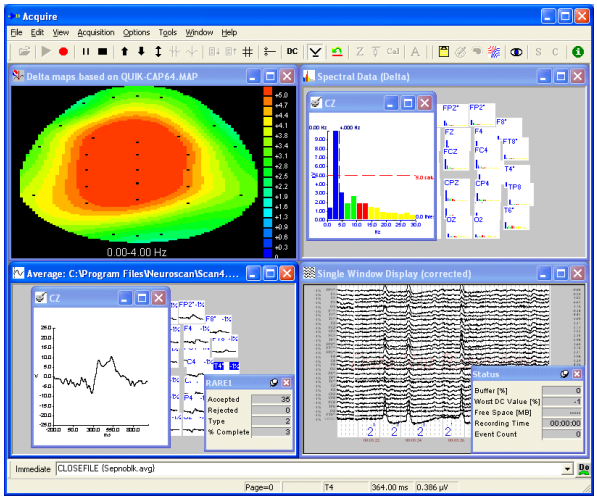
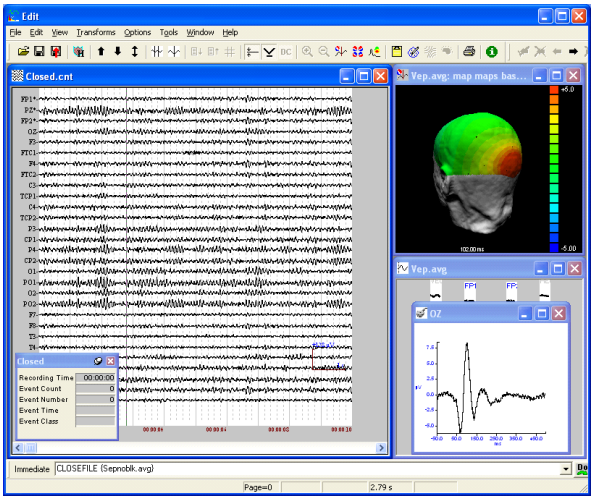
Scan Tutorials 4.5





Introduction to Acquire and Edit

COMPUMEDICS NeuroScan

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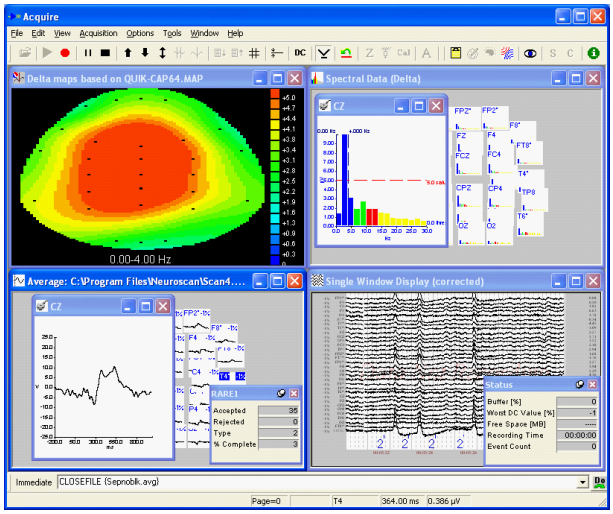
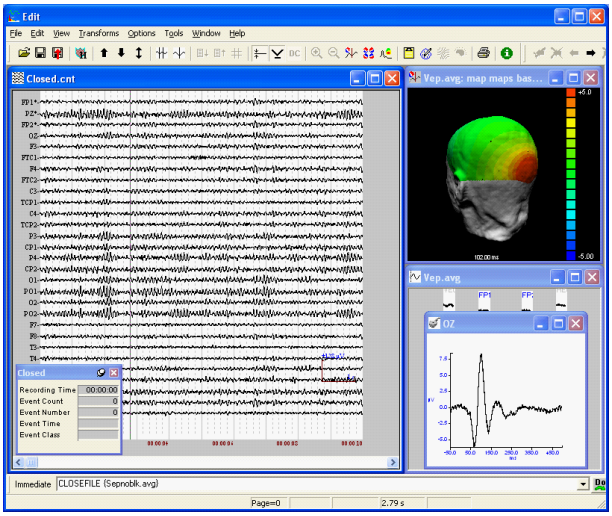
1 Introduction

Scan 4.5 Tutorials





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COMPUMEDICS
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1.1 Contact Information

For Technical Support.....

If you have any questions or problems, please contact Technical Support through any of the following routes.

If you live outside the USA or Canada, and purchased your system through one of our international distributors, please contact the **distributor** first, especially if your system is under warranty.

In all other cases, please use **techsup@neuroscan.com**, or see the other Support options on our web site (*http://www.neuroscan.com*).

Or, if you live in the USA or Canada, please call **1-877-717-3975**. International callers should use **1-704-749-3200**.

For Sales related questions, please contact your local distributor, or contact us at **sales@neuroscan.com**.

7313A Scan Tutorials

1.2 Scan Tutorials

This manual describes several configurations of ACQUIRE. The intent is to show you how quickly to configure ACQUIRE for your particular application. For most of them, we also present a sample data file similar to what might be obtained. We then present typical analysis steps for each. These applications will be presented in a tutorial format. Explanation of particular commands and settings will be brief (see the ACQUIRE and EDIT manuals for complete details). The following configurations will be presented for typical EEG and evoked potential recordings:

- Online averaging - VEP
- Single-sweep recording and online sorting - P300
- Single-sweep recording and online averaging - SEP
- Fsp averaging - ABR
- Continuous recording, online EMG audio, and filtering - N400
- Frequency analysis and topographical mapping - Continuous EEG

The tutorials have been designed to illustrate (1) the various *acquisition procedures* that are possible with ACQUIRE, and (2) the *application* of these procedures in different paradigms and modalities. In a given tutorial, the *procedure* that is being illustrated is not necessarily unique to the particular *application*. In other words, even though you may never intend to record, for example, using an N400 paradigm, the *acquisition procedure* that is described may be quite relevant to the activities you do intend to do. **You are strongly encouraged to read through all of the Tutorials to acquaint yourself fully with the various acquisition and analysis procedures in ACQUIRE.**

The Tutorials use the supplied setup and demo files. If you have XP, the setup files are installed to the *C:\Documents and Settings\All users\Application Data\Neuroscan\Scan4.5\Setup Files* folders. If you have Vista, the setup files are installed to the *C:\ProgramData\Neuroscan\Scan4.5\Setup files* folders.

The demo files are installed when you install the Scan software by selecting the **Install Sample Data** option. If you have XP, the demo files will be installed in the *C:\Documents and Settings\All users\Application Data\Neuroscan\Scan4.5\Demo Files* folder, which you may move for easier access if desired. If you have Vista, the files will be installed to *C:\Scan Data\Demo Files*.

IMPORTANT

We strongly urge you to take the following steps when conducting a study:

1. Always save your original data on a separate, external drive (computer hard drives do fail). If the data are extremely valuable, back up the files on a second external drive. Always work with a copy of your original data files, leaving the originals intact.

2. Run a few pilot subjects all the way through the study, including *all analysis steps*. You may find that the order of steps needs to be changed, or the parameters that you use in the transforms may need to be adjusted.

3. If you use batch files to analyze your data, save a copy of the

batch file with the data. This will make it much easier in the future if you need to go back and see what you have done, or reanalyze the data.

Differences in ACQUIRE among Amplifiers

There are a few differences in ACQUIRE depending upon which amplifiers you have installed - *SynAmps*, *SynAmps*^{2}, *SynAmps RT*, *NuAmps* or *SynAmps Wireless*. See the section at the end of the ACQUIRE manual for a description of these differences.

The examples below assume you are using SynAmps^2*. If you are using SynAmps, NuAmps, or SynAmps Wireless, the interface is a little different, but the same steps described below apply.*

No distinction is made between SynAmps^2 *and SynAmps RT in the examples below. As far as the software is concerned, they are the same amplifier. If you have SynAmps RT, follow the SynAmps*^{2} *examples.*

2 Online averaging - VEP

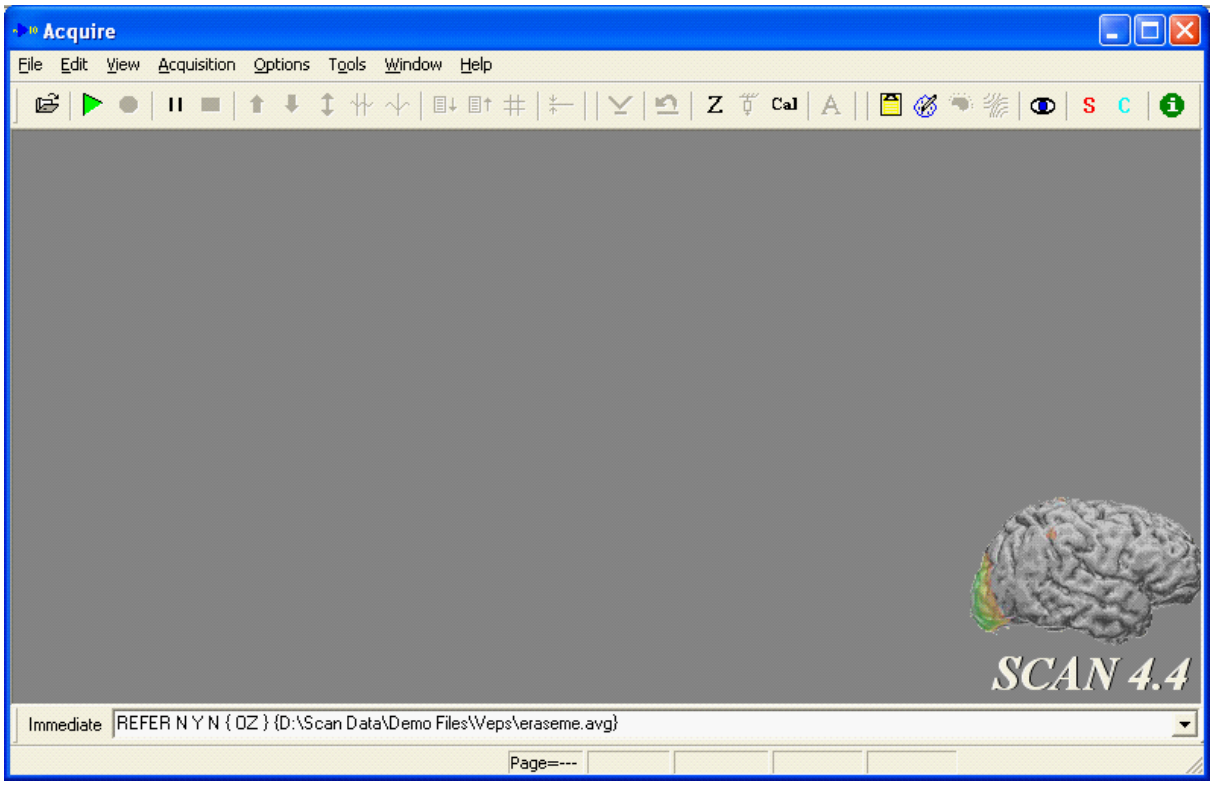
This section describes how to configure ACQUIRE for simple online averaging of an evoked potential. To illustrate this type of acquisition, the system will be configured to acquire a visual evoked potential to a contrast reversing pattern. In this example, you will see how to:

- Configure ACQUIRE for online averaging
- Online artifact rejection
- Online baseline correction
- Channel Assignment and Channel Layout

2.1 Acquisition

Follow these steps to collect an online VEP:

1. Start ACQUIRE (as described in the ACQUIRE manual). You will see the ACQUIRE main screen appear.

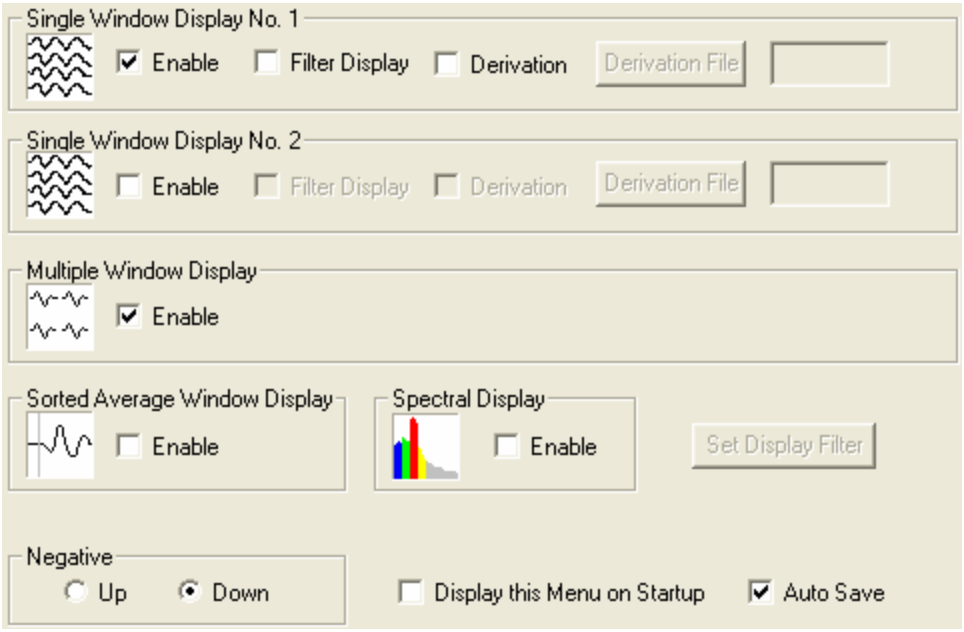


2. The next step is to create a Setup file for the VEP recording. We supply several setup files that may be used. These are called, for example, *Quik-Cap32.ast*, *Quik-Cap64.ast*, and so forth. Click Load Setup... under **File**, or click the open file icon , and look in the *Setup Files* directory under C*:\Documents and Settings\All Users\Application Data\Neuroscan\Scan4.5\Setup Files\SynAmp2*. For Vista installations, the setup files are found in *C:\ProgramData\Neuroscan\Scan4.5\Setup Files\SynAmps2*.There are separate folders for *SynAmps Wireless*, *NuAmps*, *SynAmps*, and *SynAmps*^{2} systems, and there are separate setup files depending upon how many channels you have (64, 128, 256, etc.). For this example, we will assume we have *SynAmps*^{2} amplifiers, and will be using the *SynAmps2 Quik-Cap64.ast* setup file with a few modifications.

No distinction is made between SynAmps^2 *and SynAmps RT in the Tutorials. As far as the software is concerned, they are the same amplifier. If you have SynAmps RT, follow the SynAmps*^{2} *examples.*

It is frequently easier to modify the existing setup files rather than create them from scratch. To create one from scratch, the best thing is to start by clicking **Edit** → **Make Default Setup** (click **OK** when you see the warning). The ACQUIRE program will store the most recent setup file you have loaded; it will be there when you enter ACQUIRE the next time. The setup file that is loaded will be displayed on the Status Bar at the lower right part of the screen (Synamps2 Quik-Cap64.asl). If you do not see it, you will need to increase your screen resolution, or maximize the ACQUIRE display.

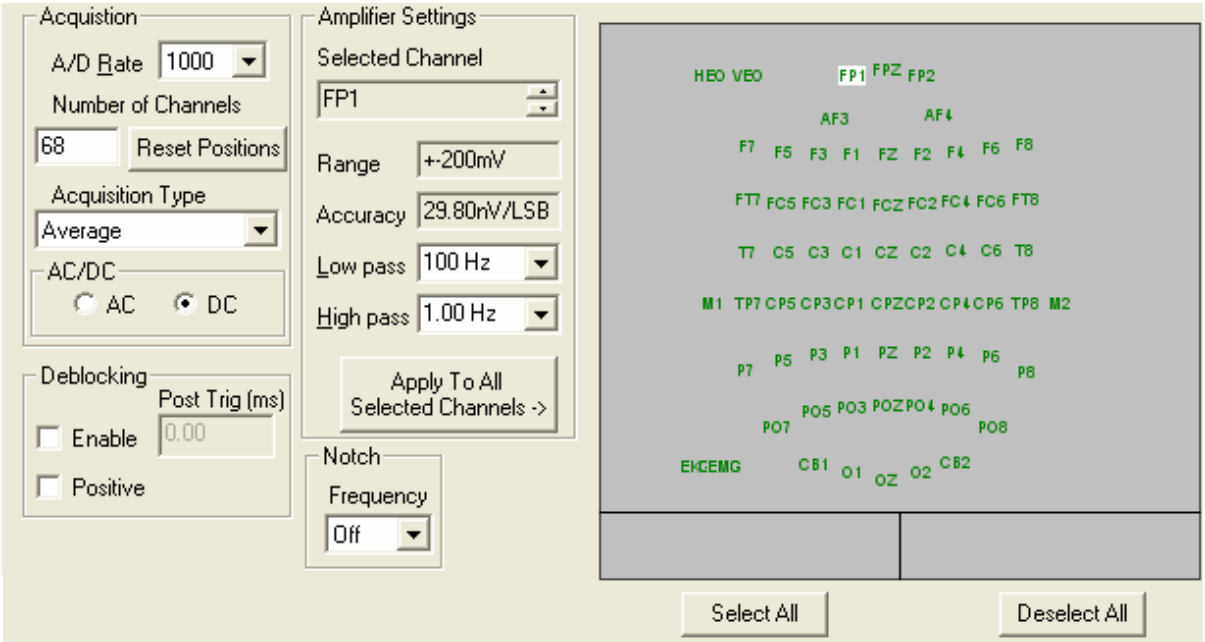
3. Once you have retrieved the setup file, go to **Edit** → **Overall Parameters** and click the **Startup** tab.



For this recording we'll look at the raw signals in a Single Window Display, as well as the VEP average as it builds. **Enable** Single Window Display No. 1, leaving the Filter Display and Derivation fields disabled. Leave Single Window Display No.2 disabled.

Enable the **Multiple Window Display**. Leave the Sorted Average Window Display and Spectral Display options disabled. Set the **Negative** polarity to be Up or Down, as desired. Enable the **Auto Save** field, so that average will be saved automatically.

4. Now select the **Amplifiers (SN2)** tab. In the Acquisition section, set the **A/D Rate** to **1000** (click in the field to the right, and select 1000, if needed). If you have *SynAmps Wireless*, select 1024Hz.



The digitization rate of 1000Hz will provide enough resolution to determine peak latency and amplitude of the major components. Leave the **Number of Channels** at **68** (the maximum number of channels is lower for *NuAmps* and *SynAmps Wireless*). For **Acquisition Type**, select **Average** to create and save an online average evoked potential. Normally, we would record in Continuous mode in nearly all circumstances (Continuous is the only mode available for *SynAmps Wireless*). The Epoched and Average modes were originally created, in part, to save disk space. That is rarely an issue now. Average mode is useful if you need a simple averaged evoked potential file during acquisition. Continuous mode has many advantages, and it should be used whenever possible. We are using Average mode here for demonstration purposes only.

If you are using *SynAmps* or *SynAmps*^{2}, select **DC** for **AC/DC**. (*SynAmps* and *NuAmps* will have additional options for DC Correction - leave them Disabled; *SynAmps Wireless* are AC only). Leave the **Notch Frequency** set to **Off**, and leave **Deblocking** disabled (*SynAmps*^{2} only).

In the **Amplifier Settings** section, set the **Low Pass** filter for **100Hz**, and the **High Pass** filter to **1.0Hz**. (If you have *SynAmps*, set the **Gain** to **1000**. If you have *SynAmps Wireless*, set the **Gain** to 1500).

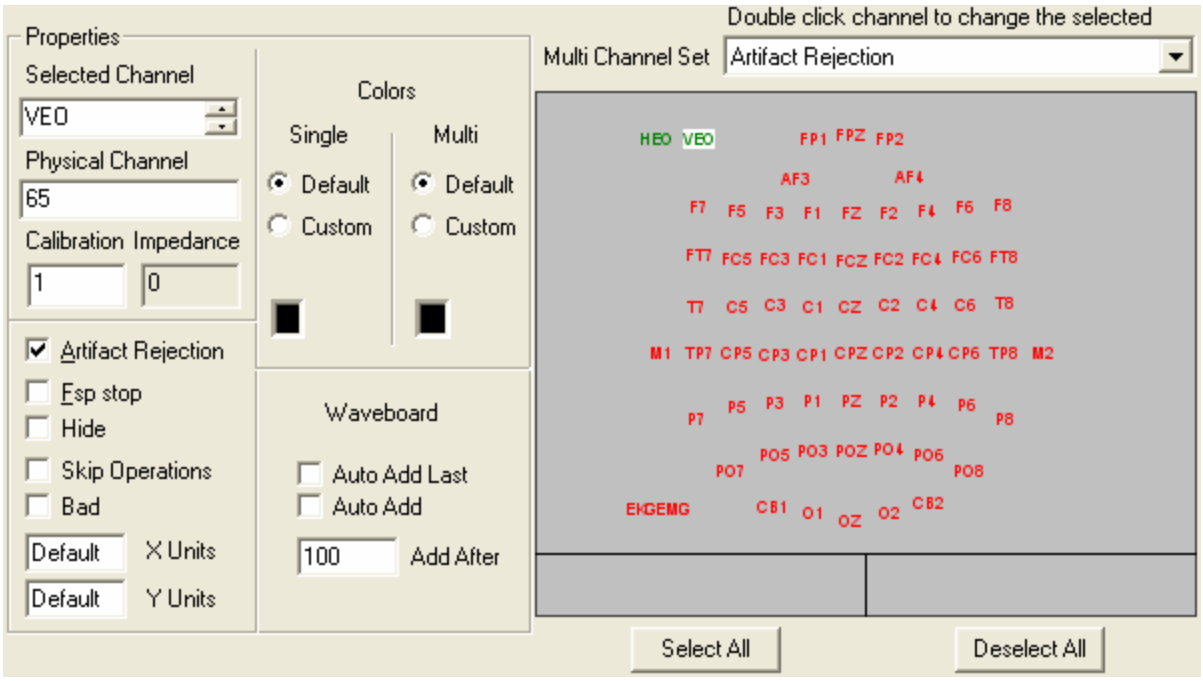
Then click the 

button (all electrode labels will be green). Click the 

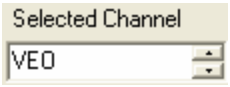
button to apply the settings you have entered to all channels. To verify your settings, click on an electrode label once in the channel display (the label will be highlighted), and check the Low Pass and High Pass settings. In this case we are using the same filter settings for all channels, but it is possible to apply different filtering to selected channels. If you have *SynAmps*, you may set different Gains for selected channels.

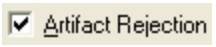
5. The next tab is used if you have any **High Level Inputs** (*SynAmps*^{2} only). These are typically the voltage outputs from peripheral devices that are inputted into the *SynAmps*^{2} headbox. We are not using HLIs in this example (nor has the setup file been configured for them).

6. Next, click the **Channel Attributes** tab. These options allow you to specify a number of parameters for each channel - collectively, or individually (please refer to the ACQUIRE manual for complete details). For this demonstration, we will set the *VEO* and *HEO* eye artifact channels as the Artifact Rejection channels. These channels will then be used by the automatic Artifact Rejection scan - online or offline. Detection of values in excess of the criteria set in the **Artifact Rejection** fields under **Epochs**, described below, will result in rejection of the sweep.



There are several ways through which you can set channels as Artifact Rejection channels. The easiest way here is to double-click the mouse on the **VEO** and **HEO** labels on the channel display (so they are green and the rest of the channels are red). Make sure that *Artifact Rejection* is displayed in the **Multi Channel Set** field. When you click one of the channels, you will see that channel label appear in the Selected Channel field



, and the Artifact Rejection field will show it is Enabled 

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The **Colors** options are used to set the colors of the waveforms in the Single and Multiple Window Displays. You can set the color for All channels or individual channels, as desired. Leave the settings as they are for this example.

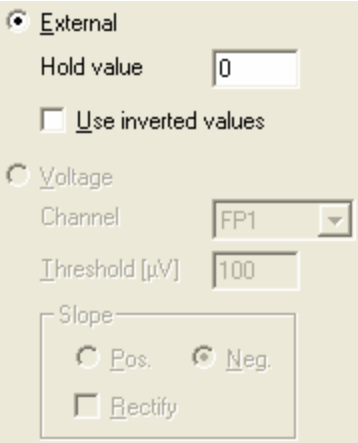
The remaining fields should be disabled, as shown above.

Note that you can use the 

and 

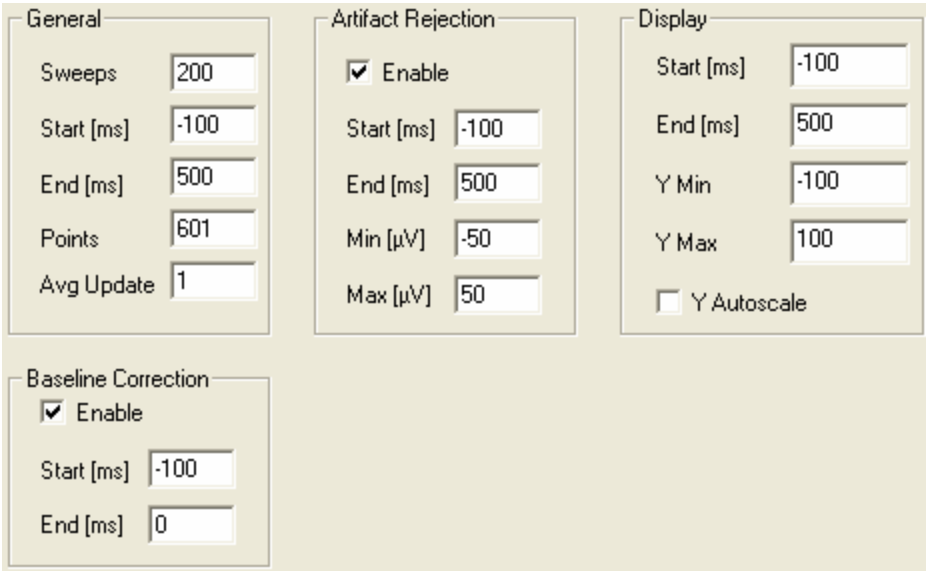
buttons, if needed, to select or deselect all channels (convenience).

7. Triggering for the VEP will be controlled by an external device (e.g., the STIM2 system). Select the **Triggers** tab.



The **Hold value** should be set to **0** in most situations (see the Triggering section in the ACQUIRE manual for special circumstances). The **Use Inverted Values** field is either enabled or not, depending on your particular system. Generally it is Disabled (if you do not see triggers with it set one way, try it the other way). If you were using the Epoched acquisition mode, the **Voltage Settings** fields will be active (refer to the ACQUIRE manual for more details).

8. Select the **Epochs** tab to set the parameters of the recording epoch. For this example, we want a 100ms pre-stimulus interval and a 500ms poststimulus span, with automatic artifact rejection and baseline correction enabled during acquisition.



In the **General** section, set the number of **Sweeps** to **200**. This should be more than adequate to provide a good signal-to-noise ratio for the contrast reversal VEP. Set the **Start** time to **-100** (pre-stimulus) and the **End** time for **500**ms. The contrast reversal VEP has components that peak before and after 100ms. The pre-stimulus interval will provide a stable baseline that can be used to remove any unwanted offset. The poststimulus interval of 500ms should be of sufficient duration to include any late components of the evoked response. The **Points** field should be set to **601** automatically. **Avg Update** sets the number of sweeps that must be accepted before the displayed average is updated.

Leave it at **1** so that the average is updated with every accepted sweep.

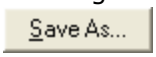
In this example a total sample interval of 601ms (100ms pre-stimulus and 500ms poststimulus, plus the zero point) has been selected. The stimulation protocol therefore must take this into consideration in order to provide at least this interval plus the overhead of the computer. A stimulation rate of 1 per second is recommended in this example. If faster stimulation rates are desired you can decrease the sample interval as long as the post-stimulus interval is long enough to view the major response components (i.e., P100).

The program is designed not to allow invalid settings for any of the fields. If you click on a field and get an error message saying to input a number within a certain range, click OK and see what field has been highlighted. It may not be the one you had clicked. Enter the appropriate number in the field that was highlighted, then return to the original field you had selected, and continue. Note the interaction between the A/D rate and the number of points - selecting the **A/D Rate** in the **Amplifier** section will affect the **Number of Points** in the **Epochs** section.

Enable the **Artifact Rejection** area, and set the **Start** time to **-100**ms and the **End** time to **500**ms. Set **Y Min** to **-50**μV and **Y Max** to **50**μV. Values anywhere in the recording epoch that exceed ±50μV at the selected artifact channels (described below) will result in rejection of the sweep.

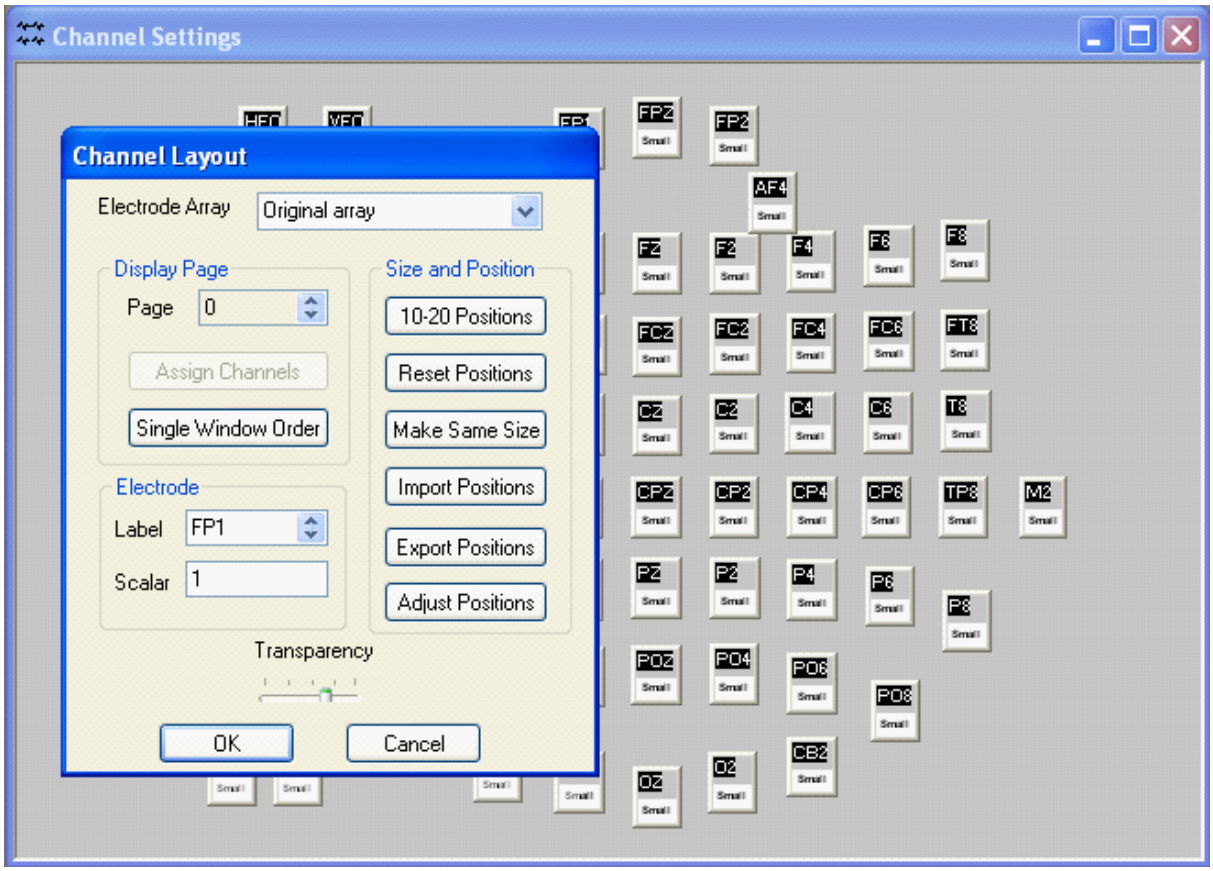
In the **Display** area, set the **Start** to **-100**ms, the **End** to **500**ms, **Y Min** to **-100**μV, and **Y Max** to **100**μV. You will see the entire epoch displayed within the ±100μV limits. Leave the Y Autoscale Disabled.

Enable the **Baseline Correction** area, and set the **Start** time to **-100** and the **End** time to **0**ms. Baseline correction will be performed online by computing the mean offset value from -100 to 0ms, and then by subtracting this value from the entire waveform (for each channel).

9. The rest of the parameters are not used in this demonstration. It would be a good idea at this point to save the settings that you have made thus far. Click the 

button, and enter *VEPSET* as the filename, noting the folder it is being save to (the *.ast* extension will automatically be added). Then click **OK**.

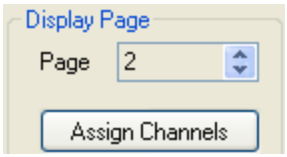
10. For the sake of demonstration, let's look at some other features. Go to **Edit** → **Channel Layout**. You will see the 68 channels laid out in a preset display. You can use this screen to reposition the electrode displays, change their sizes, rename the electrodes, import electrode position information, and so forth. Let's take a look at some of these features.



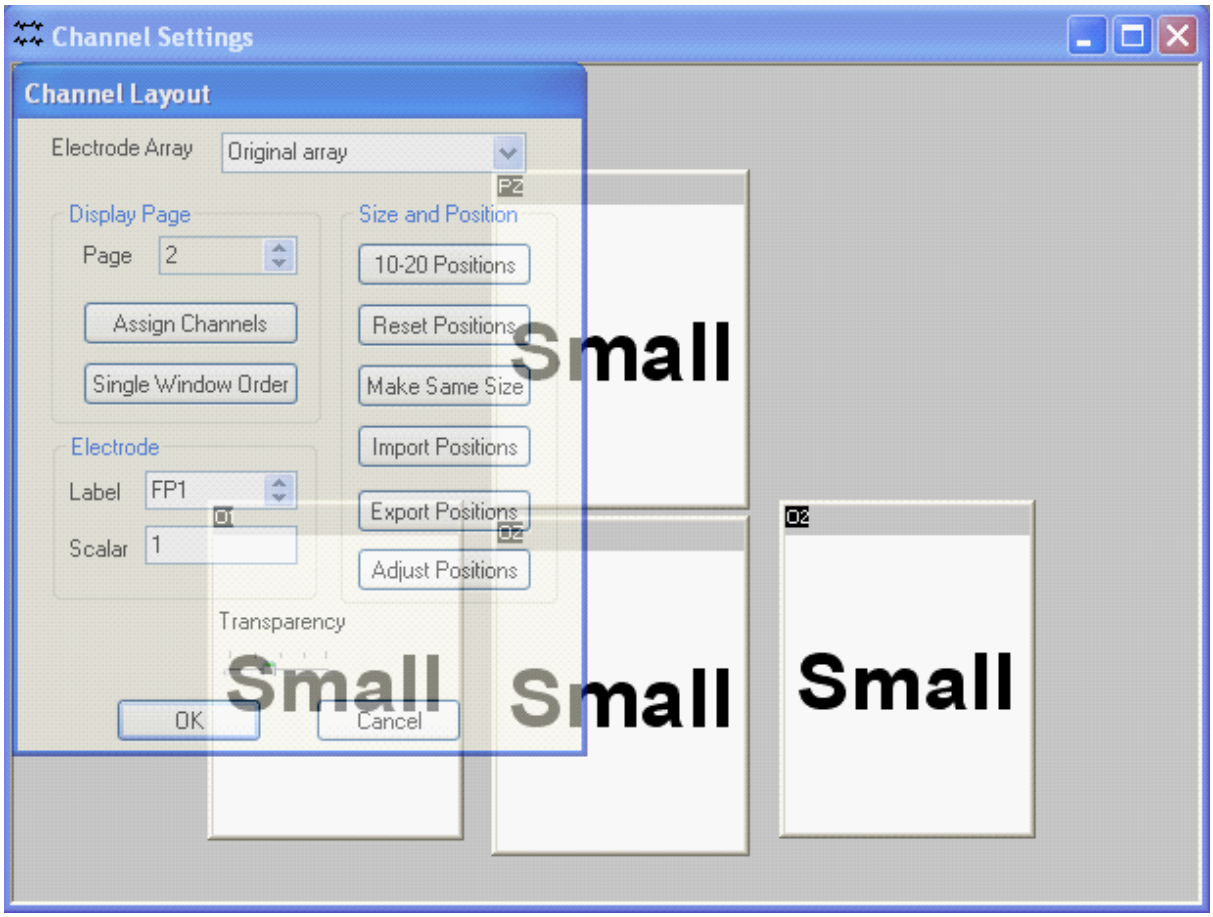
If you wish, you may resize and reposition the individual channel displays. Select one display and click/drag a corner to resize the display, then click the **Make Same Size** button to make all of the displays the same size. Move the displays around the screen by grabbing the colored bar at the top, where the electrode label is, and dragging the display to a new location.

