical time intervals, such as day time or night time for the whole recording. For more information, please see Working with Periods.
Workspace	The workspace is a name given for all data, described above, associated with the work applied to a single recording. The layout of data sheets, scored markers and reports are all stored as a part of the workspace. The philosophy behind NeuroScore workspace functionality is that the data will save and be attainable as it was previously left. For more information, please see NeuroScore Work Environment.

## Markers, Bouts, and Trimming

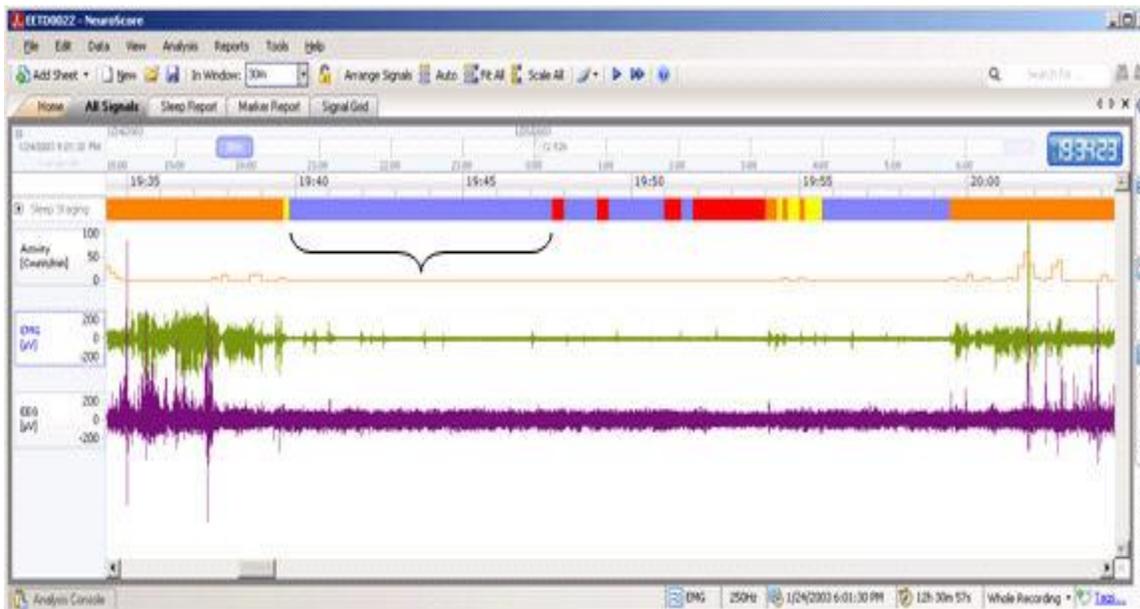
**Marker:** A marker is a single scored event. For non-sleep stage markers (ex. movement, spikes, theta, etc), markers can have arbitrary start and end times and consist of any duration. The figure below shows a movement marker on an Activity signal. This is a non-sleep marker and does not occur based on epochs.



A sleep marker (ex. Paradoxical) is scored based on a user-defined epoch duration (ex. 10 seconds). By default, the marker is scored for the entire epoch in which it occurs. A new marker would be used to score subsequent epochs even if it is of the same marker type. The figure below shows sleep markers for 10-second epochs. Notice how two consecutive paradoxical markers have occurred.

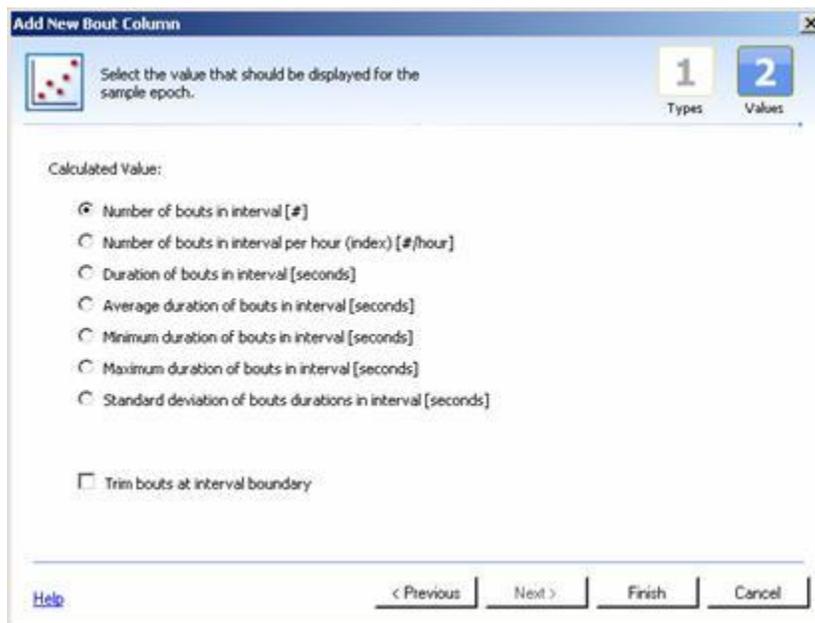


**Bout:** A bout is the entire time a particular sleep stage occurs before changing to another scored stage. If a sleep stage occurs over several epochs consecutively, it is reported as a single bout. A bout can be 1 epoch in duration or many depending on the duration the subject remains in that stage. For example, if the subject is in SWS for 47 consecutive 10-second epochs, that entire bout of SWS would be calculated with a duration of 470 seconds. Bouts are not used to report non-sleep events since they are already reported as a single event for their full duration and are not broken up by epochs. Below a bout of SWS is shown as an example. The bracketed bout occurred over 47 consecutive 10-second epochs.



## Reporting Markers and Bouts:

Information about markers and bouts can be computed using the Signal Grid and Marker Grid. When using the **Signal Grid**, marker or bout information is calculated based on a user-defined time interval (ex. 1 hour). Each row in the signal grid represents the time period designated and each column provides the desired calculated value. Calculated values can include the number, duration, min/max/ave/stdev of the duration of the marker or bout. When determining the calculated value of the marker or bout, there is an option to **Trim** the marker or bout at the interval boundary.



### Trimming

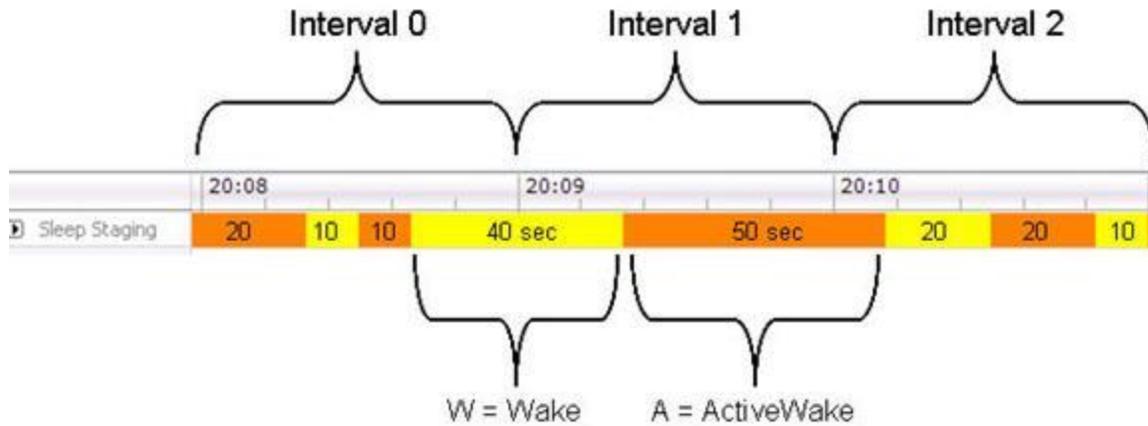
The trimming option affects how the marker or bout is defined. When trimming is not enabled, the marker or bout calculated value is not affected by the time interval boundary. For example, if a bout of SWS occurs such that it crosses the defined interval boundary (ex. 1 hour) it can either be reported in its entirety or be divided by the interval. When trimming is not enabled, the marker or bout is reported in its entirety regardless if it crosses an interval boundary. Various filter settings exist to determine which interval(s) the information is reported.

When trimming is enabled, the marker or bout is affected by the interval boundary. This option is most commonly used to divide the marker or bout and so it is reported in each of the intervals in which it occurs.

The table below provides a general summary of the reporting results using non-sleep markers and sleep bouts. Since sleep stages reported as markers are restricted by the epoch duration, they are usually not reported in this manner and do not follow the scenarios outlined. The two most commonly reported scenarios are highlighted.

<b>Filter setting</b>	<b>Overlaps</b>	<b>Ends In</b>	<b>Starts In</b>	<b>Lies Within</b>
<b>Trim not enabled</b>	The full duration is reported in each interval where any of the marker or bout occurs. The full duration will be reported more than once if it crosses an interval boundary.	The full duration of the marker or bout is reported in the interval in which it ends.	The full duration of the marker or bout is reported in the interval in which it begins.	Only markers or bouts that are fully contained within the interval boundary are reported. Any marker or bout that overlaps a boundary is ignored.
<b>Trim enabled</b>	Markers or bouts are split at the interval boundary and the duration spent in each interval is reported. The marker or bout is counted multiple times if it crosses an interval boundary.	Only the portion of the marker or bout contained within the interval in which it ends is reported. Any other portion occurring in another interval is not reported.	Only the portion of the marker or bout contained within the interval in which it starts is reported. Any other portion occurring in another interval is not reported.	Same as above since any overlapping marker or bout is ignored.

The two highlighted approaches are shown in the following example of scored data using the Wake and Active Wake sleep markers and a 1 minute time interval:



Reporting this as bouts in the Signal Grid using the Starts In filter and no trimming would give the following results:

Epoch (Interval 1 min)	Avg Bout Duration (A) [sec]	Total Duration of Bouts (A) [sec]	Number of Bouts (A) (start in interval)	Avg Bout Duration (W) [sec]	Total Duration of Bouts (W) [sec]	Number of Bouts (W) (start in interval)
0	15	30	2	25	50	2
1	50	50	1	0	0	0
2	20	20	1	15	30	2

If reporting this as bouts using the Overlaps filter and trimming would give these alternative results:

Epoch (Interval 1 min)	Avg Marker Duration (A) [sec]	Total Marker Duration of (A) [sec]	Number of Markers (A)	Avg Marker Duration (W) [sec]	Total Marker Duration of (W) [sec]	Number of Markers (W)
0	10	30	3	10	30	3
1	10	40	4	10	20	2
2	10	30	3	10	30	3

When using the **Marker Grid**, time intervals are ignored for reporting markers and bouts. Each row of the grid represents an individual marker or bout regardless of its duration. Each column represents various information about the marker and bout and can include the start time, end time, epoch number, etc. The Marker Grid is convenient for reporting non-sleep markers and sleep bouts. Since time intervals are not used, the trimming option doesn't apply to the marker grid. Below is a Marker Grid showing sleep bouts. The grid is reporting the start time, duration, start and end epoch for each bout.

The screenshot shows the NeuroScore software interface with a 'Sleep Bouts Marker Grid' table. The table contains 20 rows of data representing sleep bouts, with columns for Row, End Sleep, Start Time, Duration, Start Epoch, and End Epoch.

Row	End Sleep	Start Time	Duration	Start Epoch	End Epoch
0	W	6:01:30 PM	25:00	0	2
1	S	6:01:50 PM	15:00	2	3
2	P	6:02:00 PM	25:00	3	5
3	S	6:02:20 PM	50:00	5	10
4	P	6:03:10 PM	15:00	10	11
5	S	6:03:20 PM	40:00	11	15
6	P	6:04:00 PM	15:00	15	16
7	S	6:04:10 PM	40:00	16	20
8	P	6:04:50 PM	120:00	20	32
9	A	6:06:50 PM	15:00	32	33
10	W	6:07:00 PM	15:00	33	34
11	S	6:07:10 PM	25:00	34	36
12	P	6:07:30 PM	140:00	36	55
13	S	6:10:40 PM	30:00	55	59
14	P	6:11:10 PM	15:00	59	59
15	S	6:11:20 PM	25:00	59	61
16	P	6:11:40 PM	30:00	61	64
17	S	6:12:10 PM	100:00	64	74
18	P	6:13:50 PM	30:00	74	77
19	S	6:14:20 PM	240:00	77	101



Most sheets can be stored as layouts, where the user initially arranges the layout and then stores it under a customizable name. Layouts can then be easily applied back to any active recording.

### **Sheet View Area**

All sheets are docked in the main application. Each sheet is displayed as a tab and the user can easily switch between different sheets by selecting a tab. Sheets can also be dragged and docked to the side of or below an existing sheet, see below. Instructions on this are below under Startup Sheet.

Menu options become enabled or disabled depending on the selected sheet. Some sheets support printing and exporting while others support exporting but no printing.

### **Task Windows**

Task windows are used to manipulate the content shown in sheets. By default there are five task windows available in NeuroScore: Analysis, Scorings, Periods, Marker List and Signals & Data.

#### **Analysis**

General management of analysis protocols (see Working with Protocols). Here the user can create new, edit, delete and execute analysis protocols.

#### **Scoring**

This task window contains a list of all scorings available for the current recording. It also enables the user to manage scorings (see: Working with Scorings).

#### **Periods**

Periods allow for more isolated working conditions when working with very long data files (see: Working with Periods). Recordings spanning days and even weeks will become cluttered in the user interface, periods can be defined so the user can better organize their data; e.g. lights off or lights on periods, which applies boundaries to analysis, reports and the data views themselves. By default the entire recording splits days up into different periods.

#### **Signals & Data**

This task window allows the user to manipulate the content of signal sheets. A signal sheet is a sheet that represents the signals or a recording in one way or another. Not all sheets support the use of this task window. See Working with Signals for more information.

## Marker List

The Marker List task window allows the user to turn ON (ex. ) or OFF (ex. ) the listing of any marker of interest. Markers from the active signal in the graph page  or all markers  can be shown. Available markers and their symbols can be edited in the Working with Marker Types section.

## Bottom of Screen: Analysis Console and Bookmark

**Analysis Console:** When opened, the analysis console shows the current status of an automated protocol that is running.

**Bookmark:** The bookmark tab allows the user to add, remove and edit bookmarks to areas of interest in a recording. Bookmarks can also be added to a report. See Bookmarks for more detailed information.

## Startup Sheet

When opening up a recording, the main NeuroScore window will populate. There are two tabs: **All Signals** and **Home**. The *All Signal* tab has all the signals that were loaded with the recording. The *Home* tab allows the user to view recording information - *Animal ID*, *Species*, *Start Time*, *Duration*, *Recording Type*, *Path*, *Tags*, and *Comments* - all of which can be edited from this tab by selecting the **Edit** link.

To view multiple tabs split up into smaller windows within the current NeuroScore window:

1. Select one of the sheet tabs of interest.
2. **Click-and-drag** the tab heading towards the center of the screen.
3. Notice there is a '*cross*' shape that populates in the center of the screen.
4. **Drag and drop** the mouse pointer to the side of the '*cross*' according to where it is desired to have the sheet located.
  - a. For example, if the sheet is dragged to the right hand side, it will split the screen vertically down the middle and display the user dragged sheet on the right, while the remaining sheets share the other screen.
  - b. See **Figure 2** above for an example of this.

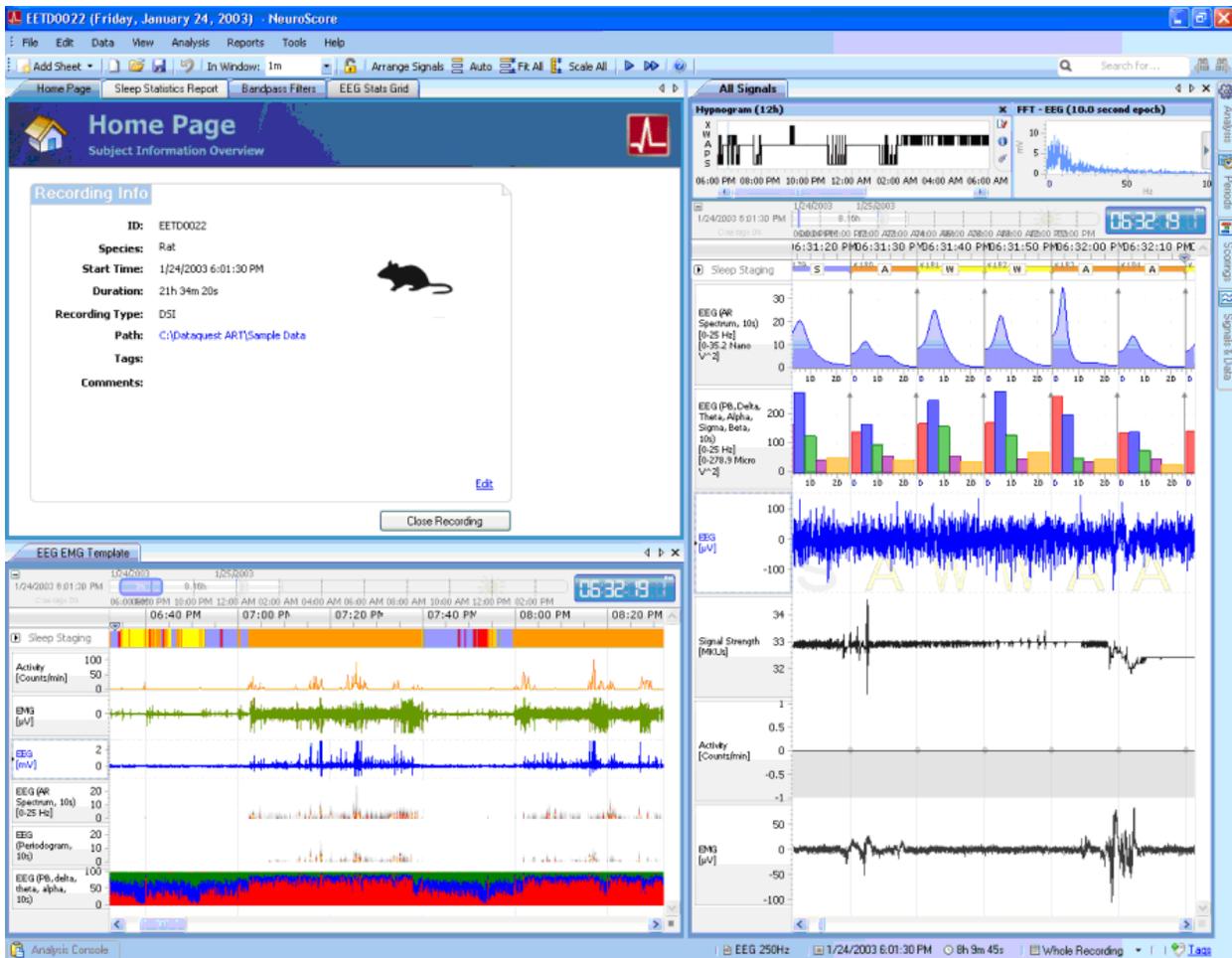


Figure 2: Multi-tab viewing work environment setup.

5. To combine the sheets back together:
  - a. **Click** on the *sheet* tab and then **drag** towards the center.
  - b. When the 'cross' shape populates, **drop** the tab
  - c. This brings back the tab to the main window and rearranges the NeuroScore window appropriately.
6. To separate tabs into separate windows that can be viewed on separate screens:
  - a. Double Click on the sheet tab
  - b. Then drag to the desired position
7. Once tabs have been separate into separate windows, to combine them back together:
  - a. Double Click on the top blue bar of the separate window
  - b. This will have the separate window go back as a tab in the Neuroscore main screen

## NeuroScore Menus

### NeuroScore Menus

The list below includes all the menus available in NeuroScore. To determine what each menu contains, click the links:

- [File Menu](#)
- [Edit Menu](#)
- [Data Menu](#)
- [View Menu](#)
- [Analysis Menu](#)
- [Reports Menu](#)
- [Batch Processing](#)
- [Tools Menu](#)
- [Help Menu](#)

*Note:* Additional information about many of the menu options can be found in subsequent sections of the user manual.

## File Menu

This menu provides access to basic functionality of software programs:

- **New Workspace [Ctrl + N]:** Opens a completely separate NeuroScore window that provides the ability to work with a different recording.
- **Open Recording...[Ctrl + O]:** Opens another recording in a new session other than the current one. For a list of files that are supported by NeuroScore see Working with Recordings.
- **Close & Save Workspace:** Saves the current settings and scorings for the recording, then closes the active workspace and returns the user to the Study Library.
- **Save Workspace...[Ctrl + S]:** Saves the current settings for the entire layout and also the scored markers to the hard drive. The *Save Workspace* is automatically done every 10 minutes and when the software is exited. It can also be done manually by using this method. Please note that scoring sessions should be saved separately (see Data Menu section)
- **Add Sheet:** Adds a new sheet to the current NeuroScore window. Examples include: signal sheet, overview sheet, signal grid and marker grid.
- **Close Sheet:** Closes the current sheet that is open.
- **Export Sheet...:** Exports the current sheet as a particular file type depending on which sheet is trying to be exported.
  - Report sheets: Excel (\*.xls), portable document format (\*.pdf), hyper text markup language (\*.html) and rich text format (\*.rtf).
  - Signal grid sheet: Excel (\*.xls), comma separated values (\*.csv), text (\*.txt) and DSI parameter text file (\*.txt).
  - Signal and overview sheets: Meta file (\*.emf) or a Png file (\*.png).
- **Export Recording...:** Exports the entire recording of data from the subject. The file formats available to export the entire recording are either EDF (European Data Format) or Embla.
- **Create Virtual Recording:** Combines 2 or more recordings into a single file, primarily for adding external sources, such as ambient light and temperature sources, to a recording or to combine data sets from the same subject recorded on 2 different computers
- **Recording Properties...[Ctrl + I]:** Opens the signal properties window providing access to Signal Info, Subject Info, Time Offsets, Species Selection, and Time Zone Specification of the loaded signal. Information about when the recording was collected can also be seen.
- **Add Recording to Library:** Adds a recording to the library of NeuroScore to make it easier to access.
- **Edit Interpretation Notes:** Opens a new **Interpretation Notes** tab. Interpretation Notes can be added to a report.
- **Reset Recording Library:** Removes all the current recordings in the library. Custom Folders are maintained, but emptied.
- **Revert Workspace:** Reverts the workspace to the point when the session was opened or last saved by the user. This option allows the user to undo work that has been performed before exiting.

- **Print [Ctrl + P]:** Prints the current sheet in the NeuroScore window. Please note that this function is only available for the report, signal and overview sheets.
- **Exit:** Exits the NeuroScore software.

## Edit Menu

This menu provides the ability to manage some of the global settings within the software. It also has some of the common editing options:

- **Undo [Ctrl + Z]:** Undoes the last action performed in the *Workspace*.
- **Redo [Ctrl + Y]:** Redoes the last action undone action performed in the *Workspace*.
- **Cut [Ctrl + X]:** Deletes the text/image that is currently selected. Can use the paste function to place at a different location.
- **Copy [Ctrl + C]:** Copies the current text/image selected. The paste function will place the copied selection.
- **Paste [Ctrl + V]:** Pastes the text/image that was copied or cut.
- **Delete Selected Marker [Del]:** Deletes the currently selected marker..
- **Remove Selected Signal [Shift + Del]:** Removes the currently selected signal..
- **Scoring Shortcut Keys...:** Launches a window that will allow the user to assign shortcut keys to the marker types and classifications that have already been created.
- **Sheet Layouts...:** Accesses the sheet layouts available and provides the option to make changes to sheets. Sheet layouts available are signal, overview, and grid.
- **Save Sheet Layout...:** Saves the active sheet as a *Layout (template)* for future use.
- **Sheet Properties...:** Allows adjustment of the active signal sheets' global settings.
- **Configuration**
  - **Marker Types and Groups...:** Populates marker types and groups property management window.
  - **Signal Types and Groups:** Populates signal types and groups property management window.
  - **Signal/Marker Mapping:** Populates signal marker/label property management window..
  - **Power Bands...:** Populates power band global settings property management window.
- **Find [Ctrl + F]:** Opens the Search for... drop-down box to allow markers to be searched.
- **Find Next [Tab]:** Advances to the next location of the current marker being searched.
- **Find Previous [Tab + Shift]:** Reverses to the previous location of the marker being searched.

## Data Menu

This menu provides the ability to work with the scorings and signals:

- **Scorings...:** Expands the *Scoring* tab on the Task Windows panel on the right hand side of the NeuroScore window. The scoring tab allows the user to select which scoring session is active for grids, reports, etc.
- **New Scoring...:** Begins scoring the data using a new scoring data set.
- **Save Scoring:** Saves the scoring that has been applied to a signal. Scorings are saved with the subject ID.
- **Save Scoring As...:** Saves the scoring as the current name or permits change to the scoring name it will be saved under.
- **Clear Scoring...:** Clears the currently selected scoring that has been applied.
- **Revert Scoring...:** The currently selected scoring will be undone (this is particularly useful with the manual scoring).
- **View Other Scorings:** Displays a list of saved scorings and allows the option to switch between scorings displayed in the signals sheet by clicking on the scoring name.
- **Signals...:** Expands the *Signals & Data* tab on the *Task Manager* panel in the NeuroScore window.
- **Add Derived Signal...:** Opens a window that will allow a specific derived signal to be opened in the current signal sheet. This can also be done by selecting a signal in a signal sheet - **Right Click - Add Derived Signal**
- **Add Reference Signal...:** Opens a window that allows the addition of a reference signal to the signal sheets.

## View Menu

This menu allows the user to change view settings of the signals within the signal sheet:

- **Navigation Bar:** Exposes or hides the Navigation Bar in Signal Sheet tabs. (The Navigation Bar displays the time duration of the active period and indicates the position and duration of the data shown in the window.)
- **Coverage Tracking:** Tracks what data has been viewed on the screen, when enabled. The percentage is the percentage of the total recording duration you have tracked
- **Scale Signals** [**<F9>**]: Adjusts the y-axis range of all the signals to completely display the signals' magnitude within that range.
- **Center Signals:** Centers all the signals within the range that is currently displayed, making its mean the center of the signal.
- **Arrange Signals** [**<Ctrl> + <A>**]: Spaces all displayed signals evenly without changing their size.
- **Auto Center After Scroll:** Re-centers the signals after the user has scrolled through the data.
- **Increase Scaling** [**<Shift> + <Up>**]: Increases the scaling of the active signal.
- **Decrease Scaling** [**<Shift> + <Down>**]: Decreases the scaling of the active signal.
- **Move Signal Up** [**<Control> + <Up>**]: Moves center of signal up
- **Move Signal Down** [**<Control> + <Down>**]: Moves center of signal down
- **Previous Signal** [**<Up>**]: Moves cursor to signal above active signal
- **Next Signal** [**<Down>**] **Previous Signal** [**<Up>**]: Moves cursor to signal below active signal
- **Playback** [**<Spacebar>**]: Advances the current recording through time from the current displayed recording position.
- **Measure XY Value:** Calculates the difference between the x- and y-values of two points. This function cannot be carried out by selecting it in this menu, but rather has to be done within the signal sheet. Determine the point of interest and then press **<Shift> + Click-Drag** to obtain the calculated difference. To clear it, click somewhere else within the sheet. This only works on the signals loaded in with the recording, not on derived signals.
- **Measure Value:** Measure the value of an arbitrary point within a signal. This function cannot be carried out by selecting it in this menu, but rather has to be done within the signal sheet. Determine the point of interest and then press **<Alt> + Click-Drag** to obtain the value. To clear it, click somewhere else within the sheet. This only works on the signals loaded in with the recording, not on derived signals.
- **Show Deleted Markers:** Displays deleted markers within the signal sheet.
- **AR Spectrum:** Displays the current AR Spectrums that have been calculated from the currently selected signal. If none have been calculated, then there will only be a black screen. See Derived Graphs from Individual Signals.
- **Staging History:** Displays the current Staging History if any sleep stages have been scored from the currently selected signal. If none have been scored, then there will only be a black screen. See Derived Graphs from Individual Signals.

- **Power Bands:** Displays the current Power Bands that have been calculated from the currently selected signal. If none have been calculated, then there will only be a black screen. See Derived Graphs from Individual Signals.
- **Periodogram:** Displays the current Periodograms that have been calculated from the currently selected signal. If none have been calculated, then there will only be a black screen. See Derived Graphs from Individual Signals.
- **Marker Overview:** Displays what markers have been applied to the currently selected signal. If none have been applied, then there will only be a black screen. See Derived Graphs from Individual Signals.
- **FFT:** Displays the current Fast Fourier Transforms that have been calculated from the currently selected signal. If none have been calculated, then there will only be a black screen. See Derived Graphs from Individual Signals.
- **Hypnogram:** Display the current Hypnograms that have been calculated from the currently selected signal. If none have been calculated, then there will only be a black screen. See Derived Graphs from Individual Signals.
- **Video Player:** Displays the Synchronized Video data of the active signal displayed corresponding to the Time Axis Synchronization Marker . This option will only be available if the Video Module is purchased.

## Analysis Menu

This menu provides the ability to create automated analysis protocols based on various detectors. Once a protocol is created, it will be listed under the Analysis Menu for use. One or more detectors can be used in a protocol. The Amplitude and EMG detectors are included with the Core Software. All other detectors are part of additional pay-for options. To set up custom protocols, please see Working with Protocols section.

- **New Protocol...:** Allows the user to setup a new protocol. A new tab, *New Analysis Protocol*, in the NeuroScore window will be added where all the settings are configured for this protocol. The tab will remain open until the *Close* or *Save and Close* button is clicked.
- **New Protocol Based On...:** Allows the user to create a new protocol based on the settings already used for an existing protocol. The settings can be modified and the protocol must be saved with a new name.
- **Manage Protocols...:** Allows the user to edit an existing protocol. The settings can be adjusted and the protocol is re-saved. In addition, the protocols can be deleted or renamed.

The following protocols are pre-configured and included as an option when the Rodent Sleep Module is purchased:

- **Rodent Sleep Scoring:** This is an automated scoring option that will allow the user to select which signals are used as inputs to the protocol. Inputs include: EEG Cortical, EEG Theta, EMG neck and activity. The same signal can be selected as the input to more than one data type (ex. the same EEG channel could be used for the Cortical and Theta designations). The settings for this protocol are universal for scoring rodents and may need to be adjusted to improve scoring results. See Creating New Analysis Protocols.
- **Rodent Sleep Scoring 2:** This is an automated scoring option that will allow the user to select which signals are used as inputs to the protocol. Inputs include: EEG Cortical, EEG Theta, EMG neck and activity. The same signal can be selected as the input to more than one data type (ex. the same EEG channel could be used for the Cortical and Theta designations). The settings for this protocol are universal for scoring rodents and may need to be adjusted to improve scoring results. Rodent Sleep 2 contains a more detailed detection level than Rodent Sleep. See Creating New Analysis Protocols.

The following protocol is pre-configured and included as an option when the Large Animal Sleep Scoring Module is purchased:

- **Large Animal Sleep Scoring:** The Large Animal Scoring protocol automatically assigns a vigilance stage to data acquired from non-human primates and other large animal species. The user may select which signal(s) to use as inputs to the scoring protocol. The scoring algorithm uses four signal inputs including EEG, EMG, EOG, and activity. The settings for this protocol may need to be adjusted for individual subjects to improve the scoring results. This can be achieved by creating a new scoring protocol using the Large

Animal Sleep detector. See Creating New Analysis Protocols.

The following protocol is pre-configured and included as an option when the Seizure Detection Module is purchased:

- **Spikes:** This is an automated scoring option intended to detect seizure activity based on a single EEG channel. The algorithm uses amplitude threshold criteria and other spike characteristics. Since the morphology of seizures vary significantly for each subject, it is highly recommended that a new protocol is created using the spike train detector with its settings established based on the particular data set. See Creating New Analysis Protocols.

## Reports Menu

This menu allows for the access and generation of reports:

- **Marker Report:** Displays statistics on each type of marker scored in the recording, where the statistics include the number of times each type is scored and the minimum, maximum, and average duration for markers of a given type. A graphical overview is also included.
- **Rodent Sleep:**
  - **Rodent Sleep Bouts Report:** Displays a summary of sleep bouts with statistics on each type of episode. A bout is a set of adjacent sleep stages of the same type. For example: ten epochs in a row scored as Wake would be reported as a single bout of Wake. For more information on Bouts and the criteria used to determine Bouts, see **Markers, Bouts, and Trimming**.
  - **Rodent Sleep Statistics Report:** Displays sleep staging statistics for each 30 minute interval. The report includes an *Epoch Statistics* table listing the duration of each type of sleep stage scored in each interval. A *Combined Epoch Statistics* table is also included where the duration of each sleep stage includes the sum of the current interval and all preceding intervals
  - **Rodent Sleep Report:** Displays a summary of the sleep scoring, a Hypnogram, and various statistics, including a summary of the transitions from one stage to the next.
- **Rodent Sleep Extended (Ex):** Includes the same information as the above Sleep Reports, but redefines Slow Wave Sleep (SWS) into two separate stages, SWS1 and SWS2, if the user has scored the data accordingly.
- **Large Animal Sleep:**
  - **Large Animal Sleep Report:** Displays subject information, hypnogram, sleep overview, sleep summary information, sleep transitions, and notes.
- **Seizure:**
  - **Seizure Report:** Displays recording information, subject information, overview of spikes, marker statistics, seizure summary, seizure episodes, and notes.
- **Report Templates:** Allows the user to create custom report templates that can be saved for future use. For more information, please see [Creating Custom Reports](#).

*Note:* All reports will be generated in separate tabs in the main *NeuroScore* window. For more information, see [Working with Reports](#).

## Batch Processing Menu

This menu provides access to the Batch Runner tab as well as allow the user to create and manage workflows used in Batch Runner.

- **Open Batch Processing:** Opens the Batch Runner tab. In Batch Runner a predefined workflow is selected and subjects are selected to apply the workflow to. See Batch Processing for more information.
- **Workflows:**
  - **New Workflow...:** Allows the user to setup a new workflow. A new tab, New Workflow, in the NeuroScore window will be added where all the settings are configured for this workflow. The tab will remain open until the *Close* or *Save and Close* button is clicked. For more information see the Creating a Workflow section.
  - **New Workflow Based On...:** Allows the user to create a new workflow based on the settings already used for an existing workflow. The settings can be modified and the workflow must be saved with a new name.
  - **Manage Workflows...:** Allows the user to edit an existing workflow. The settings can be adjusted and the workflow is re-saved. In addition, the existing workflows can be deleted or renamed.

*Note:* Batch Processing cannot be used while a recording is open.

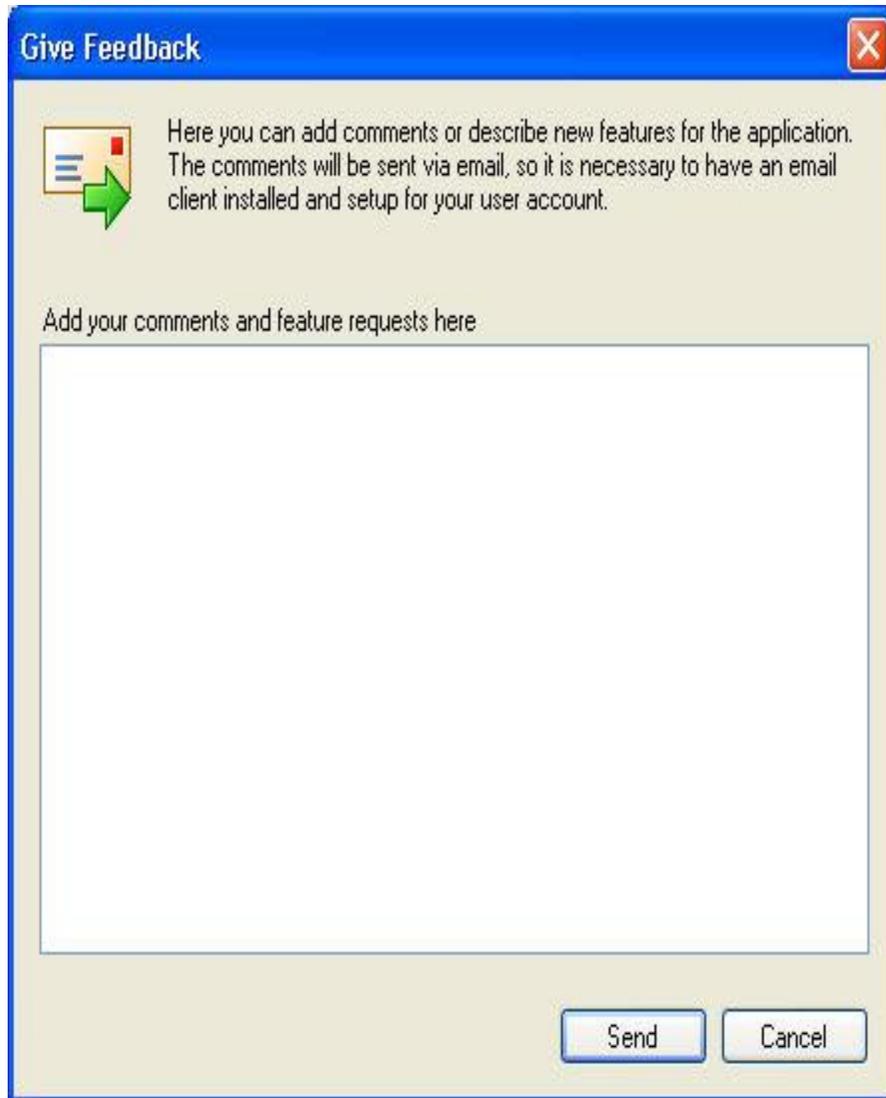
## Tools Menu

This menu provides the tools to view various software information:

- **Plugins...:** Displays a new window containing a list of all options, and their versions, loaded by the software.
- **Spectrum Export:** Allows the export of the full frequency spectrum in user-defined frequency limits and processing methods into a .txt file.
- **Import/Export Settings:** Allows the user to export settings and then import those settings into another recording.
- **View Log Files:** Generates a new tab in the main NeuroScore window that provides a synopsis of changes made to the system and their time stamps.
- **Rodent Scoring 2 Visual Tuning:** Opens a Rodent Scoring 2 Tuning tab in the NeuroScore window. From the Tuning tab the Rodent Scoring 2 protocol settings can be adjusted and re-scored to instantly view how changes affect the sleep stage marking.
- **Options...:** Displays a new window containing software settings/information in the following icons: general, user and company, advanced and data locations.

## Help Menu

- **User Manual:** Launches the Online User Manual.
- **Give Feedback...:** Allows the user to fill out a text field of comments and/or concerns about NeuroScore to help DSI improve the software. The comments will be sent to the appropriate personal at DSI.



- **About Application...:** Opens a window, *About Application*, that displays information about the software currently installed.



Notice there is the option to **Update License** or **View License**.

- **Update License:** This it will open the window displayed upon first installing the software.
- **View License:** This will open up a window that displays the software's license agreement.



# Analyzing Data

## Analyzing Data Overview

Once the data is loaded, analysis can begin. There are number of calculations and functions that can be carried out through NeuroScore. Below is a list of calculations/functions to aid the in data analysis:

- Sheets
- Markers
- Periods
- Protocols
- Scorings
- Reports
- Tools

The entire recording can be exported or archived at any point during the analysis. There are also other exporting options with each type of sheet that is created. Please see the above *Sheets* link that will walk through the individual sheet options. *Reports* can also be saved as different file formats, including pdf, in order to access them outside of the NeuroScore software.

# Recordings

## Working with Recordings

In order to perform analysis, the recordings must be loaded into NeuroScore. The following links will help explain how to work with recordings within NeuroScore:

- [Recording Library](#)
- [Opening New Recordings](#)
- [NeuroScore Files](#)
- [Recording Properties](#)
- [Tags](#)
- [Archiving Recordings](#)
- [Exporting Recordings](#)
- [Custom Fields](#)

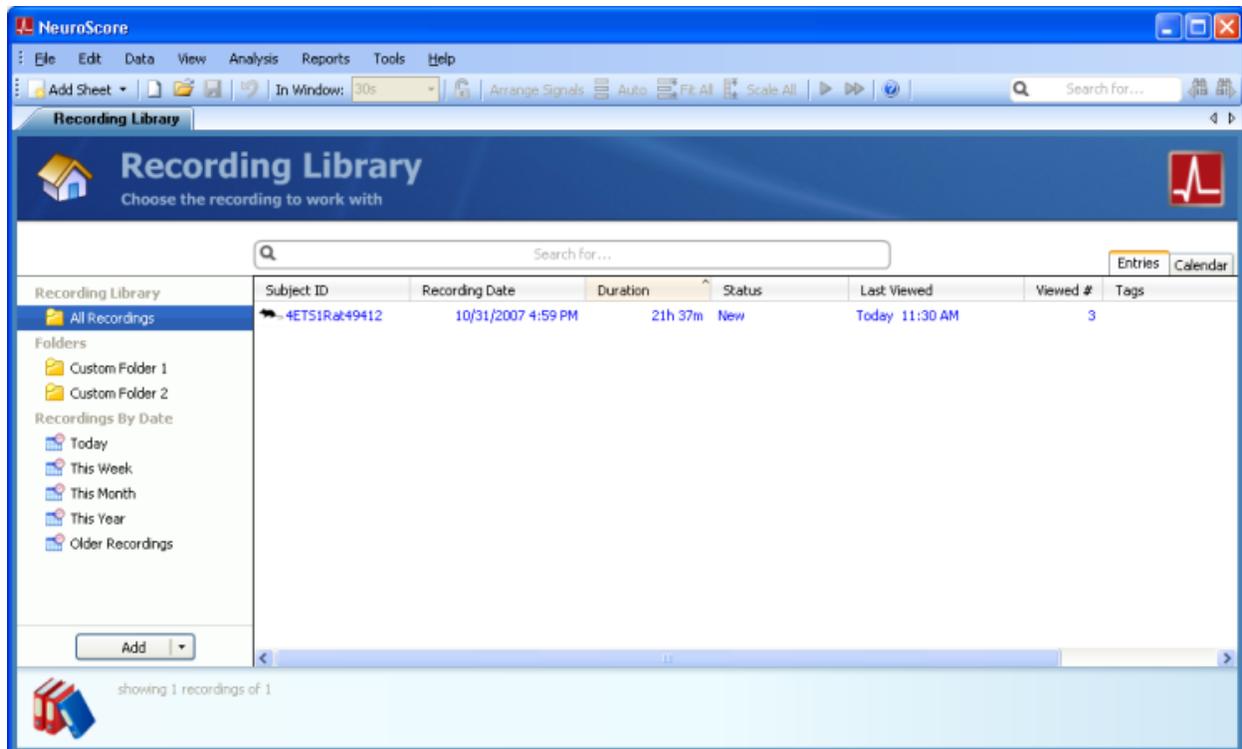
Data file formats that are compatible with NeuroScore include the following:

1. Dataquest ART files
  - [Waveform files](#)
  - [Parameter files](#)
  - [Marker files](#)
2. Ponemah files
  - Please see [Appendix A](#) for detailed information on optimally configuring Ponemah acquisition files for use with NeuroScore.
3. EDF files
4. Embla files
5. CED Spike 2 files\*
6. Biopac Acq*Knowledge* files\*
  - Please see [Appendix B](#) for detailed information on working with .acq files in NeuroScore.
7. Signal One files

\*There has been limited testing performed with these data types in NeuroScore. Importing issues may exist.

## Recording Library

Upon opening a NeuroScore, the Recording Library is displayed. The library stores a list of all known recordings that have been opened in the past or have been added manually using the **Add** drop-down or by choosing **File - Add Recordings to Library**. Custom folders can be created to group recordings within the Library by selecting the **Add** drop-down. When a custom folder is selected, choosing the **Add** drop-down will add recordings specifically to that folder, as well as the *All Recordings* folder.



*Note:* The recording duration and video indication does not populate until the recording has been opened once

### Adding/Removing Recordings

To add recordings to the library:

1. Select **File - Add Recording to Library...** or select **Add - Add Recording to Library...** from the lower left-hand corner of the *Recording Library*.
2. A new Browse For Folder window opens with the ability to navigate through the computer's drivers/folders.



3. Navigate to the folder/file of interest.
4. Click **OK**

**OR**

1. Browse to the location where the data is located via **Explorer**
2. **Click-and-drag** the folder into the *Recording Library*

*Note:* Choosing **File - Open Recording** automatically adds the recording to the *All Recordings* folder.

To remove a recording from the library:

1. Select **File - New Workspace**
2. Select/highlight the data recording desired to be removed from the library.
3. **Right click - Remove Recording**
4. A confirmation window will populate, respond by clicking **Yes** or **No**



**OR**

1. **Left-Click** the recording to be removed
2. Press <**Delete**> on the keyboard
3. A confirmation window will populate, respond by clicking **Yes** or **No**



*Note:* Neither of these methods delete the data and settings permanently from the original file; it simply removes it from the recording library.

To reset recording to original raw waveforms (delete all previous analysis done in NeuroScore):

1. Select/highlight the data recording desired to be reset – **Right Click – Reset Recording**
2. Click **Yes** to reset the recording, deleting all previous work done and revert the recording back to the original raw waveforms.

*Note:* If this option is selected, it is not possible to retrieve the deleted work.

To remove ALL recordings for the library:

1. Select **File - Reset Recording Library**

*Note:* This will clear all files from the Recording Library. Customer Folders are maintained, but emptied.

### **Adding/Removing Folders**

To add a custom folder to the library:

1. Open NeuroScore
2. Select the **Add** drop-down box
3. Select **Add New Folder**
4. Enter a folder name

*Note:* When adding *Recordings* to a customer folder, they will also be added to the *All Recordings* folder.

To delete a custom folder:

1. **Right-click** the folder
2. Select **Delete Folder**

To add a recording to a custom folder:

1. **Click-and-drag** a recording from the *All Recordings* folder into the customer folder of interest.

**OR**

1. **Left-click** the custom folder of interest.
2. Select **Add - Add Recordings to Library...**

To remove a recording from a custom folder:

1. **Left-Click** the recording desired to be removed from the folder.
2. **Right click - Remove Recording**

**OR**

1. **Left-Click** the recording to be removed
2. Press **<Delete>** on the keyboard

*Note:* Removing/Deleting a recording from a custom folder will not remove/delete the recording from the *All Recordings* folder.

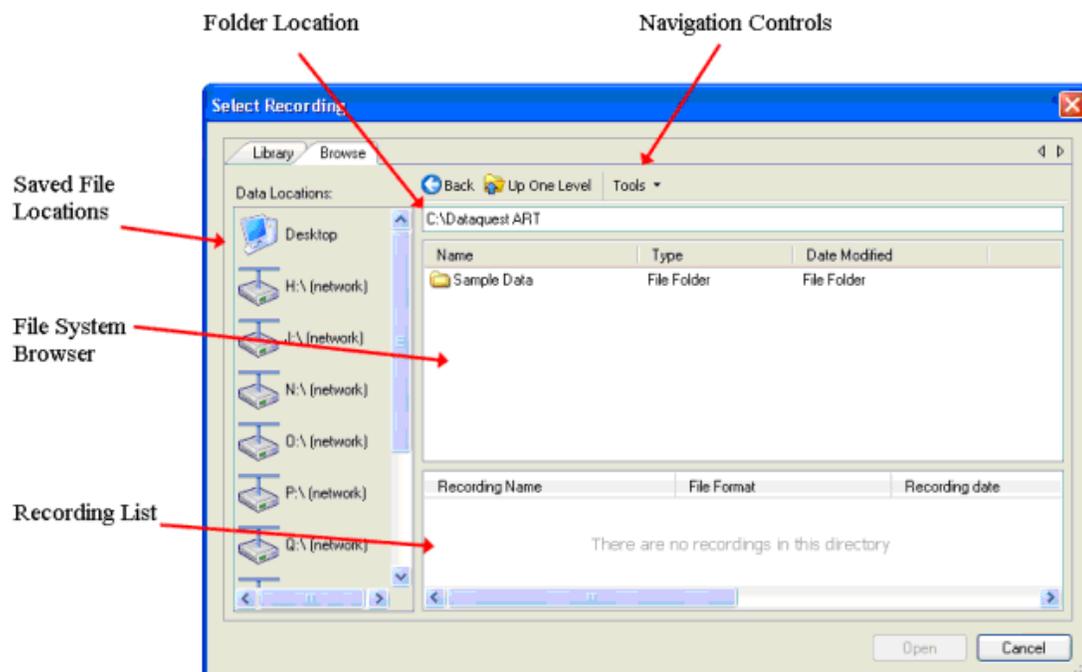
## Opening New Recordings

To *open* a recording from the Study Library:

1. **Double-click** on the recording name located in the library
2. If the recording is not in the Study Library, please see the Study Library section for further directions.

To *open* a recording from the **Browse** tab:

1. Select **File - Open Recording...**
2. Select the **Browse** tab from the Select Recording dialog



3. Navigate to the file desired to be opened as a new recording by **Double-Clicking**
4. Select the file from the directory
5. Click **Open**
6. When this file is opened, it is automatically added to the *All Recordings* folder of the *Study Library*, providing the ability to open up this same recording at a later date.

The recording browser works on the file system. All available folders and objects that potentially contain a data set, e.g. hard drives, are listed in the *file system browser*. The file system browser works in a similar manner as a standard windows file dialog. Each folder can be navigated by double clicking on it. Each time a new folder is navigated the system scans that folder to see if any recordings exist in that location. All available recordings are listed in the *recording list*

where a single recording can be opened by clicking **Open**. The recording in the *recording list* can also be **double-clicked** to open. When opening a recording, an *All Signals* tab opens with the signals will be displayed. For more information on this sheet and other sheets in the NeuroScore software, see Sheet Layouts. If a recording has previously been opened with NeuroScore, all existing sheets and analysis sessions will be maintained.

The current location can be shown in the *folder location* and the file path can be written out or pasted into the *folder location*. Use the **Back** button to navigate down to the parent folder as indicated in the *folder location*.

*Note:* Opening a recording automatically adds it to the *All Recordings* folder of the *Study Library*. Sample data is included with the installation CD for the NeuroScore software. This data can be found in the Sample Data directory on the CD. The subject EETD0022 includes EEG, EMG, and signal strength waveform data collected with a TL11M2-F20-EET transmitter in a mouse. Activity, temperature, and signal strength parameter data are also available. Waveform data was collected for 30 hours using continuous sampling. Parameter data was collected for 63 hours using continuous sampling.

See NeuroScore Files for information on the files that are created when a recording is opened.

## Virtual Recording Editor

The purpose of the Virtual Recording Editor is to combine 2 or more recordings into a single file. The combined data set must originate from the same study folder so it may be necessary to manually move the data using Explorer beforehand. The combined virtual recording is given its own subject ID and recording name. This is designed primarily for adding external sources such as light and temperature sources to a recording or to combine data sets from the same subject recorded on 2 different computers. However, it can also be used to combine two or more different subjects into the same recording. Automated scoring protocols execute the same as if it were a single subject. It is not possible to perform automated analysis on more than 1 subject simultaneously.

To create a Virtual Recording:

1. Select **Virtual Recording Editor** to open the Virtual File Format Wizard

Virtual File Format Wizard

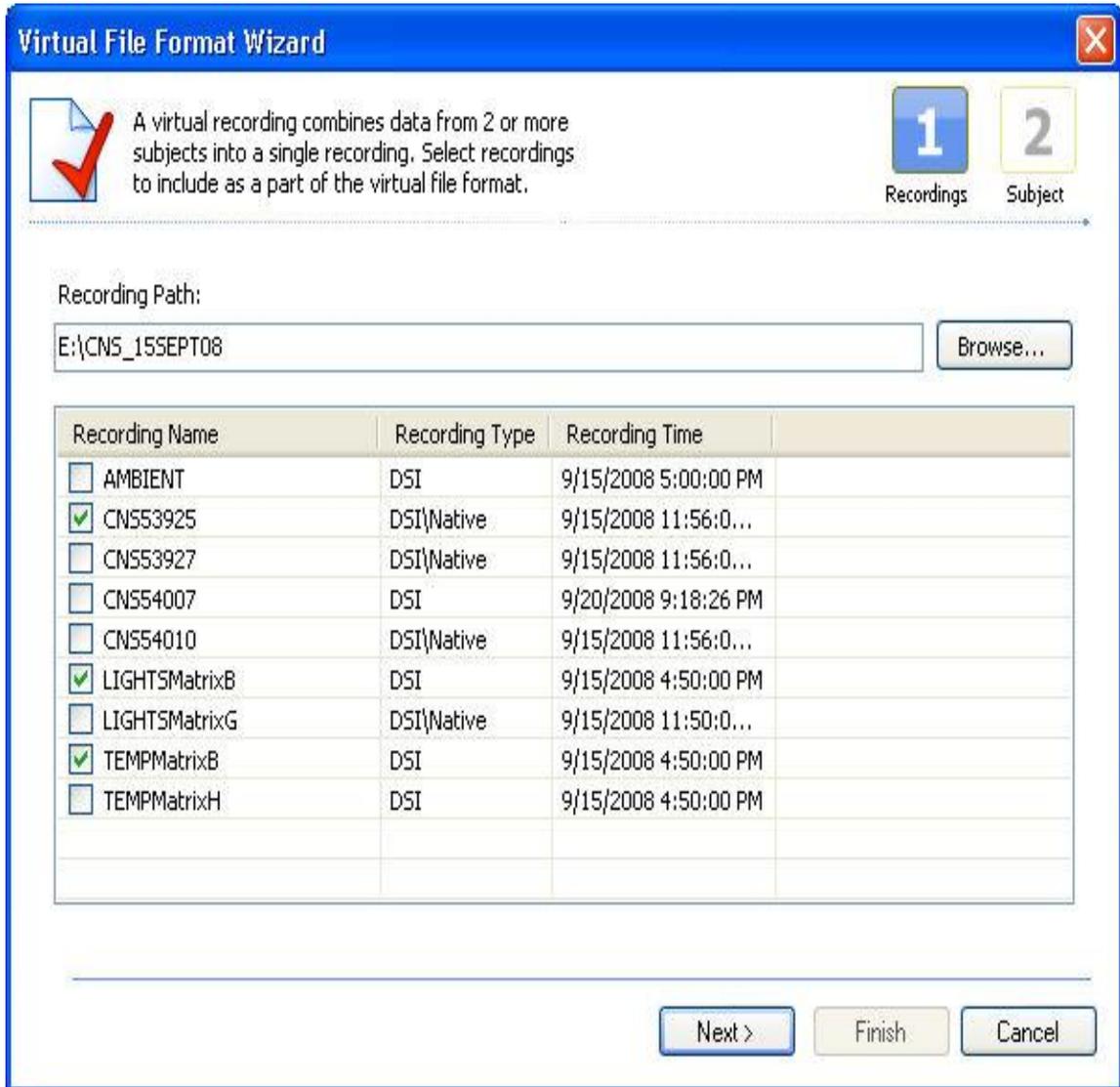
A virtual recording combines data from 2 or more subjects into a single recording. Select recordings to include as a part of the virtual file format.

1 Recordings    2 Subject

Recording Path:

Recording Name	Recording Type	Recording Time

2. Left-Click **Browse...**
3. Browse to the folder containing the recordings of interest to combine and select **OK**
4. Select the recordings to combine by checking the corresponding checkboxes and click **Next**.



5. Enter a unique *Recording Name* and *ID*, then choose the subject's *Species*.

**Virtual File Format Wizard**

Enter relevant information for the new virtual recording.

1 Recordings      2 Subject

**Recording**

Recording Name:  
Example Virtual Recording

**Subject Information**

ID:  
CNS53925

Species:  
Rat

< Previous      Finish      Cancel

6. Click **Finish**
7. Choose whether to Open the Virtual Recording or not by clicking **Yes** or **No**.
8. Once the wizard has been completed, the *Virtual Recording* will be loaded into the *All Recordings* folder of the *Recording Library*.

*Note:* The *Recording date* and *Duration* will not populate for the *Virtual Recording* until it has been opened once. Also, the *Virtual Recording* is its own entity and all scorings made in that recording are inherent to it and are thus not available to the individual recordings of which it is composed.

## NeuroScore Files

When a recording was opened in version 1.x, a subfolder was created within the folder that contains some of the NeuroScore files. The raw data files are not altered by NeuroScore. The following gives a brief description of the types of file extensions that can be found in the subfolder and within the raw data and their function:

- .log - This is a file that contains user logs associated with the recording. Each time the recording is opened a new log file is created (if there is anything to log).
- .scr - This is a file that contains a scoring. A scoring is a collection of markers.
- .scr.asav - This is the auto-save version of the .scr file. Autosave files are temporary files used by the auto-save feature of NeuroScore.
- .xml - This is just a standard .xml file.
- .grp - This is a scoring group file. Scorings can be saved into groups. Keep in mind that a scoring can only be included as part of a group after it has been saved.
- .grp.asav - This is the autosave version of the .grp file.
- .lcx - This is the license file used to link the NeuroScore software to the USB key that is connected to the computer.
- .wsp - This is the file that is saved to the folder where the data is accessed. It contains settings used in the NeuroScore software when the associated recording is opened

The file format was changed in version 2.0 and later. A single file is created within the same folder as the raw data. A subfolder is no longer created.

- .zdb - Database file containing all NeuroScore settings and results for the particular recording.

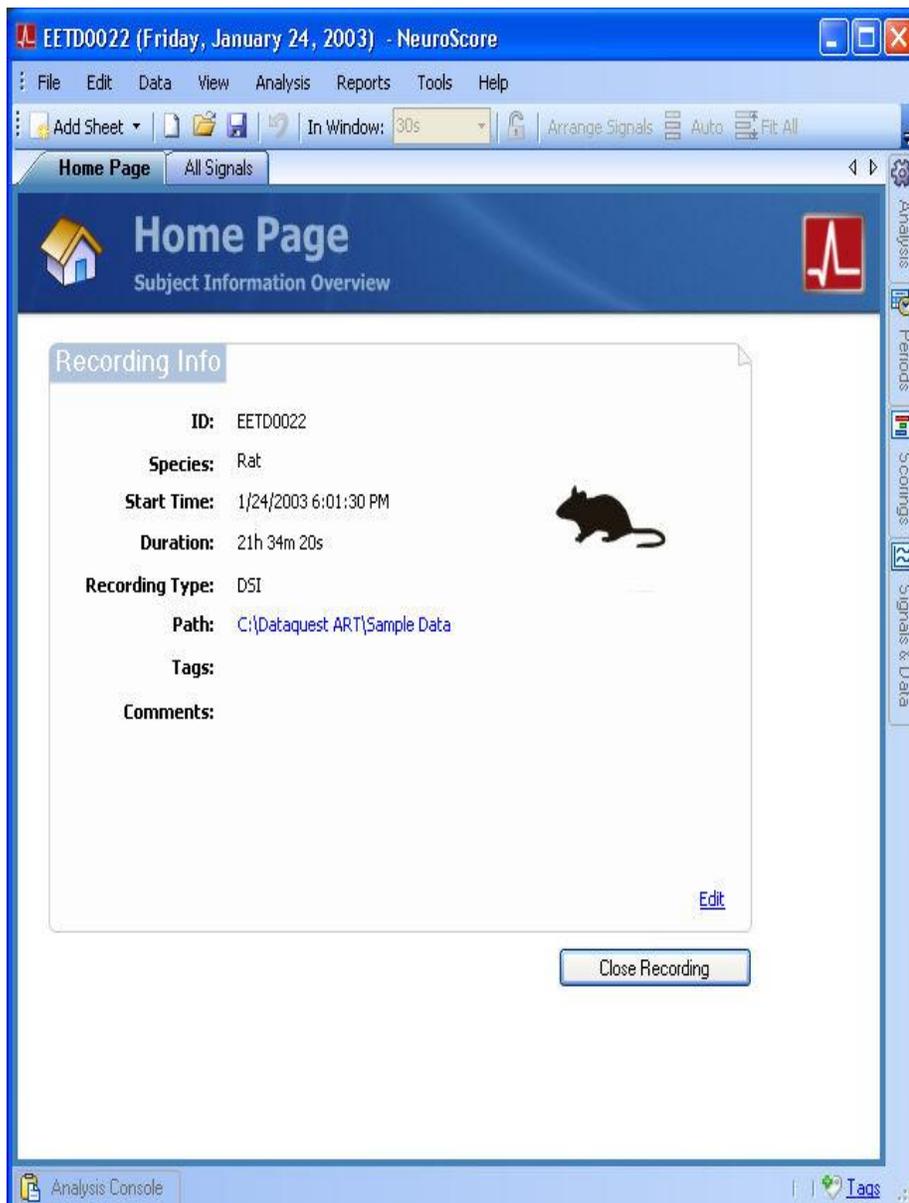
When upgrading from 1.x to 3.0, NeuroScore will read in the original NeuroScore files associated with the recording. The subfolder created in 1.x should not be deleted even after analyzing the data in 3.0.

## Recording Properties

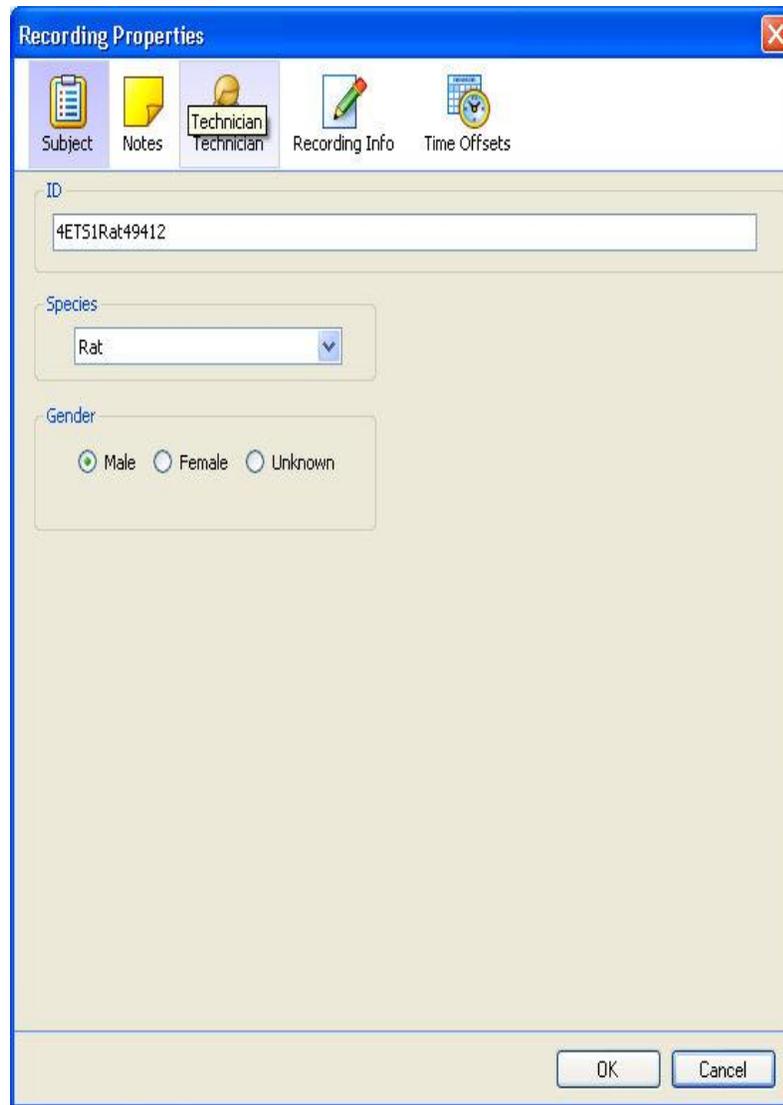
Recording properties can only be accessed through NeuroScore after the data has been opened as a recording.

To access the recording properties:

1. Open the data file as a recording
2. Navigate to **File - Recording Properties** or select the **Home tab - Edit link**

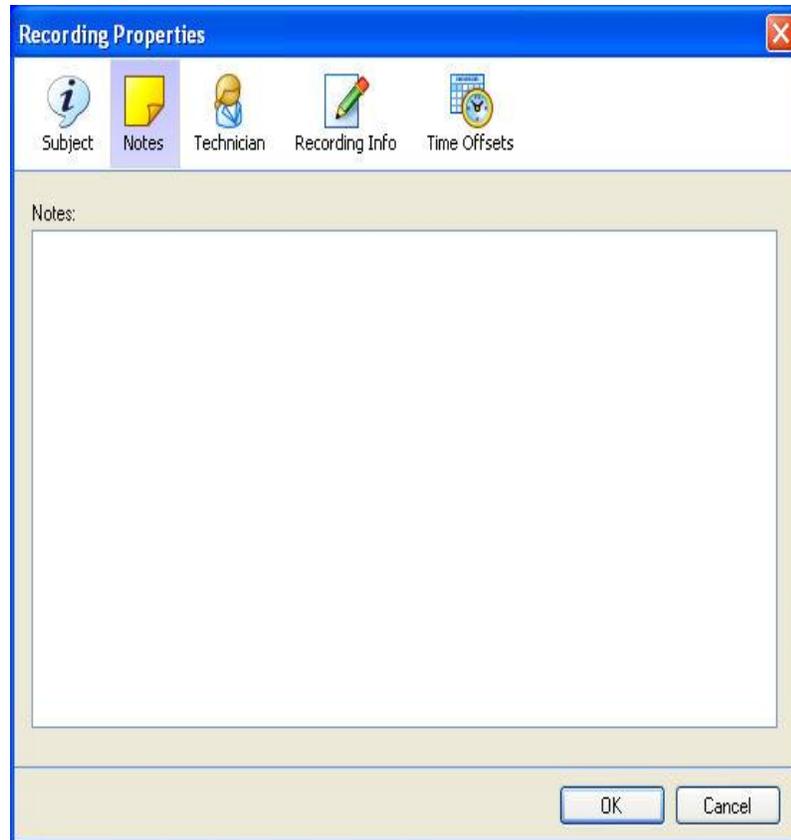


3. This opens a new window containing the recording properties.
4. Five icons are available for selection:
  - Subject Info



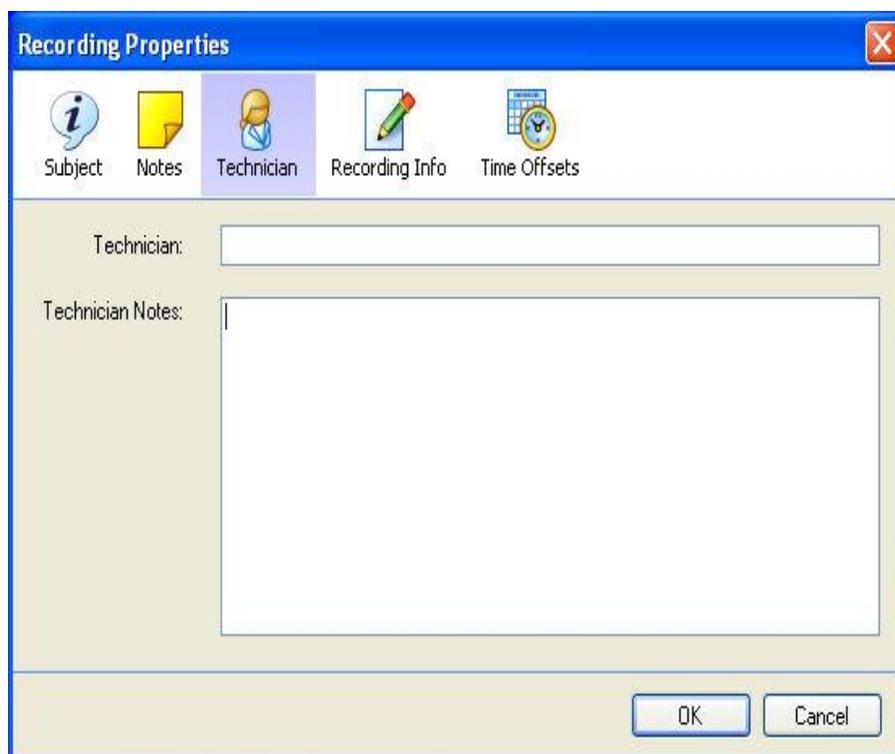
Displays the animal ID and Species that was used to obtain the recording.

- Notes



Allows the user to enter any notes about the animal, the study, or anything pertinent to the researcher. These notes can be pulled into a Report by adding **Subject Notes** to a report template.

- Technician



Provides a location for the Technicians' name and any notes they may have during Analysis. Technician and Technician Notes can be pulled into a Report by adding **Technician Notes** to a report template.

- Recording Info

The image shows a 'Recording Properties' dialog box with the following fields and values:

- Path:** C:\Documents and Settings\chrisk\Desktop\Rat Pilocarpine Seizure
- Recording Start:** 11/18/2004 2:59 AM
- Recording Stop:** 11/19/2004 6:12 AM
- Recording Duration:** 1d 3h 13m 15s
- Tags:** (empty text box)
- Recording Format:** (empty text box)
- Recorded Signals:** EEG
- Scorings:** Spike Trains, Spike Trains
- Recording TimeZone:** (GMT-06:00) Central Time (US & Canada)

Buttons for 'OK' and 'Cancel' are located at the bottom right of the dialog.

This gives general information regarding the data that was collected. Within this tab, the following fields can be adjusted: Tags, Recording Status, and Time Zone.

The recording status identifies where the recording is in the analysis process, whether it is new, scored, reviewed, or done. The recording can also be marked as Invalid when necessary. This option may be helpful when multiple people are working on analyzing the same data or for organizational purposes.

To be able to search for this specific recording in the library window, specify which tags will pull up this recording in a search.

- Time Offsets

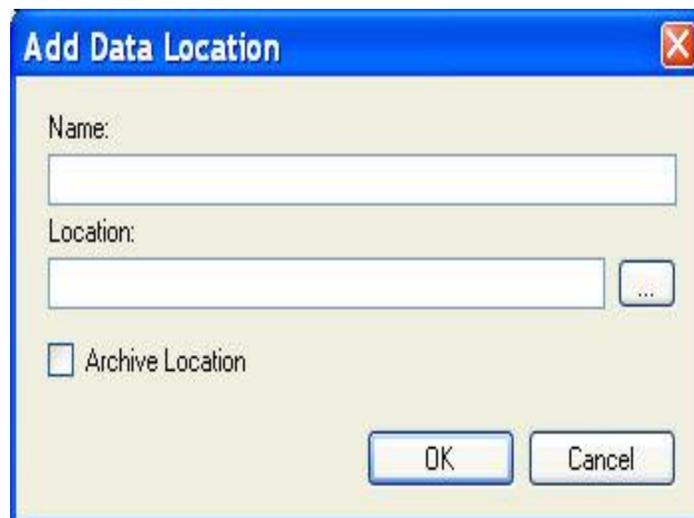


## Saving Data Locations

The *Saved Data Locations* section provides another place to save data locations for quick, easy access to specific locations saved to it. By default, network locations that are already mapped on the computer are added to Data Locations.

Two methods to *save* new Data Locations:

1. Via **File** menu:
  - a. Click **File - Open Recording...**
  - b. Select the **Browse** tab.
  - c. Navigate to the location desired to be save
  - d. Click **Tools - Add Data Location**.
  - e. Specify a name for the current location.
  - f. Click **OK**.
  - g. This adds the location to the *Saved Data Locations* section of the Select Recordings window.
2. Via Tools menu
  - a. Click **Tools - Options... - Data Locations** tab.
  - b. Press the **Add Location** button to add data to be easily accessed.
  - c. A new Add Data Location window will open where you can type the path to retrieve the data. Press the [...] button to browse to the file location.



- d. Enter a name for this data location.
- e. The *Archive Location* should be checked to archive data to the location.
- f. When finished, click **OK**. Notice that locations that are setup to for archive locations have archive listed under the Type column.

- g. To **Edit** or **Remove** data locations, select the data location that intended to work with and then select the edit or remove button.

*Note:* Tags can also be added to recordings to allow the recordings to be searchable through these tags.

To *delete* added (non-default) *Data Locations*:

1. Click **Tools - Options - Data Locations**
2. Select the data location to delete
3. Select **Remove**
4. This automatically deletes the location without any confirmation window.

*Note:* Default data locations cannot be removed.

## Tags

To be able to search for specific recordings in the library window, tags can be specified to pull up the recording in a specific search.

To add Tags are added to the recording properties:

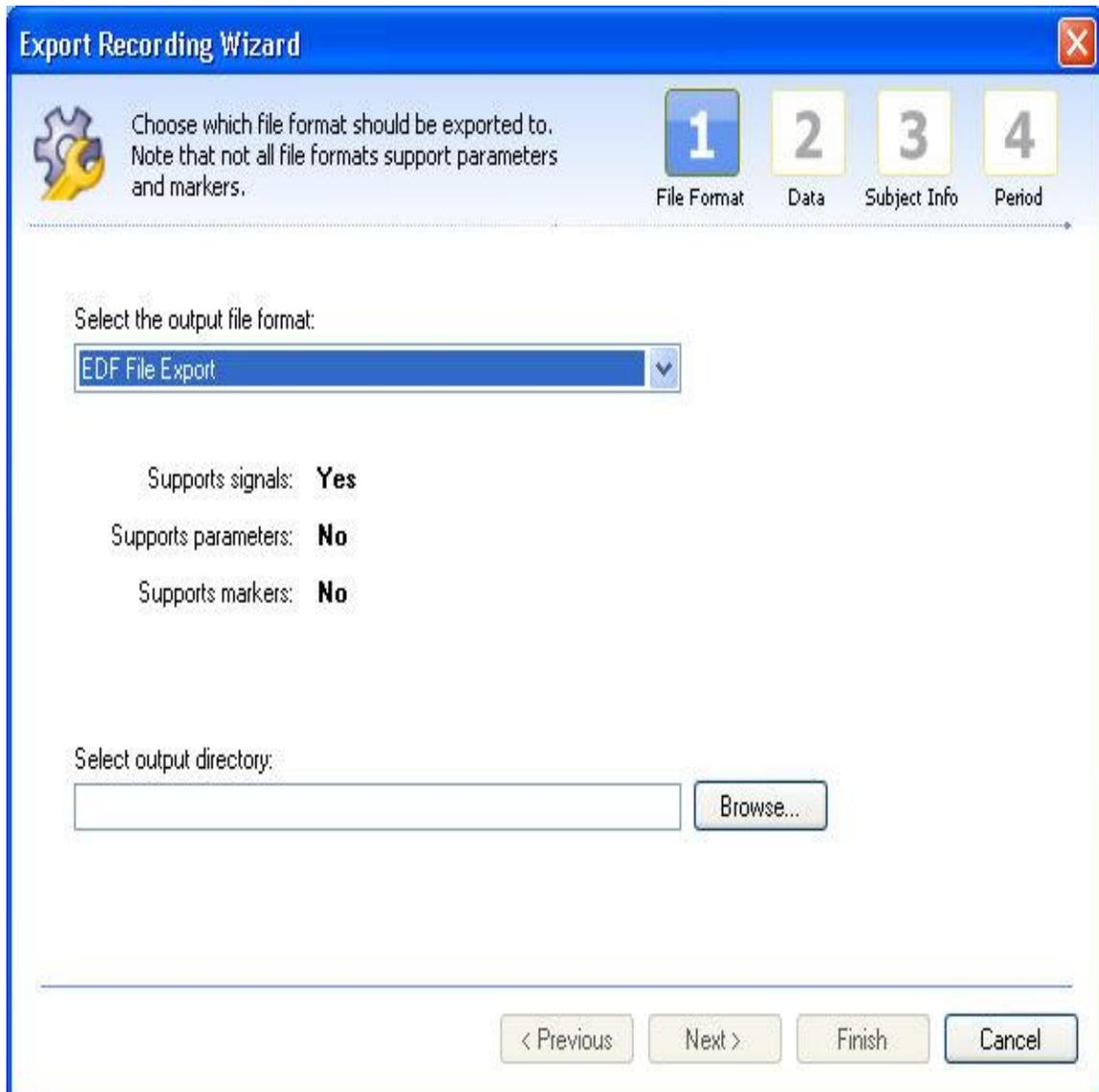
1. Open a recording as described in Opening New Recordings
2. **File-Recording Properties...-Recording Info**
3. In the *Tags* field, type in a name to define the tag.
4. The tags field can also be accessed by clicking on the *Tags...* link at the bottom, right hand corner of a NeuroScore *All Signals* sheet.

## Exporting Recording

This function allows the original data files to be exported to a specified location as either a European Data Format (.edf) or Embla (.ebm) data file(s). The user can indicate which data types and derived signals to include in the new file type.

To export:

1. Go to **File - Export Recording...**
2. A wizard will populate.



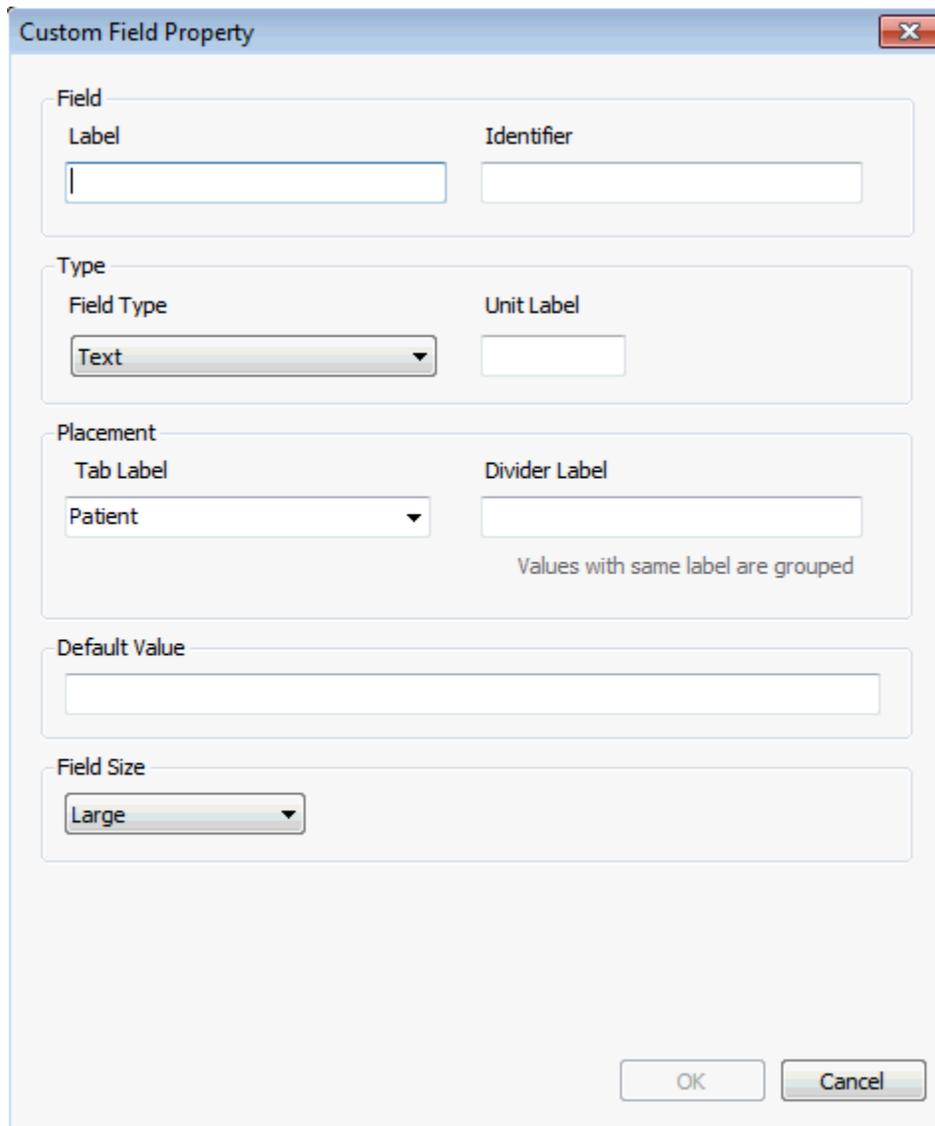
3. Indicate output file type: Embla or EDF.
4. Select the location to which the files will be output to:
  - If Embla files are exported, select a folder to place the data, the files are named according the data/signal types.

- If EDF files are exported, specify a folder and file name to save the data.
5. Select which data to export.
  6. Customize the subject identification used.
  7. Select what time period to export the data from. These periods available are dependent on the saved periods. See Working with Periods for more information.

*Note:* Data available to export includes the data originally loaded and derived signal data.

## Custom Fields

The custom fields function allows the user to create custom fields for a subject that can be added into the Interpretation Notes. Interpretation notes can then be printed or added to a report.



The screenshot shows a dialog box titled "Custom Field Property" with a close button (X) in the top right corner. The dialog is organized into several sections:

- Field:** Contains two text input fields: "Label" and "Identifier".
- Type:** Contains a "Field Type" dropdown menu set to "Text" and a "Unit Label" text input field.
- Placement:** Contains a "Tab Label" dropdown menu set to "Patient" and a "Divider Label" text input field. Below the "Divider Label" field is the text "Values with same label are grouped".
- Default Value:** A single text input field.
- Field Size:** A dropdown menu set to "Large".

At the bottom right of the dialog are "OK" and "Cancel" buttons.

Custom Fields contain the following settings:

### Field

- Label - The name of the field.
- Identifier - By default is the same as Label. The identifier can be changed if desired.

### Type

- Field Type - How the field is setup. It can be a text box, number, paragraph, dropdown choice or multiple choice.
- Unit Label - Label which will be displayed after the value.

Placement

- Tab Label - Tab where the field will be created.
- Divider Label - If desired, a label for the divider between the fields.

Option Values - (only for dropdown and multiple choice Type) Displays a list of options the user can select from.

Default Value - The default value that is used if the user does not select from the list.

Field Size - (only for text, number and paragraph Type) Allows the user to select a field size for typing information and notes.

## Sheets

### Sheets and Sheet Layouts

Four different sheet types can be created in NeuroScore. By default, an **All Signals** sheet is created upon loading a recording; however, the option to add sheets to the NeuroScore window exists. Each sheet that is added to the window can be saved as a template. In NeuroScore, templates are referred to as *layouts*. With layouts, the same sheet settings and calculations can be applied to different recordings loaded into NeuroScore.

The following is a list of sheets and layouts that can be managed within NeuroScore; **double-click** on the link to preview available, pre-configured sheet layouts:

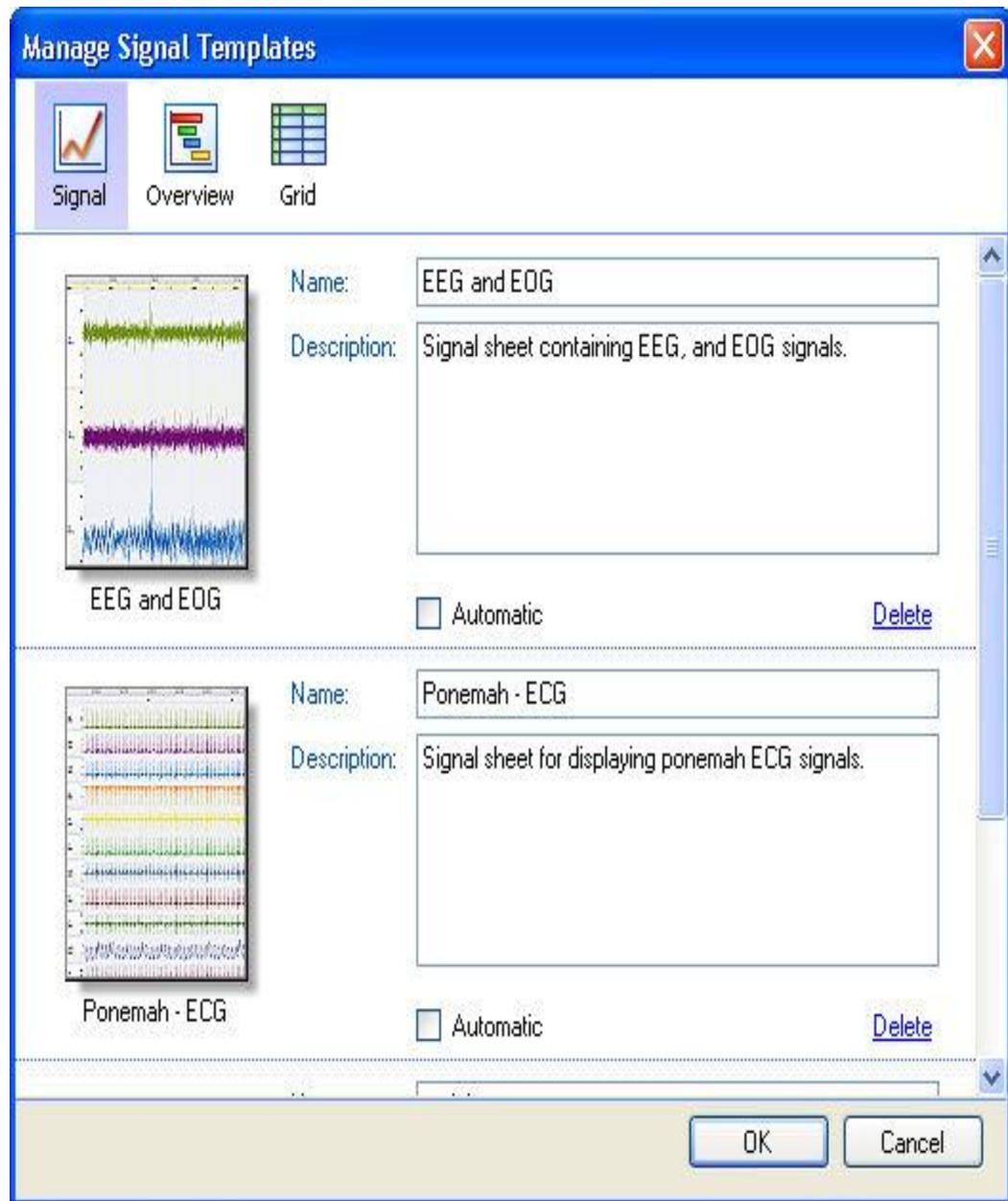
- Signal Sheets
- Overview Sheets
- Data Sheets/Grids
- Reports
- Bookmark Sheet

The following is a list of options to help manage layouts; click the link below for instructions:

- Apply saved or pre-configured layouts
  1. Click the **Add Sheet** icon in the NeuroScore tool bar.
  2. Select the desired layout.
  3. A new tab will be added to the workspace with the appropriate sheet layout that was selected.