Note
Be sure to click OK and Save the setup file before you click the Make Same Size button again. Otherwise, the new position information will be lost.

For this tutorial, let's create a second display page that will focus on the posterior leads where the VEP will be most prominent. Click the up arrow in the **Display Page** area so that a **2** appears (leaving the existing first page unchanged).

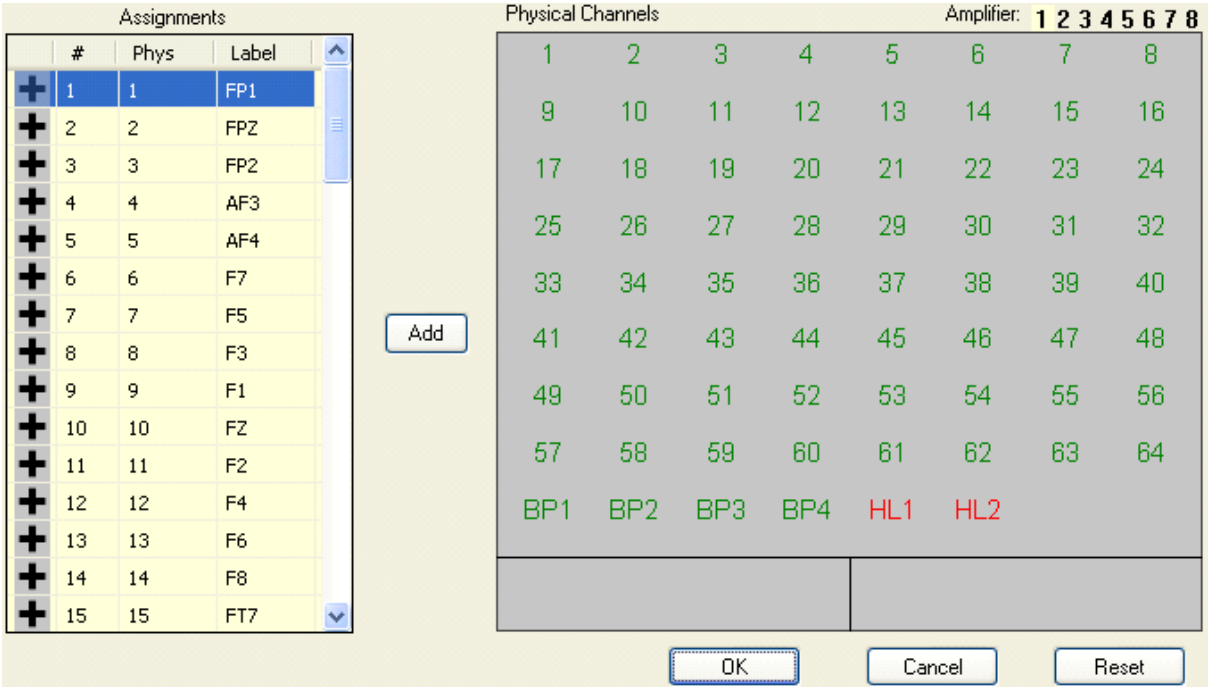


Then click the **Assign Channels** button. Double-click the PZ, O1, OZ, and O2 electrodes so that they appear in green, while the others are still red, and click OK. The 4 channel displays will appear. Resize and reposition these as desired. The result may look similar to the figure shown. Note that you can adjust the Transparency in order to see windows behind it.



Click OK to continue, and save the setup file again if you wish to retain the new display page (click **File** → **Save Setup** to resave the current setup file). During acquisition you may click on the **Next Display** button on the Toolbar to see the new display page.

11. Now go back to **Edit** → **Channel Assignment Table**. This displays a list of the physical channels and the labels created for each. You can reorder the physical channels, if desired (please refer to the *SynAmps* and *SynAmps*^{2} manuals for more details). You can also use the display to relabel channels. If you have more than one amplifier/headbox, you can select the additional one(s) using the Amplifier numbers.

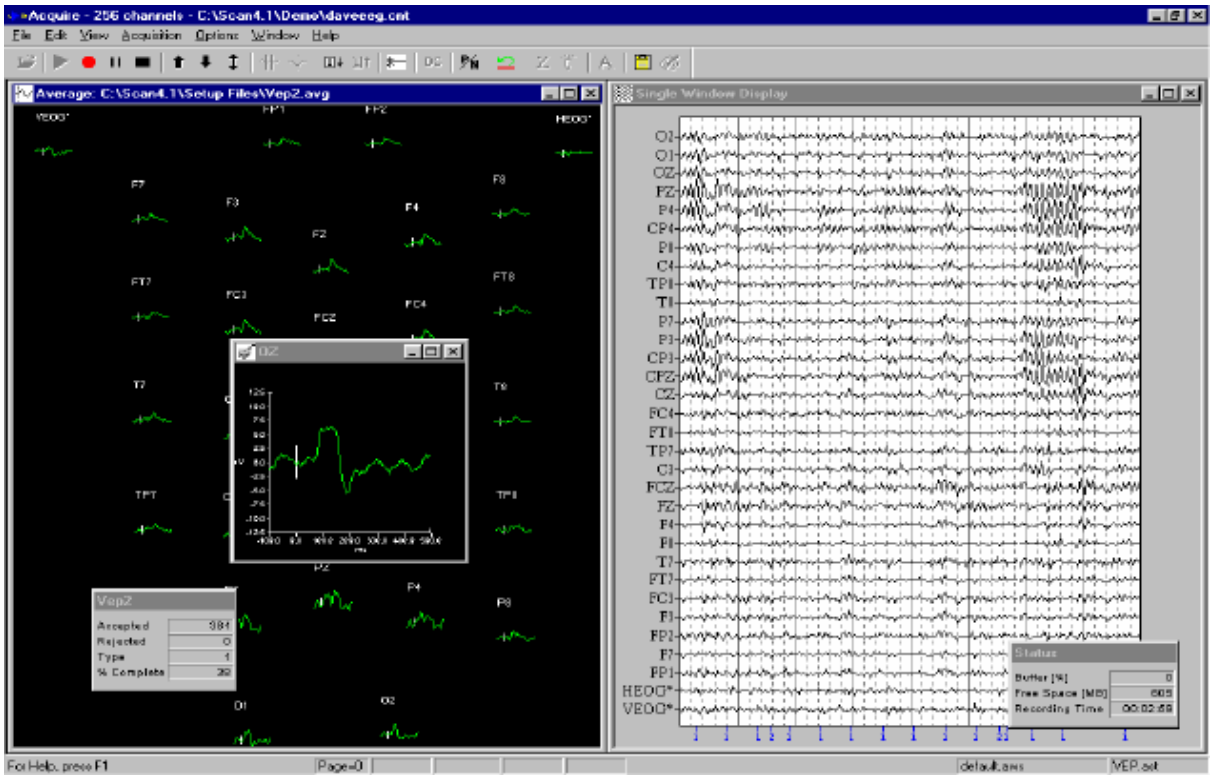


The order of the channels is contingent upon your actual cable connections and amplifiers (refer to your amplifier installation manual for more details, as well as the Channel Assignment table section in the ACQUIRE manual). Click OK to continue.

12. To begin viewing, click **Acquisition** → **Start Acquisition**, or just click on the green triangle toward the left end of the Toolbar . If the Toolbar is not displayed, enable it by clicking **View** → **Toolbars** and then enable the **Main Toolbars**.

When acquisition begins, you will be asked for a file name for the AVG file, and the program will then wait for triggers from STIM or other similar system. You will see the average waveform develop in the Multiple Window Display, with updates as specified in the **Avg Update** field in the **General** section in the **Epochs** display (set to 1 but may be changed as desired). If you did not select **Auto Save** (in the **Startup** display), you would need to click the **Record** icon on the Toolbar when you are ready to begin recording. The adjacent button with two vertical lines is the **Pause** button, and the button with the black rectangle is the **Stop** button.

The figure below displays the accumulating VEP average in a Multiple Window Display and the raw signals in the Single Window Display.



The Status box in the Multiple Window Display shows the numbers of Accepted and Rejected sweeps, the trigger Type code from STIM, and the percentage of accepted sweeps (based on the value entered for **Sweeps** in the **General** section under **Epochs** - 200 in this case). The Status box in the Single Window Display shows the percentage of Buffer space that is being used, the Worst DC Value (%), the amount of Free Space on your hard drive, the elapsed Recording Time, and the number of Events Counted. Termination will occur after the 200 sweeps are accepted (or after user interrupt by clicking on the **Stop** icon on the Toolbar).

2.2 Post acquisition processing of the VEP

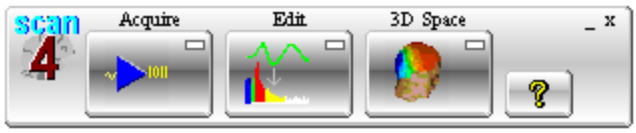
This section illustrates some of the processing steps that can be performed on averaged (AVG) files with the EDIT module. Generally, we recommend that you record the entire data as a continuous (CNT) data file, as this will give you more post-processing options. In this example, you will see how to:

- Perform basic operations
- Apply Baseline Correction
- Apply Filtering
- Export the file to ASCII

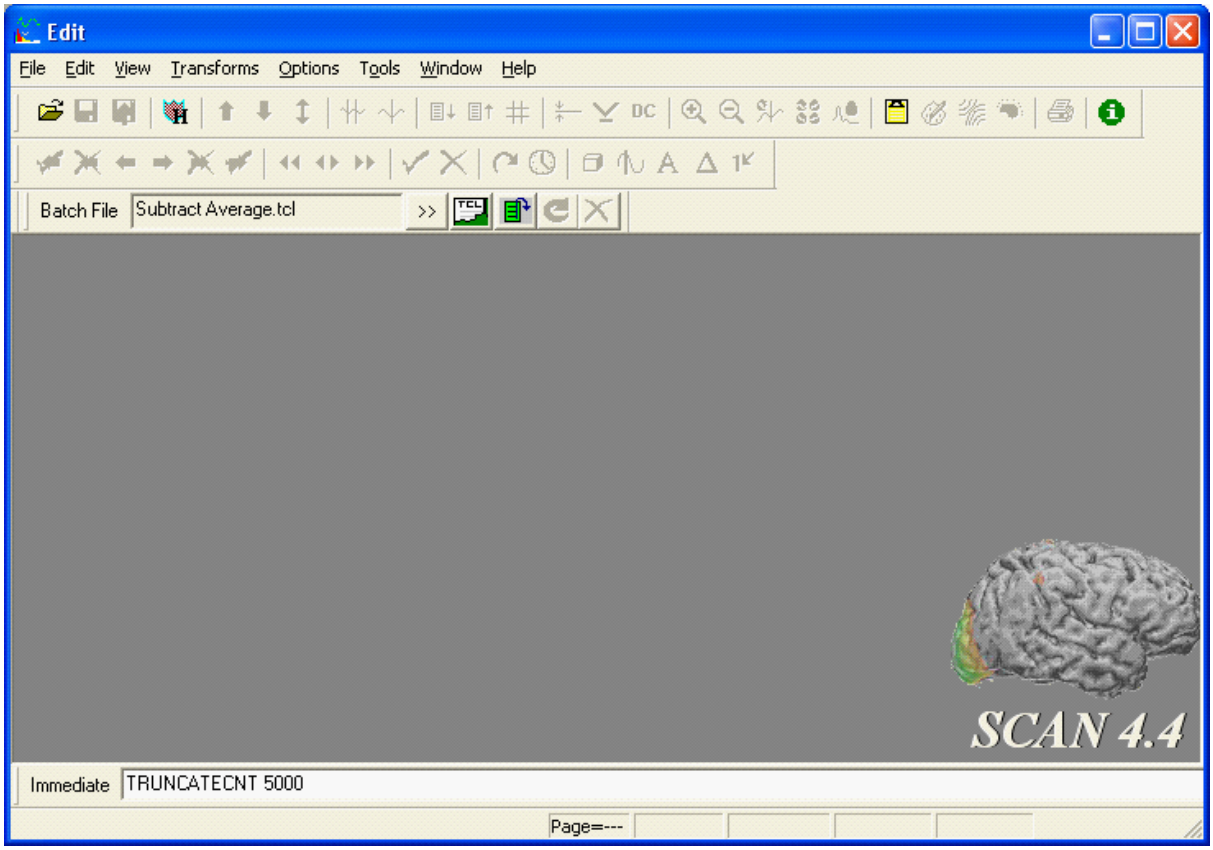
The visual evoked potential (VEP) to a checkerboard-pattern shift is one of the most widely employed neurophysiological measures. A checkerboard-pattern stimulus consists of a series of black and white checks that reverse their position at a specified rate. It is a popular stimulus because it generates a large and clearly defined series of responses at specific electrode sites. The most prominent responses are a negative peak at 70ms (N70) and a positive peak at 100ms (P100). Since the initial demonstration of delayed responses of these components in patients with multiple sclerosis (Halliday, McDonald, Mushin,

1973), the test has seen wide spread clinical application in neurology and ophthalmology. In this example, a 30 channel recording to a reversing checkerboard pattern will be used.

Click the EDIT icon From the Program Launcher.



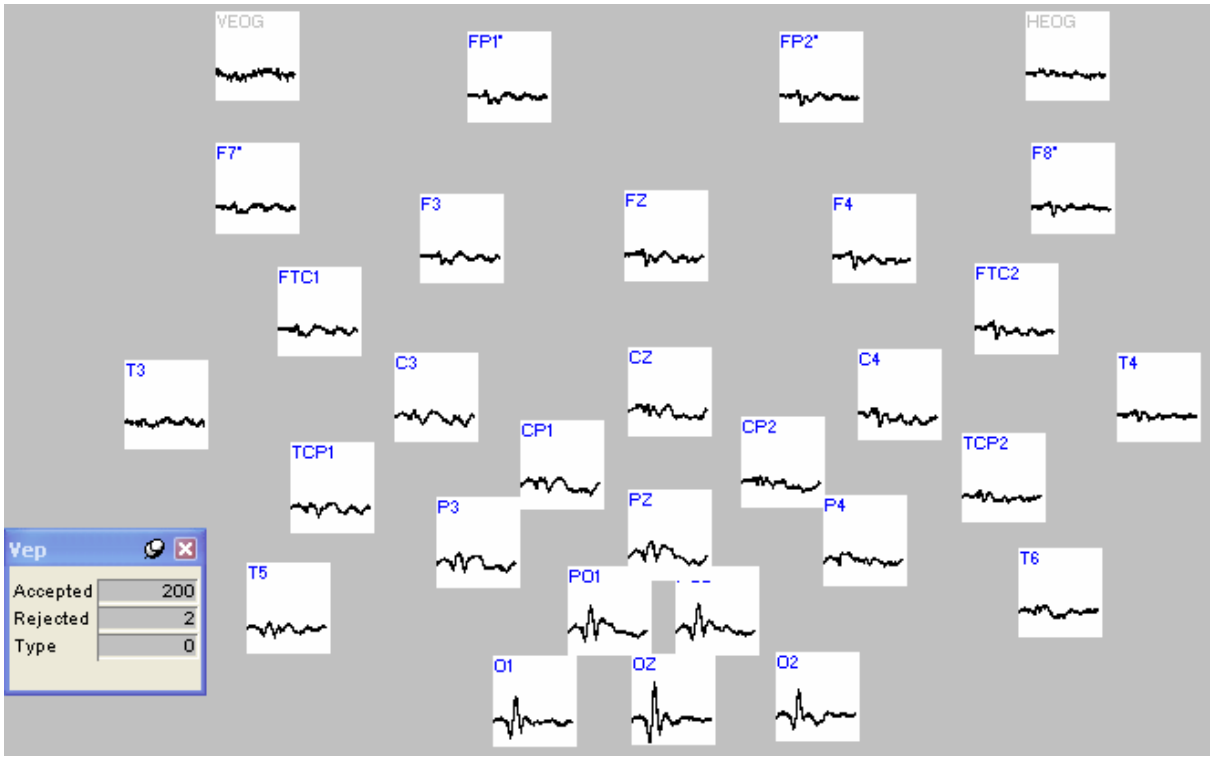
You will see the main screen in EDIT appear.



Then follow these steps to retrieve the VEP data file:

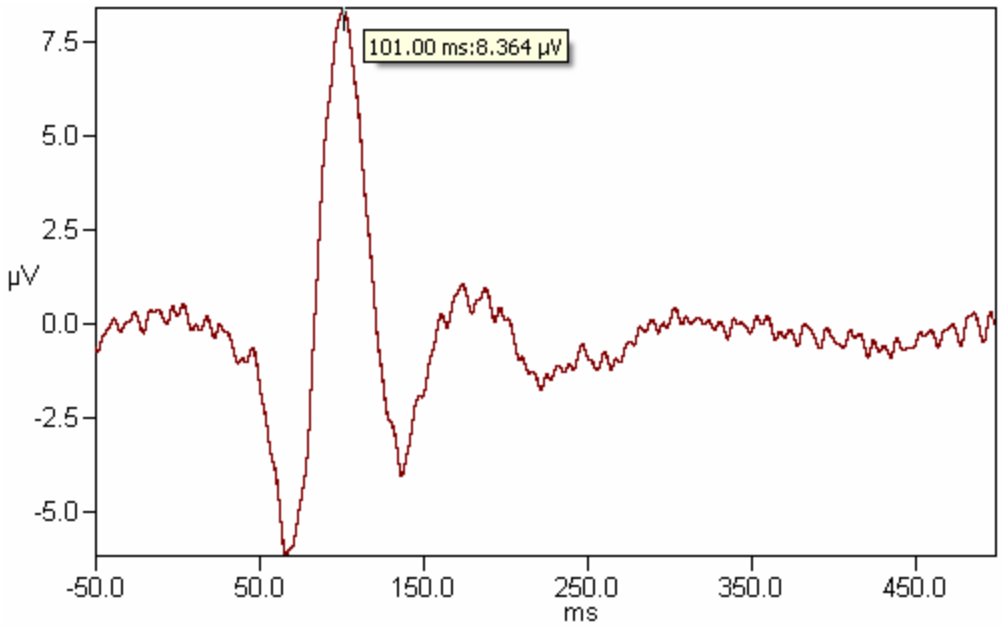
1. Loading a data file. Click **File** → **Open data file**, or click the Open data file icon . A standard Open File utility will appear. At the bottom of the screen is the "Files of type" line. Click the down arrow and select the Neuroscan Average File (**.avg*) type. Go to the *C:\Documents and Settings\All users\Application Data\Neuroscan\Scan4.5\Demo Files\Veps* folder, and retrieve the *Vep.avg* file. (For Vista installations, go to *C:\Scan Data\Demo Files\Veps*. If the lines appear flat, click the up arrow a few times to increase the display gain, or use the autoscale icon to scale the waveforms according to the largest and smallest values on the display. You should then see the VEP average waveforms. If you are used to seeing positive voltage up (or down), click the polarity invert icon to invert the waveforms, if desired. The colors in your file may be very

different to those shown below. These are controlled by the settings found under **Options** → **Multiple Window Settings** → **General** tab (described in more detail in the Acquire and EDIT manuals).



This average was collected from a normal 26 year-old male with 20/20 vision. Checker-board reversal occurred at a rate of 1 per second. The most noticeable feature of this recording is the prominent response at the occipital leads O1, O2, OZ, PO1 and PO2. This is the VEP generated to the reversing pattern. Note there is also a small Status box that contains information about how many sweeps were accepted and rejected (the Type field is explained in the ACQUIRE and EDIT manuals, and is not relevant for this demonstration).

Next, double-click on the channel labeled OZ. This will "Zoom in" to this channel and display the waveform shown below. AutoScale the display ↕, if needed.

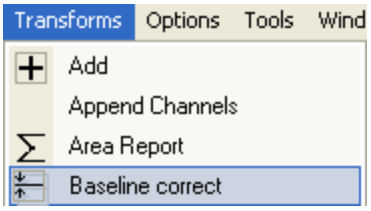


The first clearly identifiable peak is N70. In this subject, the peak occurs at 66ms. The next peak is the P100 response which occurs at 101ms. If you do not see the Tooltip, *right click* in the window and select **Show Signal Info**.

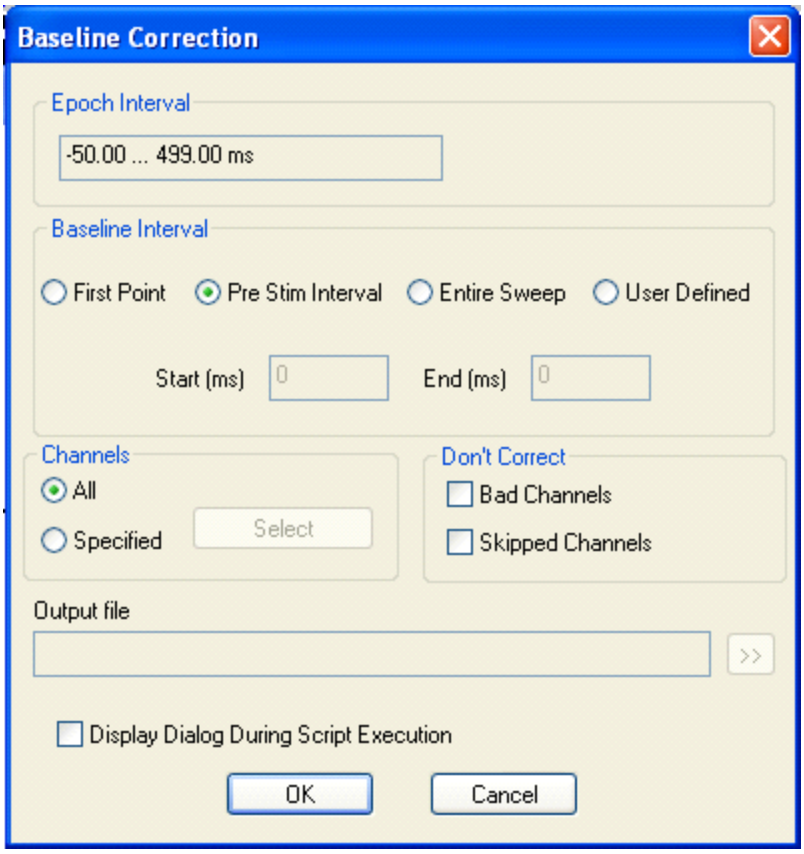
Now that we have an averaged file loaded, we can explore some of the various processing capabilities of EDIT. The primary purpose of EDIT is to change or transform a data set. Under normal circumstances a data file is loaded and then transformed in some manner. The transforms available depend on the type of file you have retrieved, and the possibilities are located in the Transforms menu. You may also access the Transforms menu by positioning the mouse between the electrode displays, and clicking the *right mouse* button.

2. Transforming the data. Click on the Transforms menu item and a list of the options that are available for the type of file will appear. A complete description of the Transforms may be found in the EDIT manual. For now, we will just use a few of them.

3. Baseline Correction. Baseline Correction computes the DC offset for each channel and then removes the offset from the working data file. Click **Transforms** → **Baseline correct** .



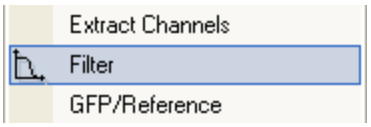
The Baseline Correction window will appear. The Epoch Interval is displayed on the top line (the start and stop time points of each sweep, as set in ACQUIRE when the file was recorded).



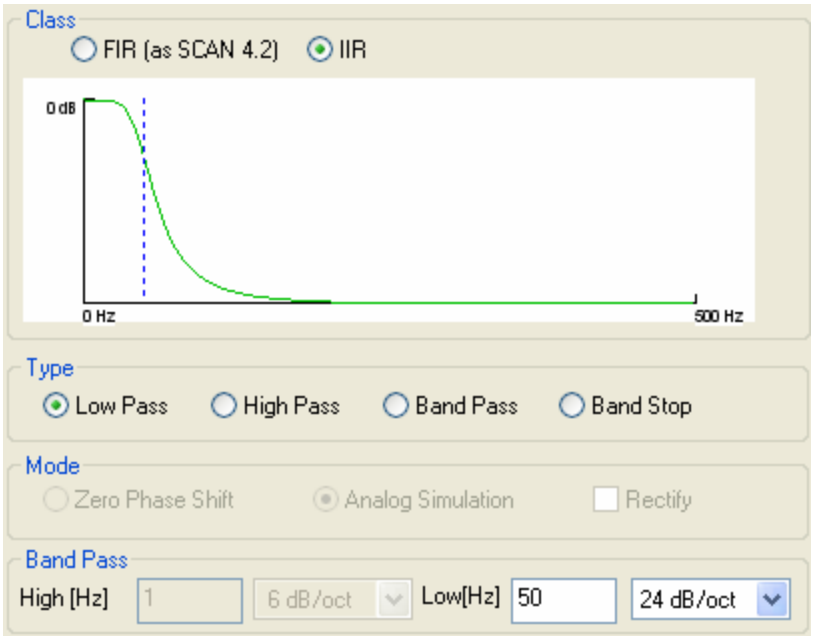
In the Baseline Interval region, select the Pre-Stim Interval, which, in this example, is -50 to 0ms. This means that for each waveform the mean DC value will be computed using the prestimulus interval. This value will then be subtracted from all points within the waveform. In the Channels region, select All to apply the correction to all channels. With AVG files, the Output file line is grayed out (>>). This is typical of many of the transforms that may be applied. With AVG files, the transform is applied "in place", meaning that the changes are applied directly to the AVG file. Save the file if you wish to keep the changes. With continuous and epoched (CNT and EEG) files, you must often use the Browse button to create a new output file.

Click OK, and the Baseline Correction will be made to the displayed file. When you close the file, you will be asked if you want to save the changes - you can overwrite the existing file or create a new file with the modifications (do not save the file yet).

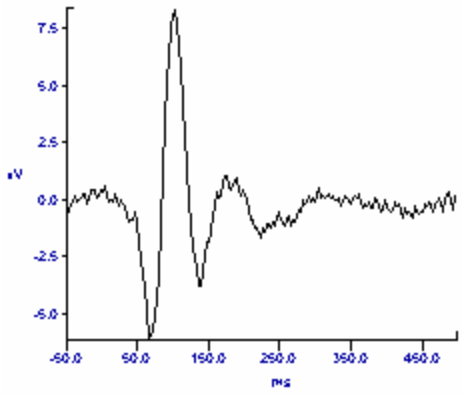
4. Filtering. The VEP file was collected with a band pass of 1 to 100Hz in a noisy (60Hz) environment. We can remove the unwanted noise by digitally filtering the data with a low pass filter set below 60Hz. The digital filter in EDIT is a zero-phase shift type which has the advantage of not producing a latency shift in the major components of the waveforms. Click **Transforms** → **Filter**. The Filter display will then appear. Select the **IIR** class, **Low Pass** for the **Type** of filtering, and enter **50** for the **Low** pass frequency cutoff. Select **24 dB/oct** for the filter slope.



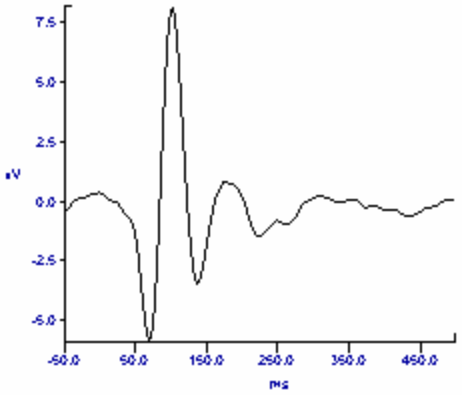
The filter display at the top shows graphically the current filter transfer function. Under Channels, select **All**. (The Output File line is grayed out for AVG files). Then click the **OK** button to apply the filter transform.



You can examine the effects of the filtering by zooming in on an electrode, such as OZ. To zoom in on an electrode, click once on the waveform to activate the window, or click twice to enlarge the window to its full size. Shown below are the effects of filtering.



Unfiltered

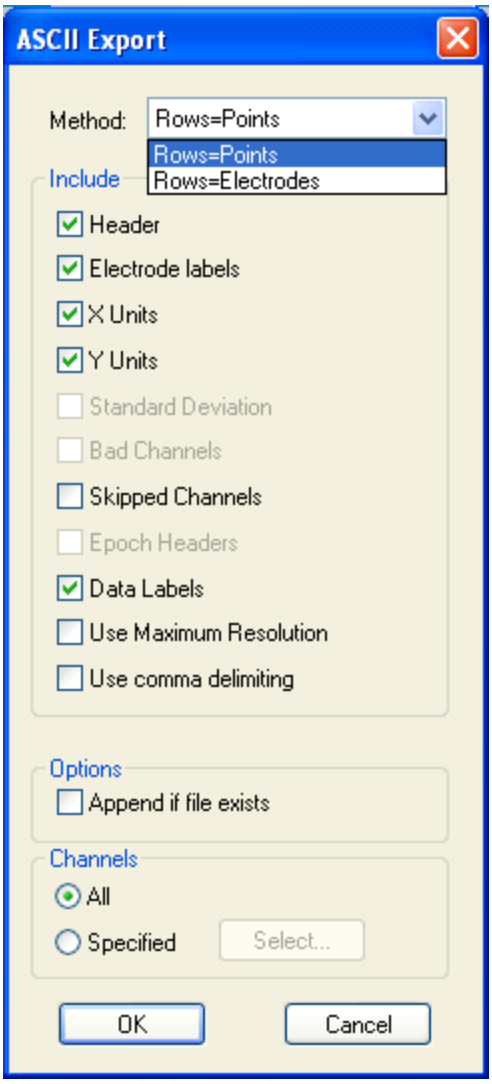


Filtered

5. Exporting the file in ASCII. Lastly, we'll export the filtered file in ASCII format. Most of the files created in SCAN 4.2 (and later versions) can be exported to or imported from ASCII. ASCII files are very useful for reading your data into other signal processing or

statistical analysis software. Files created by other acquisition systems, after conversion to ASCII with a compatible structure, may be read into EDIT for analysis.

To export the filtered VEP file to ASCII, make sure the desired file has the "focus", then select the **File** → **Save As**, or click the icon. On the Output File display, click the pull down menu on the **Save as Type** line, and select **ASCII File (*.dat)**. Enter a file name, specify a path, and click Save. You will see the following display.



These options are discussed in detail in the EDIT manual. For now, select the **Rows=Points Method** (if needed), and click **OK**. The resulting file may be viewed in WordPad or Notepad (depending on the size of the file).

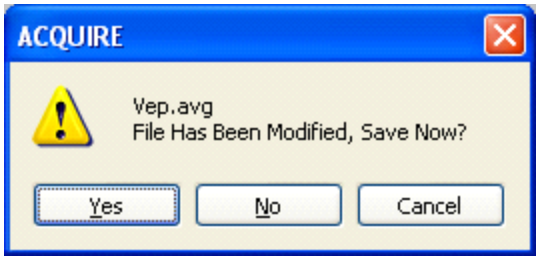
A section of the ASCII file is shown below.

```
[Electrode Labels]
[      FP1]   [      FP2]   [       F3]   [       F4]
[Electrode XUnits]
[ Default]   [ Default]   [ Default]   [ Default]
[Electrode YUnits]
[ Default]   [ Default]   [ Default]   [ Default]
[Average Data]
    -0.0004      -0.0008      -0.0008      -0.0018
    -0.0021      -0.0049      -0.0052      -0.0112
    -0.0058      -0.0148      -0.0162      -0.0349
    -0.0093      -0.0290      -0.0336      -0.0728
    -0.0076      -0.0412      -0.0525      -0.1175
     0.0041      -0.0442      -0.0666      -0.1581
     0.0276      -0.0331      -0.0712      -0.1856
     0.0613      -0.0075      -0.0655      -0.1948
     0.1010       0.0299      -0.0515      -0.1845
```

In the Rows=Points format, the electrode labels head each column, and the columns contain the sequential data points for each channel.

You may Import the ASCII file by clicking the Open File icon  , setting the **Files of Type** to **ASCII Files**, and selecting the DAT file you just created.

When you attempt to close the filtered *vep.avg* file, you will have the option to save the file with the modification you made. This display will occur anytime you modify a file, and then try to close it.



If you click Yes, you will have the option again to Overwrite the Existing File, or to Create a New File. Click the latter, and you will see a standard Output File utility, through which you may enter a file name and select a path. If you click No, the file will be closed without saving the modifications. If you click Cancel, you will be returned to the display as it was.

This concludes the first Tutorial.

3 Single sweep recording and online sorting - P300

This section describes how to configure ACQUIRE for single-sweep epoch acquisition, and how to perform online sorting of different types of stimuli. Artifactual sweeps that may not have been removed in the online average can be removed or corrected offline to minimize their effects on the reconstructed average. To illustrate this type of data

acquisition, the system will be configured to acquire a simple oddball auditory P300 evoked potential.