To automatically apply this sheet upon opening a recording:

4. Select **Edit - Sheet Layouts**
5. The Manage Signal Layouts window will populate and display currently configured layouts.



6. Select from the following icons to edit:
    - Signal
    - Grid
    - Overview
  7. Select the **Insert Automatically** checkbox.
- Create custom layouts
    1. Add a new signal sheet as outlined in the Signal Sheet help page.
    2. Click **Edit - Sheet Layouts**
    3. Save the signal sheet as a layout, as described below.

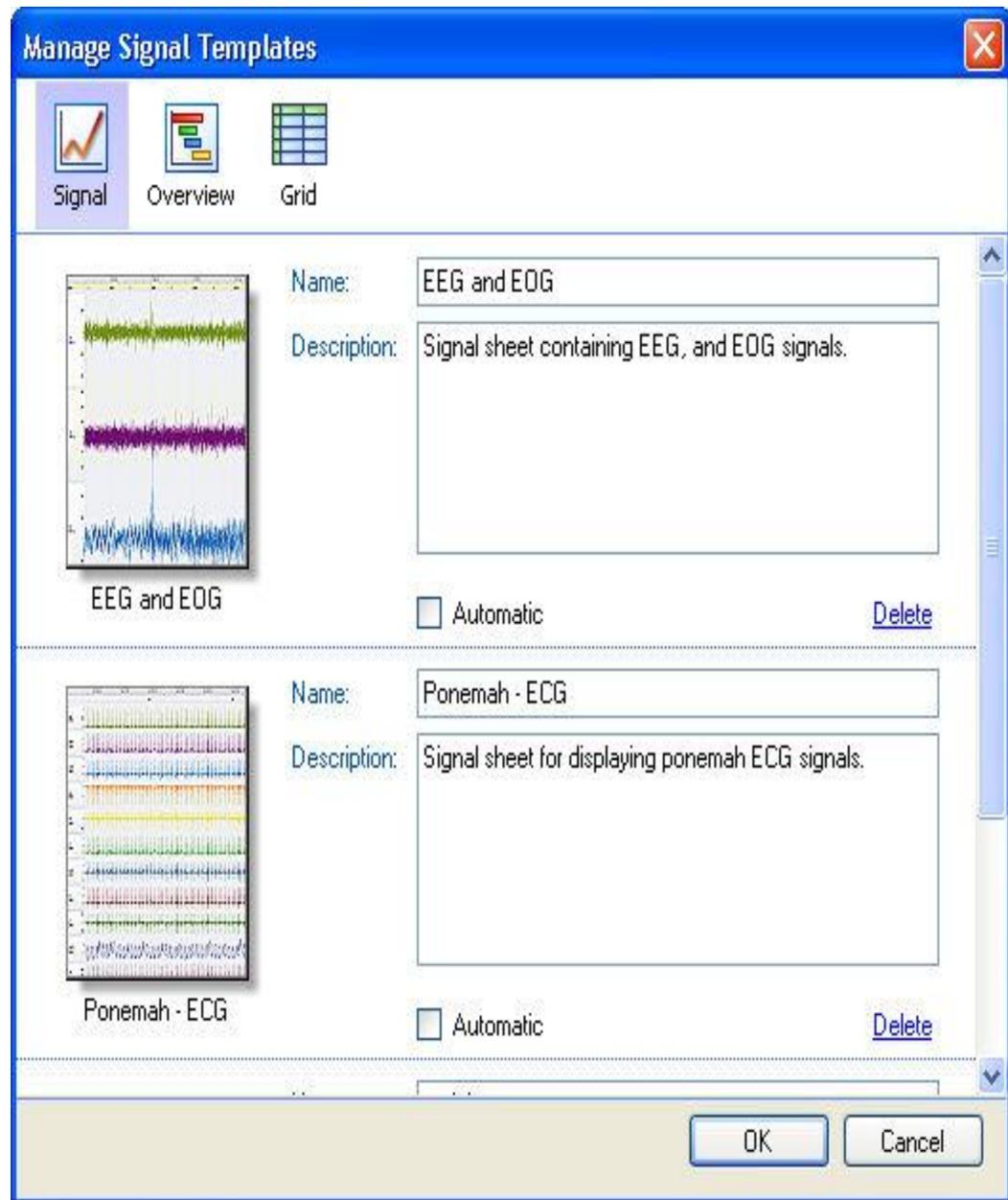
- Save custom layouts
  1. **Right-click** the signal sheet tab - **Save Sheet Layout**.
  2. Enter a *Name* and *Description* for the sheet
  3. Check the **Insert Automatically** box to add this particular layout to the NeuroScore window by default upon opening a recording.
  4. This sheet will now be available for future application when working on any future animal's analysis.
  
- Edit existing layouts
  1. Select the **Add Sheet** icon in the NeuroScore tool bar.
  2. Select the desired layout.
  3. **Right-click** the signal sheet tab.
  4. Select **Update Saved Layout**

To revert back to the original saved layout after layout manipulation:

5. **Right-click** the signal sheet tab.
6. Select **Revert to Saved Layout**

*Note:* Once the **Update Saved Layout** option has been selected, the layout cannot be reverted back to the previously saved version.

- Delete saved sheet layouts permanently
  1. Select **Edit - Sheet Layouts**
  2. The Manage Signal Layouts window will populate and display currently configured layouts.



3. Select from the following icons to edit:
  - Signal
  - Grid
  - Overview
4. Select **Delete** for the appropriate layout desired to be deleted.

## Signals

### Working with Signals

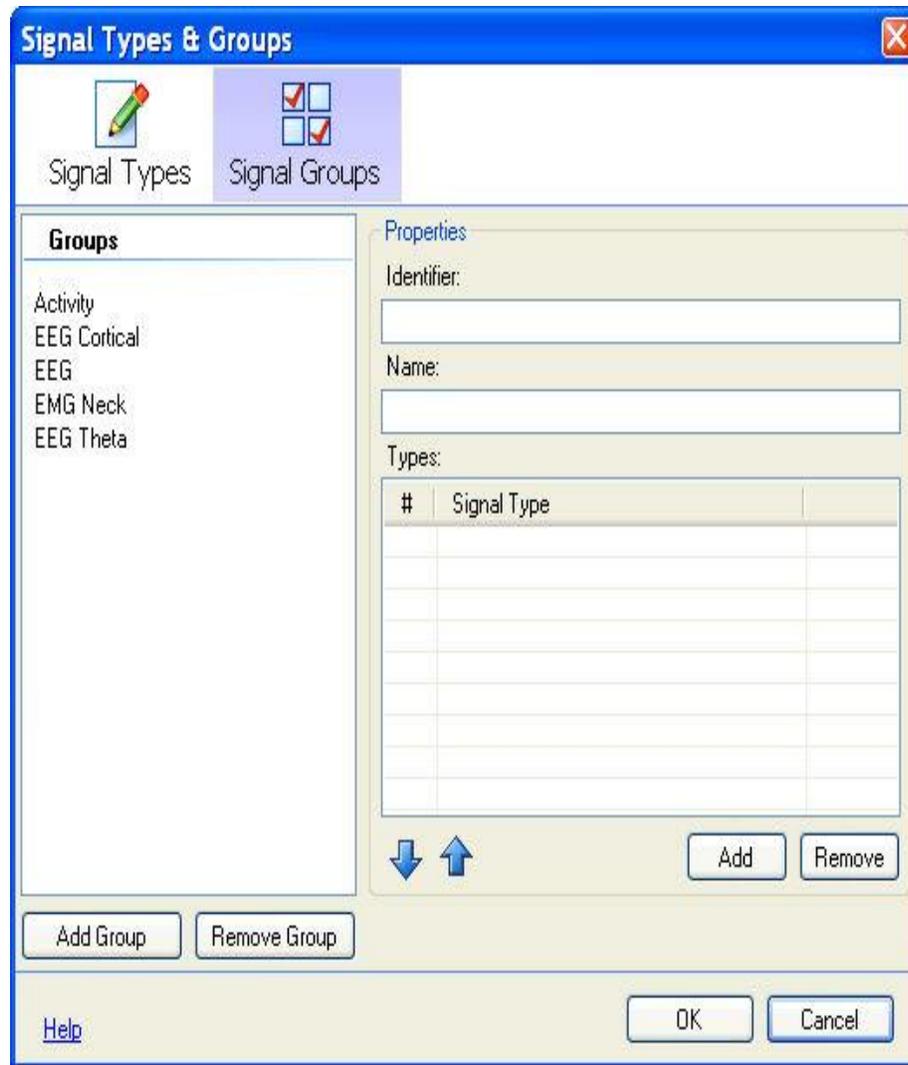
A signal can include a variety of data types. There can be waveforms and parameters generated from the acquisition program as well as derived signals created within NeuroScore.

There are a number of areas that may be useful to know when working with signals:

- Signal Sheet
- Navigation Bar
- Tool Bar Overview
- Adding and Removing Signals/Signals & Data Tab
- Dragging, Resizing, Positioning and Grouping
- Signal Properties
- Global Settings
- Tool Bar Overview
- Signal Filters
- Derived Signals
- Graphs for Individual Signals
- Exporting the Signal Sheet
- Saving the Signal Sheet as a Layout

Additionally there are three menu options that provide the ability to change signal settings.

- Signal Types and Groups
  1. Go to **Edit - Configuration - Signal Types and Groups**.
  2. The **Signal Types and Groups** window populate and allow the option to set up how signals are grouped together, as well as what types of loaded signals would be appropriate data for signals that are needed to run protocols.



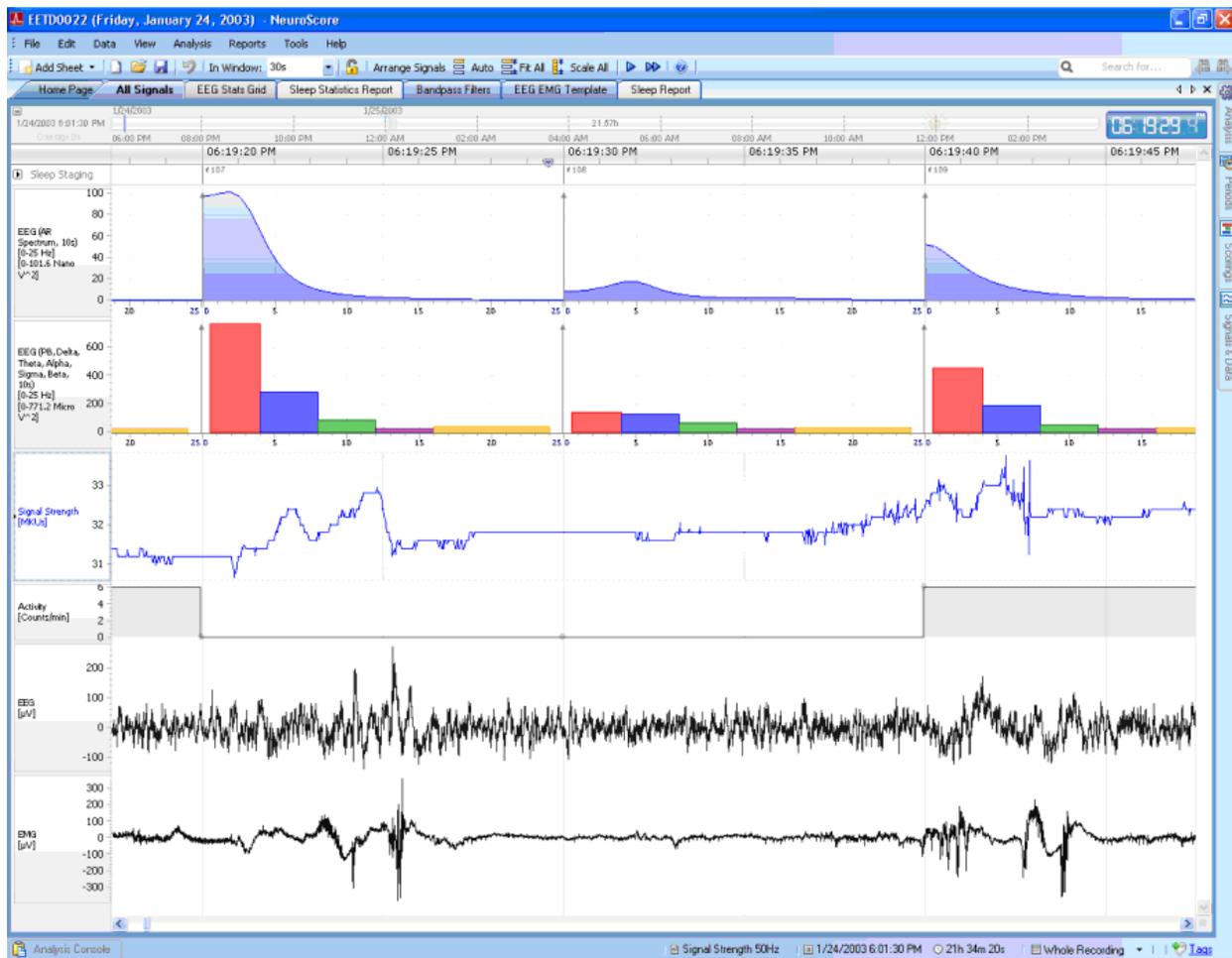
3. Select a signal under the **Signal Types** icon. There are preset signals grouped accordingly:

Activity	Pleth
CO <sub>2</sub>	Pos
EEG	PPT
ECG (EKG)	Pulse
EMG	Respiration (Resp)
EOG	SpO <sub>2</sub>
Luminance	Status
O <sub>2</sub>	Temperature
pH	Voltage

4. Select the **Add Type** button.
  5. Specify the *Main Type*. It is optional to specify *Sub Type* and *Reference*.
  6. Select **OK**. The next time the window is opened the signal type will be added under the appropriate group, depending on what *Main Type* signal was selected.
  7. Go to the **Signal Groups** window and add this new signal to an existing group or add it to a new group.
  8. To add a new group, click **Add Group**.
  9. Fill in the *Identifier* and the *Name* fields as well as *Types* field.
  10. The *Types* field will be where to indicate which signal from the recording window will provide the appropriate data for this particular group. The group will be used when running a protocol. NeuroScore will automatically decide which signals to use based on this grouping. So, the order under the *Types* is also important; it will determine priority of what signal would be used first for the needed data.
- Signal Marker/Mappings
    1. Go to **Edit - Configuration - Signal/Marker Mappings**
    2. A new *Edit Mappings* window will populate
    3. This provides the ability to change the label of the signals and markers that are loaded into the signal sheets with the current recording.
    4. To change *Maker* labels go to the **Marker** icon.
    5. To change *Signal* labels go to the **Signals** icon.
  - Global Settings

## Signal Sheet

A signal sheet is generated when opening a data file and will be labeled as **All Signals**. A signal sheet has the capability of graphically displaying all the signals that were collected for the current subject, as well as additional signals that are calculated or derived. The Signal Sheet offers flexibility in how the data is displayed. Various layouts (templates) of Signal Sheets can be generated and applied to subsequent subjects.



To add a signal sheet:

1. Click **Add Sheet** icon in the NeuroScore tool bar.
2. Select either the **All Signals** or **Empty Signal Sheet** option.
3. A new signal sheet tab will be added to the NeuroScore window.

*Note:* A shortcut is available to open a new signal sheet with a selected signal. In a signal sheet highlight/select the signal to be added to a new signal sheet, hit **<Shift> + <Return>** to open the new signal sheet with the selected signal.

To copy a signal sheet:

1. **Right-click** the sheet tab of interest
2. Select **Clone Sheet**

To close a signal sheet:

1. **Right-click** the sheet tab of interest
2. Select **Close**
3. Shortcut: hit **<Ctrl> + <F4>** (this will close the active sheet)

To navigate signal sheets using shortcuts:

1. **Hover** on the Shortcut Navigator (wooden street sign icon) located in the bottom left corner of the signal sheet.
2. A screen will pop up listing a number of shortcuts that are available (these are hard coded into the software).

The following are pre-defined Grid templates that come with the software:

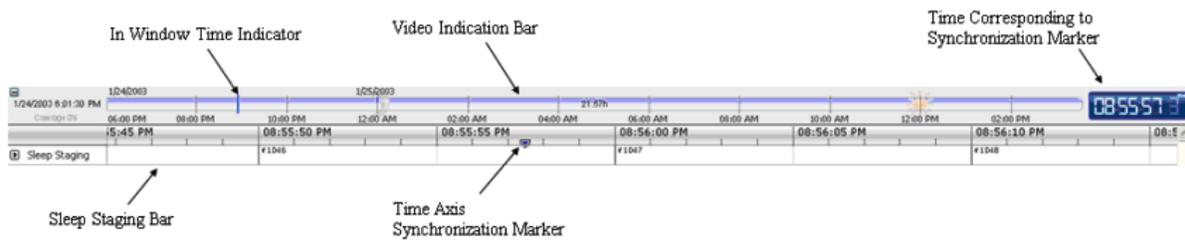
- **Bandpass Filters:** This sheet will populate with the EEG signal along with bandpass filtered signals for *Delta* (0.5 - 4 Hz), *Theta* (4-8 Hz) and *Alpha* (8-12 Hz).
- **EEG and EMG Template:** This sheet will include the following signals: *EEG*, *EMG* and *Activity*. It will also have derived signals: *EEG Periodogram*, *EEG AR Spectrum* and *EEG Power Bands* (Delta, Theta and Alpha)

There are a number of different settings/options relating to a signal sheet:

- Adding and removing signals
- Dragging, resizing, positioning and grouping signals
- Signal Properties

## Navigation Bar

The Navigation Bar is located just below the tabs in the NeuroScore window. It can be used to adjust what time period is displayed in the signal sheet. It also displays the current time location of the recording being displayed, indicated by the blue line. The clock on the right is indicating the time of the day being displayed by the *Time Axis Synchronization Marker*. The dates along the top of the bar provide the date of the recording. Notice that a moon is used to indicate night time and a sun to indicate day time. A ruler type bar, located just below the navigation bar, will provide a more specific time stamp for the data currently being displayed in the *Workspace*. The sleep stage bar displayed, will show the active scoring (see Compare Scorings for more information). If video was recorded, a blue indication bar will appear on the navigation bar, as show below.



## Adding and Removing Signals/Signals & Data Tab

Adding or removing signals in a signal sheet can be done in the **Signals and Data** tab. When the mouse cursor is over this tab a *Signals and Data* window will slide out. Clicking on the **Signals and Data** tab will keep it undocked until clicking outside of this window.



A list containing all signals capable of being displayed will be available with a box next to them. When the box is checked, the signal will be displayed in the *All Signals* sheet.

The *Signals* heading contains the following categories from which to select signals to add to the *All Signals* sheet:

- *Signals*: Displays waveform data.
- *Parameter Signals*: Displays parameter data.
- *Marker Groups*: Displays hypnogram plots of markers.
- *Derived Signals*: Displays derived signals.
- *Marker Groups*: Displays hypnogram plots of sleep scoring markers. The sleep stage is shown on the y-axis vs. time.

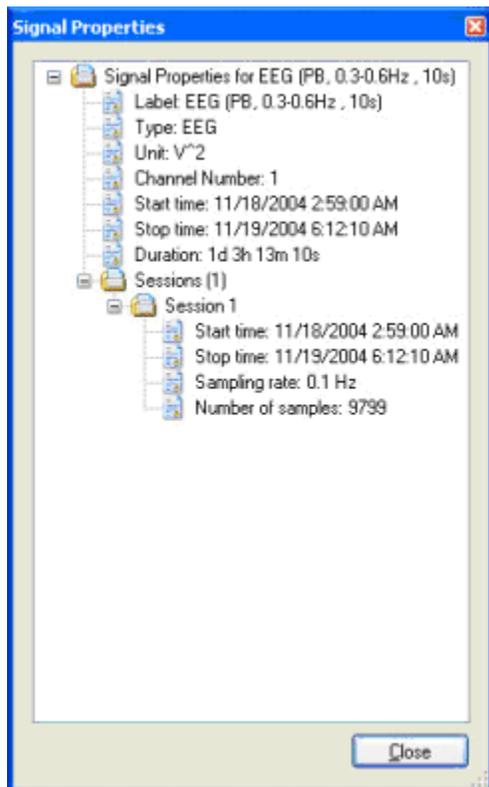
- **Rodent Sleep:** Consists of sleep markers slow wave sleep (S), paradoxical (P), wake (W), active wake (A) and artifact (X). All of these markers are used by default when using the automated sleep scoring.
- **Rodent Sleep Ex:** Consists of sleep markers: slow wave sleep 1 (1), slow wave sleep 2 (2), paradoxical (P), wake (W), active wake (A) and artifact (X).
- **Large Animal Sleep:** Consist of sleep markers for active wake (A), wake (W), non-REM(N1, N2, N3), REM (R), and artifact (X).

*Note:* Categories will only appear if a signal from that category has been loaded or derived.

The three icons at the top of this new window will have the following shortcut functions:

Icon	Function
	Checks all the signals
	Unchecks all the signals
	Groups signals by source type

The *Properties* heading lists signal properties. By selecting **More**, a new window populates with additional signal information.



The *Actions* heading provides two addition options:

- **New Derived Signal:** Opens a window that will allow a specific derived signal to be opened in the current signal sheet. Please see the Derived Signals section for further detail.
- **New Reference Signal:** Opens a window that allows the addition of a reference signal to the signal sheets.

## Dragging, Resizing, Positioning and Grouping Signals

Once the signals are displayed on the signal sheet, their settings can be changed.

Follow these steps to change the specific setting:

- Dragging

The y-axis can be adjusted by dragging:

1. When the mouse cursor is over the y-axis of the signal, a hand with all the fingers opened will appear, oriented with the fingers on top or bottom.
2. **Left-click**, the fingers will curl and the y-axis can be adjusted by dragging the hand up or down.
3. Once the y-axis has been adjusted to the desired range, then the mouse button can be released.

- Resizing

The signal can be resized:

1. Use the mouse to navigate to the top or bottom outer boundary of the signal label.
2. When the mouse is in the correct position it will change to show an arrow on both ends, indicating it can expand or shrink the size of that signal.
3. **Click and drag** on the mouse to resize it appropriately.

- Positioning

1. **Mouse** over the signal
2. When a ECG signal symbol appears next to the mouse arrow Left click-and-Drag to vertically reposition the signal

or

3. **Click** anywhere on the signal when a hand with the pointer finger extended is showing.
4. It can be moved in the vertical direction.
5. Move it to the desired location and release the mouse button.

It is possible to position the signal so that it overlaps another signal.

- Grouping

Signals that are labeled the same can be grouped together:

1. **Click** on a signal that has another signal of the same type in the signal sheet.  
**Right click - Group Signals of Same Type.** The *Group Signals of Same Type* will only be active when there is more than one signal of the same type to group.
  2. To *Ungroup* signals, click on the grouped signals, **Right Click - Ungroup Signals.**
- Zooming

To zoom in:

1. **Click-and-drag** over a particular area of a signal
  2. **Right-Click - Zoom to Area**
- OR**
3. Enter a smaller time in the **In Window** field.

To zoom out:

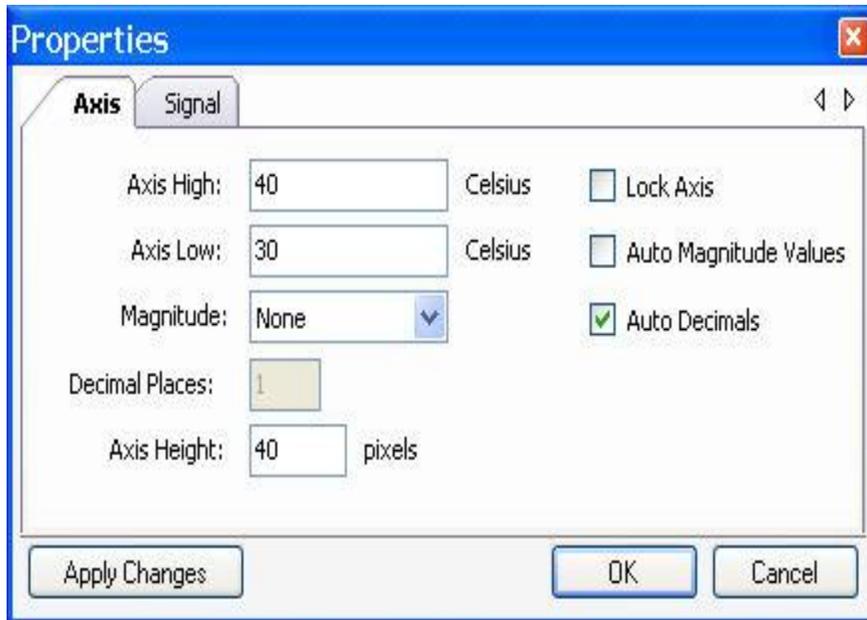
4. Select **Edit - Undo** (<Ctrl> + <z>)
- OR**
5. Press <Esc>
- OR**
6. Enter a larger time in the **In Window** field.

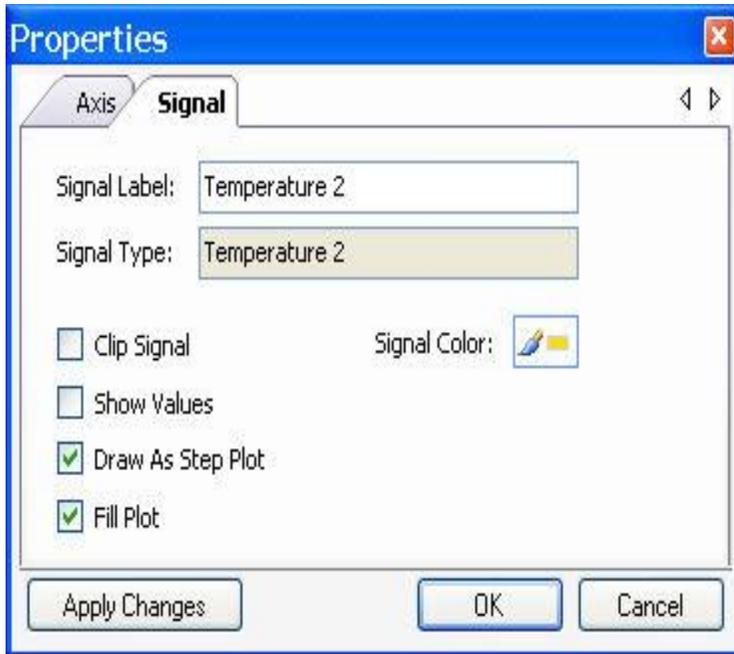
*Note:* For sheet tiling information, see the NeuroScore Work Environment.

## Signal Properties

To navigate to the signal properties, a signal must be loaded onto the signal sheet:

1. Move the mouse cursor over the label of the signal, **Right Click - Properties** or **Double-Click**
2. In the new window there will be a number of settings that can be adjusted:





a. Axis Tab

- Axis High and Axis Low

Used to adjust the y-axis range that is plotted.

*Axis High:* The maximum y-axis limit.

*Axis Low:* The minimum y-axis limit.

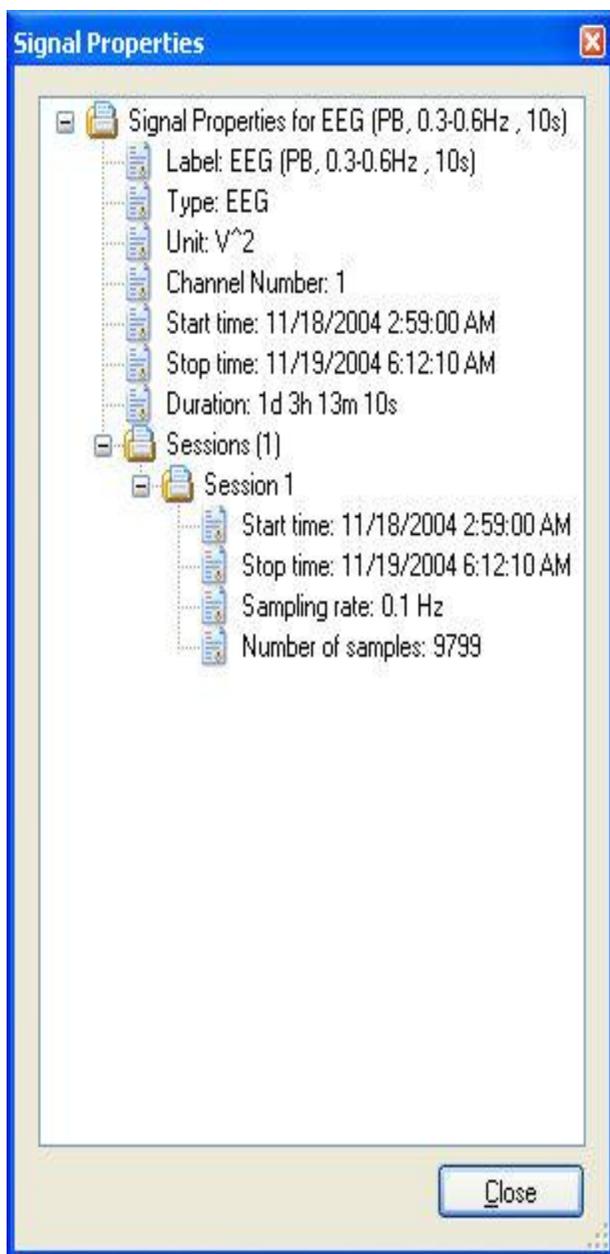
*Note:* To manually change these settings, the *Auto Magnitude Values* option must be unchecked.

- Magnitude: Adjusts the unit scaling of the signal. For example, the units can be changed from Millivolts Volts by changing the Magnitude from Milli to None.
- Decimal Places: Allows the user to define the number of decimal places shown when signal values are displayed.
- Axis Height: Provides the option to set the resolution of the signal. Increasing the number of pixels that are used will result in a higher resolution (the height of the signal currently displayed will increase).
- Auto Magnitude Values: When checked, the y-axis Magnitude will default to an appropriate range based on the data displayed in the signal sheet. Note: This must be disabled to manually adjust the y-axis range.
- Auto Decimals: The number of decimals will automatically be set when values are displayed for the signal in the signal sheet.
- Lock Axis: Enabling will lock the current axis settings. This prevents changing the axis by clicking and dragging in the signal sheet view.
- Draw Access Grid: Draws horizontal axis line for the major y-axis values.

- b. Signal Tab
    - Signal Label: Provides ability to customize the signal title as displayed in the signal sheet.
    - Signal Type: Displays the signal type assigned to the data in the acquisition program.
    - Signal Color: Allows the user to change the color used to represent signal in the signal sheet.
    - Clip Signal: Enabling the clip function will cut any part of the signal that exceeds the y-axis limits. This means that it will not plot data outside of the current y-axis range. If disabled, all data will be plotted and signal overlap may occur depending on the y-axis settings. Note: This is not the same clip function as in Dataquest ART.
    - Show Values: Enabling this will display the values of the signal in the signal sheet. Note: A value will only be displayed if the signal is zoomed in far enough.
    - Draw as a Step Plot: This will draw the signal as a step function instead of a continuous function.
    - Fill Plot: This will shade the data values. This is the default for parameter data.
  - c. 3D Tab
    - Axis High: Sets the upper limit shown on the vertical axis.
    - Axis Low: Set the lower limit shown on the vertical axis.
    - Axis Unit: Allows the user to select the graph's frequency units (Hz, Cycles/s, or bpm).
    - Color Map: Allows the user to define the color scheme used to represent the data.
    - Show major grid lines: When enabled, the major grid lines on the graph are displayed.
  - d. Derived Signal Tab
    - Indicates which data was used to obtain the derived signal. Also indicates the type of derived signal, along with the epoch duration that was chosen. For example: EEG (AR Spectrum, 10s)
3. After all settings have been adjusted, click the **Apply Changes** button.
  4. The changes should be applied to the signal. Click **OK** to accept the applied changes and close the window.

Additional Signal Properties can be found under the Signals & Data tab. To obtain these:

1. Select the **Signals & Data tab**
2. Select **More** under the Properties Heading to open a Signal Properties window.



3. Expand items by selecting the '+'
4. Select **Close**

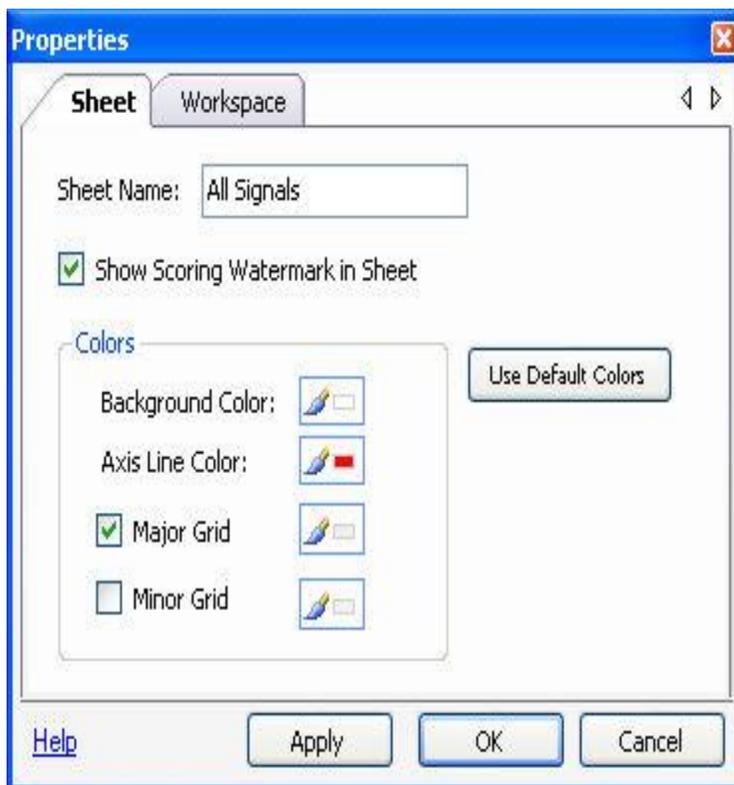
*Note:* The 3D and Derived Signal tabs will only be available in the derived signal properties.

## Global Settings

There are two property windows that are accessed through the menus in the NeuroScore window. Both of these property windows will be adjusting the global settings for the appropriate signals and graphs.

To adjust the global settings of a signal sheet, have the signal sheet open and complete the following:

1. **Edit - Sheet Properties**, opens the below window.



2. **Sheet Tab**

- *Sheet Name*: Provides ability to change the sheet title.
- *Background Color*: Allows user to change the sheet's background color.
- *Axis Line Color*: Allows the user to change the color of the x- and y- axes.
- *Major Grid*: When checked, it will display colored vertical lines for major increments depending on the interval that is chosen in the signal sheet tab.
- *Minor Grid*: When checked, it will display colored vertical lines for minor increment depending on the interval that is chosen in the signal sheet tab.

3. **Workspace Tab**

*Epoch Duration*: Defines the epoch duration, the amount of time each sleep scoring mark will be applied to. This can only be changed when the signal sheet contains no active markers.

To adjust the global settings of the power bands:





6. When power bands are Added or Edited, the settings' list will be updated with the new or updated attributes. The derived power bands signal will also adjust accordingly and will reflect the updates made in the global setting.
7. Removing a power band from settings' list will not delete it from the power band derived graph; however, it will be removed for the derived power bands signal.

## Tool Bar Overview

There are a number of buttons available in the Tool Bar.



The following are always available, regardless of the sheet tab that is active:

- **Add Sheet:** Adds a new sheet to the current NeuroScore window, both templates and blank.
- **New:** Opens a new recording in a separate NeuroScore window.
- **Open:** Opens a previously saved recording in a separate NeuroScore window.
- **Save:** Saves the current state of the opened NeuroScore window, including all calculations and analysis performed. Closing this recording and then re-opening it, will open the recording to the last saved point.
- **Undo:** Undoes the last change made to the *Workspace*.

The following are only available when a signal or overview sheet is opened:

- **Lock:** Locks the sheet in its current state of appearance. To make changes to the signals that are displayed in the sheet, it must be first unlocked.
- **Arrange Signals:** Displays the signals so they are evenly spaced and remain in the current order.
- **Auto:** When activated, it automatically arranges the signals when new signals are added or if there is an adjustment made to a signal that is already displayed.
- **Fit All:** Shifts all signals vertically to fit the window size, providing the ability to view all signals without having to use the scroll bar. Or, in the case where a small number of signals are displayed, it will spread them out and increase the vertical area they cover so the entire window is being used.
- **Scale All:** Scale all the signals appropriately for the portion of the recording that is being displayed.

The following are only available if the signal sheet is selected:

- **Search For:** When selected, a drop down menu will list a variety of options to search for within the current recording.
  - **Epoch:** Used to search for a specific epoch number, in form **#xx**, where 'xx' are numbers. *Note:* The '#' sign must be used
  - **Time:** Used to search for a specific time, in form **hh:mm**, where 'hh' would be an hour and 'mm' would be minutes. *Note:* Military Time is used.
  - **Marker:** Used to search for specific markers actively being displayed.
  - **Binoculars w/Arrow Left** [**<Shift> + <Tab>**]: Searches for the previous epoch or marker.
  - **Binoculars w/Arrow Right** [**<Tab>**]: Searches for the next epoch or marker.
- **Play Realtime:** The signal blue arrow will playback the recording in real time. If the video module is purchased, it will also playback video.
- **Play Fast:** The double blue arrows will play back a recording/video faster than real time.
- **In Window:** This is the amount of time that is displayed in the signal sheet. This is a selection of times to choose from; however, a desired time interval can also be entered.

For example, to display 24 hours of data, manually type '24h'. To increase and decrease the time interval displayed using shortcuts: <Shift> + <Right> (arrow) to decrease the amount of time displayed or <Shift> + <Left> (arrow) to increase the amount of time displayed.

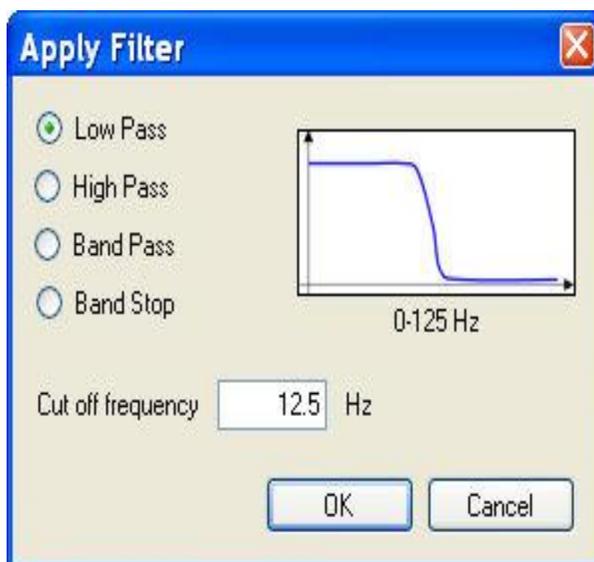
## Signal Filters

This option applies a filter directly to the signal rather than adding a new axis.

To apply a filter:

1. Select a signal.
2. **Right-click** on the signal.
3. Select the **Filters** option.
4. The following options are available:
  - Power line at 60 Hz: This will apply a standard 60 Hz power line filter to the signal.
  - Apply Filter...: This will open the following window and will list a variety of standard filter options:
    - Low pass
    - High pass
    - Band pass
    - Band stop

Select the filter by clicking on the corresponding radio button and enter the desired cut off frequency.



*Note:* By default, these filters use a filter size, in taps, equal to the sampling frequency and the Hamming windowing method.

5. Click **OK** once the filter has been chosen and the cutoff frequency entered
6. Notice that the signal label updated, reflecting the addition of the applied filter.

To Delete Filters:

1. Follow steps 1-3 above.
2. Select **Remove Filter**

*Note:* If a new axis containing the filtered signal is desired, use the *Add Derived Signals* function.

## Derived Signals

### Derived Signals

Derived signals are calculated based off of the original signals loaded in with the current recording and can be added to the signal sheet to provide further analysis.

To generate a derived signal:

1. Select a signal from which to create a derived signal.
2. **Right click** anywhere on the active signal.
3. Select **Add Derived signal...**

OR

4. With a signal sheet active, go to **Data - Add derived signal...**
5. Select the data type to create the derived signal from and then select the desired derived signal.

OR

6. Select the **Signals & Data Tab - New Derived Signal**
7. The New Derived Signal Wizard will open with two steps:

Step 1: Choose the signal from which to derive a signal

Step 2: Choose from the following options, containing various methods of calculations:

- Filtering
- General
- Quality
- Spectral
- Statistical
- Transform

8. Click **Finish** once all the user defined settings have been entered. The new derived signal will populate at the top of the active signals sheet.

*Note:* Default settings can be restored by selecting the **Restore Defaults**. By selecting the corresponding drop-down, the user can choose **Restore Current** to restore the defaults of the currently selected Derived Type or **Restore All** to restore default values to all Derived Types.

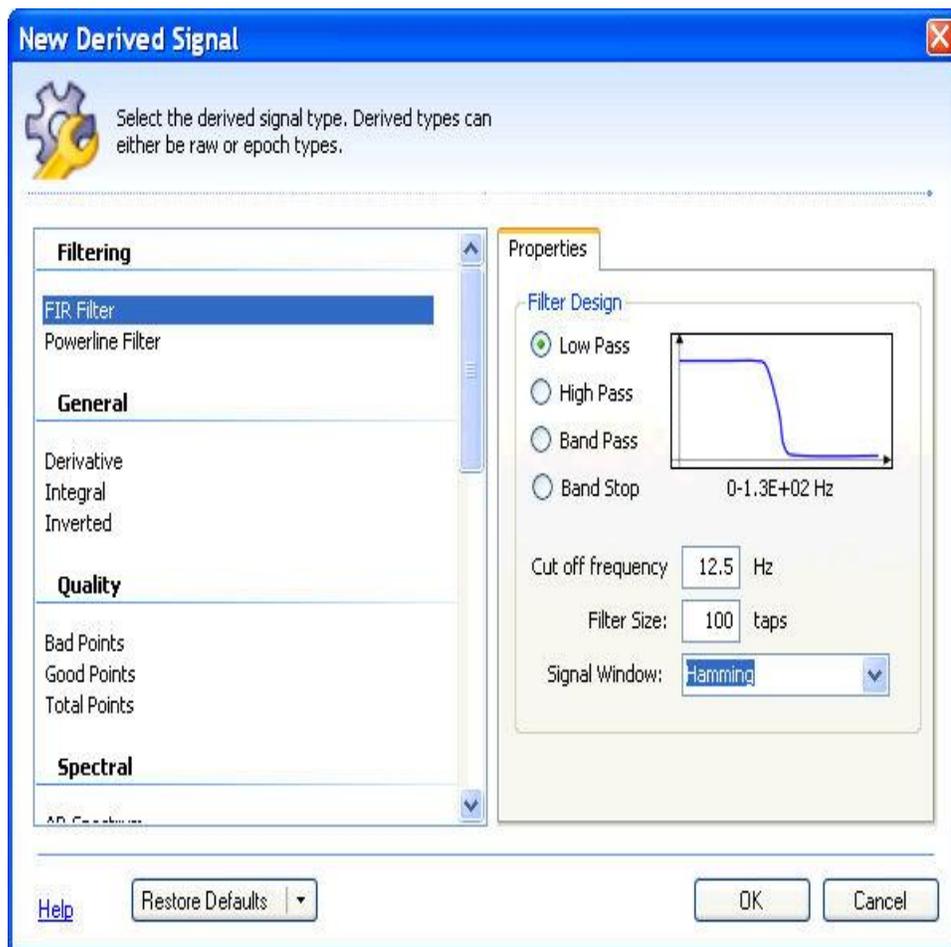
## Filtering

Two filtering options are available:

### 1. FIR (Finite Impulse Response) Filter:

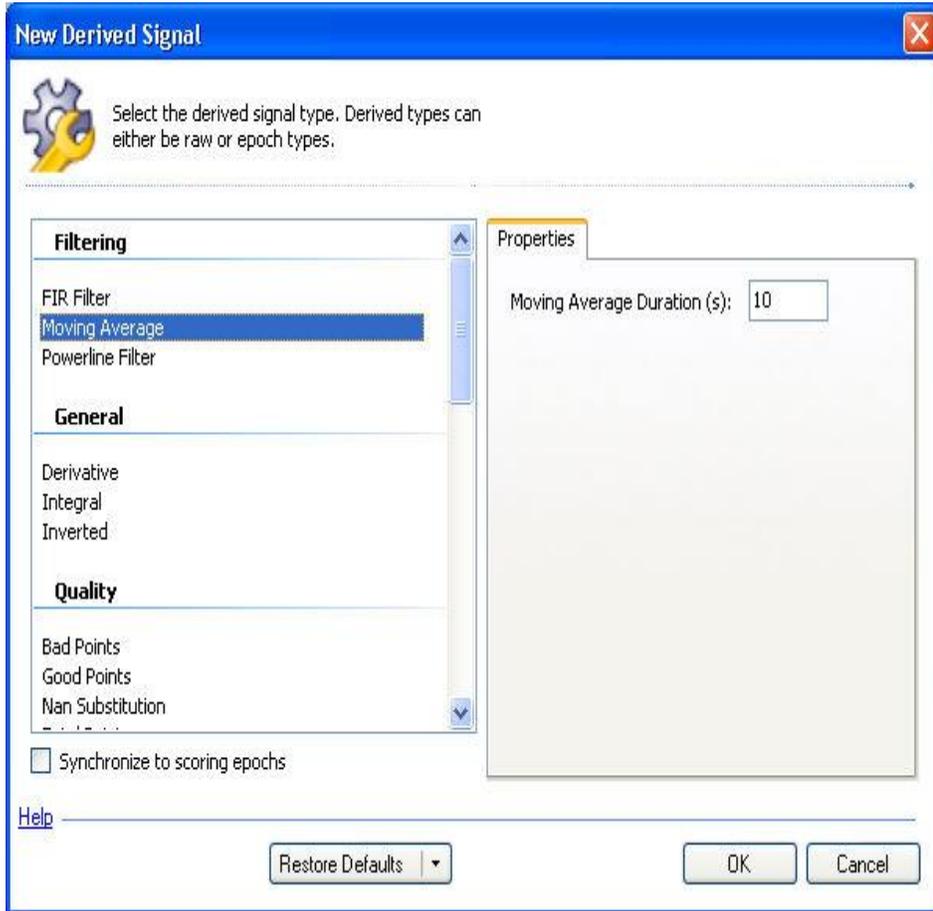
Provides the following filtering options:

- *Low Pass*: Passes low frequency components of the signal while attenuating frequencies higher than the cutoff frequency.
- *High Pass*: Passes high frequency components of the signal while attenuating frequencies lower than the cutoff frequency.
- *Band Pass*: Passes a specified frequency range of the signal while attenuating frequencies outside the range.
- *Band Stop*: Attenuates a specified frequency range of the signal while passing frequencies outside the range.



2. **Moving Average:**

Calculates the moving average over a period of time in seconds



3. **Powerline Filter:**

This is a notch filter that will filter out noise due to power line interference and provides two options:

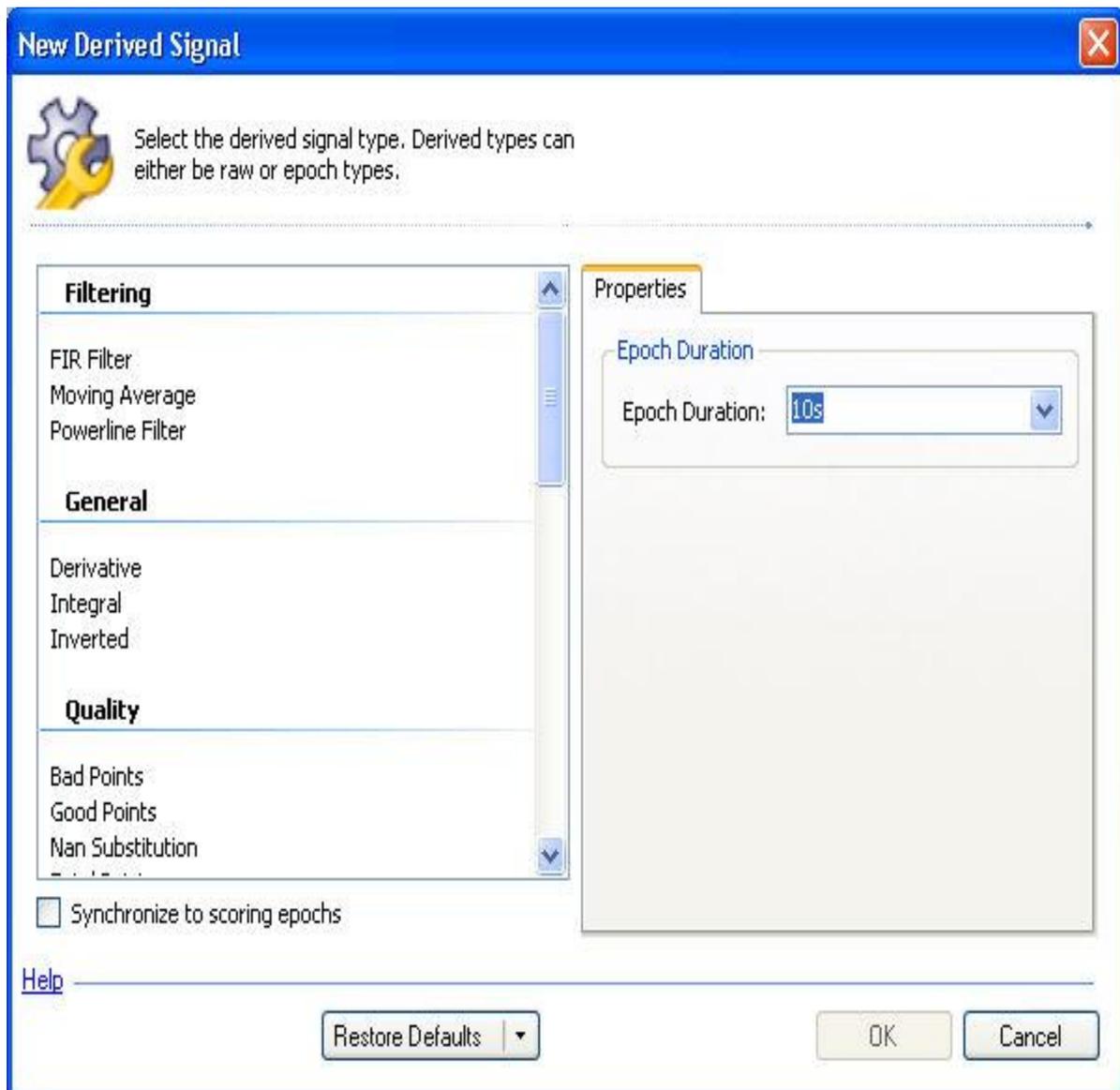
- *50 Hz*: Standard European power line frequency.
- *60 Hz*: Standard American power line frequency.
- *Note*: This filter is generally not needed with data acquired with implantable telemetry.

*Note*: Select the **Restore Default** drop down to restore the default settings. A confirmation window will appear to verify that the default settings are meant to be restored. For the filtering settings, *Restore Current* resets all of the settings for the current filtering signal selected, either *FIR* or *Powerline*, while *Restore All* resets all of the settings for both the *FIR* and *Powerline* filters.

## General

Provides three signal calculation options:

- **Derivative:** Calculates the change in the y-axis values divided by the change in x-axis values.
- **Integral:** Calculates the area under the curve. Evaluated epoch by epoch.
- **Inverted:** Inverts the signal relative to the y-axis.



*Note:* Select the **Restore Default** drop down to reset the settings to the default settings. A confirmation window will appear to verify that the default settings are meant to be restored. For the general settings, *Restore Current* and *Restore All* will reset all the settings for the current general signal selected.

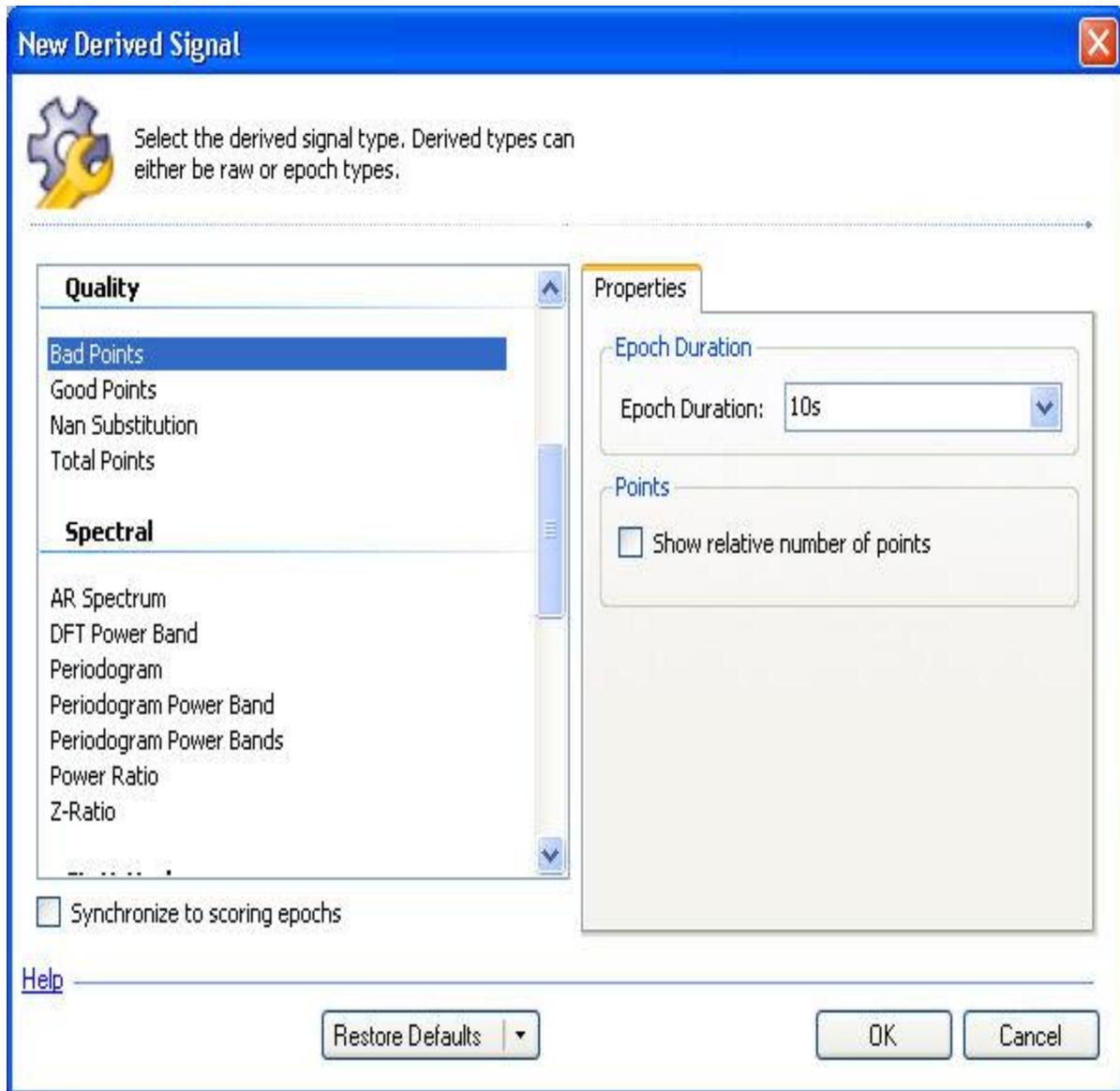
## Quality

These functions are based off of other DSI software and are generally used to monitor signal dropout:

**Bad Points:** Calculates the total number of points in the period that are NAN values.

- **Good Points:** Calculates the total number of points in the period that are not NAN values.
- **Nan Substitution:** replaces the NAN with a value. One of four options can be checked. The options are:
  - Replace with a value. The value one wishes to replace the NAN with needs to be typed into the box.
  - Replace with a previous value
  - Replace with next value
  - Interpolate between values
- **Total Points:** Calculated the total number of points in the period.

*Note:* NAN is an acronym for 'Not A Number' which indicates that a value is not within an acceptable range or does not translate to any understandable value within the limits and/or restrictions of the statistical algorithm. Some values are returned as NAN with the Acquisition program during data collection due to noise interference or signal dropout.



*Note:* Select the **Restore Default** drop down to reset the settings to the default settings. A confirmation window will appear to verify that the default settings are meant to be restored. For the quality settings *Restore Current* and *Restore All* will reset all the settings for the current quality signal selected.

## Spectral

These functions include various ways to display the signal content in the frequency domain. Each of the options is computed per epoch.

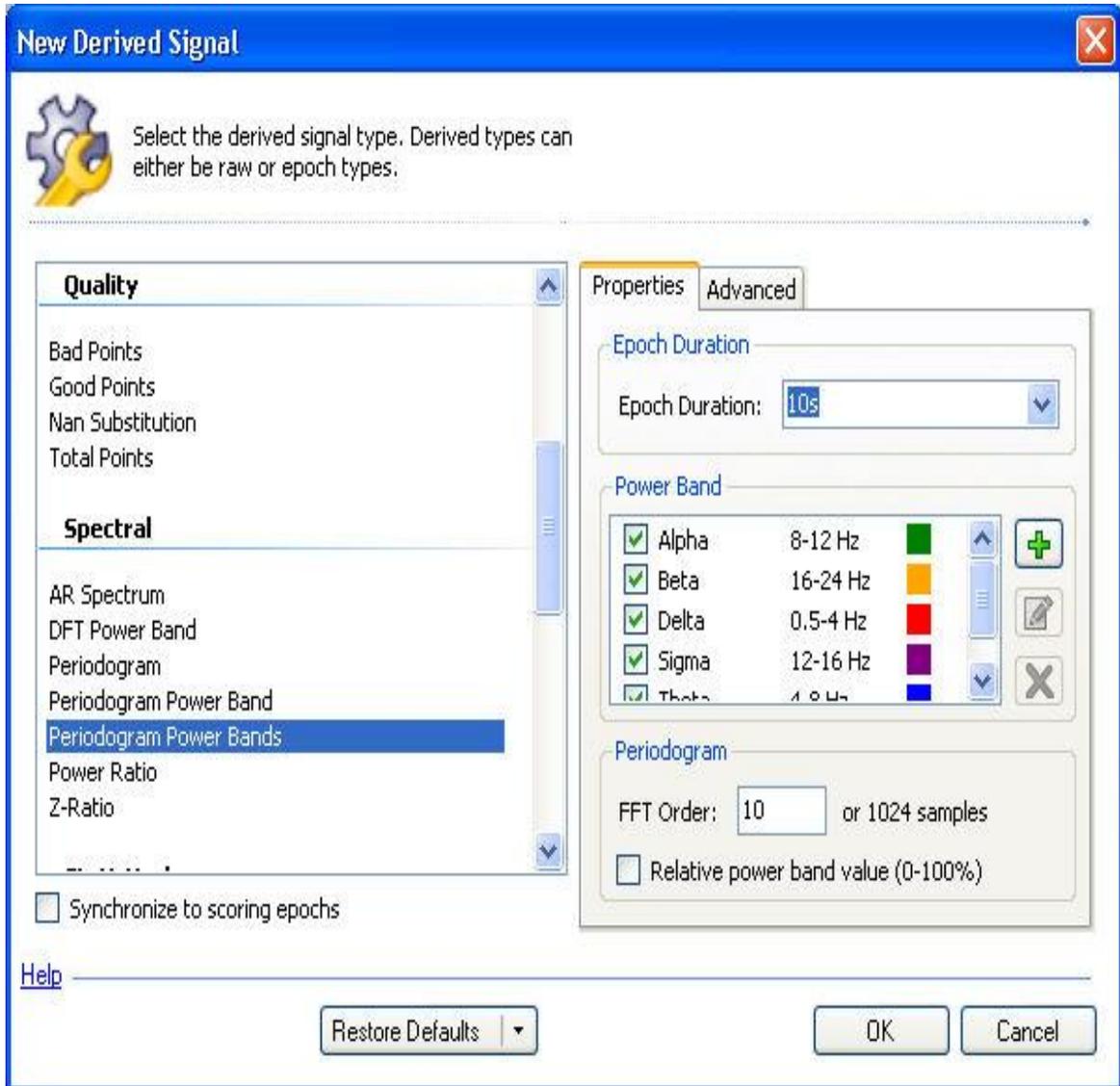
- **AR Spectrum:** Autoregressive Spectrum. This function is generated based on autoregressive modeling (parametric) instead of a transform. It provides an estimate of frequency (Hz) versus power (uV<sup>2</sup>) relationship. This is generally used to show the dominant frequency component of the epoch.
- **DFT Power Band:** Discrete Fourier Transform. Computes the frequency content for a user-defined frequency range (power band).
- **Periodogram:** Estimate of power based on the Fast Fourier Transform (FFT) designed for continuous data sets. Please see the Periodogram section for more information.
- **Periodogram Power Band:** Computes the periodogram based on a single pre-defined frequency ranges.
- **Periodogram Power Bands:** Displays the periodogram results for more than one pre-defined frequency range. User-defined Power Bands can be add to the pre-defined power bands by clicking on the "+" sign. Power bands can also be edited and deleted.
- **Power Ratio:** Calculates the ratio of two power band ranges based on the DFT. The user can specify the power band for the numerator and denominator. This function is useful for visualizing the Delta Ratio and Theta Ratio criteria used in the Rodent Auto Sleep module.
- **Z-Ratio:** Calculates the difference in low frequency power (LF: 0.5-8Hz) to high frequency power (HF: 8-20Hz) in relation to the total available power. The result is in a range from -1 to 1 where -1 indicates high frequency power concentration and 1 indicates low frequency power concentration. The equation that is used for this calculation is the following:

$$Z - Ratio = \frac{(LF - HF)}{(LF + HF)}$$

*Notes:*

- Checking the **Relative power band value (0-100%)** will normalize the output by representing the power band as a ration between the desired power band and the total power in the signal.
- When displaying a spectral derived signal with a time axis less than 5m, the frequency from 0 to 25 Hz is displayed on the x-axis for each epoch. When viewing time ranges of 5m or greater, the axis shifts and frequency is displayed on the y-axis with time on the x-axis. This view is referred to as a *Spectrogram*, where the spread of the frequency content is shown graphically with the intensity of the power content shown in the graph colors.
- Select the **Restore Default** drop down to reset the settings to the default settings. A confirmation window will appear to verify that the default settings are meant to be restored. For the spectral settings with power band settings, *Restore Current* will reset the current settings for spectral signal selected. Choosing *Restore All* will reset all the

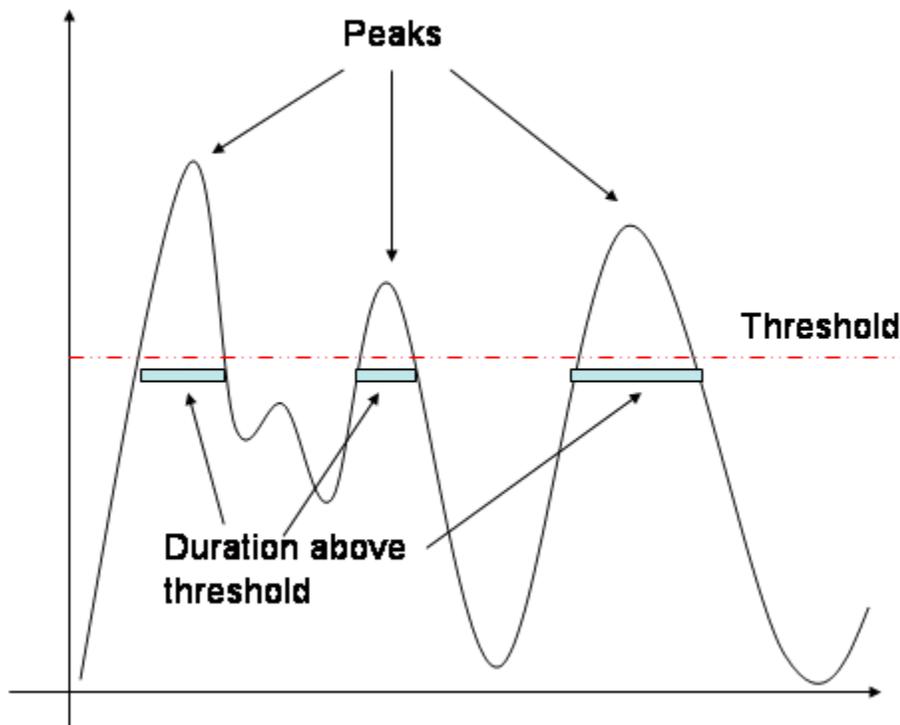
power band default settings for each spectral signal. Choosing the *Restore Current* or *Restore All* with the other spectral signals will function the same.



## Statistical

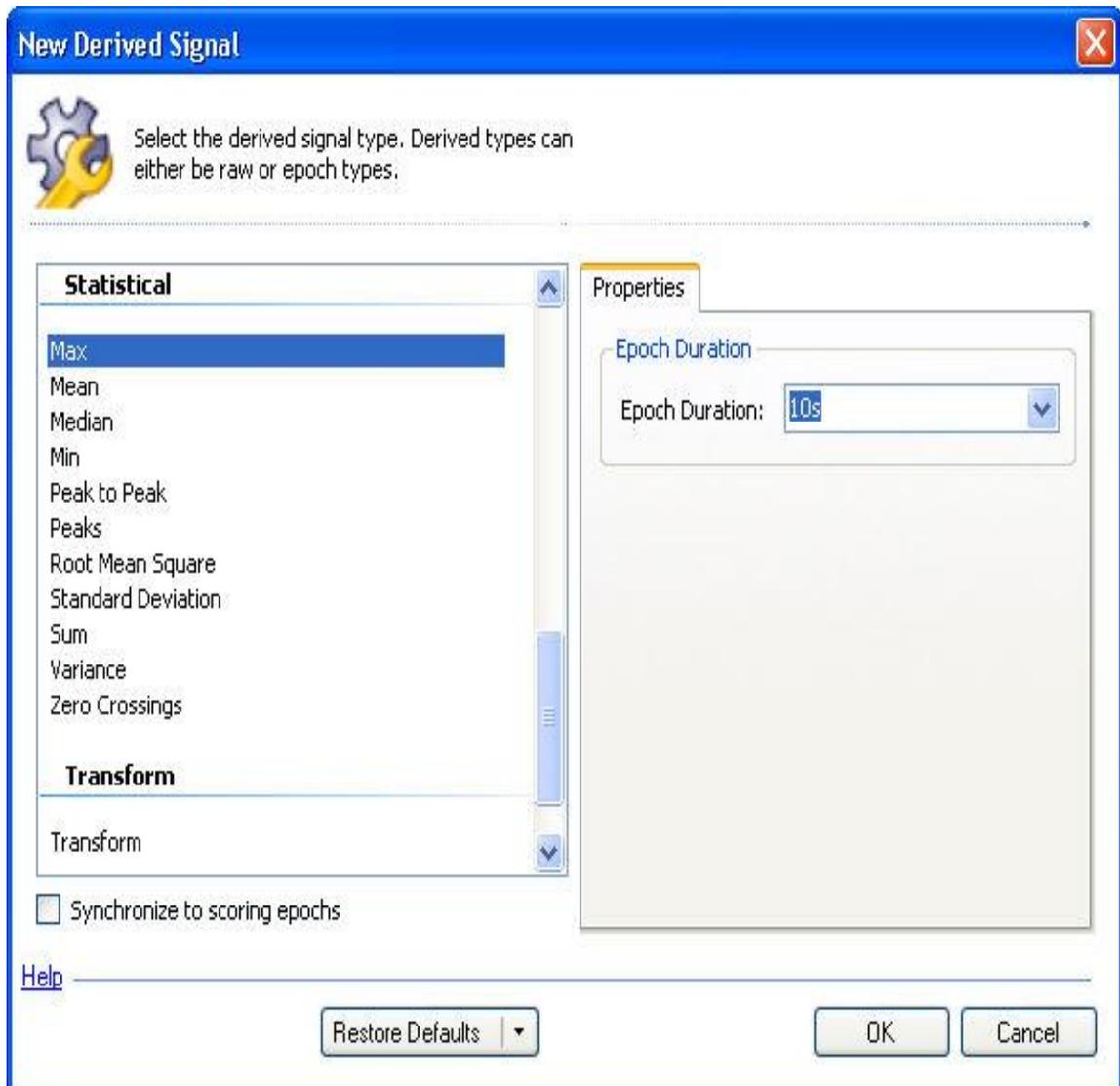
Gives the option to apply various statistical computations to the data:

- **Maximum (Max):** Finds the highest value for the specified epoch duration.
- **Mean:** Finds the arithmetic average value for the specified epoch duration.
- **Median:** Finds the middle value for the specified epoch duration.
- **Minimum (Min):** Finds the lowest value for the specified epoch duration.
- **Peak to Peak:** Calculates the largest difference between peaks for the specified epoch duration.
- **Peaks:** Finds high values in the data that fit the criteria based on the threshold entered along with the operator setting. Data can be reported as a number, as a duration or a relative value. Number will report the number of peaks, duration will report the total amount of time spent above the threshold (as seen below) and relative calculates the percentage of time spent above the threshold divided by the total epoch duration.



- **Root Mean Square:** Calculates the root mean square for the specified epoch duration.
- **Standard Deviation:** Calculates the standard deviation for the specified epoch duration.
- **Sum:** Adds together all the data points that were collected during the specified epoch duration.
- **Variance:** Calculates the variance for the specified epoch duration.

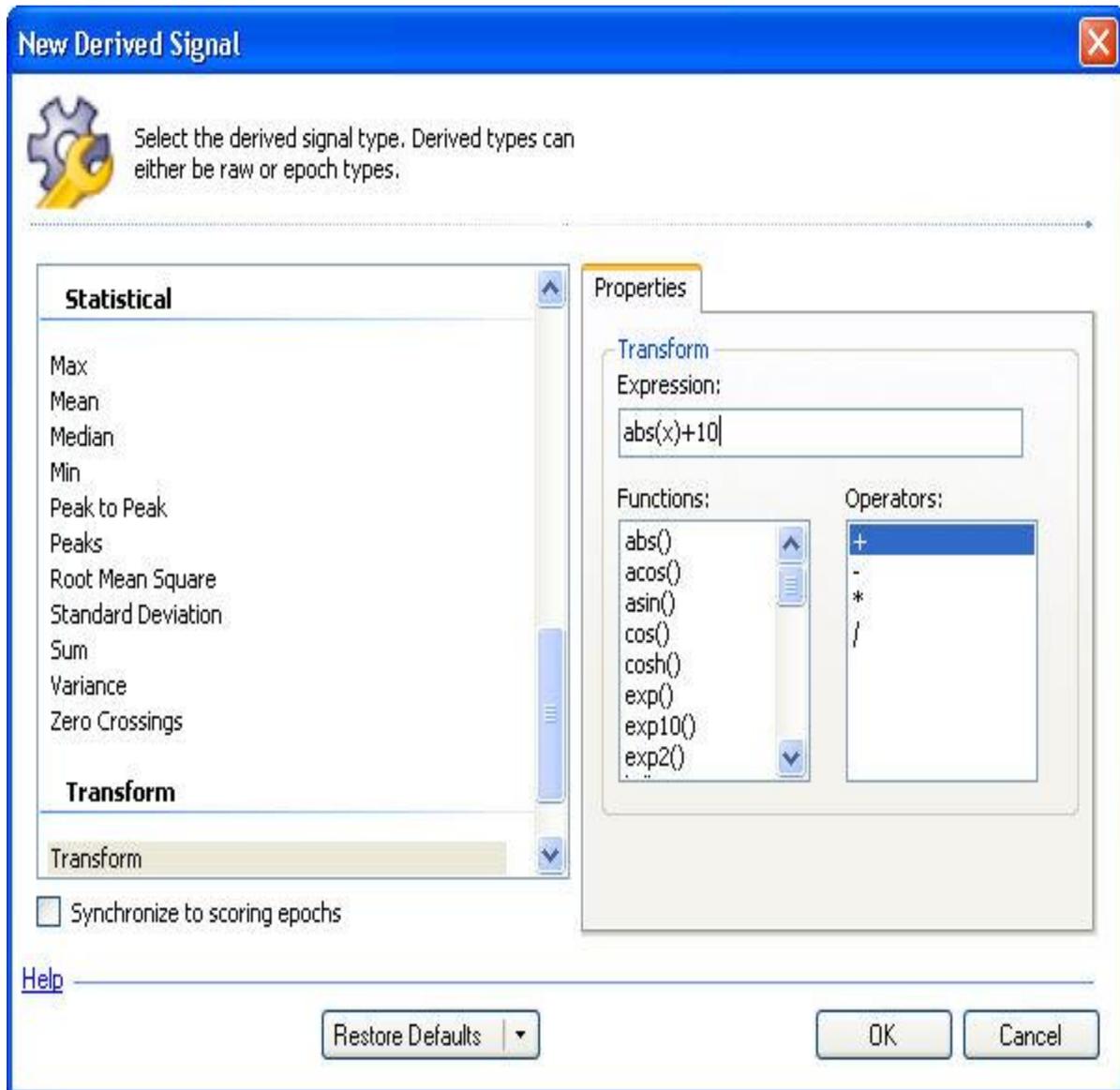
- **Zero Crossings:** Calculates the number of times the signal crosses the x-axis. The *Per Second* setting will determine if it calculates the total number of crossings or crossings per second.



*Note:* Select the **Restore Default** drop down to reset the settings to the default settings. A confirmation window will appear to verify that the default settings are meant to be restored. For the statistical settings *Restore Current* and *Restore All* will reset all the settings for the current statistical signal selected.

## Transform

A specified function will be applied to every data point to create the new derived signal. The function applied has to be a function of one variable "x".

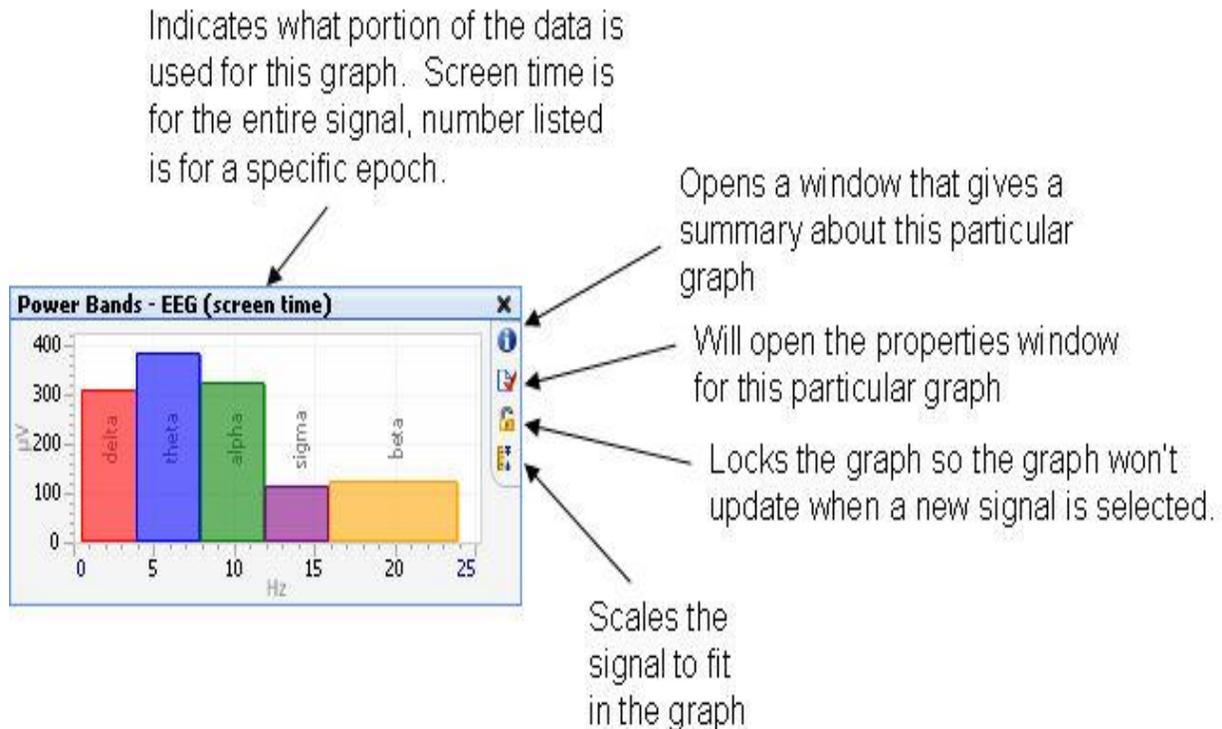


*Note:* Select the **Restore Default** drop down to reset the settings to the default settings. A confirmation window will appear to verify that the default settings are meant to be restored. For the transform settings, *Restore Current* and *Restore All* will reset all the settings for the current transform signal selected.

## Derived Graphs

### Derived Graphs from Individual Signals

Another option available in NeuroScore is to add derived graphs. These will populate at the top of the current signal sheet. These graphs will display data from an individual signal that is currently selected in the active signal sheet. Each graph will have some settings that will allow for adjustments to be made.



There is an additional icon that is only available on the Hypnogram and Marker Overview graphs called *link with screen time*. If it is active (it is grayed out), then the data being used is dependent on what period is selected.

To access these graphs go to **View - select one of the following:**

- AR Spectrum
- Staging History
- Power Bands
- Periodogram
- Marker Overview
- FFT
- Hypnogram

Click on the above links to view the property windows of the graphs and explanations of the properties.

As mentioned, each will have their own individual settings that can be accessed by clicking on the appropriate icon to open the properties window. You can also **Right click - choose from a list of menu options**.

*To change what signal these graphs are being derived from:*

1. Select the desired signal to base these derived graphs off of.
2. To change the signal, simply select a different signal and all the graphs will update accordingly. However, graphs that have been locked will not update.

*To change the amount of time that is being used for the calculations of these graphs:*

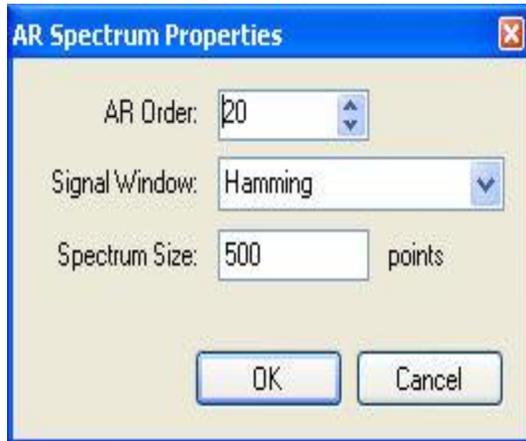
1. Select a signal to base the derived graphs off of.
2. When the signal is first selected, the derived graphs will be for the entire x-axis time span that is currently being displayed within the NeuroScore window.
3. The x-axis time interval can be changed in the following ways:
  - Click and drag the mouse pointer across the x-axis. **Right-click - Zoom to area**. This will zoom to the interval selected and the graphs will update.
  - Use the drop down window option that changes the x-axis interval or **Right-click** on the navigation bar and choose the time span of interest.
  - Choose any epoch and the graphs will update according to the time span set for an epoch.
  - To revert back to the original x-axis interval time span of the current signal sheet, press <Esc>.

#### **Other settings/options:**

- To adjust the **x and y axis ranges**, either double click on the corresponding axis or click and drag when the hand is visible on the respective axis.
- These individual graphs can be **undocked** from the top of the active signal sheet. To undock, **click** on the top of the graph (where it is labeled), then **drag** it anywhere on the computer screen; it can even be outside of the NeuroScore window. To dock it again, simply **click-and-drag** it back to the top of the signal sheet and the window will update accordingly to allow the graph to dock again.
- These graphs can be copied as well: navigate the mouse over the graph of interest, then **Right-click - Copy - Image**.
- The graphs' data can also be copied and pasted into other programs. **Right-click - Copy - Data**. Copied data can be pasted into any open program that will allow .txt files to be pasted. See Exporting Options with the Signal Sheet for more information on exporting other data.

## AR Spectrum

Shows the frequency spectrum of the selected input signal. The x-axis displays the frequency range from zero to half the sampling rate. The y-axis displays the average amplitude of the corresponding frequency.



**AR Order:** The order of an AR spectrum is the number of parameter estimated. The number of poles in the AR model is equal to the half of the AR Order. The higher the order, the more detail is added to the spectrum at the computation cost.

**Signal Window:** Spectral windows are used to minimize spectral spreading. Raw samples are multiplied, point by point, by scaling factors that will change the spectral spreading characteristics created by digital data conversion. Each signal window has different characteristics for attenuation of the spectral spreading.

**Spectrum Size:** The spectrum can be drawn using any number of data points. As the spectrum is estimated, then the spectral content can be drawn with any resolution desired.

## Staging History

Shows the scored stages that are associated with the selected marker group.



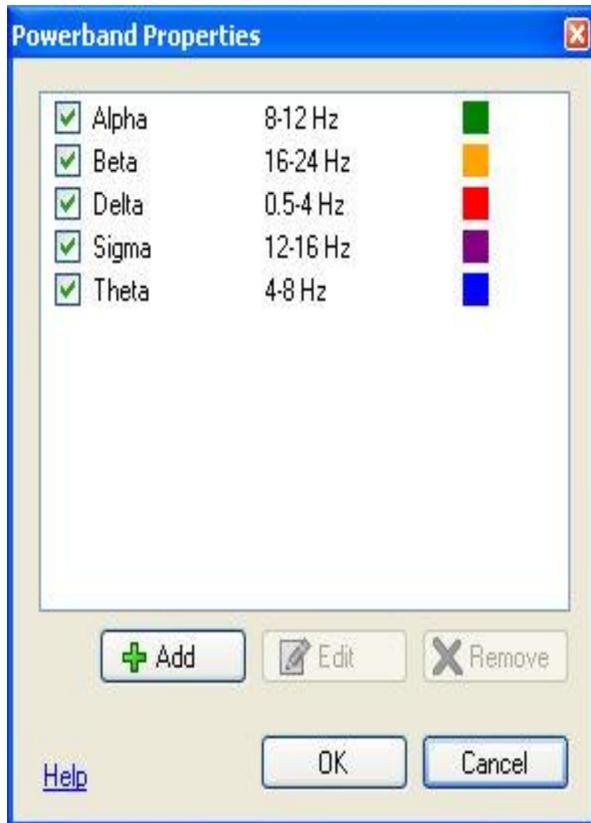
**Marker Group:** This option lists all available marker groups that contain scoring markers. The marker groups only allow marker types defined in the group to be displayed in the staging history overview.

*Note:* Marker Groups that end with **Ex** will redefine Slow Wave Sleep (SWS) into two separate stages, SWS1 and SWS2, if the user has scored the data accordingly.

## Power Bands

Shows the integral between the lower and upper bounds for a given frequency range of the power spectrum.

Additional power bands can be added by clicking on the "+" **icon** and entering the needed information (name, frequency range, and color of bar). This will add a new section named *Custom power bands*.

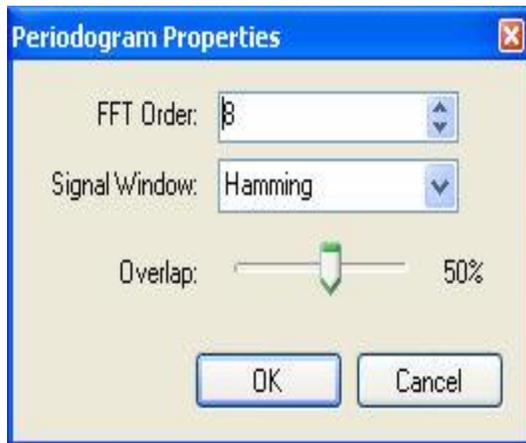


To edit a custom power band, select it and then click on the **Edit icon**.