In this example, you will see how to:

- Configure ACQUIRE for Epoched acquisition
- Perform online sorted averaging
- Set parameters for Ocular Artifact Reduction in EDIT

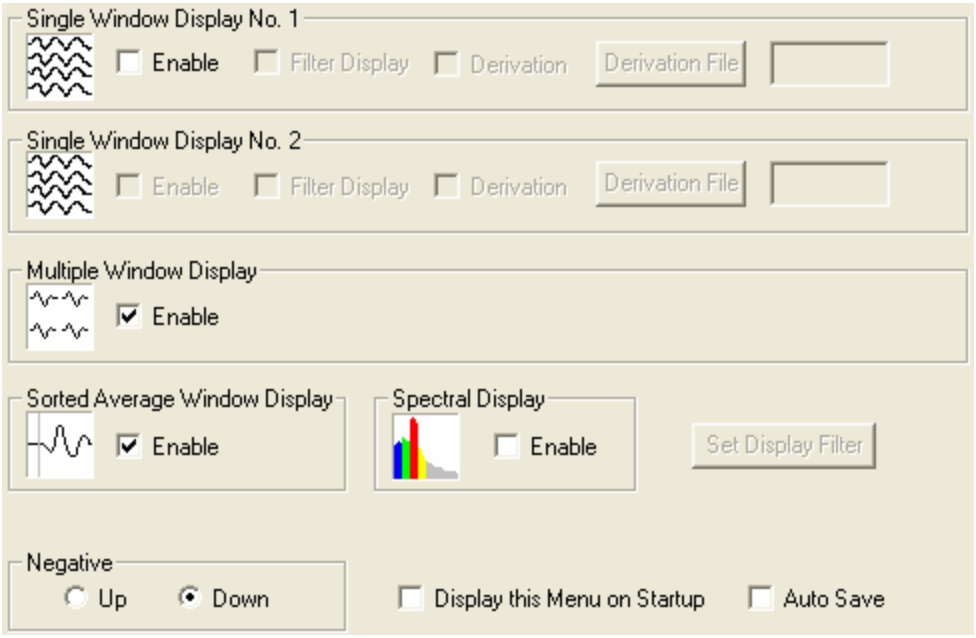
3.1 Acquisition

Follow these steps to configure the system for collection of the P300 evoked potential:

1. Start ACQUIRE (as described above). Retrieve the *Synamps2 Quik-Cap64.ast* file as described in the first tutorial. We'll begin with it and make some modifications to it. For your particular system, you may want to use a different setup file, or start with the **Make Default Setup** option (as described in the first tutorial).

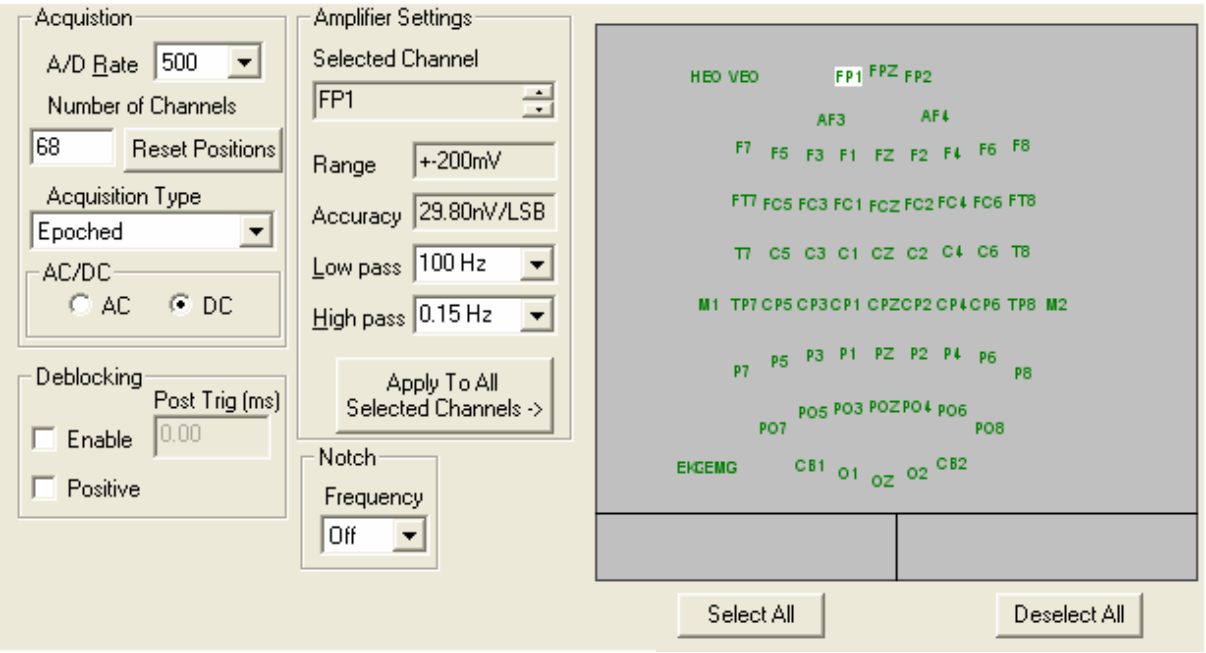
2. The next step is to modify the setup file for the P300 recording. Go to **Edit** → **Overall Parameters** and select the **Startup** tab. For this recording we'll look at the incoming signals from all channels, as well as the sorted averages. Disable both SWD's and **Enable** the **Multiple Window Display**.

Enable the **Sorted Average Window** display. Set the polarity as desired (Negative Up or Down). Make sure no other displays are enabled.



3. Select the **Amplifiers (SN2)** display. Set the **A/D Rate** to **500**Hz, or **512**Hz for *SynAmps Wireless* (click OK to any messages that appear). The digitization rate of 500Hz will provide enough resolution to determine peak latency and amplitude of the major components. Next, enter **68** for the **Number of Channels**, if not already set (fewer maximum channels with *NuAmps* and *SynAmps Wireless*). For **Acquisition Type**, select

Epoched (*SynAmps Wireless* users must use Continuous). This setting configures ACQUIRE to collect only epochs of EEG, sampled around the stimulus event trigger, and save them to disk. Real time display of the individual sweeps is shown as they are acquired.



In general we recommend that P300 and similar type recordings be acquired using the **Continuous** Acquisition type; the Epoched example is presented primarily for illustration purposes. The advantages and disadvantages of continuous mode acquisition are described in the Continuous recording tutorial using the N400 paradigm.

Under **AC/DC** select **DC** (*SynAmps Wireless* users must use **AC**). If you have *SynAmps* or *NuAmps*, enter a correction value of 70%. (If you have *SynAmps*, set the **Gain** to **1000**; if you have *SynAmps Wireless*, set the **Gain** to 1500).

In this example, we will enter different High Pass filter settings for the VEO and HEO channels in comparison to the EEG channels (*SynAmps* and *SynAmps*^{2} only).

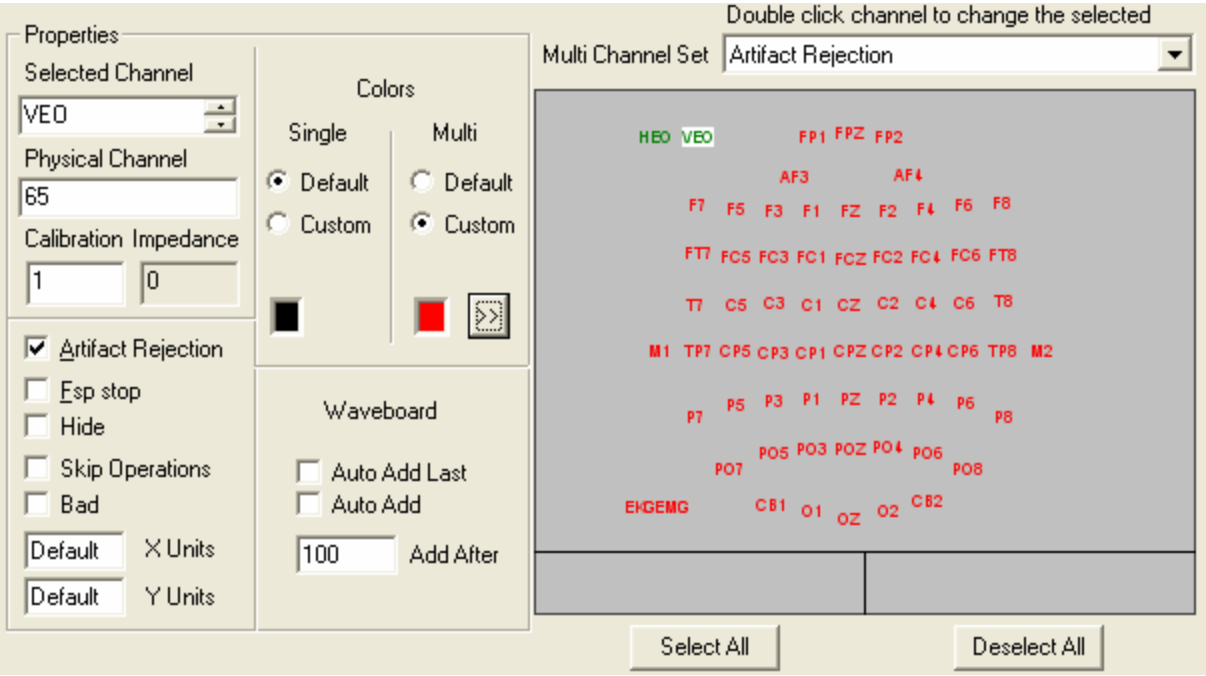
Note
If you intend to use the Ocular Artifact Reduction in EDIT to subtract eye blink artifact, we recommend that you use the same Filter (and Gain) settings for the VEOG and HEOG channels.

In the **Amplifier Settings** region, enter **100** for the **Low Pass** filter and **0.15** for the **High Pass** filter.

Click the Select All button (if needed) below the channels display so that all electrodes are green.

Now click the Apply To All Selected Channels -> button. This will apply the above Filter settings to all channels. For illustration purposes, we'll now change the Filter settings for the VEO and HEO channels. Click the Deselect All button; the labels should all be red. Double-click the VEO and HEO channels (so they turn green). Enter a **High Pass** setting of **1.0**, and click the Apply To All Selected Channels -> button again. You can verify the settings by clicking once on an electrode site and reading the settings in the Amplifier Settings fields.

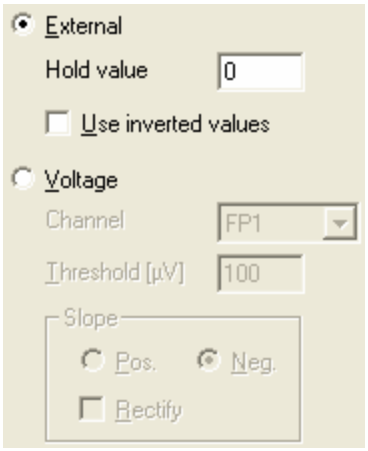
4. Select the **Channel Attributes** display. As in the prior tutorial, set the VEO and HEO channels to be Artifact Rejection channels. (Make sure the **Multi Channel Set** field is displaying **Artifact Rejection**, then double-click the VEO and HEO labels so they turn green). The VEO and HEO channels will show Artifact Rejection. You may want to have additional channels designated as artifact channels. During acquisition, and in the offline data files, you will see an asterisk at the end of each electrode label on the artifact rejection channels.



To illustrate another feature, let's change the color of the VEO and HEO channels. Click once on the VEO label in the channels display (or use the **Selected Channel** field to select the VEO channel). Then look at the Colors area. It is divided into Single and Multi fields, corresponding to the Single Window and Multiple Window Displays. In the **Startup** display, we selected a Multiple Window Display. Therefore, set **Multi** to **Custom**. Click the color field in the **Multi Color Code** to access the standard Color selection display. Select a color and click **OK**. This will change the color for the VEO channel waveform. Repeat the steps to change the HEO color.

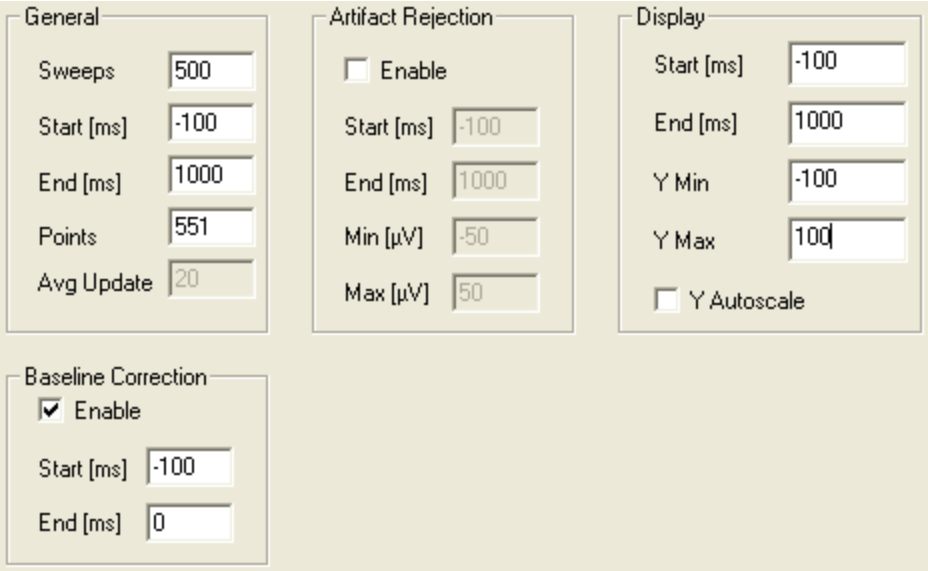
5. As in the prior tutorial, triggering for the P300 will be controlled by an External device (the Stim2 system). Select the **Triggers** display. The **Hold Value** should be set to **0**,

and **Use Inverted Values** is typically **Disabled** (see the triggering section in the ACQUIRE manual for special circumstances).



Note
The **Voltage Settings** are available in **Epoched** mode (only). In Epoched mode, triggering can be initiated based upon the voltage level in a selected channel.

6. Select the **Epochs** display. For this example, assume that you want a 100ms pre-stimulus interval, a 1000ms poststimulus span, and automatic baseline correction to be enabled during acquisition. In the General area, set the number of **Sweeps** to **500**. The stimulation device (i.e., STIM program) should provide at least 500 total events. The majority of these events will be used to construct the "Frequent" waveforms (FREQ); the remaining events will make up the Infrequent or "Rare" waveforms (RARE). Set the **Start** time for **-100** (pre-stimulus) and the **End** time for **1000**ms. The auditory P300 evoked response will contain several components peaking both before (P200) and after 300ms (late positive complex). Depending on the task conditions and subject, the late components may well extend beyond 300ms, and not return fully to baseline for periods up to perhaps 800ms poststimulus. The 100ms pre-stimulus interval will provide a stable baseline that can be used to remove any unwanted offset. The poststimulus interval of 1000ms should be of sufficient duration to include the late components. The Points field should change automatically to 551). The Avg Update field is not used for this recording.



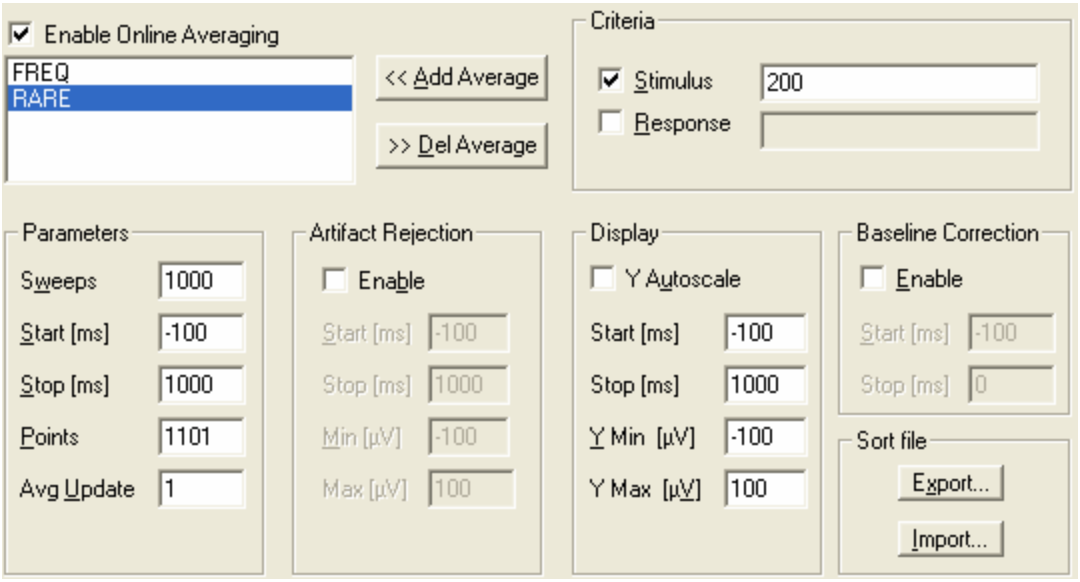
In this example a total sample interval of 1101ms (100ms pre-stimulus, 1000ms poststimulus, and the zero point) has been selected. The stimulation protocol must therefore provide at least this interval plus additional time for the overhead processing of the computer. A stimulation rate of 2 per second should easily be adequate in this example. If faster stimulation rates are desired you can decrease the sample interval as long as the poststimulus interval is of sufficient duration to view the major response components (i.e., late positive/negative complex).

In most P300 recordings you will want to store all of the epoched data to disk and then analyze the data offline with the EDIT module. By disabling the Artifact Rejection feature, all of the epochs will be stored. Disable the Artifact Rejection *Enable* field, if needed. It is still a good idea to enter the Start (-100ms) and End (1000ms), and the Minimum (-50µV) and Maximum (50µV) settings for later use (enter the values then click to disable).

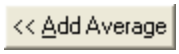
In the **Display** area, set **Start** to **-100**ms, **End** to **1000**ms, **Y Min** to **-100**µV, and **Y Max** to **100**µV. You will see the entire epoch displayed within the ±100µV limits. Leave the Y Autoscale disabled. If activated, the program will automatically scale the Y-scale voltages symmetrically to the greatest absolute value detected during the specified span of the epoch.

Enable **Baseline Correction**, set the **Start** time to **-100**, and set the **End** time to **0**ms. Baseline correction will be performed online by computing the mean offset value from -100 to 0ms, and then by subtracting this value from the entire waveform.

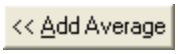
7. For this example, we will set the program to perform online **Sorting** and averaging of the RARE and FREQ stimuli. Assume that the STIM system has been set to send trigger type codes of 200 for the RARE stimuli, and trigger type codes of 100 for the FREQ stimuli. Select the **Sorting** display and **Enable** the parameters.



We will specify two averaged files to be sorted and saved. We will sort these files using the trigger type codes sent from STIM, or other similar stimulus presentation system.

Click on the 

button, and a Save File utility will appear. Enter FREQ, and you will see the FREQ name appear in the blank region below the button. Enable the **Stimulus** line and enter **100**. Set the **Parameters**, **Artifact Rejection**, **Display** and **Baseline Correction** fields as you wish. These will affect the online sorted averages only. The epoched data file that is stored is governed by the settings on the **Epochs** screen.

Then, click the 

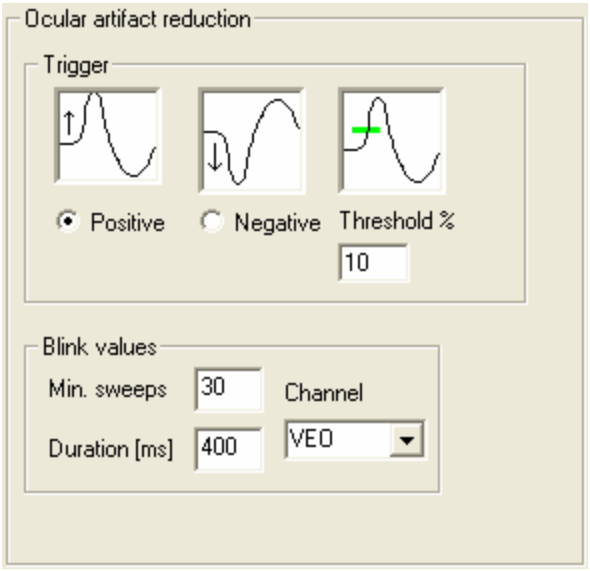
button again, enter RARE for the file name, enter **200** in the **Stimulus** field, and make any changes to the **Parameters**, **Artifact Rejection**, **Display** and **Baseline Correction** fields. The parameters are thus set independently for each sorted average. If you make a mistake and wish to change these files, highlight the averaged file you wish to edit, and make the changes.

The **Sweeps** value should not exceed the number of **Sweeps** set under **Epochs**. The **Start**, **Stop**, and **Points** are set in the **Epochs** display. The Avg Update sets the number of sweeps that must be accepted before the sorted average is updated. Leave it at **1** so that the average is updated with every accepted sweep.

If you want to delete an average file, highlight that file and click the 

button. If you use Sorting frequently, you may find it useful to save the sorting parameters as a separate file that can be retrieved in other setup files. In such cases, use the **Export** and **Import** buttons.

8. Select the **Miscellaneous** display. We will set the parameters for the Ocular Artifact Reduction transform here, and they will be retained in all data files recorded with this setup file. See the EDIT manual for an explanation of the settings - for now, just enter the values as shown. The values you use will depend upon your own experimental set up; they are refined with experience.



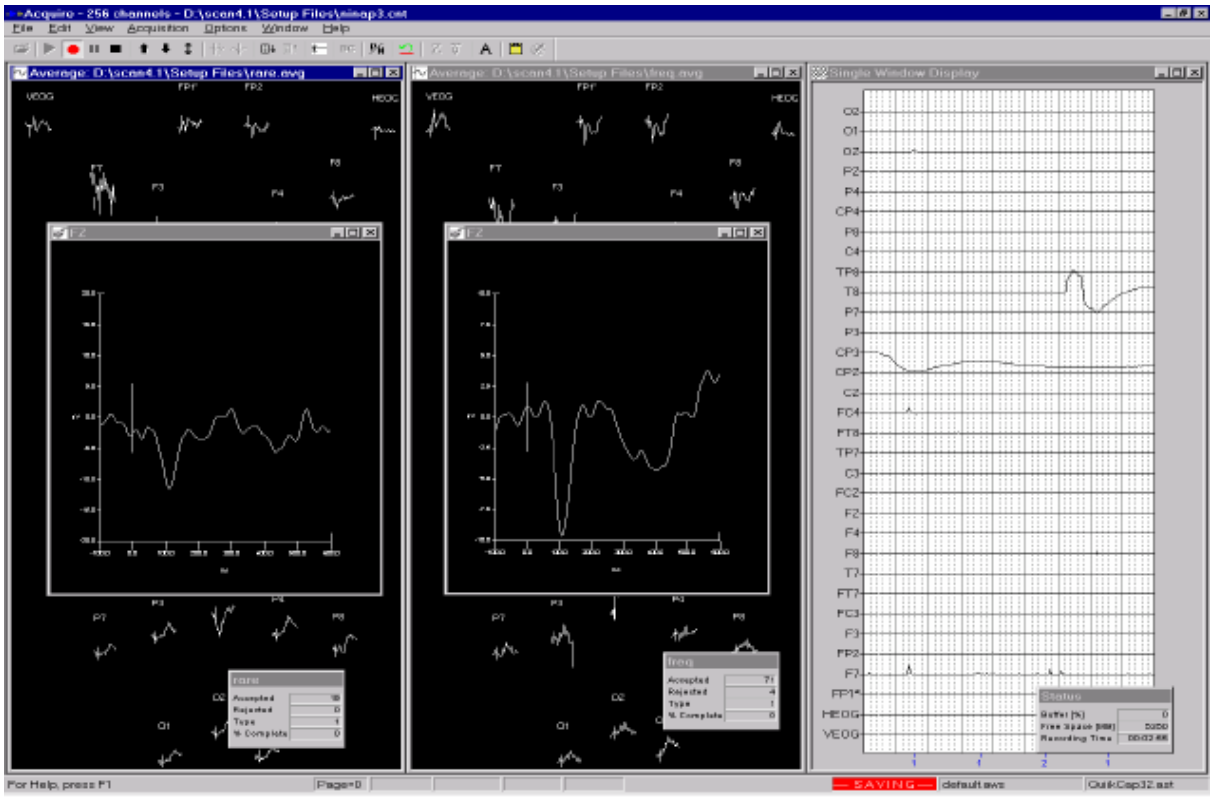
The remaining sections are not involved in these recordings.

9. Click the Save As... button, and label the setup file *P300SET* (the *.ast* extension will automatically be added).

(Make any changes to the electrode labels or the electrode positions using the Channel Assignment Table and the Channel Layout display, as described in the previous tutorial).

10. To begin viewing, click **Acquisition** → **Start Acquisition**, or just click on the green triangle toward the left end of the Toolbar . You will see the Multiple Windows Display and, after initiating data storage, two additional Multiple Windows Displays for the RARE and FREQ averaged files. Start STIM (or other acquisition system). Note that the sorted averaged displays will have no data until the first trigger is received (or first average update). When you are ready to begin recording, click on the **Record** icon (the red dot) on the Toolbar , and enter a file name. The *.eeg* extension will be added automatically. Click Save, and you will be returned to the Multiple Window Displays. The button to the right of the **Record** button, with two vertical lines, is the **Pause** button, and the button with the black rectangle is the **Stop** button.

Shown below are the waveforms for the online RARE and FREQ sorted averages. In this example, we used a Single Window Display rather than a Multiple Window Display to monitor the ongoing EEG. If you selected the **Epoched Acquisition Type**, under **Amplifiers**, the data will be stored as a *.eeg* file, regardless of whether you have a Single Window or Multiple Window selected under **Startup** (sets the display).



Termination will occur after 500 sweeps are accepted (or after user interrupt by clicking on the **Stop** icon).

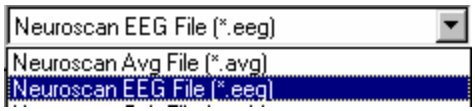
3.2 Post acquisition processing of the P300

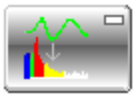
This section illustrates some of the processing steps that can be performed on single-sweep (EEG) files with the EDIT module. A 32-channel recording made with an auditory P300 paradigm will be used as an example data set. (In general, it is preferable to record the entire data as a CNT file rather than an EEG file - the EEG file is used here for demonstration purposes).

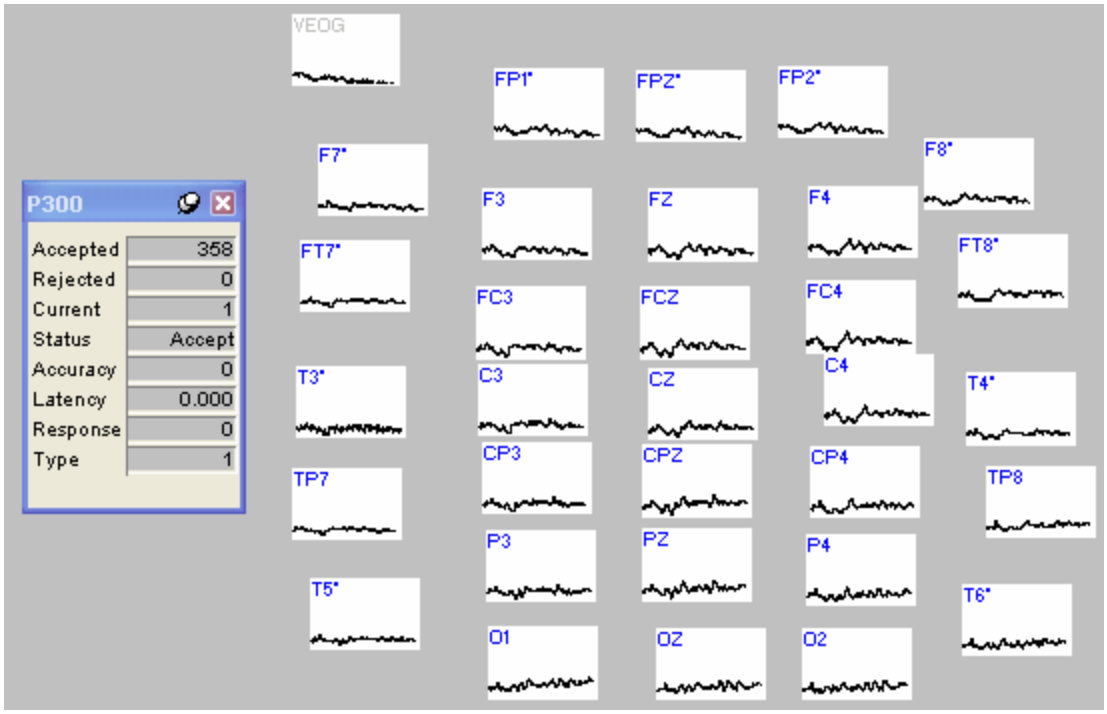
In the auditory P300 paradigm two different tones of varying frequency are played to the subject. Typically, the two tones of short duration (100ms) vary in either pitch or loudness. One of the tones is designated as the *infrequent tone*, or "Rare" or "oddball" tone, and occurs with low probability (.15). The other tone is designated as the *frequent tone* and occurs with high probability (.85). The tones are presented at a slow rate (2 second interstimulus interval) to generate auditory evoked potentials that can be easily recorded from the scalp. Evoked responses to these two tones show the large enhanced positivity at the vertex peaking near 300ms to the infrequent tone. In this tutorial, you will see how to:

- Perform Baseline Correction
- Perform Ocular Artifact Reduction
- Perform sweep-by-sweep Artifact Rejection
- Sort sweeps by trigger type code, and create averages

- Load Comparison Files



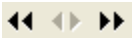
1. Loading a data file. After clicking the Edit icon  from the Program Launcher, select **File** → **Open data file**, or click the **Open Data File** icon  . A standard Open File utility will appear. At the bottom of the screen is the "Files of type" line. Click the down arrow and select the Neuroscan EEG File (*.eeg) file type. The EEG files contain single sweep data. Select the *P300.eeg* file from the ...*Demo Files**P300s* folder and click Open (or just double-click the file). The screen will clear and the first sweep of the P300 demo file will be displayed.



This file was collected from a 25 year-old male with good hearing. Tone pips (20ms duration, 5ms rise/fall) were presented via insert earphones every two seconds. A total of 358 tones was presented. Of these 358 tones, 284 were low-pitched (1000Hz) and 74 were high-pitched (2000Hz). Single-sweep epochs were recorded from 31 EEG leads and 1 ocular artifact lead to record vertical eye movements. Amplifier gain was 1000 (16-bit resolution on a *SynAmps*) with a band pass of DC to 50Hz. Each sample epoch consisted of a 300 point sample, starting 200ms prior and 996ms after stimulus onset (A/D Rate = 250).

When the data file appears, notice there is also a small status box. This will contain the Numbers of Accepted and Rejected sweeps in the EEG file, the Current sweep number, and the Status of that sweep (either Accept or Reject). If you had Merged the Task Data with the continuous file, you would see Accuracy and Latency information for each

sweep. If you had created epochs on the basis of response triggers, the trigger type would show in the Response field. The Type field shows the stimulus trigger types for each sweep.

You can review the individual sweeps from this file by clicking on one of the Arrow icons located on the Toolbar  . The two middle arrows step through the file sweep by sweep, either forward or backward. The next two with the red "x"s, on either side of the middle arrows, will jump to the next Rejected sweep, in either direction (if there are no rejected sweeps, these arrows will not be active). The outer two, with the green check marks, will jump to the next Accepted sweep, in either direction. There are also forward and backward SpeedScan buttons  . These will automatically step either forward or backward through the file, sweep by sweep. The center button stops the SpeedScan. Lastly, there is the Goto button  . When clicked, you will see the Goto Sweep window. Enter a sweep number, press OK, and the file will jump to that sweep.

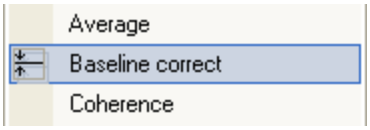
As you step through the sweeps in the file, note that the Current, Status and Type fields in the P300 status box change. Current tells you the current sweep number, Status shows whether the sweep is currently Accepted or Rejected, and Type is the trigger type code. Type will vary between 1 and 2. Sweeps identified by a type code of 1 correspond to the frequent tone and sweeps identified by a type code of 2 correspond to the infrequent tone. You can change the Accept/Reject status of a sweep by clicking on the Accept or Reject sweep buttons on the Toolbar  . The remainder of the icon options is explained in the *Operating EDIT* section of the manual.

2. Baseline correction. The DC level of individual sweeps can be removed with the Baseline Correct option in the Transforms menu. To estimate the DC level we will use the prestimulus interval of the epoch. This baseline value will be estimated for individual electrodes for each sweep.

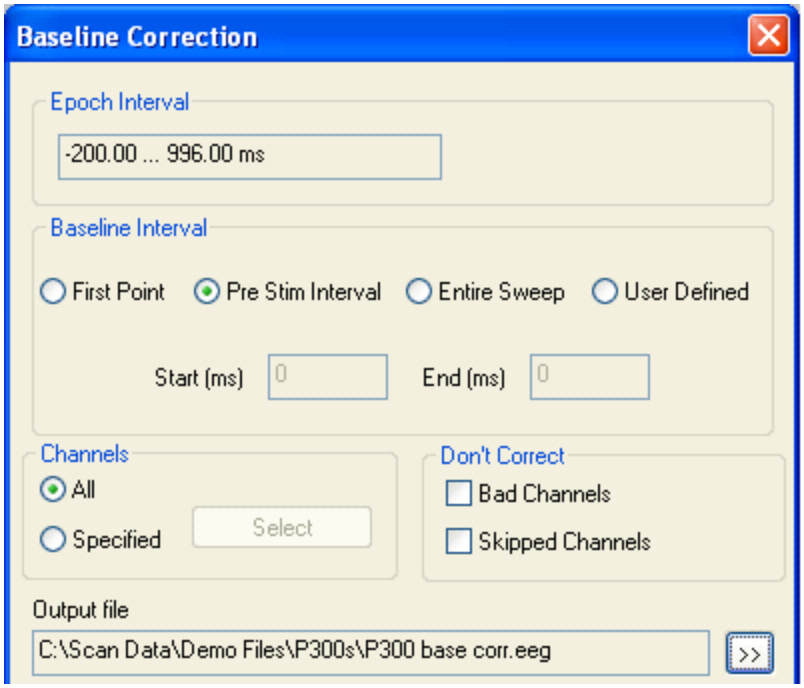
It is also possible to remove the DC level after the average has been created, as in the previous tutorial. However, there are at least two advantages to removing the offset from single-sweeps. First, although offset removal from single sweeps does not affect the averaged waveform, it can affect estimates of variability. By removing the offset from single-sweeps the variability due to offset potentials between each epoch is removed. DC offsets between sweeps can become a significant factor in slow-potential recordings. Second, the automatic rejection algorithm uses voltage excursion criteria and is sensitive to the DC level. More acceptable sweeps can often be obtained if baseline correction is performed before artifact rejection criteria are applied.

Follow these steps to remove the DC level from the P300 file:

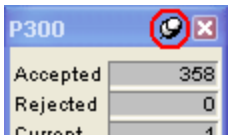
Click on Transforms from the Main Menu bar. This menu shows the Transforms that can be performed on an epoched file (see the EDIT manual for details). For now, we will look at just a few of them.



Select **Baseline correct**, and the Baseline Correction window will appear.