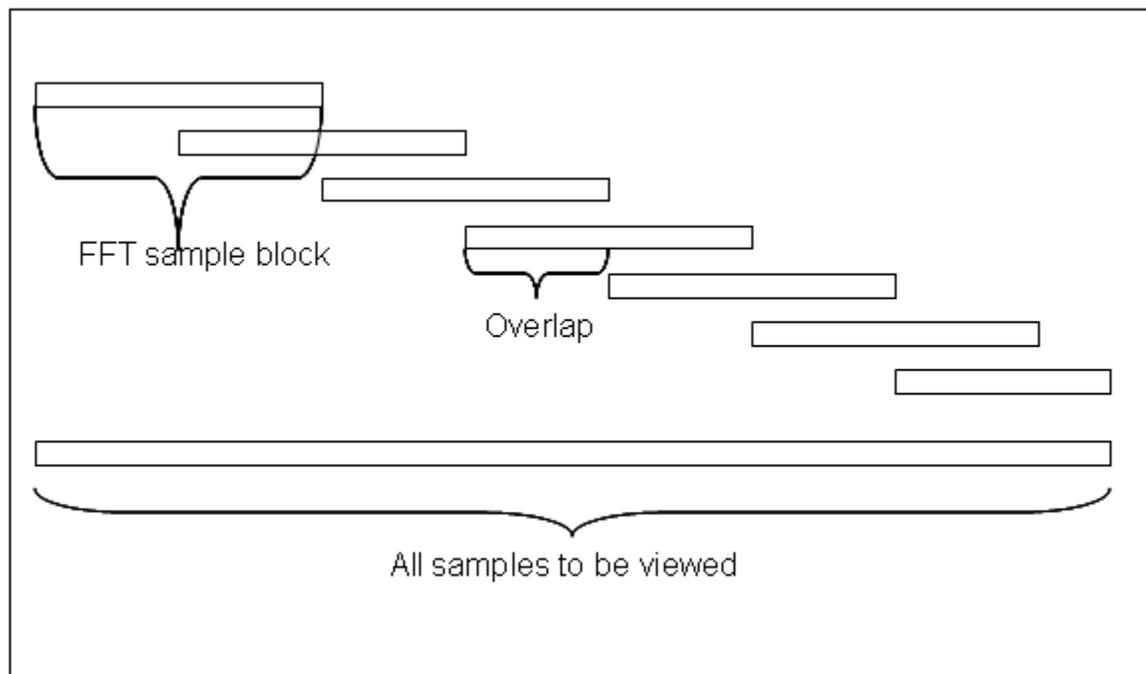
To delete a custom icon, select the power band and then click on the **Remove icon**.

## Periodogram

Displays the averaged frequency power spectrum of the selected input signal over a fixed number of points. The x-axis displays the frequency range from zero to half the sampling rate. The y-axis displays the average amplitude of the corresponding frequency.



The way the periodogram works is best explained by some simple graphics.



In the graphics above a sample batch is split up into FFT specific sizes (sizes in the power of 2). Each segment is then overlapped by some predefined factor (0.5, corresponding to 50% overlap, is the default). This method is called the Welch method of spectral smoothing. The FFT is calculated for each of the FFT segments and the average spectrum is calculated from all of them, congruently. This provides a smoother representation of the overall spectrum.

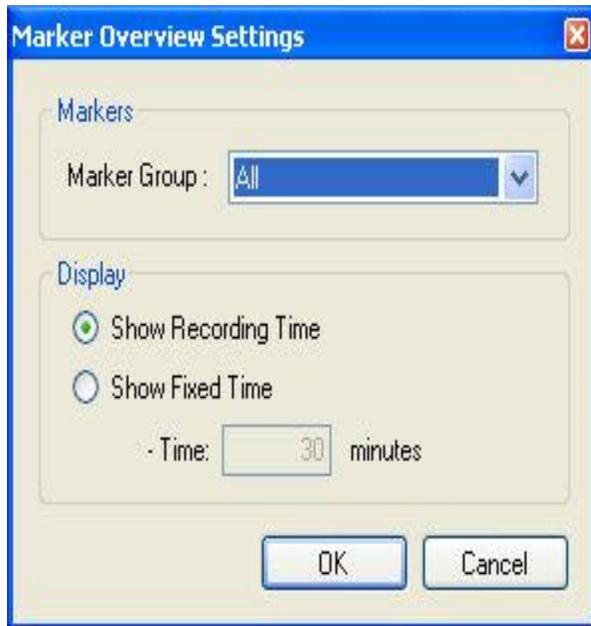
**FFT Order:** Number of points used for the FFT spectrum. The default value is 8 which gives  $2^8$  points or 256 points. Since the FFT is double sided only half of these points are used to represent the spectrum, or 128 points.

**Signal Window:** Spectral windows are used to minimize spectral spreading. Raw samples are multiplied, point by point, by scaling factors that will change the spectral spreading characteristics created by digital data conversion. Each signal window has different characteristics for attenuation of the spectral spreading.

**Overlap:** This is the overlap between segments. The overlap ranges from 0-90%. The higher the overlap, the smoother the spectrum becomes. Note: Higher overlaps need to compute more FFTs which accounts for longer computational time.

## Marker Overview

Shows all scored markers.



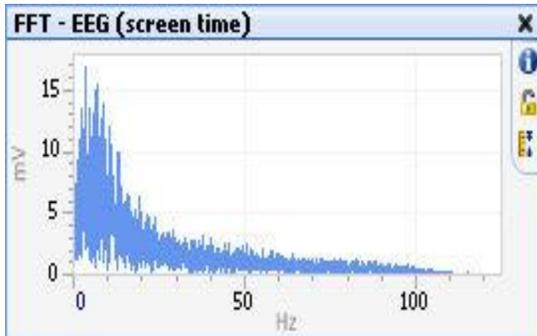
**Marker Group:** Shows all available marker groups. By selecting a marker group, the user has selected to view only the marker types belonging to that group. No other markers will be shown. This can be viewed as a marker filter, which filters out unwanted marker types.

**Display:** This group contains 2 options.

1. **Show Recording Time:** This is an option to view the marker overview for the whole recording. This option never shows more than 12 hours on the screen.
2. **Show Fixed Time:** Here the user can specify a fixed time window to view the marker overview.

## FFT

Displays the Fast Fourier Transform (FFT) of the selected input signal converting its content from the time domain to the frequency domain. The FFT function is a special case of Discrete Fourier Transform (DFT), where the number of samples calculated are in the power of 2 (4, 8, 16, 32, 64 etc.). This function optimizes spectrum calculation time and can be used when the input sample size is a power of 2. The x-axis displays the frequency range from zero to half the sampling rate. The y-axis displays the average amplitude of the corresponding frequency.

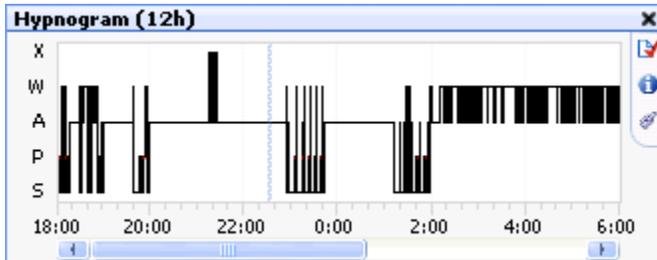


*Note:* This graph has default settings that are hard coded into the software. The graph has been hard coded using a Hamming window.

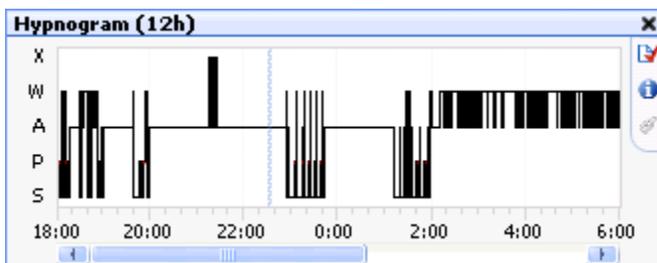
## Hypnogram

The hypnogram is a graphical representation of the subject's sleep pattern over a specific time range. The y-axis displays the sleep stage and the x-axis is time. The option to time sync between the Hypnogram and the signal sheet is available. To do this, enable the last symbol on the graph.

If time sync is enabled, it will appear as shown below:



If time sync is not enabled, it will appear as shown below:



Other hypnogram settings:



**Marker Group:** This option lists all available marker groups that contain scoring markers. The order of the markers can be modified in a new marker group.

**Display:** This group contains 3 options.

1. **Show Recording Time:** This is an option to view the hypnogram for the whole recording. This option never shows more than 12 hours on the screen
2. **Show Only Scoring Time:** This option is synchronized with the duration of the scoring. If the scoring is less than 12 hours it will only show the time that has been scored.
3. **Show Fixed Time:** Here, the user can specify a fixed time window to view the hypnogram.

## Exporting Options with the Signal Sheet

To *export* the signal sheet as an image:

1. Have the signal sheet of interest active.
2. Click **File-Export Sheet...**
3. The sheet can be exported as an ".emf" or ".png" file, both of which are image file extensions.
4. Entered the file type and the file name, then click **Save**.

*Note:* The exported sheet will need to be opened from the folder that it was just saved to, it will not automatically launch after it has been saved.

To *export* individual data values from the signal sheet:

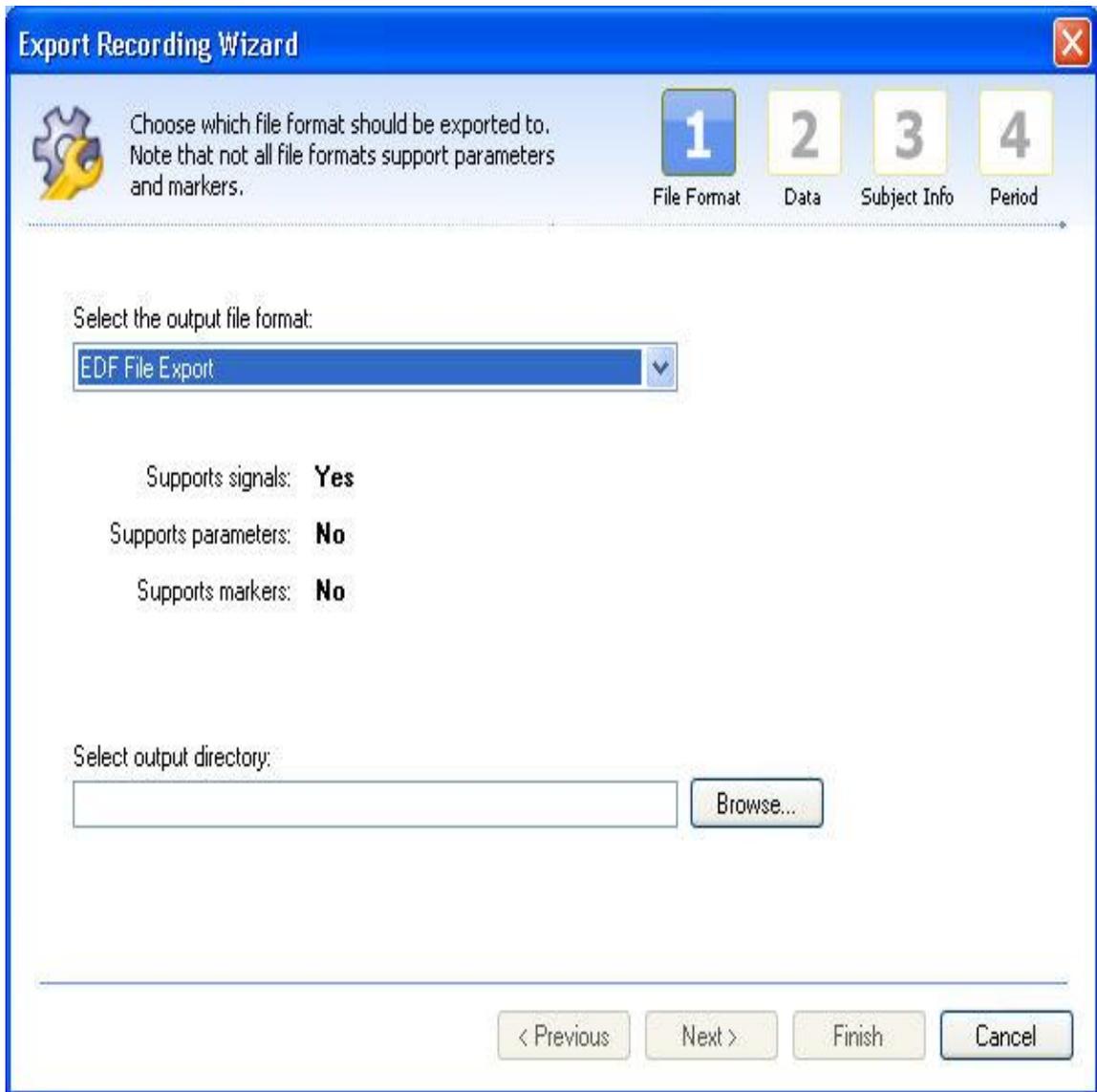
1. On the signal of interest, **Right-click - Copy - Copy Data**
2. After copying the data, open the appropriate application to paste the data into. The amount of data that will be posted will be dependent on the time interval that was selected. The amount of time on the x-axis will determine how much data will be copied. However, if an individual epoch is selected, then only the data in the epoch will be copied.
3. Pasting data into the application may have different results depending on data type that has been copied.
  - E.g. in Excel:
    - Raw waveform data will paste the y-axis data vertically, in chronological order from top to bottom.
    - Data from the Derived Graphs will paste the x-axis data horizontally with chronological order vertically.

*Note:* With raw files, the option to **Copy Image** is available; however, this is not available with derived signals.

To *export* the entire data recording:

Data can also be exported as European Data Format (EDF) or Embla data files.

1. Go to **File - Export Study...**
2. The following window will populate:.

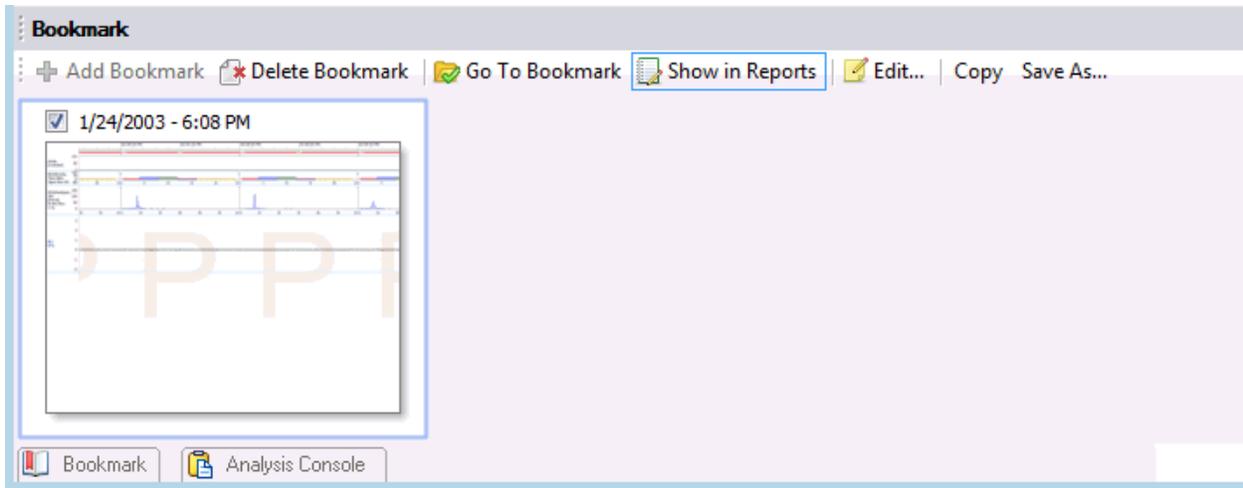


3. Select the output file format desired, Embla or EDF, and select the output directory desired for the exported files:
  - Embla files are named according to the data/signal types.
  - EDF files need to be named.
4. Select the data of interest to export - choose either the data originally loaded or the derived signal data.
5. Customize the animal identification used if necessary.
6. Select the time period of interest to export the data from. These periods available are dependent on the data's saved periods. See Working with Periods for more information on periods.

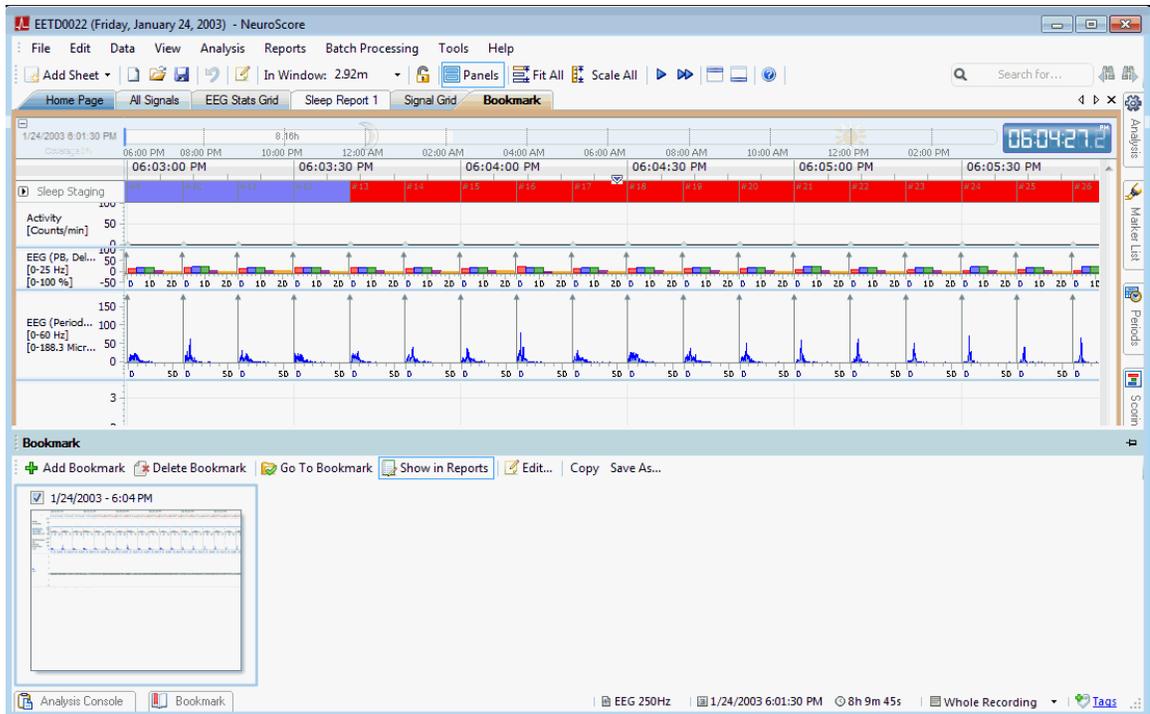
## Bookmarks

The bookmark tab allows a user to add or delete a bookmark. Once added, a bookmark will save a time point in the recording along with the current time scale. Bookmarks provide a quick and easy way to save screen shots of interest for instant access later or for inclusion in a report.

The bookmark tab has menu options described below.



- **Add Bookmark:** Adds a bookmark as a snapshot of the current screen to the bookmark tab. Bookmarks will be saved in order and a description can be added to the bookmark.
- **Delete Bookmark:** Deletes the currently selected bookmark.
- **Go To Bookmark:** Opens a new tab with the selected bookmark centered in the recording. Double clicking on a bookmark will also go to the selected bookmark.



- **Show in Reports:** Toggles the selected bookmark check-box On and Off. Selected bookmarks will be shown when bookmarks are added to a report.
- **Edit:** Allows editing of bookmark descriptions.
- **Copy:** Copies the selected bookmark to the clipboard.
- **Save As...:** Saves the current bookmark as an image file (.png, .jpg or .bmp).

## Grids

### Working with Grids

#### Signal Grid vs. Marker Grid

The signal grid sheet is very similar to an Excel sheet in the way it functions. Different types of data can be added to the signal sheet and calculations can be applied to the data. Each row represents a user-defined time range so information can be displayed for per epoch or averaged over a longer period of time.

The marker grid is designed to work with markers and bouts specifically and is particularly useful for reporting non sleep markers and sleep bouts. Unlike the signal grid, calculations in the marker grid ignore time intervals and instead, generate rows based on the duration of bouts or markers. For instructions on how to select which markers to analyze in the marker grid sheet, please see No Markers or Bouts Selected.

To add a new grid sheet:

1. Select the **Add Sheet** drop down icon in the tool bar.
2. Select the desired **Grid** type.
3. A new tab will be added to the NeuroScore workspace named according to the Grid selected.

The following are pre-defined Grid templates that come with the software:

- **30 m Bouts Grid Extend:** A pre-defined signal grid sheet for used with a recording that has been scored with rodent sleep stages. The grid will count the number times the subject is in one of the following sleep stages: Active Wake (A), Wake (W), Slow Wave (S), Paradoxical (P) and Artifact (X) for each 30 minute time interval. Additionally, for each 30 minute period it will calculate the total amount of time the subject was in each sleep stage or bout. If a bout extends into the next 30m interval, it will be fully counted in the interval in which it began (see Markers, Bouts, and Trimming section).
- **30 m Bouts Grid Trim:** A pre-defined signal grid sheet for use with a recording that has been scored with rodent sleep stages. The grid will count the number times the subject is in one of the following sleep stages: Active Wake (A), Wake (W), Slow Wave (S), Paradoxical (P) and Artifact (X) for each 30 minute time interval. Additionally, for each 30 minute period it will calculate the total amount of time the subject was in each sleep stage or bout. If a bout continues into the next 30m interval, it will be trimmed at the interval boundary and counted in each interval in which it occurs. The time duration reported will reflect the portion that occurred in that particular interval (see Markers, Bouts, and Trimming section).
- **30 m Bouts Grid:** A signal grid sheet that will count the number times the subject is in one of the following sleep stages: *Wake (W)*, *Slow Wave (S)*, *Paradoxical (P)* and

*Artifact (X)* for each 30 minute interval. Additionally each 30 minute period it will calculate the total amount of time (seconds) the subject was in each sleep stage or bout.

- **30 m Stage Grid:** A signal grid sheet that will calculate the amount of time (seconds) spent in each of the following sleep stages: *Active, Artifact, Paradoxical, Slow Wave Sleep (SWS)* and *Wake*.
- **EEG Stats Grid:** A signal grid sheet that will have the following columns for each 10 second interval: *Sleep Stage* of the subject, a *Root Mean Square* for the EMG signal, *DFT Power Band* for *Delta*, *DFT Power Band* for *Theta*, *DFT Power Band* for *Alpha* and the *Theta Ratio*.

The following list includes the different options that are available when using Grid Sheets:

- Adding Columns
- Reordering Columns
- Editing Columns
- Exporting Grids
- Saving Grids as Layouts
- Time Syncing the Signal Sheet to the Grid

Below are examples of creating commonly requested Grids:

- Creating a Custom EEG Stat Grid
- Creating a Signal Grid using the Period Start Time

## Adding Columns

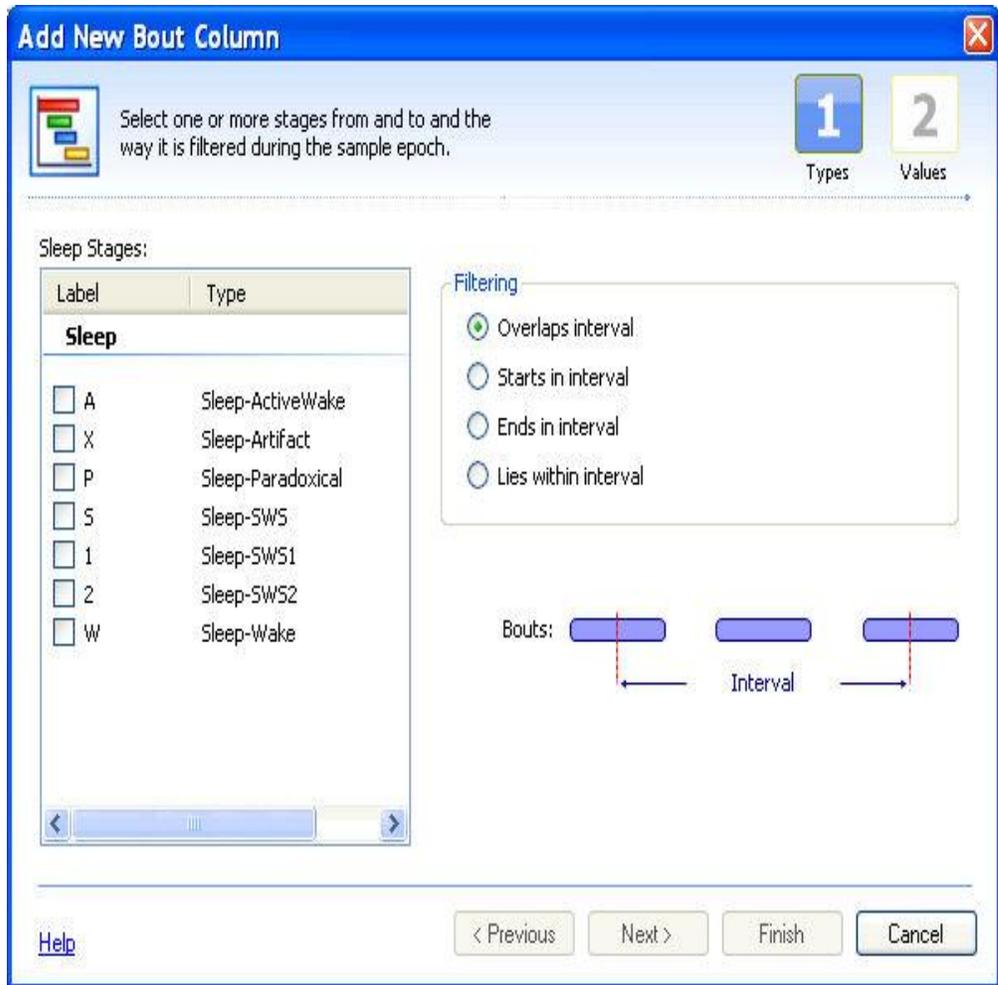
To add a column to a grid sheet:

1. Open a new *Grid Sheet* or navigate to one that has already been created
2. **Click** on the **Add Column** icon
3. Select from one of the following options:

### Signal Grid Specific Columns

- Time Stamp Column: Defines the time range for the parameters (columns) within the signal grid sheet. If this column is added first it will list time stamps beginning on the first whole interval based on the epoch chosen.
- Bouts Column

1. A New Bouts Column wizard window will open.



2. Select a filtering method:
  - **Overlaps Interval:** Will count the marker when it crosses over each boundary of the epoch.
  - **Ends in Interval:** Will count the marker when it ends in the current epoch.
  - **Starts in Interval:** Will count the marker when it starts in the current epoch.
  - **Lies within Interval:** Will count the marker when it lies within the current epoch.
3. Then select a group of markers to work with.
4. Once the markers have been selected, click **Next**.
5. Select the desired method of bout calculation:
  - Number of bouts in interval (unit: #)
  - Number of bouts in interval per hour (index) (unit: #/hour)
  - Duration of bouts in interval (unit: seconds)
  - Average duration of bouts in interval (units: seconds)
  - Minimum duration of bouts in interval (units: seconds)

- Maximum duration of bouts in interval (units: seconds)
  - Standard deviation of bout durations in interval (units: seconds)
  - There is also the option to enable (check) the trimming option: *Trim markers at interval boundary*. To see more information on the trimming option see: Markers, Bouts and Trimming.
6. Click **Finish**.
  7. A new column will be populated to the current signal grid sheet.

*Note:* To get a better understanding of how bouts are calculated, see Markers, Bouts and Trimming. This will also provide a distinction between bouts and markers calculations.

- Epoch Number Column: An additional column will populate to the signal grid sheet indicating what epoch number is associated with the interval selected.

### Marker Grid Specific Columns

- **Label:** Adds a Marker column based on the settings defined in step one.
- **Duration:** Adds a column listing the duration for each marker stage that is listed. If bouts are being listed, the duration will list how long the particular marker spanned. If individual sleep markers are listed, the duration will be the time defined for the epoch duration..
- **Start Time:** The time this marker/bout begins
- **End Time:** The time this marker/bout ends
- **Start Epoch #:** The epoch number that the marker/bout begins
- **End Epoch #:** The epoch number that the marker/bout ends

A new column will populate in the marker grid sheet once any of the above options have been selected.

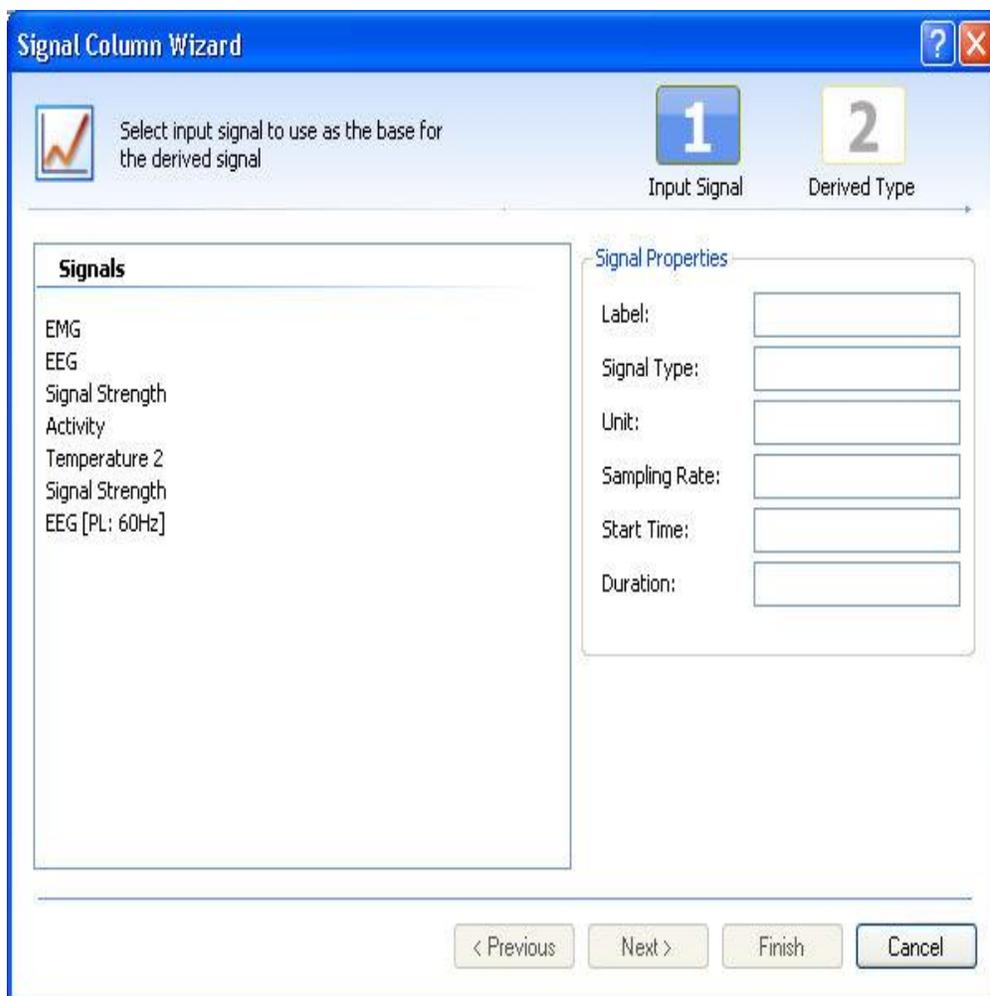
Once a column is in the marker grid window, the following options are available:

1. Change the properties of the column
2. Change the order of the columns

To get a better understanding of how bouts are calculated, see Markers, Bouts and Trimming. This will also provide a distinction between bouts and markers calculations.

### Universal Columns

- Signal Column
  1. This will launch the Signals Column Wizard



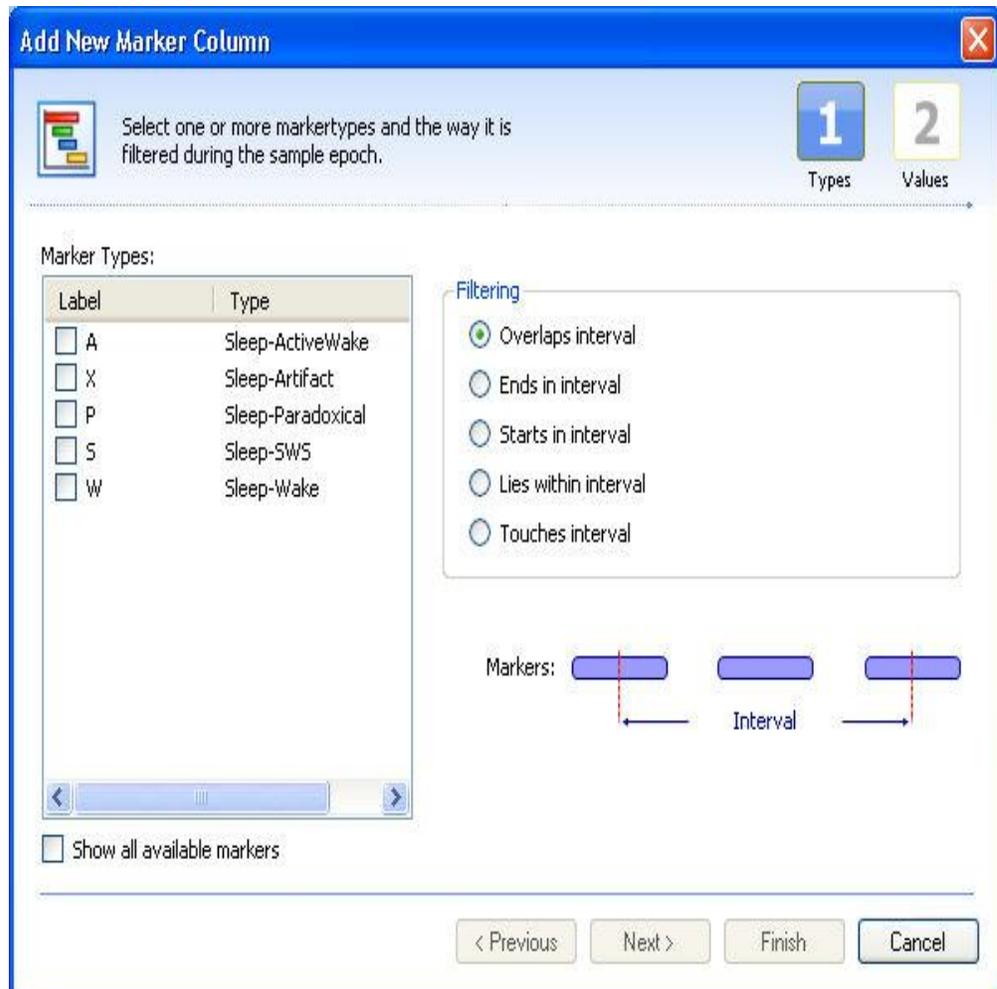
2. Select which signal to add the grid.
3. The signal *Properties* to the right in this step will automatically populate once a signal has been selected.
4. Click **Next**.
5. Select the function to be applied to the signal. The functions available will be similar to those available when creating a *derived signal*.
6. Check the box next to “Synchronize to scoring epoch” if you wish to have the time stamp start when the recording began instead of the default setting where it begins on the first whole interval according to the epoch chosen. (The time stamp column needs to be added after this signal column in order for it to work properly.)
7. Click **Finish**.

*Note:* When using the Periodogram, AR Spectrum and Periodogram Power Bands the number format looks different, containing an additional (...) on the end. It is formatted in this manner to indicate that there is data grouped together in that one cell. Once exported, the appropriate columns are added in order to view the entire

contents. It is best to use the Periodogram Power Band function or DFT Power Band to view the individual power bands in the signal grid.

- Marker Column

1. This will launch a **Marker Column Wizard** window.



2. Select which marker(s) to add to the signal grid.
3. Select a filtering method, diagrams will be displayed to help explain each case, upon selecting each type.

- **Overlaps Interval:** Counts a marker when it crosses over each boundary of the epoch.
- **Ends in Interval:** Counts a marker when it ends in the current epoch.

- **Starts in Interval:** Counts a marker when it starts in the current epoch.
- **Lies within Interval:** Counts a marker only when it lies within the current epoch.

4. Click **Next**.

5. Select the desired method of marker grouping/counting:

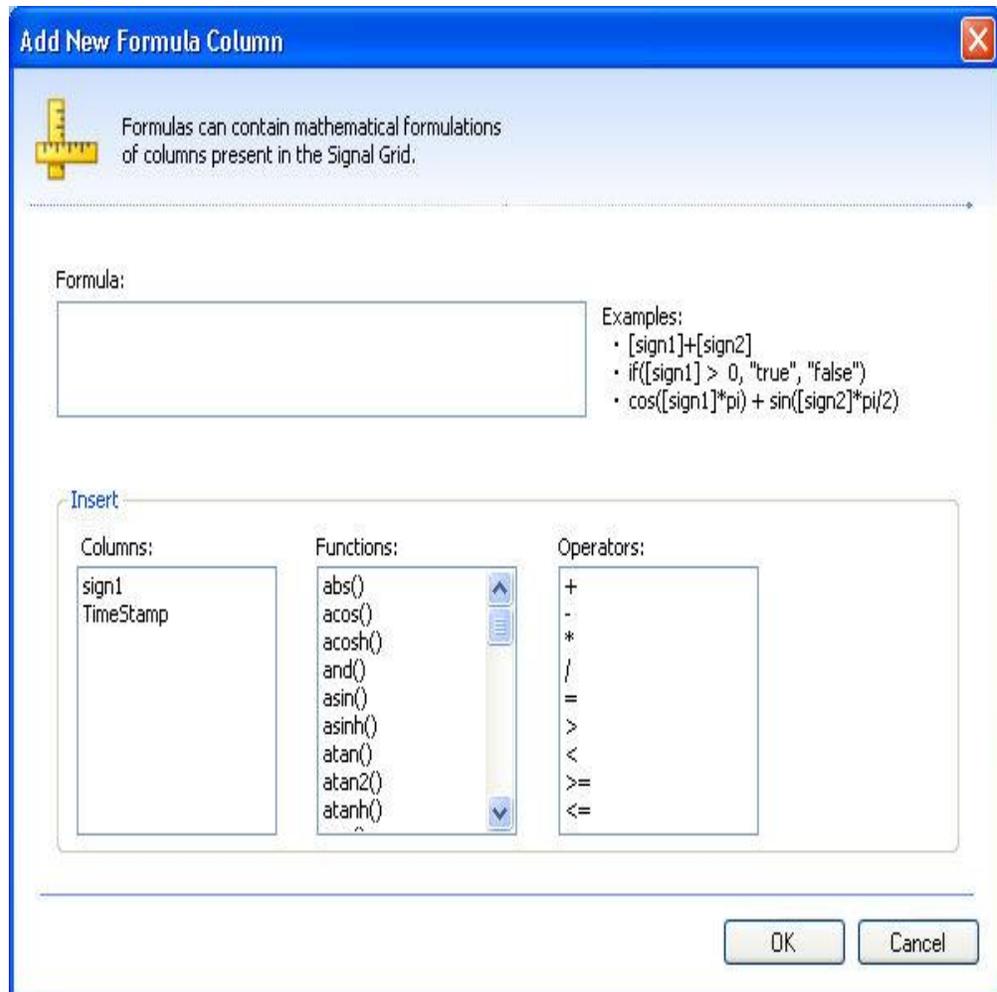
- Number of markers in interval (unit: #)
- Number of markers in interval per hour (index) (unit: #/hour)
- Duration of markers in interval (unit: seconds)
- Coverage: percentage of marker duration relative to the interval duration
- Average duration of markers in interval (units: seconds)
- Minimum duration of markers in interval (units: seconds)
- Maximum duration of markers in interval (units: seconds)
- Standard deviation of marker durations in interval (units: seconds)
- There is also the option to enable (check) the trimming option: *Trim markers at interval boundary*. To see more information on the trimming option see: Markers, Bouts and Trimming.

6. Click **Finish**.

*Note:* There is also the option to analyze data based on bouts. See Markers, Bouts and Trimming for the difference between bouts and markers.

- Formula Column

1. This will launch a **Formula Column Wizard** window.



2. Any combination of the following fields can be used to formulate the formula:
3. **Columns:** Lists the columns available to be used in the formula.
4. **Functions:** Lists all available functions: sine, cosine, absolute value, log, square root, etc.
5. **Operators:** Lists all available operations: plus, minus, multiply, divide, greater than, less than, etc.
6. Click **OK**.

*Note:*

- The formula option will only be available after one column is already loaded into the signal grid window.

- The **OK** button will only be available to exit out of this wizard after an acceptable formula has been entered. See Formula Examples to better understand how this function can be used.
  
- Sleep Scoring Column
  1. This will automatically add another column with no additional steps; however, the column will be blank until a previously saved scoring has been selected after sleep scoring the data, either manually or automated.
  2. The sleep scoring that is added to the grid is determined by what scoring is selected in the *Scorings* task window on the right hand side of the NeuroScore window. If multiple scorings have been saved, selecting a different scoring will update the signal grid will accordingly.

*Note:* The only markers that appear in this column are the sleep scoring markers based on the user-selected marker group. None of the non-sleep markers will be listed.

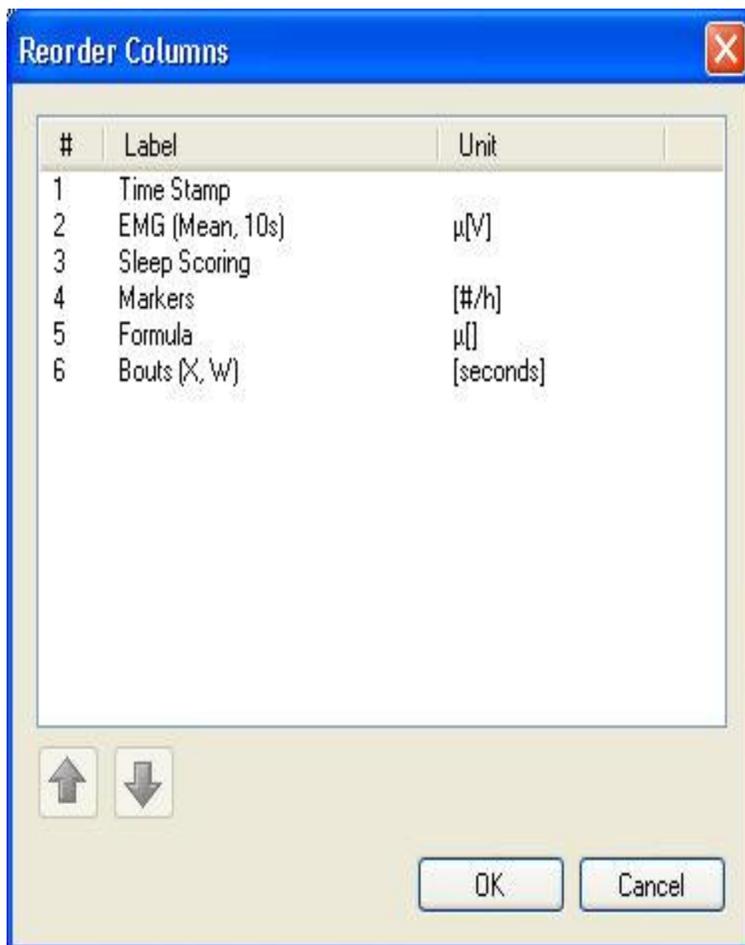
3. Click on the column type of interest above and complete the steps to add the column to the grid.

## Reordering Columns

Columns can be rearranged within the signal grid window. By default, adding a column to the window places it at the end of the columns.

To change the column order of the signal grid:

1. Click on the **Reorder Columns** icon on the tool bar.
2. A *Reorder Columns* window will launch, listing the columns in their current order along with the unit of the data.



3. Select one of the columns to be reorder.
4. Use the <Up> and <Down> arrows to adjust the column's location in the arrangement.
5. Proceed to the next column, if applicable, and adjust as needed.
6. Click **OK**, once all the columns are in their desired position.

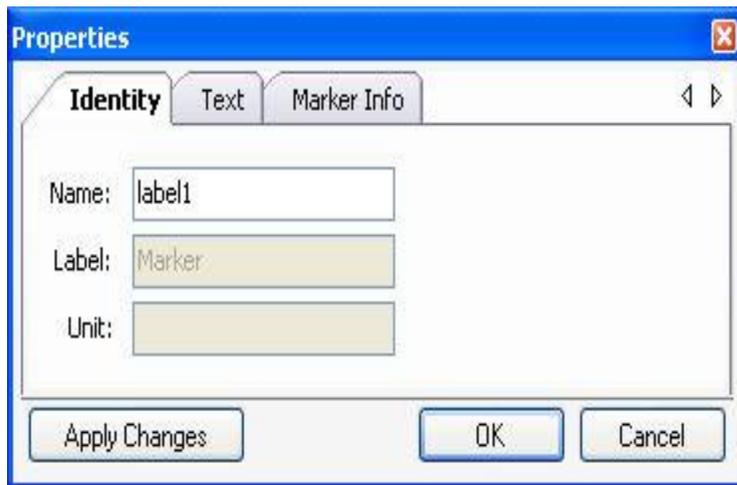
*Note:* Column order can be rearranged at anytime.

## Editing of Columns

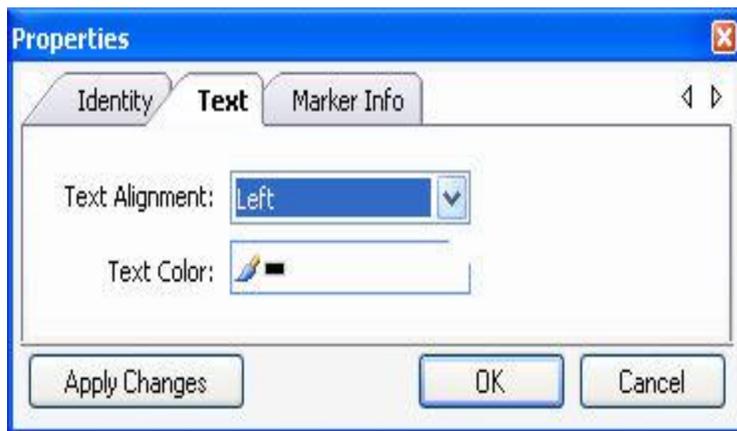
To make changes to the *Properties* of the columns:

1. Navigate to the column of interest.
2. **Double-click** the header of the column to bring up the **Properties** window.

The *Identity* and *Text* tab will always be present in the window as follows:



The *Identity* tab allows for column's name to be changed via the *Name* field. The column name allows for easy identification of the correct column when adding a Formula column to the signal grid. It will also appear in the Formula wizard. The *Label* field is used in the header of the column.



The *Text* tab allows the user to change the *Text Alignment* and *Text Color* of the columns' data.

Any additional tabs will be dependent on what type of data is in the column. Below is a list of various properties that may be available to adjust (categorized by the tab they are available under):

- **Bouts or Marker**

*Markers:* Lists the markers that are being used for calculations.

*Processing method:* Displays how markers are being calculated once they are identified as being a valid marker.

*Filter method:* Determines how the marker is identified as a valid marker

*Trim bouts by interval:* When checked (enabled), the calculation of bouts will be determined by the interval boundaries and not the natural ending boundary of the bout itself. If unchecked (disabled), the bout calculation is carried out by using the natural ending boundary.

- **Derived Signals**

Lists the data used, what is has been calculated, and the time interval that was used. For example EMG (Mean, 10s).

- **Formula**

*Formula:* Text field that allows changes to the previously created equation to be made.

*Column:* Adds a column to the calculation.

*Function:* Adds a function to the calculation.

*Operator:* Adds an operator to the calculation.

- **Marker Info**

*Display marker label:* Displays the alpha value of the marker only. e.g. W.

*Display marker type:* Displays the name of the marker only e.g. Sleep-Wake.

*Display maker label and type:* Displays the name and alpha value of the marker. e.g. W, Sleep-Wake.

- **Numbers**

*Number Format:* Determines how the number is listed. There will be four options: general, number, fixed point and scientific. General and number will display the number depending on its length. Fixed point will force the number to always be displayed as a decimal point. Scientific will force it to always be displayed scientific notation..

*Significant Digits:* Determines how many decimal places will be displayed.

*Display Scale:* Changes unit scaling for the data. e.g. milli, micro, kilo, etc.

- **Scoring**

*Scoring Group:* Select the group of sleep scoring markers of interest to display.

*Show most common sleep stage in interval:* Lists the sleep stage that the subject experienced the majority of the defined interval.

*Show first sleep stage in interval:* Lists the sleep stage that the subject experienced when the interval began.

*Show results as numbers:* If this box is checked, the sleep stages will be listed as numbers instead of alpha values. The number will be determined by the order in which they are listed in the Marker Groups settings.

- **Time Stamp**

*Long Time Format (hh:mm:ss):* Displays the time of the marker following the format in parentheses. For example, it would list the time stamp as 06:30:00 PM.

*Full Time Format [date + time]:* Displays the month/day/year and time for the data. For example 1/25/2007 06:30:00 PM.

*Custom Time Format:* Choose how the time to be listed. An example would be to list the time stamp as 01/27/2007, 06:30:00 PM. This would be entered as the following in the field MM/dd/yyyy, hh:mm:ss tt. Note, for months use capital M's and for minutes use lower case m's. The t's in the format are for the AM and PM indicators. If military time is desired, use capital H's for the hour instead of lower case h's, for example HH:mm:ss.

*Duration from start time:* Displays the amount of time that has passed since the start of the selected period (elapsed time).

- **Duration**

*Display duration in:* Select the unit of time desired to be displayed in the current column. This will only affect columns that use time as the unit of calculation.

To remove a column:

1. Select the column desired to be removed
2. **Right-click** on the column and choose **Remove Column**

OR

Click on the **Remove** button on the tool bar.

*Note:* Columns can be removed at any time.

## No Markers or Bouts Selected. Click to select...

To select what markers to analyze in the marker grid sheet:

1. Add a column named *Label*.
2. Click the **No markers or bouts selected. Click to select...** link in the tool bar.
3. The *Select Markers* window will launch (as seen below) providing the ability to *Select Markers*, listed individually, or *Select Bouts*, listed by groups. Typically, *Markers* are used for non-sleep markers, whereas *Bouts* are used for sleep markers. Listing markers by groups will group the markers by predetermined groups.



4. To select a marker, click in the corresponding box. A checkmark in the box indicated that the corresponding marker will be included in the marker grid.
  5. Each marker selected will be included in the same marker column regardless of how many markers are selected or how the markers are selected, by *Marker* or by *Bout*.
  6. Markers that are list in the marker grid window can be edited at any time.
- To get a better understanding between bouts and markers see: *Markers, Bouts and Trimming*.

## Exporting Grids

The exporting of the grids can be performed at any point using the **Export...** function.

To export a grid:

1. Have the grid open or create a new grid.
2. Click **Export...** icon near the top of the grid sheet.
3. In the newly populated window, specify where the exported sheet is to be saved.
4. Choose to save the file as one of the following file types:
  - Excel File (\*.xls)
  - Text File (\*.txt) - ASCII format
  - Text File UNICODE (\*.txt)
  - Comma Separated Values (\*.csv) - ASCII format
  - Comma Separated Values UNICODE (\*.csv)
  - DSI Parameter Export (\*.txt) - this allows for the data to be imported into the Dataquest ART Analysis program.
5. Enter the file name, then click **Save**.

*Note:* The exported sheet will need to be opened from the folder that it was just saved to, it will not automatically launch after it has been saved.

## Time Syncing Grids to Signal Sheets

This function allows you to select a time point in a Grid and bring up the corresponding waveform in a Signal Sheet.

To synch time between grids and signal sheets:

1. Select the box of interest in the grid to time sync with the signal sheets (multiple boxes can be selected by clicking and dragging).
2. **Right-click - Sync Sheet Time to Row(s)**
3. Navigate to the signal sheet by clicking on a corresponding tab in the NeuroScore window.
4. The signal sheet will have adjusted so it hovers around the time that was selected according to the boxes in the grid sheet.

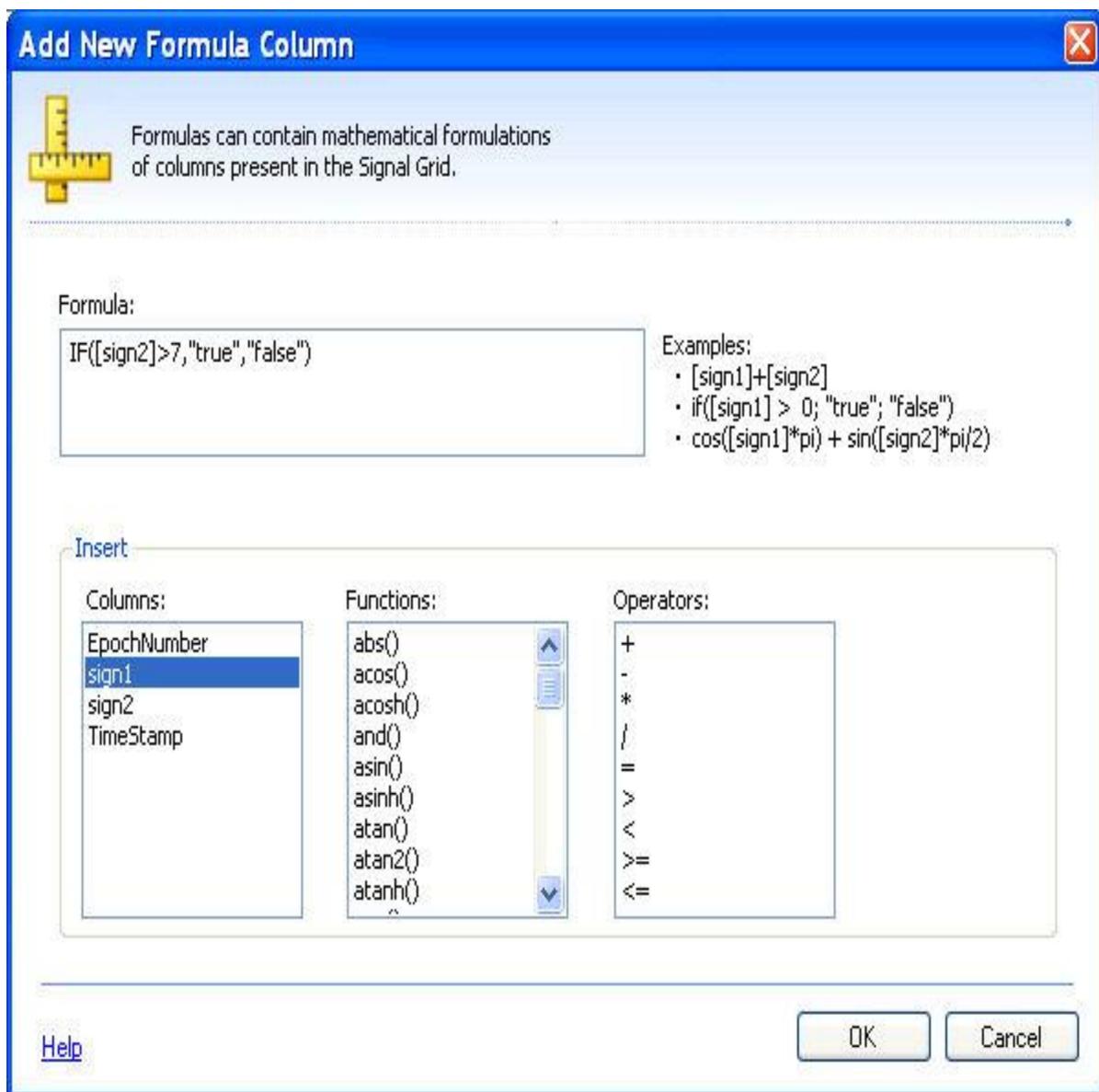
## Formula Examples

Below are examples of how the formula function can be used. Keep in mind this is only a small number of examples and does not show all the possibilities for this function.

### Formula wizard using the IF statement:

`IF([sign2]>7,"true","false")`

This would apply a function that if the sign2 signal is greater than 7 then a true statement is entered into the formula column however if it is not greater than 7 then a false statement is entered into the formula column.



**Formula wizard using any of the Functions:**

Example:  $\text{abs}(\text{sign1} * 2) + \text{abs}(\text{sign2} * 3)$

This function would take the absolute value of  $\text{sign} 1 * 2$  then add it to the absolute value of  $\text{sign} 2 * 3$ . The value of this calculation would be entered into the formula column.

*Note:* When using the formula derived signal wizard in the signal sheet it is necessary to use a variable, such as x, instead of entering actual signals or columns as shown here in the signal grid.

## Overview

### Working with the Overview

The *Overview* sheet provides an overall summary of the subject's data. The entire data set will be displayed for the active period including parameter data, derived signals, and marker results.

Waveform signals will not be displayed in the Overview sheet. Sleep markers will be displayed as a hypnogram plot and non-sleep markers will be displayed as a ribbon or marker plot. A ribbon plot shows the number of markers per minute whereas the marker plot simply shows where the markers occur over time.

To add an Overview sheet to the NeuroScore:

Go to **Add Sheet - Empty Overview Sheet** (icon in the toolbar of the NeuroScore Window)

**OR**

Go to **File - Add Sheet - Empty Overview Sheet**

The following is a pre-defined Overview template that comes with the software:

- **Sleep Overview:** An overview sheet that contains the following signals by default: *Temperature*, *Activity*, an *AR Spectrum* of the EEG signal, a *Periodogram* of the EEG signal, *Root Mean Square* data of the EMG signal and a *Hypnogram* of the sleep stages.

The links below will have information on what can be done with Overviews after they have been generated:

- Adding signals to overview
- Adding marker groups to the overview
- Exporting overview

*Note:* The *Overview* sheet will not display waveform signals.

## Adding Signals to Overview

To add a signal to the Overview sheet:

1. Select the **Overview** tab in the *NeuroScore* window.
2. Select **Signals and Data** tab from the *Task* window.
3. Select the checkbox next to the signals desired to be displayed in the *Overview* sheet.
4. A checkmark in the checkbox will indicate that it is being displayed on the *Overview* sheet, as noted in Adding and Removing Signals.

*Note:* To add a signal to the **Signals and Data** menu follow the procedure located on the Signal Sheet help page.

## Adding Marker Groups to the Overview

To add a *Marker Group* to the Overview sheet:

1. Select the **Overview** tab in the *NeuroScore* window.
2. Select the **Signals and Data** tab from the Task window.
3. Select the checkbox next to the *Marker Groups* desired to be displayed in the *Overview* sheet.
4. A checkmark in the checkbox will indicate that it is being displayed on the *Overview* sheet, as noted in Adding and Removing Signals.

*Note:* To add a *Marker Group* to the **Signals and Data** menu, follow the procedure on the Marker Group help page.

## Exporting the Overview sheet

To export the *Overview* sheet:

1. Click **File - Export Sheet...**
2. The sheet can be exported as a ".emf" or ".png" file
3. Enter the file name, then click **Save**.

*Note:* The exported sheet will need to be opened from the folder that it was just saved to, it will not automatically launch after it has been saved.

# Periods

## Working with Periods

Periods provide the ability to analyze specific parts of the data at a time.

The *Periods* menu is a part of the *Task Window* on the right hand side of the screen. Click on the **Periods** tab to expand the *Task Window* and display the *Periods* menu.



Under the *Recording Periods* box, a list of all defined *Periods* can be found. Default *Periods* are generated with each recording that is open and include one period containing the entire recording, *Whole Recording*, and periods that break the data up by day, *Day1*, *Day2*, etc. The default 'Day' periods are generated beginning and ending at 12am so it is possible for a Day period not to include a full 24 hours.

- Adding Periods and Period Rules
- Editing and Splitting Periods
- Removing Periods
- Selecting a Work Period
- What is affected by periods

*Note:* It may also be beneficial to setup night periods, which can be done by using the Period Rule option.

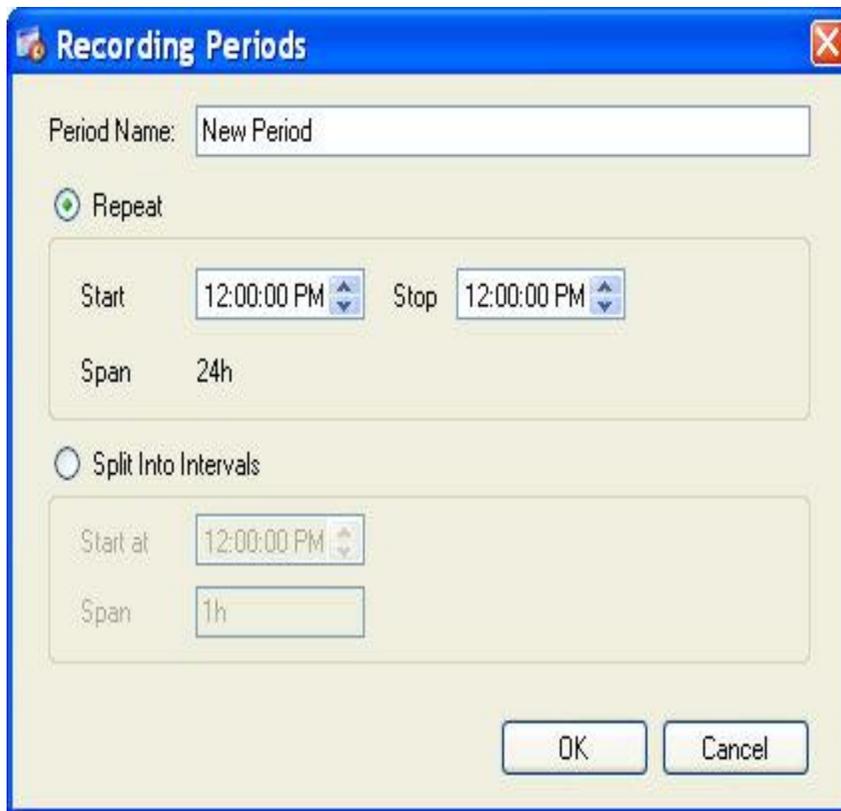
## Adding Periods and Period Rules

To add periods:

1. Click on the **Periods** tab to expand the *Task Window* and display the *Periods* menu.
2. Click **Edit Periods...** at the bottom right hand side of the Task Window.
  - The **Recording Periods** tab will be added to the NeuroScore window.
  - The sheet displays the periods listed in the *Periods* menu.
  - Notice that the recordings split up by day go from *12am to 12am*.
3. Select the **New Period...** button.
  - This populates another row in the window with an interval that can be adjusted as desired.
4. **Click-and-drag** or **expand/shrink** the period interval to the desired time length.
  - The *click-and-drag* option is available when all four arrows are showing, the *expand/shrink* will work when the horizontal arrows are only showing.
  - Period interval length can also be added by adjusting the time in the *From* and *To* fields located at the bottom of the *Recording Periods* sheet.
5. Enter the desired period name using the *Name* field.
6. **Resort Defaults...** may be selected to restore the default settings if necessary. A confirmation window will populate to confirm application of the default settings. Click **Yes** to confirm.
7. Click the **Save & Close** button to save all the new periods and close the *Recording Periods* window.

To add periods using the *Period Rule*:

1. Click on the **Period Rule** button.
2. A new **Recording Period** window opens.



The image shows a dialog box titled "Recording Periods" with a blue header bar and a close button in the top right corner. The dialog contains the following fields and options:

- Period Name:** A text input field containing "New Period".
- Repeat:** A radio button that is selected.
- Start:** A time selection dropdown menu set to "12:00:00 PM".
- Stop:** A time selection dropdown menu set to "12:00:00 PM".
- Span:** A text input field containing "24h".
- Split Into Intervals:** An unselected radio button.
- Start at:** A time selection dropdown menu set to "12:00:00 PM".
- Span:** A text input field containing "1h".
- Buttons:** "OK" and "Cancel" buttons at the bottom right.

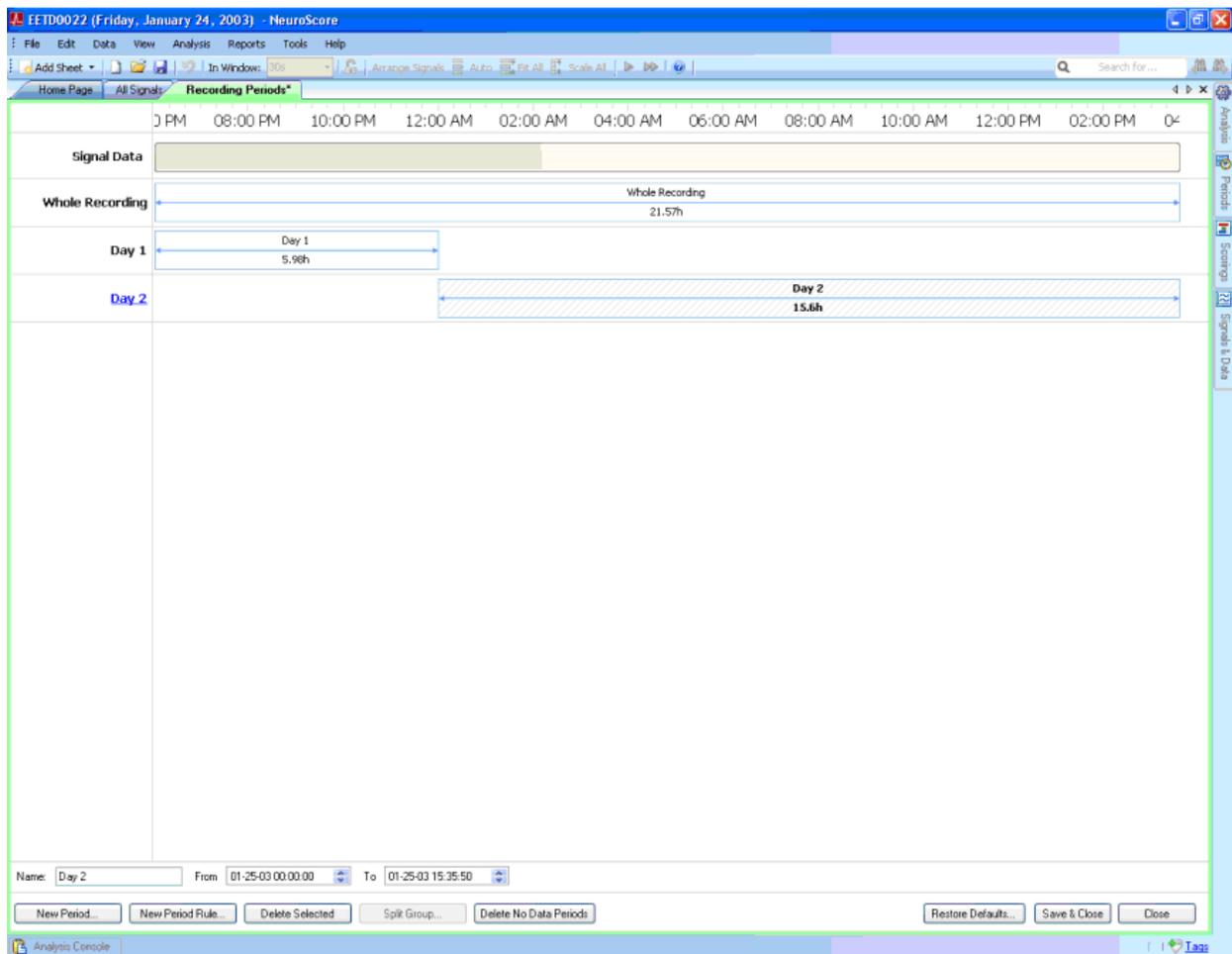
3. Enter the *Period Name* the appropriate field
4. Select between two options:
  - **Repeat:** Repeats a specified period each day. For example, setting the rule to start at 6:00 pm and then end at 10:00 pm will create intervals everyday for those four hours.
  - **Split Into Intervals:** Splits up the entire recording period into a number of smaller periods that are all incremented for the same amount of time. The period name will increment with numbers as it labels the specified split intervals. For example, enter *Night* as the *Period Name* and set the time interval to only include night time hours. The first night interval will be labeled *Night I 1*, while the second night interval will be labeled *Night I 2*.
5. Click **OK** once the settings have been adjusted.
6. A new row representing the period will be added to *Recorded Periods* sheet
7. Click **Resort Defaults...** to restore the default settings. A confirmation window will populate to confirm application of the default settings. Click **Yes** to confirm.
8. Click the **Save & Close** button to save all the new periods and close the *Recording Periods* window.

*Note:* Once a new period rule has been saved, it cannot be edited. It must be deleted and recreated to make changes.

## Editing and Splitting Periods

To edit a period:

1. Click on the **Periods** tab to expand the *Task Window* and display the *Periods* menu.
2. Click the **Edit Periods...** at the bottom right hand side of the *Task Window*.
  - This opens a new tab in the NeuroScore window named **Recording Periods**.
  - The sheet displays the periods listed in the *Periods* menu.



3. **Click-and-drag** or **expand/shrink** the period interval to the desired edited length.
  - The *click-and-drag* option is available when all four arrows are showing, the *expand/shrink* will work when the horizontal arrows are only showing.
  - Period interval length can also be edited by adjusting the time in the *From* and *To* fields located at the bottom of the *Recording Periods* sheet.

4. Click **Resort Defaults...** to restore the default settings. A confirmation window will populate to confirm application of the default settings. Click **Yes** to confirm.
5. Click the **Save & Close** button to save all the new periods and close the *Recording Periods* window.

*Note:* Period rules cannot be edited once saved.

To split a period:

1. Click on the **Periods** tab to expand the *Task Window* and display the *Periods* menu.
2. Click the **Edit Periods...** at the bottom right hand side of the Task Window.
  - This opens a new tab in the NeuroScore window named **Recording Periods**.
  - The sheet displays the periods listed in the *Periods* menu.
  - The split period button becomes available only when a period is selected that can be split.
3. Select the period of interest.
4. Click the **Split Period** button.
  - All the intervals that were included in that period are now split into their own individual period.
  - Once a period has been split, it cannot be combined back together.
5. Click the **Save & Close** button to save all the new periods and close the *Recording Periods* window.

*Note:* The periods that can be split are those that were set up using the Period Rule option.

## Removing Periods

To remove a period:

1. Click on the **Periods** tab to expand the *Task Window* and display the *Periods* menu.
2. Click the **Edit Periods...** at the bottom right hand side of the Task Window.
  - This opens a new tab in the NeuroScore window named **Recording Periods**.
  - The sheet displays the periods listed in the *Periods* menu.
  - Select the period to remove/delete.
3. Click the **Delete Selected** button.
4. There is **NOT** a confirmation window to confirm the deletion of the current period.
5. Click **Resort Defaults...** to restore the default settings. A confirmation window will populate to confirm application of the default settings. Click **Yes** to confirm
6. Click the **Save & Close** button to save all the new periods and close the *Recording Periods* window.

To remove no data periods:

1. Click on the **Periods** tab to expand the *Task Window* and display the *Periods* menu.
2. Click the **Edit Periods...** at the bottom right hand side of the Task Window.
  - This opens a new tab in the NeuroScore window named **Recording Periods**.
  - The sheet displays the periods listed in the *Periods* menu.
3. Click the **No Data Periods** button to delete periods that span within intervals where no signal data exists.
4. Click the **Save & Close** button to save all the new periods and close the *Recording Periods* window.

## Selecting an Active Period

Selecting an active period will only display the data within the specified time range. Signal Sheets and Grids will automatically update. Automated analysis protocols will only run on the active period. Reports generated will represent in the active period range and will stay fixed. See ‘What is Affected by Periods’ for more information.

To activate a period for analysis and reporting:

1. Click on the **Periods** tab to expand the *Task Window* and display the *Period* menu.
2. Click on the associated radio button for the period of interest
3. The navigation bar will adjust and the signals collected within the selected period will be displayed.
4. Click outside the *Task Window* to collapse it.

### OR

1. Click the **Period Icon** at the bottom right of the *Task Window*.



2. Select the Period of interest from the drop-down box.

## Aspects of the Program Affected by Periods

The following are the applications affected when working with periods:

1. **Signals:**
  - Only derived or reference signals collected within the selected period will be displayed.
  - Calculations applied to a previously selected period will automatically be applied and updated according to any period selected thereafter, unless unchecked in the *Signals and Data* tab on the *Task Window*.
2. **Reports:**
  - When generating a report, the period that is selected will be the basis for the report and will only include data from this period.
  - This allows the ability to generate reports broken up by period designation, i.e. day, night, etc.
  - If the period is changed, a new report must be generated in order for it to reflect the period change.
3. **Scoring:**
  - Score data within a selected period will only score data that is in this period.
  - Scoring that has been performed in the previous period(s) selected will **NOT** be performed in any newly selected period.
  - If scoring was done by a protocol, the protocol must be run again to obtain scored data in the new period.
  - Optionally, the 'Whole Recording' can be scored at once, then the desired period can be selected to display the scoring results for that time range.
4. **Signal Grid:**
  - When creating a signal grid, the current period that is selected will be the basis for what data is pulled into the signal grid.
  - If a different period is selected, the signal grid will update accordingly
5. **Marker Grid:**
  - When creating a marker grid, the current period that is selected will be the basis for what data is pulled into the grid.
  - If a different period is selected, the marker grid will update accordingly
6. **Export Recording...:**
  - Select which period to export in the final step of the *Export Wizard*.
  - The only periods available will be those that have already been saved.

# Markers

## Working with Markers

Markers provide the ability to label data at specific points or time ranges. Once the data has been marked, they can be used to apply calculations with a variety of options. To make calculations on the markers, a marker grid or signal grid can be used (see the Grid section for more details). Reports can be used to summarize the results.

The following list includes the different options that are available when working with *Markers*:

- Adding or Renaming Marker Types
- Default Marker Types
- Adding or Renaming Classifications
- Removing a Marker Type or Classification from Marker Types
- Creating New Marker Groups
- Removing Marker Groups and Types from Marker Groups
- Manually Scoring Data

*Note:* When using the non-sleep markers to mark data, a text description of the marker is only displayed if there is enough room to fit it within the marker label. To add or deleting/adjusting Non-Sleep Markers, please see Manually Scoring Data and Editing Scoring Results, respectively.

## Default Marker Types

Default Marker Types are those already configured in NeuroScore and can be used without any additional setup, if desired. In order to use these markers to score/mark recordings, please see [Manually Scoring Data](#).

The following is a list of the default *Marker Types*, their corresponding *Classifications*, and a description of their intended use. Select the *Marker Type* to view more details on the Detectors that include these markers:

- **Activity**
  - Movement - Used with Activity and/or EMG signals to mark regions of subject movement.
  
- **EyeMovement**
  - Rapid (RM) - Used with EEG signals to mark areas of Rapid Eye Movement (Paradoxical)
  - Slow (SM) - Used with EEG signals to mark areas of Slow Eye Movement (Slow Wave)
  
- **Signal**
  - Artifact - Used to mark regions of corrupt data within the signal due to external noise.
  - Invalid - Used to mark invalid signal areas.
  - LowQuality - Used to mark areas of low signal quality.
  - Theta - Used to mark regions of data high in theta activity.
  
- **Sleep**
  - Wake - Sleep stage marker used to indicate the subject's wakefulness.
  - Artifact - Sleep stage marker used to indicate areas of signal corruption due to external noise.
  - ActiveWake - Sleep stage marker used to indicate that the subject is awake and physically moving.
  - Paradoxical - Sleep stage marker used to indicate when the subject is in Paradoxical sleep.
  - SWS - Sleep stage marker used to indicate when the subject is in Slow Wave Sleep.
  - SWS1 - Sleep stage marker used to indicate when the subject is in Slow Wave Sleep 1.
  - SWS2 - Sleep stage marker used to indicate when the subject is in Slow Wave Sleep 2.
  - REM - Sleep stage marker used to indicate when the subject is in Rapid Eye Movement sleep. This marker is part of the large animal sleep marker group (Paradoxical is used for rodent sleep markers).
  - N1 - Sleep stage marker used to indicate when the subject is in non-REM stage 1. This is the part of the large animal sleep marker group.

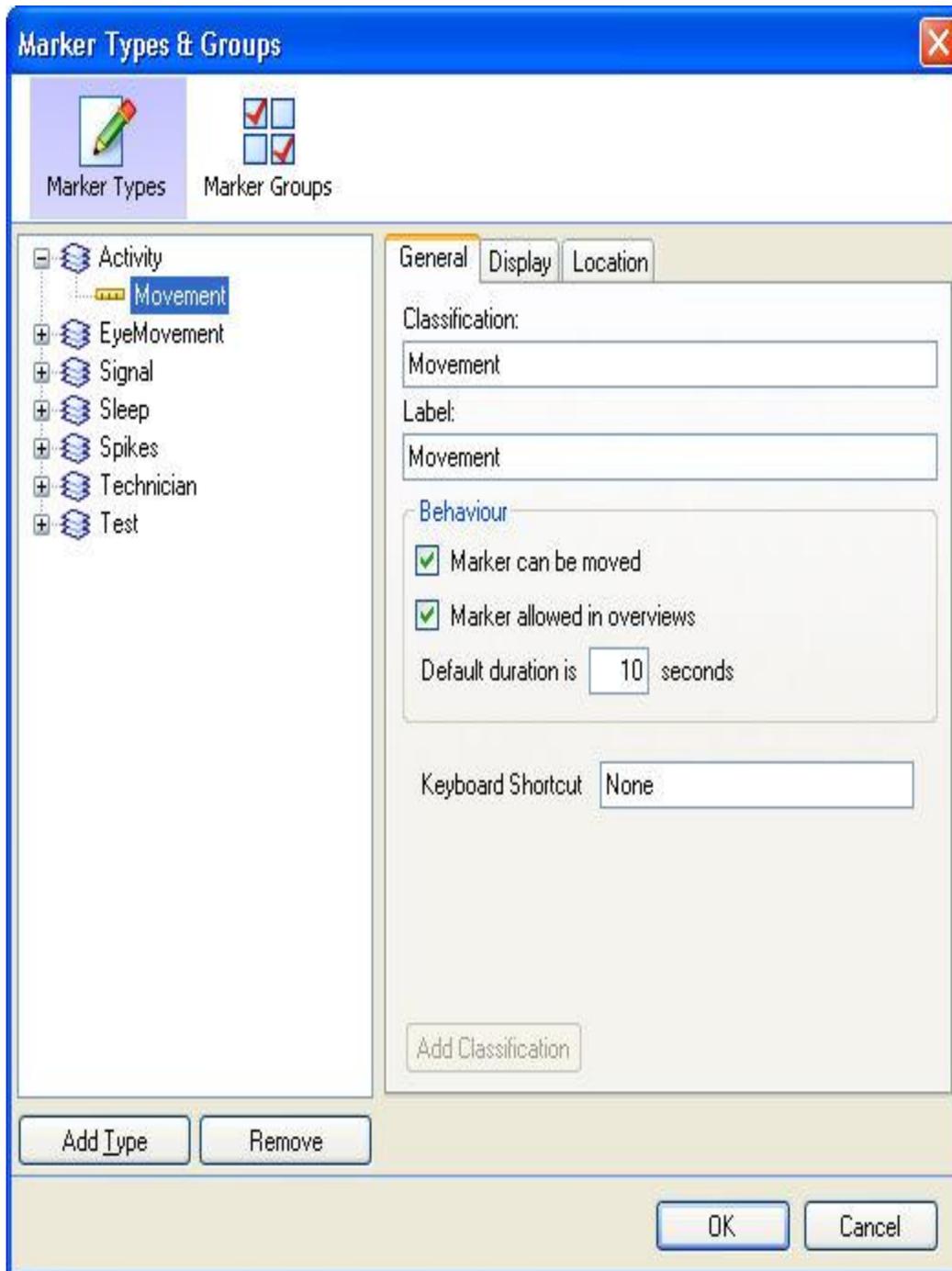
- N2 - Sleep stage marker used to indicate when the subject is in non-REM stage 2. This is the part of the large animal sleep marker group.
- N3 - Sleep stage marker used to indicate when the subject is in in non-REM stage 3. This is the part of the large animal sleep marker group.
- **Spike**
  - Train - Used to with EEG signals to indicate when the subject is experiencing a seizure.
- **Technician**
  - Note - Used to add notes to signals, if desired.
- **SpikeSingle**
  - Spike - Used to mark single spikes within an EEG signal.

*Note:* An event marker added in Dataquest ART will be brought into NeuroScore as a Technician Note marker. Custom classifications will generally not show up on the pre-defined reports

## Adding or Renaming a Marker Type

To add a marker type:

1. Click **Edit - Configuration - Marker Types and Groups** in the main NeuroScore window to open the Marker Types and Groups window.



- Click on the **Add Type** button. A new marker type icon will appear and information will need to be added about the marker. Some default settings will be applied, as seen in the window below; however, these can be adjusted as needed.

**General Tab:**

- Name:** Names the marker as it will appear in the signal sheet and allows for renaming.

- **Is staging type:** Check this box to indicate that this marker will be used for sleep scoring and direct it to appear in the sleep staging bar at the top of the signal sheet.
- **Marker can be moved:** Check this box to allow the marker to be moved once it has been placed in a certain location.
- **Marker allowed in overviews:** Check this box to allow the marker to be viewed in the overview sheet.
- **Default Duration:** Defines the amount of time this marker can span if a specific time period is not selected when the signal is marked.

**Display Tab** will have settings for how the marker will appear on the signal sheet.

- **Display as:** Select the display option the marker will be identified as on the signal sheet. Notice the example of the marker identification as the visual marker below.
- **Show Background:** Will have the background color displayed when checked.
- **Show Label:** Will display the label of the marker selected when this is checked. If it is checked it will be a global setting for the classification(s) under this marker type.
- **Show Duration:** Will show the amount of time the interval is spanning when this box is checked. It will be listed following the marker label in parentheses.
- **Show Bar:** This is only available when *Bar* is selected in the *Display as field*. When it is checked the bar will span over the interval that has been selected to be marked.

*Note:* Default marker types and groups will already be configured, please see Default Marker Types for more details. These markers can be applied by marking waveforms manually or via protocols.

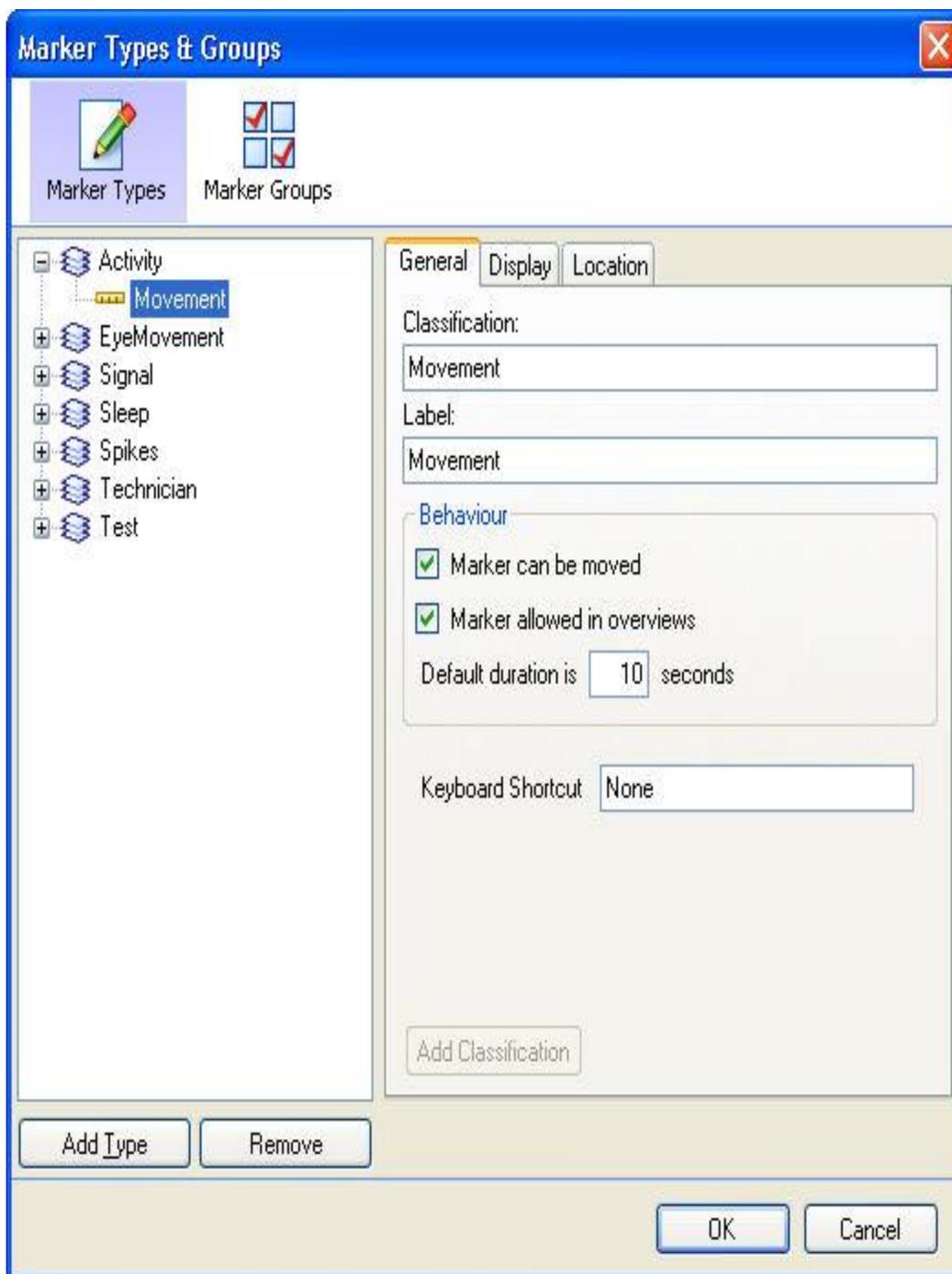
## Adding or Renaming a Classification

A *Classification* is a subcategory under the marker type that breaks it down into more specific categorizes.

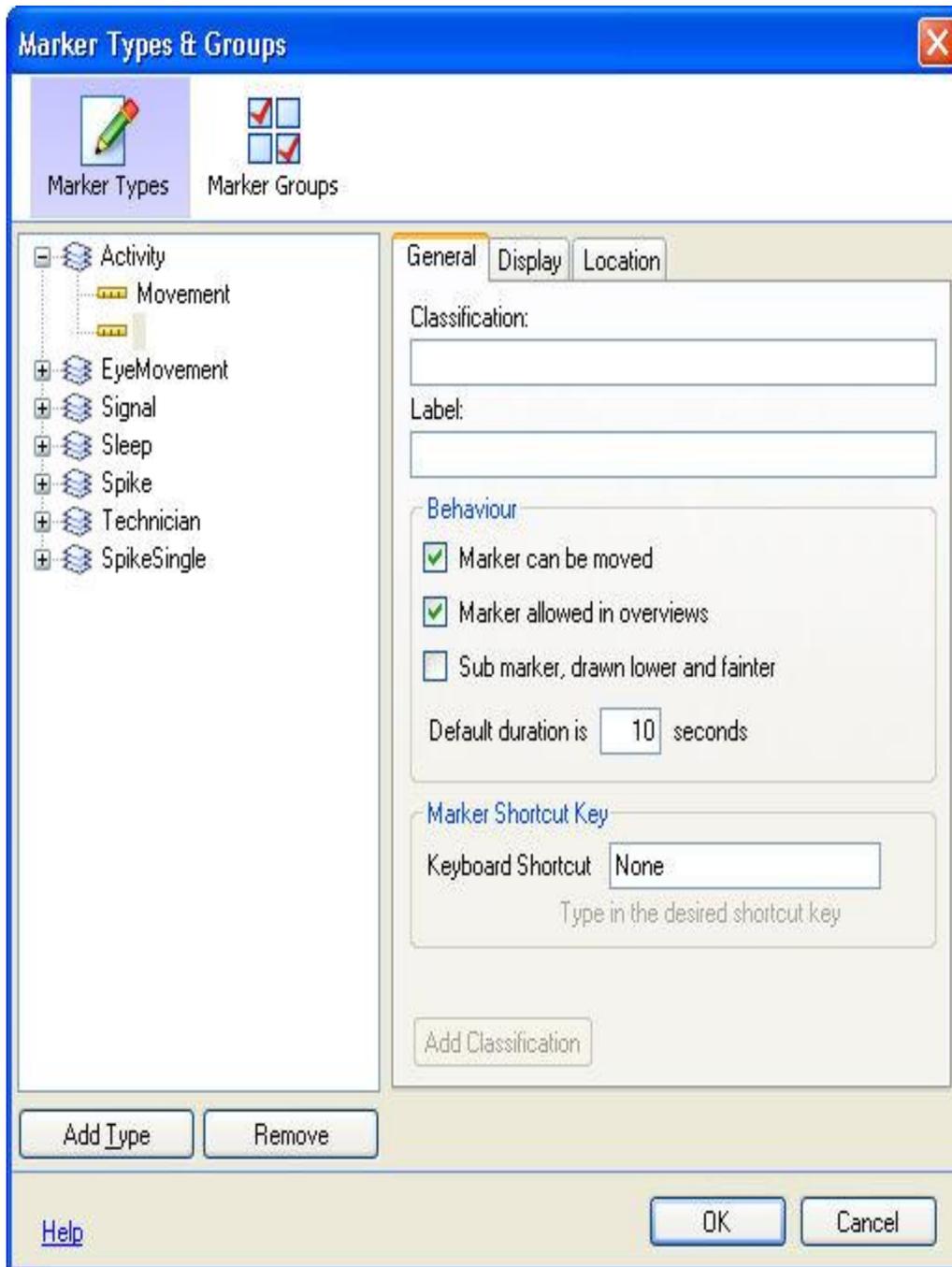
Example: The marker type 'Sleep' can be broken up into marker classification such as 'SWS' (Slow Wave Sleep) and 'P' (Paradoxical Sleep).

To add a classification:

1. Click **Edit - Configuration - Marker Types and Groups** in the main NeuroScore window to open the Marker Types and Groups window



2. Select the *Marker Type* to which the classification is desired to be added.
3. Click the **Add Classification** button to add subcategories to the marker type. The window will update with a subcategory listed under the appropriate marker type.



4. The following tabs contain options to be filled out when adding a *classification*:
- **General Tab:**
    - **Classification:** Names the classification and allows for renaming.
    - **Label:** The name displayed when using it as a marker on the signal sheet.
    - **Marker can be moved:** Check this box to allow the marker to be moved once it has been placed in a certain location.
    - **Marker allowed in overviews:** Check this box to allow the marker to be viewed in the overview sheet.

- **Sub marker, drawn lower and fainter:** Check this box to display the marker as a sub marker under a separate marker.
- **Default Duration:** Defines the amount of time this marker can span if a specific time period is not selected when the signal is marked.
- **Keyboard Shortcut:** Enter a signal character to be used as a shortcut key to mark recordings in signal sheets.
- **Display Tab:**
  - **Display as:** Select how the marker will be displayed on the signal sheet. Notice the example of the display as a visual marker at the bottom of the tab.
  - **Show Background:** Displays the background color when checked.
  - **Show Label:** Displays the maker label when checked.
  - **Show Bar:** Displays the bar over the interval span and is only available when the *Bar* option has been selected in the *Display* as field.
  - **Show Duration:** Displays the amount of time the interval spans when checked.
  - **Show Peak to Peak:**
- **Location Tab:**
  - **Display marker on all signals of the same type:** Classifies the marker as a global marker for all signals of a particular type.
  - **None:** Does not define the classification under any specific signal.
  - **Signal group:** Places the classification on one of the corresponding signal types determined by the list in the signal group.
  - **Signal:** Places the classification on a specific signal that is selected in the signal sheet.

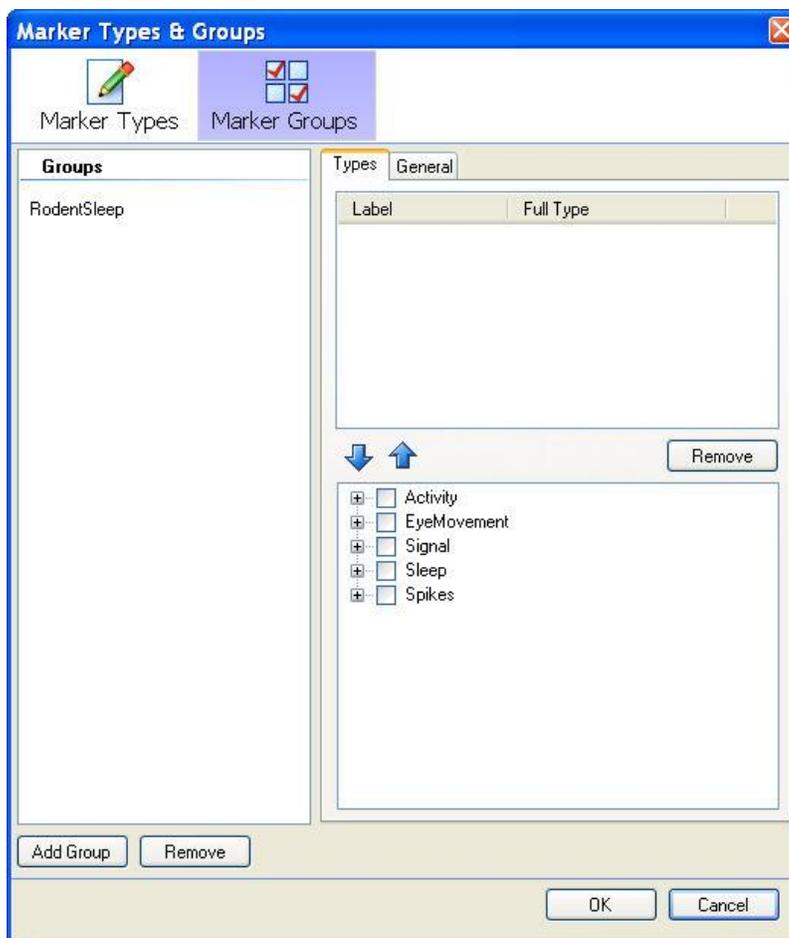
*Note:* The label field is what will be displayed in the signal sheet when the classification is used as a signal marker. Custom classifications will generally not show up on the pre-defined reports.

## Creating a New Marker Group

Marker Groups are used to associate markers with each other and correctly label signals that are scored in the software using protocols.

To create a marker group:

1. Open the Marker Types and Groups window, **Edit - Configuration - Marker Types and Groups**



2. Click the **Marker Groups** icon.
3. Click the **Add Group** button. There may already be pre-configured groups, such as *RodentSleep*, *RodentSleepEX*, and *LargeAnimals*..
4. Fill in the necessary information under the **General** tab.

5. Click the **Type** tab to add *Marker Types* to this *Marker Group*.
6. An entire *Marker Type* can be added to a *Marker Group* or individual *Classifications* can be added to a *Marker Group*.
7. Click inside the **Check Box** next to a **Marker Type** to add an entire marker type including all its *Classifications*.
8. Click inside the **Check Box** next to a **Classification** to only add that classification to the selected marker group. Expand the *Marker Type* by clicking on the '+' to display the *Classifications*.
9. Select **OK** to accept the changes and exit the window.

To reorder marker groups:

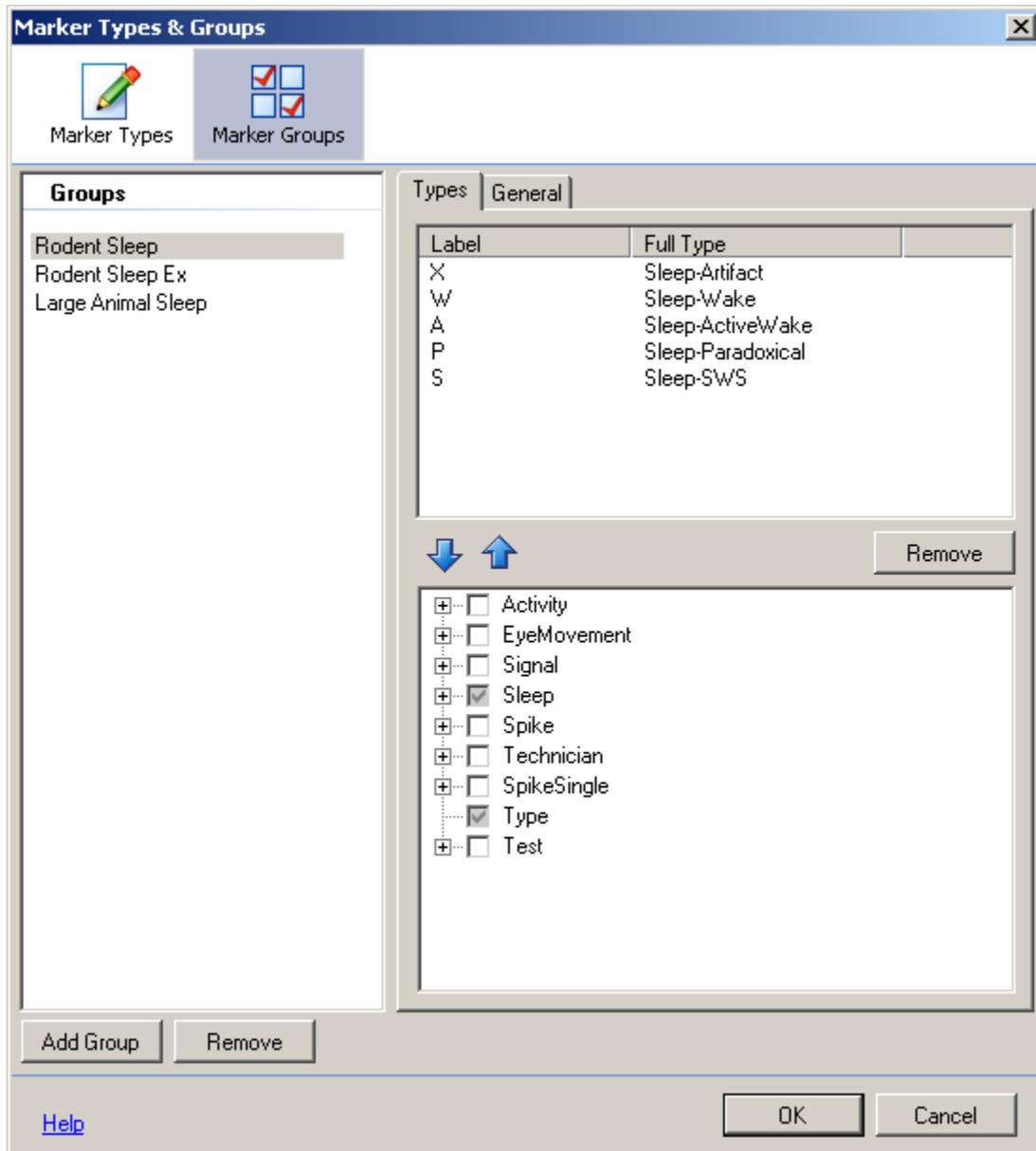
1. Select one of the markers to be reorder.
2. Use the <Up> and <Down> arrows to adjust the marker's location in the arrangement.
3. Proceed to the next marker, if applicable, and adjust as needed.
4. Click **OK**, once all the markers are in their desired position.

*Note: Marker Groups* can only be created once the necessary *Marker Types* have been created and configured.

## Removing a Marker Group or Type from Marker Groups

To remove Marker Groups:

1. Open the Marker Types and Groups. **Edit - Configuration - Marker Types and Groups**



2. Click the **Marker Groups** icon.
3. Select the Group to be deleted from the *Group* field.
4. Click on the **Remove** button.

5. A confirmation window will launch to confirm the deletion of the selected Group.



6. Click **Yes** to remove the Group.
7. Click **OK** in the *Marker Types and Groups* window once completed.

To remove Marker Types/Classifications from Marker Groups:

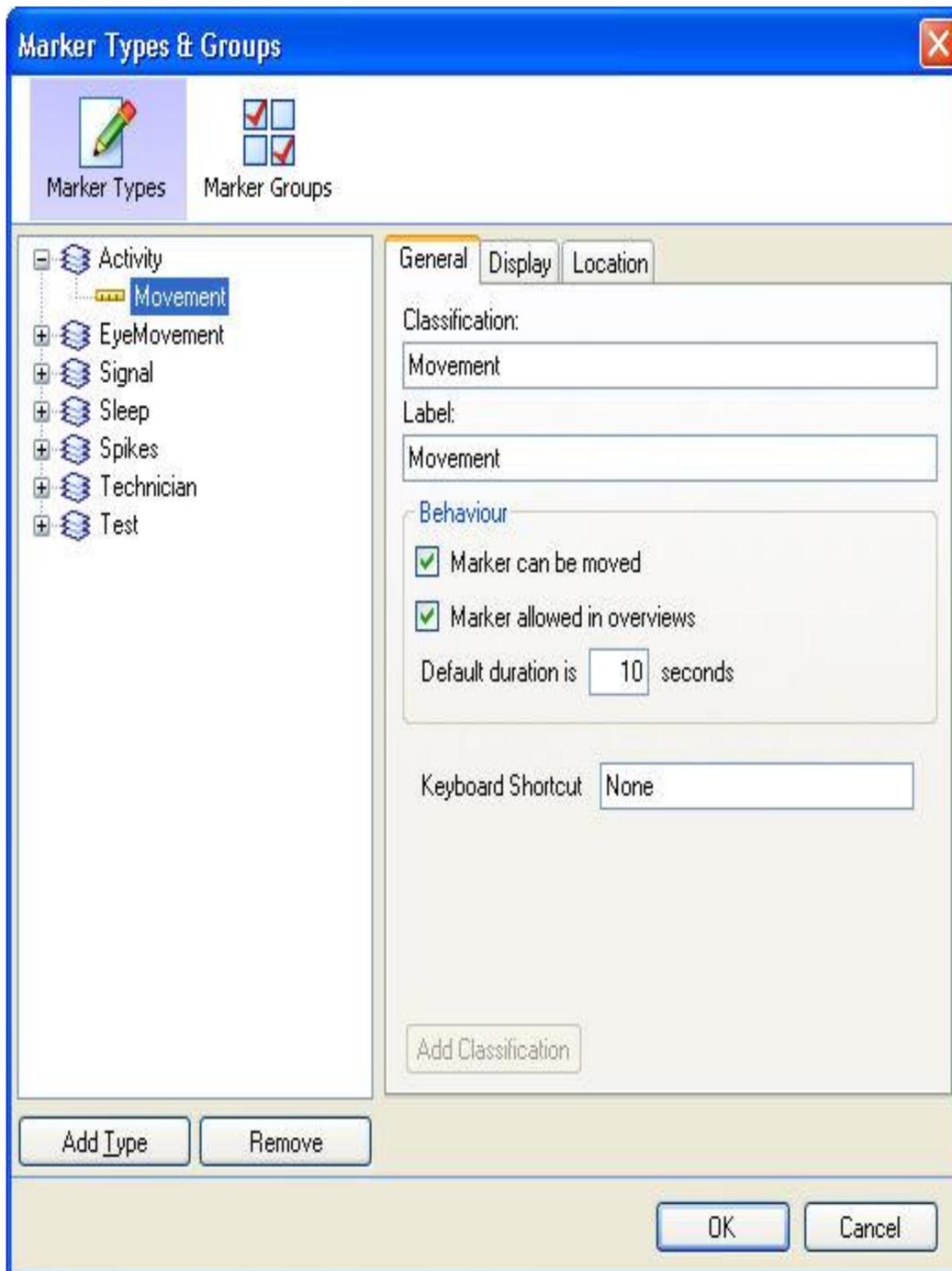
1. Open the Marker Types and Groups window. **Edit - Configuration - Marker Types and Groups.**
2. Click the **Marker Groups** icon.
3. The Marker Types/Classifications will be listed in the bottom right hand corner of the window.
4. The Marker Types/Classifications that are included in the currently selected group will have a check mark in the checkbox.
5. To remove a *Marker Type* and the associated *Classification(s)*, click in the appropriate checkbox to remove the checkmark. This will remove the Marker Type and Classification(s).
6. To only remove a *Classification*, expand the "+" signs by clicking on them. This will show the *Classification(s)* listed under the Marker Types. To remove the classification, click on the associated checkbox to remove the checkmark.
7. Click **OK** in the *Marker Types and Groups window* once completed.

*Note:* The *Marker Groups* and *Marker Types* used in the automated scoring cannot be removed or renamed because they are built into the software.

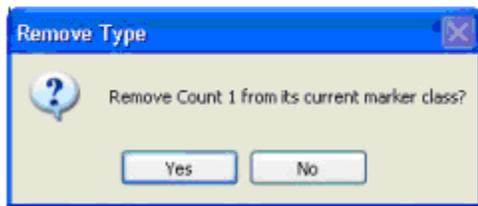
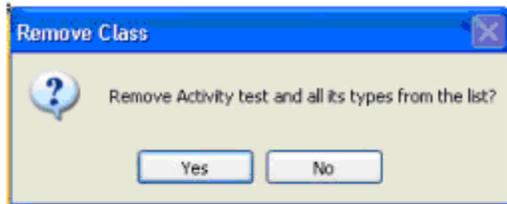
## Removing a Marker Type or Classification

To remove a marker type or classifications:

1. Click **Edit - Configuration - Marker Types and Groups** in the main NeuroScore window to open the Marker Types and Groups window.



2. Select the marker type or classification to be removed.
3. Click **Remove**
4. A confirmation window will launch to confirm the deletion of the selected marker/classification..



5. Click **YES**
6. Click **OK** in the *Marker Types and Groups window* once completed.

## Marker List

The Marker List task window shows a list of the epochs in the recording and the scoring marker for each epoch. The Marker list will display information from the active period selected in the Periods task window. Changing the period will dynamically update the Marker List.

Two display icons can be toggled on and off: the **active signal**  or **all markers**  icons.

- **Active Signals:** This will display all markers associated with the active signal (the signal selected) in the All Signals sheet.
- **All Markers:** This will display all markers within the recording, regardless of their associated signal.

The Marker List includes columns displaying marker **Color** and **Symbol**, **Time**, **Duration**, and **Location**.

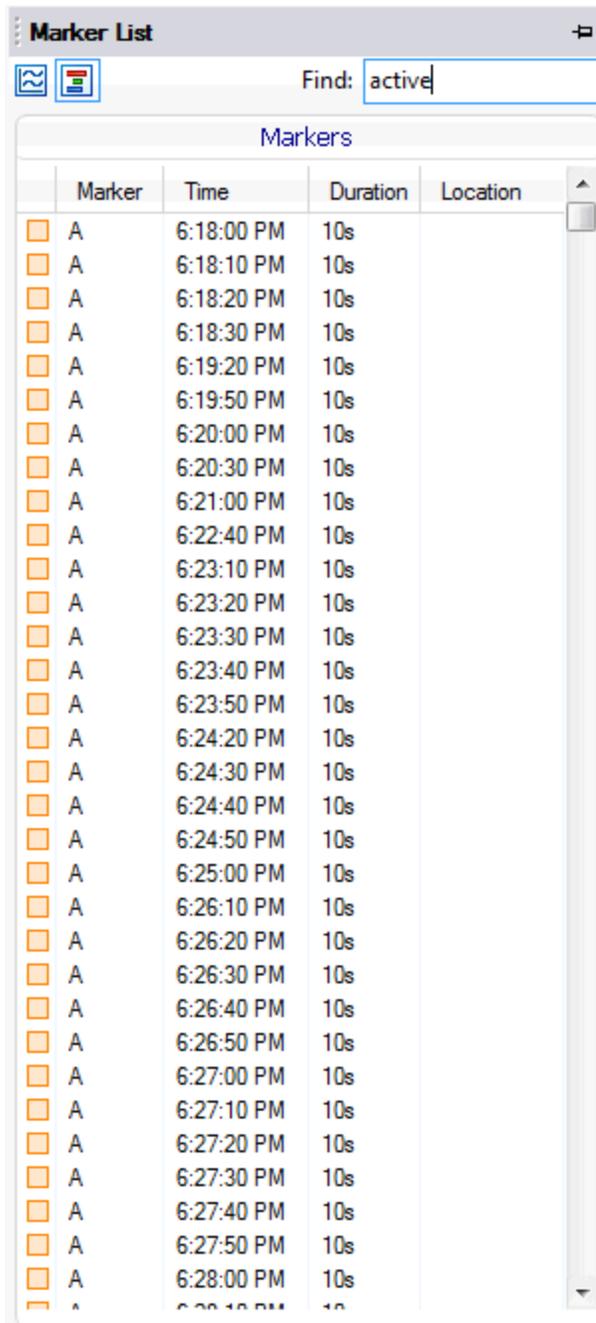
The location refers to the signal the marker is associated with, if applicable.

Marker List Functions:

- **Data Synchronization:** Double clicking on a marker from the list will synchronize the All Signals sheet with the list and center the signal in the graph window on the marker selected.
- **Marker Editing:** Markers can be edited directly from the Marker List by right clicking a marker requiring the edit. A group of markers can be multi-selected to update multiple markers at one time.

Marker	Time	Duration	Location
<input type="checkbox"/> S	6:01:30 PM	10s	
<input type="checkbox"/> S	6:01:40 PM	10s	
<input type="checkbox"/> S	6:01:50 PM	10s	
<input type="checkbox"/> S	6:02:00 PM	10s	
<input type="checkbox"/> S	6:02:10 PM	10s	
<input type="checkbox"/> S	6:02:20 PM	10s	
<input type="checkbox"/> S	6:02:30 PM	10s	
<input type="checkbox"/> S	6:02:40 PM	10s	
<input type="checkbox"/> S	6:02:50 PM	10s	
<input type="checkbox"/> S	6:03:00 PM	10s	
<input type="checkbox"/> S	6:03:10 PM	10s	
<input type="checkbox"/> S	6:03:20 PM	10s	
<input type="checkbox"/> S	6:03:30 PM	10s	
<input checked="" type="checkbox"/> P	6:03:40 PM	10s	
<input checked="" type="checkbox"/> P	6:03:50 PM	10s	
<input checked="" type="checkbox"/> P	6:04:00 PM	10s	
<input checked="" type="checkbox"/> P	6:04:10 PM	10s	
<input checked="" type="checkbox"/> P	6:04:20 PM	10s	
<input checked="" type="checkbox"/> P	6:04:30 PM	10s	
<input checked="" type="checkbox"/> P	6:04:40 PM	10s	
<input checked="" type="checkbox"/> P	6:04:50 PM	10s	
<input checked="" type="checkbox"/> P	6:05:00 PM	10s	
<input checked="" type="checkbox"/> P	6:05:10 PM	10s	
<input checked="" type="checkbox"/> P	6:05:20 PM	10s	
<input checked="" type="checkbox"/> P	6:05:30 PM	10s	
<input checked="" type="checkbox"/> P	6:05:40 PM	10s	
<input checked="" type="checkbox"/> P	6:05:50 PM	10s	
<input checked="" type="checkbox"/> P	6:06:00 PM	10s	
<input checked="" type="checkbox"/> P	6:06:10 PM	10s	
<input checked="" type="checkbox"/> P	6:06:20 PM	10s	
<input checked="" type="checkbox"/> P	6:06:30 PM	10s	
<input checked="" type="checkbox"/> P	6:06:40 PM	10s	
<input checked="" type="checkbox"/> P	6:06:50 PM	10s	

The marker list is searchable with the use of the **Find** search box at the top of the window. Typing the name of one of the marker types will filter the marker list to display only matching marker epochs.



The screenshot shows a window titled "Marker List" with a search bar containing "active". Below the search bar is a table with the following columns: Marker, Time, Duration, and Location. The table contains 30 rows of data, all with a duration of 10s. The markers are labeled 'A' and the times range from 6:18:00 PM to 6:28:00 PM. The Location column is empty for all entries.

Marker	Time	Duration	Location
A	6:18:00 PM	10s	
A	6:18:10 PM	10s	
A	6:18:20 PM	10s	
A	6:18:30 PM	10s	
A	6:19:20 PM	10s	
A	6:19:50 PM	10s	
A	6:20:00 PM	10s	
A	6:20:30 PM	10s	
A	6:21:00 PM	10s	
A	6:22:40 PM	10s	
A	6:23:10 PM	10s	
A	6:23:20 PM	10s	
A	6:23:30 PM	10s	
A	6:23:40 PM	10s	
A	6:23:50 PM	10s	
A	6:24:20 PM	10s	
A	6:24:30 PM	10s	
A	6:24:40 PM	10s	
A	6:24:50 PM	10s	
A	6:25:00 PM	10s	
A	6:26:10 PM	10s	
A	6:26:20 PM	10s	
A	6:26:30 PM	10s	
A	6:26:40 PM	10s	
A	6:26:50 PM	10s	
A	6:27:00 PM	10s	
A	6:27:10 PM	10s	
A	6:27:20 PM	10s	
A	6:27:30 PM	10s	
A	6:27:40 PM	10s	
A	6:27:50 PM	10s	
A	6:28:00 PM	10s	

Note: The marker list will not sync to signal grids.

# Scorings

## Working with Scorings

Scorings are a way to analyze data and determine what the subject is doing at specific times. An event can be assigned to every epoch of the recording, which is common with sleep scoring, or it can be assigned with arbitrary start and end times which is common with seizure detection. Scorings can be assigned manually or through NeuroScore’s automated detectors.

Once the data are scored, specific events or sleep stages can be identified visually and searched for within the recording. Scoring management can be performed in the Scorings tab of the *Task Window*. Further analysis through the Signal Grids and Marker Grids can be performed on the scored events. Reports can be used to summarize the results of the markers in the recording period. Essentially, scoring provides a method of getting the results desired much quicker and easier, especially with the automatic scoring capabilities.



Two options to score data:

- Manually Score
- Automatically Score using Protocols (may require the purchase of additional NeuroScore modules).

Options to manage data scorings include:

- Manually Scoring Data
- Automatic Scoring with Protocols
- Editing Scoring Results
- Loading and Saving a Scoring
- Comparing Scorings
- Scoring Shortcut Keys

## Manually Scoring Data

To manually score sleep data:

Open a recording.

1. Select the appropriate Marker Group from the Tools - Options menu – Workspace tab.
2. Make sure all Signal Settings are set as desired.
3. Make sure epoch durations are set to their desired length; set in **Tools - Options - General Icon**.
4. Make sure all the signals are loaded into the active *Signals Sheet*.
5. Locate the sleep staging row near the top of the signal sheet, just under the time stamp ruler.
6. **Right-click Sleep Staging - Start Scoring**.
7. The first epoch will be available to score indicated by a dashed line around the box
8. To Score an epoch **Right-click** (on the sleep staging row) - **Sleep Stage - choose appropriate stage** or use the corresponding shortcut key.
9. Either continue scoring epoch by epoch, skip to another epoch by scrolling and clicking on the epoch, or display a larger interval and highlight (**click and drag**) a period of time.
10. **Right-click** (in the highlighted area) - **Sleep Stage - choose appropriate stage**.
11. To use the shortcut keys make sure the **Start Scoring** option is active.
12. When finished, **Right-click - Sleep Staging - Stop Scoring**.
13. To save the scoring see Loading and Saving a Scoring. Otherwise be aware the scoring can be deleted/overwritten easily.

To manually insert non-sleep markers into the data set follow these steps:

1. Open a recording.
2. Make sure all Signal Settings are set as desired.
3. Make sure all the signals are loaded into the active *Signals Sheet*.
4. Select which signal contains the events to be marked by clicking on it or its axis label in the Signal Sheet so it becomes active
5. Identify a section of the data desired to mark.
6. **Click and drag** anywhere within the active signal sheet and use the green, vertical lines as marker boundaries.
7. **Right-click** (within the bound area) - **choose appropriate marker**. The marker will appear directly above the signal.
8. When finished, save the scoring as in Loading and Saving a Scoring. Otherwise be aware the scoring results can be deleted/overwritten easily.
9. Note that non-sleep markers are displayed directly above the signal type containing the events. It is not possible to visually compare one or more scoring sessions using non-sleep markers.

*Note:* The markers that are available have been set up using the Marker Types and Groups feature. A shortcut to get to the settings of the marker type would be to **Right-click - Properties** after a marker has been populated in the signal sheet. This shortcut only works on general markers, not on sleep scoring markers. To see how to use automated scoring, navigate to the Protocols section of the manual.

## **Automatic Scoring with Protocols**

To automatically score data, use the pre-configured protocols available. See [Working with Protocols](#) to get more information on this feature.

## Editing Scoring Results

To edit a scoring:

1. Open the **Scorings** tab in the *Task Window*.
2. Select the scoring to edit, under the *Scoring* section.
3. Click **Modify**.
4. Follow steps outlined in the manually scoring data section to adjust as needed.

To reassign an epoch or group of epochs to a different sleep marker:

1. **Right-click** the epoch to reassign within the *Sleep Staging* bar
2. Select **Sleep Stage - Sleep Marker** of choice

**OR**

3. **Click-and-drag** across multiple epochs
4. **Right-click - Sleep Stage - Sleep Marker** of choice

To delete a non-sleep marker from a signal sheet:

1. Select the Marker to remove
2. **Right-click - Remove Marker**

**OR**

3. **Left-click** the marker to delete
4. Press **<Delete>**

*Note:* To remove all markers of a certain type, select the marker to remove, **Right-click - Remove All Markers of this Type**.

To adjust, or finely tune, a non-sleep marker:

1. Mouse over one of the end-points of the marker until a double-sided arrow appears
2. **Click-and-drag** the marker end to the desired end-point

To search for markers:

1. Select the **Search for...** text box in the upper right of the workspace.
2. Select the Marker type of interest
3. To proceed to the next marker of this type press **<Tab>**, or click the Binoculars with Arrow Right on the toolbar.
4. To go back to a previous marker press **<Shift> + <Tab>**, or click the Binoculars with Arrow Left on the toolbar.

## Loading and Saving a Scoring

To load a saved scoring:

1. Select the **Scorings** tab in the *Task Window*.
2. The **Scoring** section will list all the current scorings that have been saved.
3. Select the scoring to load by clicking on the corresponding radio button (considered active after it is selected).
4. The radio buttons provide the ability to change which scoring is active or loaded.
5. Once the intended scoring is selected it can be viewed in all the sheets that reference the scorings and/or markers.

*Note:* To numerically view scoring results, please see the Grids section.

To save a scoring:

1. Select the **Scorings** tab in the *Task Window*.
2. The **Scoring** section will list all the current scorings that are open or available.
3. Select the scoring to save.
4. Select either **Save** or **Save as...**
  - If it is a new scoring, select either.
  - If it is a previously saved scoring that has been edited, select **Save** to simply update the scoring.
  - If it is a previously saved scoring that was edited, but needs to be saved under a different name, select **Save as...**
5. Enter the appropriate fields.
6. Click **OK**.

*Note:* DSI recommends saving all scoring sessions for future access.

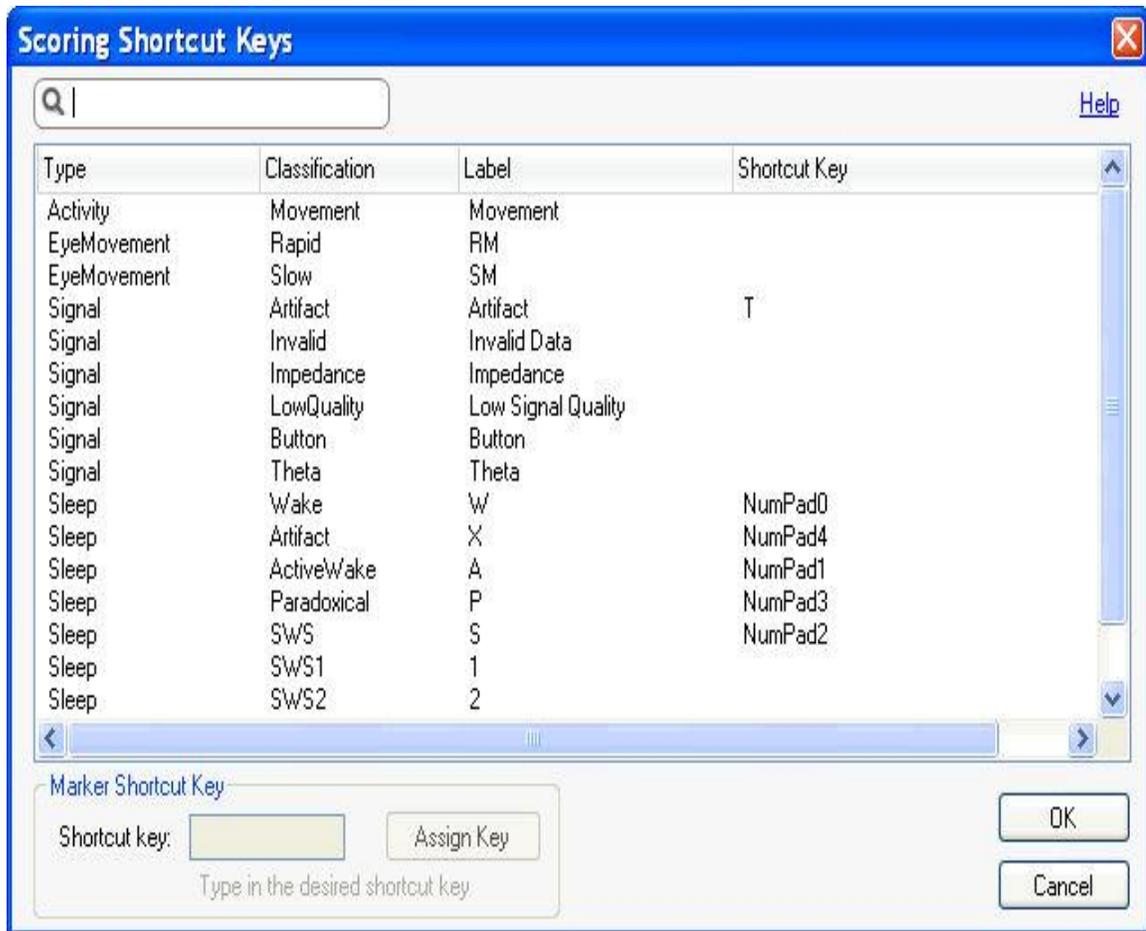


## Scoring Shortcut Keys

Assigning shortcut keys to marker types and classifications previously created provides an efficient way of manual scoring.

To add scoring shortcut keys:

1. Click **Edit - Scoring Shortcut Keys...**
2. This will open a new Scoring Shortcut Keys window.



3. Select the marker to which the shortcut key is desired to be applied.
4. Click in the *Shortcut key* field.
5. Type the key using the keyboard desired to assign it to the marker.
6. The Shortcut key field will update appropriately according to the key that was pushed.
7. Click **Assign Key**.
8. This will now update the table appropriately.
9. Follow steps 3 - 8 to assign addition shortcut key.
10. Click **OK**.

11. To access more settings for each of the markers go to **Edit - Configuration - Marker Types and Groups**. See Adding or Renaming a Marker Type for information on these settings.

*Note:* Scoring shortcut keys have not been assigned to the large animal sleep stages.

## Reports

### Working with Reports

NeuroScore provides the ability to create custom reports or choose a predefined report layout. Reports can be created based on the Sleep Scorings, Spike Trains, or other markers that have been applied to the data. After generating the report, the content remains fixed, despite changes in the scoring results or period. If changes are made to a recording, a new report can be generated to capture the most up-to-date information.

The links below will have information on what can be done with reports after they have been generated:

- [Adding Predefined Reports](#)
- [Creating Custom Reports Templates](#)
- [Viewing reports](#)
- [Printing reports](#)
- [Exporting reports](#)

*Note:* Extended Reports (containing *Ex* in their title) discriminate Slow Wave Sleep (SWS) into Slow Wave Sleep 1 (SWS1) and Slow Wave Sleep 2 (SWS2).

## Adding Predefined Reports

To add a report:

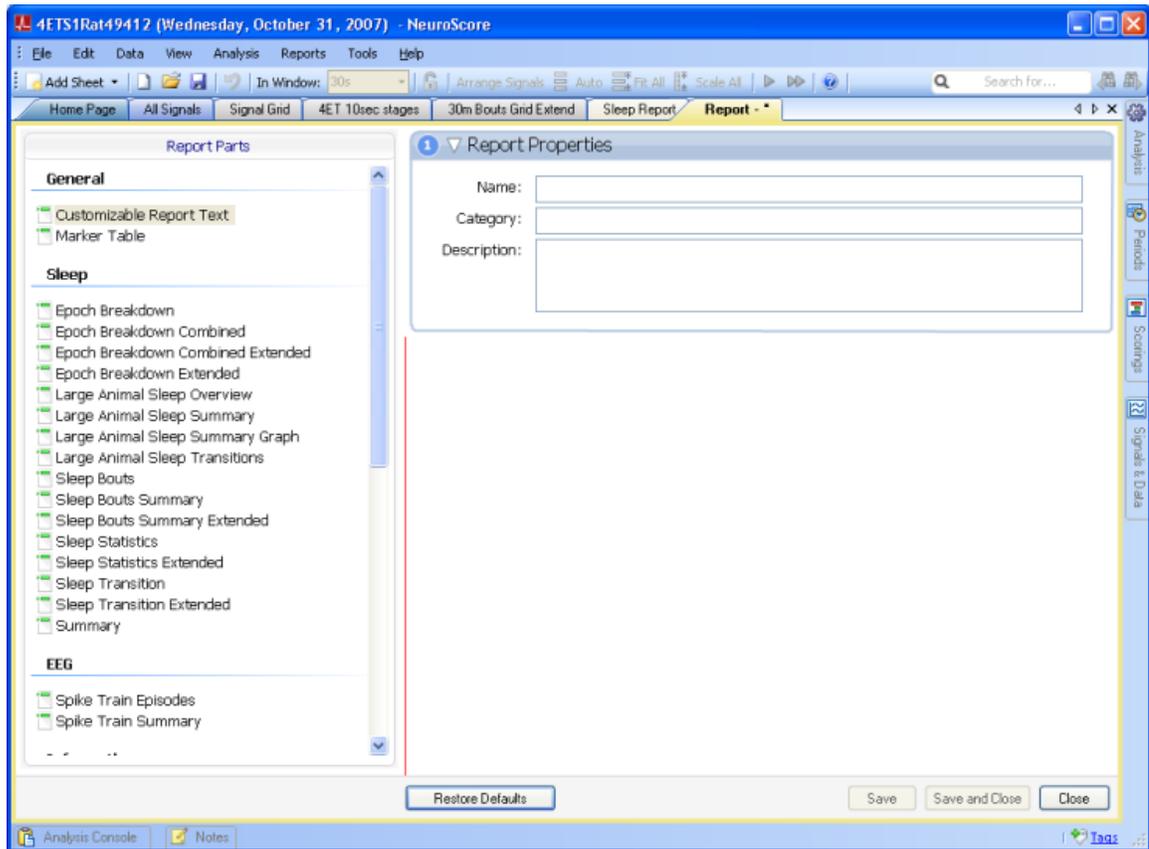
1. Open the **Reports menu** - choose **appropriate report** type to generate.
  - Marker Report
  - Seizure Report
  - Rodent Sleep
  - Rodent Sleep Extended
  - Large Animal Sleep Report
2. A new tab will populate in the NeuroScore window with the report being displayed.
3. If more than one set of sleep scoring data has been created, the active scoring will be used to create the report.
4. Once a report has been created it cannot be edited.
5. The report can be saved as a selected file format through the export feature.
6. To close the report, **Right-click** (on the *Report* tab) - **Close**.

*Note:* The reports are fixed within the session and will not update when changes are made to scorings or periods. The reports will also remain fixed when a saved analysis session is re-opened. To import company logo and information see *Options...* under the *Tools* menu.

## Creating Custom Reports

To create a custom report:

1. Select the **Reports** menu.
2. Select **Reports Template > New Template**
3. A new Report tab will populate.



4. Enter a **Report Name** within the *Report Properties* dialog box.
5. **Double-click** on one of the *Report Parts* to add to the report.
6. Select **Save and Close** to save the report as a template that can be used for future reports.
7. Select the **Reports** menu.
8. Choose the Report Name just created.

*Note:* To include corporate address and logo on the report, please see **Options...**

The following are Parts that can be added to a Custom Report:

### General

- Customizable Report Text

## Hello World

This is an example RTF text which can be used to create custom test sections in a report. It supports bullets and indentation.

- This is a bulleted list
- Bullet

It also support images:



- Marker Table

Report Part Preview						
Marker	Classification	Location	Count	Min [s]	Max [s]	Average
W	Wake		17	30	30	30
R	REM		250	30	30	30
N1	N1		72	30	30	30
N2	N2		558	30	30	30
N3	N3		206	30	30	30
Movement	Movement	Activity_A10	2	18,06	22,94	20,5
Movement	Movement	Position	8	0,1	22,8	6,98
Analysis Start	AnalysisStart	Position	1	0	0	0
Analysis Stop	AnalysisStop	Activity_A10	1	0	0	0
A. Mixed	MIXED	Flow_A10	1	13,21	13,21	13,21
A. Obstructive	OBSTRUCTIVE	Flow_A10	124	10,4	54,8	17,59

Sleep

- Epoch Breakdown

Report Part Preview					
Period	Wake [minutes]	Active Wake [minutes]	PS [minutes]	SWS [minutes]	Artifact [minutes]
22:00:00-22:30:00	4,5	0	0	0	0
22:30:00-23:00:00	2,8	0	0	0	0
23:00:00-23:30:00	0	0	0	0	0
23:30:00-0:00:00	0	0	0	0	0
0:00:00-0:30:00	0	0	0	0	0
0:30:00-1:00:00	0	0	0	0	0
1:00:00-1:30:00	0	0	0	0	0
1:30:00-2:00:00	0	0	0	0	0
2:00:00-2:30:00	0	0	0	0	0

- Epoch Breakdown Combined

Report Part Preview					
Period	Wake [minutes]	Active Wake [minutes]	PS [minutes]	SWS [minutes]	Artifact [minutes]
22:00:00-22:30:00	4,5	0	0	0	0
22:30:00-23:00:00	7,3	0	0	0	0
23:00:00-23:30:00	7,3	0	0	0	0
23:30:00-0:00:00	7,3	0	0	0	0
0:00:00-0:30:00	7,3	0	0	0	0
0:30:00-1:00:00	7,3	0	0	0	0
1:00:00-1:30:00	7,3	0	0	0	0
1:30:00-2:00:00	7,3	0	0	0	0
2:00:00-2:30:00	7,3	0	0	0	0
2:30:00-3:00:00	7,3	0	0	0	0

- Epoch Breakdown Combined Extended

Report Part Preview						
Epoch	Wake [minutes]	Active Wake [minutes]	PS [minutes]	SWS1 [minutes]	SWS2 [minutes]	Artifact [minutes]
13:30:00-14:00:00	2,2	1,5	0	0	0	0
14:00:00-14:30:00	2,2	5,3	3,0	7,0	3,0	2,5
14:30:00-15:00:00	2,2	5,3	3,0	7,0	3,0	2,5
15:00:00-15:30:00	2,2	5,3	3,0	7,0	3,0	2,5
15:30:00-16:00:00	2,2	5,3	3,0	7,0	3,0	2,5
16:00:00-16:30:00	2,2	5,3	3,0	7,0	3,0	2,5

- Epoch Breakdown Extended

Report Part Preview						
Epoch	Wake [minutes]	Active Wake [minutes]	PS [minutes]	SWS1 [minutes]	SWS2 [minutes]	Artifact [minutes]
13:30:00-14:00:00	2,2	1,5	0	0	0	0
14:00:00-14:30:00	0	3,8	3,0	7,0	3,0	2,5
14:30:00-15:00:00	0	0	0	0	0	0
15:00:00-15:30:00	0	0	0	0	0	0
15:30:00-16:00:00	0	0	0	0	0	0
16:00:00-16:30:00	0	0	0	0	0	0

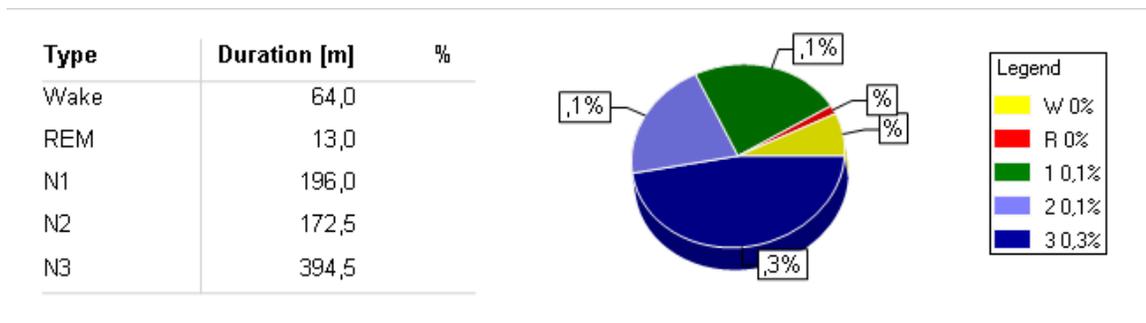
- Large Animal Sleep Overview

Total Scoring Time:	1440,0 m	Sleep Onset:	0 m
Sleep Period Time:	1440,0 m	to N1:	15,0 m
Total Sleep Time:	776,0 m	to N2:	13,5 m
Wake Time After Sleep Onset:	664,0 m	to N3:	0 m
Wake Time After Final Awakening:	- m	to 10 minutes of sleep:	0 m
Total N1 Duration:	196,0 m	Sleep Onset to REM:	17,0 m
Total N2 Duration:	172,5 m	Sleep Onset to slow wave:	0 m
Total N3 Duration:	394,5 m	Number of scoring epochs:	2880
Total REM Duration:	13,0 m		
Total NREM Duration:	763,0 m		

- Large Animal Sleep Summary

	Epochs	Minutes	%TScT	%SPT	%TST
Total Scoring Time (TScT):	2880	1440,0	-	-	-
Sleep Period Time(SPT):	2880	1440,0	100,0	-	-
Total Sleep Time (TST):	1552	776,0	53,9	53,9	-
Wake Time After Sleep Onset:	1328	664,0	46,1	46,1	-
Wake Time After Final Awakening:		-			-
Total N1 Duration:	392	196,0	13,6	13,6	25,3
Total N2 Duration:	345	172,5	12,0	12,0	22,2
Total N3 Duration:	789	394,5	27,4	27,4	50,8
Total REM Duration:	26	13,0	0,9	0,9	1,7
Total NREM Duration:	1526	763,0	53,0	53,0	98,3

- Large Animal Sleep Summary Graph



- Large Animal Sleep Transitions

	AW	Wake	REM	N1	N2	N3
Active Wake	-	82	0	18	0	6
Wake	70	-	0	21	0	3
REM	1	0	-	12	3	0
N1	22	11	4	-	75	42
N2	3	0	7	71	-	104
N3	10	1	5	32	108	-

- Sleep Bouts

Report Part Preview					
Episode #	Epoch #	Time	Sleep Stage	Count	Duration [seconds]
1	3	24.11.2005 22:25:30	W	44	440,0
2	47	24.11.2005 22:32:50	N1	22	220,0
3	69	24.11.2005 22:36:30	N2	16	160,0

- Sleep Bouts Summary

**Report Part Preview**

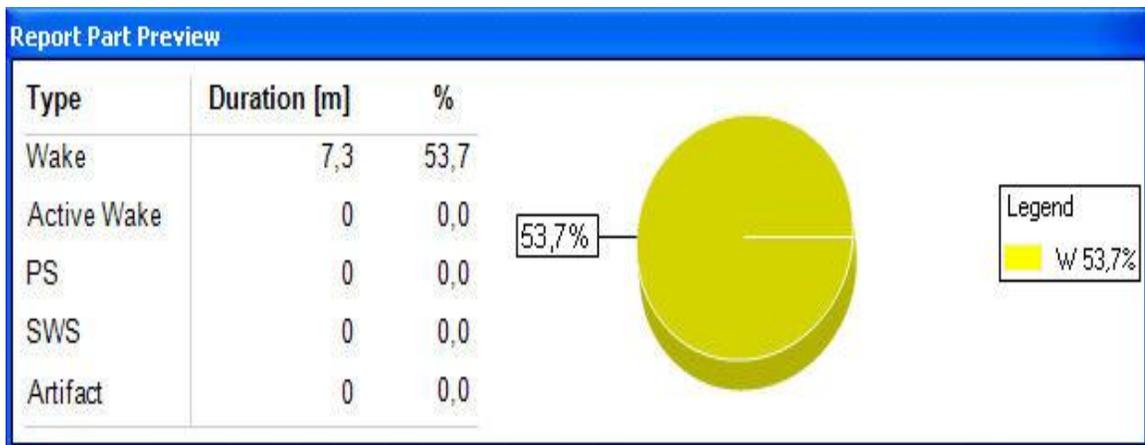
Sleep Stage	Count	Duration [seconds]			
		Mean	SD (+/-)	Shortest	Longest
Sleep-	0	0	0	0	0
W	1	440,0	0	440,0	440,0
Sleep-Paradoxical	0	0	0	0	0
Sleep-SWS	0	0	0	0	0
Sleep-Artifact	0	0	0	0	0

- Sleep Bouts Summary Extended

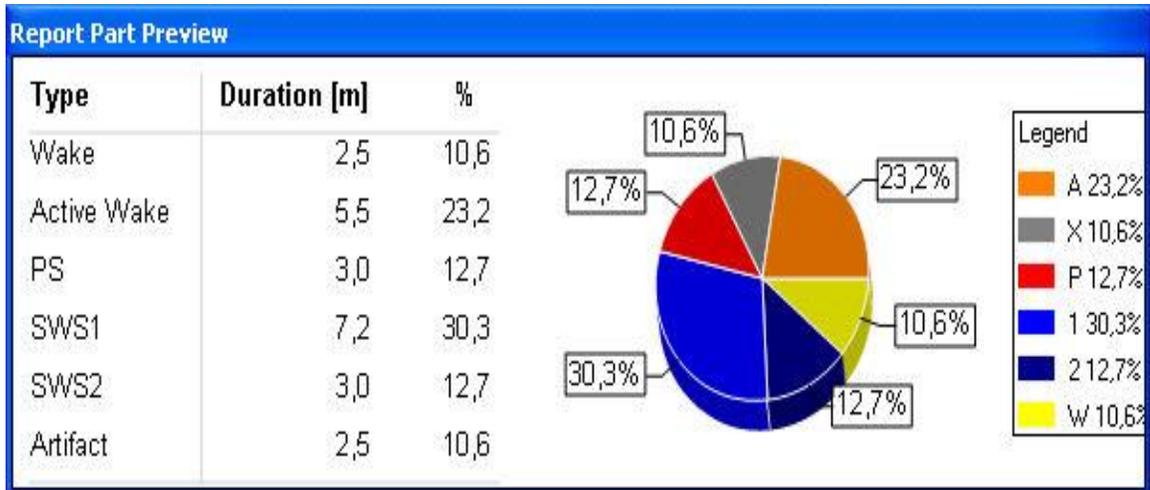
**Report Part Preview**

Sleep Stage	Count	Duration [seconds]			
		Mean	SD (+/-)	Shortest	Longest
Sleep-	0	0	0	0	0
W	1	440,0	0	440,0	440,0
Sleep-Paradoxical	0	0	0	0	0
Sleep-SWS	0	0	0	0	0
Sleep-Artifact	0	0	0	0	0

- Sleep Statistics



- Sleep Statistics Extended



- Sleep Transition

**Report Part Preview**

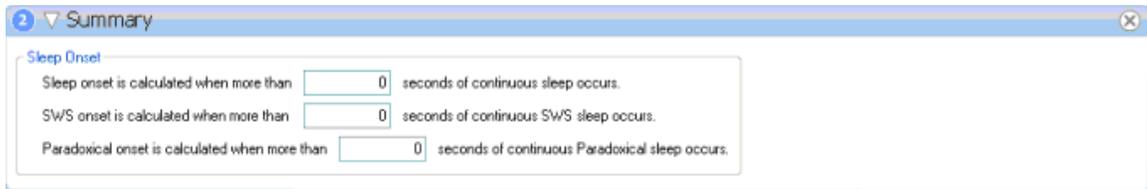
	Wake	Active Wake	PS	SWS	Artifact
<b>Wake</b>	-	0	0	0	0
<b>Active Wake</b>	0	-	0	0	0
<b>PS</b>	0	0	-	0	0
<b>SWS</b>	0	0	0	-	0
<b>Artifact</b>	0	0	0	0	-

- Sleep Transition Extended

**Report Part Preview**

	Wake	Active	PS	SWS1	SWS2	Artifact
<b>Wake</b>	-	1	0	0	0	0
<b>Active Wake</b>	0	-	0	1	0	0
<b>PS</b>	0	0	-	0	0	1
<b>SWS1</b>	0	0	0	-	2	0
<b>SWS2</b>	0	0	1	1	-	0
<b>Artifact</b>	0	0	0	1	0	-

- Summary



Report Part Preview		
Total Scoring Time:	13,7 minutes	
Total Sleep Time:	6,3 minutes	
Wake time after sleep onset:	2,2 minutes	
Sleep Period:	8,6 minutes	
Sleep Onset:	5,1 minutes	
Artifacts in Scoring:	0 minutes or	0,0 percent of total scoring time

EEG

- Spike Trains Episodes

Episode #	Time	Duration [seconds]	Spikes #	Spikes #/s	Ave. Interval seconds
1	1.8.2007 15:51:26	1,2	4	3,2	0,34
2	1.8.2007 16:42:51	1,6	5	3,2	0,26
3	1.8.2007 16:42:54	1,1	5	4,5	0,20
4	1.8.2007 16:43:04	0,7	4	5,9	0,09
5	1.8.2007 17:41:32	0,6	4	6,3	0,15
6	1.8.2007 17:48:34	2,4	8	3,4	0,24

- Spike Train Summary

Total Number of Spike Trains:	15	
Total Spike Train Duration:	0,5 minutes or	0,0 % of recording time
Average Spike Train Duration:	1,9 seconds	
Longest Spike Train Duration:	12,4 seconds	
Shortest Spike Train Duration:	0,5 seconds	
Average Number of Spikes per Train:	7,0	

Information

- Analysis Protocol

**Scoring Name:**

Rodent sleep scoring uses delta power band (0,5-4Hz) and theta power band (6-9Hz) to score sleep from the EEG. The slow wave ratio is set to 0,4, theta ratio to 3, EMG level to 10µV and activity level to 0,1. Artifacts are located in the EEG if the amplitude exceeds 1 mV. Artifacts are located in the EMG if the amplitude exceeds 1 mV.

- **Bookmark**

Bookmark adds a bookmark section that was saved from a recording

- **Interpretation Notes**

Interpretation Notes adds an interpretation notes section to the report that was created during analysis.

- **Recording Information**

Report Part Preview		
Analyzed Period:	Whole Recording	Recording Start: 24.11.2005 22:25
		Recording Stop: 25.11.2005 07:56
		Recording Time: 9h 30m 57s

- **Subject Information**

Report Part Preview	
ID:	ID_123456
Gender:	Unknown
Species:	Canine
Notes:	Canine recorded for EEG and EMG



- **Subject Notes** Allows the user to add any notes regarding the subject if necessary.
- **Technical Notes** Allows the user to add any Technical Notes deemed worthy of mentioning.

**Report Grouping**

- **Heading 1**

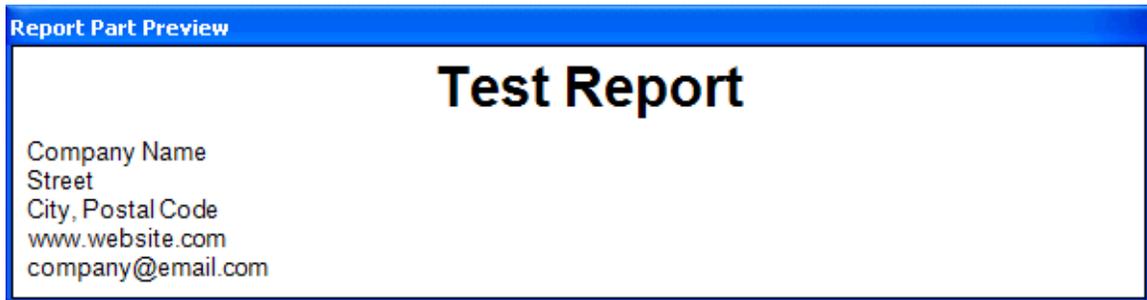
▶ **Heading 1**

---

- **Heading 2**

▸ Heading 2

- Page Break Adds a more pronounced space between report parts.
- Report Title



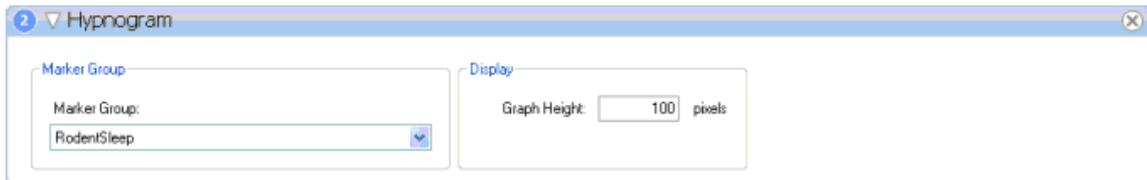
- Small Report Title

## ReportTitle

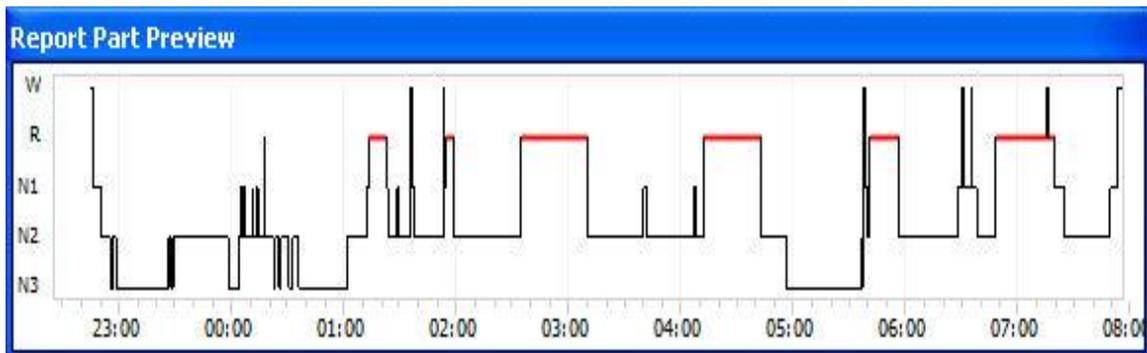
Company Name  
Street  
State ec.

### Graphs

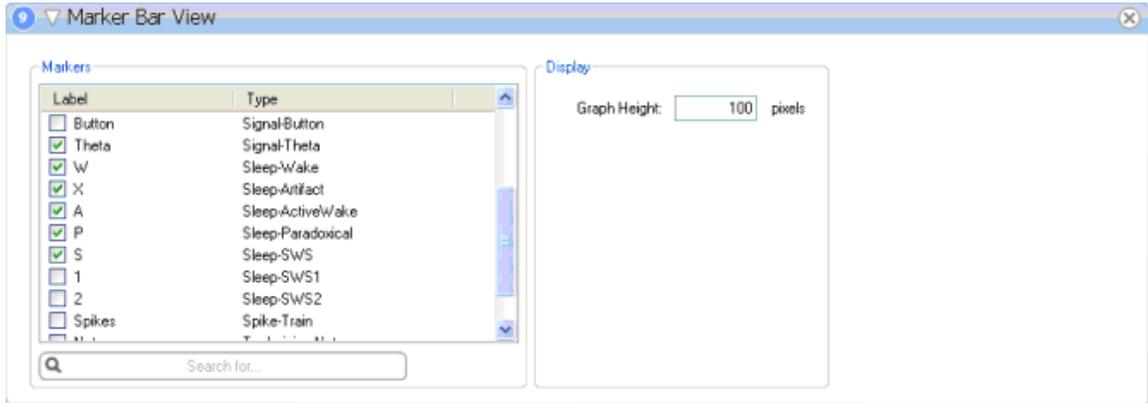
- Hypnogram



To display a *Hypnogram* of a specific marker, select the marker of interest from the *Marker Group* drop-down box. The Graph Height, as seen in the report, can also be defined. Below is an example of a *Hypnogram* as seen in a generated report.



- Marker Bar View



To add Markers to this view, select the check box corresponding to the Marker of interest, as shown below. Graph Height as seen from within the report can also be defined. Below is an example of a resultant *Marker Bar View* as seen in a generated report.



- Marker Plot



Choose the radio button corresponding to the type of markers desired to be displayed in the *Marker Plot*. To select specific marker groups, select the radio button corresponding to the View markers in group, then choose the marker group from the drop-down menu. Below is an example of a resultant *Marker Plot*, as seen from a generated report.



- Marker Value

**2** ▾ Marker Value ✕

**Markers**

Label	Type
<input type="checkbox"/> Movement	Activity-Movement
<input type="checkbox"/> RM	EyeMovement-Rapid
<input type="checkbox"/> SM	EyeMovement-Slow
<input type="checkbox"/> Artifact	Signal-Artifact
<input type="checkbox"/> Invalid Data	Signal-Invalid
<input type="checkbox"/> Impedance	Signal-Impedance
<input type="checkbox"/> Low Signal Quality	Signal-LowQuality
<input type="checkbox"/> Button	Signal-Button
<input type="checkbox"/> Theta	Signal-Theta
<input type="checkbox"/> X	Sleep-Artifact
<input type="checkbox"/> A	Sleep-ActiveWake
<input type="checkbox"/> P	Sleep-Paradoxical

🔍 Search for...

**Display**

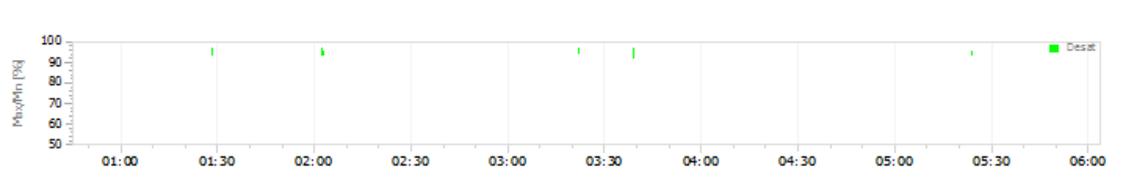
Graph Height:

Value Axis High:

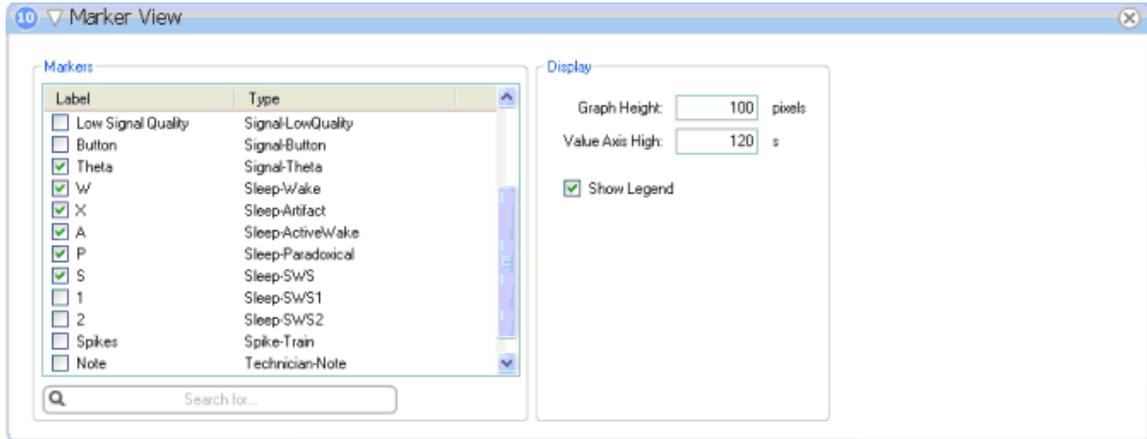
Value Axis Low:

Show Legend

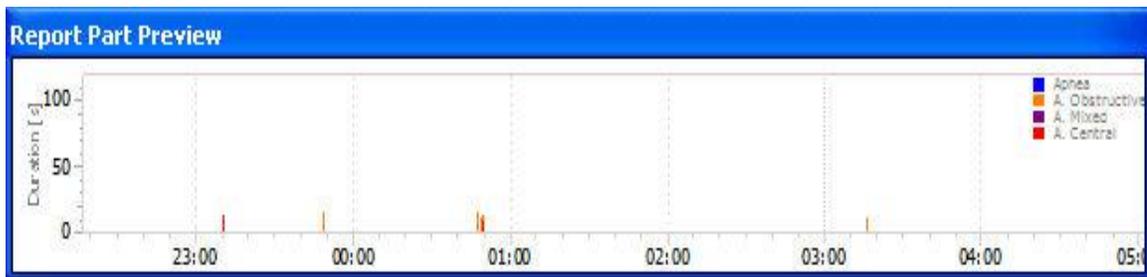
To add Markers to this view, select the check box corresponding to the Marker of interest, as shown above. Graph Height and Value Axis High/Low as seen in the generate report can also be defined. Below is an example of a resultant Marker Value as seen from a generated report.



- Marker View



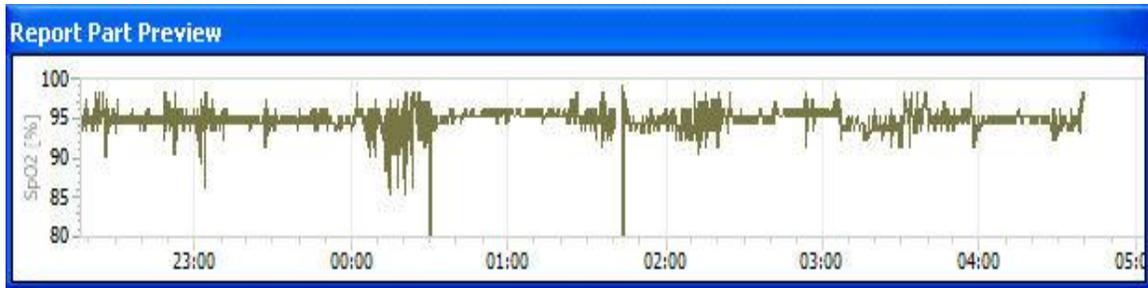
To add Markers to this view, select the check box corresponding to the Marker of interest, as shown above. Graph Height and Value Axis High as seen in the generate report can also be defined. Below is an example of a resultant *Marker View* as seen from a generated report.



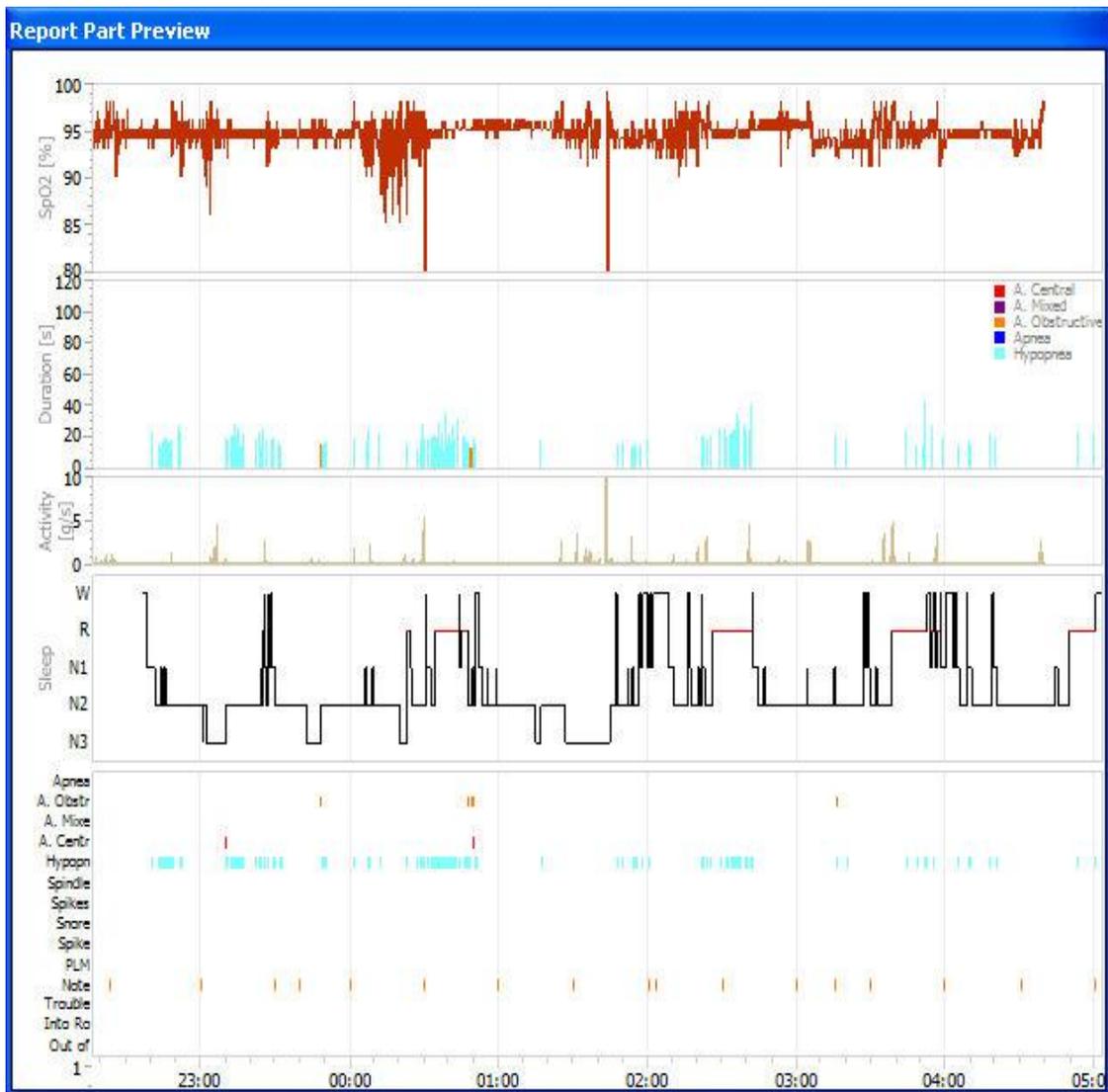
- Signal View



To add a Signal to the report, select the signal of interest from the *Signal Group* drop-down box. *Choosing Signal Type* will bring all Signal Groups of a particular type; e.g. selecting EEG as the *Signal Type* will bring in all active EEG signals into the report. Graph height, as seen in the report, Signal Color, and Axis Range can also be user-defined. Below is an example of the resultant *Signal View* as seen in a generated report.



- Trend Overview



*Note:* Extended versions discriminate Slow Wave Sleep (SWS) into Slow Wave Sleep 1 (SWS1) and Slow Wave Sleep 2 (SWS2).

## **Viewing Reports**

As long as the report is open in the NeuroScore window with a tab, it can be viewed at anytime. Multiple reports can be generated and viewed based on active periods or scorings.

The NeuroScore software will display the report similar to a .pdf document.

## Printing Reports

To print a report:

1. Click on the report tab of interest.
2. Click the **Printer icon** or go to **File - Print**.
3. The *Printing* options window will populate.
4. Click **Print** when the settings have been adjusted accordingly.

## Exporting Reports

To export a report:

1. Select the tab of the report interested in exporting
2. Go to **File - Export Sheet...**
3. Specify the *file format* and the *file name*.
4. Click **Save**.
5. This will save the report sheet as a file format allowing it to be accessed outside of the NeuroScore software.

The file formats available:

- .Pdf (default)
- Excel
- Html
- Rich text

*Note:* When exporting a report as an excel or rich text document, the tables and figures become objects and can be moved, copied to a new document (such as a PowerPoint presentation), or removed to customize the reported information.

# Tools

## Tools

The **Tools** menu allows access to global settings of the NeuroScore software. Please note the *Options...* settings include defining a global epoch duration, company logo, and company information for reports that are generated. Shortcuts can be made for commonly used data locations so they can be easily accessed. Follow the links below for further explanation:

- [Plugins...](#)
- [Spectrum Export](#)
- [View Log Files](#)
- [Options...](#)

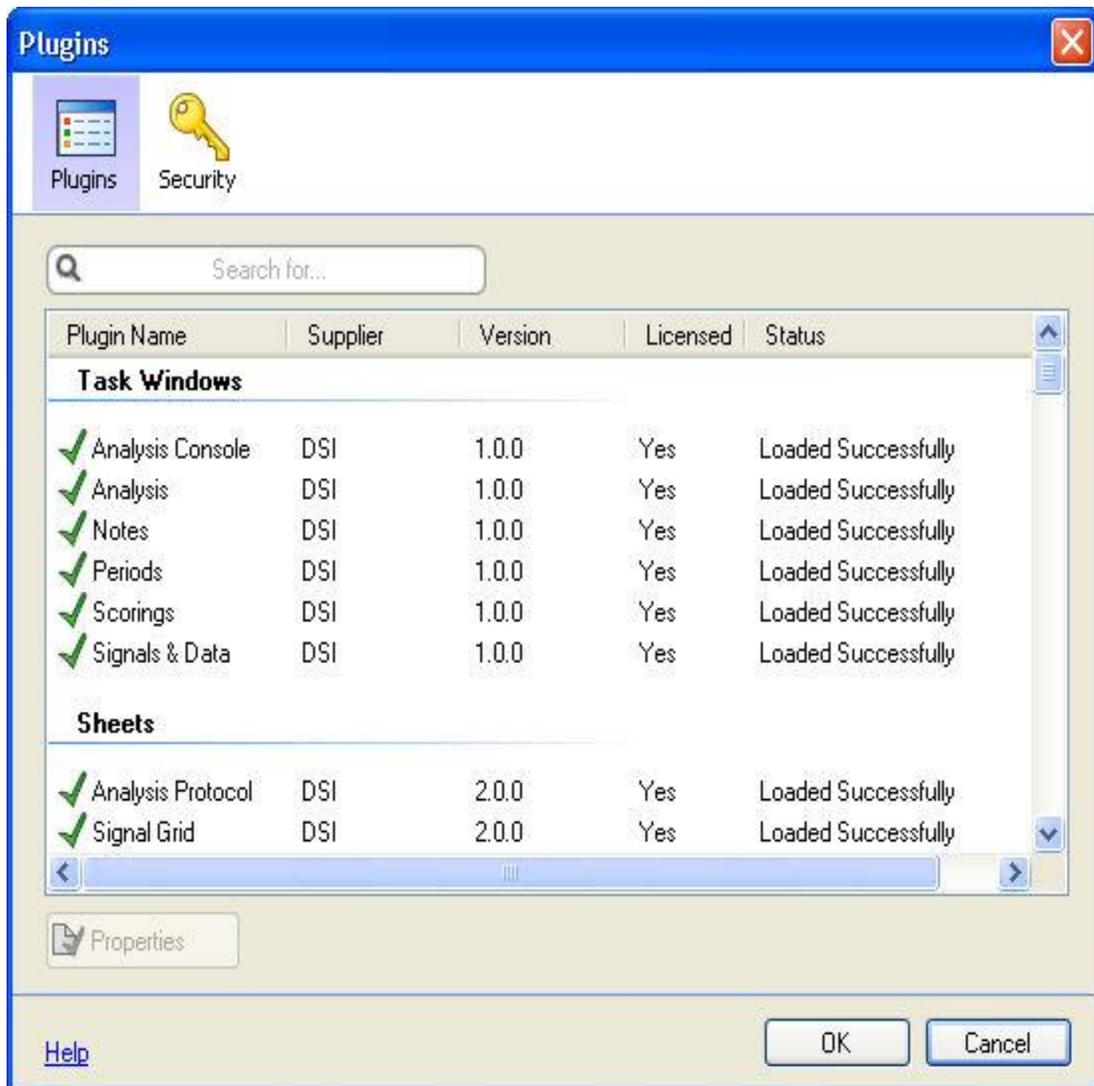
*Note:* The **Tools - Options** settings set in NeuroScore version 1.0 do not carry through to later versions.

## Plugins...

This provides a list of all the functions that have been installed with NeuroScore and are currently available.

To view this list:

1. Go to **Tools - Plugins...**
2. This will populate a Plugins window

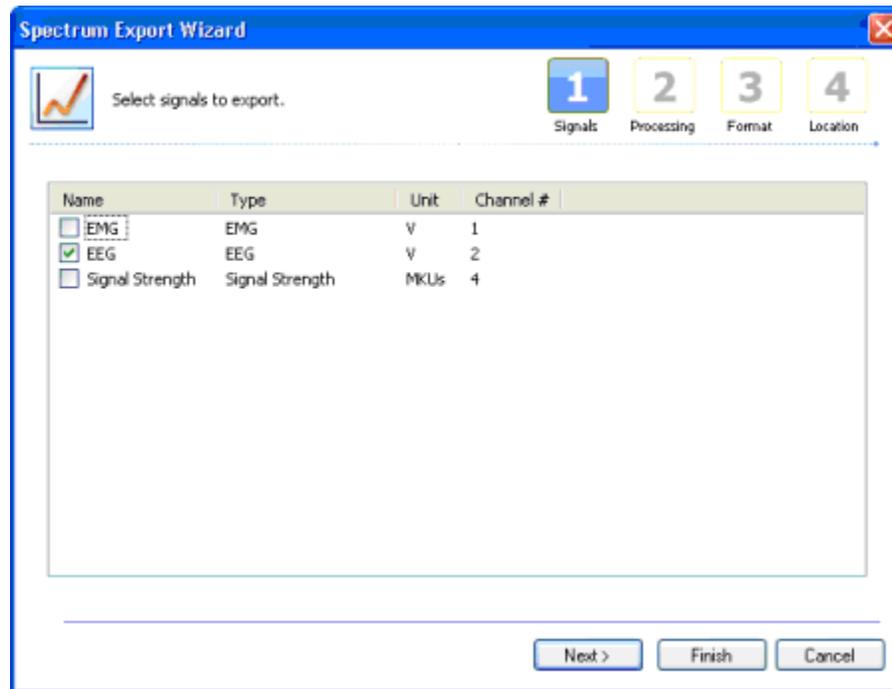


3. There will be a number of functionalities and features listed, along with other information including what source, version, if it is licensed, and its status.
4. To view the properties of a specific function or feature, select any of them and click **Properties**.

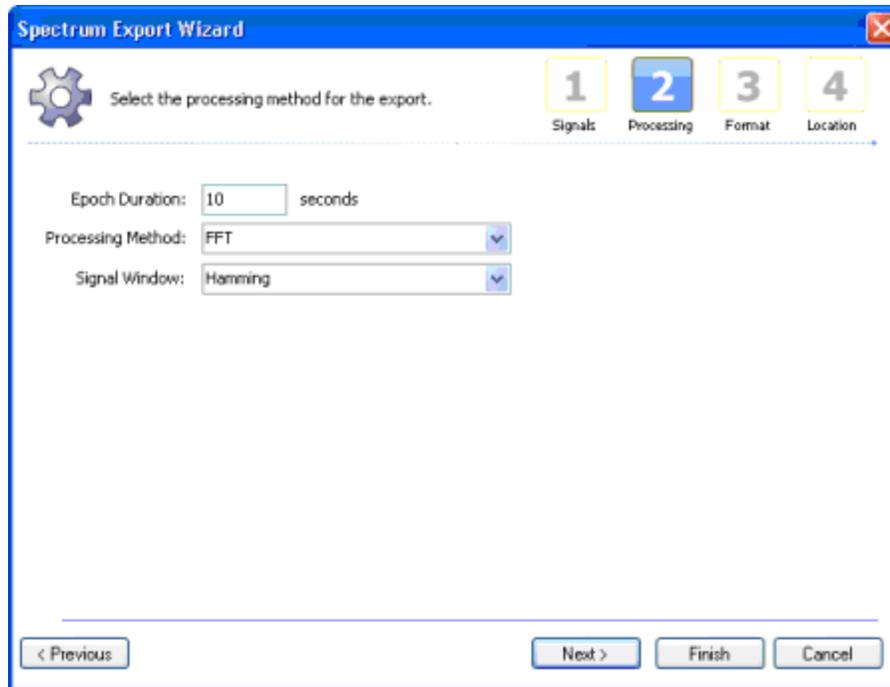
## Spectrum Export

To export the full frequency spectrum into a .txt file, please perform the following tasks:

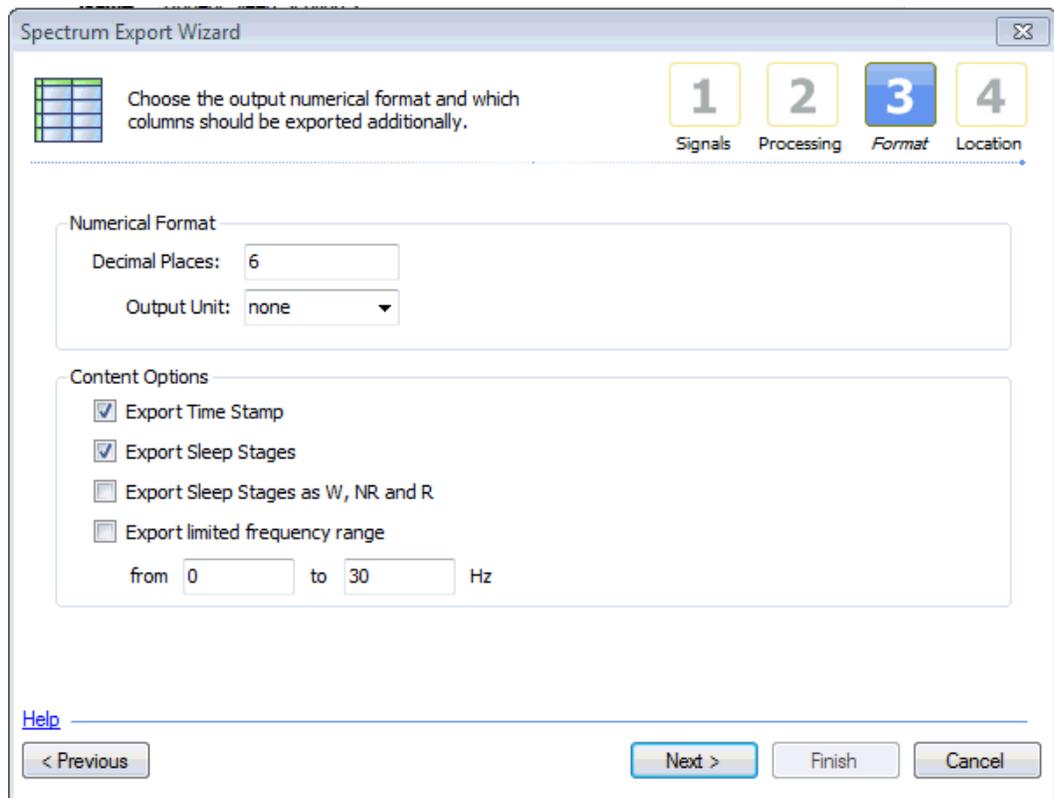
1. Select **Tools - Spectrum Export** to populate the 4-step wizard.
  - Step 1 - Enable the signal to export, then click **Next**



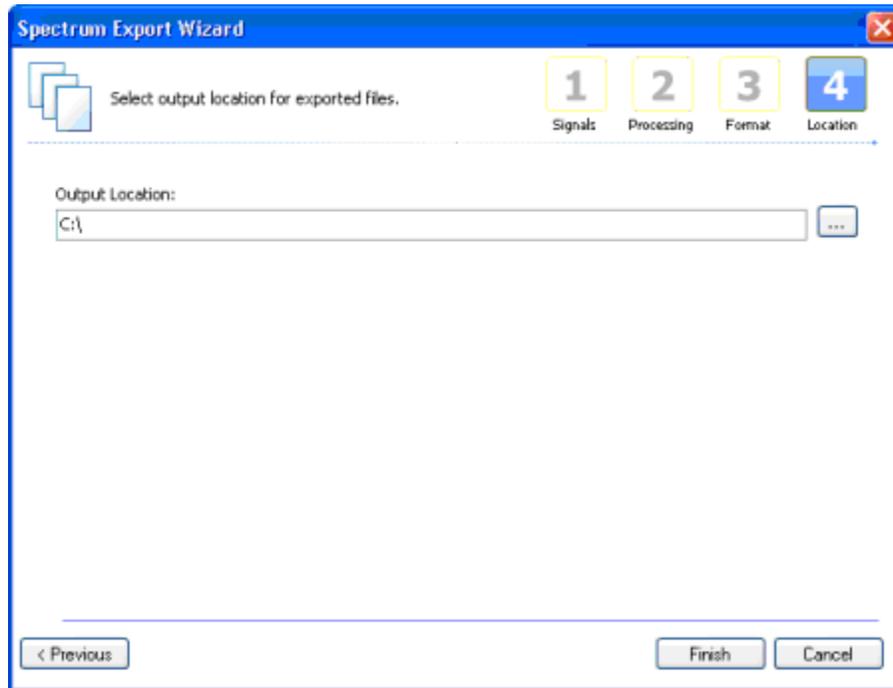
- Step 2 - Choose the Processing Method from the drop-down and enter the desired processing options.