The Epoch Interval is displayed on the top line. In the Baseline Interval region, select the **Pre-Stim Interval**, which, in this example, is -200 to 0ms. This means that for each waveform the mean DC value will be computed using the prestimulus interval. This value will then be subtracted from all points within the waveform. In the Channels region, select **All** to apply the correction to all channels. Click the  button to display the standard Output File dialog box. Select a folder and enter an output file name, click Save, and then the OK button to perform the correction. A progress bar will track the new file as it is being created and saved. When completed, you will see a new Multiple Window Display with the baseline corrected file. Be sure to use this file for the next step.



Note

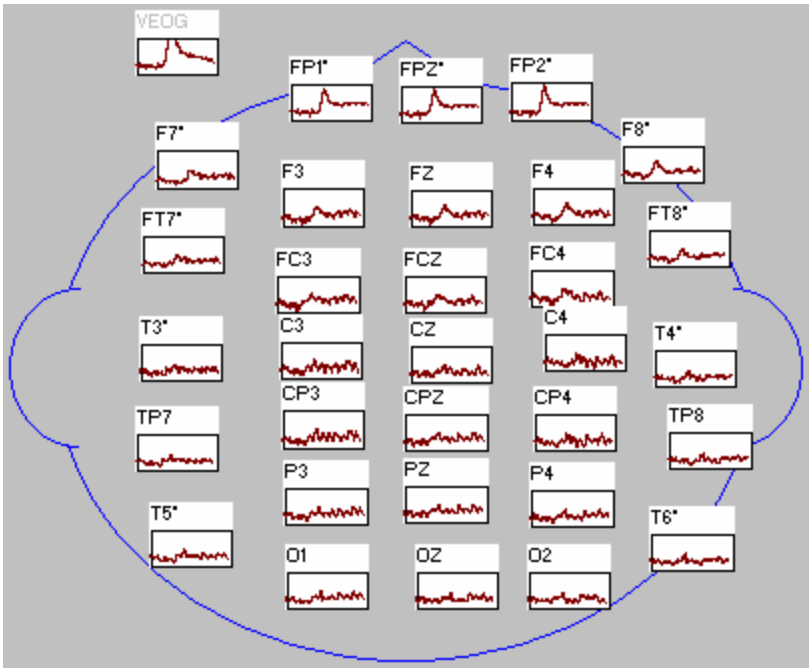
Use the "Sticky pins" to stick the Status boxes inside their corresponding displays.

3. Ocular artifact reduction. The artifact generated by eye movements often greatly exceeds the EEG. This is particularly true for frontal, and, to a lesser extent, centrally-placed electrodes. If eye movements are retained in the spectral or evoked potential average, they will greatly distort your results. One strategy for dealing with these eye movements is to visually or automatically reject sweeps of EEG that contain significant eye movements. However, this approach often results in an unacceptable loss of data.

A better solution is to use an eye movement reduction algorithm that can subtract the eye movements from the ongoing EEG. We will apply an artifact reduction transform to

improve the EEG before it is submitted to averaging.

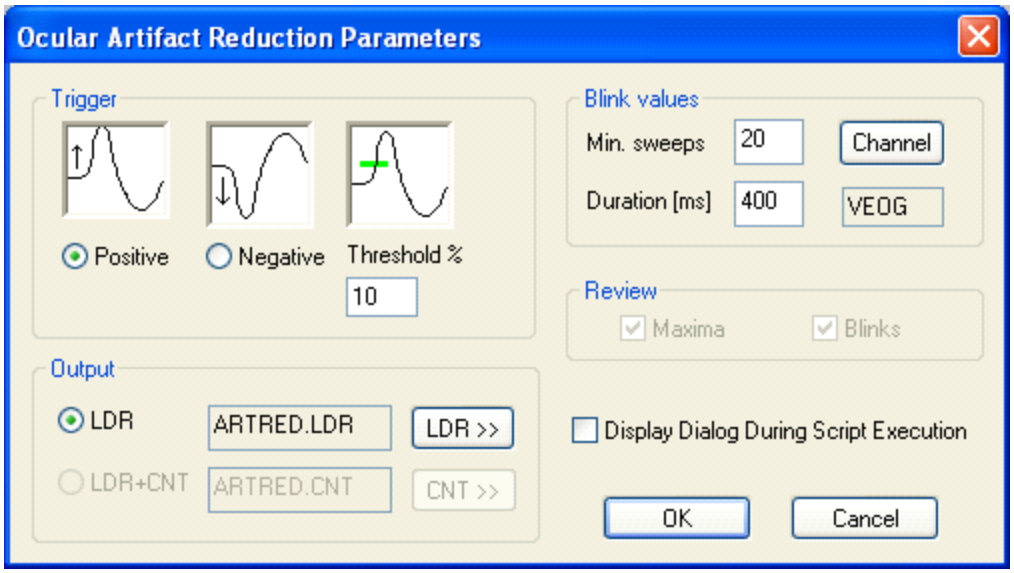
Let's review some of the individual sweeps that contain eye movements or blinks. Use the arrow buttons  on the Toolbar to move through the individual sweeps of the evoked potential data (or use the arrows keys on the keyboard). The second sweep of the P300 file contains a clear eye-blink, as shown below.



Notice that the blink is most prominent at the VEOG electrode, and then decreases as you move back. As you step through the file, note that these large excursions are found in many of the sweeps. In these sweeps, the electrodes FP1, FPZ, and FP2 are strongly affected, and these artifacts need to be reduced before constructing average waveforms. Find a few sweeps with an eye movement artifact, and note their sweep numbers. We will return to these sweeps after using the eye movement reduction algorithm.

The Ocular Artifact Reduction algorithm proceeds through three steps: 1) the VEOG channel is scanned for the largest eye movement, or blink; 2) an average is constructed from the blinks; 3) the artifact is subtracted proportionally from the raw EEG waveforms.

Click **Transforms** → **Ocular Artifact Reduction**, and the Ocular Artifact Reduction Parameters window will appear.



The following is a brief description of each of the fields. (A much more complete explanation of the artifact reduction algorithm is given in the EDIT manual).

Note

The "default" settings can be entered under the **Miscellaneous** display in ACQUIRE when you create the setup files for acquisition. These settings will then be stored with the data files you acquire, and will appear automatically in the Ocular Artifact Reduction Parameters dialog screen.

Trigger - Selecting either of the first two radio buttons determines whether a positive or negative deflection will trigger the onset of an artifact event. The third setting is the Trigger Threshold. This sets the percent deviation from the maximum artifact voltage needed to initiate the onset of an artifact event. (Select **Positive** and **10%** for this demonstration).

Blink Values - The Blink Values area has the following settings:

Min. sweeps - Minimum sweeps sets the minimum number of artifact events needed to estimate transmission weights for ocular correction. Enter **20** for this demonstration.

Duration - The sweep Duration field determines in milliseconds the span of the eye blink segment to be used in the average blink artifact. This is explained in more detail in the EDIT manual. For now, enter **400**.

Channel - The Channel field is used to select the blink channel. The electrode label must correspond to an existing electrode name that is assigned to a bipolar vertical or horizontal channel. To change the channel, click the Channel button, and the montage diagram will appear. Click the channel that you desire (typically the **VEOG** channel), and say OK to return to the parameters screen.

Review - The review settings allow you to select manually the sweep with the maximum voltage and the individual blinks to be used on the average artifact calculation if, and only if, you are using a continuous file. With the *P300.eeg*, there is no option to review the Maxima and Blinks. Their functions are listed below anyway, for informational purposes.

Maxima - When the Maxima field is enabled, you will have the opportunity to review the maximum voltage that is detected, and then determine if it is a genuine blink.

Blinks - When the Blinks field is enabled, you will have the opportunity to accept/reject the "blinks" that are detected by the reduction routine.

Output - These fields determine the type(s) of output files to be created. Since we are using the *P300.eeg* file, the LDR+CNT option is not available. You will have an opportunity to enter a file name for the output EEG file shortly. The LDR+CNT output description is included below for informational purposes.

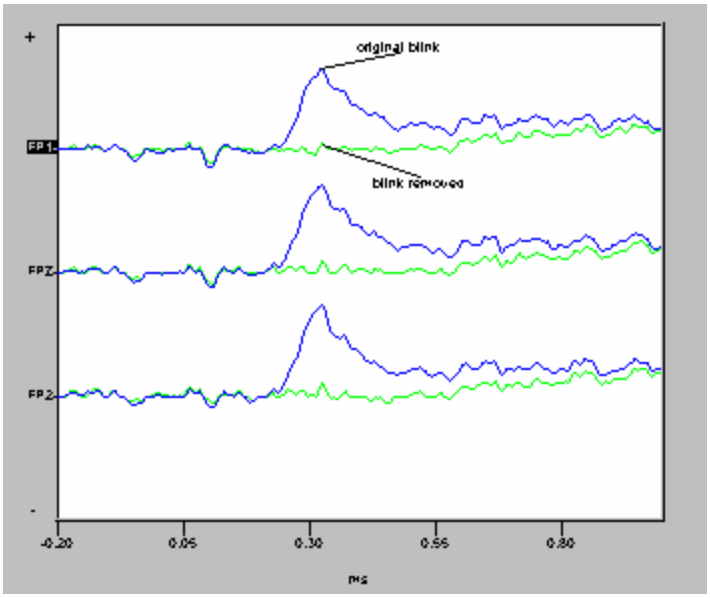
LDR - When enabled, this option will create an LDR (linear derivation; .LDR extension) file. The LDR file, created in conjunction with the Spatial Filter and Spatial SVD, can be used in place of the Ocular Artifact Reduction routine with other data files from the same subject, assuming the recording conditions are the same (refer to the Ocular Artifact Reduction section in the EDIT manual). Click the **LDR>>** button to access a Save As... utility display in which you may enter a file name and path for the new file. (We will ignore the LDR file for this demonstration).

LDR+CNT - When enabled (assuming you start with a CNT file), this option will create a new .LDR and a new .CNT data file with the artifact transform applied. Click the radio button to enable the option, and then the **CNT>>** button to enter a file name and path for the new file. Then click the OK button to continue. (With EEG files, an Output File display will appear before the transform is applied, allowing you then to create a new file with the transformed data).

When you have entered the desired settings, click OK, and the routine will begin. The routine will automatically find the Maximum voltage and average the Blinks. Next you will see an Output File utility display for the corrected EEG file. Enter a file name, specify a folder, and click OK. When the correction has been completed you will need to retrieve the new EEG file.

Note
With EEG files, you will not have the opportunity to see the transmission coefficients or SDs prior to performing the artifact subtraction. You do see these if you are using a CNT file, which is another advantage to recording your data in continuous mode.

Now let's look at the effects of the reduction process. Advance to the second sweep in the file. The figure below shows the corrected FP1, FP2 and FPZ channels superimposed on the uncorrected channels. (This graphic was created with the Waveboard feature, described in the Waveboard Appendix in the back of the EDIT manual).



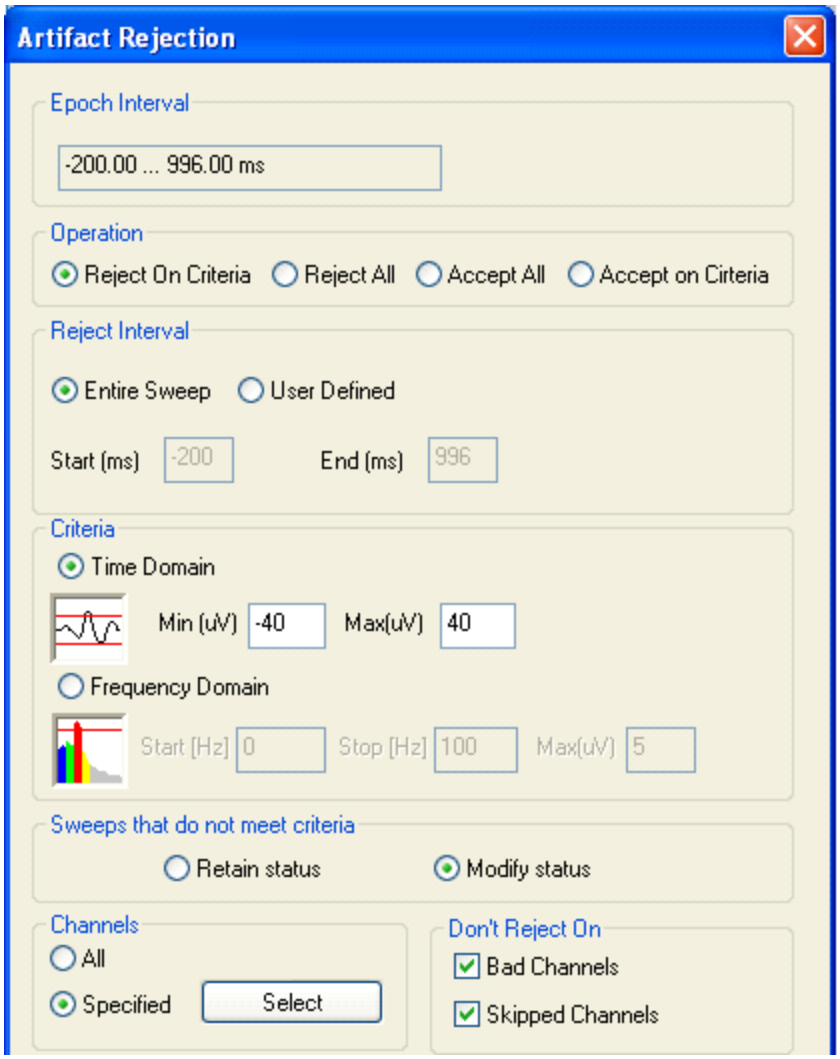
The algorithm effectively removed the blink artifact. Step through your original and corrected EEG files to see results for several of the sweeps. The blink is still seen in the VEOG channel, which remains unchanged in this process. There are different ways to remove blink artifact while retaining genuine EEG activity. One is described in the Spatial Filter description in the EDIT manual, and another uses the Blink Noise Reduction transform.

4. Automatic artifact rejection. Individual sweeps in the designated Artifact Rejection channels that contain voltages exceeding the thresholds you specify, will be automatically rejected using the Artifact Rejection command. In the P300 demo file we are using, the VEOG and most of the fronto-temporal channels were set as Artifact Rejection channels when the data file was recorded (using the Channel Attributes window in ACQUIRE). These channels may be recognized by the asterisk that appears just after the electrode label 

. Since we have already removed the blink artifact in the step above, it may not be necessary to do Artifact Rejection - a manual review of the sweeps would suffice. However, for the sake of illustration, we will perform Artifact Rejection using a different set of channels that do not include the VEOG channel. (If you include the VEOG channel, there will be about 250 sweeps rejected using +/- 50μV thresholds).

Follow these steps to automatically reject artifact:

Click **Transforms** → **Artifact Rejection**. The Artifact Rejection window will appear.



The following is a brief description of each of the fields in this dialog box:

Epoch Interval - This field displays the starting and ending time points of the epochs in the file.

Operation - The Operation field allows you to Reject On the basis of the Criteria you enter below, Reject All sweeps, Accept All sweeps, or Accept on the basis of the Criteria you enter below. Rejecting all sweeps is useful in cases where most of the sweeps are bad, and you wish to accept only a few good ones. Accepting all sweeps can be used to restore all of the rejected sweeps to accepted status. Select **Reject On Criteria** for this example.

Reject Interval - This section allows you to set the range of the epoch during which the rejection criteria will be applied.

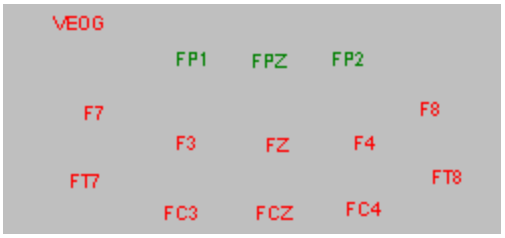
Entire Sweep - When enabled, the entire epoch will be searched for voltages exceeding the amplitude criteria. **Enable** it.
User Defined - When enabled, you may select the time range in which you want the amplitude criteria to be applied. The Start(ms) and End(ms) windows will become

active, and you may enter the desired time points.

Criteria - Select the Time Domain option, and enter the Minimum and Maximum microvolt values. Any voltages from the Artifact Rejection channels that exceed these limits will result in rejection of that sweep. Enter **-40** and **40** for these fields. (The frequency domain option lets you reject sweeps when the amplitude within a specified frequency range exceeds a specified voltage threshold).

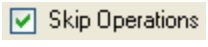
Sweeps that do not meet criteria - If you have already rejected some epochs, such as through manual sweep rejection, you can opt to keep these sweeps as rejected by clicking the Retain Status radio button. The sweeps will remain rejected regardless of whether they exceed the criteria or not. Select the **Modify Status** option if you want the new criteria to be applied regardless of whether any sweeps had been previously rejected (previously rejected sweeps will be accepted if they do not exceed the criteria set above).

Channels - When the All option is selected, the criteria will be applied to all channels. When the Specified option is selected, the Select button will become active. Click it and you will see a display from which you may select the channels that will be used for artifact rejection. The ones that appear selected are those that were set in the setup file created in ACQUIRE. For this demonstration, select **Specified** and click the **Select** button. The channel display will appear.

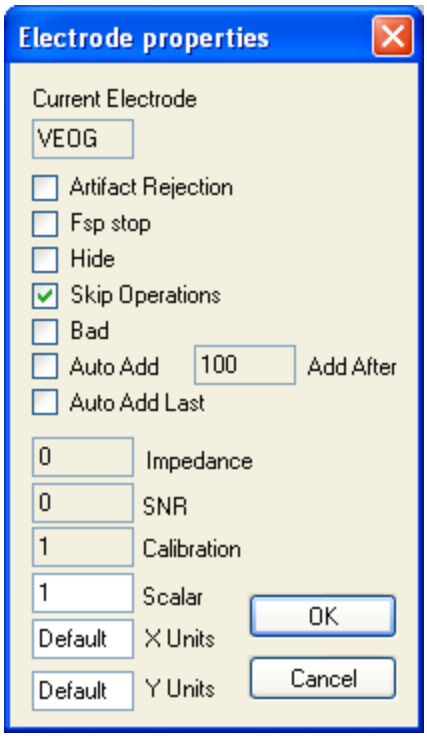


Deselect all 

of the channels, then select only FP1, FPZ, and FP2 by double-clicking them (they will change color from red to green). Then click **OK**. Only these three channels will be monitored for artifact rejection.

Don't Reject On - In ACQUIRE you had the capability of designating channels as Bad or Skip (you can set them in EDIT as well). The **Don't Reject On** fields let you remove either or both of these channels from the artifact rejection scan. The VEOG channel was recorded as a Skipped channel - you can recognize Skipped channels because the electrode label will be gray, as opposed to whatever color you had selected under **Options** → **Multiple Window Settings** → **General** → **Text**. You can also click the *right mouse* button on an electrode display, and select the **Channel Properties** option. If you *right click* on the VEOG channel, and you will see the 

option has been enabled.



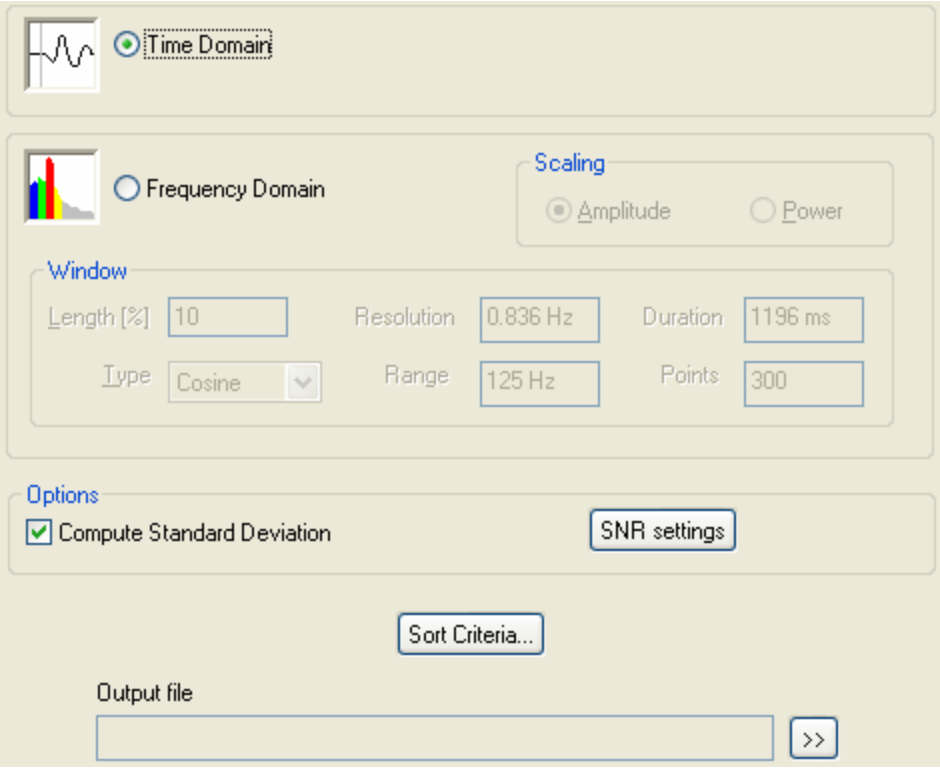
For this demonstration, leave both **Don't Reject On** fields **enabled** on the Artifact Rejection display.

Click **OK** and the artifact scan will begin. During the scan you will see a progress bar displaying the progression of the scan. After it is complete, the P300 status box will show how many sweeps were accepted and rejected.

Step through the corrected EEG file to see which sweeps are rejected or not.

5. Sorting and construction of averaged waveforms. The last step is to sort the different single-sweep types (1=frequent and 2=infrequent) into separate averages. Follow these steps to construct averaged waveforms:

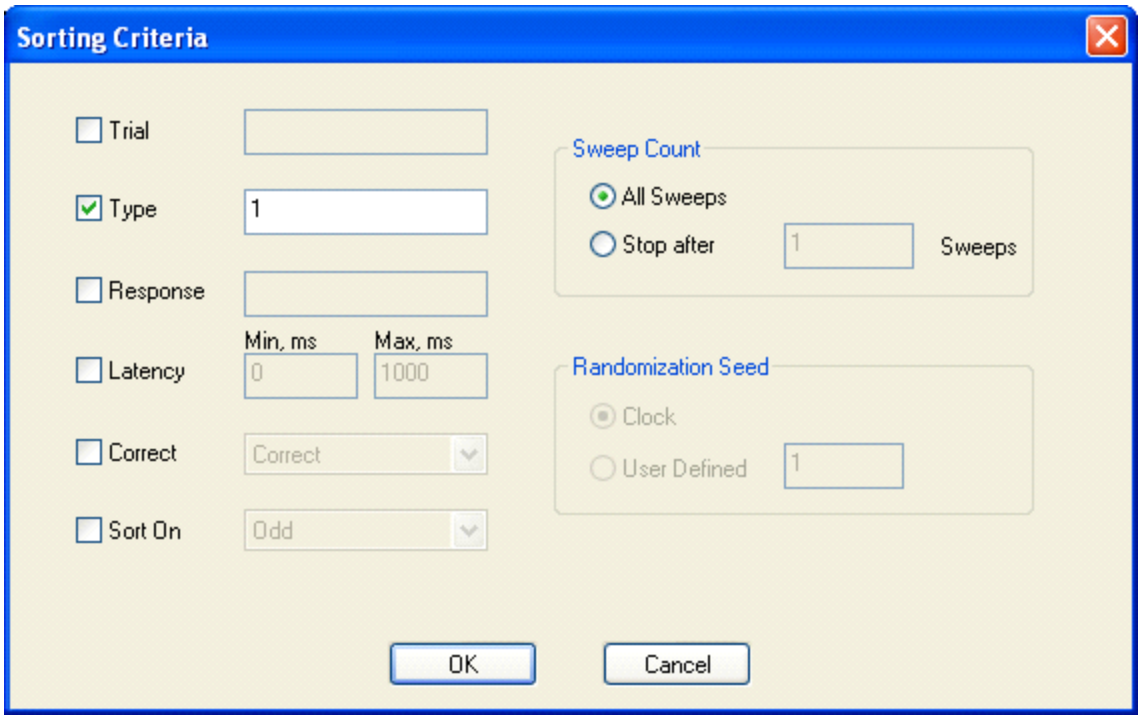
Click **Transforms** → **Average**, and you will see the Averaging window.



The parameters of this window control the conversion of the single-sweep file to an averaged waveform. Data files are either in the Time or Frequency domain. Time Domain files consist of amplitude changes over a time span, as in the case of an evoked potential waveform or single-sweep of raw EEG (the x-axis is measured in time). Frequency Domain files consist of amplitude changes over a frequency range, as in the case of a file containing FFT spectrum data (the x-axis in measured in Hz). Time Domain averages are generated by creating a simple point-for-point averaged waveform. Frequency Domain averages are generated by computing an FFT and power spectrum prior to averaging. Since the purpose of this example is to generate an event-related potential waveform, the **Time Domain** option should be selected. The Options section contains the following choices.

Compute Standard Deviation - The Standard Deviation (SD) field. when enabled, will compute the SD on a point-by-point basis. **Disable** the option for this demonstration.
SNR settings - This is used in the computation of Signal-to-Noise Ratios (SNRs). We will ignore it for now.

Before we begin averaging, we need to set the sorting criteria to select the sweeps of interest. Click the Sort Criteria... button, and the following window will appear.



The following is a brief description of each of the fields in this dialog box:

Trial, **Type**, **Response**, and **Latency**. The Trial, Type, Response, and Latency sort fields determine a range of values for sweep inclusion into the averaged waveform/ spectrum. The range is determined on a single line, such as 1-4, or by entering Min and Max latencies in the Latency field.

Correct - The Correct sort field will accept sweeps that have been tagged as correct, incorrect, both, or no response.

Sort On - The Sort On field can be used to select just the odd numbered sweeps, the even numbered sweeps, or a random sampling of sweeps. When you select the Random option, the Randomization Seed area becomes active. There are two choices of methods for selecting random sweeps. The Clock option uses the PC's clock to select sweeps on a randomized basis. This will give a different set of sweeps each time it is used on the same data file. The User Defined field will accept a number between 1 and 255. Each number is used to generate a unique randomization sequence. The sequence will be preserved, that is, a seed of 10 will always use that same sequence.

Sweep Count - These fields allows you to use All the sweeps in the building of the average, or you can Stop After a designated number of sweeps.

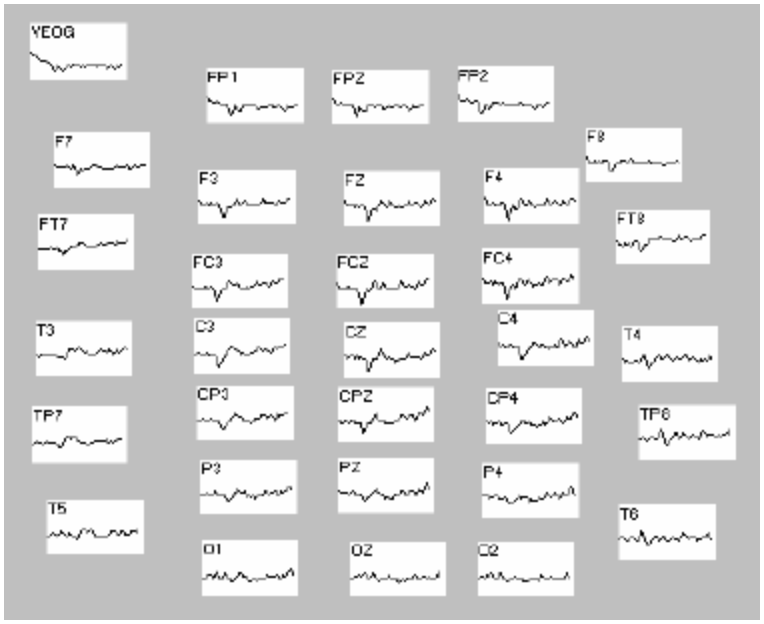
In this example we need to sort on the two different type values. Type values of 1 correspond to the frequent tone. Type values of 2 correspond to the infrequent tone.

These two type values are the only ones we need to be concerned with since there were no behavioral responses recorded from the subject.

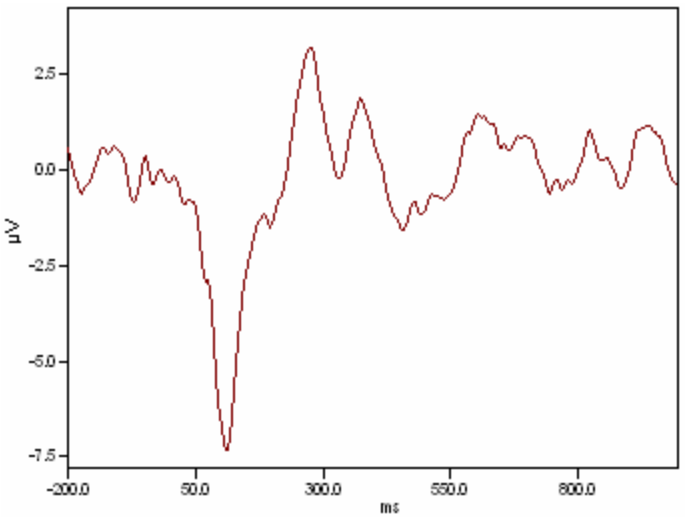
Let's first sort on type 1 to select the sweeps that contain the frequently occurring tone. Click on the **Type** field (so that a check appears), and enter **1**. Your Sort dialog box should match the one shown above.

Click **OK** and the Averaging window will reappear. Click the >> button at the end of the Output file line, and select a folder and enter a file name (*FREQ*; the .avg extension will be added automatically), then click Save. Click OK to initiate averaging. A progress will track the operation. A second multiple window display will appear containing the averaged waveforms.

The averaged waveforms initially may appear to be low in amplitude. This is because the display is still set to the original scale factor used with the single sweep EEG file. The most convenient method to scale your waveforms is to use the autoscale option located on the Toolbar ↕. Click it and the waveforms will be redisplayed with the new minimum and maximum values shown below.



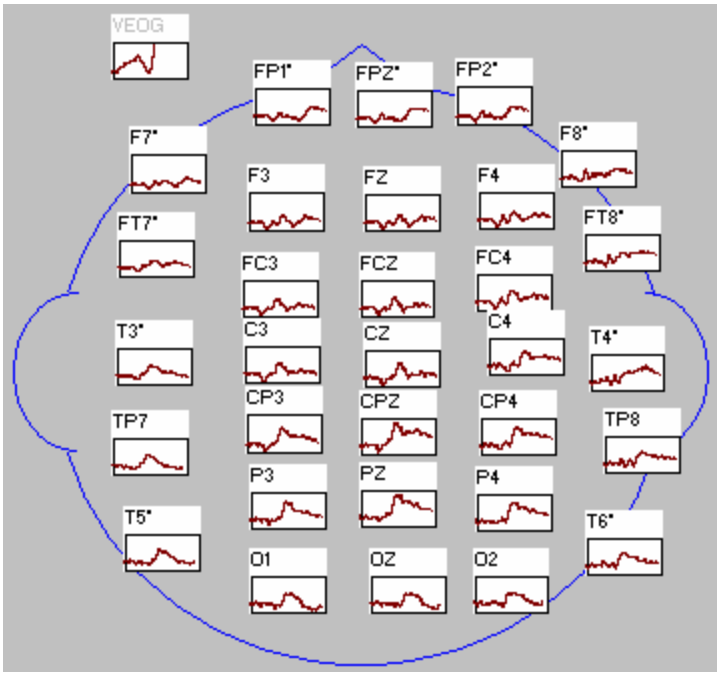
Your screen should now display the frequent waveform. The FREQ status box will display how many sweeps were accepted. The waveforms display the typical N100 component (sharp negative going wave) that has a maximum distribution near the central electrode sites.



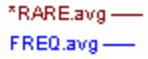
Finally, we need to construct the average for the infrequently occurring or 'rare' tone. You do not need to retrieve the file again. Instead, just select the display tab for the artifact rejected .eeg file. You can also select the desired file from the list under **Window** on the Main Menu bar.

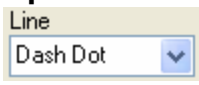
Next, repeat the process that you used to construct the frequent tone average. Click **Transforms** → **Average**. Click the **Sort Criteria** button. Then enter a **2** in the **Type** field

, and click **OK**. Enter *RARE* for the output file, and click **OK** again on the Averaging window. After the averaging process is completed, you will see another Multiple Window Display containing the average waveforms for the RARE sweeps.

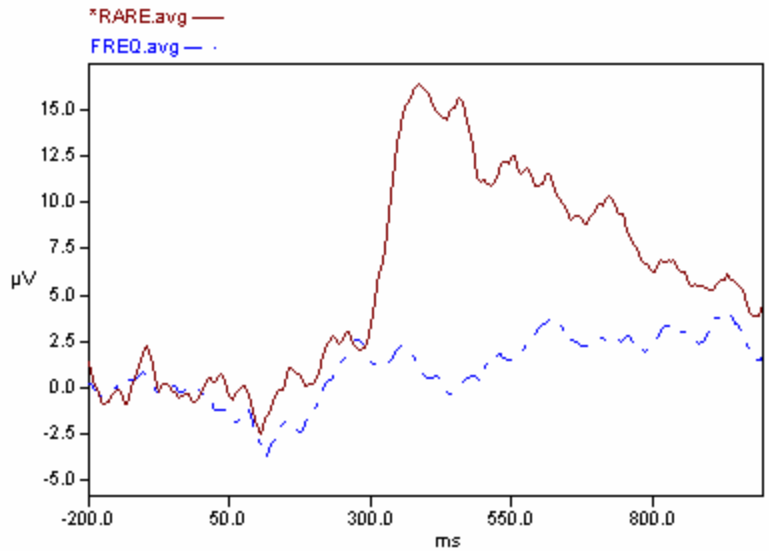


These waveforms show a large positive component peaking between 300 and 400ms. This is the P300 component elicited by the infrequent tone.

If you want to superimpose the RARE and FREQ waveforms, *right click* in the *RARE.avg* window and select **Load Comparison File**. Enlarge one of the displays to see the waveforms more clearly. If you want to change the color of a waveform, *right click* on one of the file names 

, and select **Change Color**. You can then select whatever new color you like. To change a waveform to a dotted or dashed line (which is convenient for figures for publication), *right click* between the channel windows, and select **Comparison File Options**. Use the pull-down menu for **Line** to select a different line style 

. You can change colors from the same screen. The superimposed waveforms will appear similar to the following (for PZ).



This concludes the P300 tutorial. The essential product of the processing steps are two waveforms. These waveforms are stored in separate files named 'FREQ' and 'RARE'. Please save these files. They will be used in later tutorials for the mapping and statistical operations.

This concludes the second Tutorial.