- Step 3 - Enter the desired Numerical Format and enable the appropriate Content Options.



- Step 4 - Enter an Output Location to store the generate file or select the ... button to browse to the desired location.



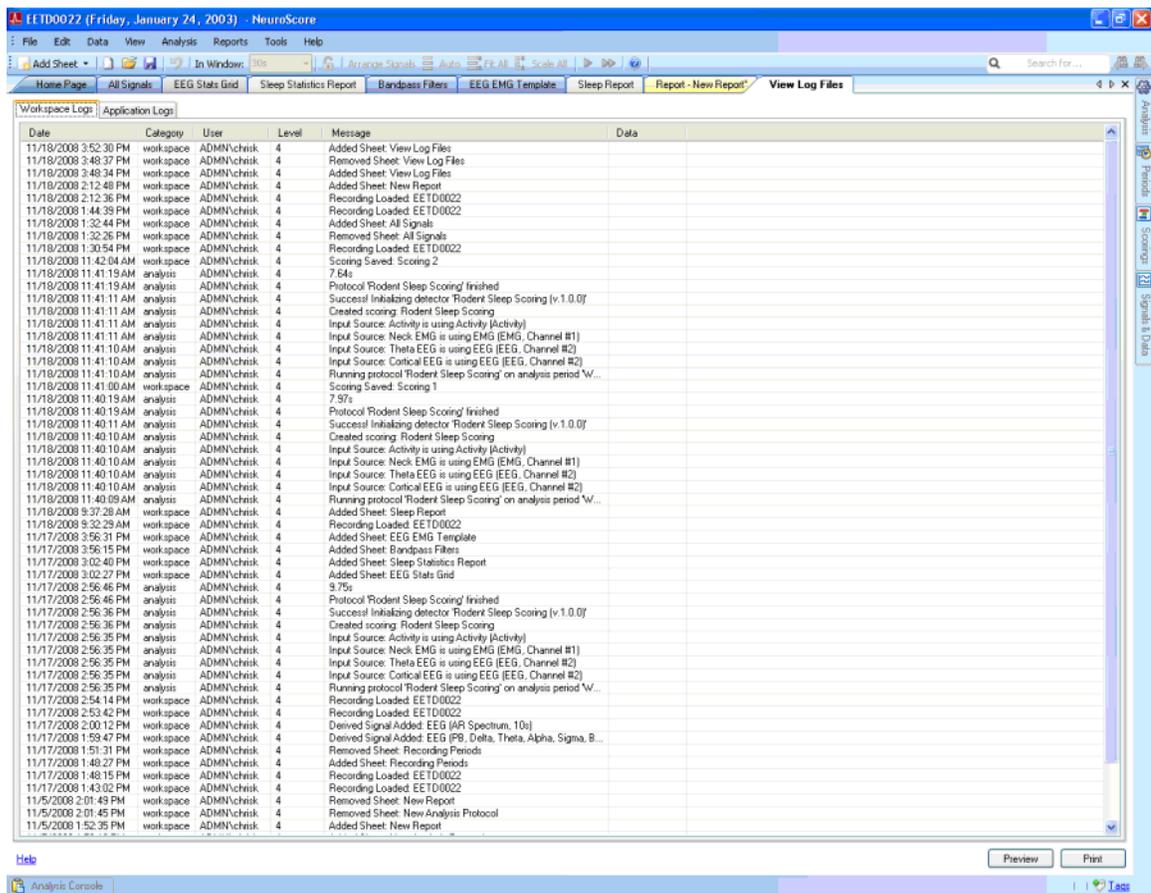
2. Click **Finish**

## View Log Files

Log files list out all the key strokes that have occurred with the active recording.

To view the log files:

1. Go to **Tools - View Log Files**.
2. This will open a new tab named View Log Files.
3. Two tabs will be contained within the View Log Files tab.



4. Click on the *Workspace Logs* tab to view activities that occur within the NeuroScore application; i.e. adding a sheet or performing any analysis function.
5. Click on the *Application Logs* tab to view activities that occur to the NeuroScore application; i.e. Starting and Closing NeuroScore.
6. To print the log:
  - Select the appropriate tab
  - Click **Preview** to preview what the log file will look like when printed
  - Click **Print**
7. To close, **Right Click - Close** on the *View Log Files* tab.

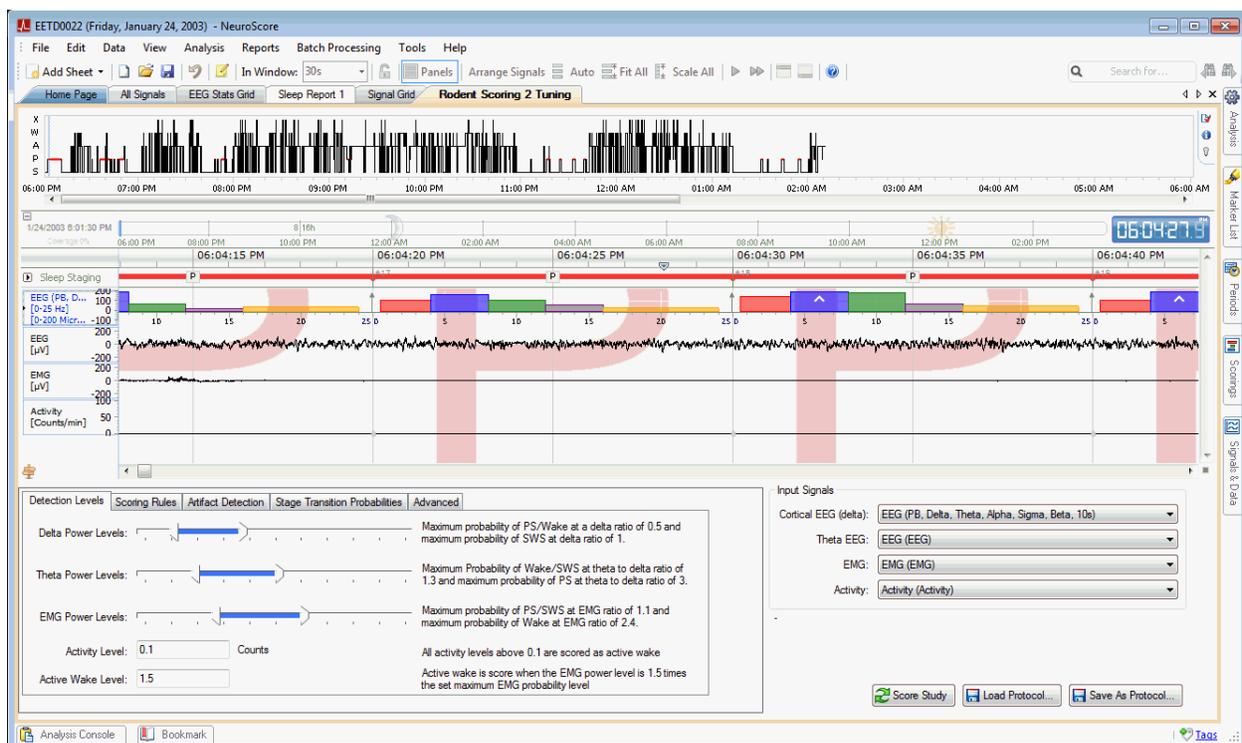
## Rodent Scoring 2 Visual Tuning

The Visual Tuning tool is used to help researchers configure the Rodent Sleep Scoring 2 automated sleep detector. When selected, a new tab will be added to the Recording Workspace and display the following:

- Hypnogram of the scored period
- 30 seconds of the recording signals selected in the Input Signals dropdown menu
- Detector Settings for augmenting analysis settings

Note: Although the In Window time is grayed out, the time displayed in the Visual Tuning sheet can be changed by right-clicking the time axis and choosing a new duration.

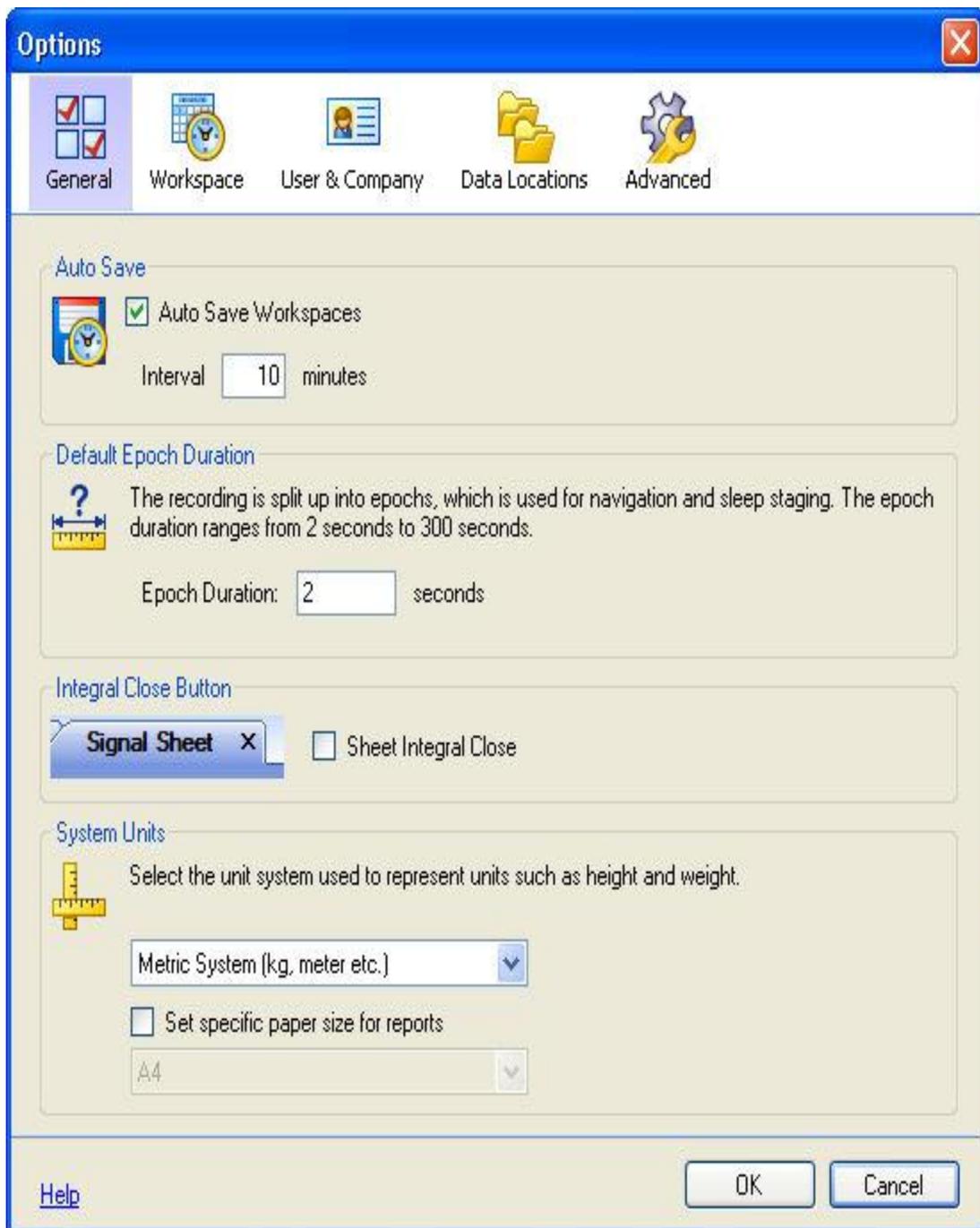
Please see Configuring the Rodent Sleep 2 Detector for more details.



## Options...

To view the settings of the active recording, along with other global settings of the NeuroScore software:

1. Go to **Tools - Options...**
2. This will open a new Options window.



## 3. You will notice there are four icons:

- General
  - **Auto Save:** Sets a time period in which NeuroScore will automatically save the workspace.
  - **Default Epoch Duration:** Sets a time period for an epoch. This value will be the default value used when creating derived signals.
  - **Integral Close Button:** When checked, it will include a shortcut close button on all sheet tabs in NeuroScore.
  - **System Units:** Sets the units the system will use.
- Workspace
  - **Default Sleep Marker Group:** Selects the default sleep marker group the program will default to when using markers throughout the program. The default value is Rodent Sleep, but other options include Rodent Sleep EX , Large Animal Sleep, and any custom sleep marker groups that have been created. This applies to manual sleep scoring selections, the hypnogram graphs, sleep scoring columns in grids, and more. Be sure this is selected appropriately according to what data will be analyzed.
  - **Light/Dark Time:** Allows the user to select what time frame the lights were out during data collection. The darkness interval will be displayed on the hypnogram in sleep reports.
- User and Company (information used in reports)
  - **User Information:** Enter your name, initials and email.
  - **Company Information:** Enter the company's name, address, web site and email.
  - **Logo:** Directs the software to the company logo's location on the network.
- Custom Fields
- Reports

Allows the custom creation of report header and footer information.

- Advanced
  - **Local Settings:** local settings can be reset by this button.
  - **Power Line Filter:** Filters the common power line frequencies, 50 or 60 Hz.
  - **Setting Directories:** Click on any of the links to be brought to their location on the hard drive of the computer.
  - **Aliasing:** When selected aliasing is applied to both signals and markers.
  - **Recording Period:** Defines the recording period from strictly waveforms (having the box checked) or also parameters (having the box unchecked).

4. Clicking **OK** to close the window.

Here is an example of how a report can be customized using the DSI logo and contact information:

The screenshot displays the NeuroScore software interface. The main window shows a 'Sleep Report' for file 'EETD0022'. The report includes the following information:

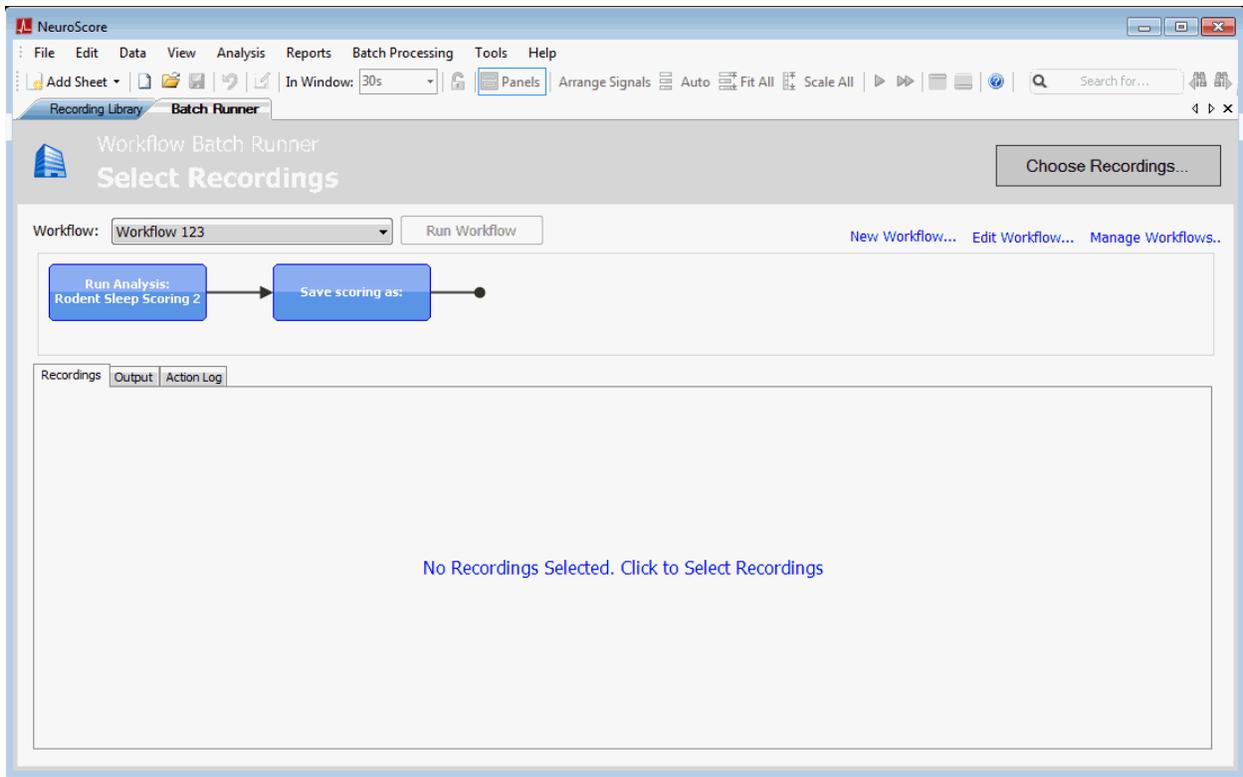
- DSI™** logo
- Sleep Report**
- Data Sciences International  
St. Paul, MN  
www.datasci.com
- Recording Info**
- Analyzed Period: Day2
- Recording Start: 1/24/2003 6:01 PM
- From: 1/25/2003 12:00 PM
- Recording Stop: 1/27/2003 9:39 AM
- Duration: 1d
- Recording Time: 2d 15h 37m 42s

The software interface includes a menu bar (File, Edit, Data, View, Analysis, Reports, Tools, Help), a toolbar with various analysis tools, and a sidebar with navigation options like 'Analysis Console', 'Periods', 'Scoring', and 'Signals & Data'. The status bar at the bottom shows 'Day2' and 'Tags...'.

# Batch Processing

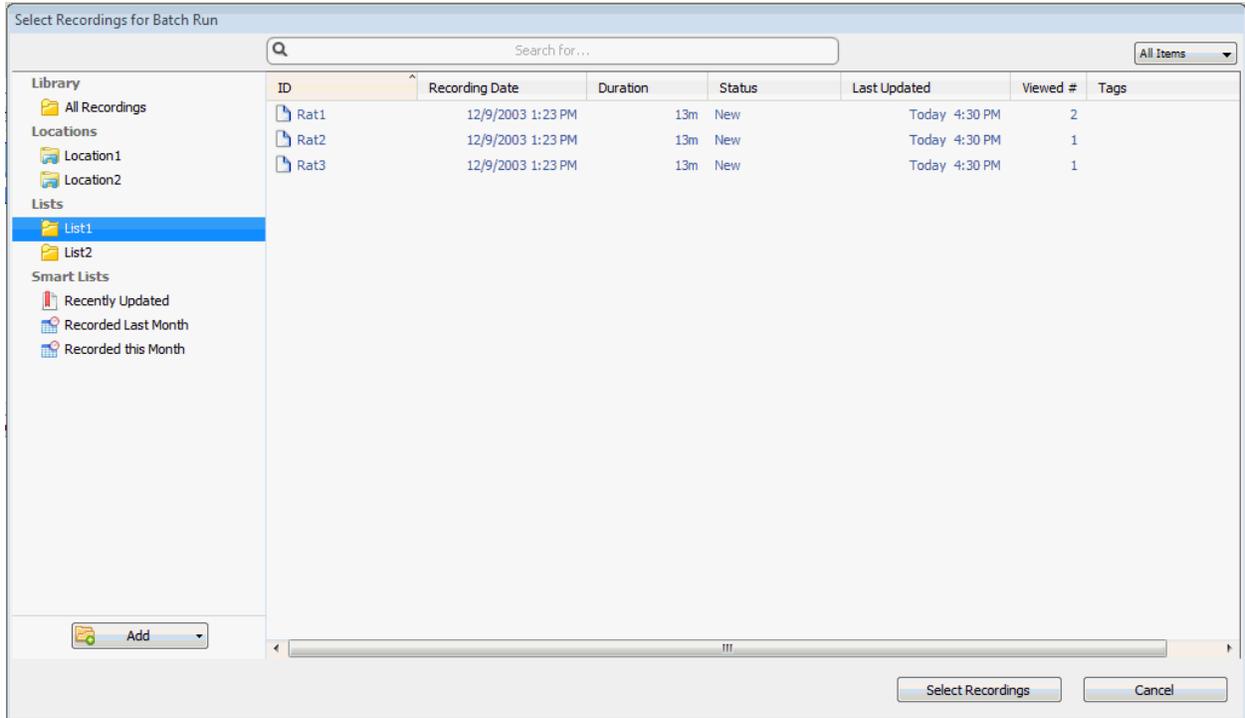
## Batch Runner

The Batch Runner sheet is the user interface to the Batch Processing module. From this interface, users can create a Workflow (see [Creating a Workflow](#)) or select a predefined Workflow to run on multiple subjects. Once a Workflow is created it can be selected from the drop down list.

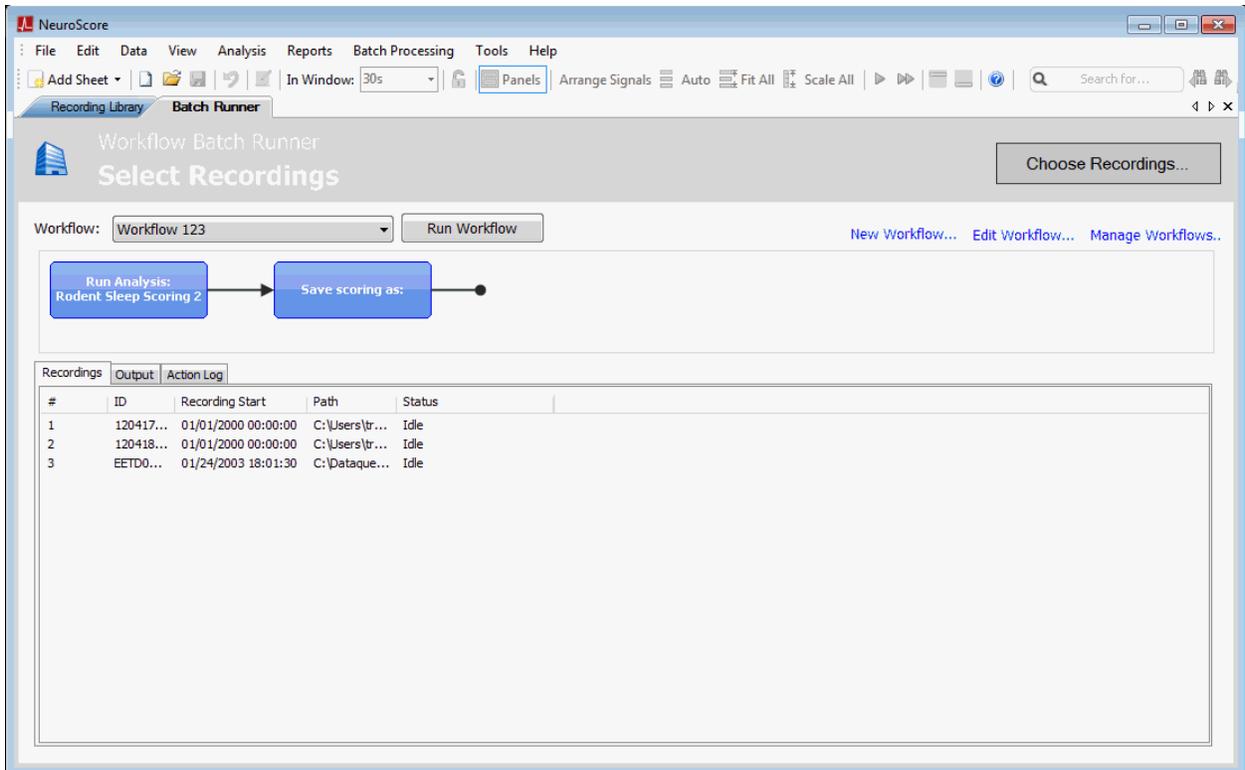


Once a Workflow is selected, any number of subjects can be selected to run the workflow on. Select [Choose Recordings](#) to select recordings for the desired workflow. Recordings can be selected from a list of all the recordings in the library, in a specific location or from a specific list.

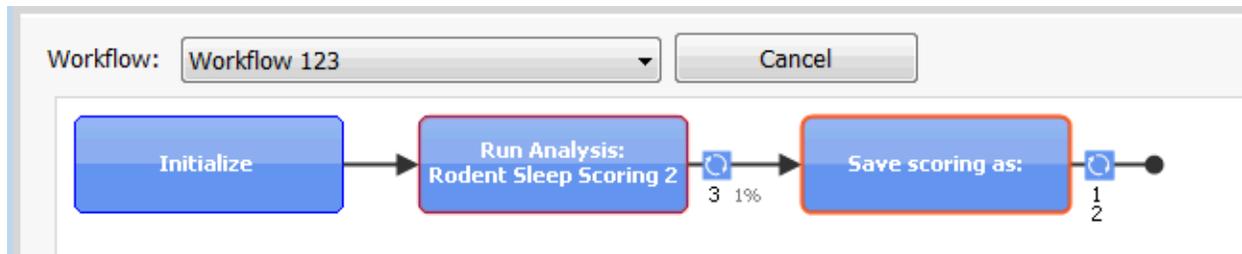
# NeuroScore Version 3.0



Selected recordings will be shown in the Recordings tab at the bottom of the screen. The initial status of the recordings will be *Idle*.



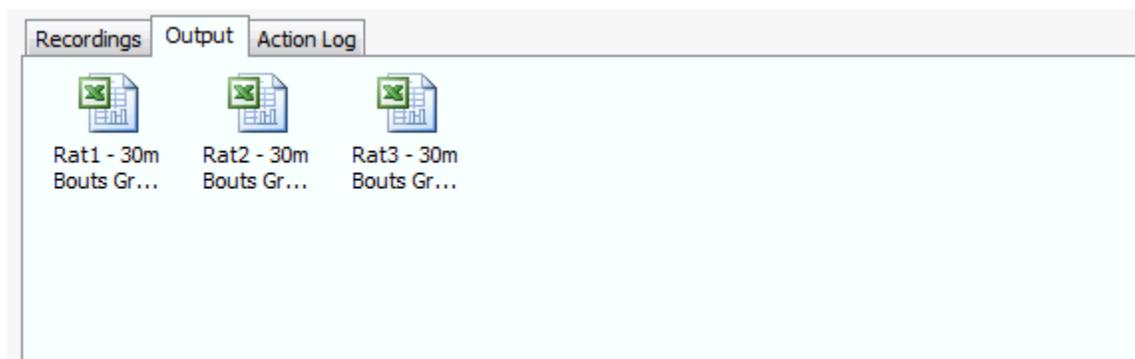
Selecting Run Workflow will initialize the Batch Runner. The Batch Runner will display real-time status of the workflow execution on the selected recordings, including the current Workflow step and percent completion.



Once completed, the status of the recordings will display **Finished**.

#	ID	Recording Start	Path	Status
1	Rat1	12/09/2003 13:23:20	C:\Dataquest ART\Sample Data	Finished
2	Rat2	12/09/2003 13:23:20	C:\Dataquest ART\Sample Data	Finished
3	Rat3	12/09/2003 13:23:30	C:\Dataquest ART\Sample Data	Finished

The **Output** tab will display any output from the workflow including sheets that were exported and reports.



The **Action Log** will display a list of the steps performed in the workflow and any errors that were encountered.

```
Recordings Output Action Log
Scanning for recordings
[Rat1] -> Opening C:\Dataquest ART\Sample Data
[Rat3] -> Opening C:\Dataquest ART\Sample Data
[Rat2] -> Opening C:\Dataquest ART\Sample Data
[Rat2] -> Recording Loaded: Rat2
[Rat2] -> Starting task: Run Analysis Rodent Sleep Scoring 2
[Rat3] -> Recording Loaded: Rat3
[Rat3] -> Starting task: Run Analysis Rodent Sleep Scoring 2
[Rat1] -> Recording Loaded: Rat1
[Rat1] -> Starting task: Run Analysis Rodent Sleep Scoring 2
[Rat2] -> Analysing: Rodent Sleep Scoring 2 (ON: Rat2)
[Rat2] -> Running protocol 'Rodent Sleep Scoring 2' on analysis period 'Whole Recording'
[Rat2] -> No signal found for Input Source: Cortical EEG << WARNING
[Rat2] -> No signal found for Input Source: Theta EEG << WARNING
[Rat2] -> No signal found for Input Source: Neck EMG << WARNING
[Rat2] -> Input Activity = Activity (Activity)
[Rat2] -> Fail! Initializing detector 'Rodent Scoring 2 (v. 1.0.0)' << WARNING
[Rat2] -> Protocol 'Rodent Sleep Scoring 2' finished
[Rat2] -> 0s
[Rat2] -> Done Running Analysis: Rodent Sleep Scoring 2
[Rat2] -> Starting task: Save scoring as
[Rat3] -> Analysing: Rodent Sleep Scoring 2 (ON: Rat3)
[Rat3] -> Running protocol 'Rodent Sleep Scoring 2' on analysis period 'Whole Recording'
```

## Creating a Workflow

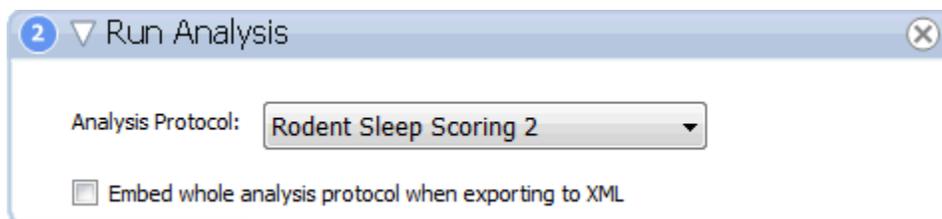
To create a workflow to run on a group of subjects:

1. Select the **Batch Processing** menu.
2. Select **Workflows > New Workflow**
3. A new workflow tab will be created.
4. Enter a **Workflow Name** within the *Workflow Info* dialog box.
5. **Double-click** on one of the *Workflow Actions* to add to the report.
6. Select **Save and Close** to save the report as a template that can be used for future reports.
7. Select the **Batch Processing > Open Batch Processing** to open the Batch Runner tab.
8. Click **Choose Recordings** to select subjects for the workflow.
9. Select desired workflow from the drop down tab. The workflow chosen will be displayed as a flow chart.
10. Select **Run Workflow** to execute.

The following are Parts that can be added to a Workflow:

### Analysis

- Run Analysis



A default or custom analysis protocol can be selected.

Embed whole analysis protocol: The protocol can be displayed in the XML sheet when export to XML is performed.

### Export

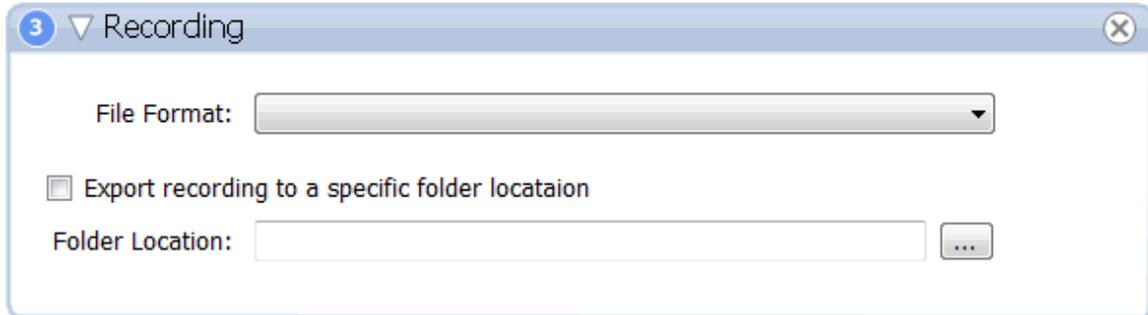
- Reports



A predefined or custom report can be selected to export. The user can select from the list of available formats.

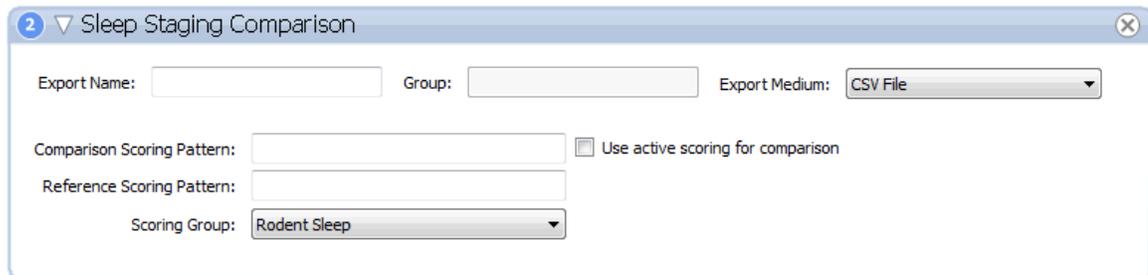
The report can be saved to the recording folder if desired.

- Recording



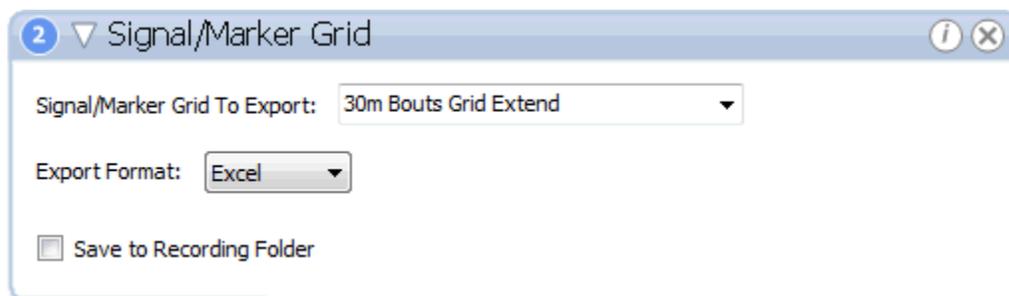
The recording can be exported in one of Neuroscore's available export formats. If desired, a specific location for the export can be specified.

- Sleep Staging Comparison



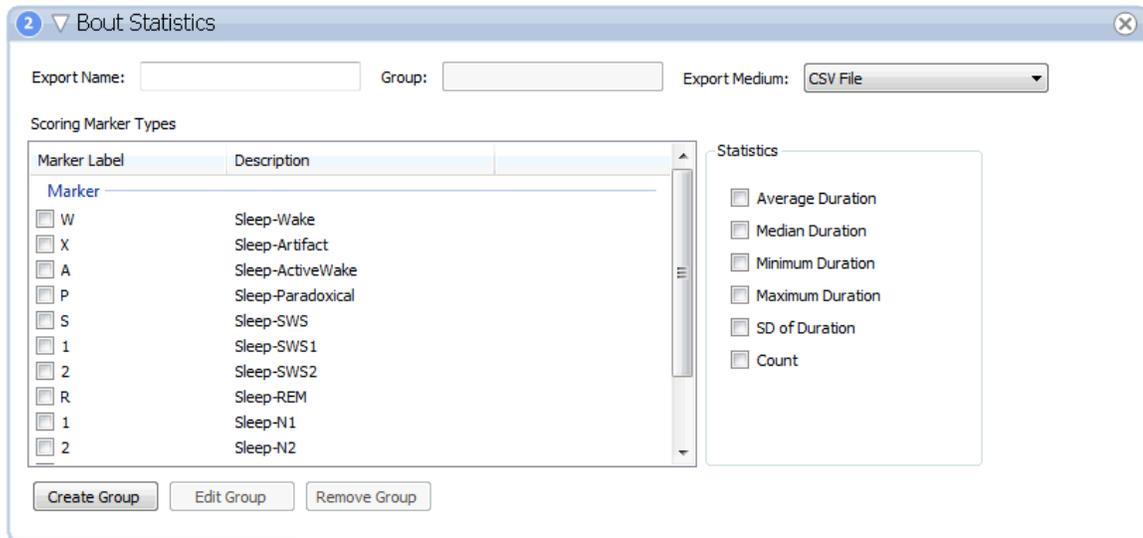
If desired a comparison can be added to a report containing the results of two sleep scorings.

- Signal/Marker Grid



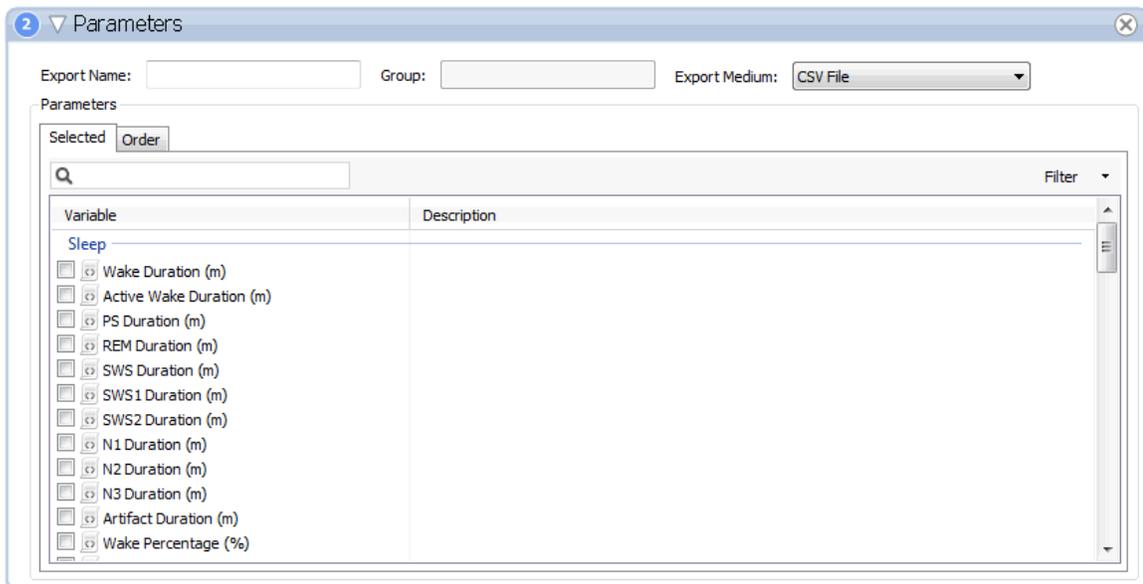
A signal or marker grid can be exported as an excel, text, or csv file.

- Bout Statistics



A custom bout statistics file can be exported. Marker types of interest and available statistics can be added to the export file. The file can be either csv, excel, access database or SQLite database.

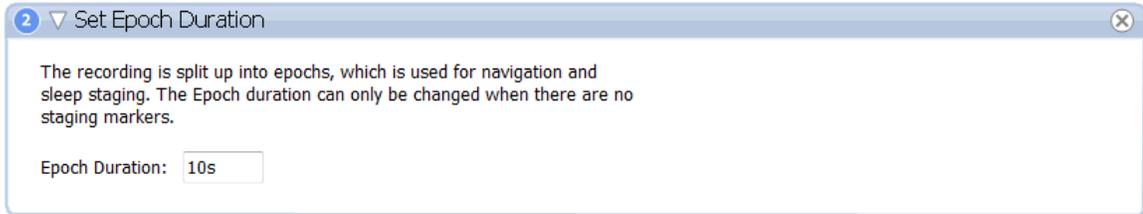
- Parameters



Parameters for a particular subject can be exported as csv, excel, access database or SQLite database.

## General

- Set Epoch Duration



Default epoch duration is 10 seconds but can be modified.

### Periods

- Select Day Period



A particular day can be selected as an active period.

- Select Relative Period



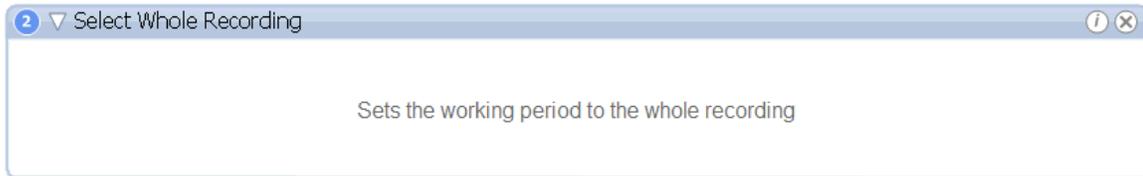
A specific relative period can be selected as the active period.

- Select Period



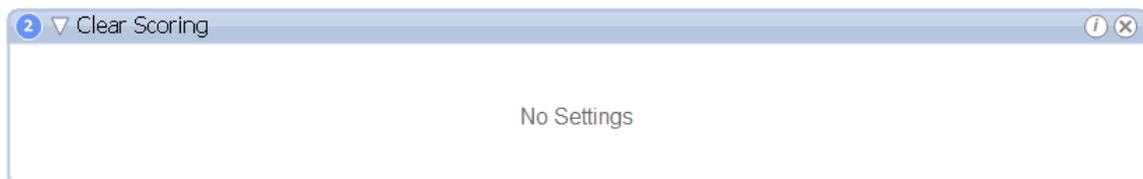
A specific time of day can be selected as a start time and run for a user defined duration.

- Select Whole Recording



## Scoring

- Clear Scoring



Clear scoring can be used if the workflow has multiple analysis runs configured or if any recording had previously been opened, scored, and had an active scoring selected when the recording/workspace was closed.

- Save Scoring



The scoring will be saved with the name entered here. When the recording is opened, the saved scoring will be listed in the Scoring Task window.

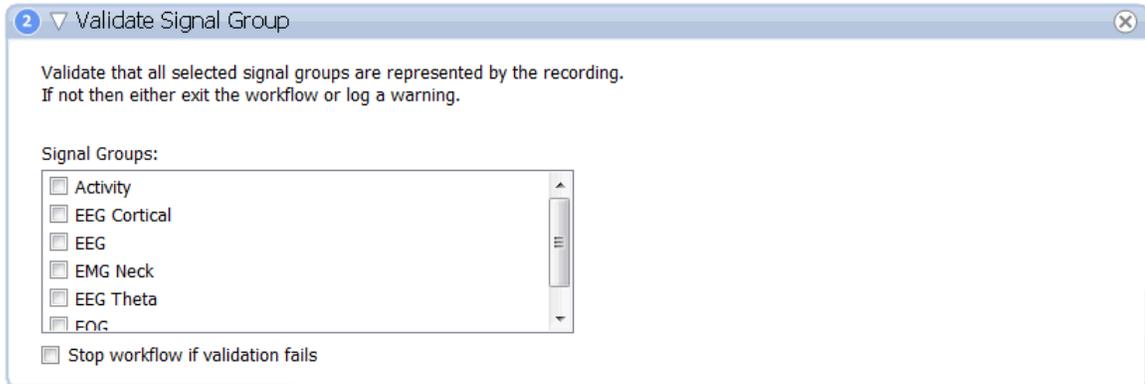
- Select Scoring



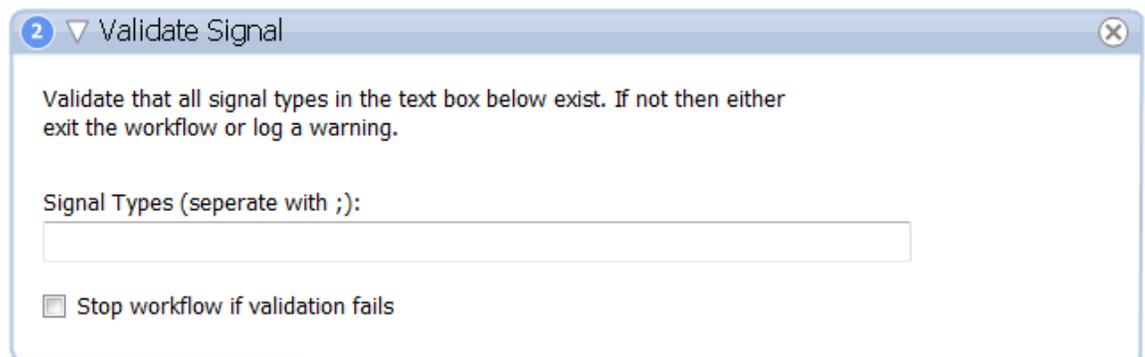
Select Scoring can be used to select the scoring just run during a workflow in order for that scoring to be selected and display immediately upon opening the recording within NeuroScore. It can also be used prior to export parameter, bout, grid, or report data.

## Validation

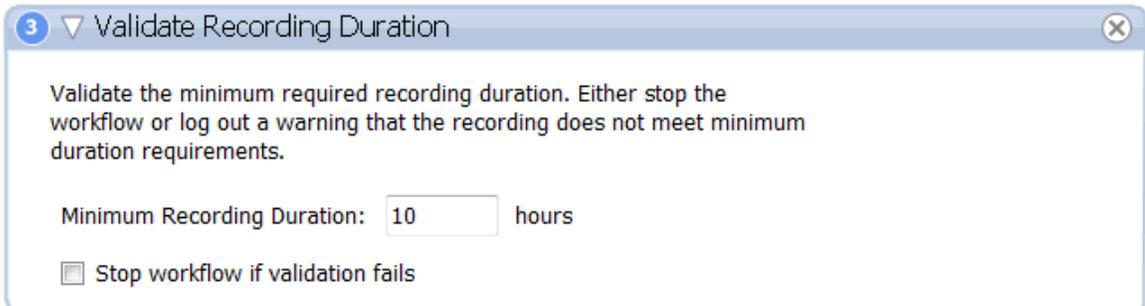
- Validate Signal Group



- Validate Signal

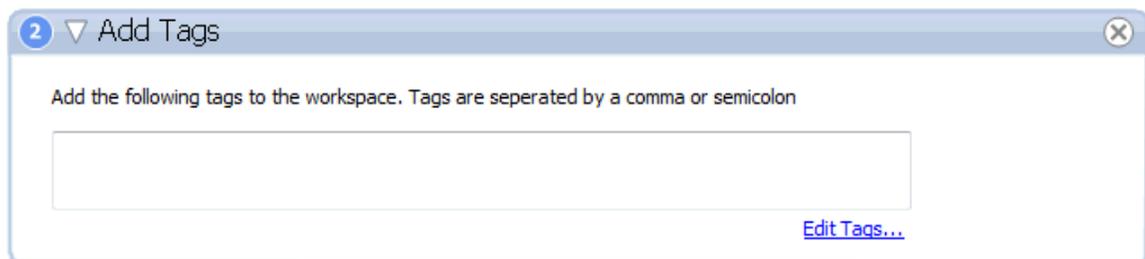


- Validate Recording Duration

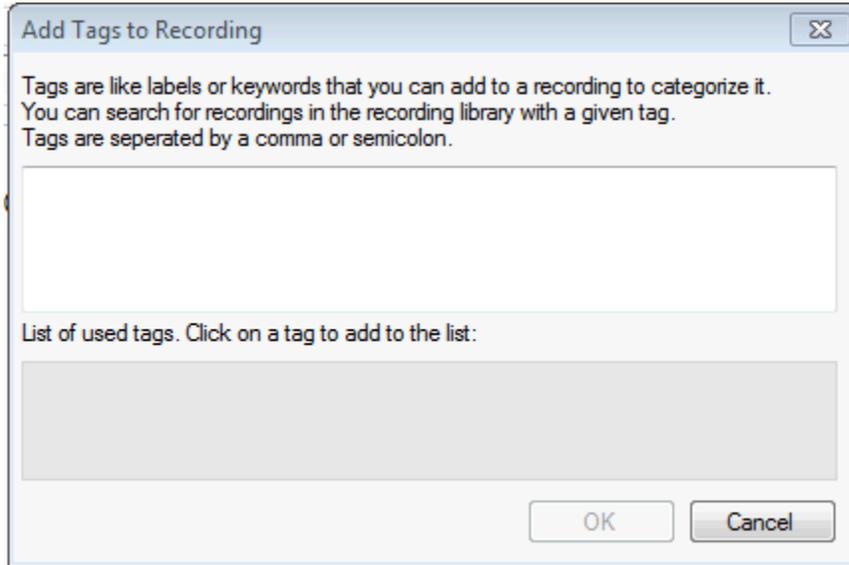


## Workspace

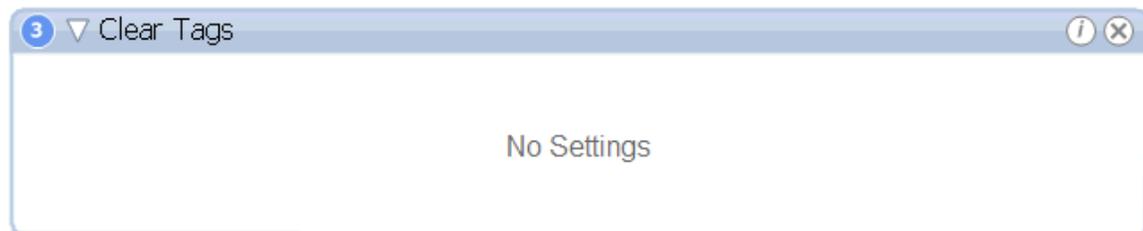
- Add Tags



Tags can be added to the workspace. Tags can be chosen in the edit Tags menu.

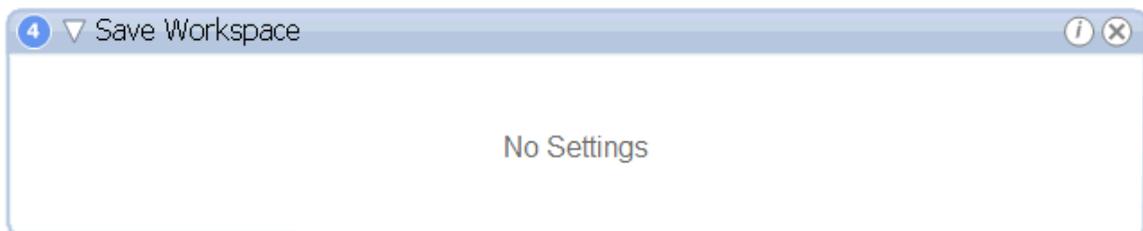


- Clear Tags



Clears all Tags

- Save Workspace



Saves the current workspace

## NeuroCMD

NeuroCMD is the Batch Processing executable that allows workflows to be executed on recordings from the Windows® command line without needing to enter the NeuroScore application. When the Batch Processing module is purchased, NeuroCMD will be included.

The core software is required to run NeuroCMD and will need to be installed on any PC or Server where NeuroCMD is used. Although this allows workflows to be executed on recordings outside of NeuroScore, it still uses functions from the core software. The core software and Batch Processing interface will be used to build workflows that can be exported as .xml files to be used within NeuroCMD.

### Running NeuroCMD

In order to execute batch processing workflows using NeuroCMD, the user will need to call the NeuroCMD.exe, point to the workflow .xml, point to the data path the recordings are stored in, enter the recording IDs, and, if desired, choose an output path (default output path is the My Workflow Runs folder within My Documents.)

*Example:*

```
C:\>> "Program Files\DSI\NeuroScore\NeuroCMD.exe /wfl "C:\UserFolder\workflow.xml"  
/datapath "C:\UserFolder\Recording Location" /ids "Rat1"; "Rat2"; "Rat3"
```

*Note: NeuroCMD supports the help function from the command line: e.g., "NeuroCMD.exe help wfl". This will provide information on how to execute a workflow with proper command line notation.*

# Automated Scoring Protocols

## Working with Protocols

Protocols provide the ability to analyze data using set criteria via automated scoring. Pre-configured protocols are included with the software when it is installed on an operating system. Protocols can also be created as desired and will assign markers into the recording based on the settings in the protocol. Protocol options can be found in the Analysis tab of the *Task Window*. To learn more about these options, select from the links below:



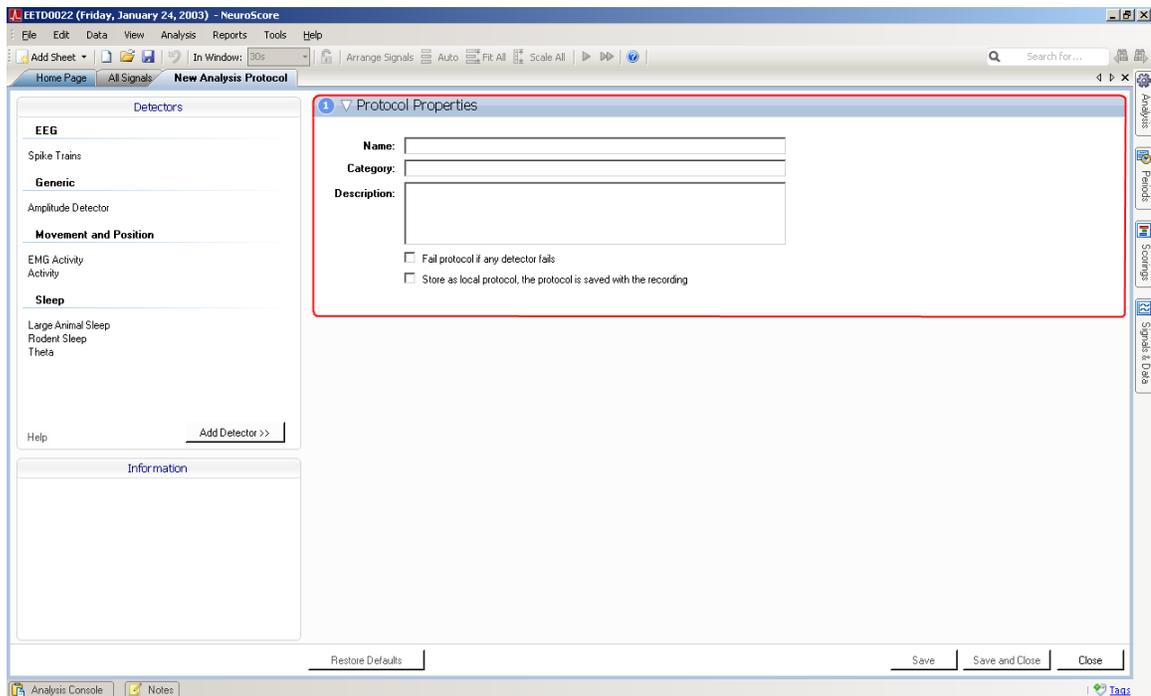
- Creating Analysis Protocols
- Editing and Removing Analysis Protocols
- Running Analysis Protocols
- Analysis Results, Scorings
- Analysis Console

*Note:* Protocols will only be able to be created and detectors will only be able to be worked with if an automated scoring package has been purchased.

## Creating New Analysis Protocols

To create a new protocol:

1. Click on the **Analysis** tab to expand the *Task Window*.
2. Click **Create New Protocol** under the *Actions* section to populate a New Analysis Protocol tab in the NeuroScore window.



3. Enter the name, keywords, and description of this new protocol. Before a protocol can be saved, a name must be entered for the protocol.
4. Click Add Detectors.
  - Detectors indicate how a signal is analyzed to determine when to mark it with the corresponding markers.
5. **Save** the protocol or **Save and Close** the protocol. If the **Cancel** button is hit before saving, none of the changes/settings made will be saved.

To create a new protocol based on an existing protocol, which is useful for making subtle adjustments to an existing protocol and re-saving it with a unique name:

1. Click on the **Analysis** tab to expand the *Task Window*.
2. Click on a Protocol that has already been created.
3. Select **Create New Based on Selected Protocol** under the *Actions* tab to populate a New Analysis Protocol tab in the NeuroScore window.
4. The settings that were used for the selected protocol will automatically be loaded in for this new protocol.
5. Enter a *Name* for this protocol.

6. Make the appropriate changes by Adding Detectors or change the settings of the current detectors.
7. Click the **Save** or **Save and Close** buttons. This will automatically make this protocol available for an analysis option to mark data.

*Note:*

- Detectors will only be listed if the corresponding NeuroScore module has been purchased. See the Detectors section for a list of available options.
- Protocols can be made up of multiple detectors.

## Editing and Removing Analysis Protocols

To edit a protocol:

1. Click on the **Analysis** tab to expand the *Task Window*.
2. Click on a Protocol that has already been created.
3. Select **Edit Selected Protocol**.
4. This will open a New Analysis Protocol tab in the NeuroScore Window.
5. Change settings and Add Detectors as desired.
6. Click **Save** or **Save and Close**.

To remove a protocol:

1. Click on the **Analysis** tab to expand the *Task Window*.
2. Click on a Protocol that has already been created.
3. Select **Remove Selected Protocol**.
4. A confirmation window will populate to confirm the deletion the selected protocol.



5. Click **Yes**.
6. Protocols can continue to delete following steps 1 through 5.

*Note:* Protocols will only be able to be created and detectors will only be able to be worked with if an automated scoring package has been purchased.

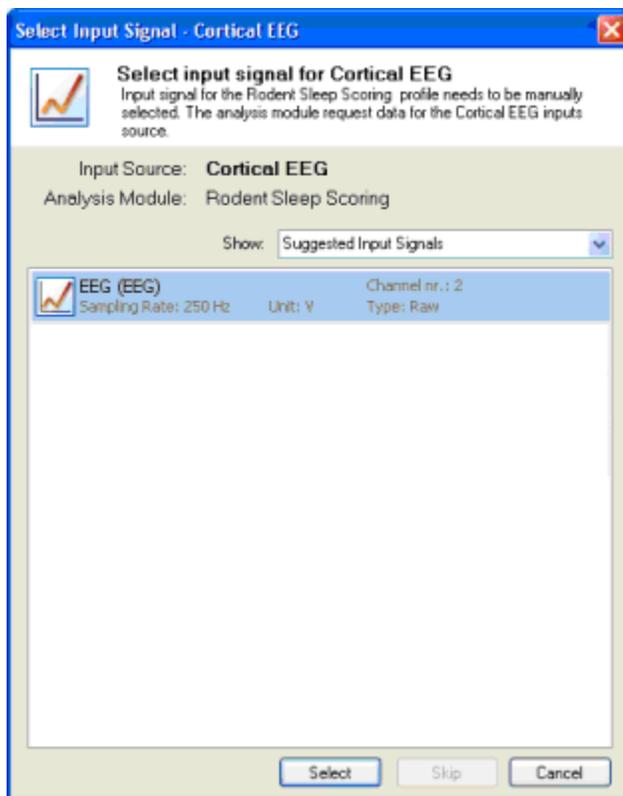
## Running Analysis Protocols

To run an analysis protocol:

1. Click on the **Analysis** tab to expand the *Task Window*.
  - **Protocols:** Lists all current, available protocols.
  - **Properties:** Lists the name, keywords and description of the protocol that is selected.
2. Select the protocol to run on the active recording.
3. Select **Run Selected Protocol** under the *Actions* section.

**OR**

1. Select the **Analysis** menu.
2. Select the protocol of interest to be run from the list.
3. A wizard will populate allowing the user to select the signal on which the protocol will run.



4. After all of the input signals are selected, the algorithm will execute on the active period of data.
5. The **Analysis Console** tab will become available at the bottom of the NeuroScore window and will display protocol completion data.

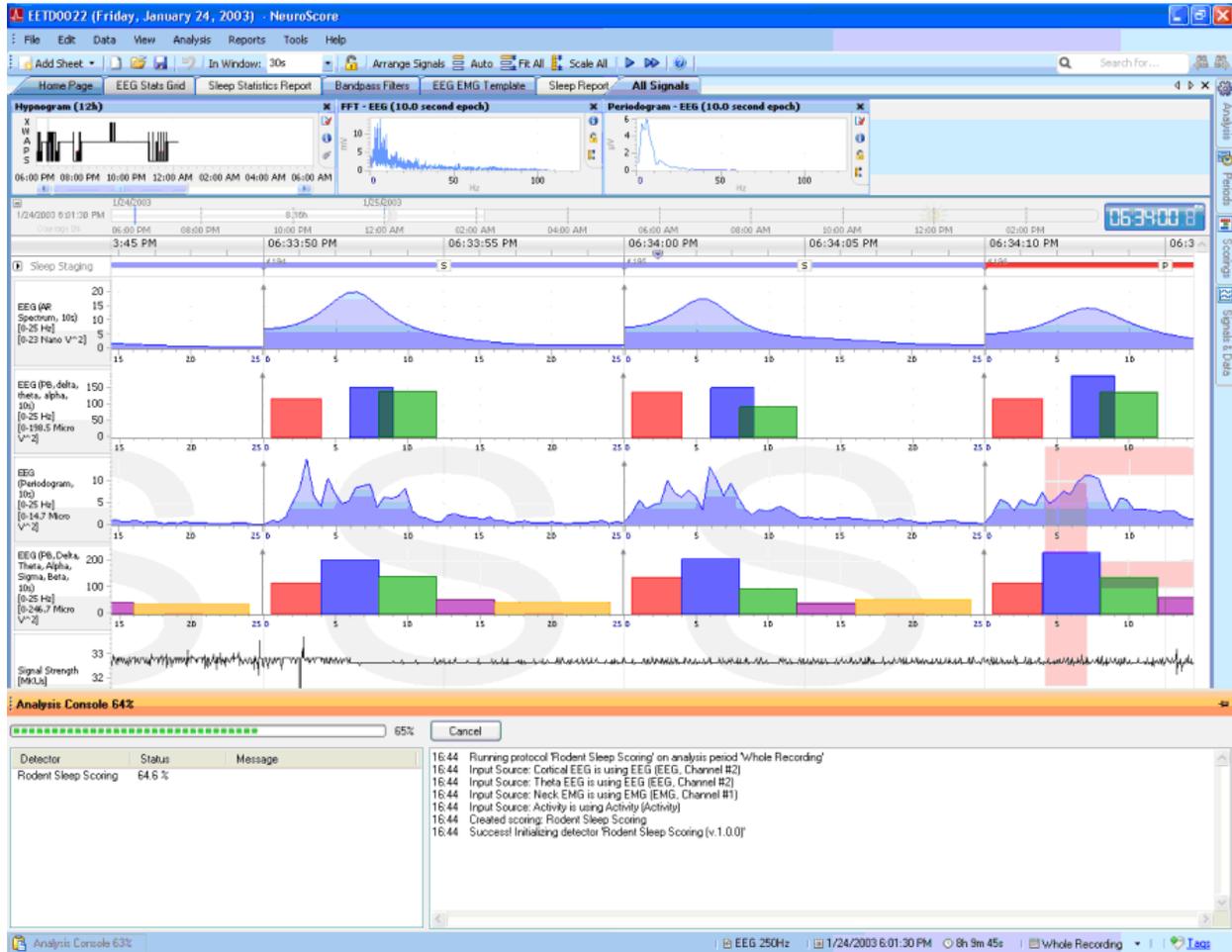
6. Once the protocol has finished running, the appropriate scoring markers will be displayed in the signal sheet.
7. To edit the Automated Scoring, please see Editing Scoring Results.
8. To save the scoring results, please see Loading and Saving a Scoring.

*Note:*

- To select a *Derived Signal* as an Input Signal, select **Available and Derived Signals** from the *Show* drop-down menu.
- Automated Scoring results can be saved, edited by the user and saved again.
- The protocol will be run on the currently selected Period.
- See Interpreting the Results of Protocols for regarding the markers.

## Analysis Console

This window is part of the Task Window and is located in a tab labeled *Analysis Console* near the bottom of the main *NeuroScore* window. When an analysis protocol is running this window will update appropriately. If there are any issues or errors when trying to run a protocol the information will be provided in this window.



## Interpreting the Results of Protocols

After running a protocol, the data from the active recording will have markers added to indicate what is occurring according to the settings in the protocol(s) ran.

Marker placement on the signal sheet is dependent on which signals are used for a detector. It is possible to have non-sleep markers that overlap; however, sleep scoring markers will not overlap. These markers will provide aid when analyzing the data. If it is desired to seek particular changes in the data, detectors can be adjusted to expose these changes. Markers will be placed on the signal during the intervals where the detector settings are found to be true. If markers are found marking data differently than intended, the detector settings may need to be adjusted (see [Editing and Removing Analysis Protocols](#)).

Reports can be generated to provide a summary of data previously analyzed with one of the sleep scoring protocols. See [Working with Reports](#) for further information. These reports can only be generated using the active sleep scoring data. All other markers will need to be analyzed with a manual interpretation.

*Note:* When using the non-sleep markers to mark data, the markers are only labeled when there is enough room to include the marker label text.

## Detectors

### Working with Detectors

Detectors are used by Protocols during Automated Scoring sessions in order to seek out specific events based upon user defined criterion. To add detectors to an Automated Scoring Protocol, please see the Adding Detectors sections.

The following is a list of all available detectors separated by the add-on modules in which they are included:

#### Core Software:

- **Amplitude:** Locates regions where the values of the chosen signal meet the criteria of the user-defined threshold. This can be used on a variety of signal types.
- **EMG Activity:** Locates areas where EMG signal values meet the user-defined criteria, marking areas of muscle contraction.

#### Rodent Sleep:

- **Activity:** Locates regions where Activity signal values exceed a user defined threshold, marking areas of subject movement.
- **Theta:** Locates areas of low frequency component (centered around 4-8 Hz) in the EEG signal measured from the hippocampus.
- **Rodent Sleep Scoring:** Assigns a vigilance stage to each epoch based on EEG, EMG, and activity data. Stages include Paradoxical Sleep, Slow Wave Sleep (with option to distinguish between SWS-1 and SWS-2), Wake, and Active Wake.
- **Rodent Sleep Scoring 2:** Assigns a vigilance stage to each epoch based on EEG, EMG, and activity data. Stages include Paradoxical Sleep, Slow Wave Sleep (with option to distinguish between SWS-1 and SWS-2), Wake, and Active Wake. Rodent Sleep Scoring 2 contains more detailed features than Rodent Sleep Scoring.

#### Large Animal Sleep Scoring:

- **Large Animal Sleep Scoring:** Assigns a vigilance stage to each epoch based on EEG, EMG, EOG, and activity data. Stages include active wake (A), wake (W), non-REM (N1, N2, N3), REM (R), and artifact (X).

#### Seizure:

- **Spike Trains:** Scans the EEG signal for repeating spike activity using amplitude-based criteria for seizure detection.

*Note:* Video Synchronization is also an add-on module. Video cannot be analyzed directly by NeuroScore, nor is it considered by the Detectors in NeuroScore's Automated Scoring Protocols; it is meant strictly for observatory purposes.

## Add Detectors

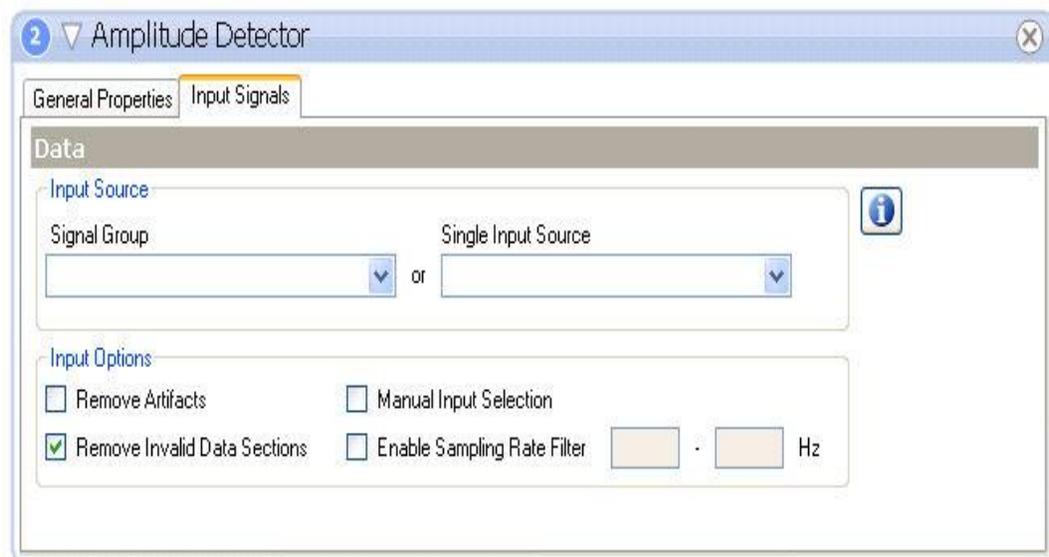
Detectors indicate how a signal is analyzed to determine when to mark it with the corresponding markers

To add detectors:

1. Select a detector from the *Detectors* list on the left hand side of the *New Analysis Protocol* sheet.
2. Click **Add Detector >>**
3. This will bring the detector settings to the right half of the window.
4. There will be two tabs:
  - General Properties

To access the explanations for the *General Properties* in a detector follow the links below:

- Amplitude Detector
  - EMG Activity Detector
  - Activity Detector
  - Theta Detector
  - Rodent Sleep Detector
  - Large Animal Sleep Detector
  - Spike Train Detector
- 
- Input Signals



**Input Source:**

For each detector, a signal type needs to be specified to determine how the data will be marked. The only signal types available for this will be the signals that were loaded with the current recording.

- **Signal Group:** This will determine which signal is used for this marker according to the settings of the signal group that is selected. The order in which the signals are listed in the group will determine which signal gets selected. The software goes through the list sequentially and the first signal it finds is used.
- **Single Input Source:** Using this setting will result in one particular signal always being used regardless of what type of data is available.

Clicking on the "i" in the upper, right hand corner (with a square shape) of the input signal box will bring you to the *Signal Types and Groups* window.

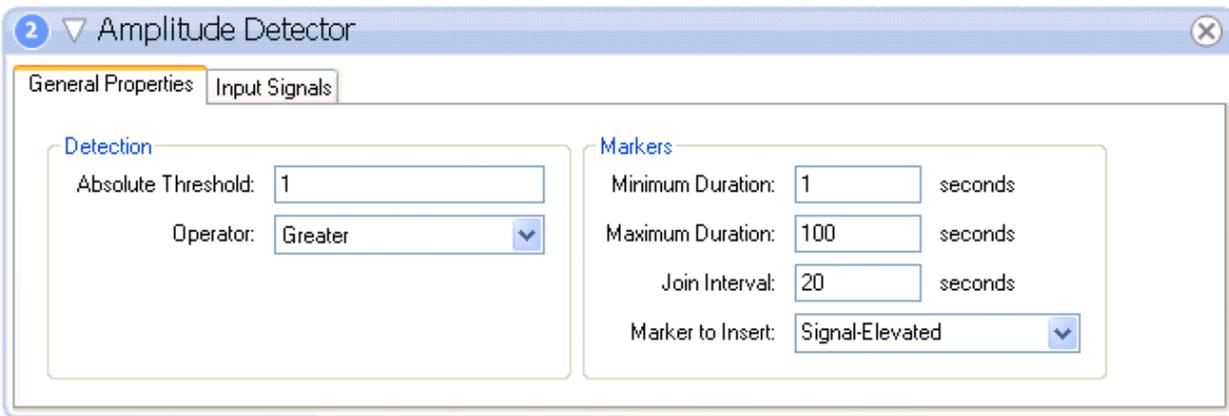
#### **Input Options:**

1. **Remove Artifacts:**
  - *Checked:* All areas where *Artifact Markers* have been placed on the signal are removed from being analyzed in the protocol.
  - *Unchecked:* All data points will be used in the protocol analysis.
2. **Remove Invalid Data Sections:**
  - *Checked:* All areas that have been defined as invalid by the *Invalid Signal Marker* are removed from being analyzed in the protocol analysis. The *Invalid Signal Marker* also works globally and is applied to all signals.
  - *Unchecked:* All data points will be used in the protocol analysis.
3. **Enable Sampling Rate Filter:**
  - *Checked:* The protocol will select a signal, within the signal group (see above), containing a sampling rate within the range of the sampling rate filter.
  - *Unchecked:* The protocol will select the first signal contained within the signal group, despite the sampling rate.
4. **Manual Input Selection:**
  - *Checked:* A prompt will open asking for input signals to be selected for the protocol to be run on. Enabling this is recommended when performing spike train detection.
  - *Unchecked:* The protocol will run based on the input source, discussed above.
5. Complete the settings within the tabs.
6. Follow steps 1 through 5 to add another detector.

*Note:* Protocols will only be able to be created and detectors will only be able to be worked with if an automated scoring package has been purchased.

## Amplitude Detector

The *Amplitude Detector* can be applied to any signal type. It is used to locate regions where the values of the chosen signal meet the criteria of the user-defined threshold. See the properties for the amplitude detector below. The threshold setting assumes the units of the signal in which the detector is applied. To determine a signal's units, select the **Signals & Data** tab and select the signal. For example, an EEG signal will typically have units in Volts (not uV or mV) and a threshold would need to be scaled accordingly.



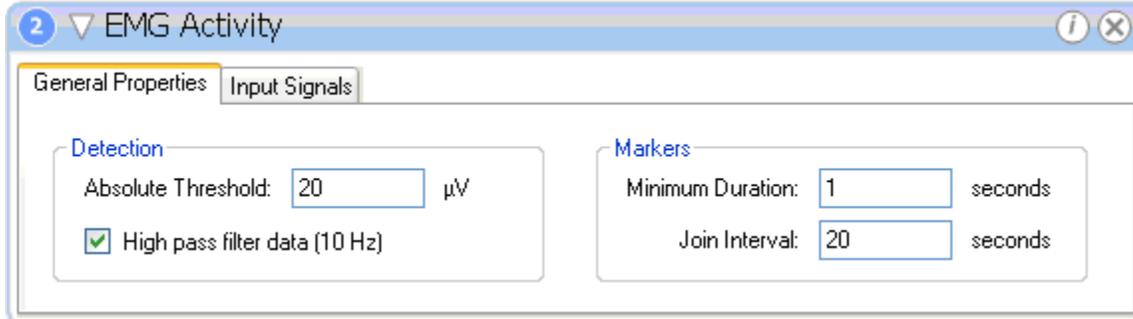
Property	Description
Absolute Threshold	The threshold defines the boundary between the signal being marked and not marked. If the signal value meets the threshold and operator criteria, it is considered a region of interest and is marked. The units used are relative to those the signal was recorded in, not what is on the y-axis label of the signal being analyzed.
Operator	Defines how the detector operates on the signal, choosing whether the detector marks the signal based on the signal values being Greater, Greater or Equal, Less, or Less or Equal to the Absolute Threshold value entered.
Minimum Duration	This property defines the minimum duration of the amplitude criteria, meaning the signal level must meet the absolute threshold and operator criteria for a minimum period of time to be considered. It can be from one second to any duration, although making this value extremely long will cause almost no markers to be scored.
Maximum Duration	This property defines the maximum duration of the marker. It can be from one second to any duration, although making this value extremely short will cause almost no markers to be scored.
Join Interval	This value defines the minimum interval between two periods of marked interest. If the interval is less than this value, the two markers will be joined into one.

Marker to Insert	Choose the appropriate marker to use for this protocol. <i>Signal-elevated</i> is the default meaning a horizontal bar will be placed above the region meeting the criteria. If none of the markers from the drop down menu seem appropriate, add a new marker that would be more applicable.
------------------	---

For information on the *Input Sources* and *Input Options*, please see *Input Signals* in the Adding Detectors section of this manual.

## EMG Activity Detector

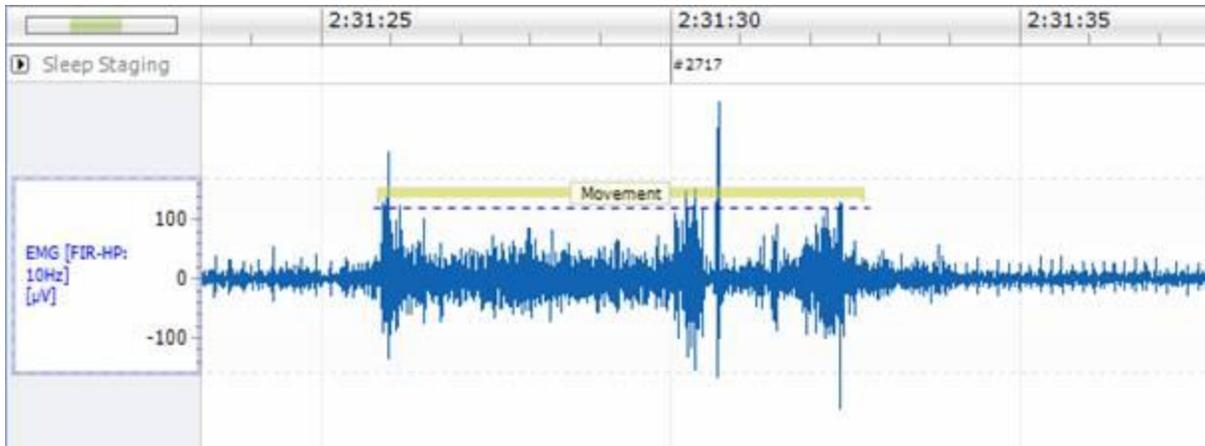
The EMG Activity detector locates areas of high activity in the EMG. The EMG algorithm is the same as in the Rodent Sleep Scoring module and to tune it see [Configuring the EMG Threshold](#).



Property	Description
Absolute Threshold	The threshold defines the boundary between movement and no movement based on the RMS amplitude of the EMG signal. If more than 20% of samples in every 1 second interval is above this threshold, it is considered a movement.
High pass filter data (10Hz)	Enable this option to help remove baseline wander from the signal and improve detection accuracy.
Minimum Duration	This property defines the minimum duration that the signal must meet the criteria to be marked. It can be from one second to any duration, although making this value extremely long will cause almost no markers to be scored.
Join Interval	This value defines the minimum interval between two periods of high activity. If the interval is less than this value, the two markers will be joined into one.

*Note:* Because the criteria are based on the RMS value of the EMG, it may be necessary to set the absolute threshold lower than anticipated to detect events. For information on the *Input Sources* and *Input Options*, please see *Input Signals* in the [Adding Detectors](#) section of this manual.

The algorithm inserts *Movement Markers* into the EMG where there is high activity, see image below.



## Rodent Sleep

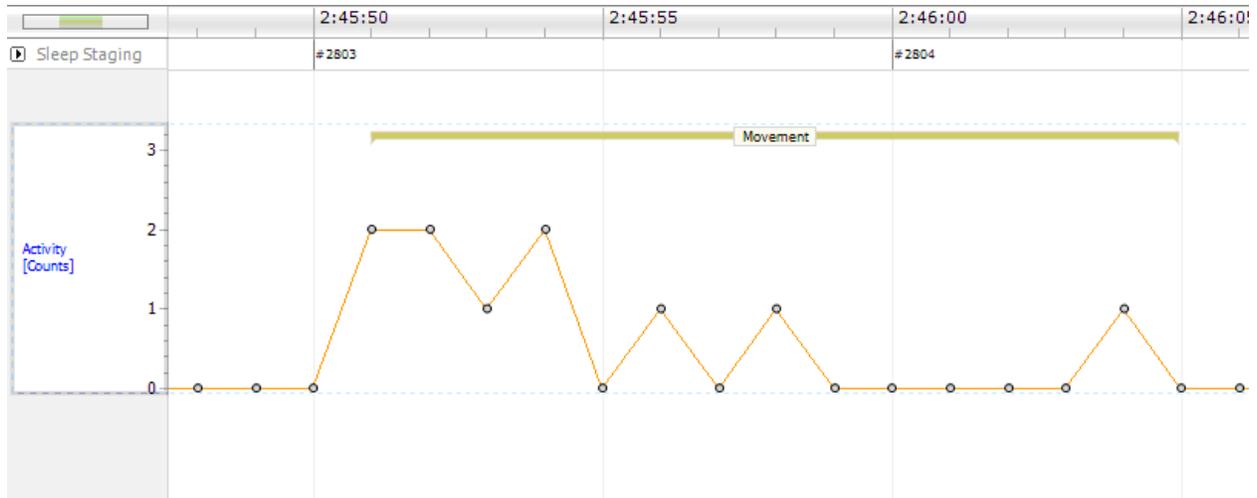
### Activity Detector

The Activity detector module locates areas of high activity in the activity signal. The activity is located when the values on the activity signal become greater than the user defined threshold. See the properties for the activity analysis module below.



Property	Description
Absolute Threshold	The threshold defines the boundary between activity and no activity. If the activity value is greater or equal to the threshold, it is considered a period of increased activity.
Minimum Duration	This property defines the minimum duration of the movement marker. It can be from one second to any duration, although making this value extremely long will cause almost no markers to be scored.
Join Interval	This value defines the minimum interval between two periods of high activity. If the interval is less than this value, the two markers will be joined into one.

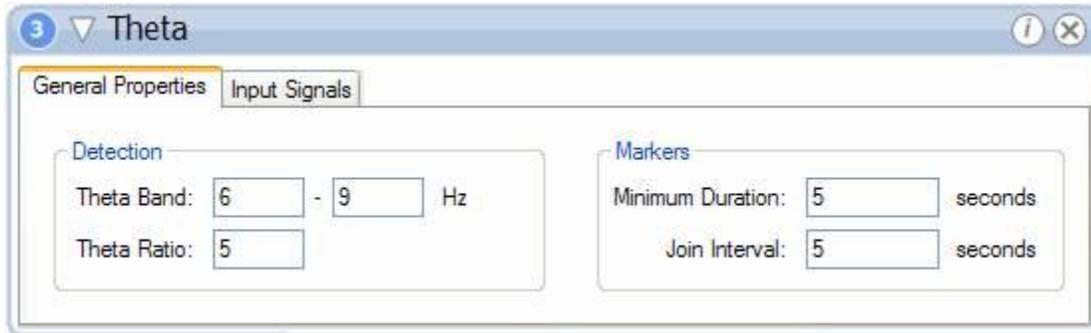
The algorithm inserts *Movement Markers* into the Activity signal where there is high activity, see image below.



Note: For more information on the *Input Sources* and *Input Options*, please see *Input Signals* in the Adding Detectors section of this manual.

## Theta Detector

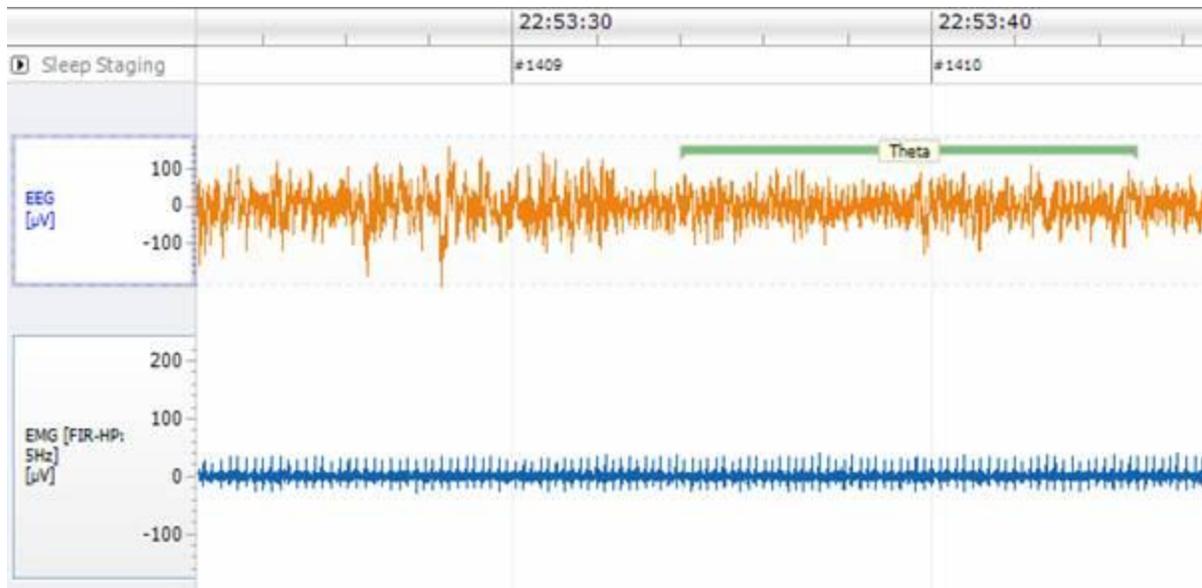
The Theta analysis module locates high levels of theta activity in an EEG signal. Theta activity is a low frequency component in the EEG measured from the hippocampus and has its main frequency component centered around 4-8 Hz. This module utilizes the same algorithms used by the Rodent Sleep Scoring module and is configured in a similar manner. See [Configuring the Theta Power Band](#) and [Configuring the Theta Ratio](#) for more detailed information on how to configure the analysis properties.



*Note:* The default settings for the Theta Detector are 6-9 Hz; however, the standard definition is 4-8 Hz.

Property	Description
Theta Band	This is the frequency range used to determine the theta power band. The standard definition is from 4-8 Hz but a tighter range is used for the default theta range. A tighter range provides better results than a greater spread. Although, care must be taken that theta activity is different between species, strains and age of the subject. If range is too tight it can completely miss the theta activity altogether.
Theta Ratio	This parameter evaluates the power in the theta band divided by the power in the delta band (0.5-4 Hz). This criterion is used to mark regions where the theta component is dominant within the EEG signal. It may need to be adjusted depending on the subject and data set.
Minimum Duration	This property defines the minimum duration that the theta ratio criteria is met in order to be marked. It can be from one second to any duration.
Join Interval	This value defines the minimum interval between two theta periods. If the interval is less than this value the two markers will be joined into one.

The properties used for the Theta analysis module are the same as the ones used in the Rodent Sleep Scoring module. The algorithm inserts markers on the areas of high theta activity, see image below.



*Note:* For more information on the *Input Sources* and *Input Options*, please see *Input Signals* in the Adding Detectors section of this manual.