4 Single-sweep recording and an online average - SEP

This section describes how to configure ACQUIRE for simultaneous online averaging and storage of single-sweep epochs to disk. This option is particularly useful for monitoring both the acquisition of the average and the reconstruction of the average offline with the EDIT module. Artifactual sweeps that may not have been removed in the online average can be removed or corrected offline to minimize their effects on the reconstructed average. A configuration for a somatosensory evoked potential to median nerve stimulation will be given to illustrate simultaneous average and epoch based acquisition. In this tutorial, you will see how to:

- Create a setup file with fewer channels

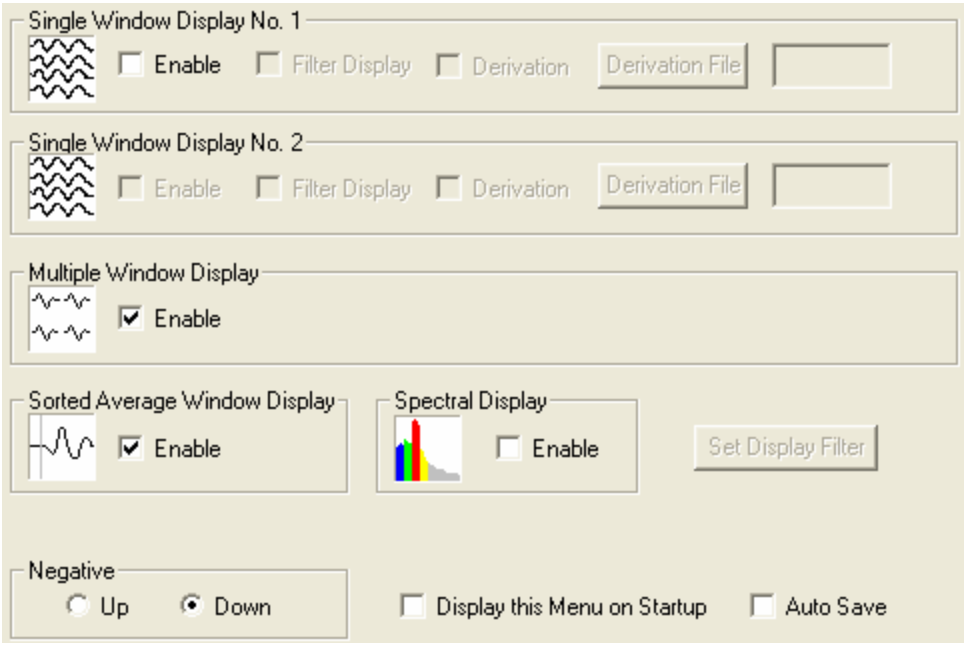
- Interface with an external SEP stimulator
- Create a click in Stim2 to use as a trigger

4.1 Acquisition

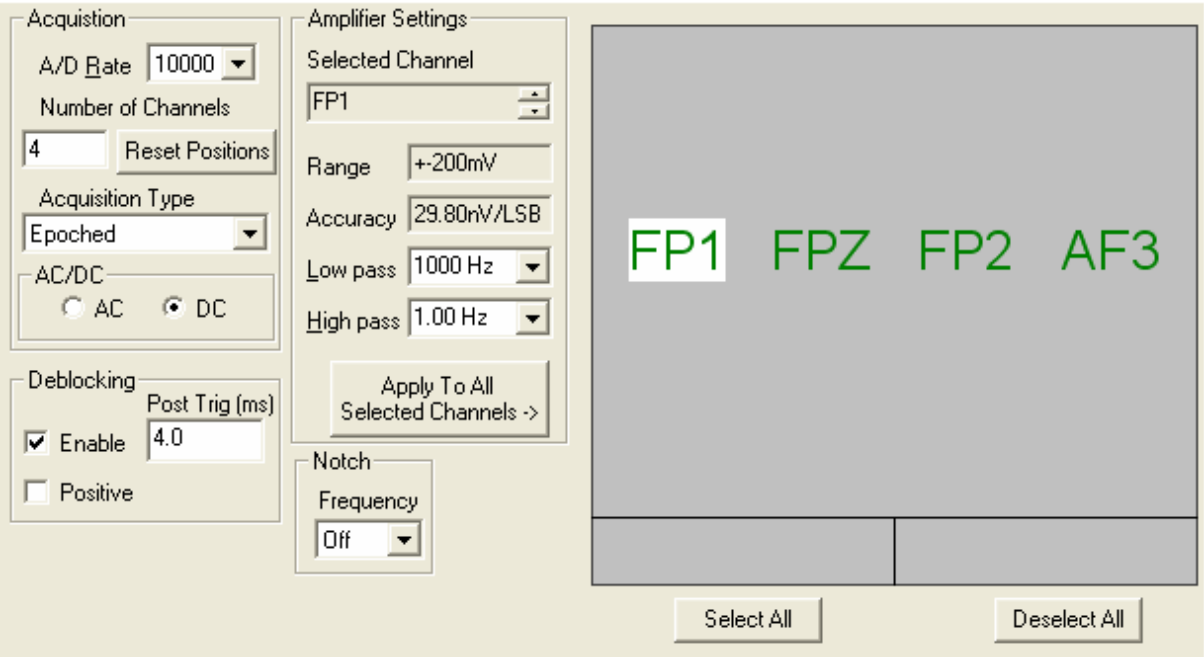
Follow these steps to configure the system for online SEP collection:

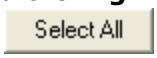
1. Start ACQUIRE as usual. Retrieve the *Synamps2 Quik-Cap64.ast* setup file.

2. Go to **Edit** → **Overall Parameters**, and select the **Startup** display. For this recording, enable the **Multiple Window Display** and **Sorted Average Window Display**. Set the polarity as desired (Negative Up or Down). Make sure no other displays are enabled.



3. Select the **Amplifiers (SN2)** tab. Set the **A/D Rate** to **10000**Hz (The maximum AD Rates for *NuAmps* and *SynAmps Wireless* are not fast enough for SEP recordings). Enter **4** for the **Number of Channels**, corresponding to electrode placements we will set for C3, C3', C4 and C4'. Click the Reset Positions button. Don't worry about the labels or positions at this point; we will modify them shortly. For **Acquisition Type**, select **Epoched** (Continuous preferred in most situations; Epoched is used here for demonstration purposes). This setting configures ACQUIRE to store the single-sweep data. Select **DC** mode. Leave the **Notch Frequency** filter **Off**. If you have *SynAmps*^{2}, you can employ the **Deblocking** feature. This is useful in cases where there is a brief stimulus artifact, as may be seen with an SEP stimulator, or with TMS recordings. Whether you use **Positive** or **Negative** logic depends on the TTL pulse from the SEP stimulator (see the ACQUIRE manual for details). In this case, Deblocking is used to remove the first **4**ms post-stimulus (and replace with 0V).

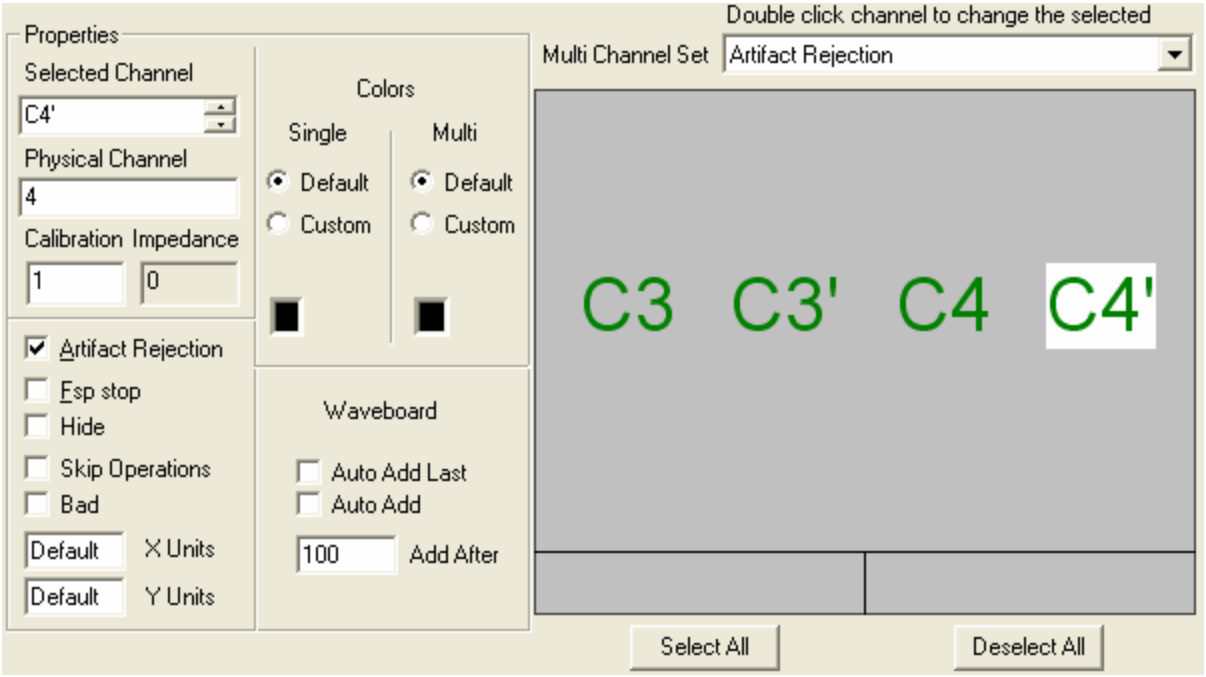


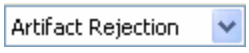
Under **Amplifier Settings**, set the **Low Pass** filter to **1000Hz** and the **High Pass** filter to **1.0Hz**. (If you have *SynAmps*, use a **Gain** of **1000**). Click the 

button under the channel display (all channels should be green), and then click the 

button to apply the filter settings to all channels.

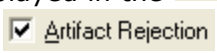
4. Select the **Channel Attributes** tab. There are several places in ACQUIRE where channel labels can be changed. To change the labels here, go to the **Selected Channel** region, change the label to "C3", and click in the montage display region (the label should change to C3). Highlight the next channel and change the label to C3'. Continue the process until you have renamed the channels to C3, C3', C4, and C4'. We will reposition the displays shortly.



We can also set all the channels as Artifact Rejection channels. Make sure that 

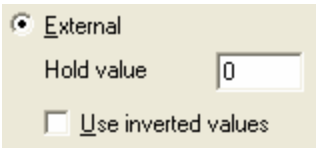
is displayed in the 

field, then click 

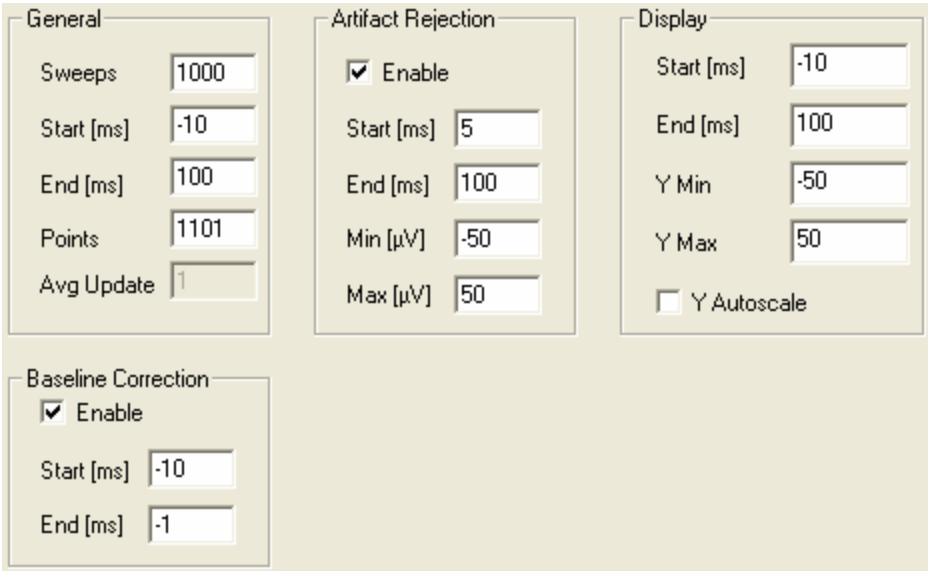
. You should also see that the 

field is enabled (for all channels).

5. Triggering for the SEP is best controlled by the STIM system that simultaneously sends a TTL trigger to SCAN and the SEP somatosensory stimulator. The **Hold Value** should be set to **0**. The **Use Inverted Values** field is typically **Disabled**.



6. Select the **Epochs** tab to set parameters of the recording epoch. For this example, assume that you want a 10ms pre-stimulus interval, a 100ms poststimulus span, and the Artifact Rejection and automatic Baseline Correction features *enabled* during acquisition. In the **General** area, set the number of **Sweeps** to **1000**. Set the **Start** time for **-10** (pre-stimulus) and the **End** time for **100**ms. The **Points** field should automatically update to **1101**. The Avg. Update field is not accessible for this operation.



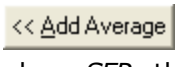
In this example a total sample interval of 111ms (10ms pre-stimulus, 100ms poststimulus, and the zero point) has been selected. The stimulation protocol must therefore allow for at least this interval plus additional time for the processing overhead of the computer. A stimulation rate of about 5-6 per second is therefore recommended. If faster stimulation rates are desired you can decrease the sample interval as long as the poststimulus interval is of sufficient duration to view the major response components.

Enable **Artifact Rejection** and set the **Start** time to **5**ms and the **End** time to **100**ms. The Start and End interval determines the range of the artifact scan. In this setup the scan begins after the stimulus artifact. Next, set the Min (**-50**µV) and Max (**50**µV) voltage threshold settings. Values in excess of ±50µVs will result in rejection of the sweep.

Under **Display**, enter **-10** and **100** for the **Start** and **End** time points, respectively, if these have not already been set. Enter **-50** and **50** for the **Y Min** and **Y Max** microvolt settings, respectively. These settings affect the display of the averaged waveforms: the entire epoch will be displayed, and the amplitude will be scaled to ±100µVs. Do not enable Y Autoscale for these recordings.

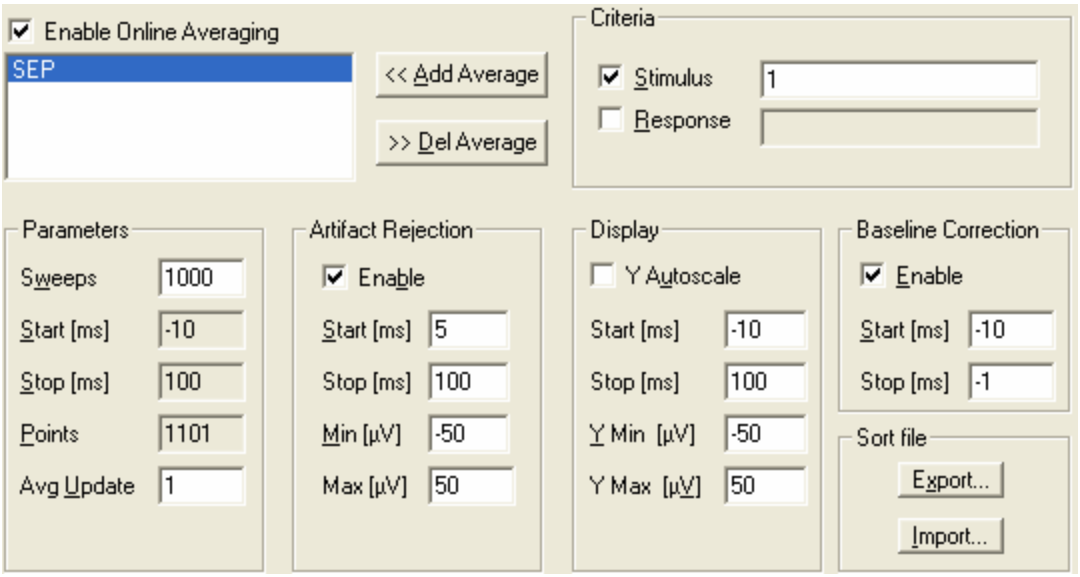
Enable **Baseline Correction** and set the **Start** time to **-10** and the **End** time to **-1**ms. The End point has been set prior to time zero to avoid potential stimulus artifact. Baseline correction will be performed online by computing the mean offset value from -10 to -1ms, and then by subtracting this value from the entire waveform.

7. To perform the online average, let's assume that the SEP stimulator is being controlled by the STIM system, and that STIM is sending a trigger type code of 1 via the STIM to SCAN cable to the SCAN system. While we are not actually sorting the stimuli, we can use the Sorting option to create an online SEP average.

Select the **Sorting** display, and **Enable Averaging**. Click the 

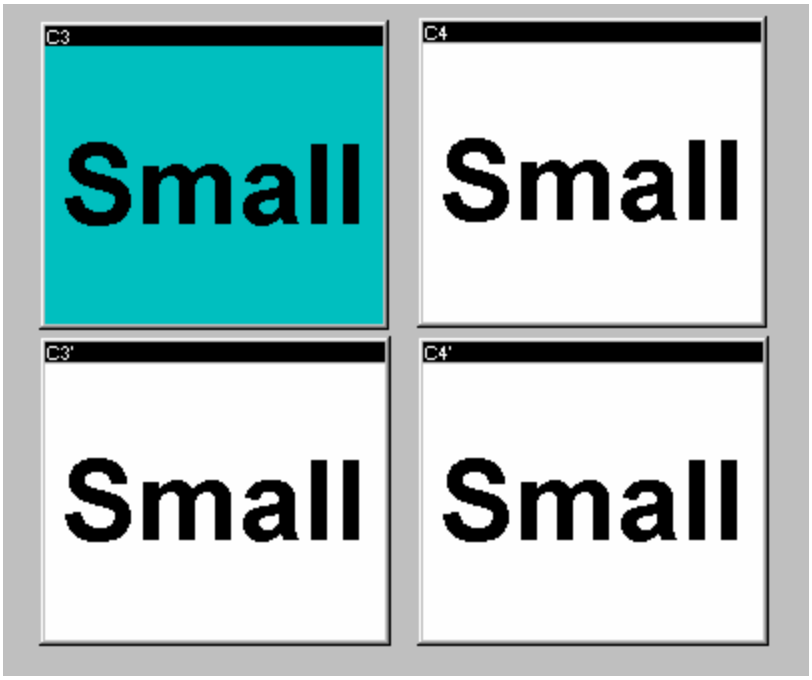
button at the bottom and a Save file utility will appear. Enter a file name (such as *SEP*; the *.avg* extension is added automatically), and click *Save*. Next, enable the **Stimulus Criteria** field, and enter **1**. The online average will trigger when a trigger type code of 1 is received (i.e., all stimuli). Make any changes to the *Parameters, Artifact Rejection,*

Display and *Baseline Correction* fields. Again, these settings are for the sorted average file only, and will not affect the EEG file that is being acquired (governed the settings under **Epochs**).



8. It would be a good idea at this point to save the settings that you have made thus far. Click Save As..., and label the Setup file SEPSET (the *.ast* extension will automatically be added).

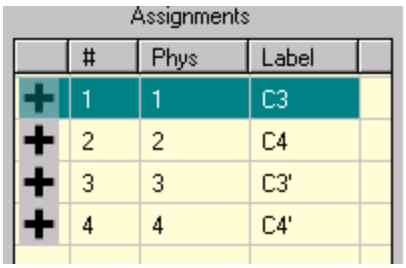
9. Click **Edit** → **Channel Layout**. You have 4 EEG channel displays. Let's resize and reposition the displays. Select one of the displays and resize it (grab and drag a lower corner). Then click the Make Same Size button to change all the displays to that size. Drag the displays to the positions you wish, again using the standard Windows conventions. The result might appear similar to the figure below.



You can also use the Adjust Positions buttons to reposition the electrode windows automatically.

The "Small" and "Large" designations allow you to set the displays to two sizes. The "Small" size is the one that appears as the default size. If you click inside the window to enlarge it to the midsize (as opposed to double-clicking to get the full screen display), that intermediate size is the "Large" size, which you may also set as desired. Click **OK** to continue.

10. Now, go to **Edit** → **Channel Assignment Table**.

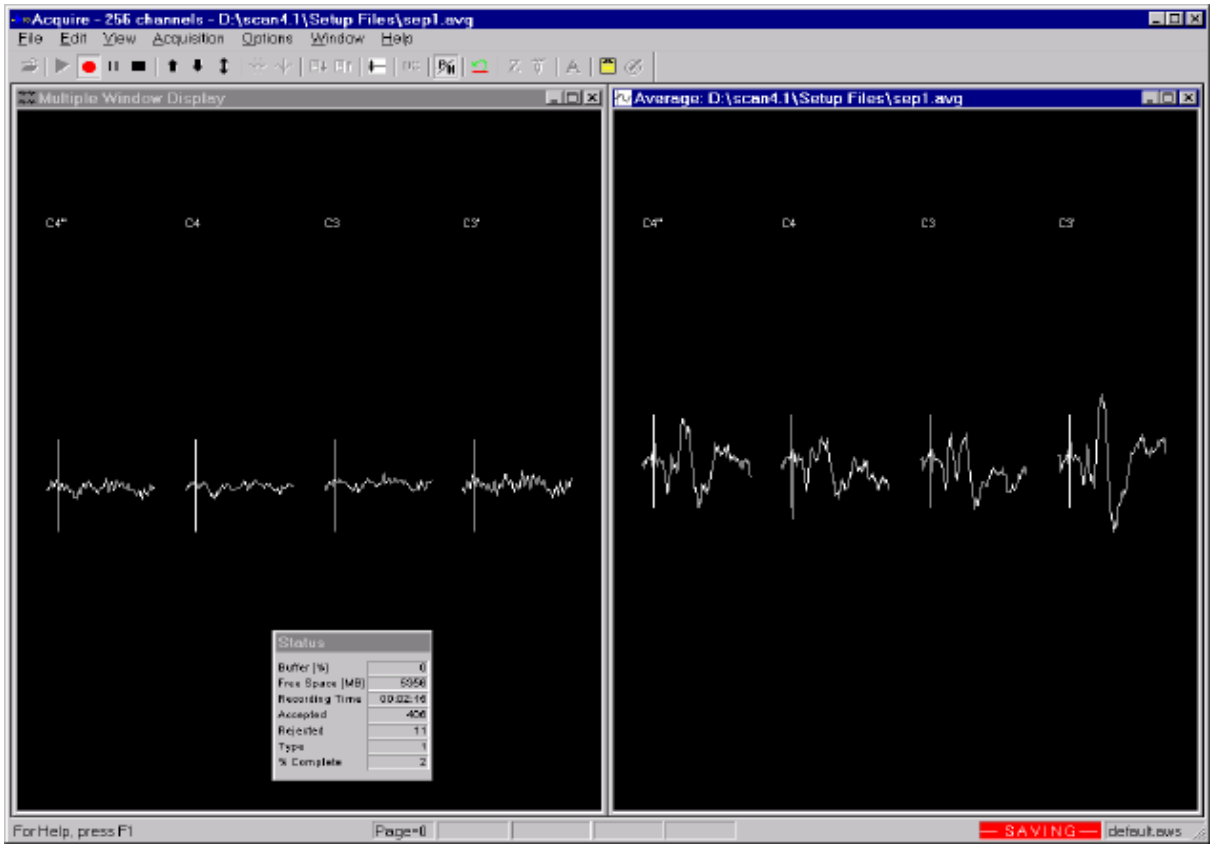


You will see the 4 channels. The order of the channels is contingent upon your actual cable connections and amplifiers (refer to your physical installation manual for more details, as well as the Channel Assignment table section in the *Operating* ACQUIRE section in the ACQUIRE manual). If you have not already relabeled the electrodes, you may relabel them here. When you are finished, click OK.

11. If you have made any changes since the prior Save step above, be sure to update the setup file by clicking the button.

12. To begin recording, click the green triangle on the Toolbar (or **Acquisition** →

Start Acquisition).



You will see the Multiple Window Display and, after initiating data storage, the sorted Average window display. When you are ready to begin recording, click on the *Record* icon (the red dot) on the Toolbar  , and enter a file name. The *.eeg* extension will be added automatically. Click on Save, and you will be returned to the Multiple Window Displays. The adjacent button with two vertical lines is *Pause*, and the button with the black rectangle is *Stop*.

In the averaged window display you will see the average waveform develop, with updates as specified in the **Epochs** display. Note that you will not see any data in the average display until the first trigger is received (or until you have reached the average update number of sweeps). Refer to the description of the **Options** section in the ACQUIRE manual to see how to change display colors and to select different aspects of the window display.

A Status box will show the percentage of buffer space that is being used, the amount of free space on your hard drive, as well as additional information. In general, the buffer space should never climb beyond a few percent. If the buffer indicator does start to climb then this means that you are exceeding the data processing capacity of your computer. If the buffer continues to climb eventually you will receive a buffer overflow condition and data will be lost. Should this event occur please contact Compumedics/Neuroscan technical support. It is also important to monitor the amount of free disk space. It is not good practice to allow the system to fill up the available disk space. Free space is particularly important for the system drive. The free space in Windows is used to swap

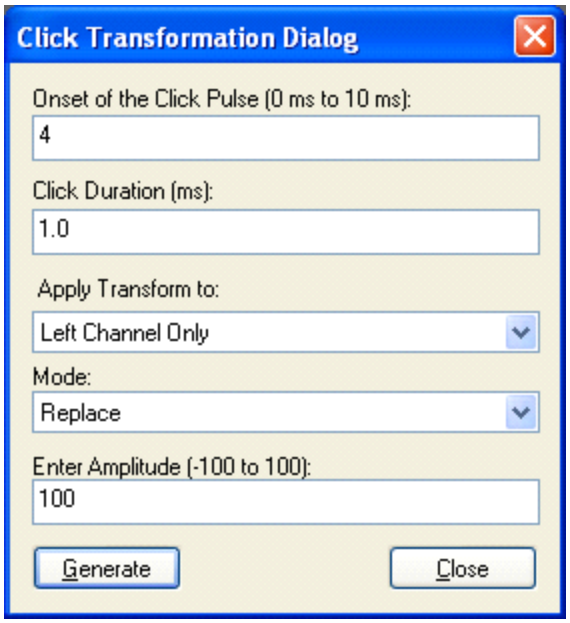
memory. System performance can be degraded dramatically if this swap space is reduced. Termination will occur after the 1000 sweeps are accepted (or after user interrupt by clicking on the Stop icon).

4.1.1 Interfacing with an external SEP stimulator

There are 2 common ways to interface with an external SEP stimulator. The first is to use the Stim^2 Sound Editor module to trigger the SEP stimulator and the SCAN acquisition. The second method uses the SEP stimulator's internal triggering mode to control the stimulus presentation and SCAN acquisition. Stim^2 can be set to send either TTL or voltage signals, and SCAN can receive either TTL or voltage signals from the stimulator. You should first familiarize yourself with your stimulator's capabilities and requirements. Then, do you want Stim^2 to control the stimulus presentation, or do you want to use the stimulator's internal triggering? If you want to use Stim^2, the easiest configuration is to send a voltage signal from Stim^2 to the stimulator. If you don't want to use Stim^2, the easiest configuration is to send a voltage signal from the stimulator to SCAN (to mimic Stim^2's trigger).

Triggering from the Sound Editor. The Sound Editor module is capable of sending either a voltage pulse or a TTL signal to control the SEP stimulator.

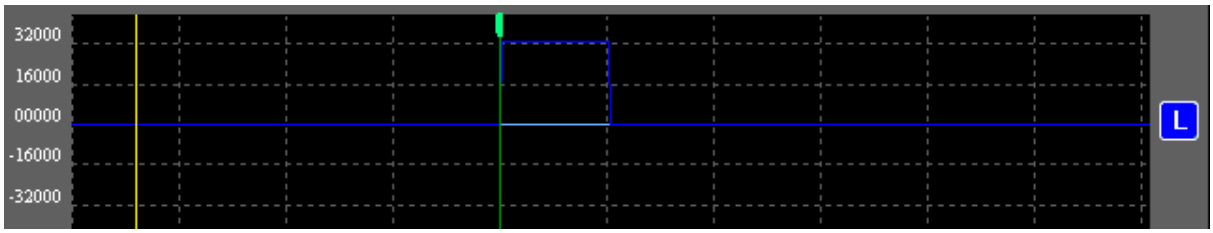
Voltage trigger. Instead of sending a click stimulus to the headphones, the signal is sent as a voltage pulse to the SEP stimulator. You will need to construct a cable from the Stim^2 Audio System Unit to the SEP stimulator trigger input. This is a regular phone jack on the Stim^2 side - refer to your SEP stimulator to see which input jack to use, and what type of connector. On the Stim^2 side, use the same headphone jack on the front of the STIM Audio System Unit that you use for headphones. If you have the Software Only version, you can take the output from the audio board.



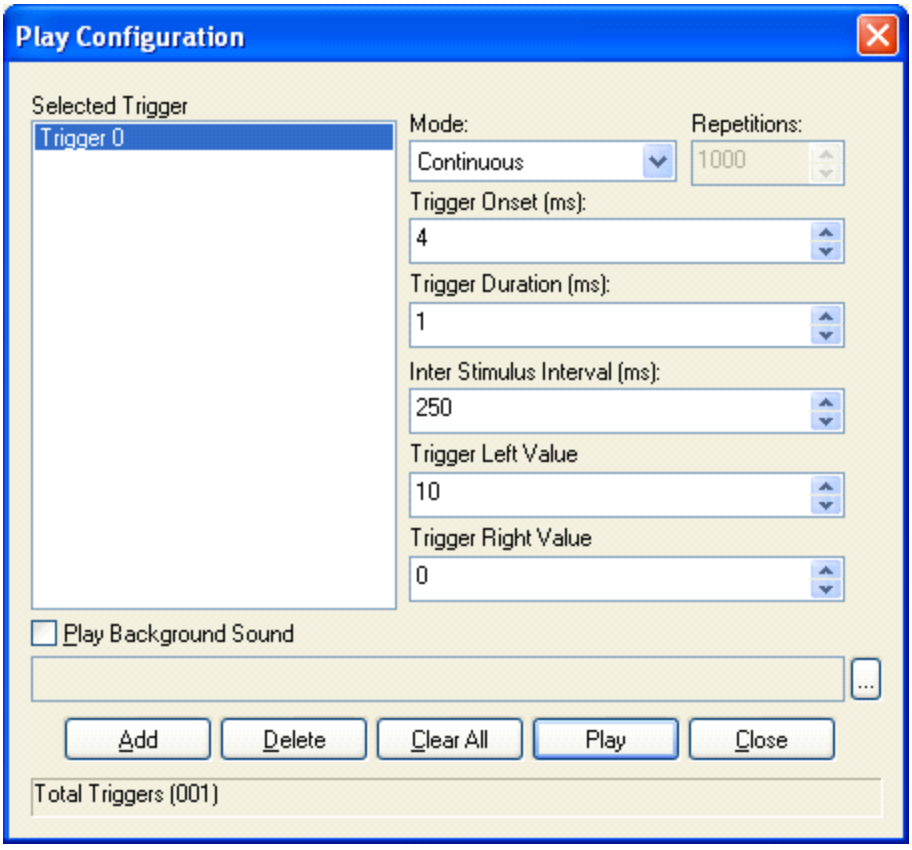
In Sound, create a click with at least a 1ms delay, in a 10ms file (for example), approximately 1ms in duration, on one channel only, with 100% of Maximum

amplitude. Set the dB level to 120 dBs. It is the *voltage* pulse of the click stimulus that is the trigger. Measure the output with a scope to determine the actual voltage; use the dB controls to decrease the voltage. Check your stimulator manual for duration and polarity of the pulse. Polarity is flipped by Scaling the channel using a -1 (see under Transforms).

Use the Insert Trigger option  to place a trigger at the beginning of the click (the green vertical line). The click display should appear similar to the following.



Stim^2 will simultaneously send a TTL trigger to SCAN. Click the  button to see the Play Configuration dialog screen. In Continuous mode, the click will be repeated until you stop it (in Sweep mode, you can specify the number of Repetitions).



The TTL trigger should coincide with the click onset, which would be 4ms in this example. Trigger Duration of the TTL pulse is typically 1ms for SCAN. Set the Interstimulus Interval to the desired length. The Trigger Left and Right Values are the type codes that are sent to SCAN. In the displayed example, the click will be

played continuously, with an ISI of 250ms. A trigger type code of 10 will be sent to ACQUIRE. Again, these are suggested settings - your actual values may vary depending on your recording paradigm.

TTL triggers. You may also use Stim^2 to send a TTL trigger to the SEP stimulator. This is a little more involved because it requires splitting the STIM-to-SCAN cable. The idea is to send low number bits to the stimulator, and higher number bits to the SCAN system, or vice versa, depending on what the stimulator needs. If you are looking at the back of the STIM connector of the STIM-to-SCAN cable, pins 2 through 9 carry bits 0-7. Pin 2 is bit 1, pin 3 is bit 2, pin 4 is bit 4, pin 5 is bit 8, pin 6 is bit 16, and so forth. By splitting the cable, you can send low numbers, such as 1 (pin 2 on the back of the STIM connector) to one system and higher numbers to the other. Higher numbers use the higher order bits of the port. For example, the number 64 corresponds to pin 8 on the back of the STIM connector. Contact Compumedics/ Neuroscan Technical Support if you need assistance in building this cable.

Triggering from the SEP stimulator. You can bypass Stim^2 and use the SEP stimulator to control triggering of acquisition. SCAN can receive the TTL voltage triggers.

TTL triggers. Having the stimulator send TTL signals is preferred because the procedure mimics the Stim^2 system - trigger settings within ACQUIRE are the same as those for use with Stim^2 (External triggers, with Hold value of 0, Invert On or Off, depending). You will need to construct a cable to replace the STIM-to-SCAN cable on the SCAN side, with whatever connector you need for the stimulator connection. This can be a much simplified cable, typically carrying a single bit for a trigger of "1". Contact technical support if you need assistance with the cable.

With some SEP stimulators we have found that the duration of the TTL pulse is too short to be recognized by the *SynAmps*. In that case, you will need to build a pulse stretcher or you may obtain one from Compumedics/Neuroscan.

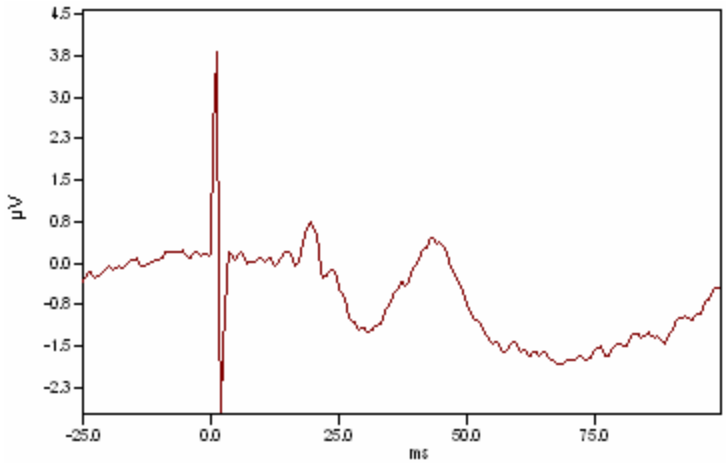
4.2 Post acquisition processing of the SEP

This section illustrates some of the processing steps that might be performed on SEP recordings. A 31-channel recording of an SEP will be used as an example data set. In this example, the epochs were already averaged to form an averaged SEP.