## Rodent Sleep Detector

### Rodent Sleep Scoring Detector

The *Rodent Sleep Scoring* detector uses one or two EEG signals along with EMG and activity data to automatically assign a vigilance stage to each epoch. The epoch duration can range from 2s to 300s. This module scores sleep/wake in the rodent into 4 different stages: *active wake (A)*, *quiet wake (W)*, *slow wave sleep (SWS)* and *paradoxical sleep (P)*. Each of these stages has different properties derived from the signals needed to score the rodent sleep reliably. The primary signal used for scoring rodent sleep is the cortical EEG. Additional signals used are the neck EMG, theta EEG (located directly over the hippocampus) and Activity.

*Note:* Slow wave sleep (SWS) can be discriminated into slow wave sleep 1 (SWS1) and slow wave sleep 2 (SWS2). This feature can be turned ON and OFF in the protocol settings.

The table below shows the relationship between a recorded signal and the properties used to determine different sleep states in the rodent.

Signal type and location	Parameter	Description
EEG-Cortical	Delta Power	The delta power band ranging between 0.5-4Hz, is the most dominant factor in sleep, and is mostly present during slow wave (deep) sleep. The delta power is a useful variable in determining the difference between sleep on one hand and wakefulness and paradoxical sleep on the other.
EEG-Theta	Theta Power	The theta power band ranging between 4-8 Hz depending on the species, is present in wake, but is also a required aspect for paradoxical sleep. Theta power is very low during sleep, other than paradoxical sleep.
EMG	Muscle tone	EMG measures the electrical activity in the muscle. The most common placement for rodents is on the back of the neck. EMG levels are high when the subject is awake and moving (performing actions requiring the use of related muscle). EMG is useful for determining the difference between active wake vs. quiet wake and wake vs. paradoxical sleep.
Activity	Movement	Activity is an indication of subject movement based on the transmitter and is used to determine active wake.

The table below displays how relationships between sleep/wake stages and the measured parameters given in the table above.

Sleep Stage	Delta Power	Theta Power	Muscle Tone	Movement
Active Wake	low	low	high	low-high
Quiet Wake	low-mid	low-high	low-mid	low
Slow Wave Sleep	mid-high	low-mid	low-mid	low
Paradoxical Sleep	low	high	low	low

In addition to the 4 sleep stages, the scoring module scores an epoch as an artifact if there are missing samples of a segment or if a movement artifact distorts the signals all together.

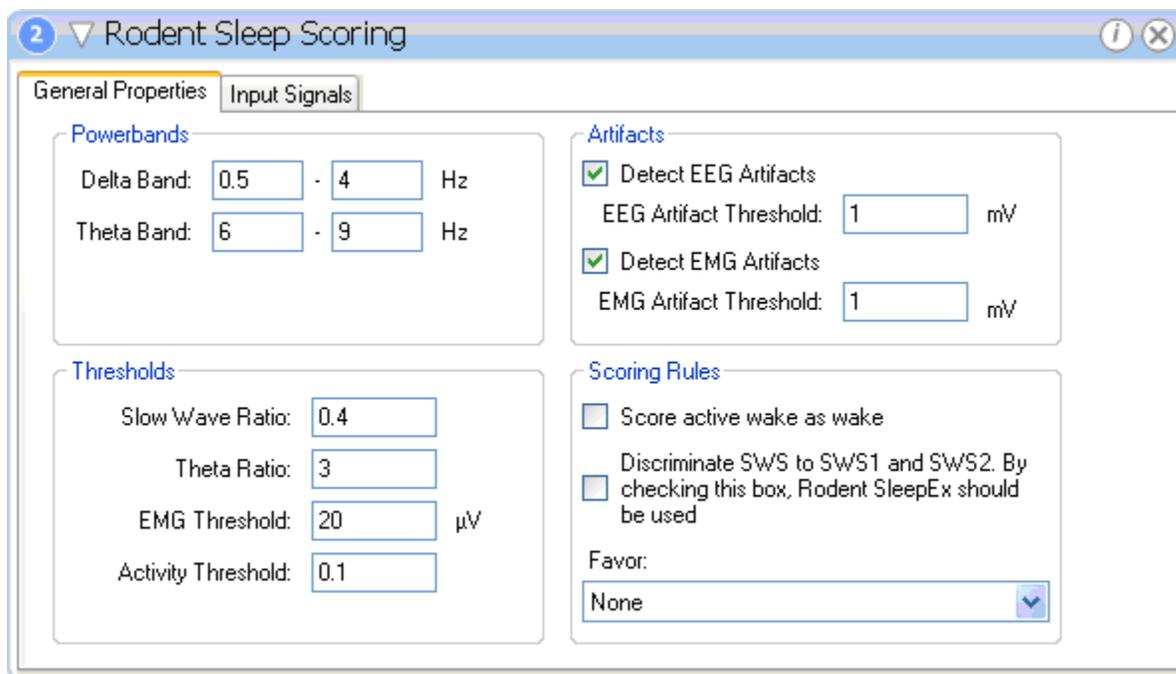
For more specific definitions of the sleep stages and the method NeuroScore uses to score rodent sleep, please see the NeuroScore's Rodent Sleep Scoring Algorithm.

*Note:* Additional sleep stages not included in the automated protocol can be manually added and assigned if desired

## Rodent Sleep Detector Analysis Settings

To score rodent sleep, use one of the default analysis protocols shipped with the NeuroScore application or create one. To create an analysis protocol, view [Creating New Analysis Protocols](#).

After the *Rodent Sleep* detector has been added to the protocol, the *General Properties* associated with the rodent sleep scoring module should be displayed. Please note that the default settings may not be appropriate for the subject being analyzed and should be adjusted if needed.

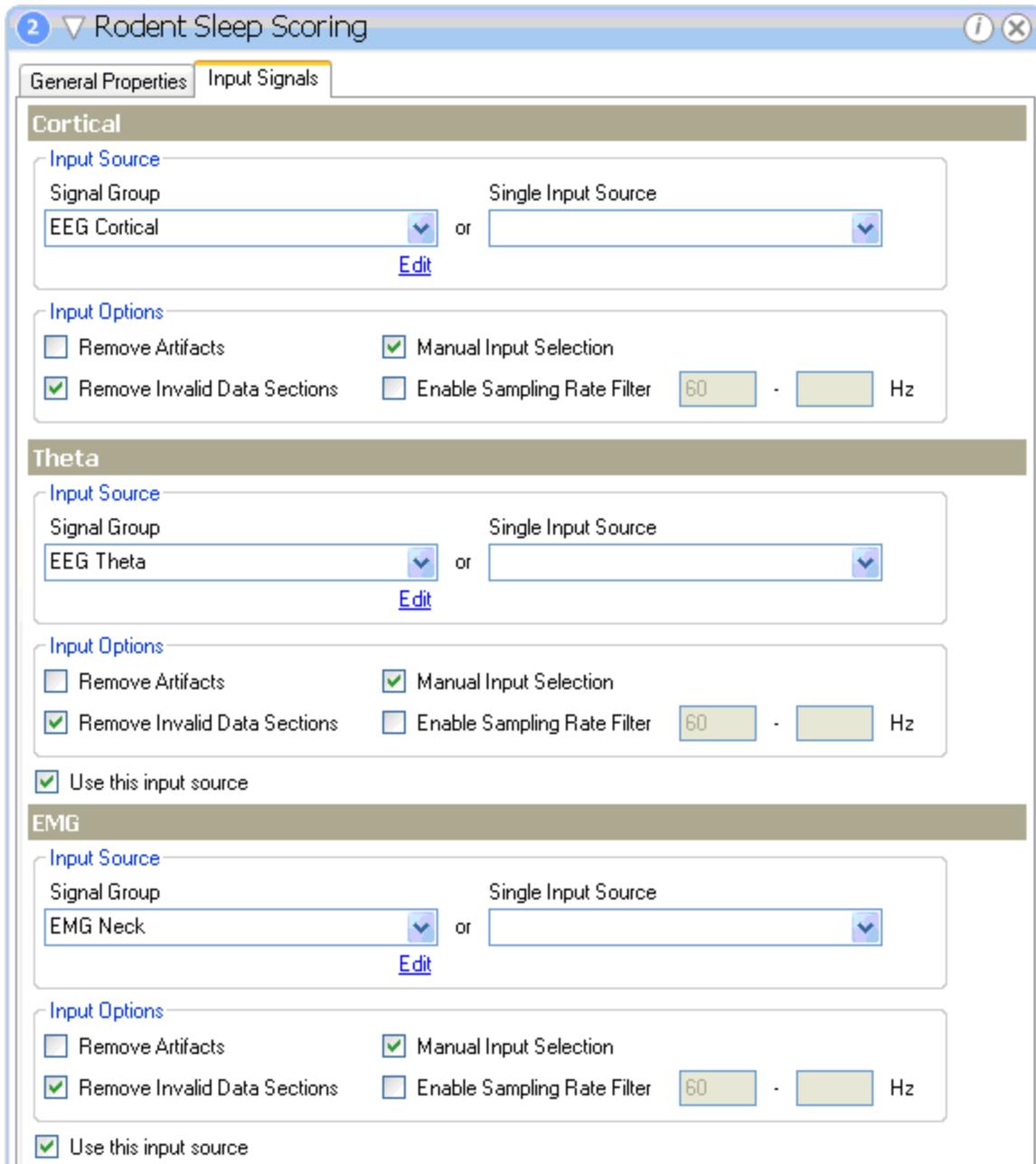


The table below lists the adaptable properties available in the *Rodent Sleep Scoring* module and a description of each parameter.

Parameter	Description
Delta Band	Frequency range used to define delta power. The standard definition is 0.5-4 Hz, but for smaller rodents the definition could be changed to 1-4 Hz.
Theta Band	Frequency range used to define theta power. The standard definition is from 4-8 Hz, but a tighter range is used for the default theta range. A tighter range provides better results than a greater spread. Although theta activity is different between species, strains and age of the subject, too tight of a range can completely miss the theta activity altogether.
Detect EEG Artifact	If checked, an algorithm will test if the EEG scoring epoch contains artifact and will score that epoch as such.
EEG Artifact Threshold	The value used to determine if the values in a scoring epoch are artifact or not. The criteria for an artifact state that if the absolute value of the samples in the epoch exceeds this threshold for at least 10% of the samples, the epoch is an artifact.

Detect EMG Artifact	If checked, an algorithm will test if the EMG scoring epoch contains artifact and will score that epoch as such.
EMG Artifact Threshold	The value used to determine if the values in a scoring epoch are artifact or not. The criteria for an artifact state that if the absolute value of the samples in the epoch exceeds this threshold for at least 10% of the samples, the epoch is an artifact.
Slow Wave Ratio	This parameter determines the level of delta power versus the total power in the epoch to discriminate between slow wave/deep sleep and wake/paradoxical sleep. A dominant delta component is present during slow wave sleep. Note: the total power range is 0.5-25.0 Hz.
Theta Ratio	This parameter determines the level of theta power versus delta power to discriminate between paradoxical sleep and slow wave sleep. Paradoxical sleep has a dominant theta component.
EMG Threshold	The EMG threshold determines the threshold between activity and no activity for the subject. If the root mean squared value of the EMG in the epoch exceeds this threshold for more than 20% of the samples the algorithm will consider the epoch as active wake.
Activity Threshold	The Activity threshold defines the boundary between activity and no activity. If the activity value is greater or equal to the threshold, it is considered a period of activity.
Score Active Wake as Wake	If checked, all active wake stages are scored as quiet wake stages.
Discriminate SWS to SWS1 and SWS2	If checked, Slow Wave Sleep (SWS) will be further classified into Slow Wave Sleep 1 (SWS1) and 2 (SWS2). When check, use the Extended version of reporting options.
Favor	When discriminating between SWS1 and SWS2, the Favor drop-down can be used to shift the SWS1 and SWS2 discrimination ratio threshold (Slow Wave Threshold) either up 20% while favoring SWS1 or down 20% while favoring SWS2.

The *Input Signals* tab will provide the ability to specify which signals to be used during the Rodent Sleep Scoring to determine how the data will be marked. The only signal types available for input will be the signals that were loaded with the current recording. If more than one channel of each data type were collected, it is recommended the **Manual Input Selection** is checked so the user is prompted to choose which channel corresponds to which signal input.



**Activity**

**Input Source**

Signal Group: Activity ▼ or Single Input Source:  ▼

[Edit](#)

**Input Options**

Remove Artifacts       Manual Input Selection  
 Remove Invalid Data Sections       Enable Sampling Rate Filter  -  Hz

Use this input source

For more information on the *Cortical*, *Theta*, *EMG*, and *Activity* signals and how they relate to Rodent Sleep Scoring, please see the Rodent Sleep Scoring Detector section of this manual.

For more information on the *Input Source* and *Input Options*, please see *Input Signals* in the Adding Detectors section of this manual.

## Configuring the Rodent Sleep Detector

In many instances the *Rodent Sleep* detector needs some fine tuning. These instances might occur when

- Different species are used
- Different strains of the same species are used
- A difference has occurred in the signal scaling or magnification
- A characteristic change of the signals due to high impedance or bad placement of electrodes.

There are 4 primary parameters that can be changed to increase the scoring module's accuracy. These include the *Theta Power Band*, the *Delta (Slow Wave) Ratio*, the *Theta Ratio*, and the *EMG Threshold*. Going through the following configurations will help to tune the Rodent Sleep Scoring module for reliable scoring.

### Configuring the Theta Power Band

The theta power band can be different between species and strains within the same species. The theta band is most effective if it covers only the theta elevation occurring during the paradoxical sleep. Theta activity in rodents ranges from 4 to 8 Hz, but is usually placed between 6 to 8 Hz. To determine the spread of the theta band, use either the *FFT* or *Periodogram Derived Graphs*.

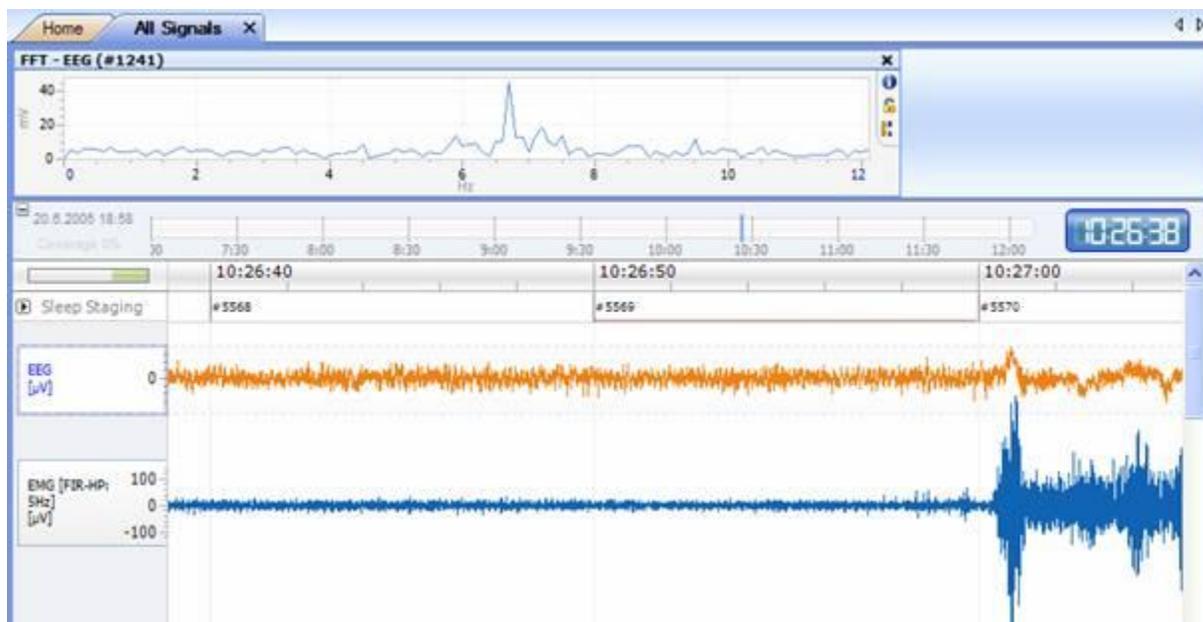


Figure 1 FFT of a paradoxical sleep epoch

In Figure 1, it can be seen that the main theta activity is centered around 6-8 Hz. By changing the theta power band to 6-8 Hz in this instance the sensitivity of the algorithm has been increased and will result in a more accurate detection of paradoxical sleep.

### Configuring Slow Wave Ratio

The Slow Wave Ratio is used to discriminate between slow wave sleep (deep sleep) and wake/paradoxical sleep, making it one of the most important parameter in the scoring module. The ratio is the amount of delta power to the total power in the epoch. For deep sleep, most of the signal's power content is normally located in the lower spectrum, between 0.5 and 4 Hz, which would result in a higher Slow Wave Ratio. The ratio describes how much of the signal's power is concentrated in the delta power band and determines the transition point, the amount of power that needs to be present in the delta region, for the stage to be classified as slow wave sleep.

The Slow Wave Ratio threshold can be determined by comparing the power bands for a wake or paradoxical sleep vs. a slow wave sleep. Determine the Slow Wave Ratio by dividing the red bar (delta band) value by the summated value of all bars (power bands). In other words, it is  $[\text{delta band (0.5-4Hz)}/\text{total power (0.5-25Hz)}]$ . To do this, see Calculating Power Ratios. Determine this ratio for a few epochs considered to depict wake or paradoxical sleep. Then, determine this ratio for a few epochs considered to depict slow wave sleep. By comparing these two sets of ratios, a reference range that separates the two sets should become apparent. Select the threshold from within this reference range. See the figures for further clarification.

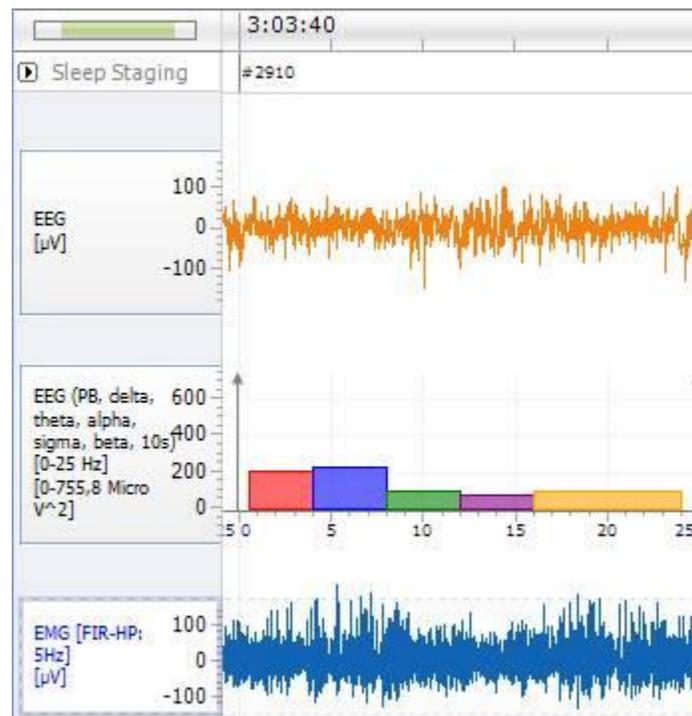


Figure 2 EEG, EMG, and the standard EEG power bands. Red bar is the delta power. This image depicts a wake state.

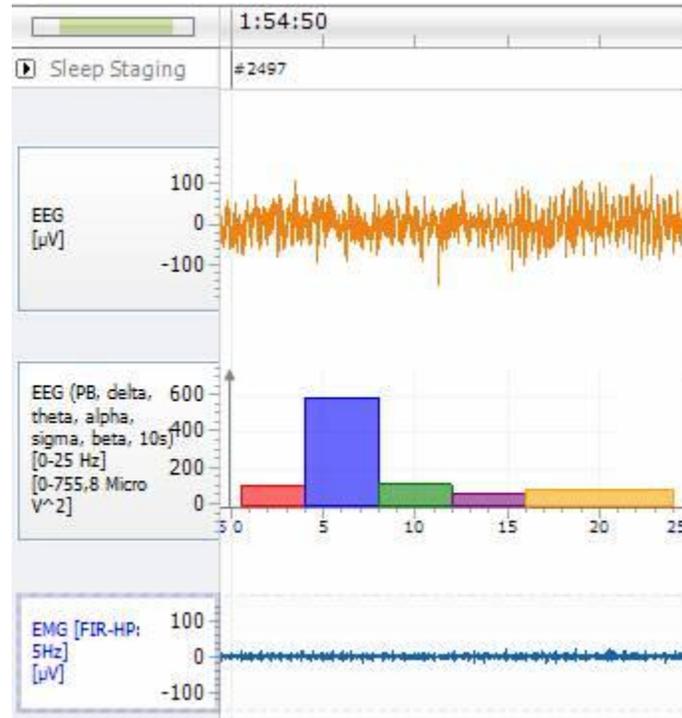


Figure 3 EEG, EMG, and the standard EEG power band. Red bar is the delta power. This image depicts a paradoxical state.

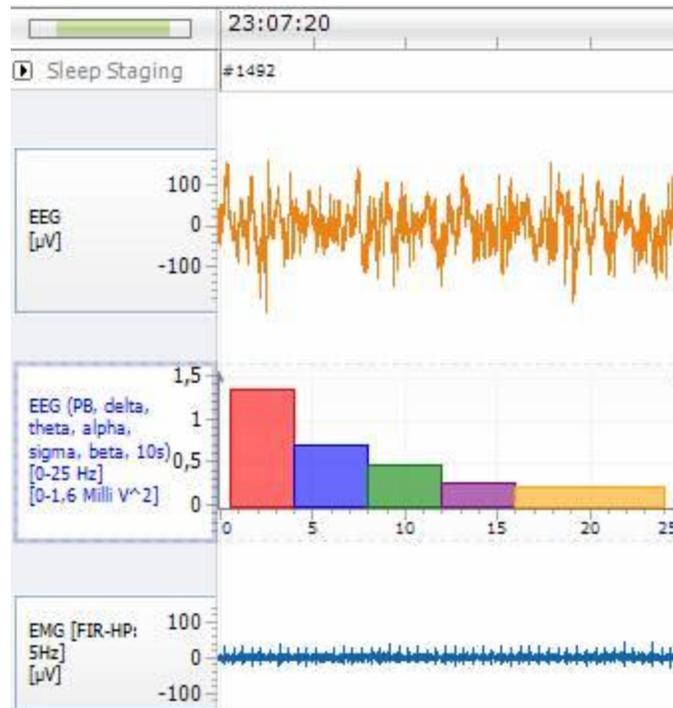


Figure 4 EEG, EMG, and the standard EEG power bands. Red bar is the delta power. This image depicts a slow wave state.

In Figure 2 and Figure 3, the delta power band is lower in relation to the other power bands resulting in a lower delta ratio, denoting that the subject is not in slow wave sleep. In these instances, the threshold would be placed around 0.3-0.4 as the power distribution is rather flat and the difference between the delta powers for the slow wave state is not very dominant. In Figure 4, the delta power band is large in relation to the other powers bands resulting in a larger delta ratio and a scoring of slow wave sleep.

### Configuring the Theta Ratio

The Theta Ratio is the ratio between the theta power and delta power. It is used to discriminate a paradoxical stage from other sleep stages. Although wake, especially active wake, can show similar theta activity, as is present in paradoxical sleep, it is accompanied by high levels of EMG activity which excludes it from being classified incorrectly as paradoxical sleep.

To determine the Theta Ratio, compare the power bands for paradoxical vs. slow wave sleep. The Theta Ratio can be determined by dividing the blue bar (theta band) values by the red bar (delta band) values. In other words, it is  $[\text{theta band (4-8Hz)}/\text{delta band (0.5-4Hz)}]$ . Please keep in mind that the default settings for the Theta Detector are 6-9 Hz; however, the standard definition is 4-8 Hz. To calculate this ratio, see Calculating Power Ratios. Determine this ratio for a few epochs considered to depict paradoxical sleep. Then, determine this ratio for a few epochs considered to depict slow wave sleep. By comparing these two sets of ratios, a reference

range that separates the two sets should become apparent. Select the threshold from within this reference range.

In Figure 3 and Figure 4, the distribution of power changes from slow wave sleep to paradoxical sleep. In Figure 3, the ratio between theta and delta power bands is approximately 5-6. This displays the higher end of the ratio and thus corresponds to a paradoxical sleep. However, Figure 4 depicts the ratio as approximately 0.5, which corresponds to slow wave sleep. The lower - middle end of this range is at about 2-3 and can be used for the theta ratio threshold. Lowering this value further increases the detection of paradoxical sleep stages, but might produce false positives.

### Configuring the EMG Threshold

EMG is used to discriminate between sleep stages, specifically between active wake and paradoxical sleep. The criteria for the EMG threshold states that if 20% of the absolute EMG samples in a scoring epoch are over the threshold, that epoch should be classified as wake.

To measure this 20%, use the axis lines available in the NeuroScore application by **right-clicking** on the signal and selecting **Add Axis Line**. Then, locate regions where the sleep stages change from slow wave sleep to wake. These locations can provide a good indicator for where to place the threshold. See Figure 5.

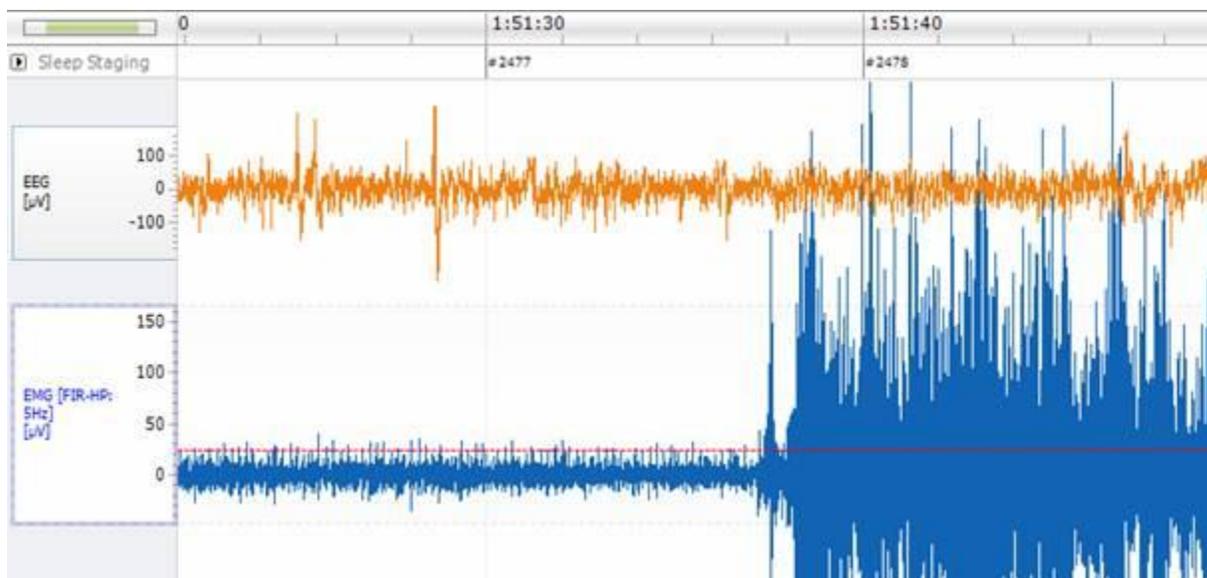


Figure 5 EMG and axis line showing a possible threshold

In Figure 5, a transition of the EMG from sleep to wake can be seen. Placing an axis line at the amplitude of the sleep EMG provides a good estimation for the EMG threshold value. Here, the EMG threshold is approximately 25µV.

*Note:* For a better understanding of the order in which NeuroScore's Rodent Sleep Scoring algorithm works, see NeuroScore's Rodent Sleep Scoring Algorithm.

## Calculating Power Ratios

To calculate power ratios:

1. **Right-click** on the EEG signal of interest.
2. Select **Derived Signals - Power Ratio**
3. Select the *frequency power band* to be used for the *numerator* and *denominator*.
  - For Delta Ratio, a user define band can be defined by entering a unique denominator name
  - Then define the frequency to the entire *band range* contained in the signal; i.e. **0** to **25** Hz
4. Choose the *DFT Function Signal Window*; the Hamming Window is typically used.
5. Select **OK**

*Note:* It may be easier to view the Power Ratio derived signal as a step function in order to obtain epoch power ratio values. To do this, please see the *Signal Tab* within the Signal Properties section of this manual.

## NeuroScore's Rodent Scoring Algorithm

The automated scoring algorithm will proceed in the following order until the first matching criterion is encountered.

1. The scoring will only be applied to the active period.
2. Any data that has already been manually scored will not be overwritten.
3. If more than 10% of the EEG or EMG signal exceeds the artifact threshold, the epoch will be scored as Artifact.
4. If more than 10% of the EEG signal is “bad” (i.e. signal dropout), the epoch will be scored as Artifact.
5. If there is any activity in the epoch, the epoch will be scored as Active Wake (or Wake if Active Wake and Wake are being combined).
6. If the EMG signal exceeds the EMG Threshold according to the definition above, the epoch will likely be scored as Active Wake (or Wake if Active Wake and Wake are being combined).
7. If the theta ratio exceeds the threshold, the epoch will likely be scored as Paradoxical sleep.
8. If the slow wave ratio exceeds the threshold, the epoch will likely be scored as Slow Wave/Deep Sleep.
9. If none of the other criteria have been met, the epoch will be scored as Wake.

Criteria used to discriminate between Slow Wave Sleep 1 (SWS1) and Slow Wave Sleep Two (SWS2):

If a SWS event is detected, then NeuroScore uses the Delta to Total Power ratio to deduce if a Slow Wave Sleep stage is SWS1 or SWS2. By default, if the Delta Power to Total Power ratio is greater than the User Defined Slow Wave Ratio, then the stage is SWS2; otherwise the epoch is defined as SWS1. Please see the Rodent Sleep Scoring Settings section for more information.

*Note:* A single sleep stage will be assigned to an entire epoch based upon whichever stage represents the majority of the epoch. Epochs with transitions from one stage to another will be labeled with the stage that occurs for the majority of the time.

## Rodent Sleep 2 Detector

### Rodent Scoring 2 Detector

Similar to the *Rodent Sleep Scoring* detector, the *Rodent Sleep Scoring 2* detector uses one or two EEG signals along with EMG and activity data to automatically assign a vigilance stage to a user defined epoch. However, this module provides greater user control over how the algorithm scores the recording for greater accuracy in scoring rodent sleep/wakefulness into the 4 different sleep stages: *active wake (A)*, *quiet wake (W)*, *slow wave sleep (SWS)* and *paradoxical sleep (P)*. In addition to the 4 sleep stages, the scoring module scores an epoch as an artifact if there are missing samples of a segment or if a movement artifact distorts the signals all together.

*Note:* Slow wave sleep (SWS) can be discriminated into slow wave sleep 1 (SWS1) and slow wave sleep 2 (SWS2). This feature can be turned ON or OFF in the protocol settings.

Unlike the original Rodent Sleep Scoring detector, which calculates the periodogram over the user defined epoch, the Rodent Sleep Scoring 2 detector calculates the periodogram over 1 second epochs and assigns each a unique sleep stage. To assign sleep stages per 1 second epoch, the detector takes into consideration the previous stage (if one exists), the user defined probability the subject will move from that stage to the next, and the delta, theta, and EMG power levels present in the epoch. Based on the power levels present, the detector will decide which sleep stage is the most probable for that 1 second epoch based on the user defined ranges. Once all 1 second epochs are scored, a sleep stage will be determined for the entire user defined epoch (e.g. 10sec or 30sec) and scored based on the stage with the majority of 1 second epochs. The Rodent Sleep Scoring 2 detector also provides access to the Visual Tuning tool for quicker, easier configuration of analysis settings.

The table below shows the relationship between a recorded signal and the properties used to determine different sleep states in the rodent.

Signal type and location	Parameter	Description
EEG-Cortical	Delta Power	The delta power band ranging between 0.5-4Hz, is the most dominant factor in sleep, and is mostly present during slow wave (deep) sleep. The delta power is a useful variable in determining the difference between sleep on one hand and wakefulness and paradoxical sleep on the other.
EEG-Theta	Theta Power	The theta power band ranging between 4-8 Hz depending on the species, is present in wake, but is also a required aspect for paradoxical sleep. Theta power is very low during sleep, other than paradoxical sleep.
EMG	Muscle tone	EMG measures the electrical activity in the muscle. The most common placement for rodents is on the back of the neck. EMG levels are high when the subject is awake and moving (performing actions

		requiring the use of related muscle). EMG is useful for determining the difference between active wake vs. quiet wake and wake vs. paradoxical sleep.
Activity	Movement	Activity is an indication of subject movement based on the transmitter and is used to determine active wake.

The table below displays how relationships between sleep/wake stages and the measured parameters given in the table above.

Sleep Stage	Delta Power	Theta Power	Muscle Tone	Movement
Active Wake	low	low	high	low-high
Quiet Wake	low-mid	low-high	low-mid	low
Slow Wave Sleep	mid-high	low-mid	low-mid	low
Paradoxical Sleep	low	high	low	low

In addition to the 4 sleep stages, the scoring module scores an epoch as an artifact if there are missing samples of a segment or if a movement artifact distorts the signals all together.

For more information about the detector please see the following:

- Rodent Scoring 2 Detector Analysis Settings.
- Configuring the Rodent Scoring 2 detector to learn how to use the Visual Tuning tool.
- For more specific definitions of the sleep stages and the method NeuroScore uses to score rodent sleep, please see NeuroScore's Rodent Sleep Scoring 2 Algorithm.

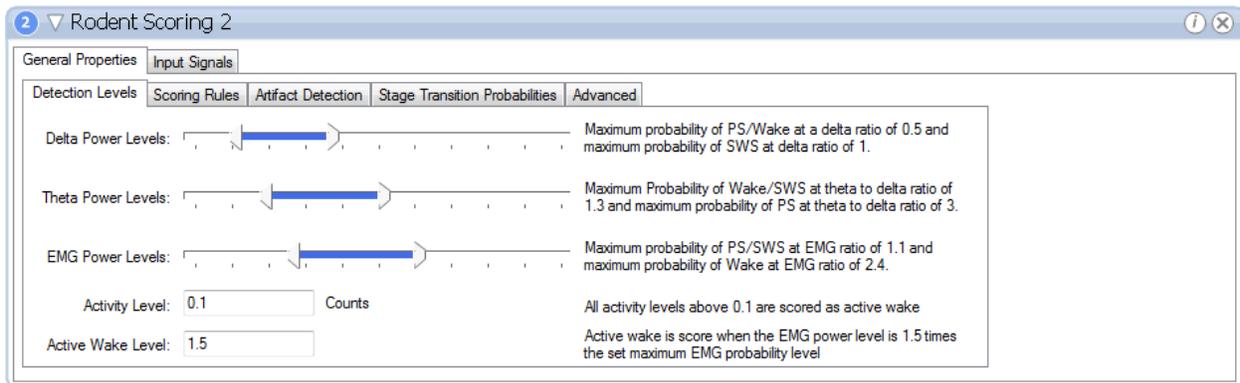
*Note:* Additional sleep stages not included in the automated protocol can be manually added and assigned if desired.

## Rodent Sleep Detector 2 Analysis Settings

To score rodent sleep, use one of the default analysis protocols shipped with the NeuroScore application or create one. To create an analysis protocol, view [Creating New Analysis Protocols](#).

After the *Rodent Scoring 2* detector has been added to the protocol, the *General Properties* associated with the rodent scoring 2 module should be displayed. Please note that the default settings may not be appropriate for the subject being analyzed and should be adjusted if needed. Within the General Properties section there are multiple tabs.

### Detection Levels

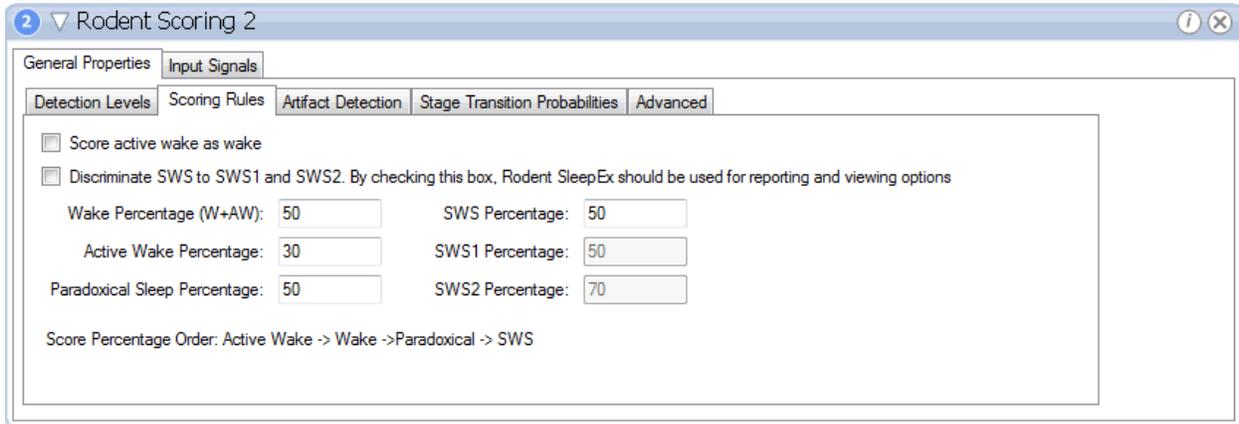


The table below lists the adaptable properties available in the *Detection Levels* tab and a description of each parameter.

Parameter	Description
Delta Power Levels	Setting for sleep stage probability based on Delta ratio, which is delta power divided by total power in the epoch. If delta power is less than lowest setting, there is 100% probability of PS/Wake. If delta power is greater than highest setting there is 100% probability of SWS.
Theta Power Levels	Setting for sleep stage probability based on Theta ratio, which is Theta power divided by Delta power in the epoch. If Theta power is less than lowest setting, there is 100% probability of Wake/SWS. If Theta power is greater than highest setting there is 100% probability of PS.
EMG Power Levels	Setting for sleep stage probability based on EMG ratio, which is a ratio of the RMS of the EMG vs the average of the RMS of the EMG*. If EMG power is less than lowest setting, there is 100% probability of PS/SWS. If EMG power is greater than highest setting there is 100% probability of Wake.
Activity Level	An epoch with a majority above the set Activity Level will be scored as Active Wake
Active Wake Level	When the EMG power is the set value times the maximum EMG Power level the for the majority of the epoch it will be scored as Active Wake.

\*Note: The EMG power is a ratio of the RMS of the EMG vs the average of the RMS of the EMG where 30% of the highest values and 10% of the lowest values have been excluded from the average for the entire recording.

### Scoring Rules

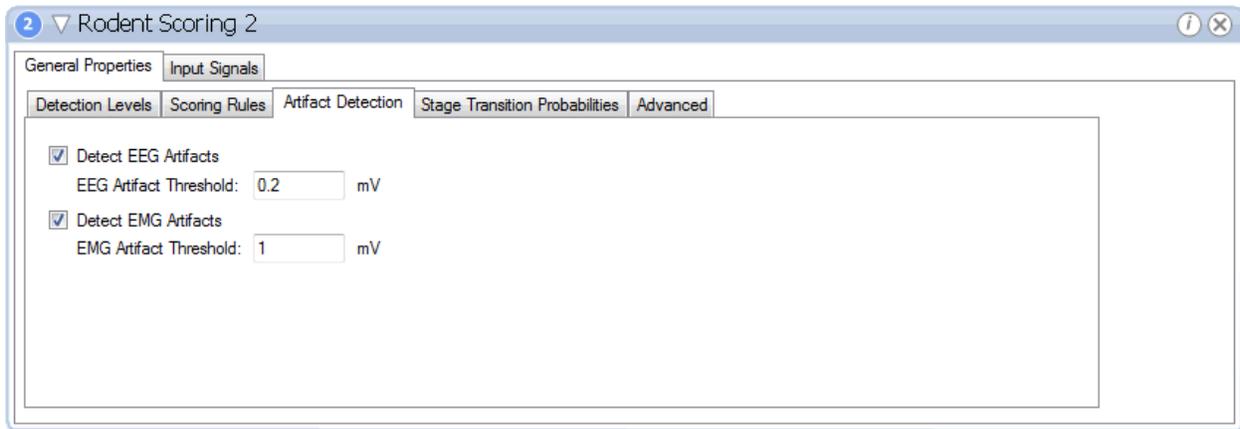


The table below lists the adaptable properties available in the *Scoring Rules* tab and a description of each parameter.

Parameter	Description
Score AW as Wake	Check this box to NOT discriminate between Active Wake and Wake.
Discriminate SWS to SWS1 and SWS2	Check this box to allow the algorithm to break SWS into SWS1 and SWS2.
Wake Percentage (W+AW)	If more than 50% of the Total Epoch* is W+AW it will be scored as Wake.
Active Wake Percentage	If more than 30% of the Total Epoch is Active Wake it will be scored as Active Wake.
Paradoxical Sleep Percentage	If more than 50% of the Total Epoch is Paradoxical Sleep it will be scored as PS.
SWS Percentage	If more than 50% of the Total Epoch is Slow Wave Sleep it will be marked as SWS.
SWS1 Percentage	If more than 50% of the Total Epoch is <b>Slow Wave Sleep</b> it will be marked as <b>SWS1</b> .
SWS2 Percentage	If more than 70% of the Total Epoch is <b>Slow Wave Sleep</b> it will be marked as <b>SWS2</b> .

\*Total Epoch denotes the user defined Epoch size and is default of 10 seconds. Each Total Epoch is broken down and scored in 1 second epochs by the algorithm. The Total Epoch is then scored based on the percentage of the parameters.

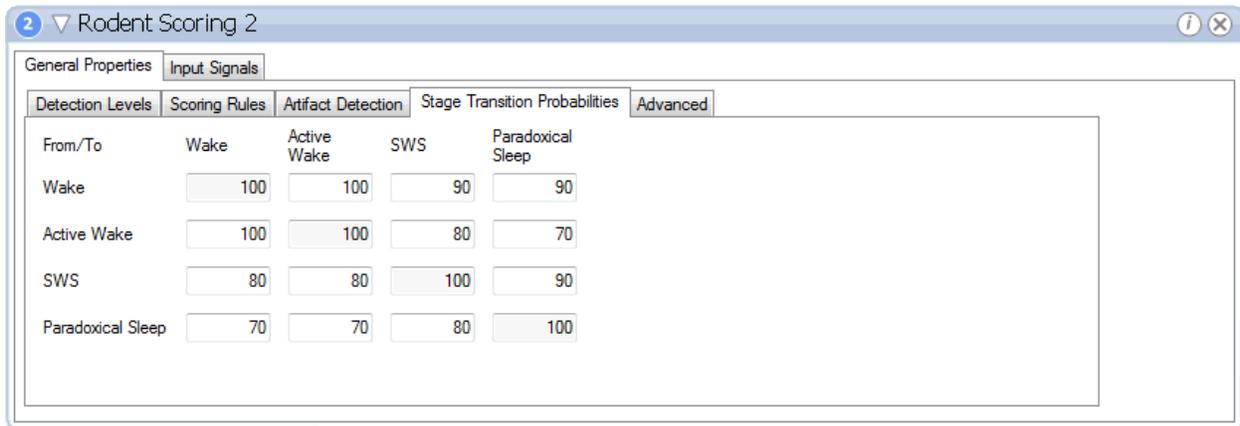
### Artifact Detection



The table below lists the adaptable properties available in the *Artifact Detection* tab and a description of each parameter.

Parameter	Description
Detect EEG Artifacts	If the majority of the EEG signal in the epoch is greater than this threshold the epoch will be marked as artifact.
Detect EMG Artifacts	If the majority of the EMG signal in the epoch is greater than this threshold the epoch will be marked as artifact.

### Stage Transition Probabilities

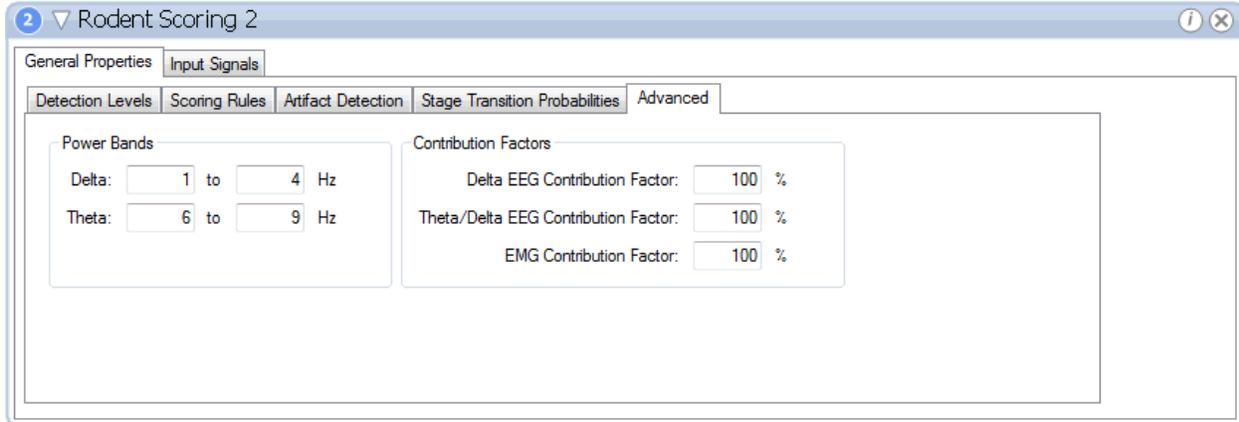


The table below lists the adaptable properties available in the *Stage Transition Probabilities* tab and a description of each parameter.

Parameter	Description
Wake	This row shows probabilities that sleep stage will transition from wake to another stage.
Active Wake	This row shows probabilities that sleep stage will transition from Active Wake to another stage.

SWS	This row shows probabilities that sleep stage will transition from Slow Wave Sleep to another stage.
Paradoxical Sleep	This row shows probabilities that sleep stage will transition from Paradoxical Sleep to another stage.

**Advanced**



The table below lists the adaptable properties available in the *Advanced* tab and a description of each parameter.

Parameter	Description
Delta Power Band	The range of the Delta Power band can be modified.
Theta Power Band	The range of the Theta Power band can be modified.
Delta EEG Contribution Factor	If desired, the Delta EEG can be weighted more or less as a contributing factor in Sleep Stage scoring. Default is 100%.
Delta/Theta EEG Contribution Factor	If desired, the Theta/Delta EEG can be weighted more or less as a contributing factor in Sleep Stage scoring. Default is 100%.
EMG Contribution Factor	If desired, the EMG signal can be weighted more or less as a contributing factor in Sleep Stage scoring. Default is 100%.

The *Input Signals* tab will provide the ability to specify which signals to be used during the Rodent Sleep Scoring to determine how the data will be marked. The only signal types available for input will be the signals that were loaded with the current recording. If more than one channel of each data type were collected, it is recommended the **Manual Input Selection** is checked so the user is prompted to choose which channel corresponds to which signal input.

The screenshot shows the 'Input Signals' tab in the 'Rodent Scoring 2' window. It is organized into four distinct sections, each with its own header and settings:

- Cortical EEG:** The 'Input Source' section has 'Signal Group' set to 'EEG Cortical' and 'Single Input Source' as an empty dropdown. The 'Input Options' section has 'Manual Input Selection' checked and 'Enable Sampling Rate Filter' unchecked with a value of 60 Hz.
- Theta EEG:** The 'Input Source' section has 'Signal Group' set to 'EEG Theta' and 'Single Input Source' as an empty dropdown. The 'Input Options' section has 'Manual Input Selection' checked and 'Enable Sampling Rate Filter' unchecked with a value of 60 Hz.
- Neck EMG:** The 'Input Source' section has 'Signal Group' set to 'EMG Neck' and 'Single Input Source' as an empty dropdown. The 'Input Options' section has 'Manual Input Selection' checked and 'Enable Sampling Rate Filter' unchecked with a value of 60 Hz.
- Activity:** The 'Input Source' section has 'Signal Group' set to 'Activity' and 'Single Input Source' as an empty dropdown. The 'Input Options' section has 'Manual Input Selection' checked and 'Enable Sampling Rate Filter' unchecked with empty input fields.

At the bottom of each section, there is a checkbox labeled 'Use this input source', which is checked for all four sections.

For more information on the *Cortical*, *Theta*, *EMG*, and *Activity* signals and how they relate to Rodent Sleep Scoring, please see the Rodent Scoring 2 Detector section of this manual.

For more information on the *Input Source* and *Input Options*, please see *Input Signals* in the Adding Detectors section of this manual.

## Configuring the Rodent Sleep Detector 2

In many instances the Rodent Sleep detector needs some fine tuning. These instances might occur when:

- Different species are used
- Different strains of the same species are used
- A difference has occurred in the signal scaling or magnification
- A characteristic change of the signals due to high impedance or bad placement of electrodes.

There are many parameters that can be changed to increase the scoring module's accuracy, such as the Detection Levels, Activity and Artifact thresholds, Sleep Transition Probabilities, and percent contribution of the Detection Levels. To configure the Rodent Sleep Scoring 2 module, it is recommended to use the Visual Tuning tool to modify settings and quickly view how the modifications affect the scoring.

### Configuring the Visual Tuning Tool Workspace

Within the Visual Tuning tool, define the Input Signals that will be used for the sleep scoring using the dropdown menus. These signals will be display in the signals section of the tuning tool.

Define the duration of time desired to view the recordings within the tool by right-clicking the time axis and choosing the desire time. The workspace should update to display that duration in the tool.

Ensure that the appropriate Hypnogram settings are configured to display only the scoring markers to be used within the scoring by right-clicking the Hypnogram and choosing settings. From the Marker Group dropdown menu, choose the marker group that should be displayed. Since the Visual Tuning tool is only compatible with the Rodent Sleep Scoring Module 2, choose between Rodent Sleep or Rodent Sleep Ex. Rodent Sleep Ex should only be used if the check box to discriminate SWS to SWS1 and SWS2 is checked (Scoring Rules tab) and that discrimination is desired.

### Configuring the Power Bands

Before running the analysis protocol on the data, it is important to define the Delta and Theta Power Bands the detector will use for power calculations. The theta power band can be different between species and strains within the same species. The theta band is most effective if it covers only the theta elevation occurring during the paradoxical sleep. Theta activity in rodents ranges from 4 to 8 Hz, but is usually placed between 6 to 8 Hz. To determine the spread of the theta band, use either the *FFT or Periodogram Derived Graphs*.

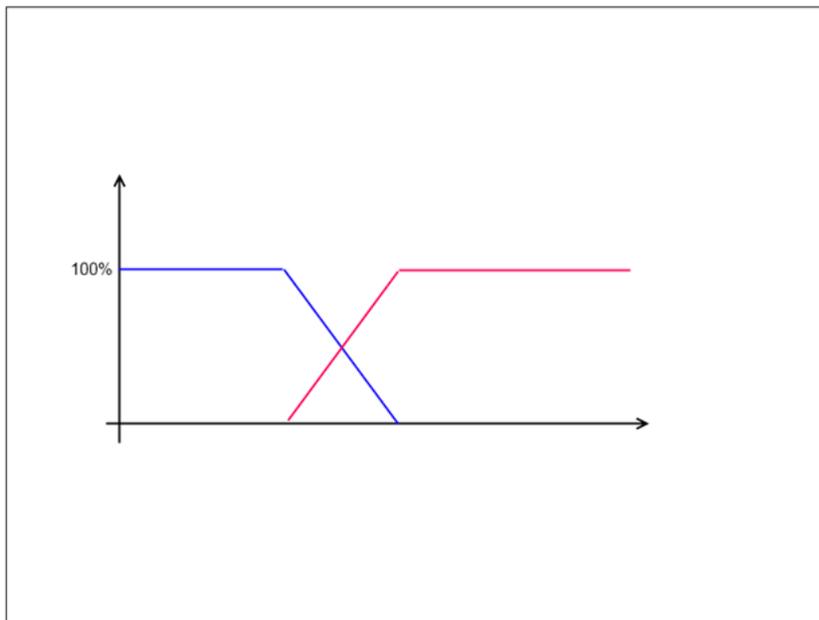
### Configuring the Stage Transition Probabilities

Sleep Transition Probabilities are used by the detector to determine how probable it is for the subject to transition out of one stage and into another. The detector follows the general rule that once a sleep stage is entered, the subject wants to stay in that stage, unless some tipping point moves it into another stage. For example, if the subject is in Wake, there is a 100% probability that the subject will remain in Wake for the next epoch and only a 90% probability that that subject will move into either Slow Wave Sleep or Paradoxical Sleep and would require a high Theta ratio to increase the probability of moving out of Wake and into Sleep. These sleep stage transition probabilities can be defined by the user to provide complete control over how probable the subject will transition out of one stage and into the next.

### Configuring the Detection Levels

It is recommended to initially score the recording with the default power levels from within the Visual Tuning tool by clicking the Score Study button. This will calculate all power levels for the recording, display the sleep markers based on the detector settings, and update the hypnogram. Once this initial scoring is complete, the Visual Tuning tool will store the calculations in memory so that any change made to the detector settings can be applied to the recording and reviewed instantly by clicking Score Study again. All markers and the hypnogram will update to represent the probability changes made.

The image below roughly shows how the probabilities are calculated. The x-axis can be thought of as the delta ratio, theta to delta ratio or EMG ratio. The y-axis is the probability. The break points in the lines are the user defined thresholds and the area between the two breaks represents the blue bar that connects the thresholds. For the Delta Power Level, the blue line would be the probability for Wake and PS, while the red line would be the probability for SWS. Similarly, for the Theta Power Level the blue line would be the probability for Wake and SWS, while the red line would be the probability for PS. To learn how to use NeuroScore to determine Delta and Theta Ratios, please see Configuring the Rodent Sleep Detector.



## **Configuring Scoring Rules**

The Scoring Rules tab is used to configure three main settings. The first two, score active wake as wake and discriminate SWS to SWS1 and SWS2 should be used based on the discretion of the user and do not require anything to be configured outside of checking the correct box. The Wake Percentages define how the total user defined epoch should be scored based on the summarized percent coverage of the 1 second epochs. For example, if the user has defined 10 seconds as the duration over which to report sleep staging markers, then each 1 second scoring epoch (used by the detector) represents 10% of the total epoch. So if there are four 1 second epochs of Paradoxical Sleep, then Paradoxical Sleep has a 40% coverage of the total epoch. The total epoch will be scored based on the user defined criteria entered in the Scoring Rules tab.

Note: When checking the boxes to score Active Wake as Wake or discriminate between SWS1 and 2, the available Score Rule percentage boxes will enable or disable appropriately. In other words, if scoring Active Wake as Wake, then the Active Wake Percentage will gray out and not be considered by the detector.

## **Configuring Contribution Factors**

Contribution Factors allow the user to control how much each Detection Level contributes to the overall scoring probability. When defined to 100%, each Detection Level will fully contribute to the overall scoring probability. By lowering any Detection Level percent contribution, probabilities from that Detection Level will not weight as heavily toward the overall scoring probability. In other words, if the Delta Power Level Contribution Percentage is 100% and the Theta Power Level Contribution Percentage is 80%, then the Delta Power Level probability will have more influence on what the final overall scoring probability than the Theta Power Level.

Note: For a better understanding of the method NeuroScore's Rodent Sleep Scoring 2 algorithm uses to score the data based on the scoring probability, please see NeuroScore's Rodent Sleep Scoring 2 Algorithm.

## NeuroScore Rodent Scoring 2 Algorithm

The rodent automated scoring 2 algorithm will proceed in the following order until the first matching criterion is encountered.

1. The scoring is only applied to the active period.
2. Any data that has already been manually scored will not be overwritten.
3. Each scoring epoch is split into 1 second epochs. Calculations are made for each second and scored individually.
4. If the EEG or EMG amplitude exceeds the artifact threshold or has any bad samples (i.e. signal dropout) the 1 second epoch is scored as Artifact.
5. The detector will then determine the most probable sleep stage for that 1 second epoch based on summarizing the overall calculated probability from the following user defined analysis setting criteria.
  1. The algorithm will calculate the sleep stage probabilities based on where the Delta and Theta ratios fall within the user defined Power Levels.
    - Paradoxical Sleep has the highest probability if the Theta to Delta ratio is high and EMG is low.
    - Slow Wave Sleep has the highest probability if the Delta is high and the EMG is low.
    - Wake and Active Wake has the highest probability when the Delta is low and the EMG is high.
    - (optional) Active wake is scored if the activity signal or EMG amplitude exceeds a user defined threshold.
  2. Once these probabilities are determined, they are weighted based on the Contribution Factors defined in the Advance tab.
  3. The final consideration in determining the overall sleep stage probability is the probability that the subject will transition from the previous sleep stage to a new stage. The user can define this probability dependency within the Sleep Transition Probabilities tab.
6. All 1 second epochs are summarized to determine which sleep stage is most present within the user defined epoch to be marked. E.g., for a 10 second epoch each 1 second scoring epoch represents 10% of the total epoch. So if there are four 1 second epochs of PS then the PS has a 40% coverage of the epoch. The total epoch will be scored based on the criteria below:
7. By default the following scoring rules are applied to determine the scoring of the total epoch. All thresholds can be modified by the user:
  - Artifact is scored if coverage exceeds 50%
  - Active wake is scored if coverage exceeds 30%
  - Wake is scored if coverage exceeds 50%
  - SWS is scored if it exceeds 50%
  - (optional) SWS1 is scored if SWS coverage exceeds 50%
  - (optional) SWS2 is scored if SWS coverage exceeds 70%

- If none of the rules above are met then the highest coverage is scored.

*Note:* Steps that are (optional) are those that can be turned on and off with within the Rodent Scoring 2 Settings.

## Large Animal Sleep Scoring Detector

### Large Animal Sleep Scoring Detector

The Large Animal Sleep detector uses EEG, EMG, EOG and activity data to automatically assign a vigilance stage to each epoch. The epoch duration can range from 2s to 300s. This module scores sleep/wake in the large animal into different stages including: active wake (A), wake (W), non-REM (N1, N2, N3), REM (R), and artifact (X). In the scoring algorithm, each of these signal inputs is used independently to determine the likelihood of each sleep stage for an epoch. The features extracted from each signal type to contribute to the scoring decision are described below. The final sleep stage is assigned to the epoch based on a probability vector from the signal inputs as well as knowledge about the stage assigned to the previous epoch. The user has the ability to adjust the weights and thresholds used in computing the probability vector to improve the scoring results. The algorithm is fairly complex and future releases are anticipated to simplify the user-interface to the scoring criteria. More information about the algorithm can be obtained by contacting DSI Technical Support.

*Note:* Additional settings allow the user to select:

- Artifacts to be marked as Active Wake
- Active Wake to be scored as Wake

The table below describes the features that are extracted from each of the input signals which are used in the scoring algorithm. In each case, the feature extracted is based on a ratio of the value for the epoch being scored divided by the average value for the recording period.

Signal type	Feature Extracted	Description
EEG	Delta Power Ratio	The delta power band ranging between 0.5-4Hz, is the most dominant factor in sleep, and is mostly present during non-REM sleep. The delta power is a useful variable in determining the level of non-REM sleep.
EMG	RMS Ratio	EMG measures the electrical activity in the muscle. EMG levels are high when the subject is awake and moving (performing actions requiring the use of related muscle). A 10Hz high-pass filter is applied and then the RMS is computed. EMG is used primarily for determining the difference between wake and REM sleep.
EOG	RMS Ratio	EOG measures the electrical activity in the muscle of the eye. EOG levels are high when the subject is awake or in the REM sleep state. The RMS value is computed. This input is primarily used for differentiating REM and wake stages from non-

		REM.
Activity	Activity Value	Activity is an indication of subject movement based on the transmitter and is used to determine active wake.

The table below displays the general relationship between sleep/wake stages and the measured parameters given in the table above. Keep in mind, the algorithm is complex and additional criteria are incorporated when assigning a vigilance stage.

Sleep Stage	Delta Power	Muscle Tone	EOG	Movement
Wake (W)	low	low-mid	mid-high	low-mid
Active Wake (A)	low	mid-high	mid-high	high
N1	low-mid	low	low	none
N2	mid-high	low-mid	low-mid	none
N3	high	low	low	none
R (REM)	low	very low/none	mid-high	none

In addition to the above sleep stages, the scoring module scores an epoch as an artifact if there are missing data samples or if a movement artifact distorts the signals all together.

For more specific definitions of the sleep stages and the method NeuroScore uses to score large animal sleep, please see the NeuroScore's Large Animal Sleep Scoring Algorithm.

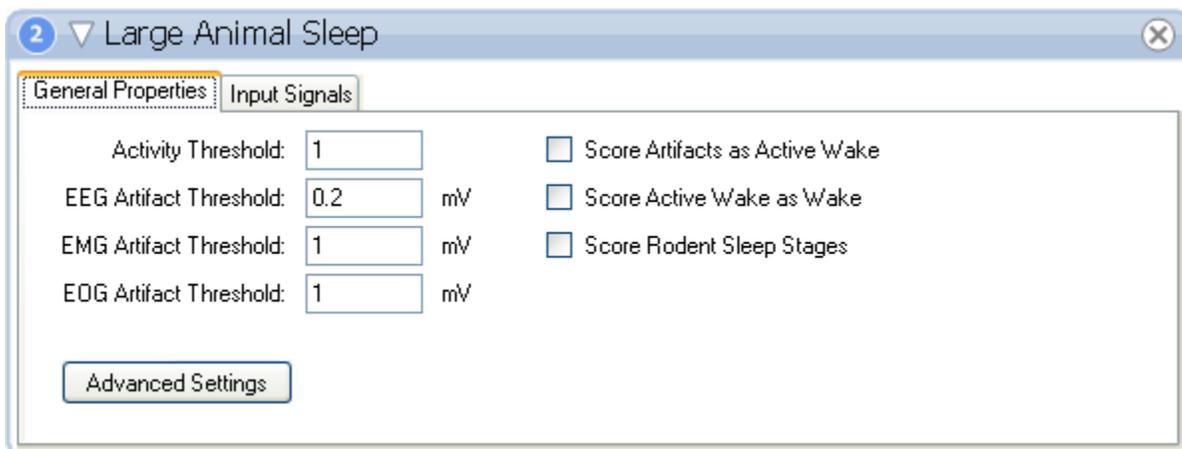
*Note:* Additional sleep stages not included in the automated protocol can be manually assigned to an epoch, if desired.

## Large Animal Sleep Detector Settings

To score large animal sleep, use one of the default analysis protocols shipped with the NeuroScore application or create one. To create an analysis protocol, view [Creating New Analysis Protocols](#).

*Note:* When executing a protocol containing the Large Animal Sleep detector, there is a long pause before sleep stages begin to be assigned into the data set. This pause is when much of the algorithm's calculations are occurring.

After the Large Animal Sleep detector has been added to the protocol, the General Properties associated with the large animal sleep scoring module should be displayed. Please note that the default settings may not be appropriate for the subject being analyzed and should be adjusted if needed.



The table below lists the adaptable properties available in the Large Animal Sleep Scoring module and a description of each parameter.

Parameter	Description
Activity Threshold	The threshold defines the boundary between activity and no activity. The activity parameter is provided when using DSI transmitters and acquisition software. If the activity value is greater or equal to the threshold, it is generally considered a period of active wake.
EEG Artifact Threshold	The value used to determine if the EEG signal in an epoch contain artifacts (i.e. noise spikes) and therefore should not be used for sleep scoring. The criteria for an artifact state that if an absolute value of the samples in the epoch exceeds this threshold the epoch is scored as an artifact (X) rather than a sleep stage.
EMG Artifact Threshold	The value used to determine if the EMG signal in an epoch contain artifacts (i.e. noise spikes) and therefore should not be used for sleep scoring. The criteria for an artifact state that if an absolute value of the samples in the epoch exceeds this threshold the epoch is scored as an artifact (X) rather

	than a sleep stage.
EOG Artifact Threshold	The value used to determine if the EOG signal in an epoch contain artifacts (i.e. noise spikes) and therefore should not be used for sleep scoring. The criteria for an artifact state that if an absolute value of the samples in the epoch exceeds this threshold the epoch is scored as an artifact (X) rather than a sleep stage.
Score Artifacts as Active Wake	If checked, all artifacts stages are scored as active wake (A) stages. This is based on the assumption that noise spikes are more likely to occur in the data when the animal is moving.
Score Active Wake as Wake	If checked, all active wake (A) stages are scored as wake (W) stages.
Score Rodent Sleep Stages	If checked the rodent sleep stage markers will be used instead of the large animal sleep stage markers.

## NeuroScore's Large Animal Sleep Scoring Algorithm

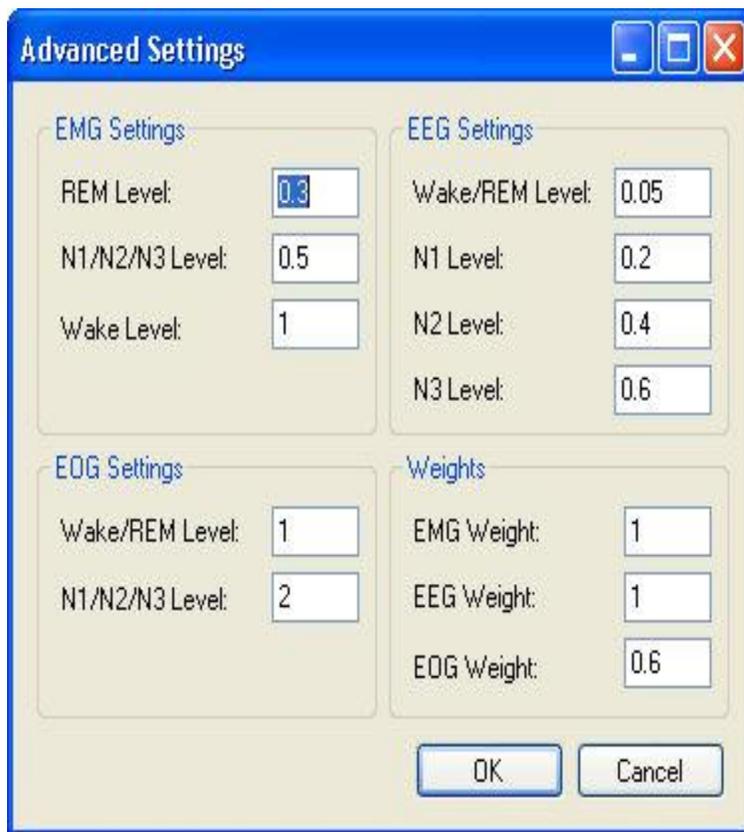
Before describing the Advanced Settings of the detector, it is helpful to first understand the fundamental theory of NeuroScore's Large Animal Sleep Scoring Algorithm. The below description will help to understand the fundamental theory of the scoring algorithm:

1. Features are extracted from the signal inputs. These features are described in the previous section.
2. For each signal input, an independent probability vector of sleep stages is generated. This vector represents the likelihood of each sleep stage occurring based on thresholds found in the advanced settings.
3. A weight is applied to the vector from each signal input. This weight is user-defined in the advanced settings.
4. The weighted probability vectors are summed to reveal the most likely overall sleep stage for the epoch.
5. Additional logic and scoring rules are applied based on the sleep stages assigned before and after the particular epoch to determine the final assigned sleep stage.

## Large Animal Sleep Detector Advanced Settings

Before describing the Advanced Settings of the detector, it is helpful to first understand the fundamental theory of NeuroScore's Large Animal Sleep Scoring Algorithm.

Allows the user to change the following settings:



### EMG/EEG/EOG settings:

These values are thresholds used to determine which sleep stage is most likely occurring based on the feature extracted from the signal type. A probability vector of the sleep stages is generated for each signal type independently based on these thresholds and the corresponding calculated feature value for a particular epoch. These thresholds can be adjusted to increase or decrease the likelihood of a particular stage from being selected. Typically values range from 0 to 4 depending on the signal type. Determining the appropriate threshold is rather complex and more information on the algorithm and adjusting these values can be provided by DSI Technical Support.

### Weights:

The weight of a signal determines how much the algorithm will rely on it in the scoring process. For example, a user may prefer that more emphasis is given to the EEG signal versus the others.

If a particular signal is poor quality or does not accurately represent the data type, its weight should be decreased to improve the accuracy of the automated scoring results.

**The Input Signals tab:**

The large animal sleep detector uses 1 channel of EEG, EMG, EOG, and activity as inputs to the scoring algorithm. Each signal being used to determine the sleep stage has a group of signals or one specific signal that is used to carry out the calculations. The Signal Group drop down lists signal groups setup by default that can be changed to include signals you may have collected that aren't included. If more than one channel of any data type were collected, it is recommended the Manual Input Selection is checked so the user is prompted to choose which signal is used when carrying out the automated sleep scoring algorithm.

2 ▾ Large Animal Sleep

General Properties | **Input Signals**

---

**EEG**

**Input Source**

Signal Group: EEG or Single Input Source:

[Edit](#)

**Input Options**

Remove Artifacts       Manual Input Selection

Remove Invalid Data Sections       Enable Sampling Rate Filter    60 -  Hz

---

**Neck EMG**

**Input Source**

Signal Group: EMG Neck or Single Input Source:

[Edit](#)

**Input Options**

Remove Artifacts       Manual Input Selection

Remove Invalid Data Sections       Enable Sampling Rate Filter    60 -  Hz

Use this input source

---

**EOG**

**Input Source**

Signal Group: EOG or Single Input Source:

[Edit](#)

**Input Options**

Remove Artifacts       Manual Input Selection

Remove Invalid Data Sections       Enable Sampling Rate Filter    60 -  Hz

Use this input source

---

**Activity**

**Input Source**

Signal Group: Activity or Single Input Source:

[Edit](#)

**Input Options**

Remove Artifacts       Manual Input Selection

Remove Invalid Data Sections       Enable Sampling Rate Filter    60 -  Hz

For more information on the EEG, Neck EMG, EOG, and Activity signals and how they relate to Large Animal Sleep Scoring, please see the Large Animal Sleep Scoring Detector section of this manual.

For more information on the Input Source and Input Options, please see Input Signals in the Adding Detectors section of this manual.

## Spike Train Detector

### Spike Train Detector

The *Spike Train Detector* analysis module scans an EEG signal to detect patterns of repeating spike activity, based primarily on amplitude changes, contained within the signal. NeuroScore defines a *Spike Train* as a series of signal spikes over time considered to be linked to the same event depicted through the EEG signal activity. The user can define the spike characteristics and rules for periodicity to help differentiate spike trains from 'normal' EEG signal. The Spike Train Detector is not limited to marking spikes on an epoch to epoch basis; instead, markers denoting these spikes can span across multiple epochs of data. In addition to Spike Trains, this detector can mark signal spike events.

The *Spike Train Detector* analysis module has been designed to detect seizure events in a variety of species. The spike train detector can be added to any protocol and works on one EEG signal per protocol application

The links below provide further information to further customize the Rat Seizure Detector to increase detection accuracy:

- [Spike Train Detector Settings](#)
- [Configuring the Spike Train Detector Module](#)

## Spike Train Detector Settings

To automatically score seizures within an EEG signal, create a new protocol using the Spike Train Detector. To create an analysis protocol, view [Creating New Analysis Protocols](#).

*Note:* The detector can be applied to the EEG waveform or its derived signals, including filtered signals if desired.

After the Spike Train Detector analysis module has been added to the protocol, the *General Properties* associated with the module should be displayed.

The screenshot shows a software window titled "Spike Trains" with two tabs: "General Properties" (selected) and "Input Signals". The "Spike Detection" section is active, showing two threshold options: "Dynamic Threshold" (selected) and "Absolute Threshold". Under "Dynamic Threshold", the settings are: Threshold Ratio: 3, Maximum Ratio: 20, and Minimum Value: 100  $\mu\text{V}$ . Under "Absolute Threshold", the settings are: Threshold Value: 200  $\mu\text{V}$  and Maximum Value: 1000  $\mu\text{V}$ . Other settings include: Minimum Spike Duration: 1 ms, Maximum Spike Duration: 100 ms, and a checked box for "Mark individual spikes". The "Spike Trains" section on the right contains: Minimum Spike Interval: 0.05 s, Maximum Spike Interval: 0.3 s, Minimum Train Duration: 0.5 s, Train Join Interval: 1 s, and Minimum Number of Spikes: 4.

The table below lists the adaptable *Spike Detection* properties available in the *Spike Train* detector and a description of each property.

Property	Description
<b>Dynamic Threshold</b>	This option allows the user to define a threshold based on a multiplication of the RMS value of the EEG signal approximately one minute prior to the point being analyzed. The spike will be considered in the additional criteria if it meets or exceeds the threshold ratio.
Threshold Ratio	Defines the minimum threshold for spike detection criteria as described above.
Maximum Ratio	Defines the maximum threshold for spike detection criteria as

	described above.
Minimum Value	Defines a minimum amplitude value (voltage) to prevent false positives from being detected in very low noise areas.

Property	Description
<b>Absolute Threshold</b>	This option allows the user to define a fixed amplitude threshold (voltage) that is applied in both the positive and negative direction. If a spike activity is within this range it can be used to test for periodicity, otherwise it is discarded.
Minimum Value	Defines the minimum amplitude value a spike must exceed to be considered. Used to prevent baseline EEG from spikes from being detected.
Maximum Value	Defines the maximum amplitude value of the absolute threshold range. Used to prevent large noise spikes from being detected.

The table below lists the adaptable *Spike* properties available in the *Spike Train* detector and a description of each property.

Property	Description
Minimum Spike Duration	Defines the minimum time duration an individual spike must span in order to be considered a valid spike. The time duration is measured from the point it crosses the amplitude threshold.
Maximum Spike Duration	Defines the maximum time duration an individual spike can span in order to be considered a valid spike. The time duration is measured from the point it crosses the amplitude threshold.
Mark individual spikes	Check this box to enable the detector to mark individual spikes, in addition to the spike trains, using the same Spike Detection conditions.

*Note:* The individual spike markers are referred to as *Spike* whereas the spike train is referred to as the plural *Spikes*.

The table below lists the adaptable *Spike Trains* properties available in the *Spike Train* detector and a description of each property.

Property	Description
Minimum Spike Interval	Defines the minimum time interval allowed between spikes for them to be considered possible members of a spike train.
Maximum Spike Interval	Defines the maximum time interval allowed between spikes for them to be considered possible members of a spike train.
Minimum Train Duration	Defines the minimum amount of time required for a train to span in order to be considered a valid spike train.
Train Join Interval	Defines the upper limit of the time interval between spike trains to determine if the trains should be marked as a single train or marked

	separately.
Minimum Number of Spikes	Defines the minimum number of spikes within a series of spikes to be considered a valid spike train. Otherwise, it is kept to see if it meets the join interval requirements.

For information on the *Input Source* and *Input Options*, please see *Input Signals* in the Adding Detectors section of this manual. Enabling the Manual Input Selection is recommended when performing spike train detection. This provides the option to select derived signals, such as filtered signals, as input signals by selecting *Available and Derived Signals* from the **Show** drop-down box.

*Note:* For a better understanding of the order in which NeuroScore's Spike Train Detector algorithm works, see NeuroScore's Spike Train Detector Algorithm.

## Configuring the Spike Train Detector

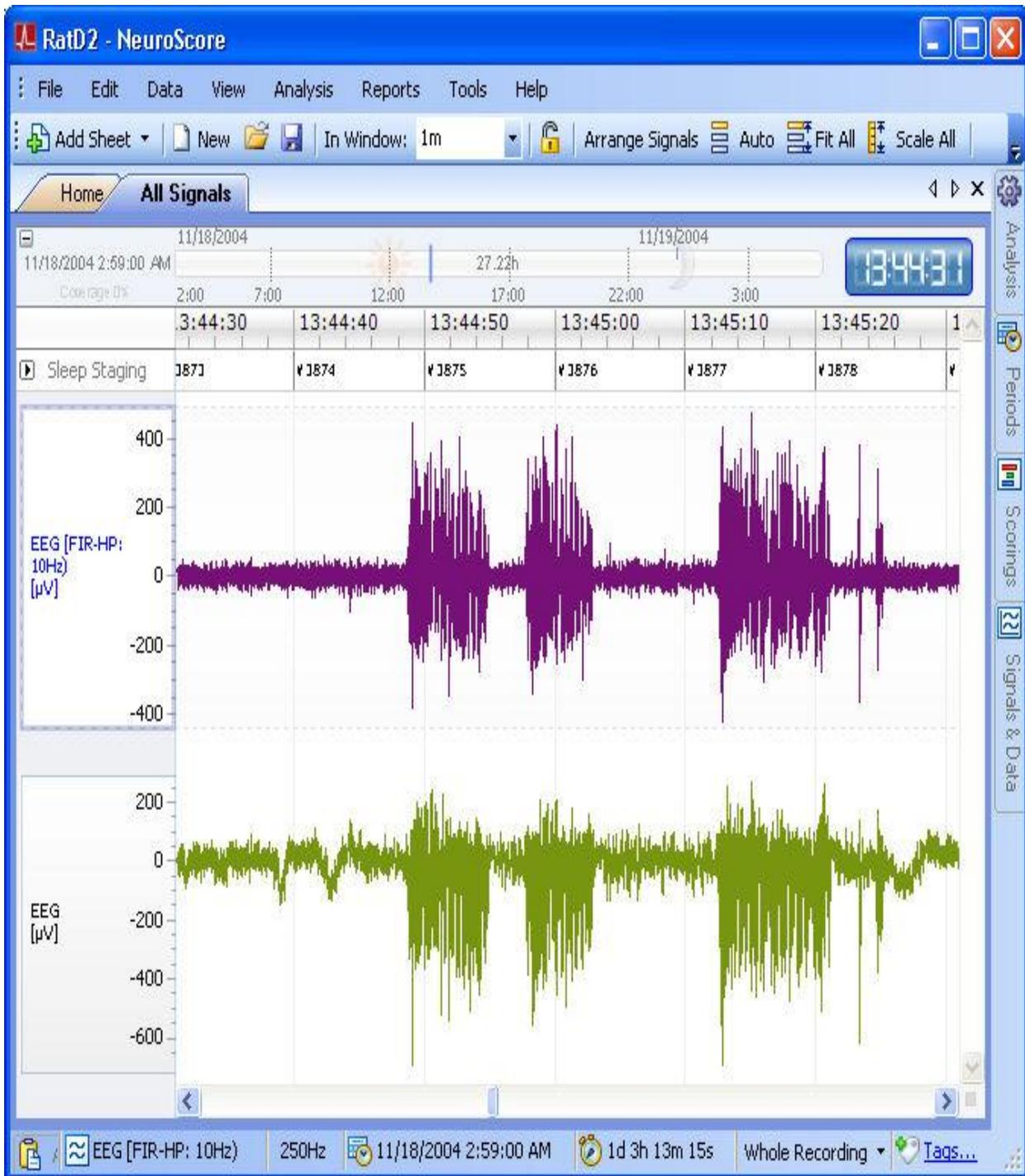
The Spike Train Detector has the ability to be fine tuned to the specific EEG signal being analyzed. This can prove to be useful when:

- Different species are used
- Different strains of the same species are used
- A difference has occurred in the signal scaling or magnification
- A characteristic change of the signals due to high impedance or bad placement of electrodes.

There are 4 primary parameters that can be changed to increase the module's accuracy. These include the Dynamic Threshold, Absolute Threshold, Spike Duration, and Spike Interval. The Spike Train Parameters can also be adapted in order for the spike markers to be applied according to the users' interests. Going through the following configurations will help tune the Spike Train Detector for reliable marking.

The first step is to select which amplitude detection criteria to use. The absolute threshold method is simpler and focuses on spikes that exceed the fixed voltage level. The dynamic threshold option should be used if it is difficult to establish a fixed voltage level that the spikes consistently exceed. In this case, the dynamic threshold is used to search for anything that has a spike like behavior.

*Note:* A high pass filter can be used to smooth the EEG signal for seizure detection using a cutoff frequency of 5-10 Hz. Please see **Figure 1**.



**Figure 1:** Displays the smoothing effects of a high pass filter, with cutoff frequency of 10 Hz, by comparing an EEG signal (bottom/green) to its filtered resultant (top/purple).

### Configuring the Dynamic Threshold

The *Dynamic Threshold* can be used to help determine if a spike is valid through the use of an RMS (Root Mean Square) function. NeuroScore compares the RMS value of the point being analyzed to the average RMS value of the points approximately 1 minute preceding the analyzed

point. Ultimately, this method of spiked detection compares RMS values of the analyzed point to the average RMS value of the baseline. Thus, the *Threshold Ratio* is the RMS value of the point of interest to the average RMS value of the baseline.

To determine the *Threshold Ratio*, determine the RMS values for the EEG Signal of interest. The RMS values of the signal can be determined using the Root Mean Squared function within the derived signal options. It is beneficial to view this derived signal as a Step Function since RMS values are determined on an epoch-to-epoch basis. Using this derived signal, obtain RMS values that correlate to with the section of EEG signal where spikes are considered to be and where the signal is considered to be 'normal'. To determine the Threshold Ratio, divide the Spike RMS values by the baseline values and then select a threshold slightly lower than this calculated ratio. I.e. if the Spike RMS is 45 and the baseline RMS is 10, then the ratio is 4.5 : 1 and the threshold value should be set to 4.

A *Maximum Threshold Ratio* can also be set to eliminate noise spikes from being detected from the signal. The *Minimum Value* should be set to prevent false positives from being detected in low noise areas of the signal.

### **Configuring the Absolute Threshold**

The *Absolute Threshold* can be used to determine if a spike is valid by determining if the spike's amplitude is within a certain range. This range is set by selecting a *Threshold Value* and a *Maximum Value*. Please see **Figure 2** below.



**Figure 2:** Depicts valid and invalid peaks based on the *Absolute Threshold* method considering both filtered (top) and unfiltered (bottom) EEG signals.

To determine these values, use the axis lines available in the NeuroScore application by **right-clicking** on the signal and selecting **Add Axis Line**. Then, locate regions where the baseline EEG activity changes to Spike Train EEG activity. Placing an axis line at the amplitude of the baseline EEG provides a good estimation for the *Threshold Value*.

*Note:* The **Axis Line** can be added and deleted using shortcuts. To **add axis lines** using the shortcut, hold <Ctrl> + <Alt> + **Mouse Click** on the signal. To **delete axis lines** using the shortcut, **hover** over the axis line to be deleted, when the axis line is bolded hit **Delete**.

### Configuring the Spike Duration

The *Spike Duration* defines the time duration range a spike must span within to be considered a valid spike. This range is set by defining the *Minimum* and *Maximum Spike Durations*. Please see **Figure 3** below.

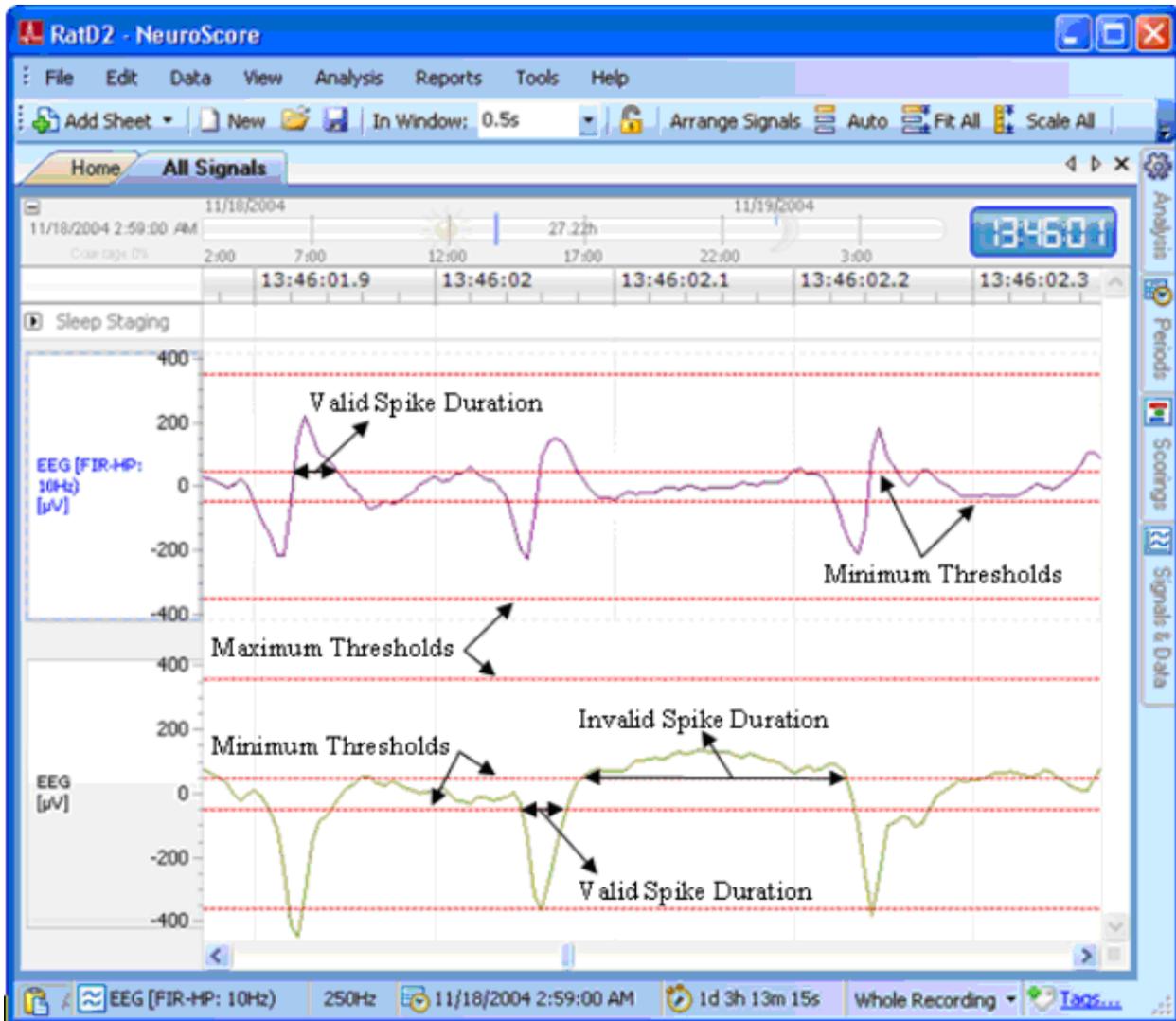
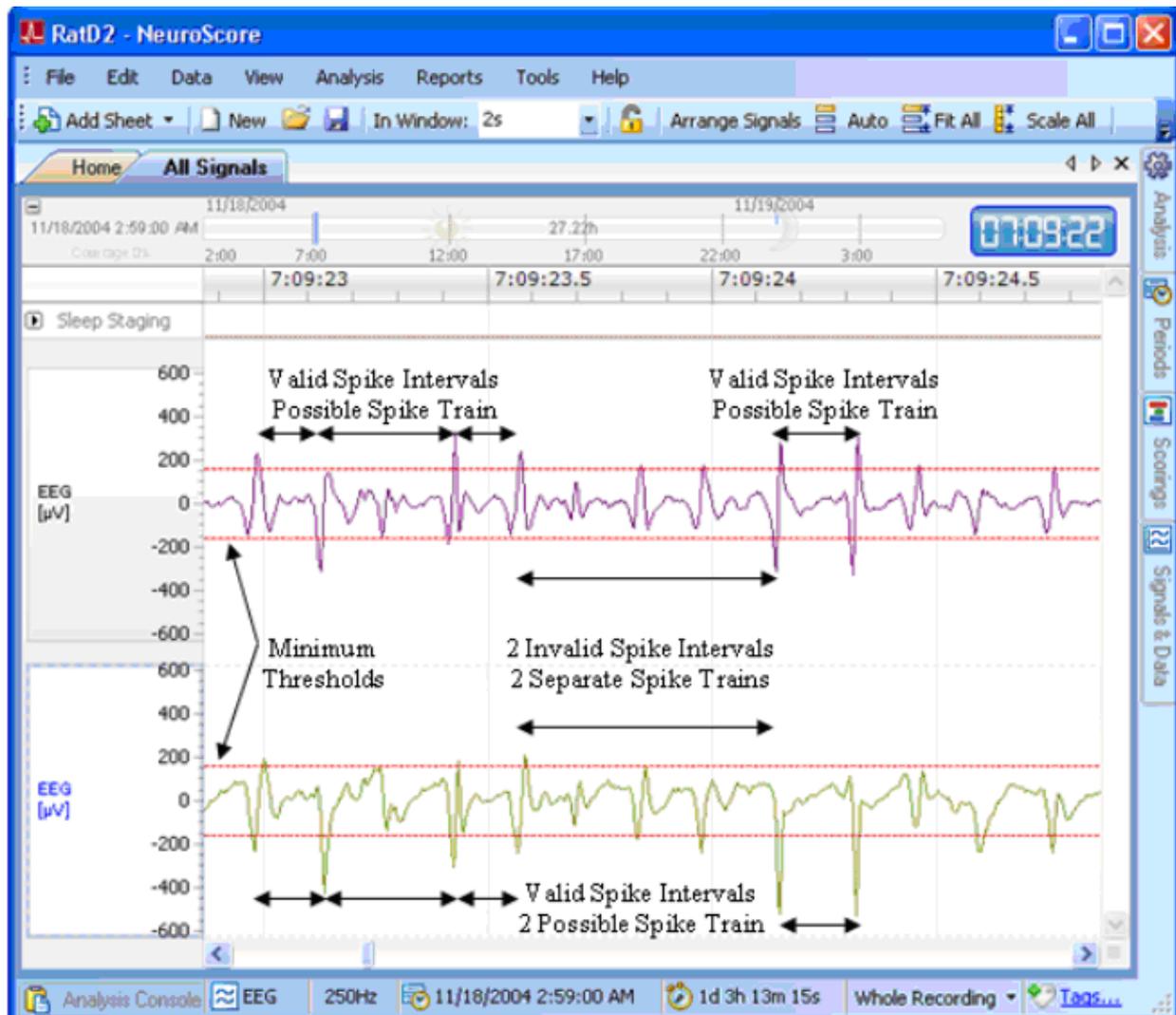


Figure 3: Depicts valid and invalid peaks based on *Spike Duration*.

To determine these *Spike Durations*, locate sections of the EEG signal considered to contain valid spikes. Use the XY Measure function to determine the time duration a valid spike spans. Spike Durations are measured from the point the ascending portion of the signal spike crosses the threshold to the point the descending portion crosses the threshold. It could be helpful to zoom in on the signal to get a more accurate look between the spike. Zoom in by **clicking-and-dragging** within the signal sheet, then select **Zoom To Area**. Once zoomed in, select **<Shift> + clicking-and-drag** to obtain the difference in x- and y-values between the points selected. Perform these functions on multiple spikes to obtain a good representation of the time durations to base the *Minimum* and *Maximum Spike Durations* on.

### Configuring the Spike Interval

The *Spike Interval* defines the periodicity of valid spikes. If the interval between spikes falls within the range set by the *Minimum* and *Maximum Spike Intervals*, the spike is possibly a member of a spike train. Please see **Figure 4** below.



**Figure 4:** Depicts valid and invalid peaks to be included within spike trains based on *Spike Intervals*.

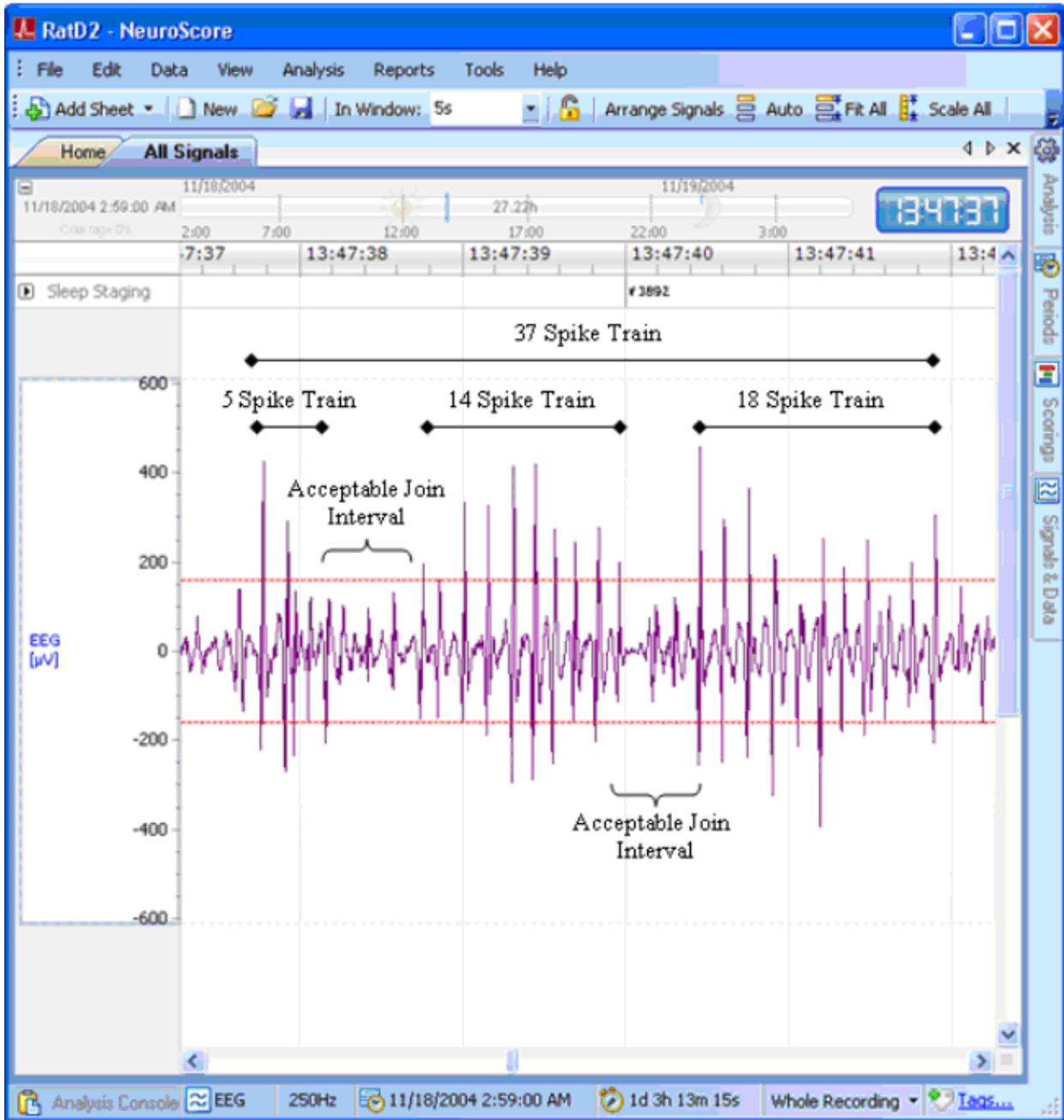
To determine these *Spike Intervals*, locate sections of the EEG signal that contain valid spikes separated by various time durations. *Spike Intervals* are measured peak-to-peak across spikes that exceed the threshold value either positively or negatively. Thus, it is important to make the Minimum Interval short enough to detect durations between consecutive positive-to-negative peaks and the Maximum Interval long enough to detect durations between consecutive positive-to-positive peaks.

Use the **Zoom (click-and-drag)** and **XY Measure (<Shift> + click-and-drag)** functions to determine the time durations between spikes. Perform these functions between multiple spikes to obtain a good representation of the time durations to base the *Minimum* and *Maximum Spike Interval* constraints on.

### Configuring Spike Train Parameters

The *Spike Train Parameters* define group spike characteristics to determine which spikes collectively constitute a single spike train. The three parameters include *Minimum Train Duration*, *Train Join Interval*, and *Minimum Number of Spikes*.

The *Minimum Train Duration* defines the time duration a spike train must span in order to be considered a valid train. The *Train Join Interval* defines the upper limit of the time range subsequent trains must begin within to be marked as a single train. The *Minimum Number of Spikes* defines the least number of valid spikes that must be present in order for them to collectively be marked as a train.



**Figure 5:** Depicts multiple spike trains that would be marked together as one spike train since the time between each spike train meets the defined join interval.

To configure these parameters, use the **Zoom (click-and-drag)** and **XY Measure (<Shift> + click-and-drag)** functions to determine the time durations for the appropriate parameter of interest. Perform these functions on multiple trains to obtain a good representation of the time durations to base the time constraints on.

## NeuroScore's Spike Train Algorithm

The automated Spike Train Detecting algorithm will proceed in the following order on each possible spike it passes over.

1. The protocol will only be applied to the active period.
2. Any data that has already been marked manually will be overwritten. Save previous results before applying the protocol.
3. If the spike meets the amplitude criteria, specified using either the *Dynamic* or *Absolute Thresholds*, the spike will move to the next test.
4. If the spike spans over a time duration within the defined range set by the *Spike Duration*, it will move on.
5. If the spike is within the time constraints of the *Spike Interval*, it will be considered as part of a train and will move on.
6. If the number of spikes detected as part of the train exceeds the *Minimum Number of Spikes*, it will move on.
7. If not, the spikes are tested to see if they fall within the *Join Interval* to be taken in by the previous train.
8. If the train spans longer than the time defined by the *Minimum Train Duration*, it will be marked as a Spike Train.
9. NeuroScore will then repeat steps 1-8 on the next spike(s).
10. If the next train begins within the time specified by the *Join Interval*, it will join the previous spike train and both will be marked as a single spike train.

# Video Synchronization

## Video Synchronization Module

Video Synchronization is available as an additional accessory to the NeuroScore's core software, which allows for recorded video data to be loaded along with data from other sources, such as telemetry. Once loaded, video data can be reviewed with the associated data, fully synchronized, to complement the analysis process. Video information allows visual assessment of the subject's behavior, confirmation of scoring events, classification of seizure types and more.

NeuroScore video reviewing is compatible with the following video data acquired using the following systems:

1. Dataquest A.R.T.
2. Ponemah Physiology Platform

*Note:* Video cannot be analyzed directly by NeuroScore, nor is it considered by the Detectors in NeuroScore's Automated Scoring Protocols; it is meant strictly for observatory purposes.

## Reviewing Video Data

To play video data:

1. Open a recording that contains video data.
2. Select the **View** menu
3. Select **Video Player**
4. **Click-and-drag** the *Time Axis Synchronization Marker*  to the corresponding time point of interest
5. Select the **Play** button in the toolbar to begin video playback

**OR**

6. Select **View - Playback - Play Realtime/Play Fast**

**OR**

7. Press the **<Spacebar>**

*Note:* Locations where video data is present within the study is depicted by a solid, blue bar at the top of the *Time Axis Bar*, see the *Navigational Bar* section. Also, *Video* will not show up in the *Media* column of the library until after the recording has been opened once. Also, make sure that the recording time zone is set properly for the video to show. Please see *Recording Properties* for further information.

Three ways to stop video playback:

1. Click the **Stop** button in the tool bar.
2. Select **View - Playback - Stopped**
3. Press the **<Spacebar>**

To Dock/Undock the Video Player from the top of the active signal sheet:

1. To *undock* - **Click-and-drag** the top of the player (where it is labeled) anywhere on the computer screen; it can even be outside of the *NeuroScore* window.
2. To *dock* - **Click-and-drag** the top of the player back to the top of the signal sheet and the window will update accordingly to allow the player to dock again.

Resizing the Video Player:

1. Mouse over its edge until a black, double-sided arrow appears.
2. **Click-and-drag** the edge to an appropriate size.

# Analysis Examples

## Analysis Examples

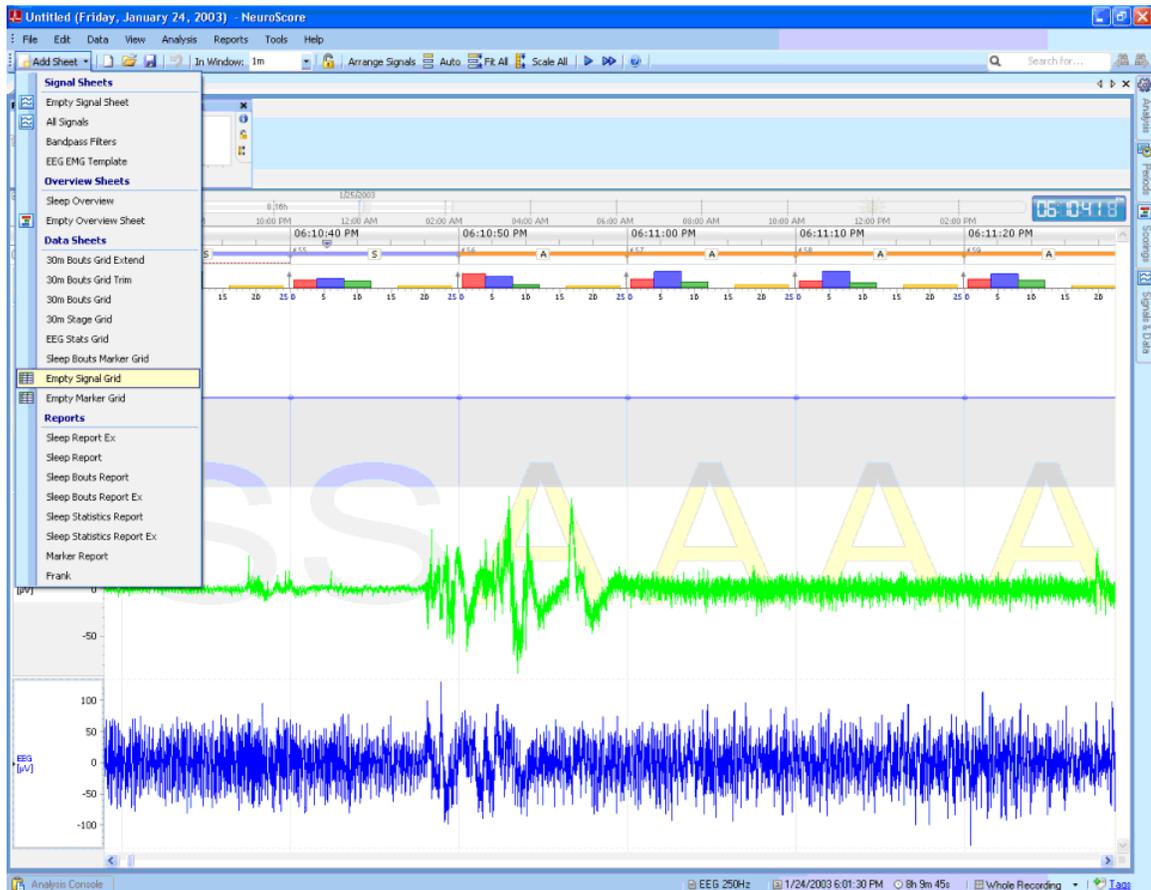
Follow the links below to go through examples of step by step methods for analyzing data:

- [Creating a Custom EEG Stat Grid](#)
- [Rodent Sleep Scoring Analysis Session](#)
- [Seizure Module Analysis Session](#)
- [Start to Finish using Templates](#)

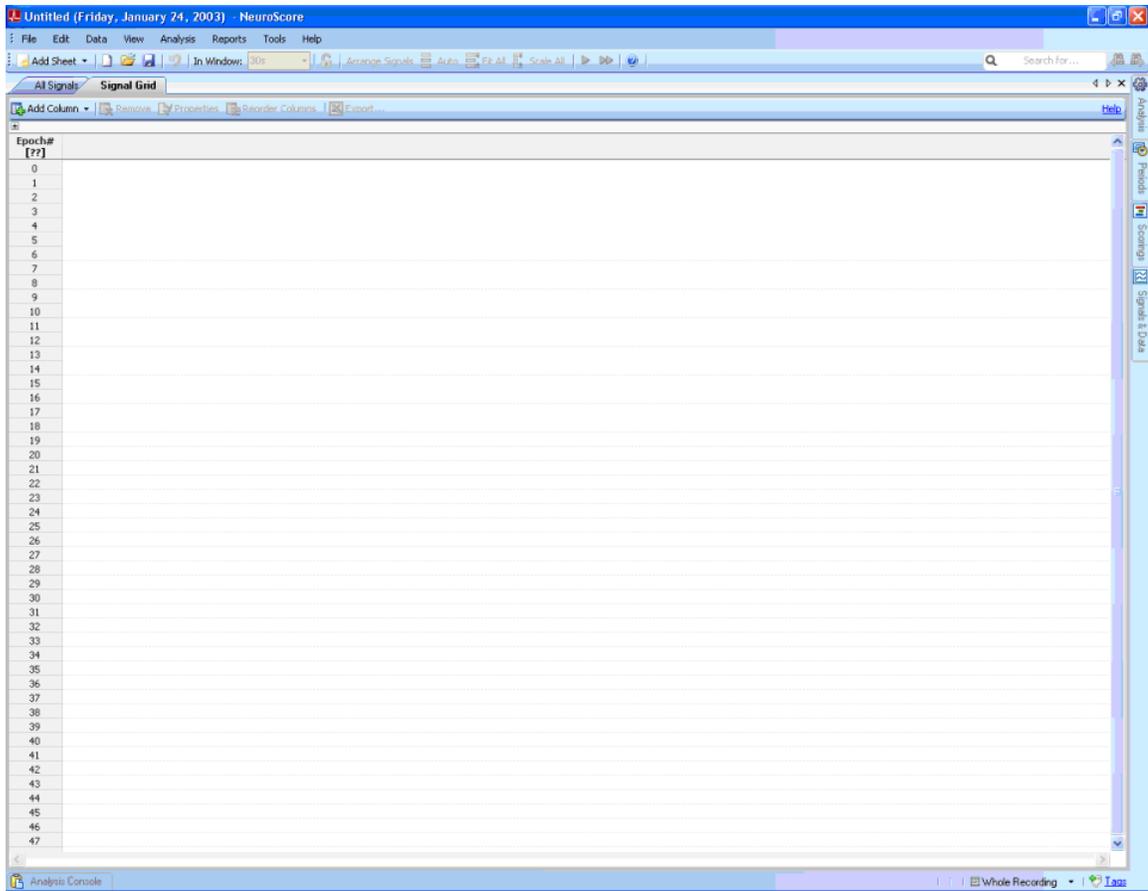
## Creating a Custom EEG Stat Grid

Follow the steps below to go from a blank signal grid sheet to a template signal grid sheet that is saved as a layout for future use.

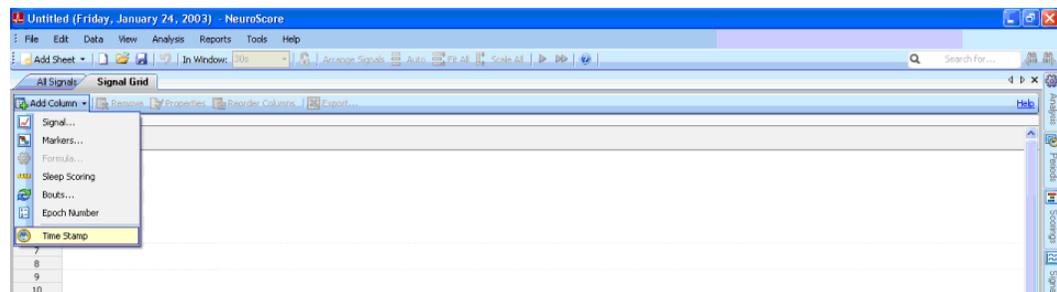
1. Click the **Add Sheet - Empty Signal Grid**



2. A new tab will open in the *NeuroScore* window.



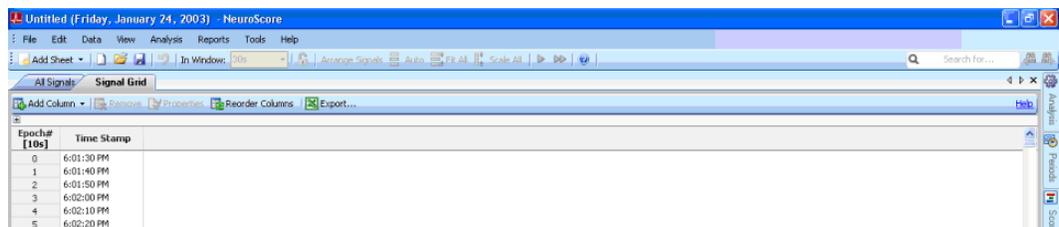
3. To rename the grid: **Right-click** (on the sheet tab)-**Rename Sheet**.
4. Add **Time Stamp**
  - a. Select **Add Column - Time Stamp**



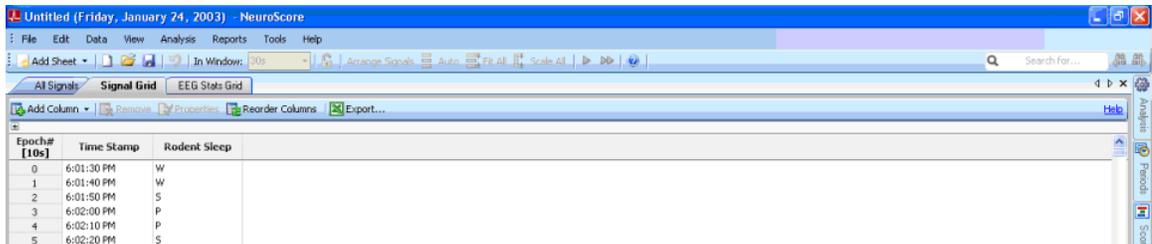
- b. Enter the desired Epoch Duration; default is 10 seconds



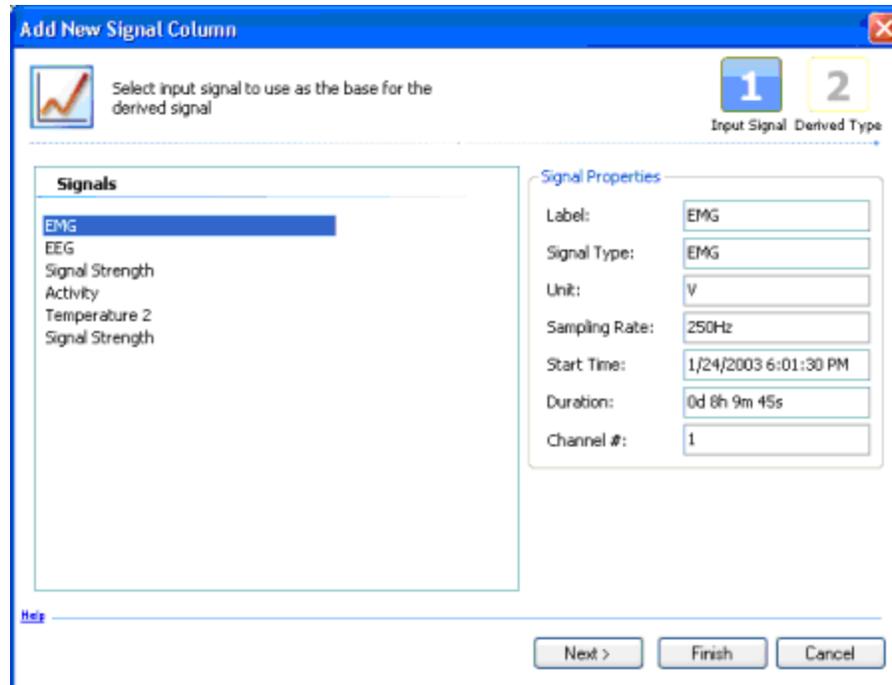
c. Click **OK**



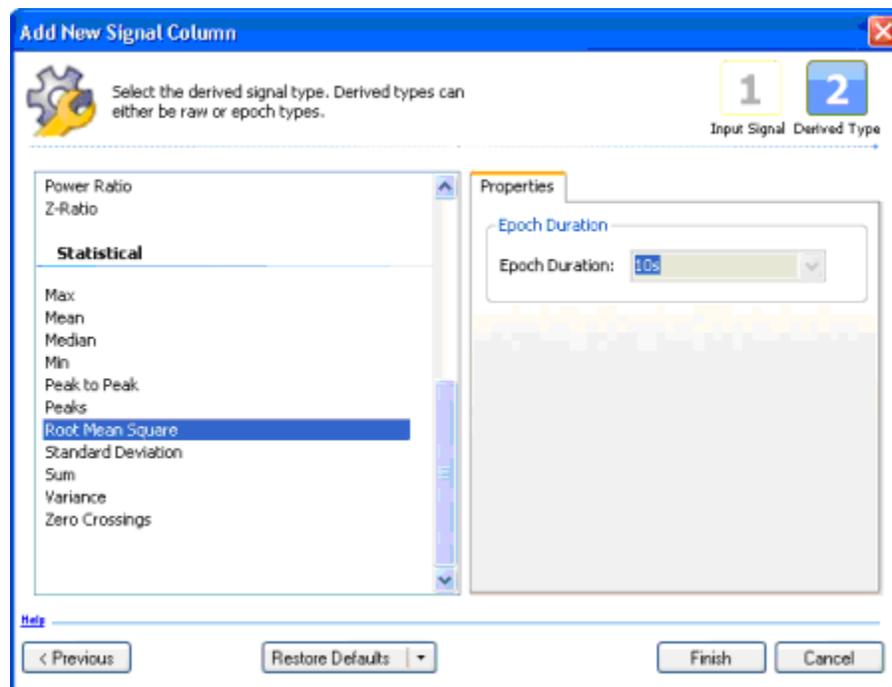
5. Add the **Sleep Scoring** markers for each epoch by selecting **Add Column - Sleep Scoring**



6. Add *EMG Root Mean Square* data  
 a. Select **Add Column - Signal**  
 b. Select **EMG** under the *Signals* heading



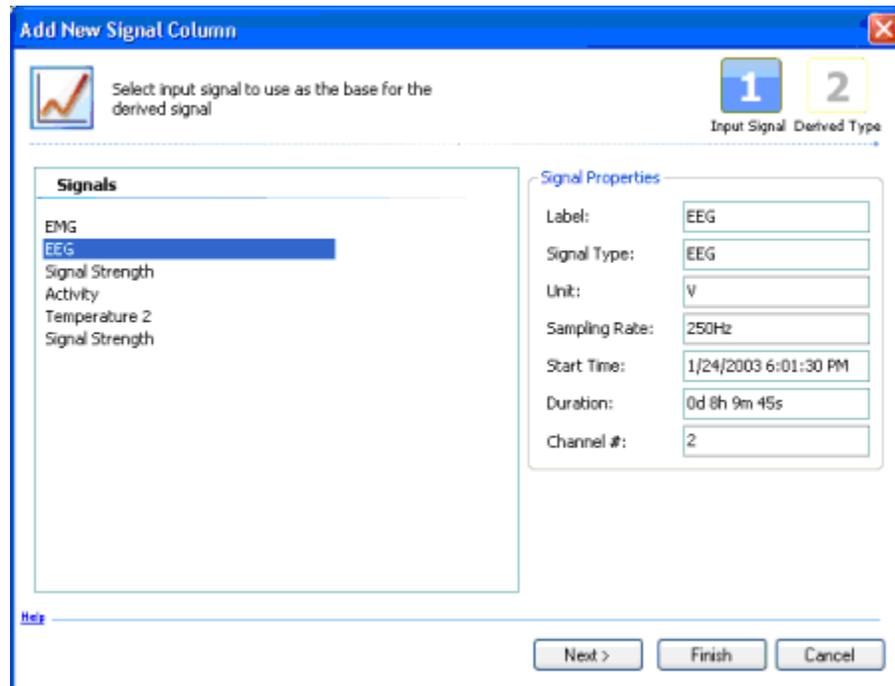
- c. Click **Next**
- d. Select **Root Mean Square** under the *Statistical* heading



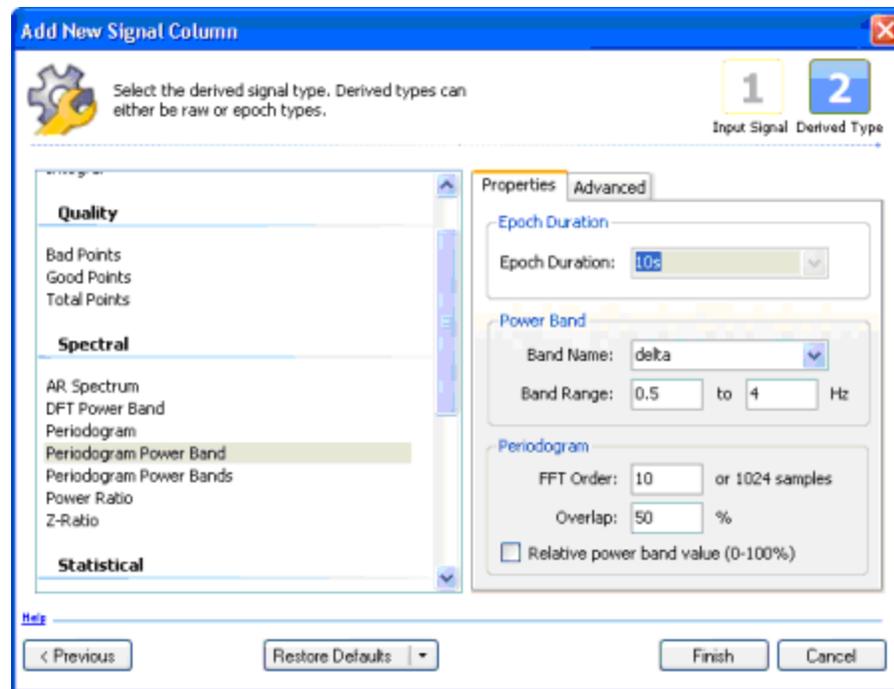
- e. Choose an **Epoch Duration** equivalent to the one choose in Step 4.b.
- f. Click **Finish**

Epoch# [10s]	Time Stamp	Rodent Sleep	EMG (RMS, 10s)
0	6:01:30 PM	W	2.167e-06
1	6:01:40 PM	W	2.172e-06
2	6:01:50 PM	S	6.447e-06
3	6:02:00 PM	P	2.563e-06
4	6:02:10 PM	P	2.435e-06
5	6:02:20 PM	S	2.515e-06

7. Add *EEG Periodogram Power Bands* in their own columns
  - a. Select **Add Column - Signal**
  - b. Select **EEG** under the *Signals* heading



- c. Click **Next**
- d. Select **Periodogram Power Band** under the *Spectral* heading
- e. Enter a **Power Band Name and Range, and Periodogram FFT Order and Window Overlap** under the *Properties* heading



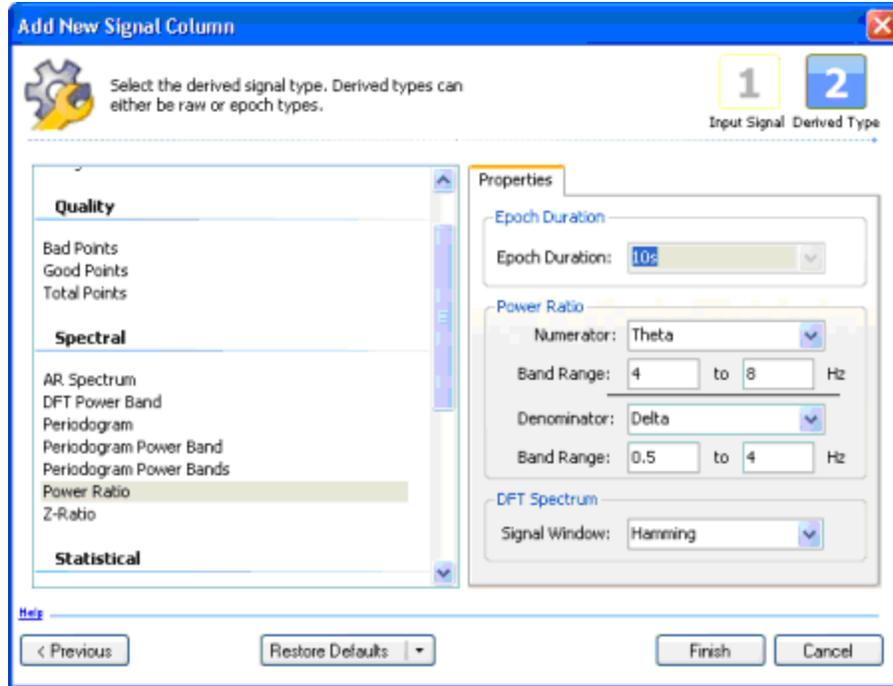
f. Click **Finish**

Epoch [10s]	Time Stamp	Rodent Sleep	EMG (RMS, 10s) V	EEG (Delta, 0.5-4Hz, 10s) V <sup>2</sup>
0	6:01:30 PM	W	2.167e-06	0.0001509
1	6:01:40 PM	W	2.172e-06	0.0001022
2	6:01:50 PM	S	6.447e-06	0.0001541
3	6:02:00 PM	P	2.563e-06	0.0001184
4	6:02:10 PM	P	2.435e-06	0.000139
5	6:02:20 PM	S	2.515e-06	0.0001656

g. Repeat steps **a-f** for additional Power Bands of interest

Epoch [10s]	Time Stamp	Rodent Sleep	EMG (RMS, 10s) V	EEG (Delta, 0.5-4Hz, 10s) V <sup>2</sup>	EEG (Theta, 4-8Hz, 10s) V <sup>2</sup>	EEG (Alpha, 8-12Hz, 10s) V <sup>2</sup>
0	6:01:30 PM	W	2.167e-06	0.0001509	0.0002233	9.983e-05
1	6:01:40 PM	W	2.172e-06	0.0001022	0.0001467	0.0002164
2	6:01:50 PM	S	6.447e-06	0.0001541	0.0001919	5.287e-05
3	6:02:00 PM	P	2.563e-06	0.0001184	0.0001934	0.000181
4	6:02:10 PM	P	2.435e-06	0.000139	0.0003624	0.0001658
5	6:02:20 PM	S	2.515e-06	0.0001656	0.0001928	9.679e-05

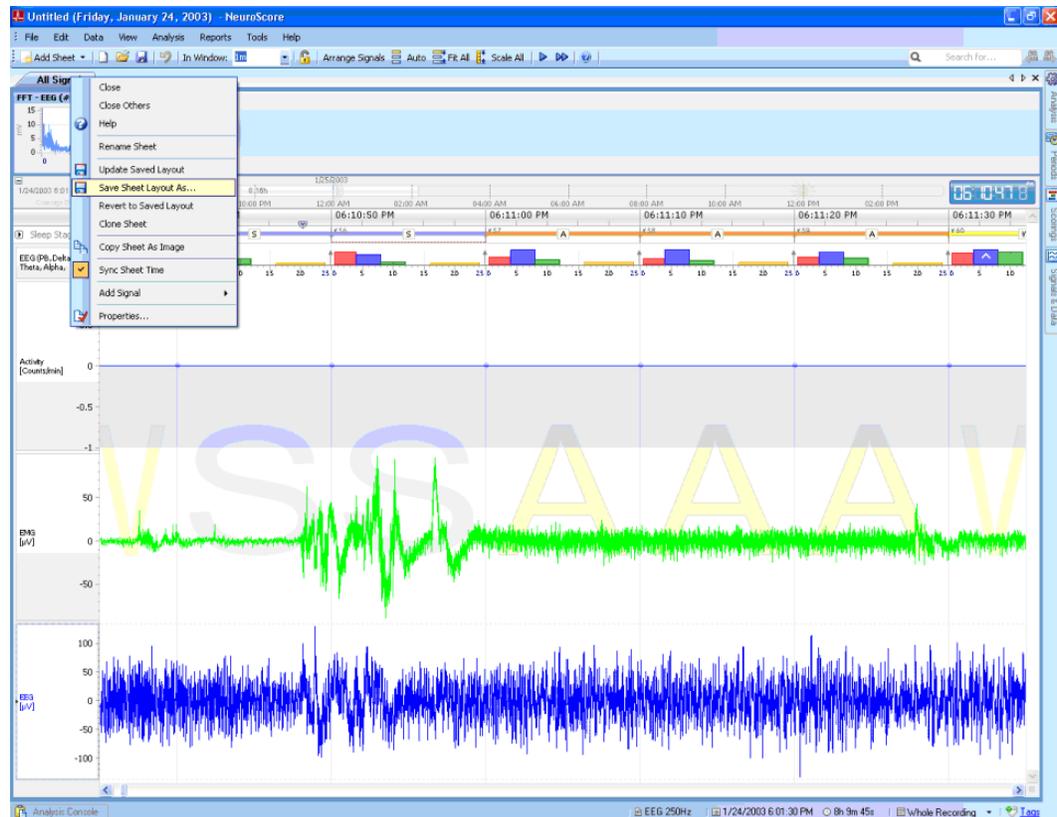
8. Add a column for the *Theta Ratio*
  - a. Select **Add Column - Signal**
  - b. Select **EEG** under the *Signals* heading
  - c. Click **Next**
  - d. Select **Power Ratio** under the *Spectral* heading
  - e. Set the **Numerator and Denominator Band Range to the appropriate frequencies, and select the DFT Spectrum Signal Windowing** method under the *Properties* heading.



f. Click **Finish**

Epoch# [10s]	Time Stamp	Rodent Sleep	EMG (RMS, 10s) V	EEG (Delta, 0.5-4Hz, 10s) V <sup>2</sup>	EEG (Theta, 4-8Hz, 10s) V <sup>2</sup>	EEG (Alpha, 8-12Hz, 10s) V <sup>2</sup>	EEG (Theta, 4-8Hz)/(Delta, 0.5-4Hz), 10s)
0	6:01:30 PM	W	2.167e-06	0.0001509	0.0002233	9.983e-05	1.273
1	6:01:40 PM	W	2.172e-06	0.0001022	0.0001467	0.0002164	1.184
2	6:01:50 PM	S	6.447e-06	0.0001941	0.0001919	5.287e-05	1.237
3	6:02:00 PM	P	2.563e-06	0.0001184	0.0001934	0.000181	1.911
4	6:02:10 PM	P	2.435e-06	0.000139	0.0002624	0.0001658	1.694
5	6:02:20 PM	S	2.515e-06	0.0001656	0.0001928	9.678e-05	1.176

9. Save the Custom EEG Stat Grid as a Layout to allow the use of the same analysis on other recordings opened in the future.
  - a. **Right-click on the Signal Grid - Save Sheet Layout As...**



- b. Enter information in the *Name* field and *Description* field as needed and check the checkbox to automatically insert this sheet layout upon opening a new workspace

- c. Click **Save**

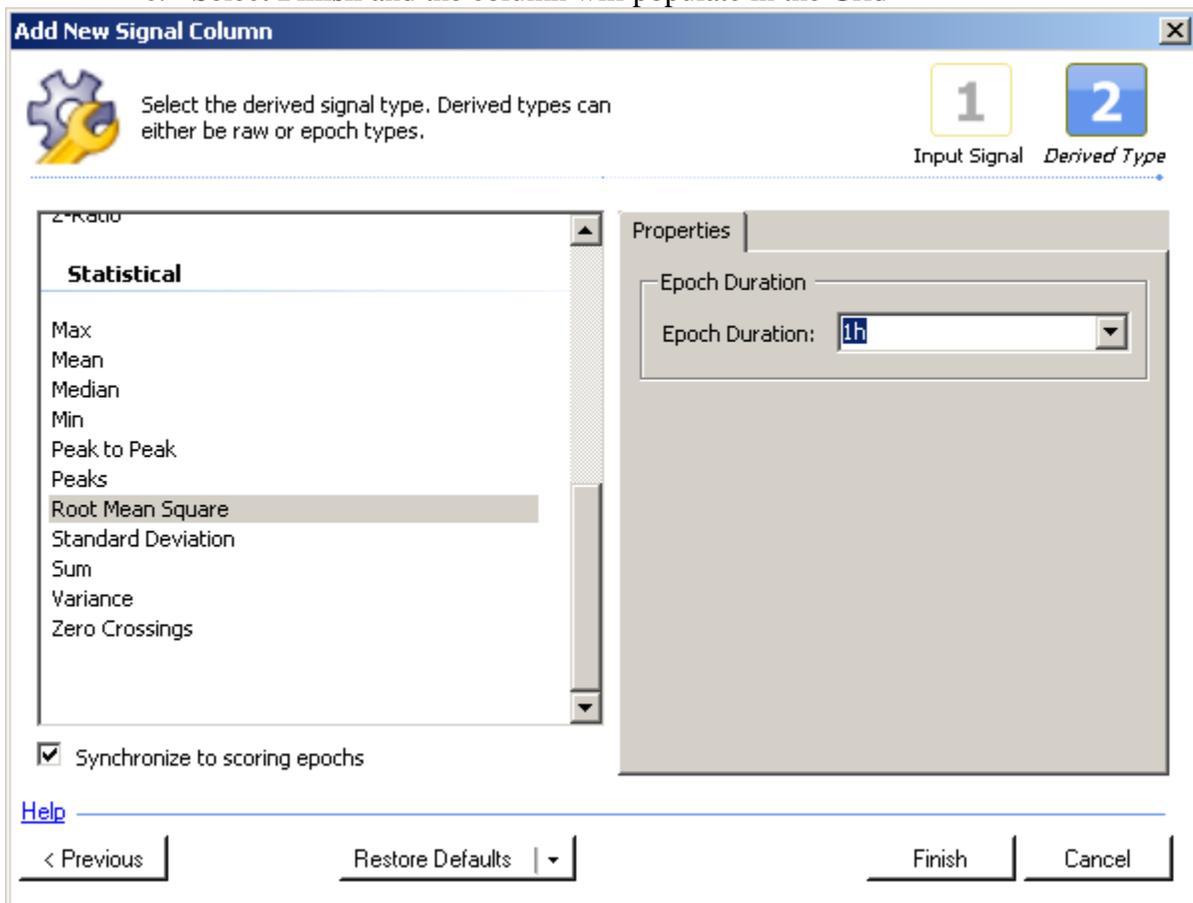
*Note:* For other *Signal Grid* options, such as Editing, Exporting, and Time Syncing, please refer to Working with Grids.

## Creating a Signal Grid using the Period Start Time

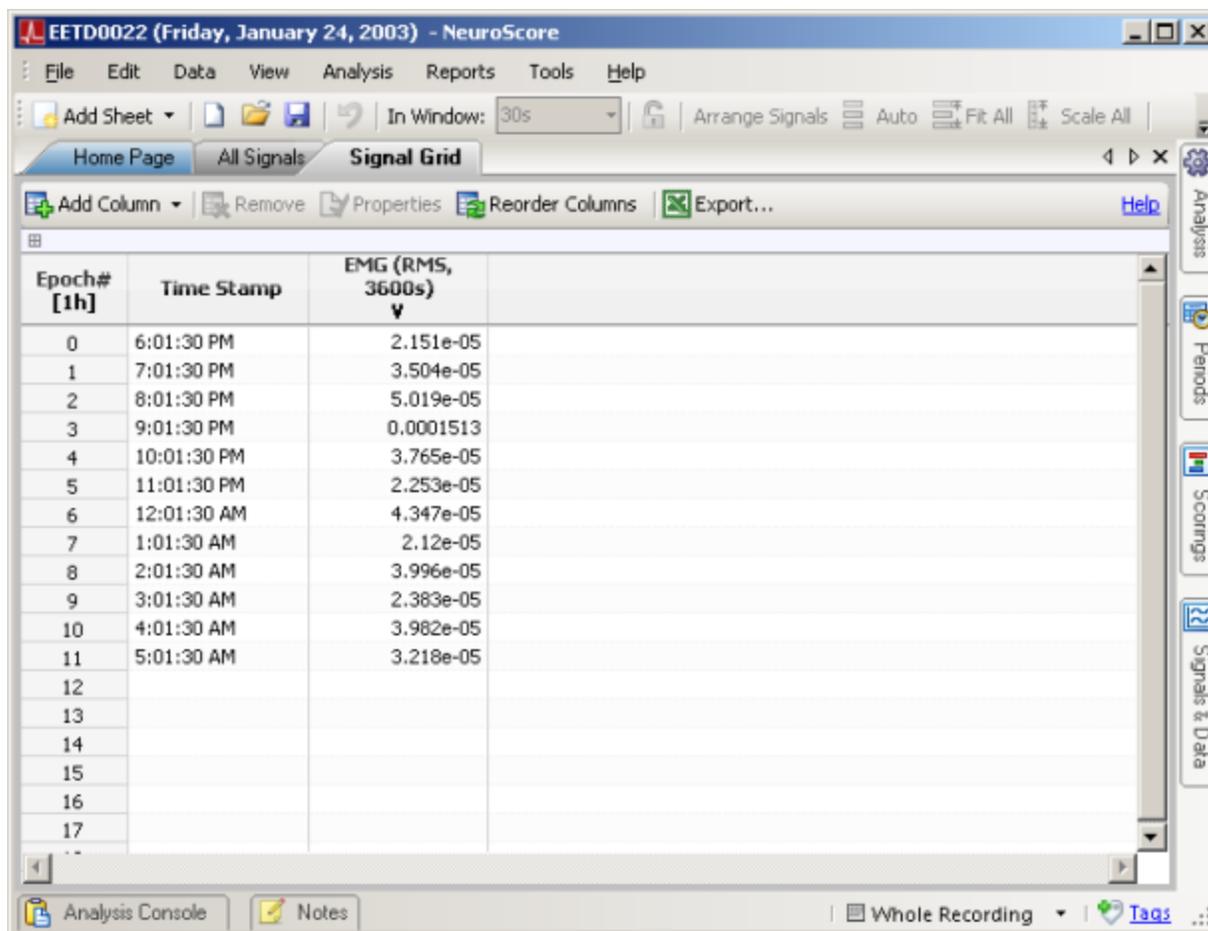
Displaying a Signal Grid interval using the period start time instead of the start of the next full interval

Assuming your recording is open in NeuroScore and you have added an Empty Signal Grid. It is necessary to first add your column of data before adding a Time Stamp. For example, to display the RMS value of the EMG in 1 hour intervals with a period that begins at 6:01:30 (instead of 7:00:00), I would follow these steps:

1. Choose **Add Column - Signal**
2. Select **EMG** and **Next**
3. Select **Root Mean Square** (or other derived signal)
  - a. Check the box **Synchronize to scoring epochs** at the bottom
  - b. Select an Epoch duration of **1h**
  - c. Select **Finish** and the column will populate in the Grid

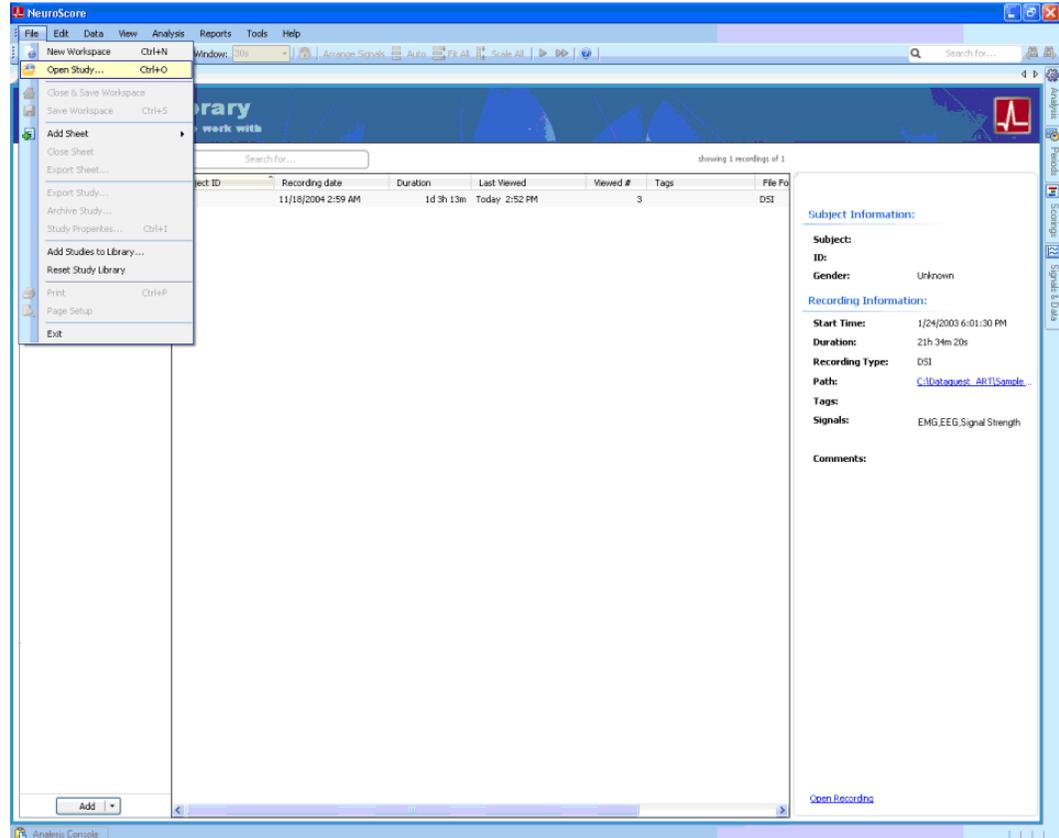


4. Then, choose **Add Column - Time Stamp** and the times will begin at the start of the period

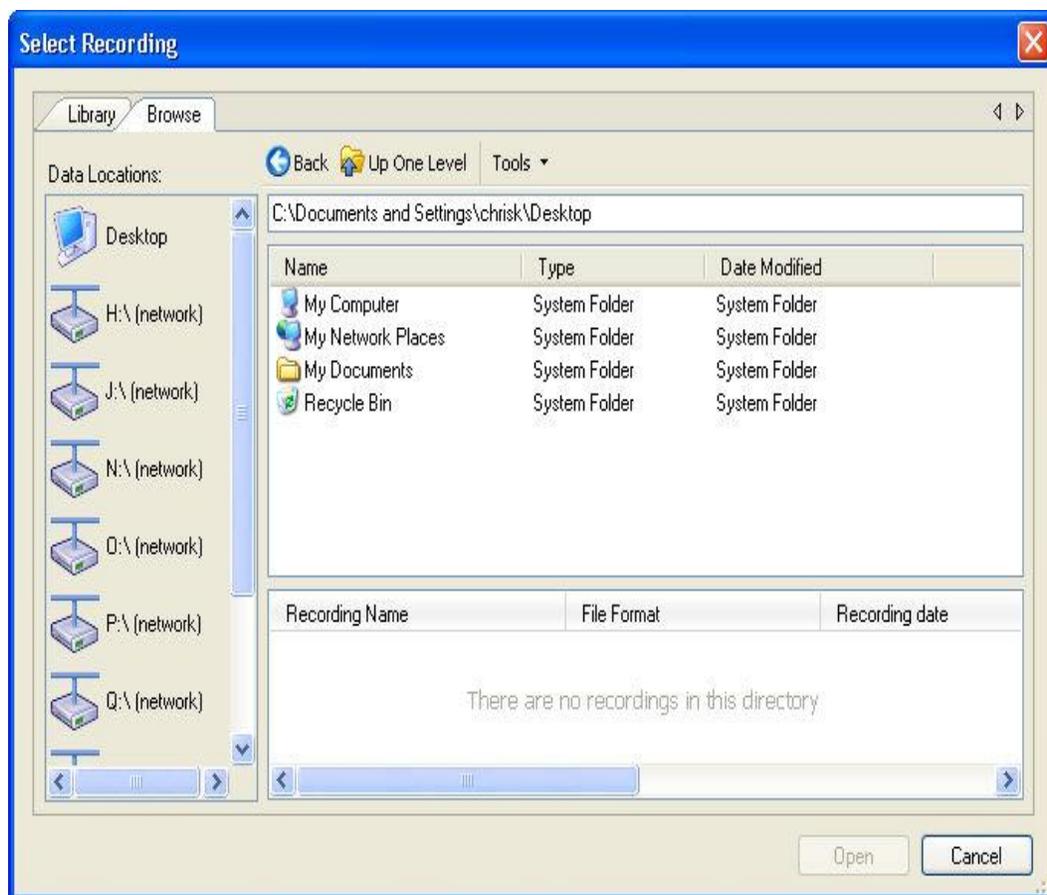


## Rodent Sleep Scoring Analysis Session

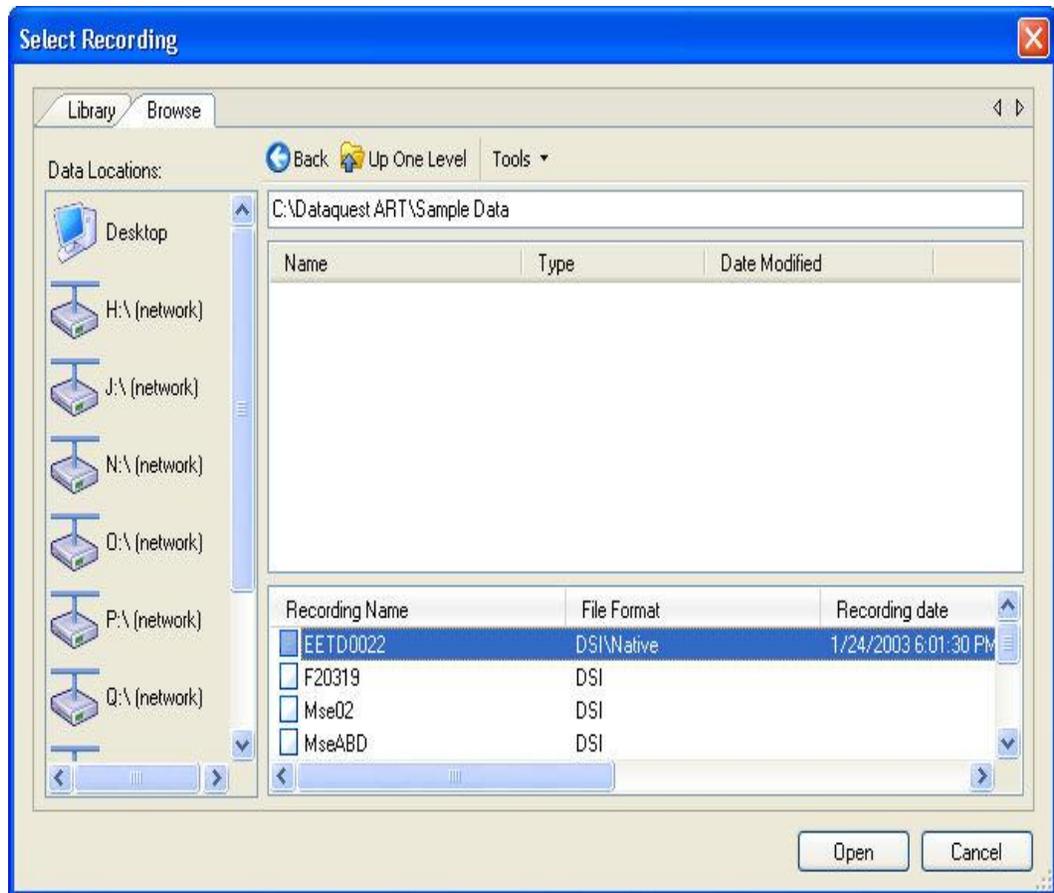
1. Load data from EETD0022 from the *Study Library*
  - a. This is mouse EEG, EMG, Temperature and Activity from an F20-EET
  - b. **Open** NeuroScore
  - c. Select the File Menu - Open Study...



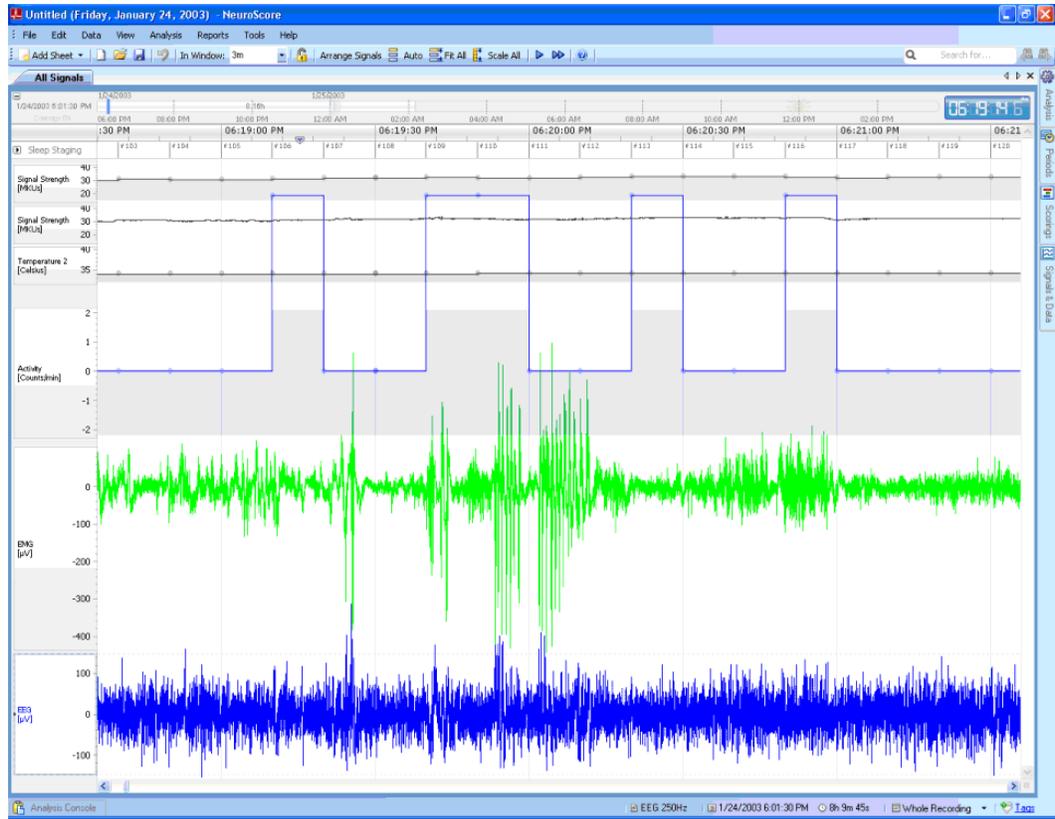
- d. Select the Browse tab



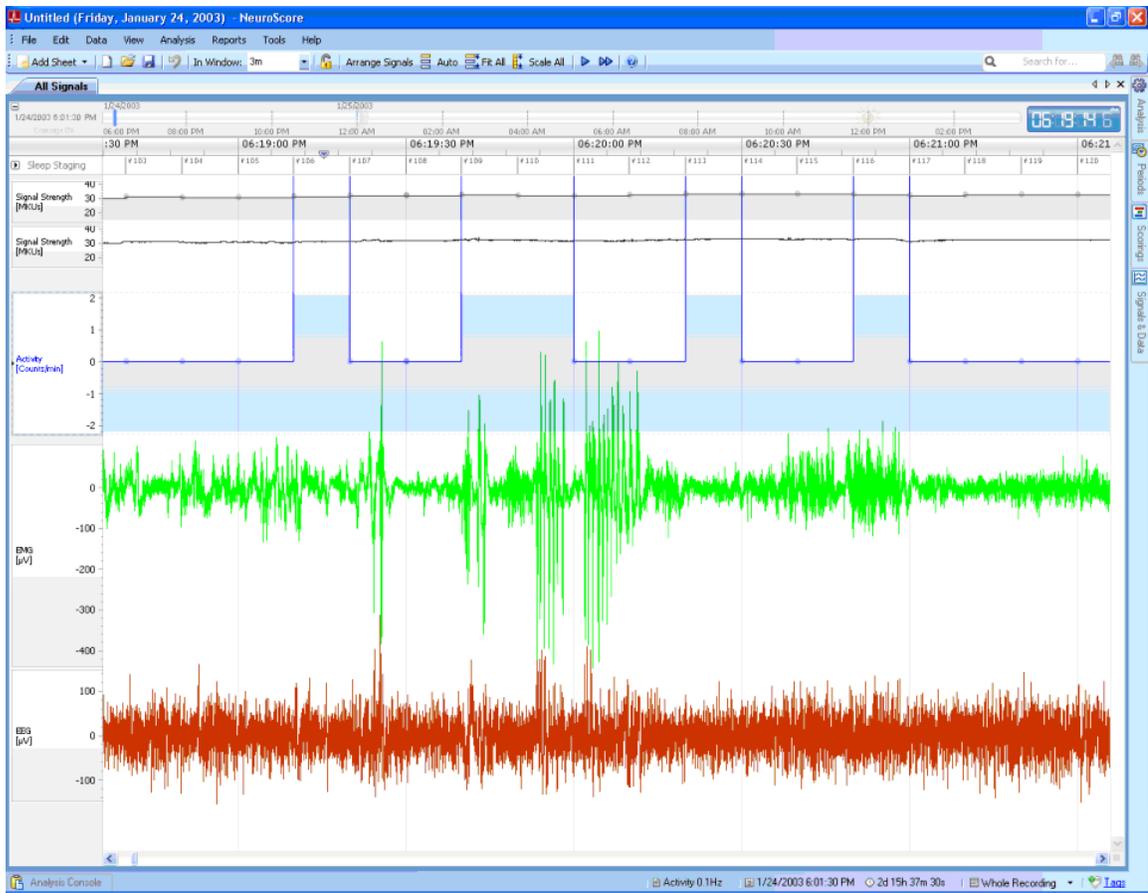
- e. Browse to C:\Dataquest ART\Sample Data\EETD0022 by double left-clicking through each folder and selecting EETC0022



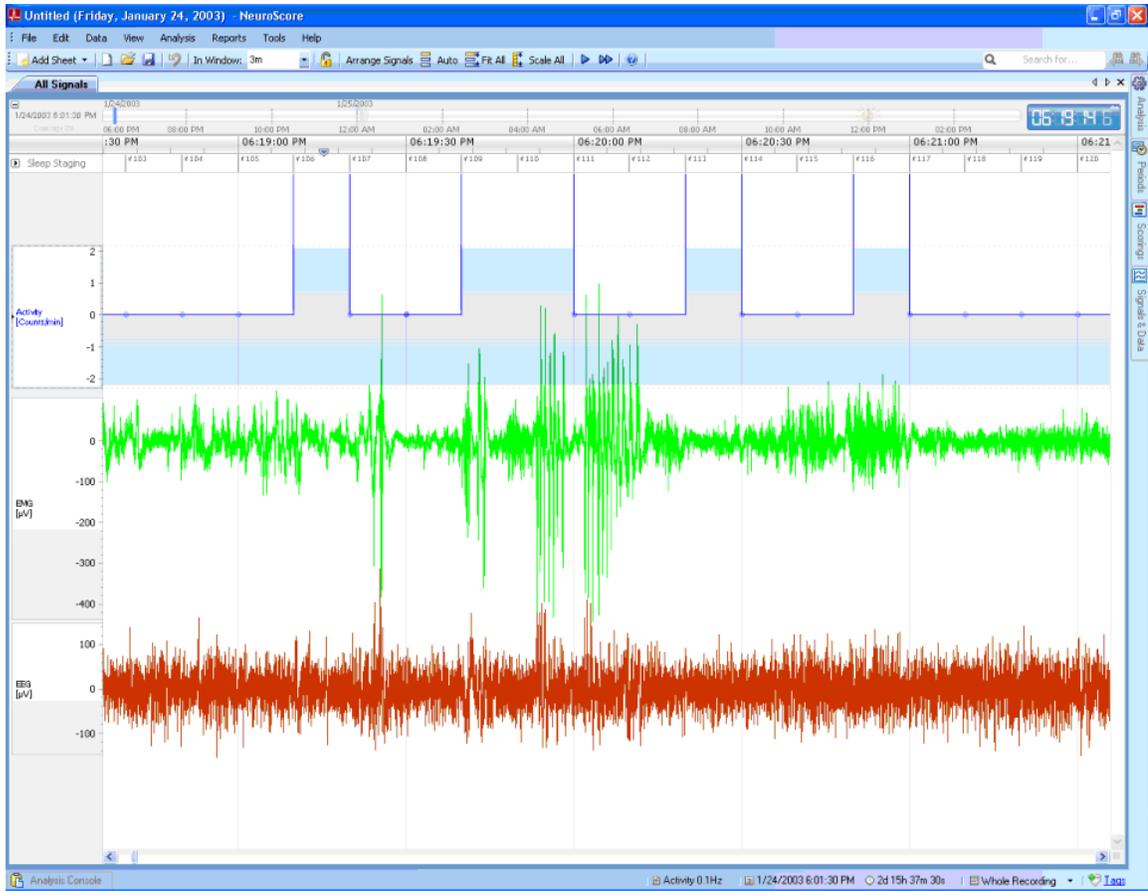
f. Select **Open**



2. Disable temperature (**Right click - Remove Signal**)

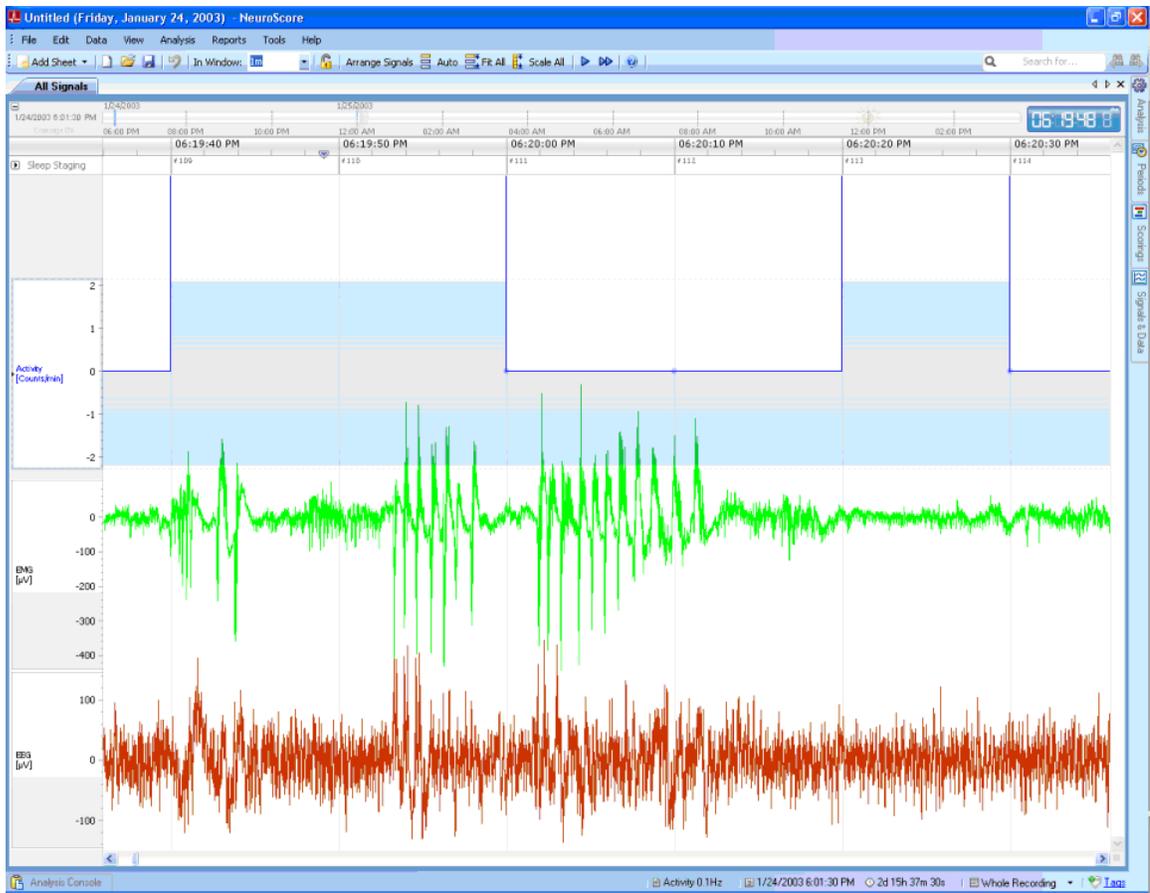


3. Disable signal strength parameter and signal strength waveform from *Signals and Data* tab on the Task Window (**uncheck box**).

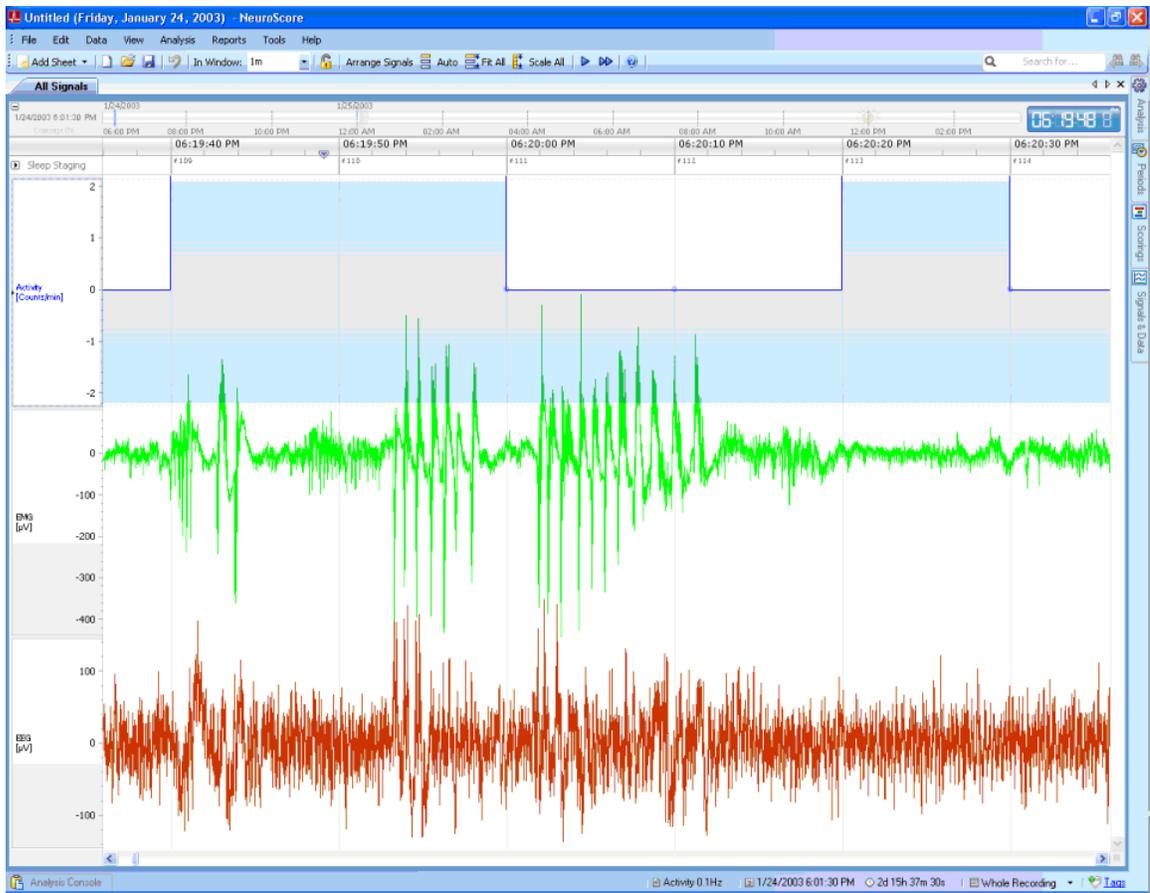


4. Set x-axis to 1 minute (**In Window - 1m**)

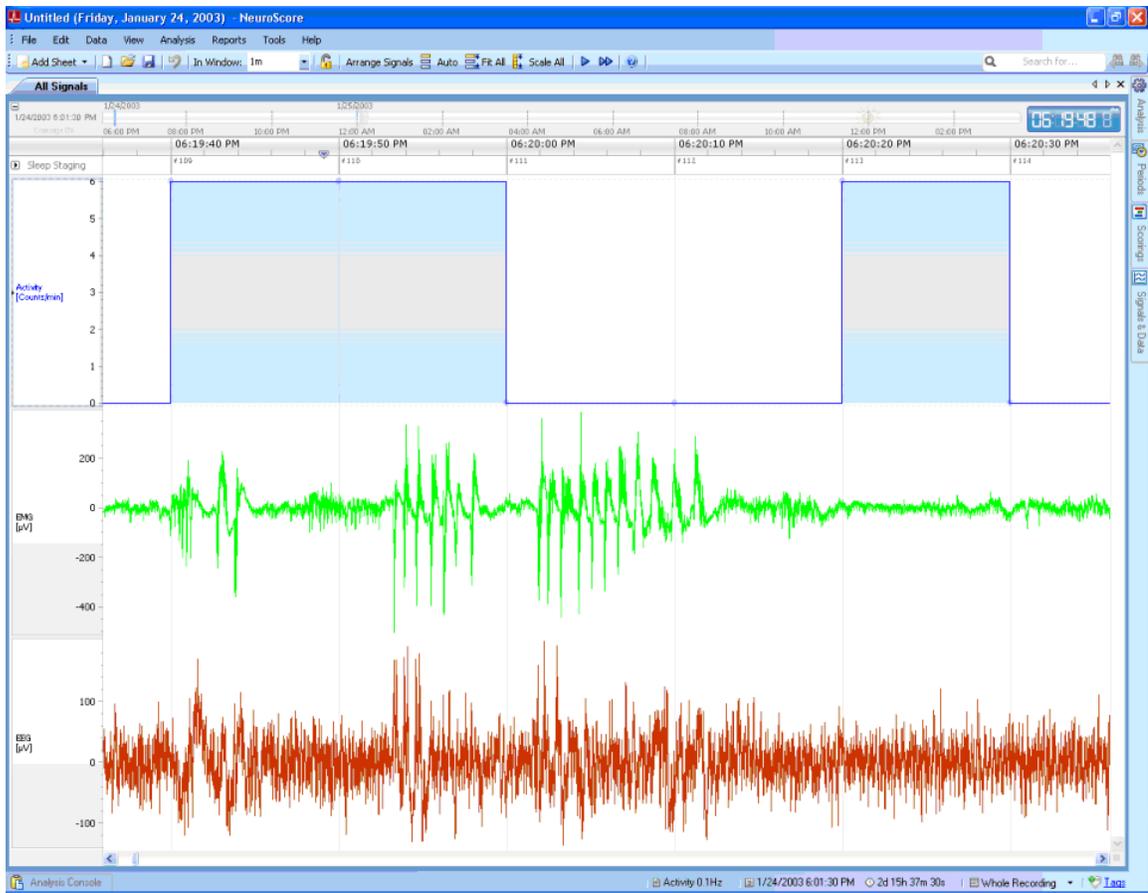
# NeuroScore Version 3.0



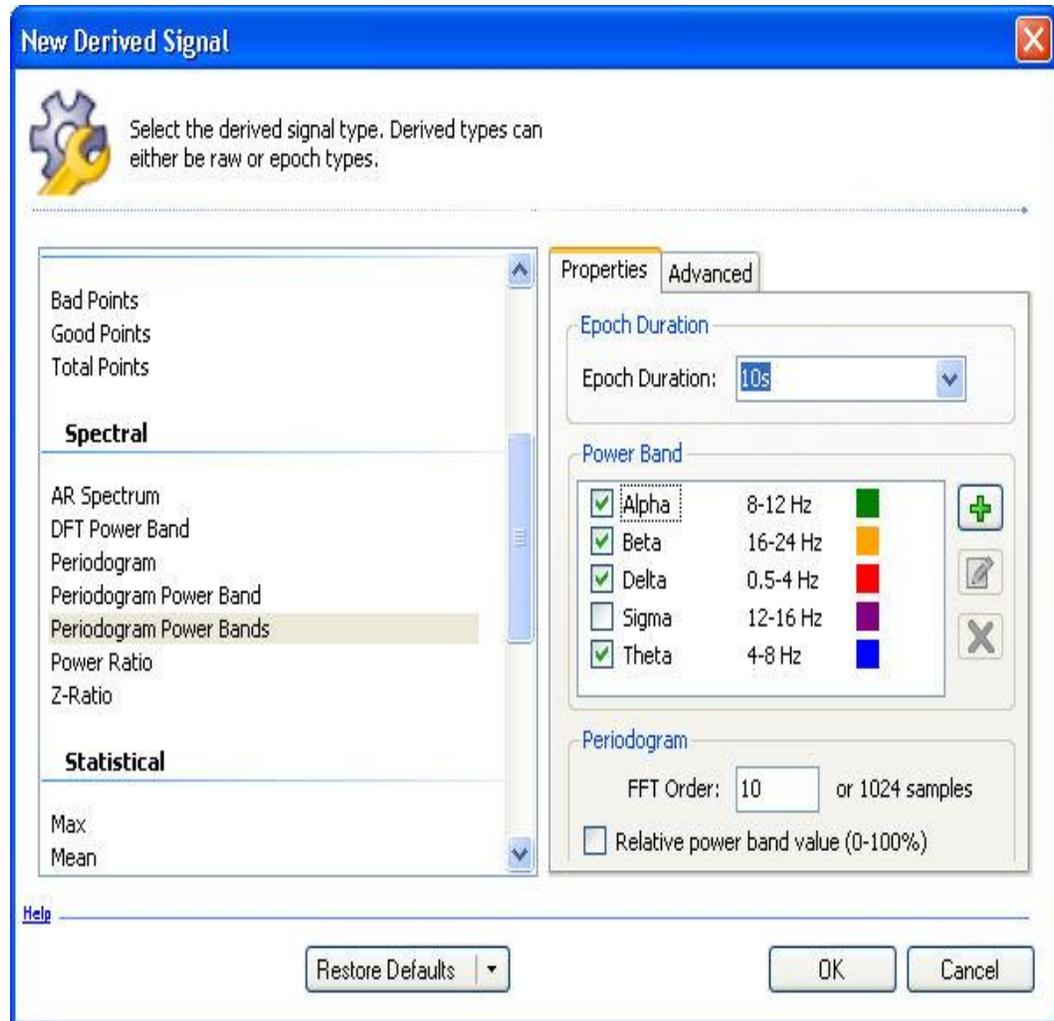
5. Select Fit All from the toolbar



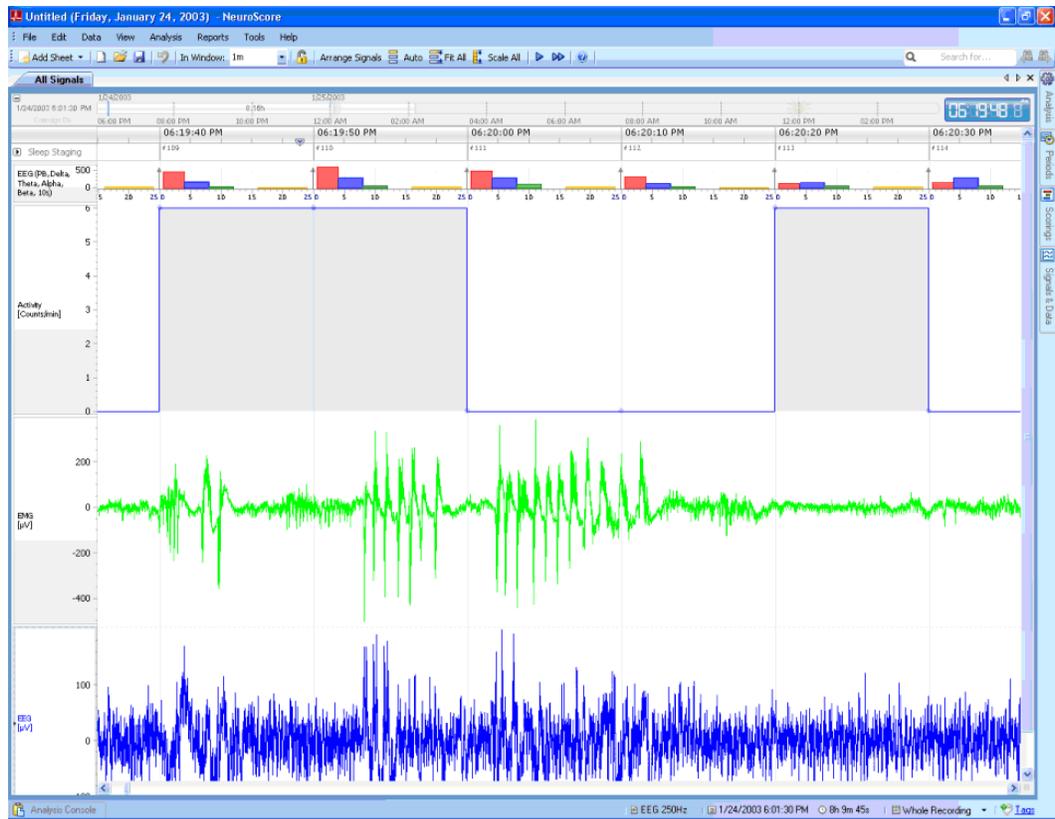
6. Select Scale All from the toolbar



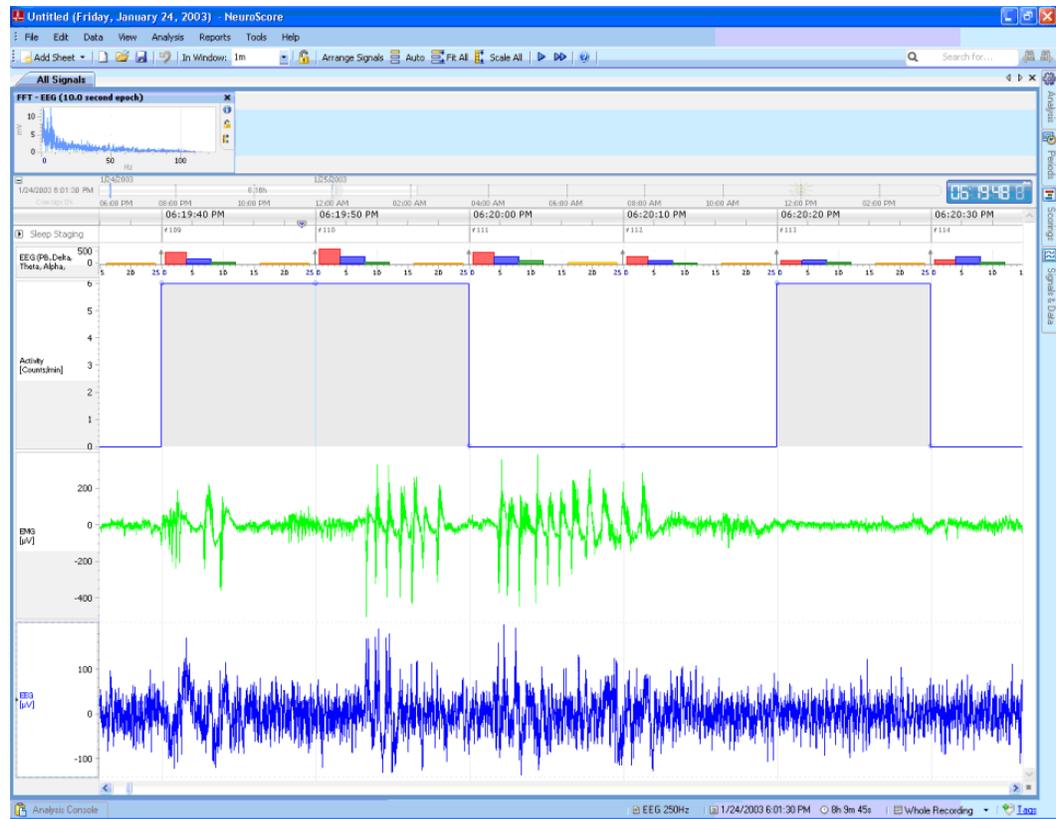
7. Create a derived signal from the EEG waveform and add it to the *All Signals* sheet.
  - a. **Right click on EEG waveform - Add Derived Signal...**
  - b. From the *Spectral* section of the *Derived Signal Wizard*, choose *Periodogram Powerbands* signal
  - c. Turn off the *Sigma* power band by unchecking that corresponds to the Sigma band
  - d. The other settings can remain as is