In this tutorial, you will see how to:

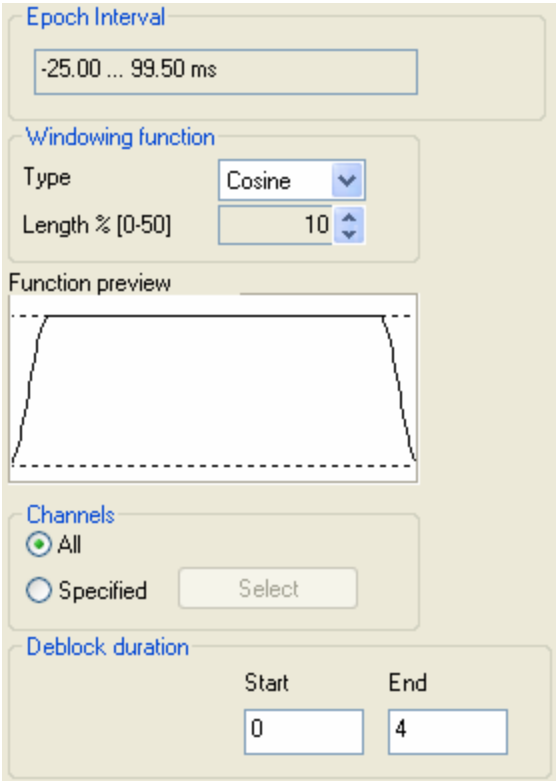
- Use Deblocking to remove stimulus artifact
- Apply Display Filter
- Use Spline Fitting
- Compare Electrodes

1. Retrieve the *sepnoblock.avg* file (...*Demo Files**SEPs* folder). Expand the FZ display to see the prominent stimulation artifact from 0-4ms.

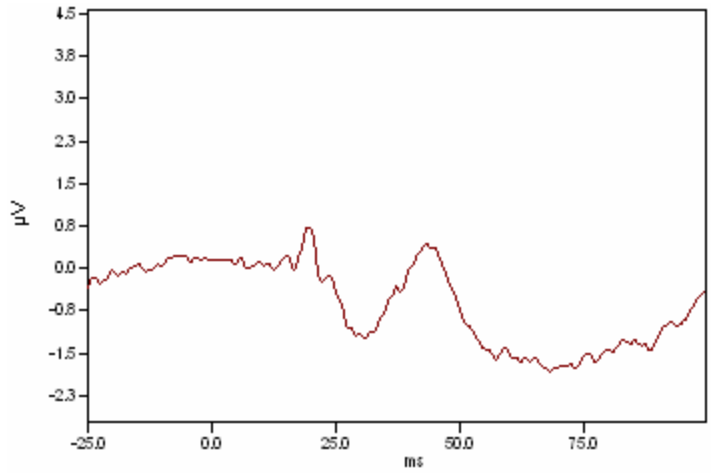


In the setup described above, with *SynAmps*^{2}, we enabled the **Deblocking** option to avoid the stimulus artifact. If you have *SynAmps*, there is a hard-wired way to perform Deblocking. However, if you have stimulus artifact you can still remove it in EDIT.

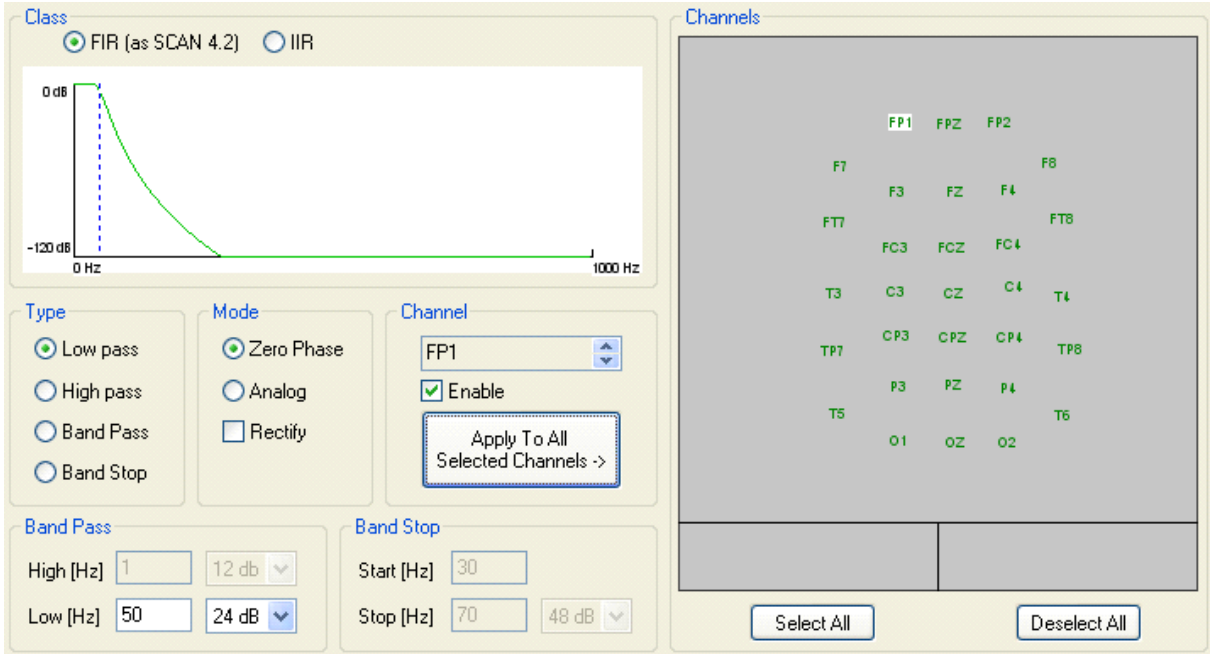
2. Click **Transforms** → **Deblock**. Use a **Cosine** Window Type, with a **10%** Length, applied to **All** channels. Set the **Start** time to **0** and the **Stop** time to **4**. Then click **OK**. The artifact has been removed.



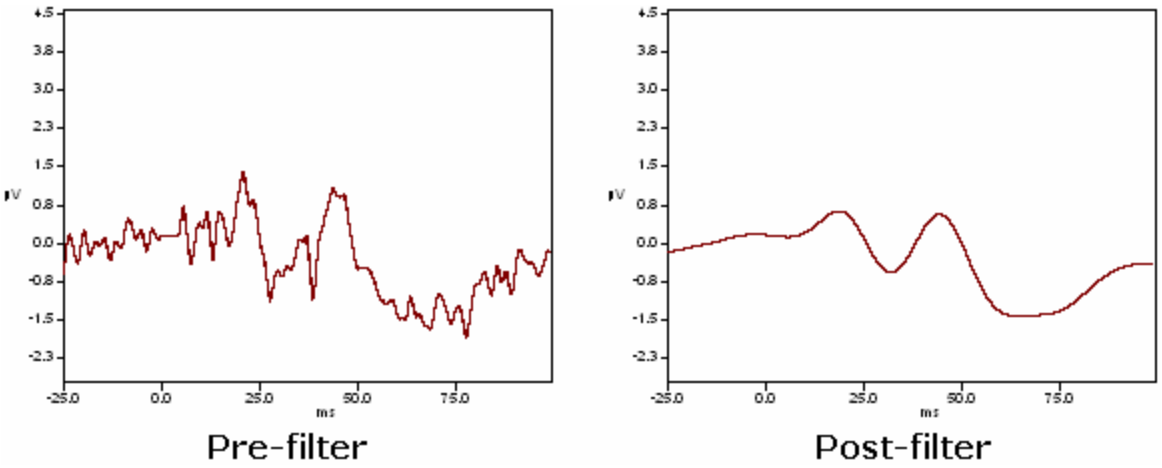
3. There is considerable EMG in several channels (F3 is a good channel to watch since it has EP components as well as EMG).



The EMG can be filtered out, but realize that any genuine EEG in the same frequency range will be affected also. You may find that you need to experiment with different filter settings to find the ones that best remove the noise without affecting the EP components. The best way to experiment is to apply the filter initially to the display only. *Right click* between electrode windows and select **Add Display Filter**. The Filter dialog appears.

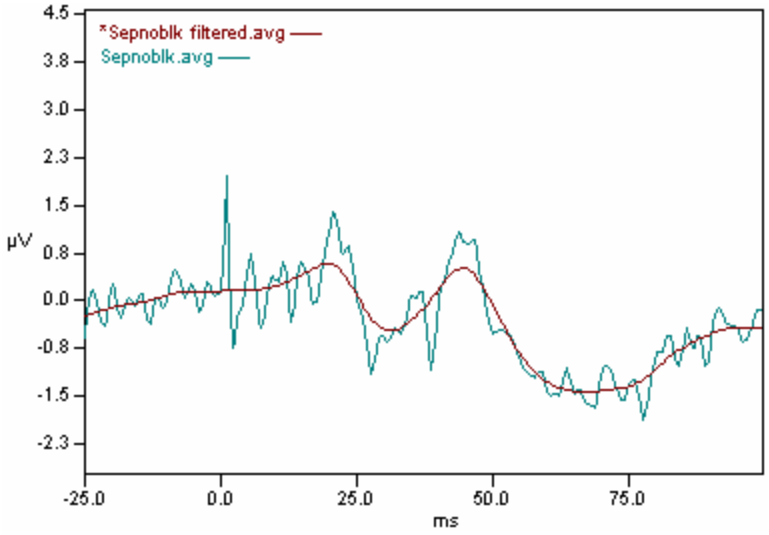


For **Class**, select **FIR**. For **Type**, select **Low pass**. For **Mode**, select **Zero Phase**. In the **Band Pass** area, enter **50**Hz with a **24**dB slope. make sure all channels are selected (green in the channels display), and then click the **Apply to All Selected Channels** button. Then click **OK** to apply the filter to the display.



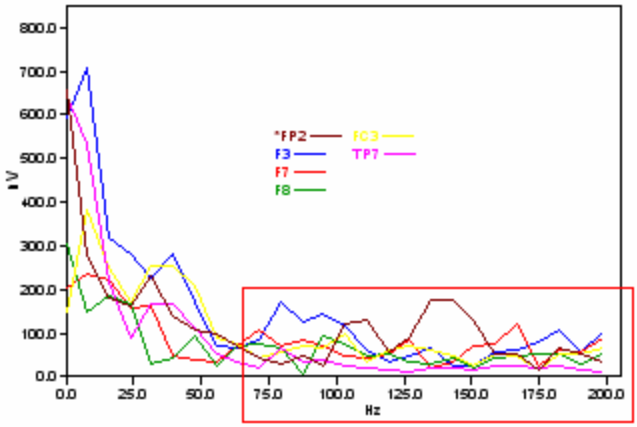
These settings appear reasonable effective for removing the faster frequencies. *Right click* between the electrode displays and select **Remove Display Filter**. Repeat the process until you find settings that are most effective. Be careful using **Analog** filters (for Mode) since they could result in latency shifts they pass the data in only one direction; **Zero Phase** passes in both directions).

To make the changes permanent, click **Transforms** → **Filter**. Enter the same settings as used for the display filter. Click **OK**. You can now save the file with the changes (if you save the file following application of the Display Filter, the changes are not saved. The Display Filter affects the display only). You can now use **Load Comparison File** as in the previous tutorial to superimpose the undeblocked and deblocked, and unfiltered and filtered waveforms.



You may find it useful to perform an FFT on the waveforms prior to filtering. This may help you determine which frequencies to filter out. In the above example, we used **Transforms** → **Spine fit** to change the number of points to 256 (a power is 2 is required for the FFT), and then used **Transforms** → **Spectrum** to compute the power spectrum. You can then super-impose electrodes by *right-clicking* within an electrode display and selecting **Compare Electrodes**. By including those channels with EMG and as well as some without, you will get a better idea which frequencies can be filtered safely. From

the figure shown, we could have used filter frequencies greater than about 60Hz and not affected the EP components.



This concludes the third tutorial.

5 Fsp averaging - ABR

The F_{sp} averaging mode configures the system to compute an F statistic based on a single-point estimate of background noise. The F statistic can be used as a measure of signal reliability and waveform quality. Although it was originally developed for use with the auditory brain stem response (ABR), it may be extendable to other types of signals that are stationary in nature. The F values are computed for a series of block averages. These block averages are summed together to form an overall grand average. In addition to computing the F statistic, the contribution of an individual block average to the grand average is weighted by the background noise (Bayesian weighting). This has the effect of minimizing noisy blocks in the grand average. The F_{sp} averaging mode is particularly useful in recording ABR waveforms from noisy or uncooperative subjects. It provides feedback on the quality of the signal and minimizes the need to replicate waveforms.

In this tutorial, you will see how to:

- Configure ACQUIRE to use Fsp Averaging mode
- Create a click in Stim^2 for use with ABRs
- Send waveforms to the Waveboard

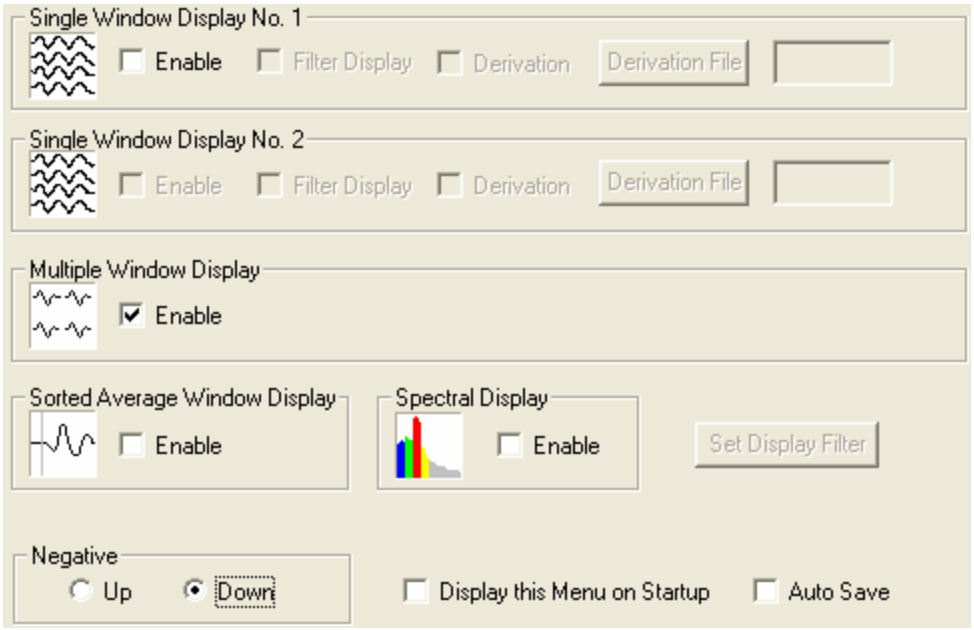
5.1 Acquisition

Follow these steps to configure the system to record an ABR using the F_{sp} averaging mode:

1. Start ACQUIRE as usual. Retrieve an existing .ast file, or use the **Make Default Setup** option to create a setup file with a single channel. We will modify the *Synamps2 Quik-Cap64 .ast* file for this demonstration.

2. Select the **Startup** options under **Overall Parameters**. For this recording we will

monitor the ongoing EEG channel in a Multiple Window Display, and view the ABR average as it builds. Enable only the **Multiple Window Display**.

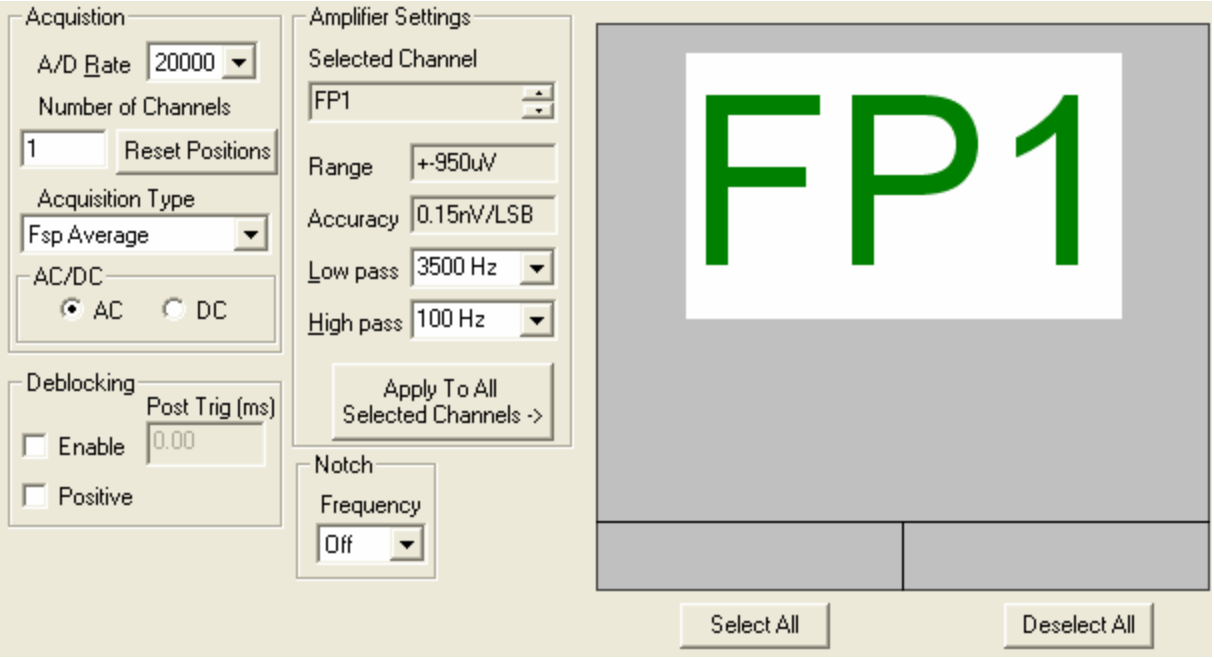


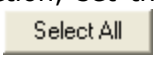
Select the desired polarity (Negative Up or Down).

3. Select the **Amplifiers** tab. Set the **A/D Rate** to **20000** (the maximum AD rate for *NuAmps* and *SynAmps Wireless* is not be fast enough to do ABRs; for *SynAmps*, use 100000 and a high speed bipolar channel). Digitization rates of 20000Hz will provide enough resolution to determine peak latency and amplitude of the major ABR components. For this ABR example, only one channel will be needed. One electrode will be placed on the right ear lobe (A2), and the other at CZ. Enter **1** for the **Number of Channels**. Click the Reset Positions button to see the single channel. For **Acquisition Type**, select **F_{sp} Average**. This setting configures ACQUIRE to record with the F_{sp} mode. Select **AC** mode. (If you have *SynAmps*, set the **Gain** to **2500**). Leave the Notch Frequency Filter Off.

Note

If you are using SynAmps^2 or SynAmps RT, we strongly recommend you use a bipolar channel(s) for the recording. The active lead should go to the positive input, and the reference lead should connect to the negative input. You should then use a jumper to connect the negative pin to the Reference jack.

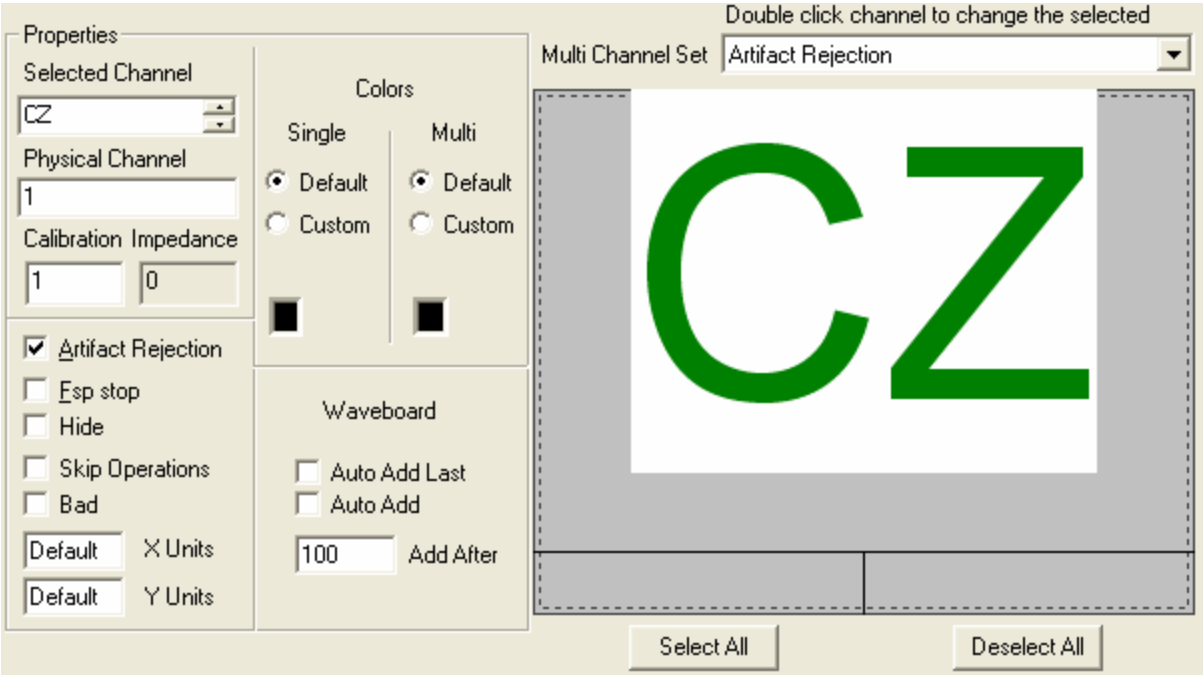


In the **Amplifiers Settings** section, set the **Low Pass** filter to **3500**Hz, and the **High Pass** filter to **100**Hz. Click the 

button to select the channel (or just double-click the label), and then click the 

button to apply the settings.

4. Select the **Channel Attributes** display. Relabel the single channel to **CZ**, and set it to be an **Artifact Rejection** channel (as described in previous tutorials). If you have "Artifact Rejection" displayed in the **Multi Channel Set** field, the Artifact Rejection will be applied automatically when you select the channel. (You can resize and reposition the display shortly, if desired).

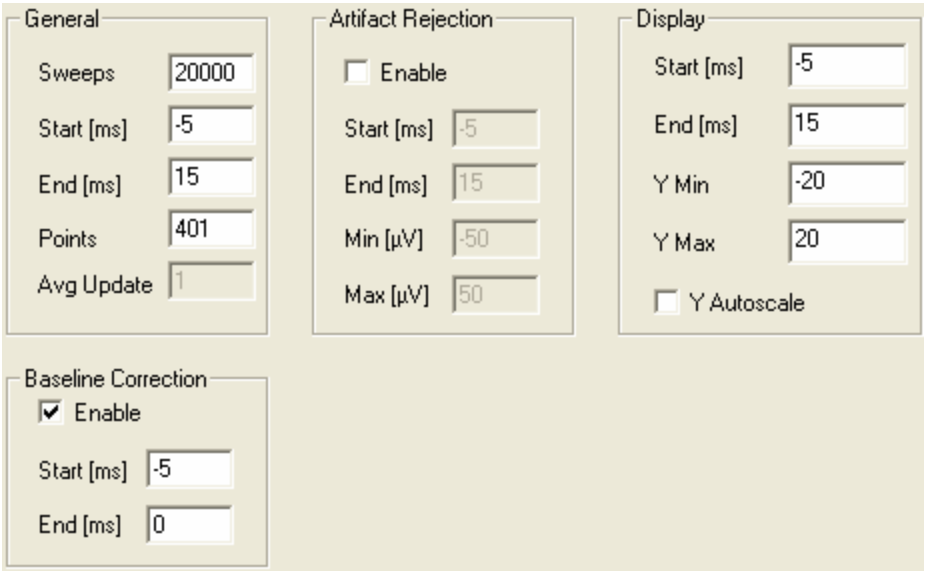


Leave the F_{sp} stop field disabled. This field allows you to designate channels as termination channels for use with F_{sp} averaging (discussed below). Since we are only using the one channel, and will be selecting **All** for the Termination channels on the F_{sp} page, it is not necessary to designate the channel with the F_{sp} option on the Channel Setup window. If we were recording from several channels, and had chosen **Selected** under Termination channels on the F_{sp} page, we could designate which channels were to be used as termination channels by clicking on the F_{sp} field in the same fashion as we designate artifact rejection channels.

5. Triggering for the ABR will be controlled by an external device (typically the Stim^2 system). Select the **Triggers** tab. The **Hold Value** should be set to **0** and **Use Inverted Values** should typically be **Disabled**.

6. Select the **Epochs** tabs to set the parameters of the recording epoch. For this example, assume that you want a 5ms pre-stimulus interval, a 15ms poststimulus span, with Baseline Correction and Artifact Rejection *enabled* during acquisition.

In the General area, set the number of **Sweeps** to **20000**. Enter **-5** for the **Start** point, and **15** for the **End** point. The **Points** field will automatically change to **401** points. The Avg. Update field will not be used.



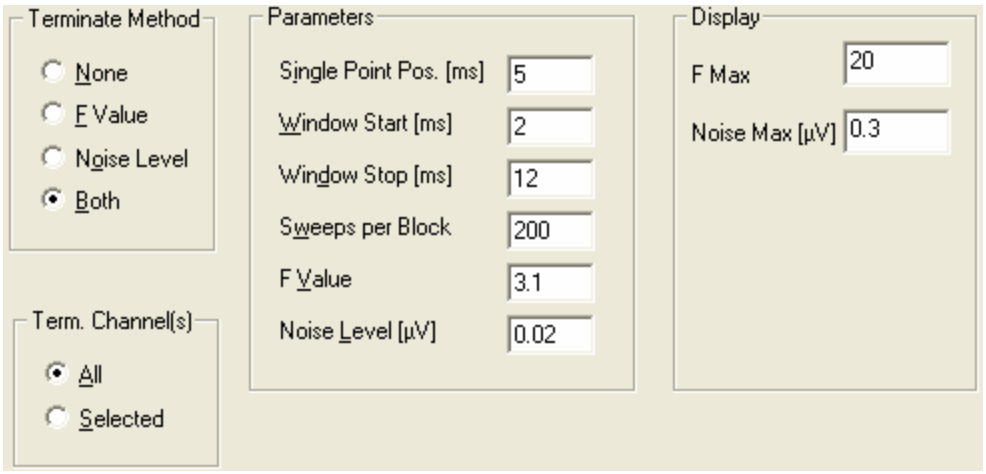
In this example a total sample interval of 21ms (5ms pre-stimulus, 15ms poststimulus, and the zero point) has been selected. The stimulation rate must therefore provide at least this interval plus additional time for the processing overhead of the computer. A stimulation rate of approximately 15-20 per second is recommended in this example. If faster stimulation rates are desired you can decrease the sample interval as long as the poststimulus interval is of sufficient duration to view the major response components (at least 10ms).

Artifact Rejection is not needed. Bayesian weighting handles high amplitude epochs by assuming they are noise and scaling their contribution to the overall average.

In the **Display** area, set **Start** to **-5**ms, the **End** to **15**ms, **Y Min** to **-20**µV, and **Y Max** to **20**µV. You will see the entire epoch displayed within the $\pm$ 20µV limits. Leave the Y Autoscale disabled.

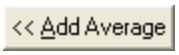
Enable **Baseline Correction** and set the **Start** time to **-5** and the **End** time to **0**ms. Baseline correction will be performed online by computing the mean offset value from -5 to 0ms, and then by subtracting this value from the entire waveform.

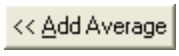
7. Select the **F_{sp} Average** tab. Select **Both** for the **Terminate Method**, set **Terminate Channels** to **All**, **Single Point Position** to **5**ms, **Window Start** to **2**ms, **Window Stop** to **12**ms, **Sweeps per Block** to **200**, **F value** to **3.1**, and the **Noise level** to **0.02**. Under the Display area, enter **20** for the **F Max** value, and **0.3** for the **Noise Max** value.



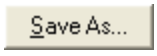
These settings will configure the system to compute the F_{sp} over a 2 to 12ms interval. The Fsp window duration should be equal to the period of the frequency used for the high pass filter setting. For example, ABRs are typically recorded with a bandpass of 100-3000 Hz or 100-2500 Hz. With the high pass filter setting at 100Hz, it requires 10ms to resolve one cycle of 100Hz activity. Therefore, the Fsp window must be sufficiently long to resolve that 10ms window. If the high pass was 50Hz, it would increase to 20ms. If the high pass was 200Hz it would decrease to 5ms, and so forth. The single point will be located within the window at 5ms. A yellow line located at 3.1 will be shown in the Fsp display indicating the F Value threshold value. Termination will occur automatically if either the F value (3.1) or the Noise Level (0.02) criterion is reached - otherwise termination will occur after 20,000 sweeps, or by clicking on the Stop button on the Toolbar.

8. This is an optional step that is included for comparison's sake. To show the advantage of using the F_{sp} option, you can simultaneously acquire a simple online average (acquired outside of the F_{sp} program). To do this, assume that the trigger type code coming from the STIM (or other) system is a 1.

In the **Sorting** display, click the 

button, and enter a file name for the online average file (the *.avg* extension is added automatically). Enable **Stimulus**, and enter 1 in the Stimulus field. Make any changes in the **Parameters**, **Artifact Rejection**, **Display** and **Baseline Correction fields**. Notice also that, if you wish, you could have two identical averages that are accumulating, differing only in that one has, for example, **Artifact Rejection** enabled, while the other has the feature disabled. Do this by creating a second average file using the 

button, and changing only the Artifact Rejection **Enable** field.

9. It would be a good idea at this point to save the settings that you have made thus far. Click 

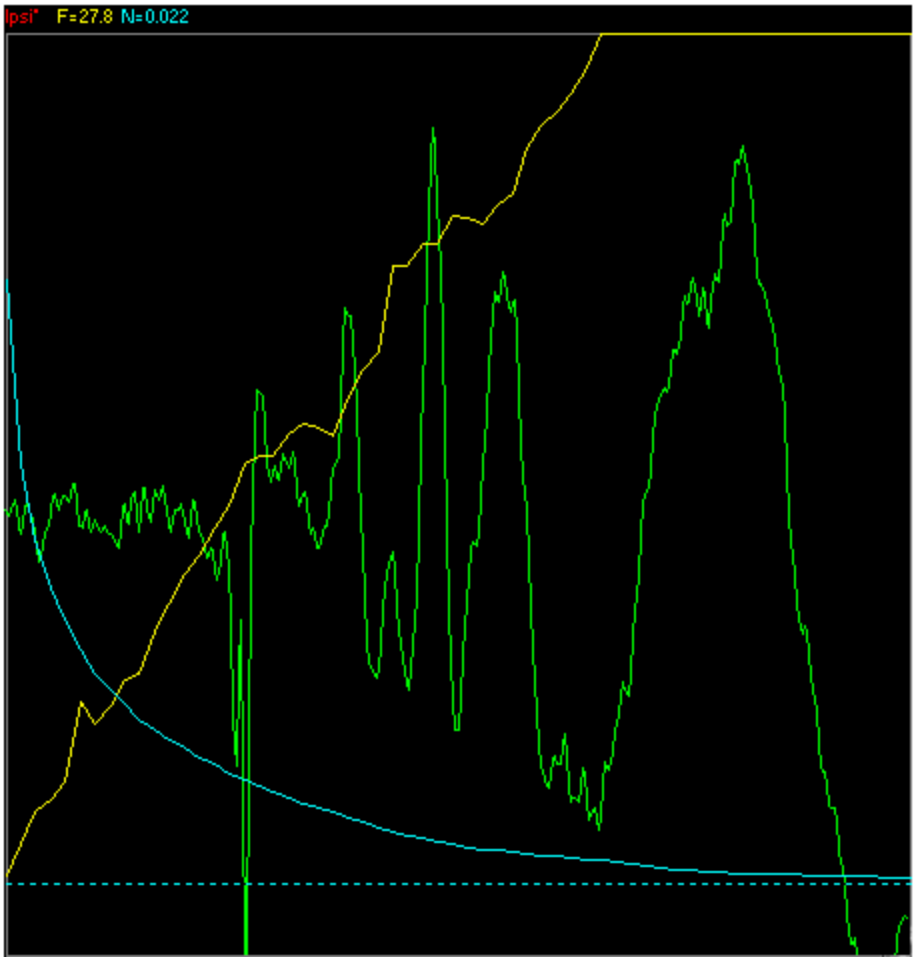
, and enter *ABRSET* (the *.ast* extension will be added).

10. Click **Edit** → **Channel Layout**. You should have one EEG channel labeled CZ. For the one channel ABR recording, the only input at this screen is to resize and reposition the display, as desired.

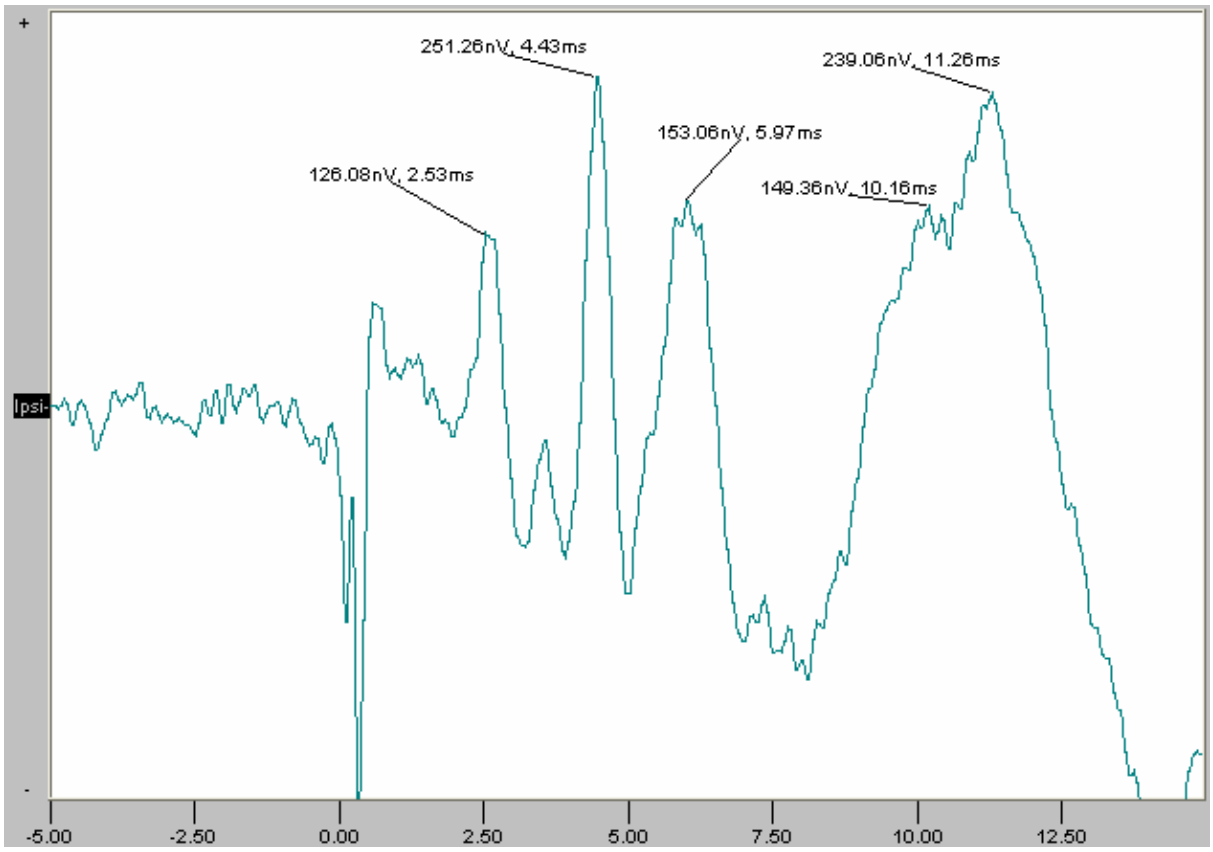
11. To begin recording, click the green triangle on the Toolbar 
, or click ***Acquisition*** → ***Start Acquisition***. You will see the Multiple Window Display, with one channel in it. When

you are ready to begin recording, click on the **Record** icon (the red dot) on the Toolbar  , and enter a file name. The *.avg* extension will be added automatically. Click on Save, and you will be returned to the Multiple Window Displays, and in addition you will see the Average window display as well as the F_{sp} data display. In these windows you will see the average waveform develop, and the F ratio and noise lines as they are generated. Below is the resulting average using the F_{sp} option.

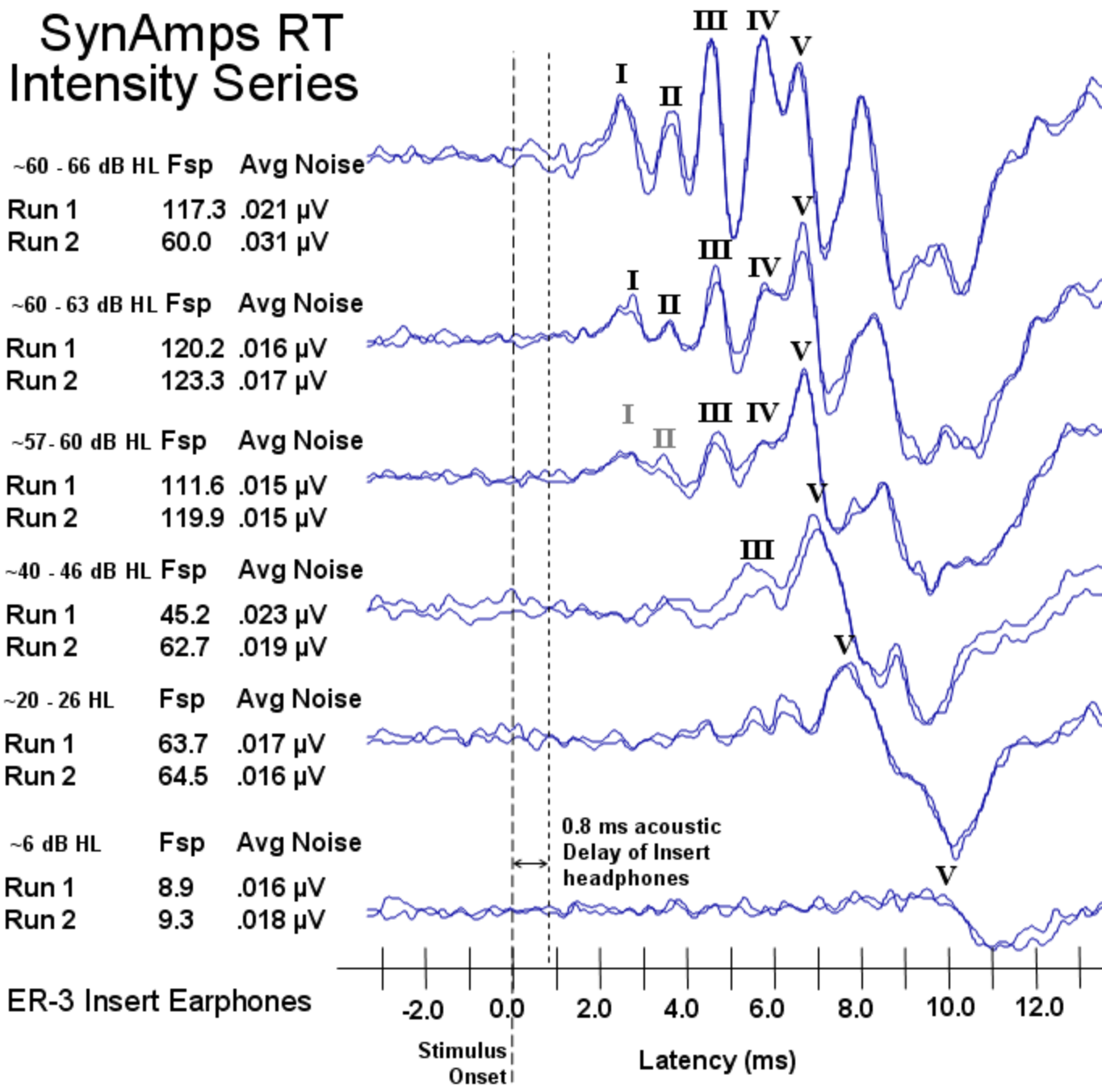
Termination will occur when either termination criterion is met, the 20,000 sweeps are accepted, or you click on **Stop** on the Toolbar. In the example below, acquisition was terminated when the F criterion was met.



Transfer the waveform to the Waveboard (*right click* in the display and select **Send Data to Waveboard**), where you may measure the peaks (and print the results).



The following ABR intensity series was recorded with a SynAmps RT, where the intensity decreased from 60-66dB HL (top) down to approximately 6dB HL (two runs per level).

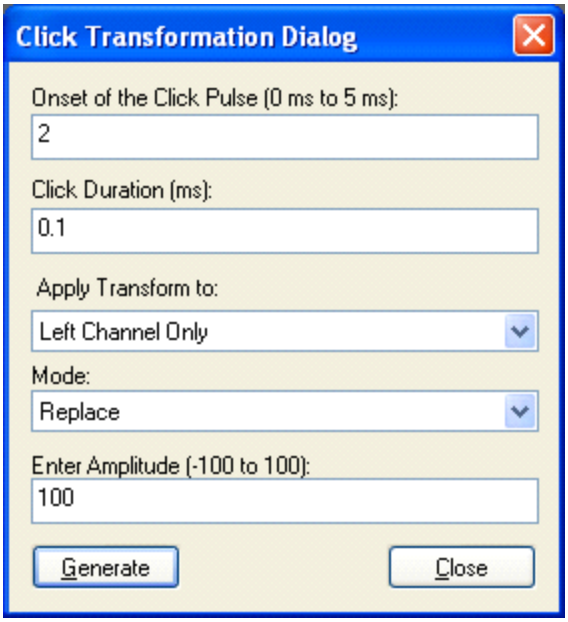


This concludes the fourth tutorial.

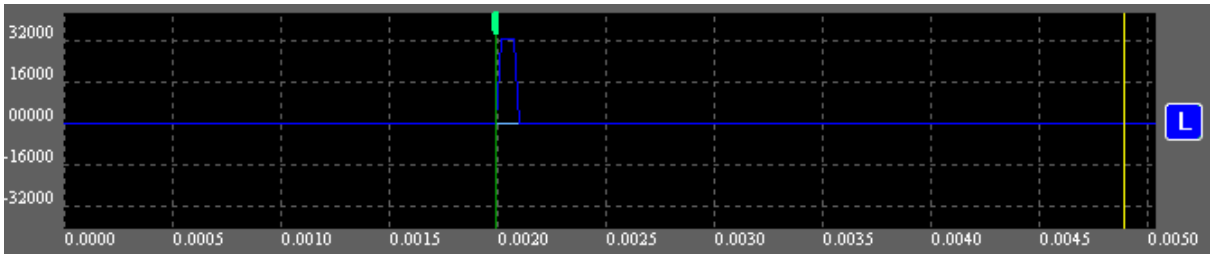
5.1.1 Creating Click Stimuli in Stim2

If you are using the Sound Editor module in the Stim^2 system to provide clicks for the ABR, we recommend the following settings. For the clicks themselves, use a delay of at least 1ms (in a file of, for example, 5ms in length), a duration of .1ms for the click, and 100% of maximum amplitude. You may want to Window the click stimulus to remove any unwanted

sounds.

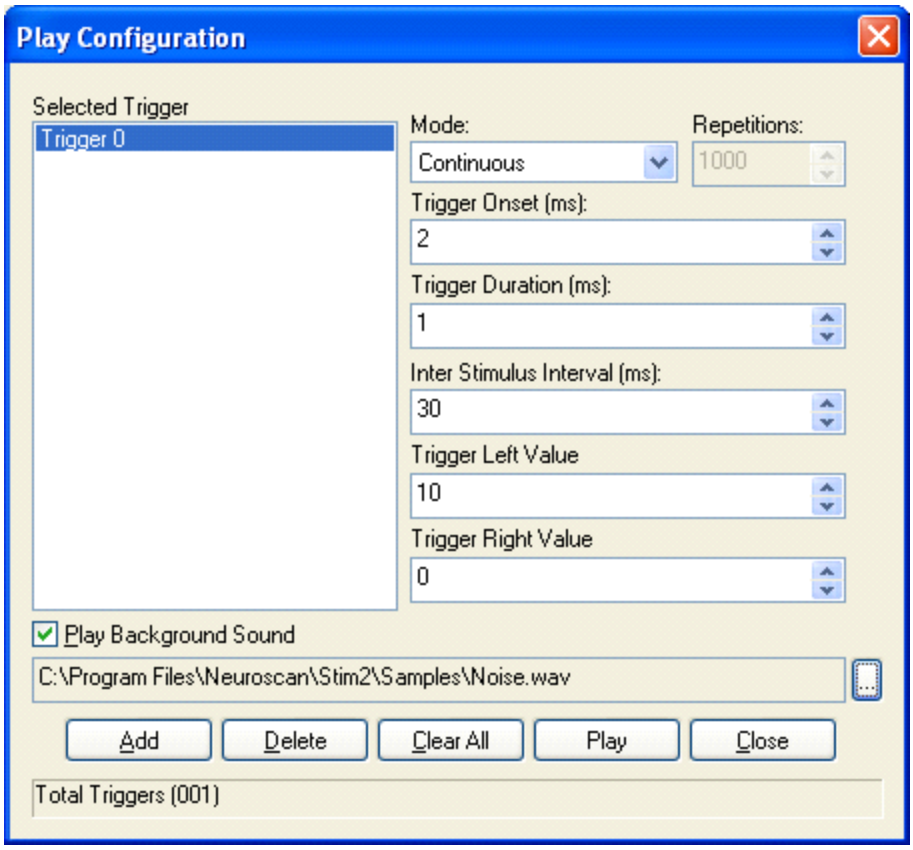


Use the Insert Trigger option to place the trigger pulse at the beginning of the click (see the vertical green line below).



Generally, you record the clicks from one ear then the other, with masking in the contralateral ear. Also, the decibel level is typically varied to obtain the best ABRs; similarly, the masking volume may also be adjusted, as needed. Rarefaction is indicated by an upward deflection for the click in the main display window in Sound. To get Compression, go under Transforms and rescale the values with a -1. This will be seen as a downward deflection of the click.

When you play the clicks from the Sound Editor, by clicking the icon, you will first have the opportunity to set the ISI, the trigger type code, and to select a Background Sound file (such as white noise on the contralateral channel).



We suggest you try the displayed settings at least initially, then vary them as needed. In most situations these settings are optimal for obtaining the best ABRs; however, they are offered as suggestions, not as an absolute guideline. *Note: when you are using the ear insert earphones, the air conduction of the sound introduces a latency increase of 1ms.*

Note

If you compute an FFT of, for example, a .1ms click, the results may show a dip in the spectrum around 12kHz, rather than the expected 10kHz, which would indicate that the duration of the click was really about 0.08ms.

This can happen if the off-sampling frequency in Stim^2 was, for example, 44.1kHz, or 48kHz. The duration of very short transient stimuli like clicks requires the use of specific sampling frequencies. The card that came with your Stim^2 computer (if you bought the complete Stim^2 system) should allow the setting of an arbitrary sampling frequency. Setting the sampling frequency at 20kHz or 40kHz produces a click of exactly the proper duration with the first spectral null at 10kHz, as it should be.

6 Continuous recording, online EMG audio, and filtering - N400

The continuous direct-to-disk recording mode of ACQUIRE can be used when a gap-free recording of EEG is required. Data are stored along with event markers in a continuous

format. One of the primary advantages of a continuous recording is that it provides flexibility for offline data analyses. The data can be replayed and processed any number of times to explore different hypotheses. Some transforms, such as the newer artifact reduction ones, are available only with CNT files. With a continuous recording it is a simple matter to change the size of an epoch. New pre- and poststimulus intervals can be recomputed for any length (limited only by available memory) with the EDIT module. Data recorded in the epoched mode, however, remain fixed and cannot be transformed. Another advantage to the continuous recording is that epochs can overlap. This feature is particularly important in more complex paradigms in which multiple events may occur in close temporal proximity. Cognitive tasks that explore attention and memory often have events that generate overlapping epochs. A continuous recording is required for such tasks. The behavioral data file, created in Stim2, can only be merged with continuous data files. The disadvantage to continuous recording is that it can, depending on the number of channels and digitization rate, generate large data files. However, this limitation is becoming much less of a problem with the rapid improvements in data storage devices (gigabyte hard drives).

 **Note**
You should record in Continuous mode in all cases unless there is a good reason not to.

To illustrate continuous recording, we will configure the system for a visual N400 paradigm. In this paradigm a list of words in the form of a sentence is presented one word at a time on the screen. Each word will send a sequence code via the parallel port to the ACQUIRE module. These codes will precisely mark the onset of each word and will appear at the bottom of the continuously scrolling data screen. Simultaneously, the continuous data file will be written to disk. For half of the sentences the terminal word will be a highly predictable, semantically correct word (congruent ending). The other half of the sentences will end in an unpredictable semantically incorrect word (incongruent ending). These two types of words will be indicated by different stimulus codes so that they can be sorted from each other during the analyses. In addition, the words leading up to the congruent/ incongruent word (sentence prime) will be identified as to their serial position in the sentence by additional stimulus codes.

We will take advantage of having two Single Window Displays to view the "raw" incoming EEG signals, as well as filtered incoming EEG with attenuation of the anticipated increase in EOG activity due to the task.

In this tutorial, you will see how to:

- Configure ACQUIRE to use Continuous mode
- Use two Single Window Displays
- Perform online Filtering
- Perform online Sorting
- Online Blink Reduction

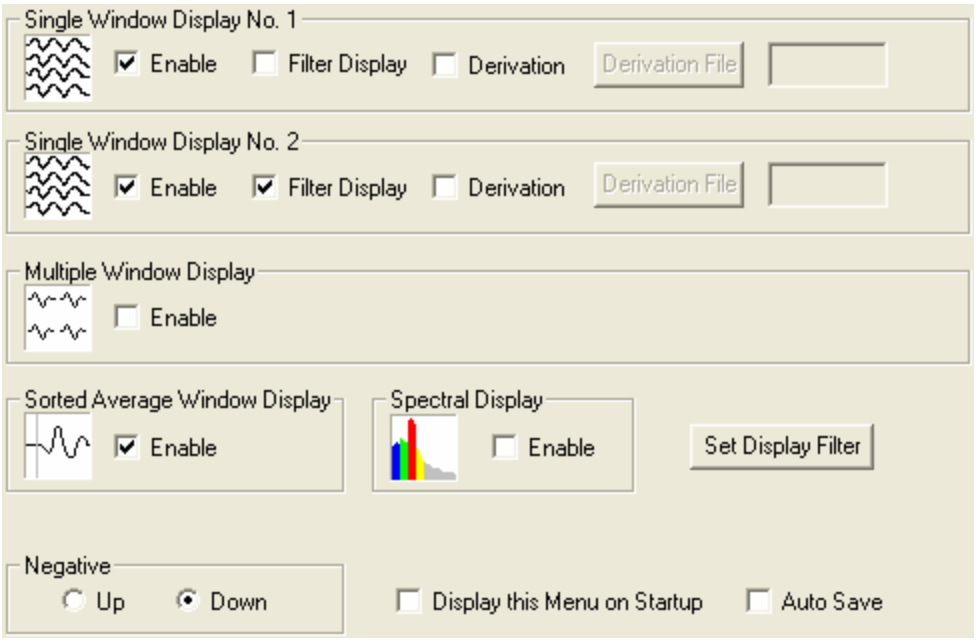
6.1 Acquisition

Follow the steps below to configure the system:

1. Start ACQUIRE as usual. The next step is to create a Setup file for continuous recordings. The easiest way is to start with the *Synamps2 Quik-Cap64.ast* setup file and

modify it. We'll omit the HEO channel for this recording.

2. Go to **Edit** → **Overall Parameters** and click the **Startup** tab. For this recording, **Enable** the **Single Window Display No. 1**. For the sake of this demonstration, let's say also that you are recording with a very wide filter range. However, because of likely increased EOG activity inherent in the task, you also would like to see in real time how the data would appear with additional filtering. To do this, **Enable** the **Single Window Display No. 2**. Now, click on the **Filter Display** field for SWD 2. This will activate the **Set Filter Display** button.



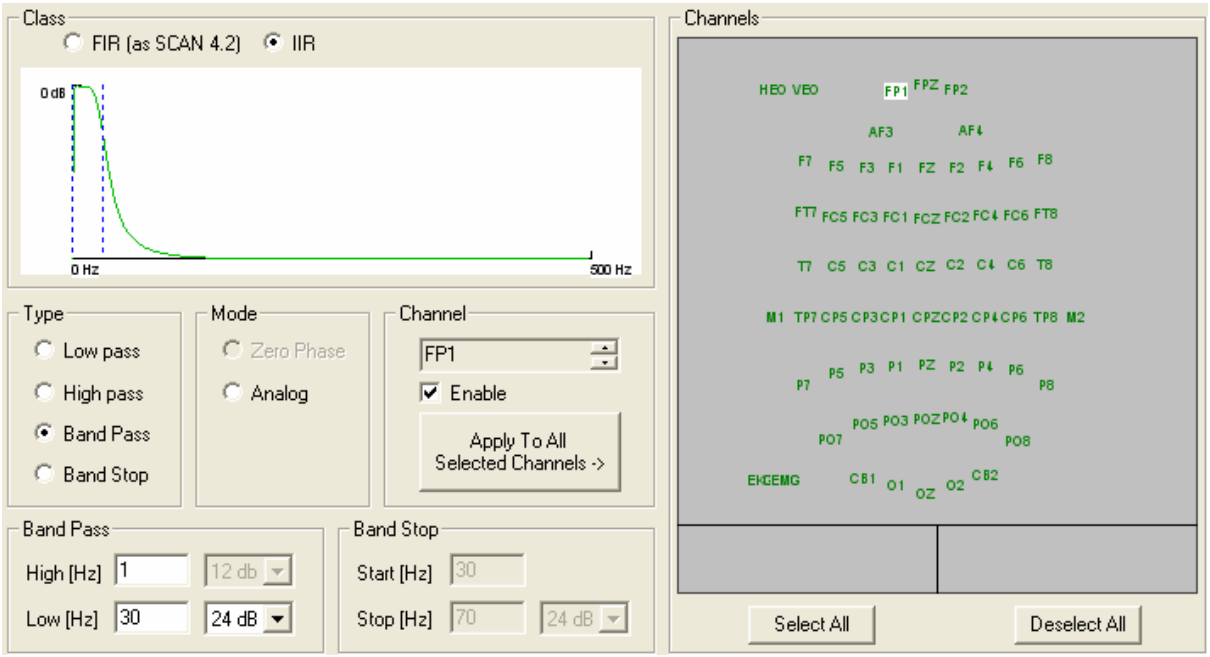
Click on the open file icon for the **Set Filter Display**, and you will see the Filter window. Select **IIR** in the Class region (the differences between FIR and IIR are discussed in the Filter section in the ACQUIRE and EDIT manuals). In the **Type** region, select **Band Pass**. This will allow you to set the high and low pass filter settings. In the Band Pass area, enter **1**Hz for the **High** pass filter, and enter **30**Hz for the **Low** pass filter setting, with **24** dB. The effect of the filter settings can be seen in the diagram window at the top of the display.

As with similar displays, you may select the channels to be affected. For this example, we'll select all the channels. Click the Select All button, if needed (labels should be green). Then click the Apply To All Selected Channels -> button. These settings will perform band pass digital filtering of frequencies outside the 1-30Hz range on all channels, on the second Single Window Display.

Note

Unlike the other similarly appearing displays, the Filter display contains an Enable *field. This is necessary for removing default filter settings that may be present in the setup file. It is not relevant in this example where we are applying the filter settings to all*

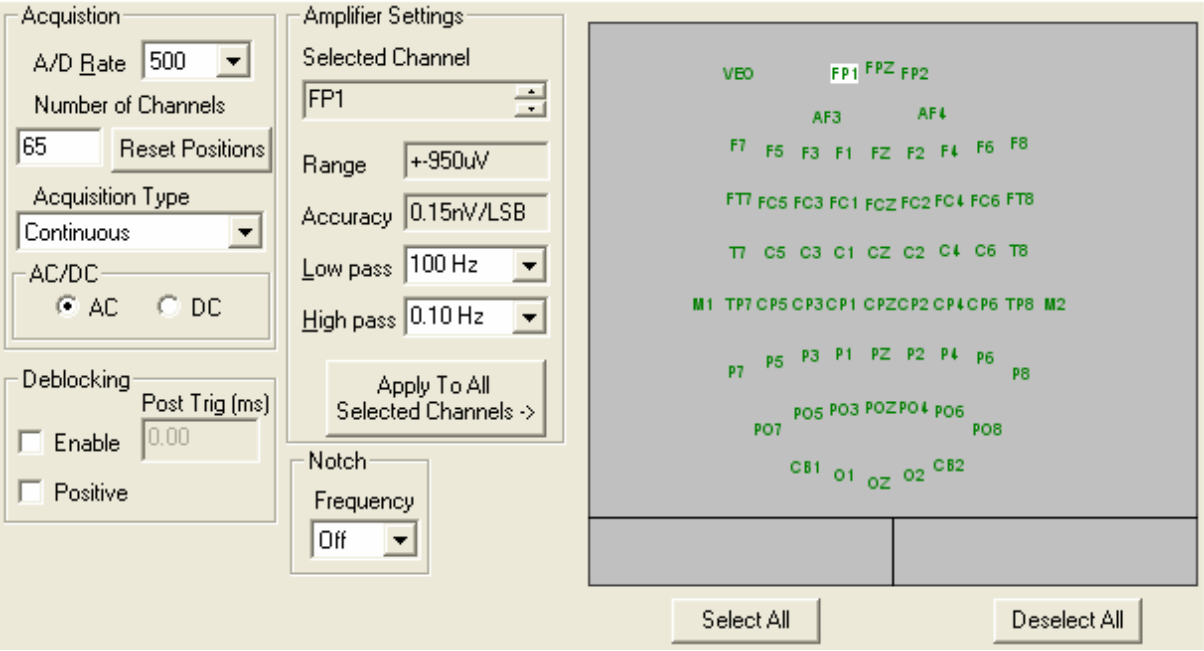
channels. Please refer to the ACQUIRE manual for more details. Click **OK** to continue.



Enable the **Sorted Avg Window**. Make sure no other display options are enabled. Set Negative as desired (Up or Down).

3. Select the **Amplifiers** tab. Set the **A/D Rate** to **500**Hz (512Hz for *SynAmps Wireless*).

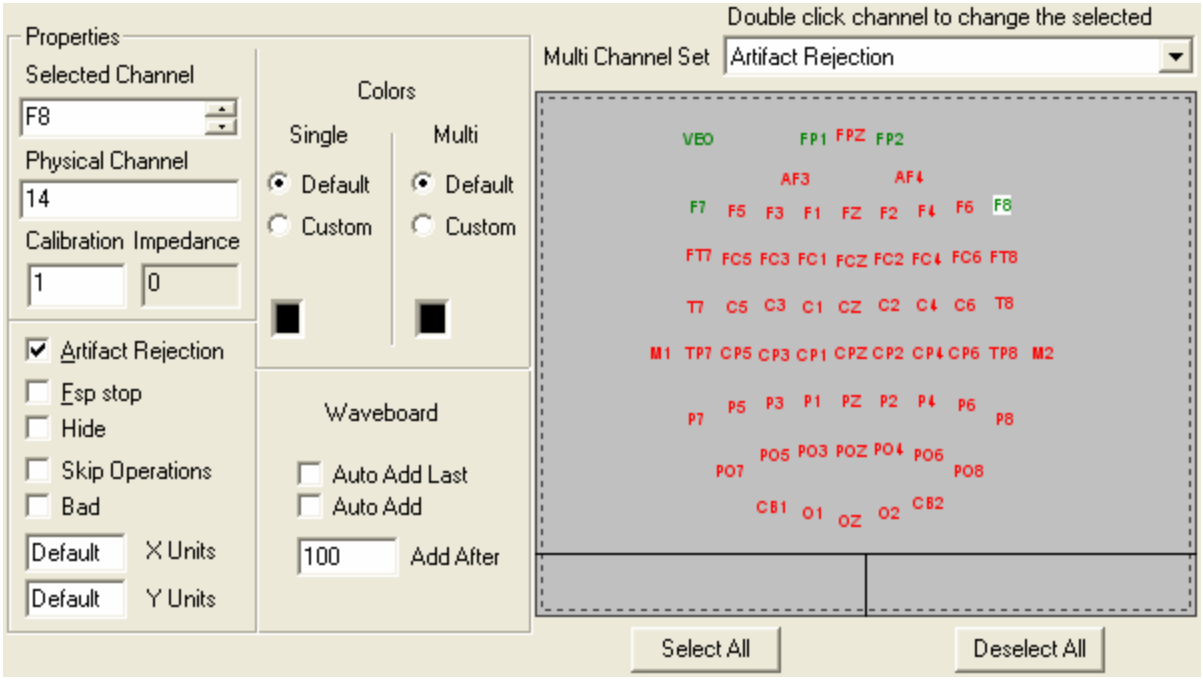
Enter **65** for the **Number of Channels** (*don't* click the Reset Positions button). In this example, the last channel is a vertical eye movement monitoring channel, recorded from sites above and below one eye (bipolar), referred to as VEO (and there is no HEO channel). For **Acquisition Type**, select **Continuous**. This setting configures ACQUIRE to store data in a continuous format. Under AC/DC select **AC**. (*SynAmps* users set the **Gain** to **250**; **1500** for *SynAmps Wireless*). Leave the Notch Frequency filter Off. We will not use Deblocking.



In the **Amplifier Settings** section, set the **Low Pass** filter to **100**Hz and the **High Pass** filter to **0.1**Hz. This is a wider range than that set in the online filter set for SWD 2. With all channels selected (green), click the 

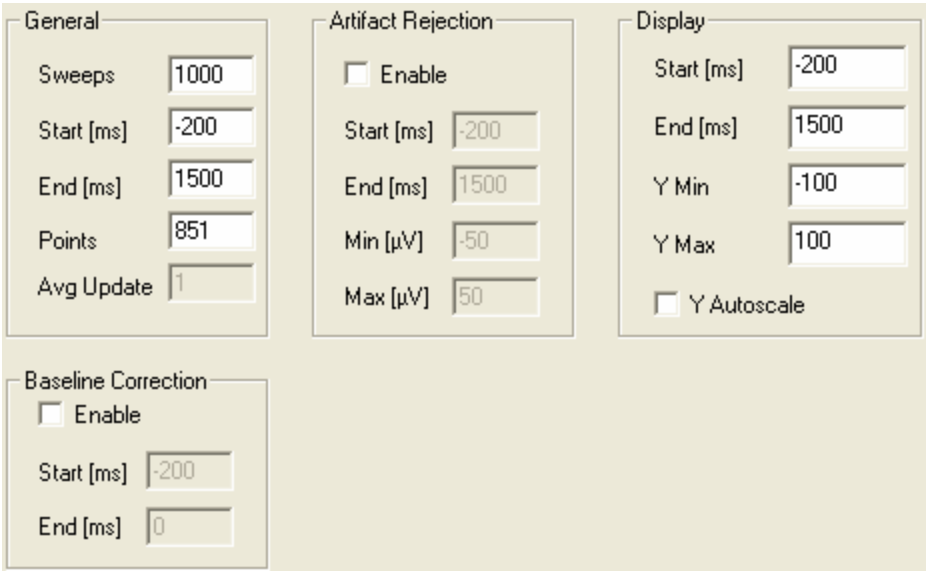
4. Select the **Channel Attributes** tab. For this recording, we will set FP1/2, F7/8 and the VEO channels to be Artifact Rejection channels. Do this by double-clicking these channels in the channels display (so they are green). Make sure that **Artifact Rejection** is displayed in the **Multi Channel Set** field. The 

field will be enabled for these channels. You will see an asterisk beside the electrode label for these channels when the data files are displayed online or offline.



5. Triggering for the continuous recording will be controlled by an External device (i.e., STIM). The **Hold** value should be set to **0**.

6. Select the **Epochs** tab to set the parameters of the recording epoch. The number of Sweeps in the **General** section is not relevant in continuous recordings. Set the **Start** time for **-200**ms and the **End** time for **1500**ms. The sample interval has been set with a pre-stimulus interval of 200ms and a poststimulus interval of 1500ms. Since this is a continuous recording, setting the sample interval will have no effect on data acquisition. However, it is convenient to have these parameters ready for offline epoching performed with the EDIT module. Click on the Points field, and the field should change automatically to **851**. The Avg Update field is not used with continuous recordings.

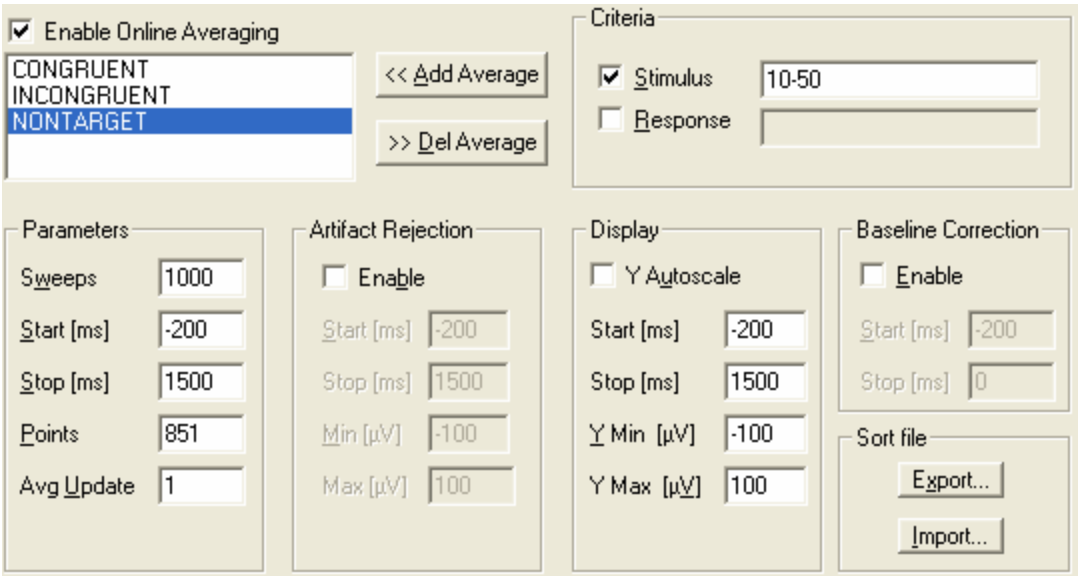


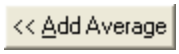
Disable the **Artifact Rejection** feature. For later reference, you might wish to enter the Start (-200ms) and End (1500ms) values, and the Maximum (50μV) and Minimum (-50μV) voltage thresholds. To do this you should first Enable the feature, enter the values, then disable it - the values will still be displayed.

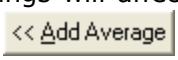
The **Display** fields are more relevant for offline analysis; you can enter the parameters and they will be carried with the data file. Use the same Start and Stop times, with Y Min set to -100μV and Y Max set to 100 μV.

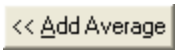
Disable the **Baseline Correction** option. For later reference, you might wish to enter the Start (-200ms) and End (0ms) values. To do this you should first Enable the feature, enter the values, then disable it - the values will still be displayed.

7. For this recording, we will also look at the online averages created for the combined nontarget words in the sentences (the words leading up to the target word at the end of the sentence; ordinarily these might be analyzed separately, but for simplicity's sake they will be combined for this demonstration), as well as for the congruent words and noncongruent words. Assume that the STIM system has been set to send trigger type codes of 200 for the CONGRUENT stimuli, and trigger type codes of 100 for the INCONGRUENT stimuli. Assume also that the Nontarget words leading up to the final target word have trigger type codes of 10, 20, 30, 40, and 50. Select the **Sorting** tab. We will first specify 3 averaged files to be created and saved.



We will sort these files using the trigger type codes from STIM. Click on the field to enable the Online Averaging (under **Parameters**). Click the 

button, and a Save File utility will appear. Enter *INCONGRUENT*, and click *Save*. You will see the *INCONGRUENT* name appear in the sorting box. Enable the **Stimulus** field, and enter **100**. Make any changes to the settings in the Parameters, Artifact Rejection, Display or Baseline Correction fields. These settings will affect the sorted averages but not the saved CNT file. Then click again on the 

button, enter *CONGRUENT* for the file name. Enter **200** in the **Stimulus** field. Make any changes in the other parameter fields. Then click again on the 

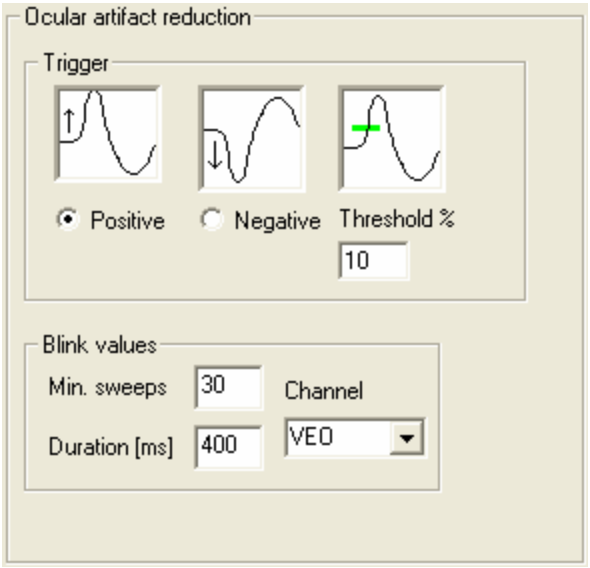
button, enter *NONTARGET* for the file name. Enter **10-50**

in the **Stimulus** field (*entering 10,20,30,40,50 is also valid*), and make any desired changes in the parameters fields.