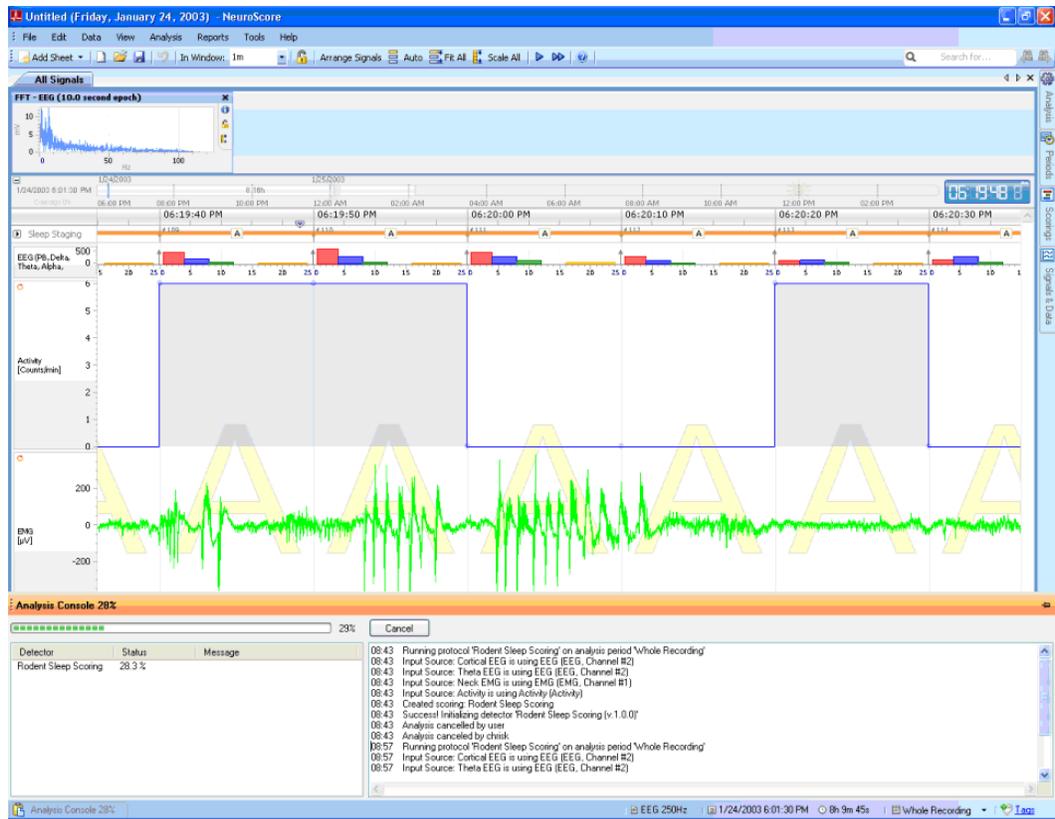
e. Click **OK**



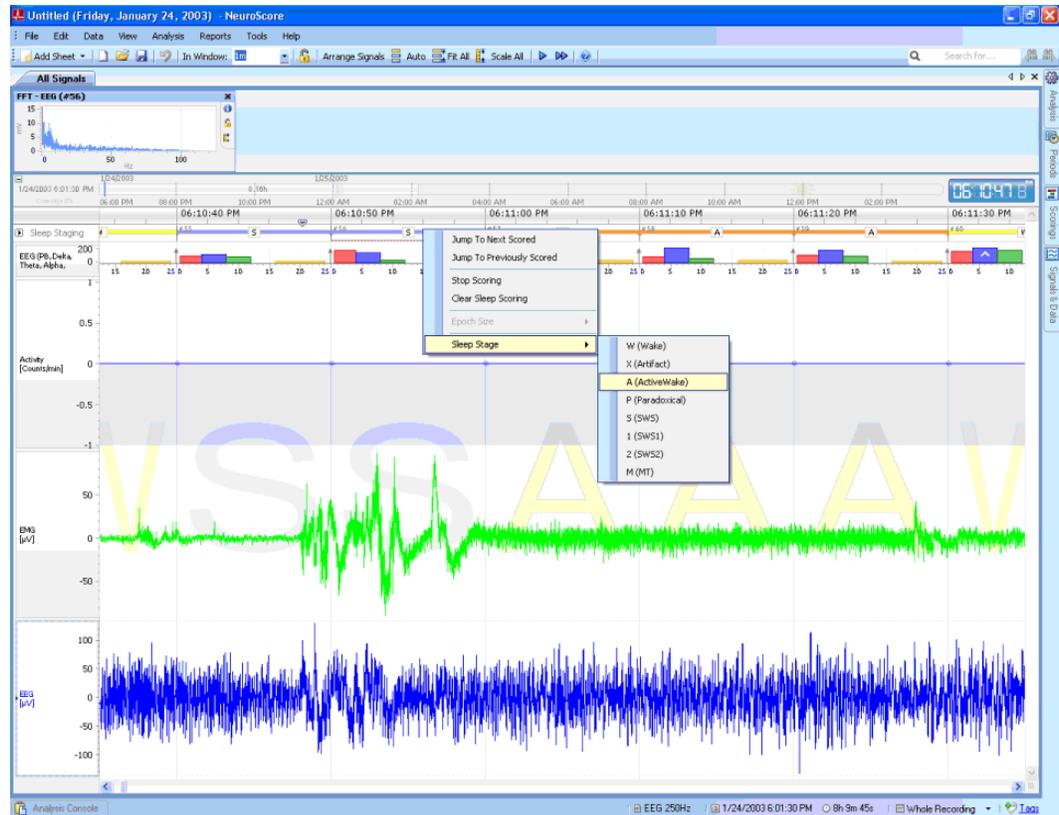
8. The x-axis time interval displayed can be changed using step 4 above, the sheet will update and will display larger amounts of data accurately.
9. Add a derived graph
  - a. Left-click on the EEG waveform
  - b. Select **View - FFT**



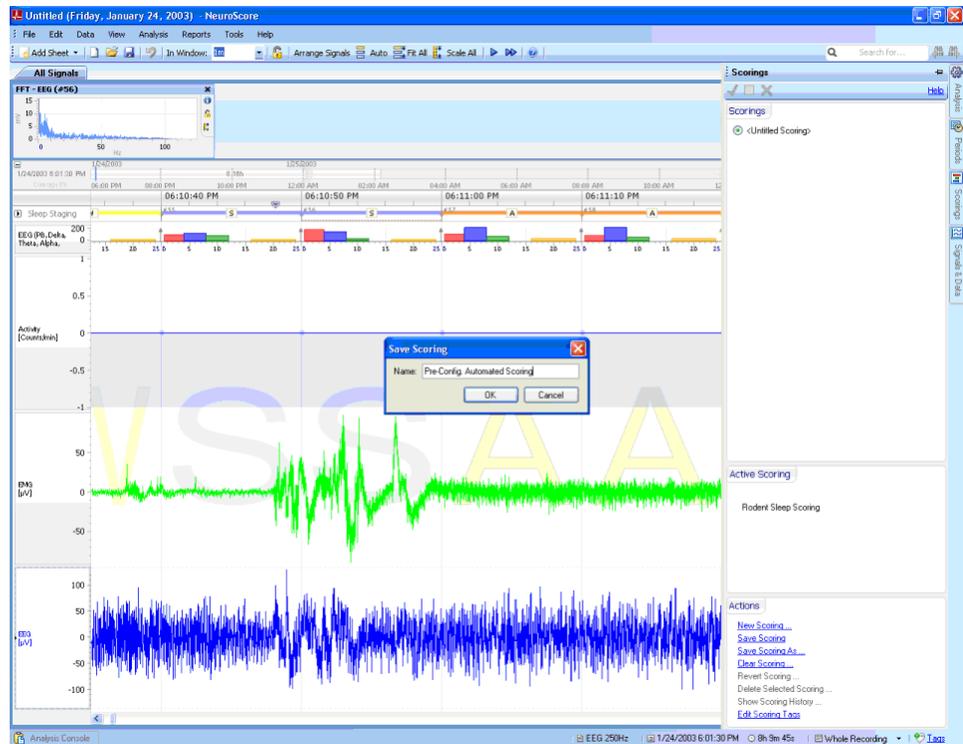
10. Run a pre-configured protocol to get an automated scoring of the loaded data.
  - a. Click **Analysis - Rodent Sleep Scoring**



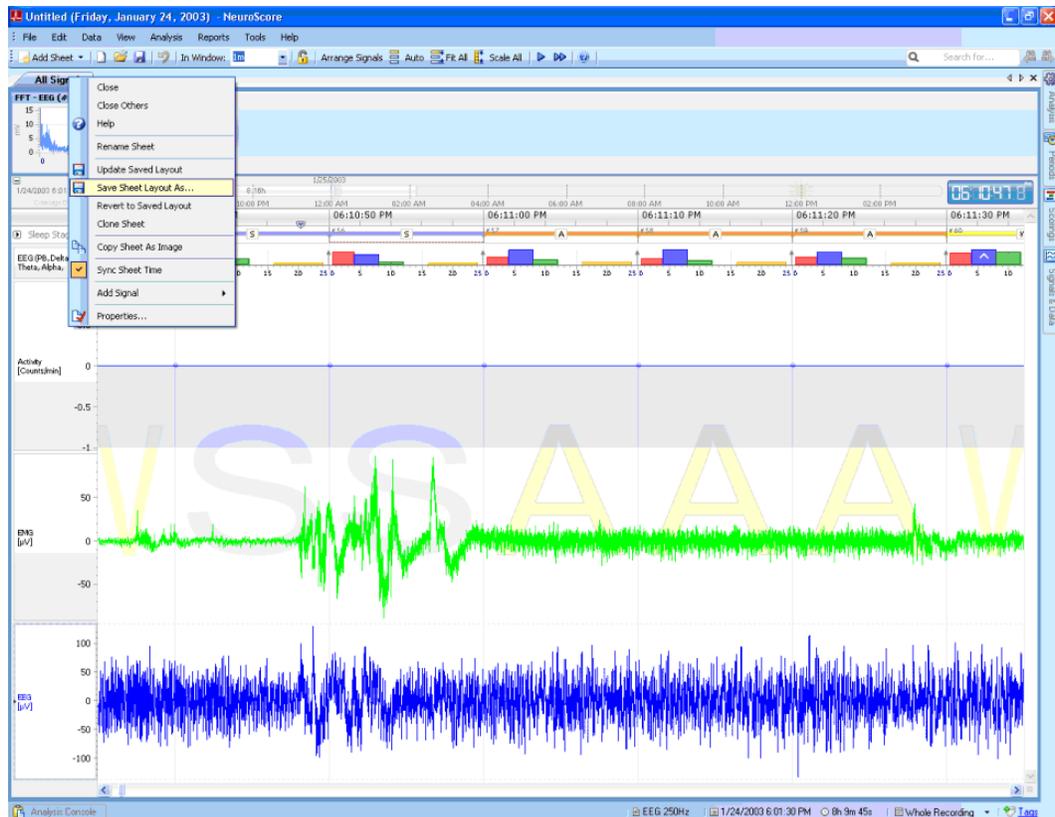
- b. This will mark the data with sleep stages according to the protocol
- c. These marks can be changed by Right-clicking on the Sleep Staging bar and then selecting **Sleep Stage - Appropriate stage**



- d. Save this protocol
  1. Click **Scorings** tab on the Task Window
  2. Under the *Active Scoring* section click **Rodent Sleep Scoring**
  3. Under *Actions*, select **Save Scoring As...**
  4. Enter a name for this *Scoring*

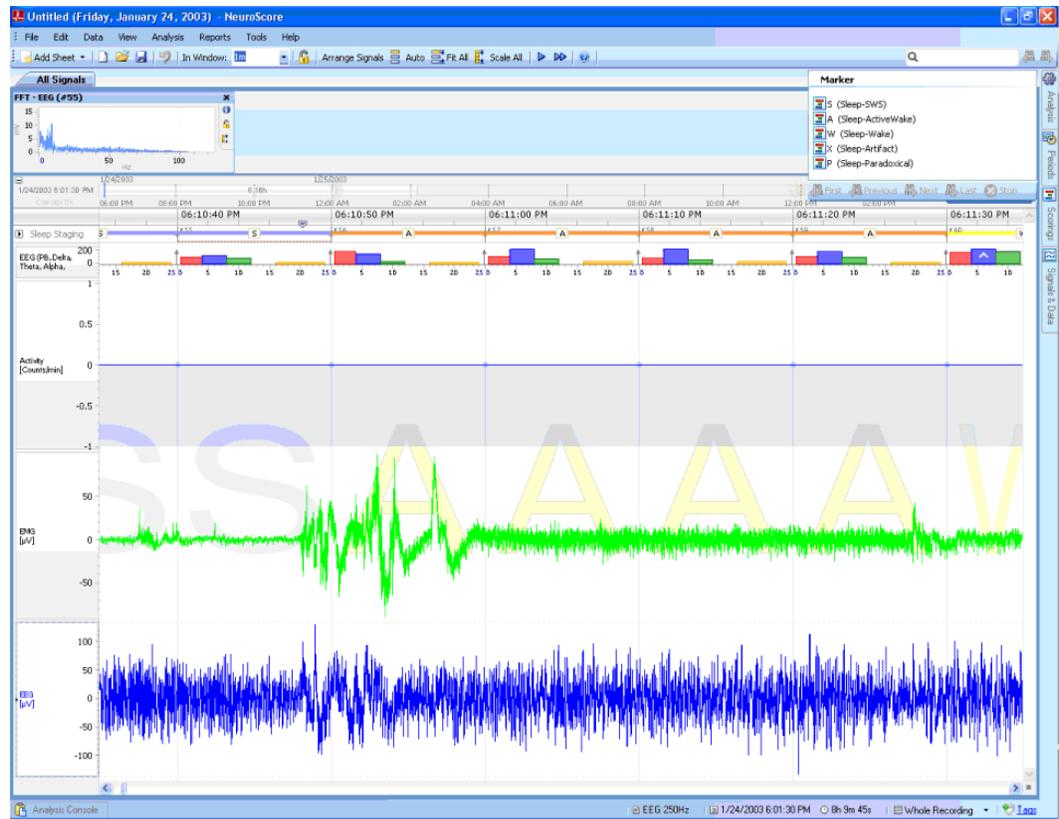


5. Click **OK**
6. To access the recording in the future, click the *Scorings* tab and click on the associated radio button to have it displayed on the signal sheet.
11. Save the current *All Signals* sheet as a *Layout* to allow the use of the same analysis on other recordings opened in the future.
  - a. **Right-click** on the *All Signals* tab - **Save Sheet Layout As...**

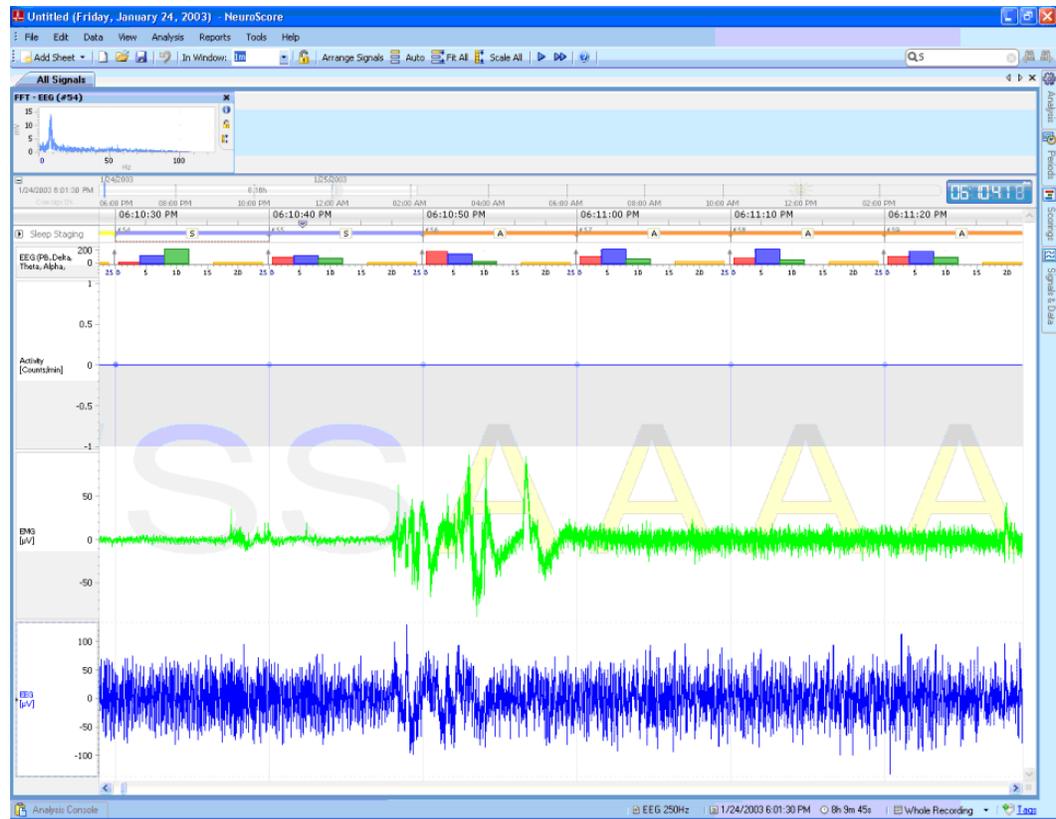


- b. Enter information in the *Name* field and *Description* field as needed and check the checkbox to automatically insert this sheet layout upon opening a new workspace

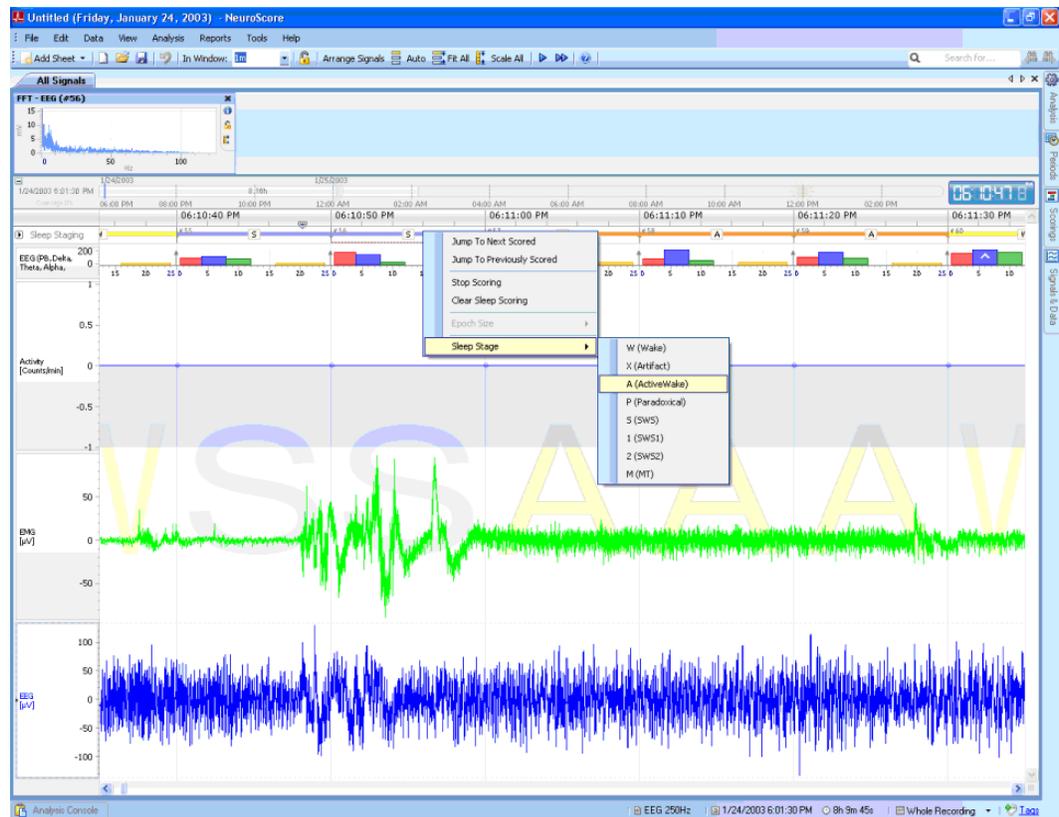
- c. Click **Save**
- 12. Search for specific *Sleep Marker*
  - a. **Left-click** the **Search for...** text box



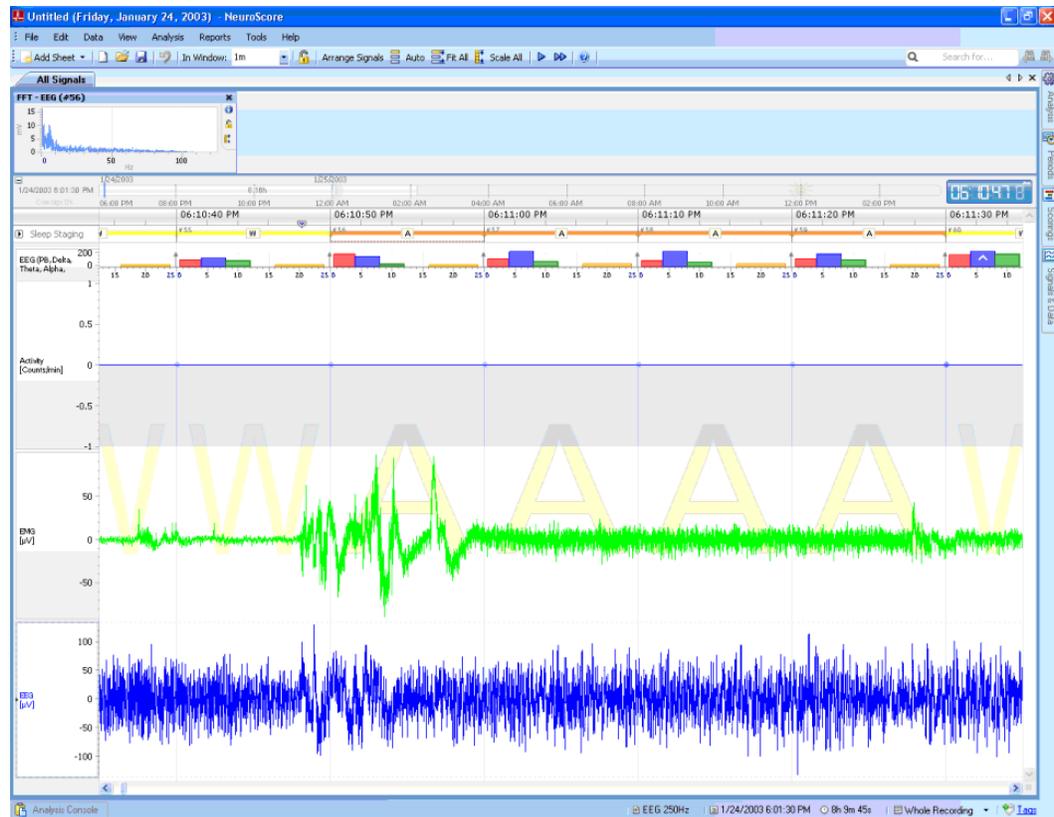
- b. Select the **S (Sleep - SWS) Marker** from the drop-down box. This will update the time position of the active sheet to the first P Marker



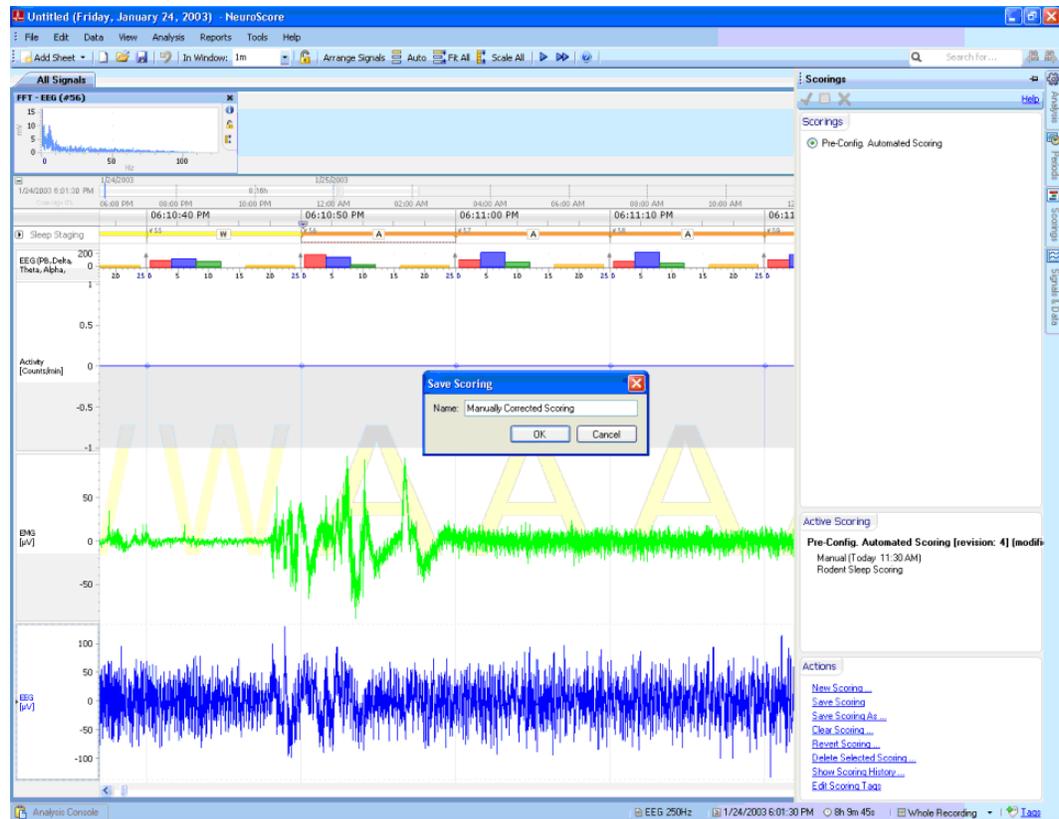
- c. Select the **Binocular Icon with Arrow to the Right** from the tool bar to move to the next **P Marker**
13. Correct Automated Scoring Manually
- a. **Right-click** the *Sleep Marker* of interest to change within the Sleep Staging bar
  - b. Select **Sleep Stage - Appropriate stage**  
**OR**



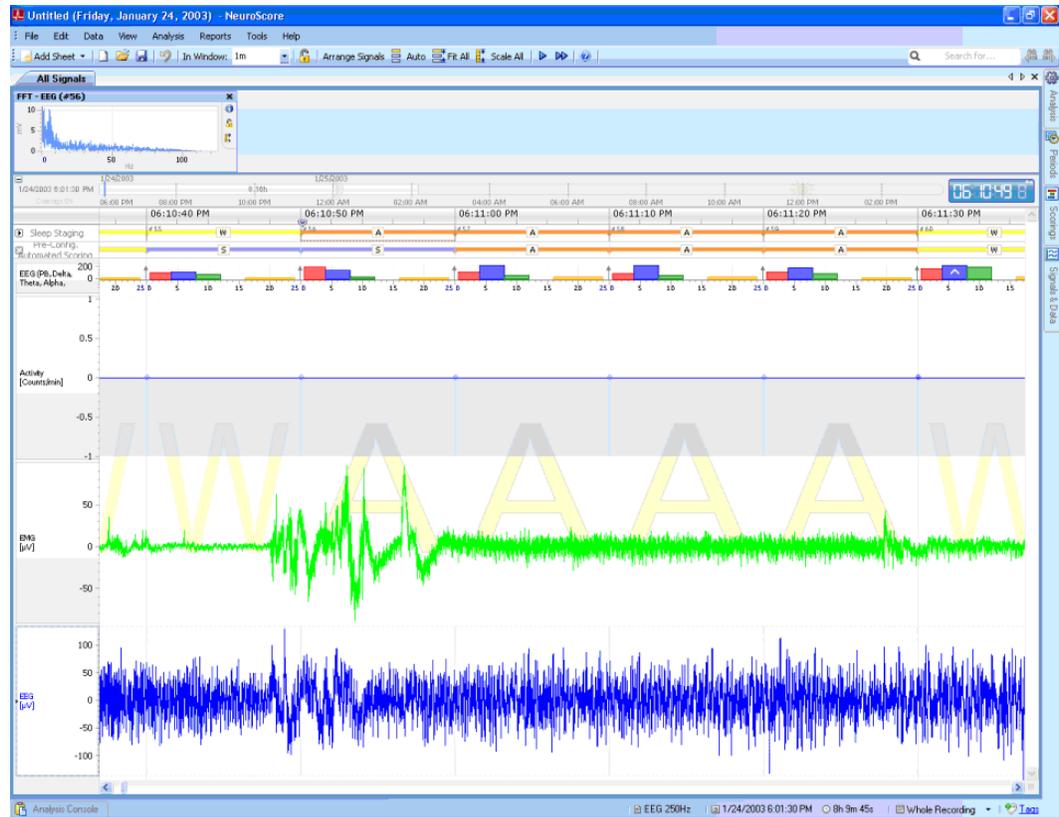
- c. **Left-click** the *Sleep Marker* of interest to change
- d. Use the **Number Pad** to correct the *Sleep Marker*. See *Manually Scoring Data* for *Shortcut Keys*.



14. Save corrected Scoring for comparison
  - a. Click **Scorings** tab on the Task Window
  - b. Under the *Active Scoring* section click **Manual**
  - c. Under *Actions*, select **Save Scoring As..**
  - d. Enter a name for this *Scoring*



- e. Click **OK**
- 15. Compare two different Sleep Scorings
  - a. **Right-click** the *Sleep Staging* bar
  - b. Select **View Other Scorings - Pre-Config. Automated Scoring**
  - c. Select **Fit All** from the toolbar



- d. Notice the difference in **epochs 55 and 56** between the *Manually Corrected Scoring* and the *Pre-Config. Automated Scoring*.

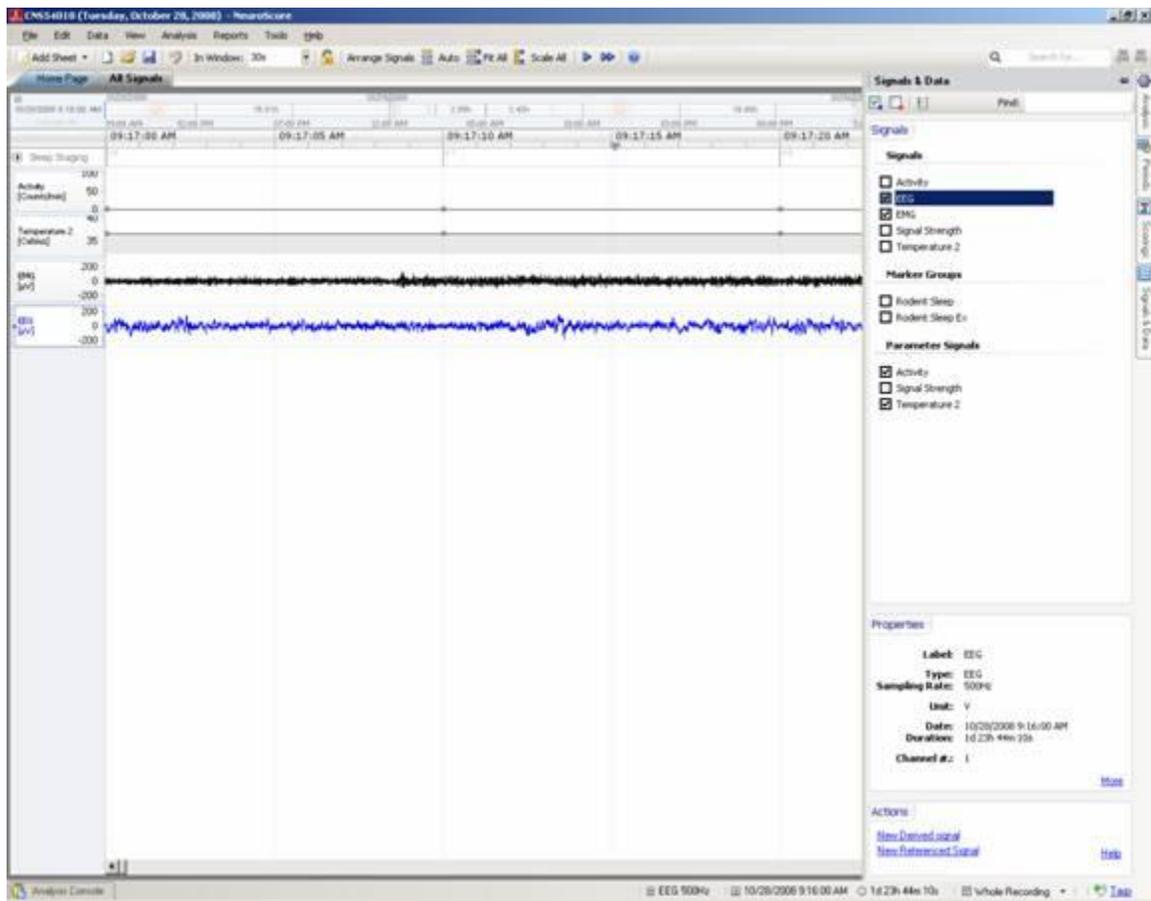
## Seizure Module Analysis Session

This analysis session is designed to demonstrate some of the capabilities available in NeuroScore to detect seizure events, analyze, and report results. These steps should be tailored to meet the needs of the particular study. Please contact DSI with questions.

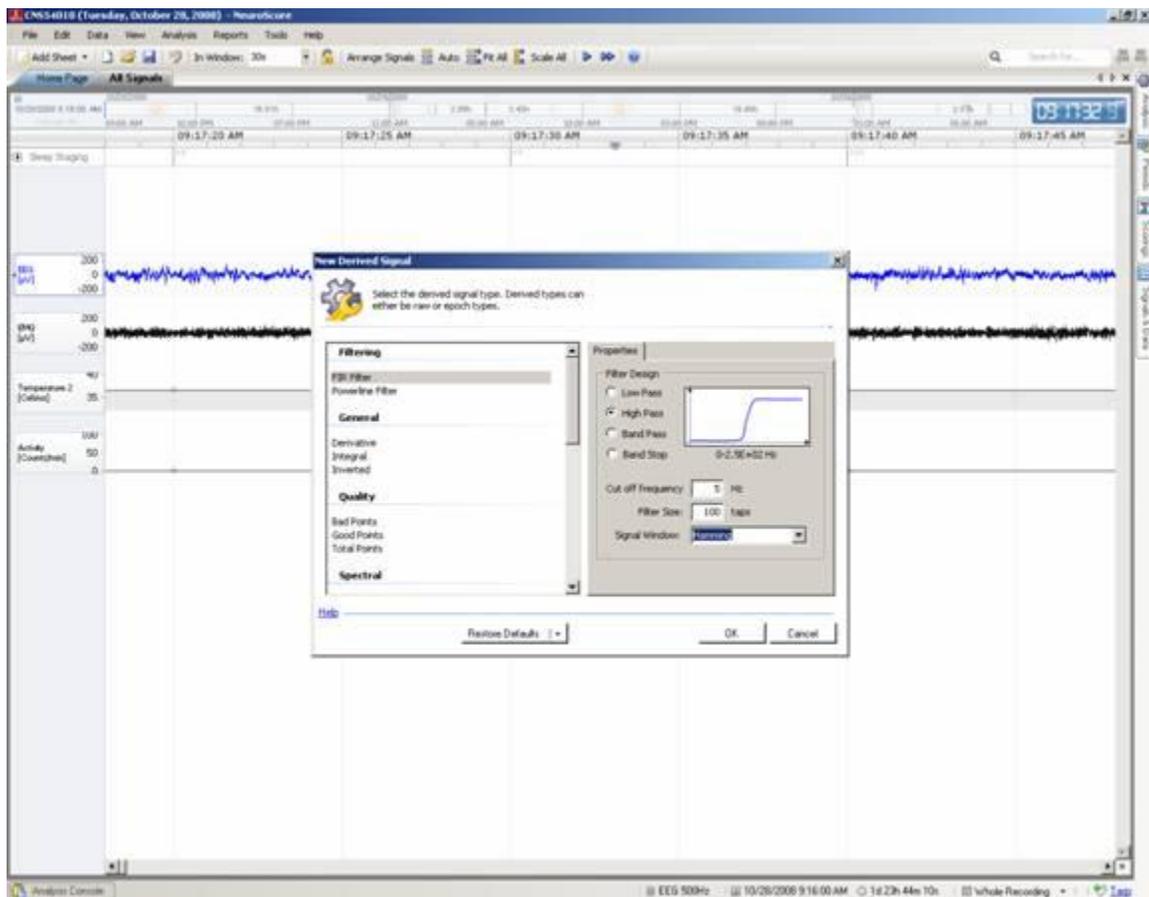
This analysis session assumes that the optional Seizure Module has been purchased. However, manual identification and reporting of seizure events is possible with the Core software component. Please see the [Spike Train Detector](#) section for additional information about the module. The detector is designed to work on a single EEG channel or its derived signals (ex. filtered EEG).

### Loading Data

1. Open NeuroScore
2. Load data from the subject of interest by Opening a New Recording
3. All signals that were recorded will appear in the NeuroScore window.
4. Select which signals should remain visible by going to the Signals & Data tab on the right side of the window. Disable any signals by removing the check.



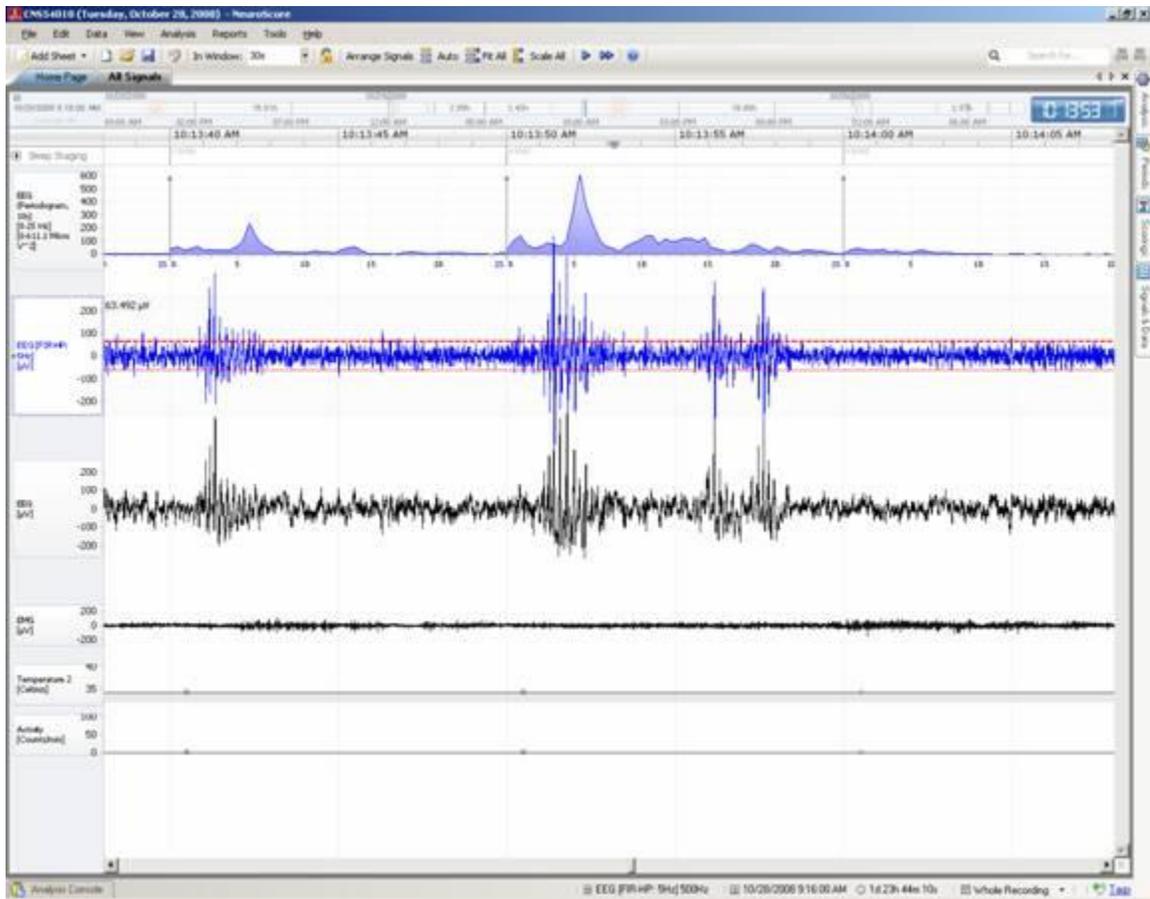
5. If more than one channel of EEG were recorded, select the EEG channel that will be used for analysis. Note that additional channels can be analyzed separately.
6. Add Derived Signals based on the EEG signal if desired. For example, the EEG signal can first be filtered before it is used as an input to the protocol. A high-pass filter of 5-10Hz can remove baseline wander and improve detection accuracy. It may also be of interest to display the frequency content of the EEG, although this information is not taken into consideration during the automated detection.



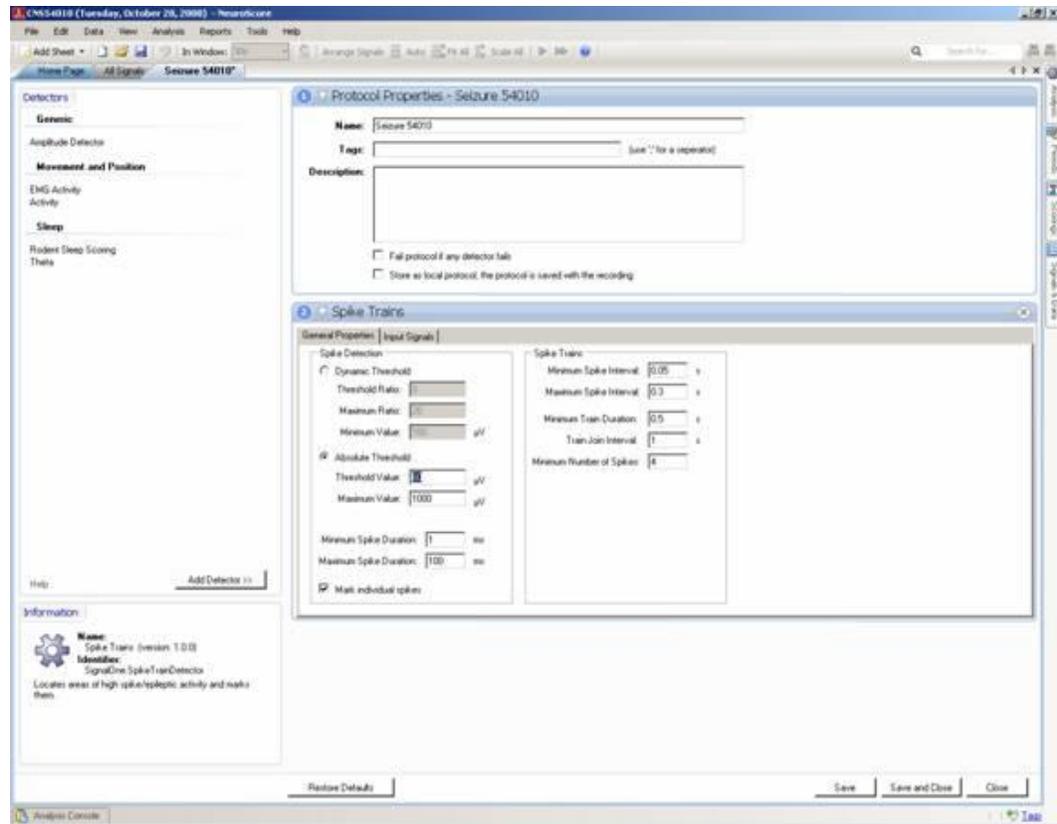
### Scoring the data

7. Browse through the data and find where a seizure event can be visualized. This will aid in determining the settings for the automated scoring protocol.
8. **Right-click** the signal that will be used as an input to the seizure detection algorithm (ex. filtered or raw) and choose **Add Axis Line**.
9. **Click-and-Drag** the axis line to a point that distinguishes the seizure spike events from baseline EEG.
10. Add another axis line at the same voltage level in the negative direction. Take note of the voltage level.

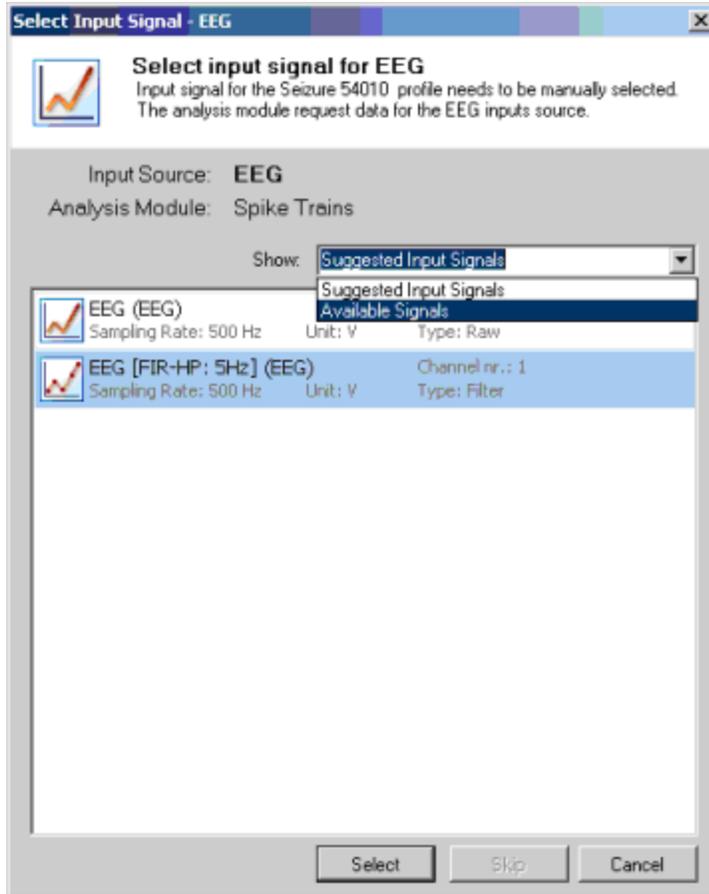
11. Browse through the data set to visually determine if the voltage limit can consistently be used throughout the recording. If it is difficult to determine a fixed threshold, it may be better to use the Dynamic Threshold option in the detector settings.



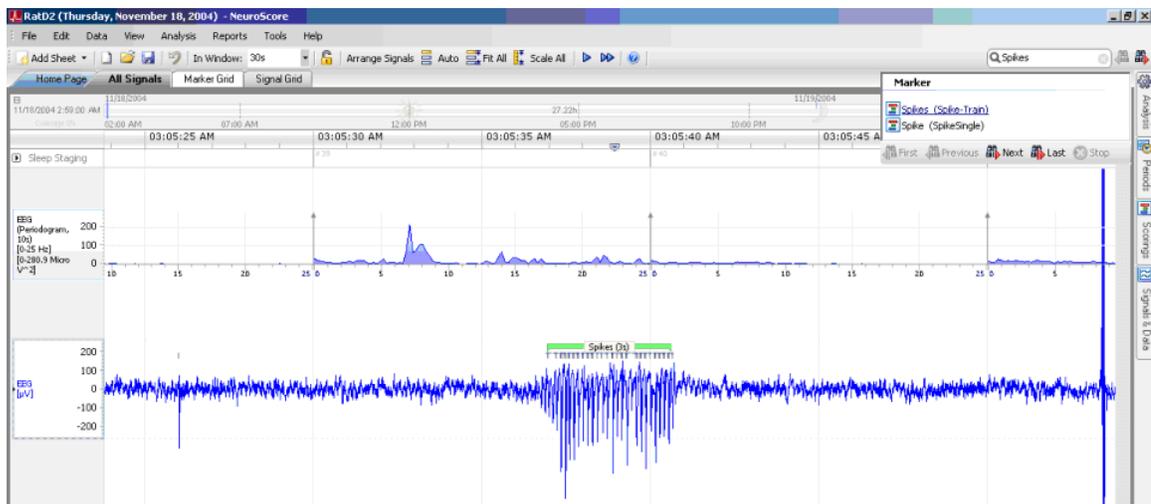
12. Setup the Analysis Protocol:
  - a. Choose **Analysis - Analysis Protocol - New Protocol...**
  - b. Once in the new protocol, enter a unique name.
  - c. Select the **Spike Train detector** and choose **Add Detector>>**
  - d. Select either the *Dynamic* or *Absolute Threshold* amplitude criteria. See *Configuring the Spike Train Detector* for more information.
  - e. If *Absolute Threshold* is chosen, enter the voltage level established in Steps 8 & 9 as the *Threshold Value*.
  - f. Adjust the settings for the remainder of the protocol. It is often helpful to leave the default settings if you are uncertain as these can be altered later depending on the detection results. Please see *Configuring the Spike Train Detector* for suggestions on setting appropriate values based on the data set and seizure morphology.



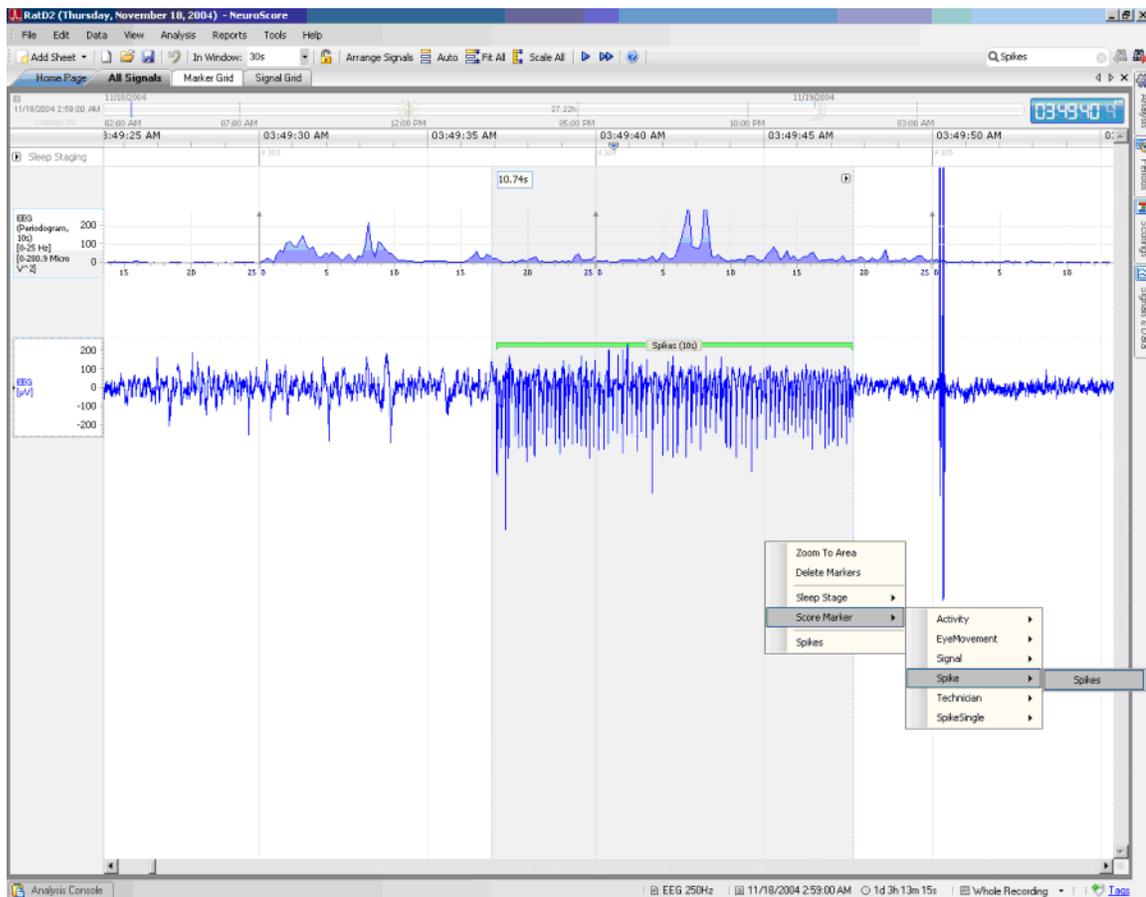
- g. **Save and Close** the protocol
13. Run the protocol
- From the *Analysis* menu, select the protocol established in Step 12.
  - Select which signal to use as the input to the protocol from the prompt window. If the desired signal is not visible, use the dropdown menu to select 'Available Signals'.



14. After the scoring is complete, save the scoring results if desired.
  - a. Go to **Data - Save Scoring As...**
  - b. Enter a unique name for the scoring session.
15. Visually review the scoring results by scrolling through the data. It is helpful to use the ‘*Search for...*’ option in the top right area of the screen and select **Marker - Spikes (Spike-Train)**. Use the **Next** arrow button to scroll through the data set event by event.



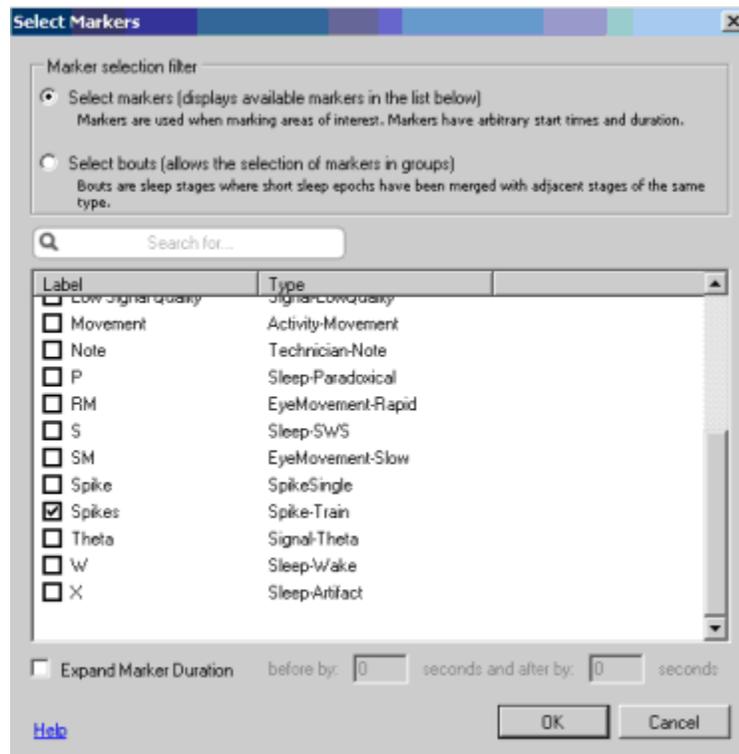
16. If the scoring is not accurate, there are 2 options:
  - a. Manually edit the results by adjusting, deleting, or adding markers (see Step 17)
  - b. Modify the automated analysis protocol and rerun it (see Step 18)
17. To manually edit seizure markers, simply select a marker by clicking on it. Hit **<Delete>** to remove it or change the duration by extending or contracting the horizontal length. A new marker can be added by **Clicking-and-Dragging** over a region of the graph, **right-clicking** and choose **Score Marker – Spike - Spikes**.



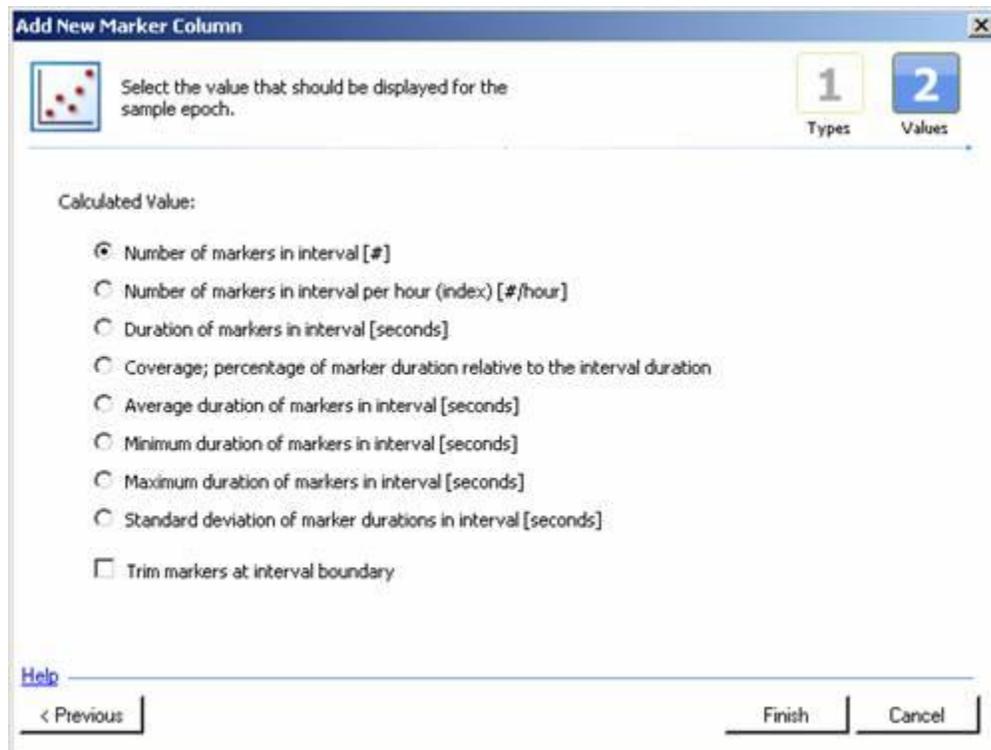
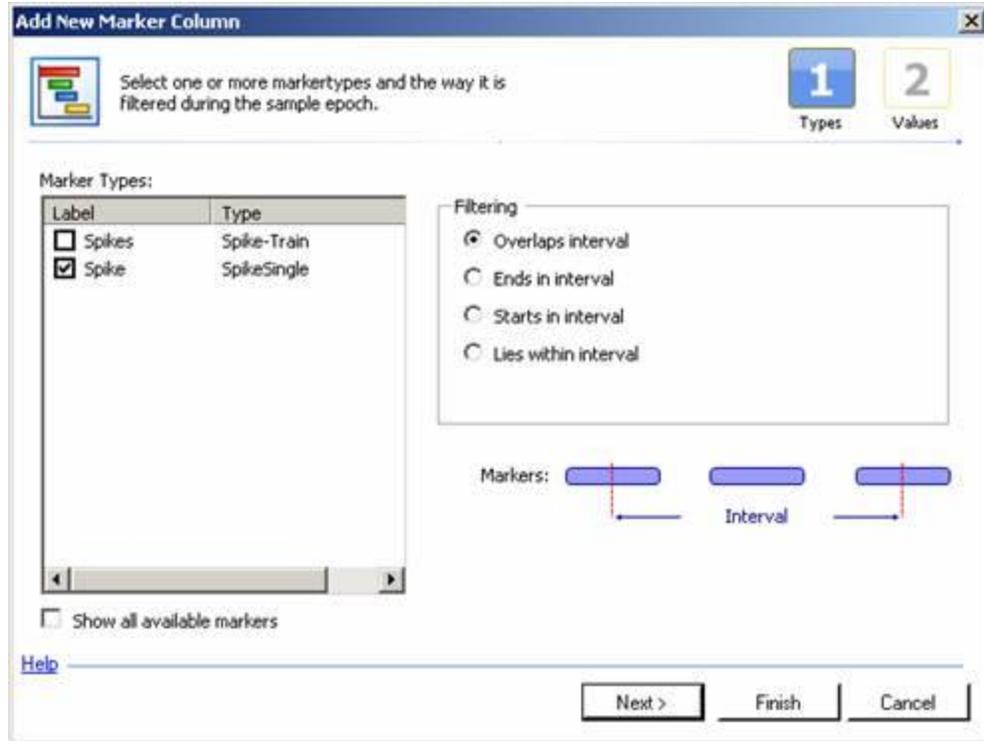
- a. Save the edited results by going to **Data - Save Scoring As...**
  - b. Enter a unique name for the Scoring.
18. To modify the automated scoring protocol:
  - a. Select **Analysis - Analysis Protocols - Manage Protocols...**
  - b. Select the protocol used and choose **Edit**.
  - c. Adjust the detector values and choose **Save and Close**.
  - d. Rerun the protocol by selecting it under the *Analysis menu*
  - e. Choose **Data - Save Scoring As...** to save the results
19. Although only one scoring result can be viewed at a time, scorings can be toggled between by selecting the *Scorings tab* on the right and selecting which scoring session should be active.

## Displaying Results

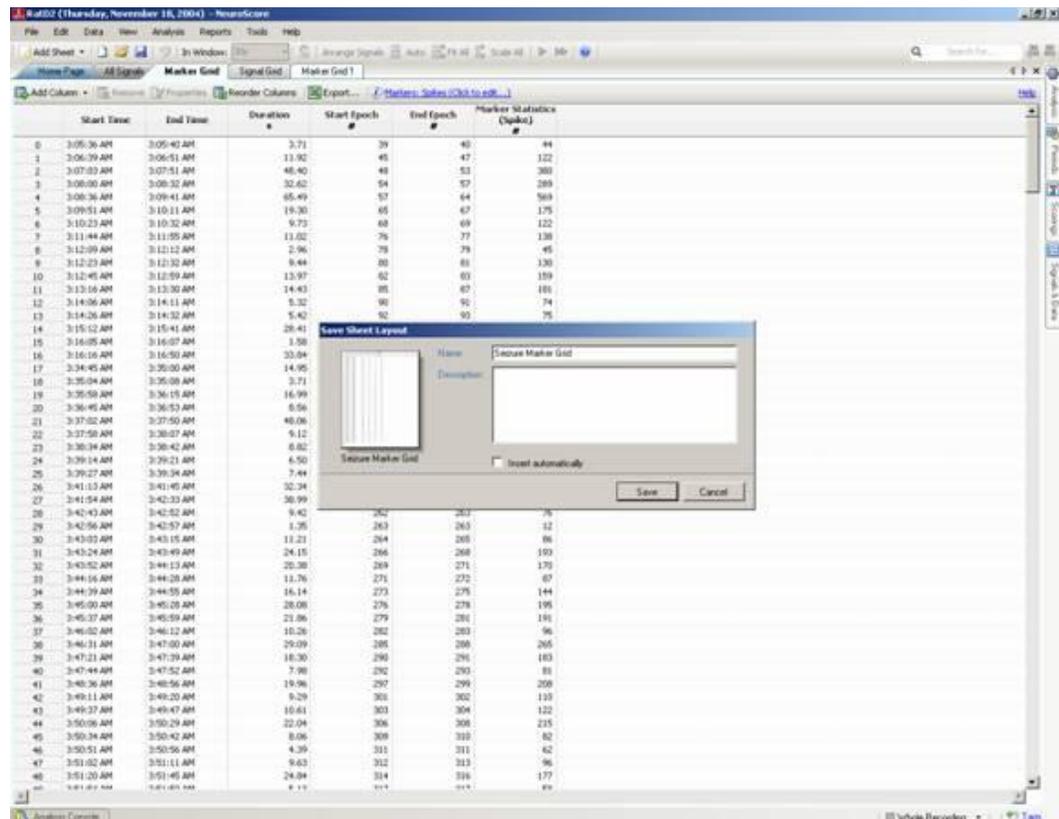
20. Create a Marker Grid to numerically summarize the results for each detected seizure (spike train marker)
  - a. Select **Add Sheet - Empty Marker Grid**
  - b. Choose **No marker or bouts selected. Click to select...** and enable (check) **Spikes** from the list of available markers.



- c. Select **Add Column - Start Time** to display the time each detected spike train began in a row
- d. Continue to add preferred columns including *End Time*, *Duration*, *Start Epoch*, *End Epoch*
- e. Display the number of individual spikes for each seizure by selecting **Add Column - Markers...** From the prompt, select **Spike** and then **Next>**. Then select **Number of markers in interval** and **Finish**



- f. Once the grid is finished, save it as a sheet layout for future use. Go to **Edit - Save Sheet Layout...** enter a unique name and click **Save**.



21. Create a Signal Grid to numerically summarize the events over a particular time range (ex. number of seizures per hour)
  - a. Select **Add Sheet - Empty Signal Grid**
  - b. Choose **Add Column - Time Stamp** and select the time interval in which to report the information (ex. 1h) in the Epoch Duration field. Note that a time range can manually be entered if the desired option is not part of the dropdown menu.
  - c. Choose **Add Column - Markers...**select Spikes and then **Next>**. Choose the information to be displayed (ex. number of markers in interval).
  - d. Continue to add columns of interest to the Signal Grid.
  - e. Once the grid is finished, save it as a sheet layout for future use. Select **Edit - Save Sheet Layout...**enter a unique name and click **Save**.
  
22. Run a pre-defined report
  - a. Select **Reports – Seizure – Seizure Report**. A new tab will appear with the report content.
  - b. Create a custom report by adjusting the report fields. See Creating Custom Reports section for additional information.

*Note:* The content of the Marker Grid and Signal Grid will update if changes are made to the active scoring or period. However, the reports will remain fixed and will need to be regenerated if the scoring results are updated.

## Start to Finish using Layouts

Follow the steps below to go from loading recordings to completing sleep scoring analysis and report generation.

1. Open the *NeuroScore* software.
2. Load the recording by Opening a New Recording.
3. An *All Signals* tab will open in the *NeuroScore* window.
4. Add the following Sheet Layouts to the *NeuroScore* Work Environment:
  - EEG EMG Layout This sheet will include the following signals: EEG, EMG and Activity. It will also have derived signals: EEG Periodogram, EEG AR Spectrum and EEG Power Bands (Delta, Theta and Alpha)
  - Bandpass Layout This sheet will populate with the EEG signal along with bandpass filtered signals for Delta (0.5 - 4 Hz), Theta (4-8 Hz) and Alpha (8-12 Hz).
  - Sleep Overview An overview sheet that contains the following signals by default: Temperature, Activity, an AR Spectrum of the EET signal, a Periodogram of the EET signal, Root Mean Square data of the EMG signal and a Hypnogram of the sleep stages.
5. Score the data using one of the following:
  - Manual Scoring
  - Automated Scoring using Analysis Protocols
6. Add the following report:
  - Sleep Report

Displays a summary of the sleep scoring, a Hypnogram, and various statistics, including a summary of the transitions from one stage to the next.

7. Add the following Grids:
  - EEG Stats Grid A signal grid sheet that will have the following columns for each 10 second interval: Sleep Stage of the animal, a Root Mean Square for the EMG signal, DFT Power Band for Delta, DFT Power Band for Theta, DFT Power Band for Alpha and the Theta Ratio.
  - 30 min Bouts Grid A signal grid sheet that will count the number times the animal is in one of the following sleep stages: Wake (W), Slow Wave (S), Paradoxical (P) and Artifact (X) for each 30 minute interval. Additionally each 30 minute period it will calculate the total amount of time (seconds) the animal was in each sleep stage or bout.
  - 30 min Stage Grid A signal grid sheet that will calculate the amount of time (seconds) spent in each of the following sleep stages: *Active*, *Artifact*, *Paradoxical*, *Slow Wave Sleep (SWS)* and *Wake*.
8. Save/Export Grids
9. Save/Export Reports

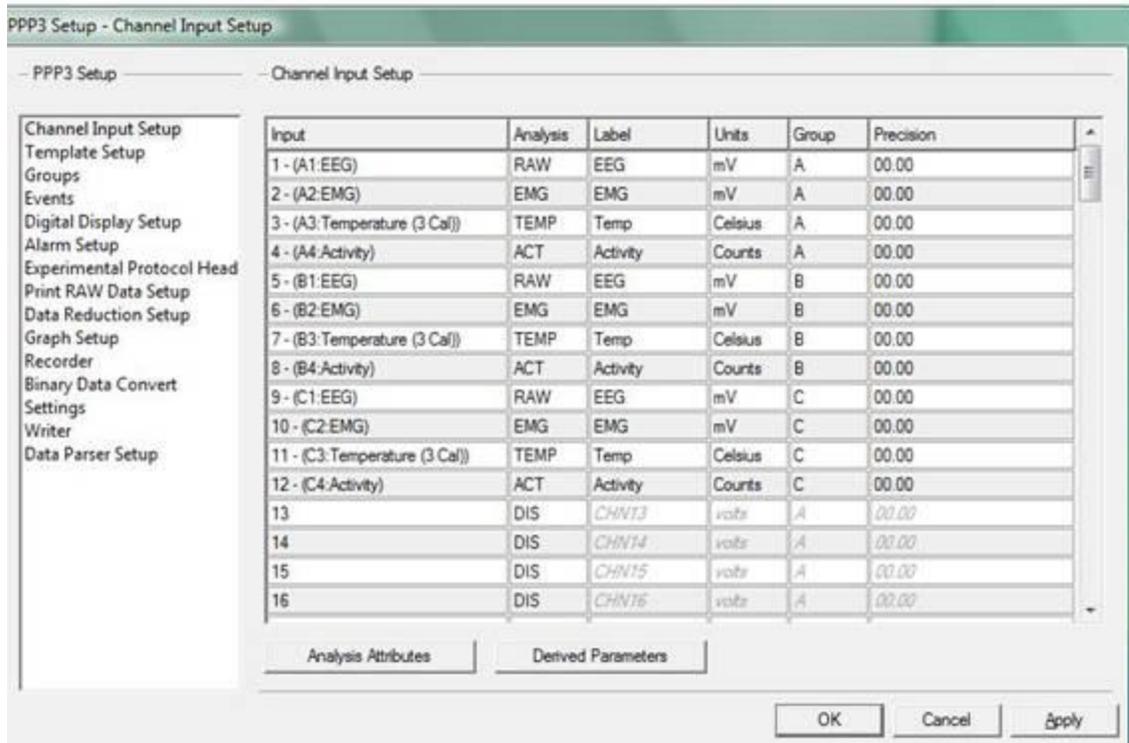
# Appendix A: Configuring Ponemah Acquisition

## Appendix A: Configuring Ponemah Acquisition for Optimal File Handling in NeuroScore

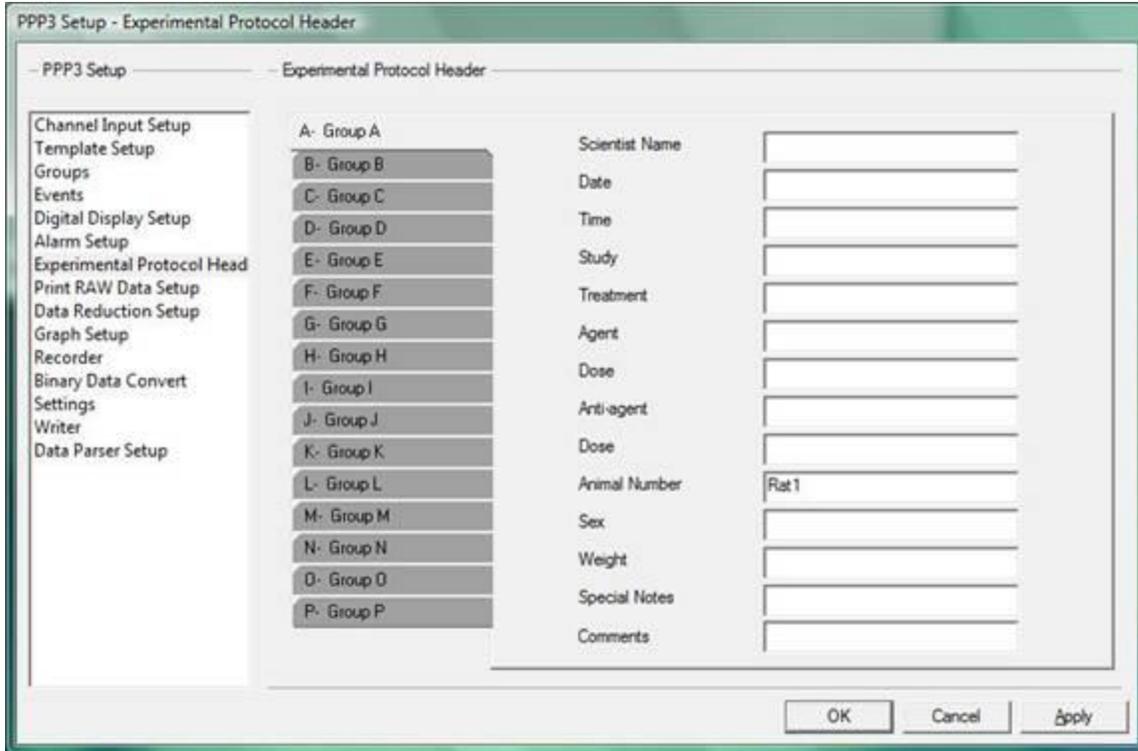
If the Ponemah Physiology Platform is used to record data that will be subsequently analyzed in NeuroScore, it is critical that these steps are followed to ensure proper handling of the files. This section is intended to be a supplement to the Ponemah user manual. Please reference the Ponemah help section or DSI technical support for more detailed information.

### Configuring Ponemah Acquisition

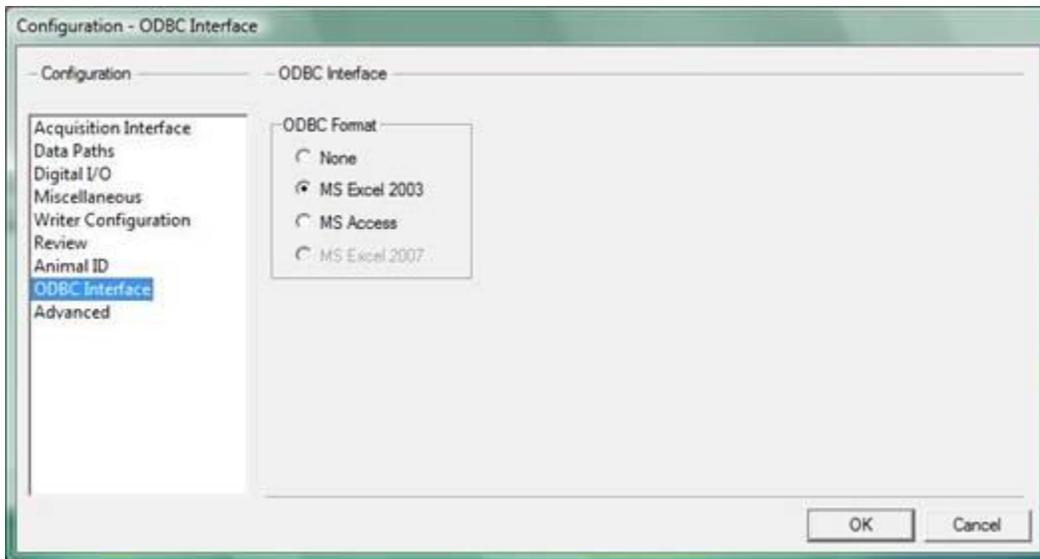
1. The protocol file (.PRO) must have the same name as the data set file (.RAW)
2. In the P3 Setup menu – Channel Input Setup, follow these steps:
  - a. In the **Label** column, type the appropriate signal type (ex. EEG, EMG, Temp, Activity). This is how the axis will be labeled in NeuroScore.
  - b. In the **Units** column, type the appropriate units for each data type. The default is volts which should not be used. For all biopotential signals (EEG, EMG, EOG, or ECG), the units are **mV**. For temperature data, the units are **Celsius** and for activity data, the units are **Counts**.
  - c. In the **Group** column, assign a unique group to each subject that is part of the data set. For example, Group A could be assigned to EEG, EMG, Activity, and Temperature for the first subject. This is critical for loading derived parameter and video data. Please take note of which Group was assigned to each subject.
  - d. Disable any unused channels by changing the Analysis column to **DIS**.



- The subject ID name can be assigned to a particular group in the Experimental Protocol Header. Type the name in the **Animal Number** section. If this is not done, the data will be labeled by the Group name in NeuroScore.



4. In the **Options - Application Configuration** menu, designate the **ODBC Interface** format source in either **Excel** or **Access** format, do not set to **None**. This database file will provide the capability to load the derived parameter data in NeuroScore, if applicable. Please note that the derived parameter data will not have units.

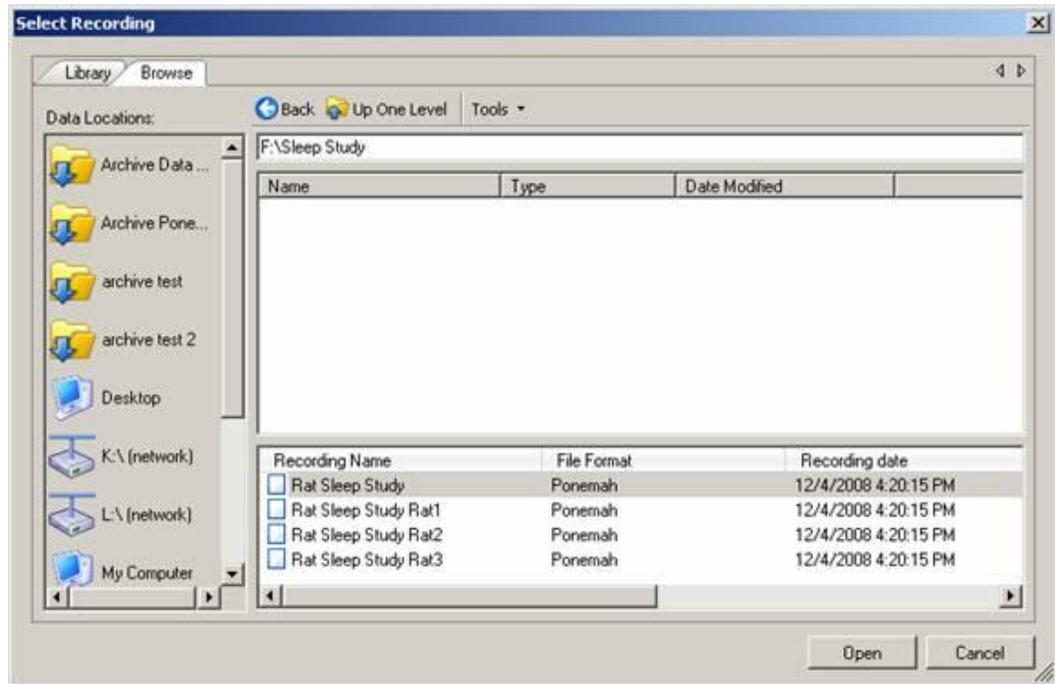


5. Please reference the Ponemah user manual for configuring the cameras and enabling video recording if applicable.
6. Keep all Ponemah files (including video) in the same directory after they are recorded.

### Loading Ponemah Files in NeuroScore

When browsing to a folder containing a Ponemah data set, multiple recording files will appear:

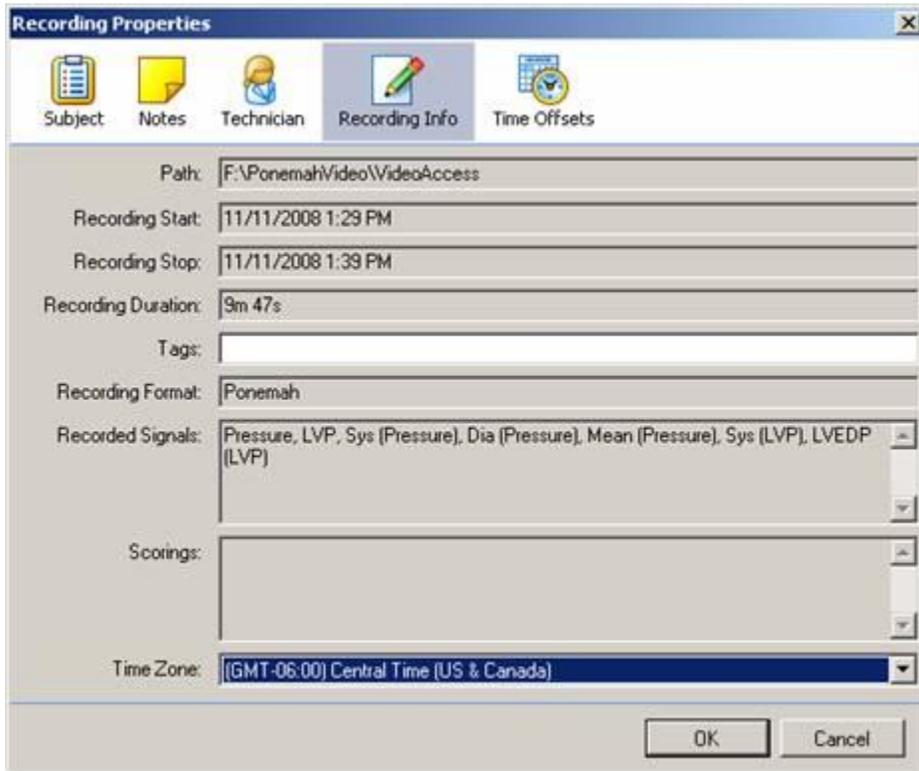
- a. One file will be listed that contains the data set name – this will contain signals in the .RAW file only (waveforms). If more than one subject was recorded, all data will be included in the file and will appear in the NeuroScore session. It is not possible to view the derived parameters or video data when loading this file.
- b. An additional file for each group associated with the data set will also be listed (ex. *<Data set name + Animal Number for Group A>*, *<Data set name+ Animal Number for Group B>*, etc). Provided a unique group was assigned to each subject (Step 2c), these files will contain both the waveform data and derived parameters for the individual subject. Additionally, these Group files contain the video data if acquired.
- c. It is recommended that the Group files are primarily used since NeuroScore is designed to work with one subject at a time.



- d. Only one .RAW file can be loaded into Neuroscore at a time. This means that if the recording was stopped and restarted again in P3 so that there are two separate .RAW files for the same animal, then the user can only view one of the files at a time in Neuroscore.

*Note:* When recording video with Ponemah, if the Ponemah files are acquired in one time zone and analyzed with NeuroScore in another time zone, the file properties must be changed to reflect the time zone used when originally recording the data.

1. Open the Recording file for a particular Group (subject).
2. After opening the recording, go to **File - Recording Properties...**
3. Go to the **Recording Info** section and change the **Time Zone** designation at the bottom of the window.
4. Close and reopen the recording for the changes to take effect.
5. Repeat for additional Group files (additional subjects) as necessary.



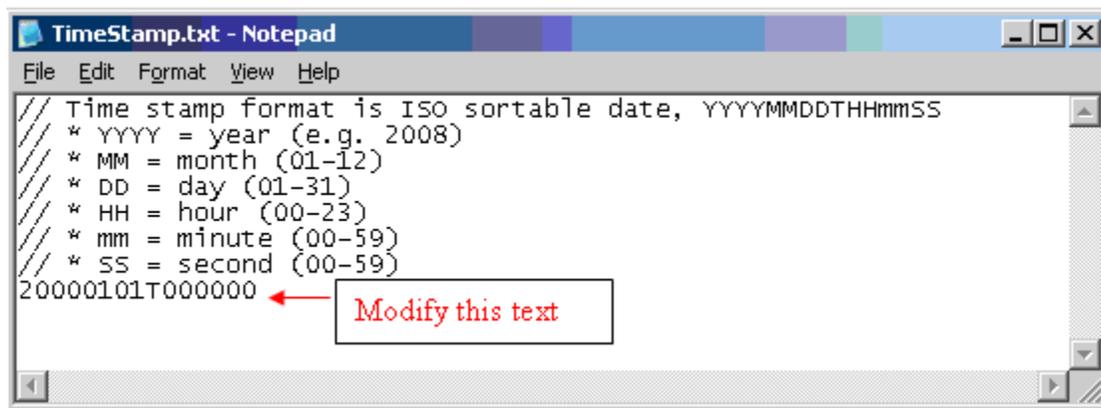


# Appendix B: Working with Biopac Files

## Appendix B: Working with Biopac AcqKnowledge (.acq) files in NeuroScore

When working with Biopac *AcqKnowledge* files in NeuroScore, the time stamp of the recording is not maintained. By default, the recording will load with a timestamp of January 01, 2000 12:00:00AM. If desired, the user can manually track and enter the time stamp of the recording for it to appear in NeuroScore. Please follow these steps to accurately input the time stamp of the recording:

1. Note the original start date and time of the recording including the month, day, year and hours, minutes, seconds.
2. Place each .acq file into its own folder prior to opening the file in NeuroScore. Additional files are generated and will be overwritten if other .acq files exist.
3. Open the .acq file in NeuroScore (see [Opening New Recordings](#)). The time stamp will read 1/1/2000 12:00:00AM by default.
4. Close the recording in NeuroScore. The NeuroScore program has now created a file 'timestamp.txt' in the same folder as the .acq file.
5. Open the timestamp.txt file using a text editor (ex. Notepad).
6. Manually change the text reading 20000101T000000 to the actual starting time using the format YYYYMMDDTHHmmSS as depicted in the .txt file.



For example, “20090112T225010” would be entered for January 12, 2009 at 22:50:10 or 10:50:10PM.

7. Save and close the .txt file.
8. Reopen the .acq file in NeuroScore and the new time stamp will be imported.
9. It may be necessary to rescale the y-axis of the signals for viewing.