If you make a mistake in one of the files, highlight the one you wish to edit, and make the changes. To delete a file, highlight the file then click on the 

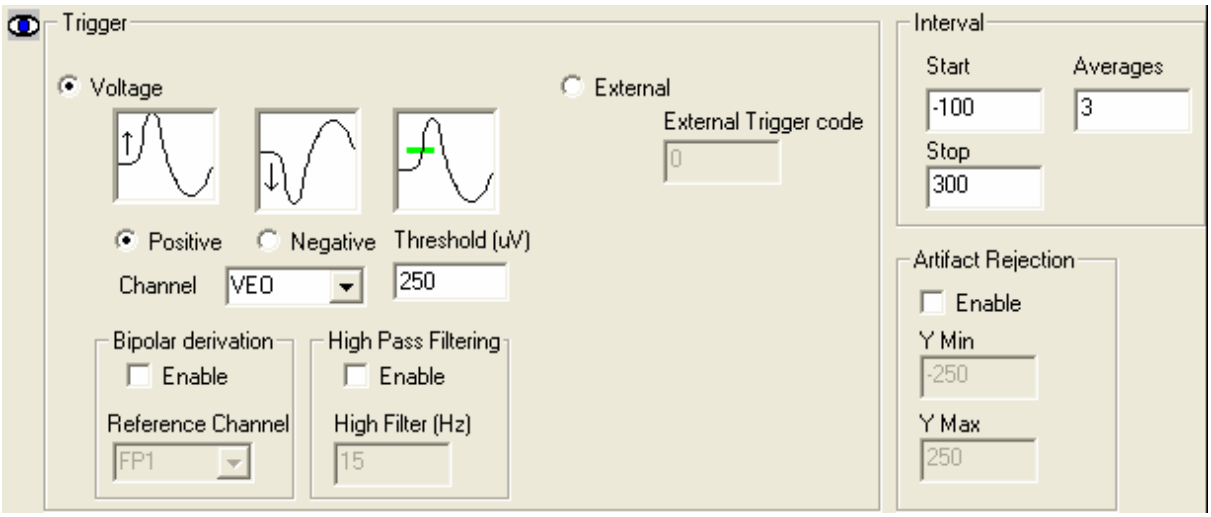
button. The program is set to create the three *.avg* files, based on the settings entered for each.

8. Select the **Miscellaneous** options. Since this is an eyes-open, visually oriented task, we expect considerable EOG artifact. We will set the parameters for the Ocular Artifact Reduction transform here, and they will be retained in all data files recorded with this setup file. See the EDIT manual for an explanation of the settings - for now, just enter the values as shown.



9. We also have the option to remove the VEOG artifact online during acquisition using online **Blink Reduction** (this requires a Toolbox license). The corrected data are not saved; however, we can get an good idea of how effective the offline correction will be.

Click the **Blink Reduction** tab. Select **Voltage** for the **Trigger** method. Set **Voltage** to **Positive** with a **Threshold** of **250**uVs. Select the **VEO Channel**. Leave the Bipolar Derivation and High Pass Filtering options disabled.



In the Interval section, set the **Start** time to **-100** and the **Stop** time to **300**ms, with **Averages** set to **3**. Disable Artifact Rejection.

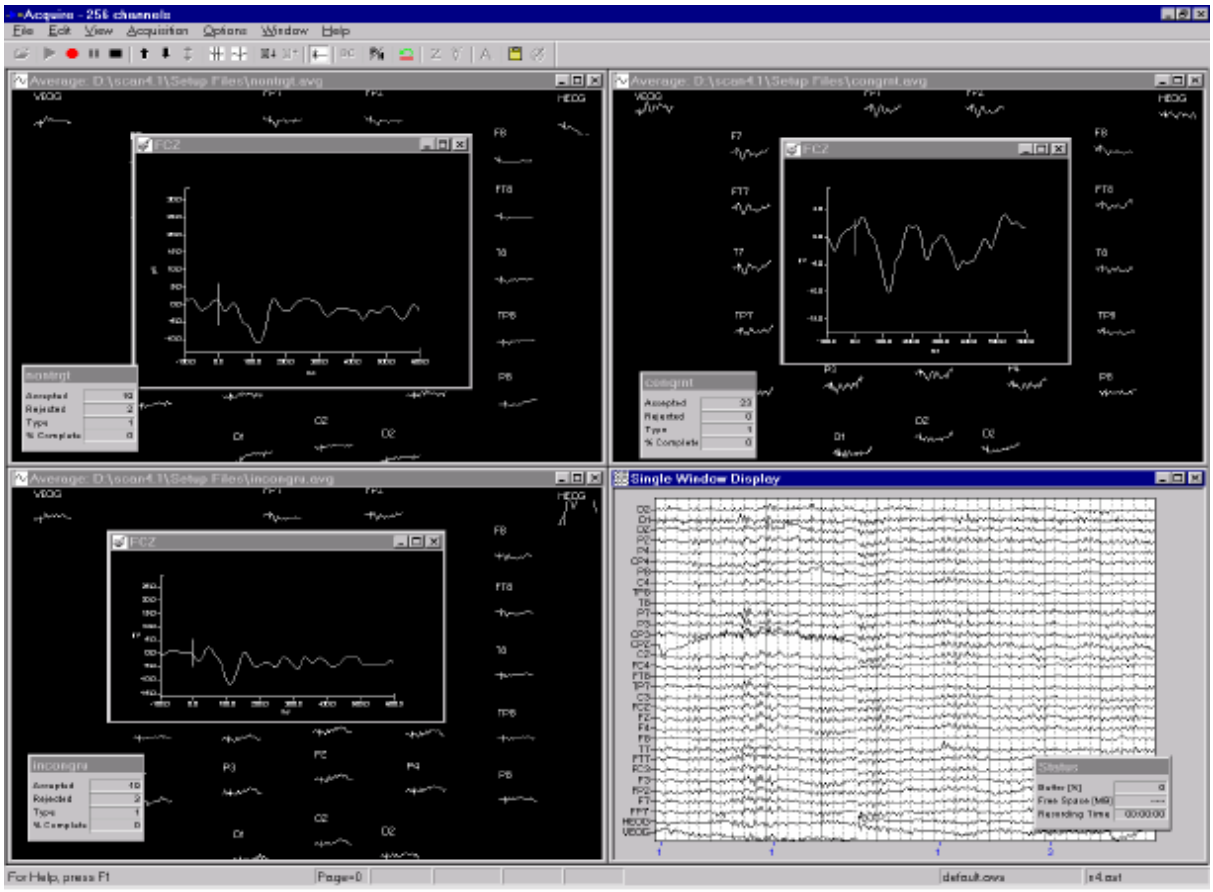
Briefly, when the voltage in the VEO channel exceeds 250uVs, the section from -100 to 300ms about the trigger point (peak voltage) will be stored. When 3 artifacts have been detected, they are averaged together, and the regression/proportional subtraction process will begin, correcting each data point from each channel. The average is rolling, that is, it is based on the 3 most recent artifacts (and the correction is constantly updating).

10. It would be a good idea at this point to save the settings that you have made thus far. Click the Save As... button, and label the file *N400SET* (the *.ast* extension will automatically be added).

If you want to resize or reposition the electrode displays, go to the **Channel Layout** option as described in previous tutorials.

11. To begin viewing, click the green triangle on the Toolbar, or use **Acquisition** → **Start Acquisition**. You will see the 2 Single Window Displays and the 3 sorted average window displays. The effects of the online filtering should be apparent in the second Single Window Display. When you are ready to begin recording, click on the **Record** icon (the red dot) on the Toolbar, and enter a file name. The *.cnt* extension will be added automatically. Click Save, and you will be returned to the Single and Averaged Window Displays.

Note
Only the Single Window Display No. 1 will be saved - the second Single Window Display is for display purposes only. In the Averaged windows you will see the average wave forms develop, with updates as specified in the **Epoch** section in the **Sorting** display. (*Use **Window** → **Tile Horizontally** to arrange the multiple windows automatically*).

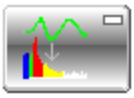


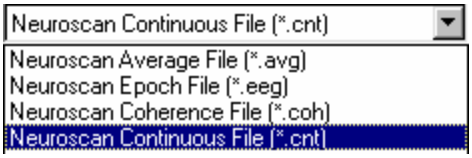
6.2 Post acquisition processing of the CNT file

This section illustrates processing steps for constructing averages from a continuous data file. A 32-channel recording from a subject performing the sustained visual attention task described above will be used as an example data set.

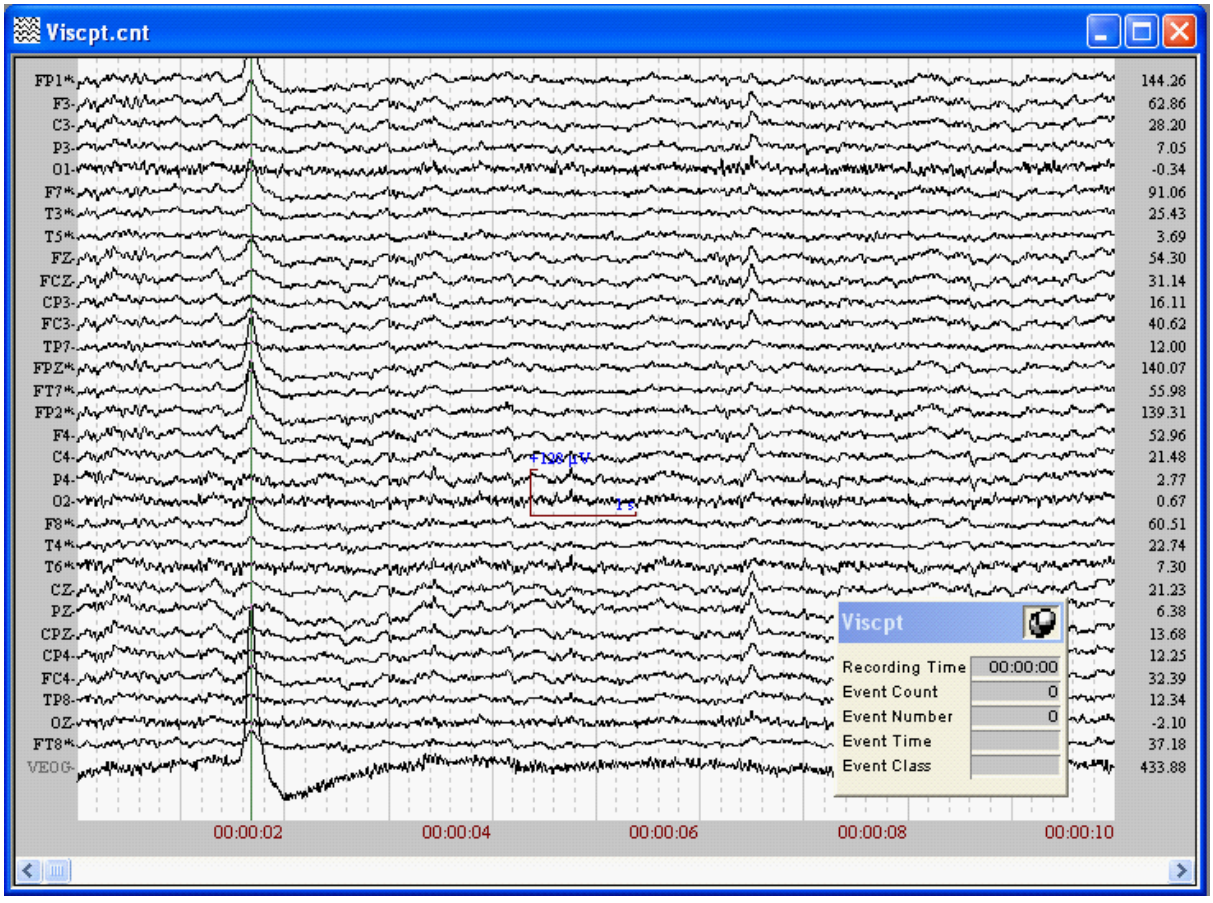
The visual sustained task (*viscpt.cnt*) used to generate these data consisted of a series of centrally presented digits (subtending 1 degree of visual arc) ranging from 0 to 9. The digits were presented for a duration of 100ms and were separated by a visual noise mask. An interstimulus interval of 2000ms with a $\pm$ 100ms 'jitter' was employed. The subject's task was to identify target (the digit '0') from nontarget (digits 1-9) stimuli. The accuracy and latency to identify targets and non-targets was recorded and saved to a separate behavioral data file.
In this tutorial, you will see how to:

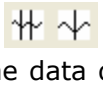
- Navigate through the CNT file
- Remove blocks of artifact
- Perform Ocular Artifact Reduction with CNT files
- Merge behavioral data with the CNT file
- Epoch the CNT file
- Artifact Rejection
- Average by event type codes
- Use Multiple Window Settings
- Subtract AVG files

1. Loading a data file - After clicking the Edit icon  from the Program Launcher, click **File** → **Open data file**, or click the **Open File** icon  . A standard Open data file utility will appear. At the bottom of the screen is the "Files of type" line.

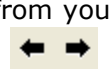


Click the down-arrow and select the Neuroscan Continuous File (*.cnt) file type. Go to the ...*Demo Files**VisualAttention* directory and retrieve the *Viscpt.cnt* by double-clicking it. The *Viscpt.cnt* demo file will be displayed.



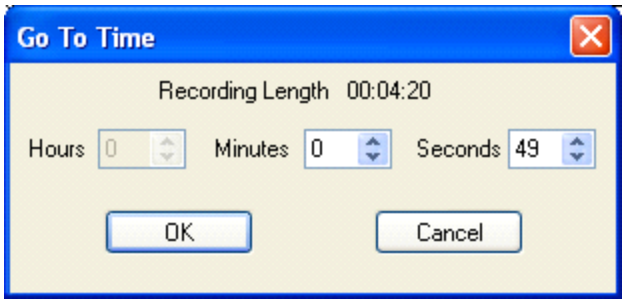
If your display differs from the above, you may need to increase or decrease the display scale using the up and down arrows  on the Toolbar, or the autoscale icon  . Click the Accelerate or Decelerate Display icons  to vary the number of seconds displayed on the screen, or *right click* in the data display, and select **Set seconds per page**.

The continuous file was collected from a 25 year-old male recorded from 31 EEG leads and 1 ocular lead to monitor vertical eye movements and blinks. Amplifier gain was 1000 (16-bit resolution on a *SynAmps*) with a band pass of .15 to 30Hz and was digitized at 250Hz. The epoch displayed on the screen represents the first epoch of the continuous file. Since the file is continuous, individual sweeps in this display are contiguous.

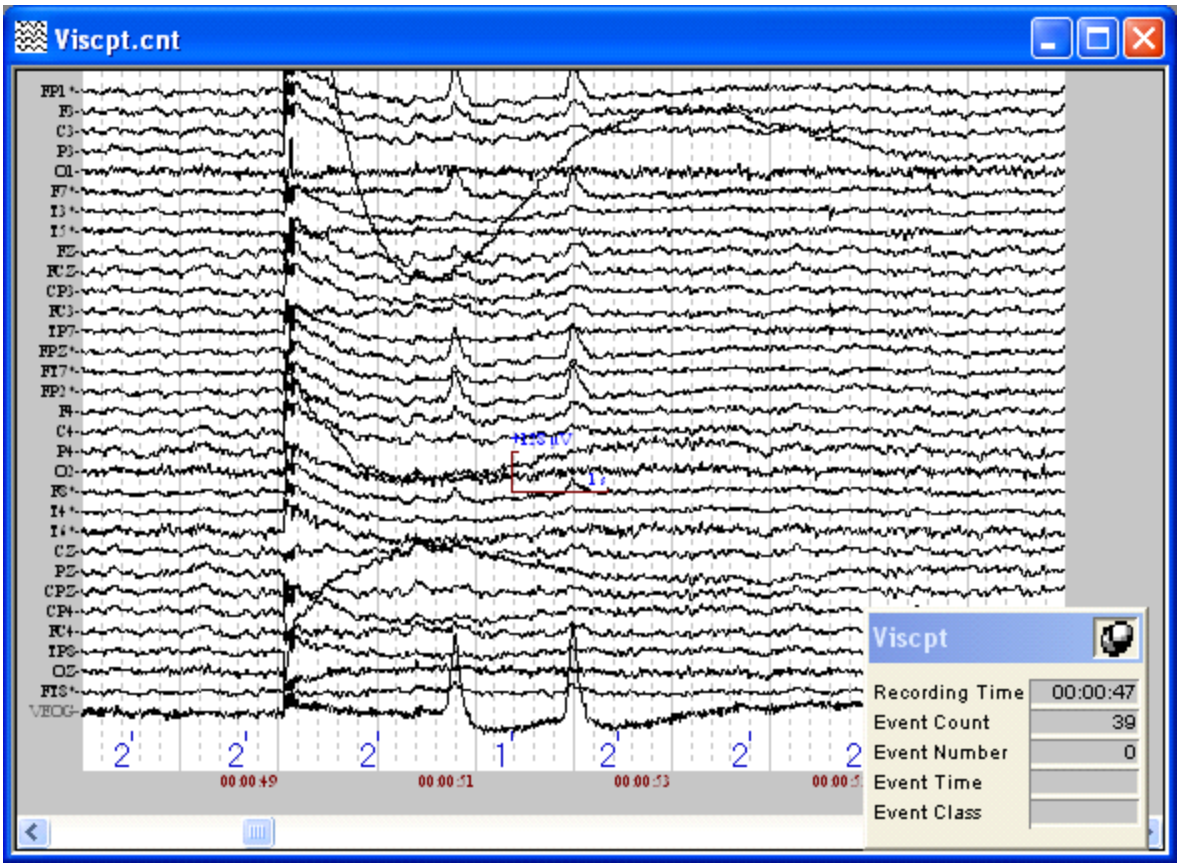
There are several ways to navigate through the file. If you have a *mouse wheel*, one easy way to move through the file is to just rotate the wheel. Rotating the wheel toward you moves ahead in the CNT file; rotating it away from you moves backward. To move forward or backward by one display page, click the  buttons located on the Toolbar, or use the *arrow* keys from the keyboard. As you move forward or backward, note that the Recording Time indicator in the Playback Status box will increase or decrease. This value indicates the current recording time in hour, minutes, and seconds at the start of the display page. You may also scan automatically through the file by clicking the **SpeedScan** buttons on the Toolbar  . The center button will stop the SpeedScan. You may jump to a desired event or time point in the file by clicking the "Go to" buttons on the Toolbar  . The first option will display the **Go To Event** screen, from which you can jump to any desired Stimulus, Keypad, Reject, Accept, Keyboard, DC Correction, or Segment event (described in more detail in the EDIT manual). The second option opens the **Go To Time** window, in which you may select a precise time point to jump to.

At the bottom of screen a scrollbar indicator will also move from left to right indicating the current file position  . The scrollbar provides a way to move quickly to a different position within the file. To use the scrollbar, click on the rectangle button while holding down on the left mouse button. Drag the rectangle to a new position and release the mouse button. The screen will refresh displaying the new file position. The arrows on the left and right of the scrollbar are used for alignment of the current display page. Each press of these buttons will move the current page by one second.

2. Reviewing and editing artifact with a continuous file - Let's begin by removing some bad sections of the recording. In this file there are at least six obvious artifact events that should be identified and removed. The first artifact is located 49 seconds into the recording. You can search to this location quickly by clicking on the **Go To Time** button  , and entering "49" in the Seconds field, as shown.



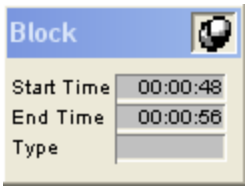
Shown below is the artifact that starts at this point in time.



Artifacts occur at approximately 0:49.05, 0:1:43.22, 0:2:30.58, 0:3:11.19, and 0:3:52.78. You can use the search button to move quickly to these locations or you can scan manually or automatically through the file and identify them.

After identifying the onset of the artifact, the next step is to reject the section of data that contains the artifact. This is done with the **Mark Block** function from the Toolbar. The mouse cursor is now active for marking points in the CNT file, and will allow you to mark the section to be rejected. After clicking the Mark Block icon, click the mouse one time just before the beginning of the artifact, and then again where the artifact resolves. The second click denotes the end of the marked block.

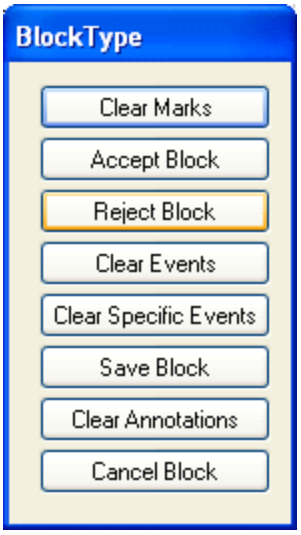
You will then see the Start and Stop Times written in the Block status box, and the Block Type menu will appear.



Note *If the artifact extends beyond what is displayed in the current screen, you can move the cursor off the waveform display area, click on the page forward arrow, or the right arrow button on your keyboard, and the screen will advance to the next page (or*

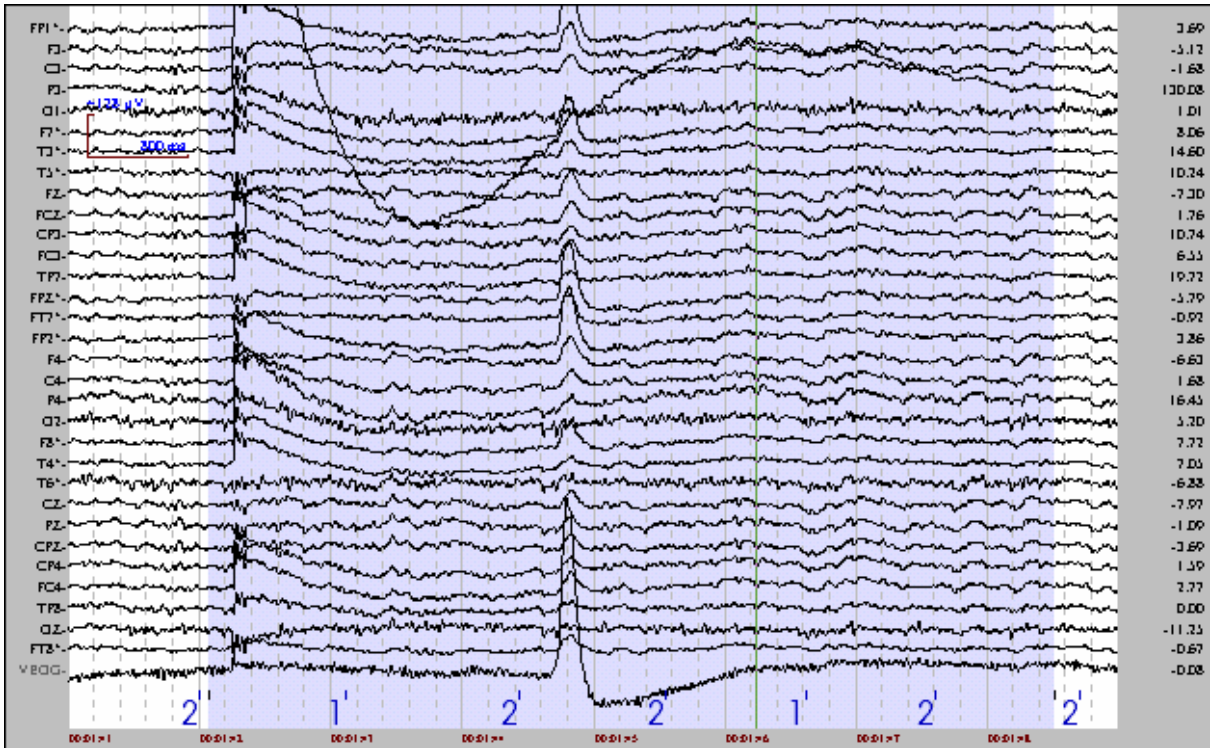
you can increase the number of seconds displayed).

Click the Reject Block option and the screen will refresh showing the marked block in color.



Note

Rejected blocks can be accepted again with the Accept block command.

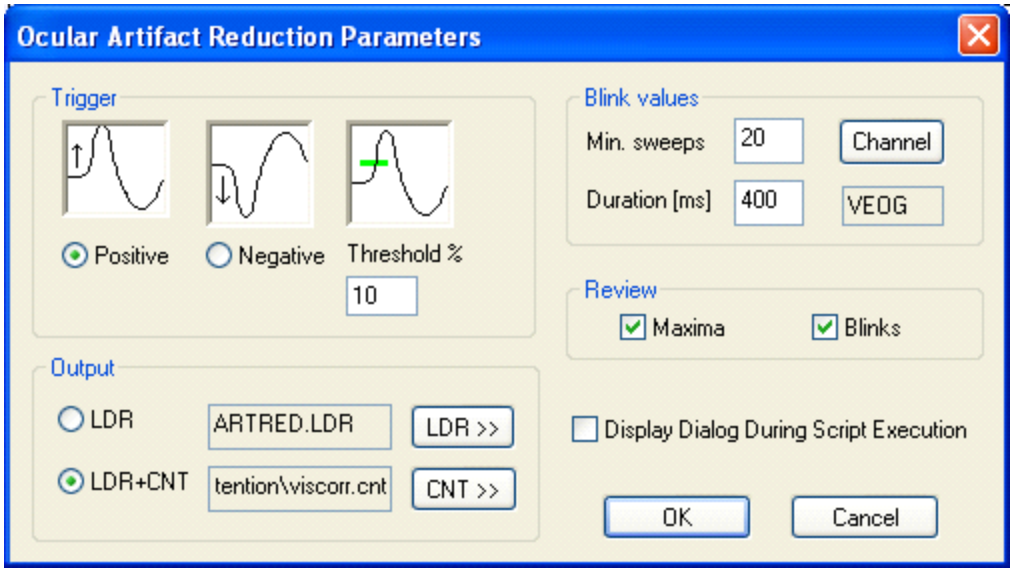


Repeat this step for each of the artifact regions in this file.

3. Ocular artifact reduction - Ocular artifact reduction can be performed with continuous

or epoched files. The procedures are similar to those used with the single-sweep epoch files (see previous P300 tutorial). There are, however, advantages to performing ocular correction with a continuous file over an epoched file. First, in a epoch file, a blink or eye movement can occur at any point within the sample epoch. This means that there may be a significant number of artifacts that either start too early or too late with respect to the epoch interval. Second, in an epoched recording it is possible to miss artifacts resulting in fewer sampled eye movements. Since the reduction algorithm becomes more reliable with increasing numbers of samples, a continuous recording that contains additional artifacts will actually improve the quality of the ocular reduction. Third, with continuous files you have the opportunity to review the Maxima, the Blinks, the transmission coefficients, and the Standard Deviations (SDs).

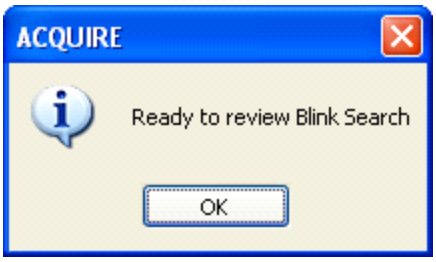
Follow these steps to perform ocular reduction on a continuous file:
Click **Transforms** → **Ocular Artifact Reduction**, and the Ocular Artifact Reduction Parameters window will appear.



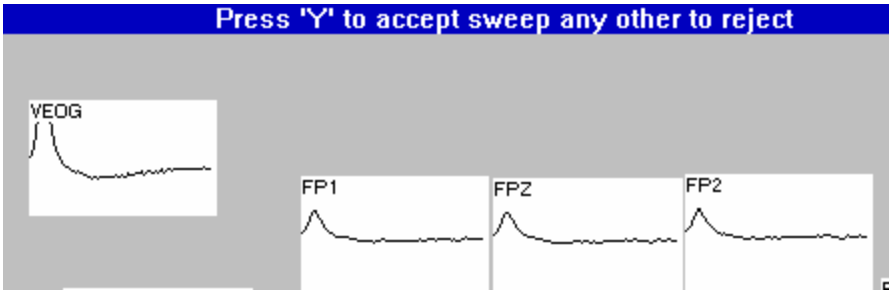
Verify that the values in your ocular reduction dialog box match those shown in the box above, enter a name for the output CNT file, and click OK. You will then see the first sweep, and you will be asked if this looks like a genuine maximum (from the VEOG channel), that is, does it contain the greatest voltage peak for a genuine eye blink (in the VEOG channel). Chances are this will not be contained in the first sweep. If you say Yes, the program will go the next sweep that has a higher voltage value in it. If you say No, it will go to the next sweep. In either case you will see the same screen asking if this is a maximum. Typically, there will be some No's at the beginning until you see a legitimate looking blink. Then click Yes. From then on, if you say "Y", the program will only select sweeps where there is a larger voltage. Ultimately, it will accept the blink with the highest voltage. Be sure not to accept a sweep with a higher voltage that is not from a blink. If you are sure that there are no artifacts in the file with voltages greater than that of the largest blink, you can save time by not enabling the Review Maxima option. In that case, the Maximum will be detected automatically.

Once the Maxima has been determined, the program will then go through the file looking for blinks to use to create an average blink artifact. You will see a notice

saying that the review of the blinks is about to begin.

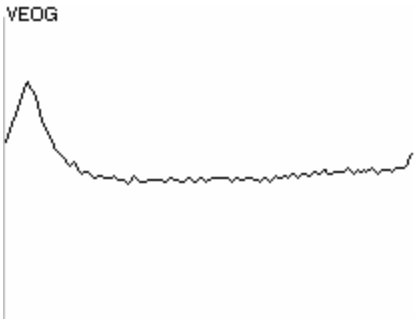


The beginning of the blink artifact is defined as X% of the Maximum voltage, where X is the value you entered for Threshold (under Trigger; typically 10%). With a CNT file, the routine will search for the first point that exceeds the threshold value. If you look at your designated channel (e.g., VEOG), the very first point is the one that exceeds the threshold. The next X ms (where X is the Duration) should be part of a well defined blink.



If it is, Press "Y", and the next X ms will be used to create the average blink artifact. If you press any other key, the routine will skip the next X ms, and then find the next point that exceeds the threshold.

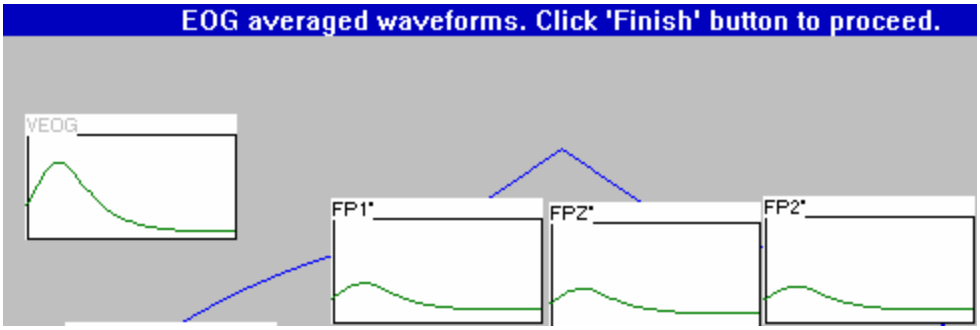
Hint: With CNT files, the routine will find the first point in the designated channel that meets the 10% threshold. When you are reviewing the Blinks, you will have the options to include or exclude the next 50, 200, 400ms, or whatever your Duration is, in the averaged artifact. The routine will then skip the Duration time, and find the next point that meets the threshold. If your Duration is short, the next point could easily be IN THE SAME BLINK. You do NOT want to accept the second one. You want to take the same section from each blink, such as, the ascending limb and peak section of the blink. If you accept separately the ascending limb and also the descending limb of the same blink, imagine what will happen when these are averaged together, and what that will do to the variability of the averaged blink (which you want to be as small as possible). We recommend a duration of about 400ms. The types of blinks to accept are similar to ones shown below. Realize that the Up and Down arrows icons  *can be used for display scaling.*



Continue reviewing the Blinks until you reach the end of the file. At that point, the routine will take over and calculate the averaged artifact and transmission coefficients.

If you did not elect to review Blinks, the routine will continue automatically. Realize, however, that the threshold may be reached for any number of reasons besides blinks, and those sections will then be included in the average blink artifact. This may result in a less than optimal subtraction of the blink. Generally, if you have a recording with blink artifact that is otherwise clean, the automatic routine will often do as good a job as your manual review.

When averaging is completed, you will see a Multiple Window Display showing the averaged artifact. Vertical eye movements and blinks have a pronounced effect on the frontal electrodes that diminishes as it moves to posterior electrodes. You should see the greatest similarity among the frontal sites, and essentially flat lines at posterior sites.



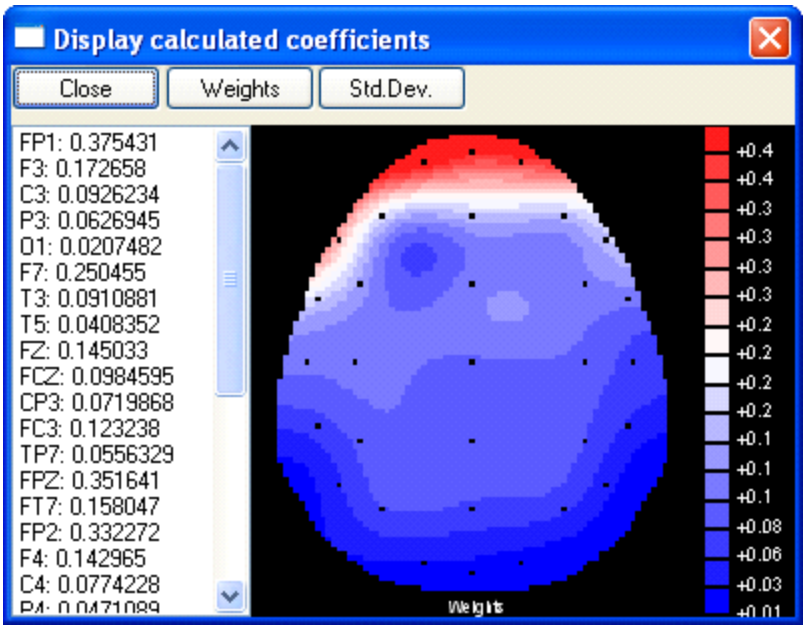
Viewing the transmission coefficients - To view the transmission coefficients and SDs, point the mouse to an electrode label. The weights and SDs will appear in the form of a Tool Tip.

To see all of the Weights or SDs in a map display, click the Show button in the lower left hand corner 

.

The transmission coefficients are typically much higher in the frontal leads than they are

in the posterior leads. This is because the vertical eye movements and blinks spread in an anterior-to-posterior manner. Consequently, much more of the VEOG channel is subtracted from the FP1 and FP2 electrodes than from posterior electrodes such as O1 and O2. Horizontal eye movements, on the other hand, have a pronounced effect on lateral electrodes such as F7, F8, T3, and T4. The largest effects are in the anterior electrodes (F7 and F8), with the polarity being reversed across the left and right hemispheres depending on the direction of the movement.



As for the information conveyed by the SD statistic, recall that the transmission coefficients are determined by a linear regression procedure. First an average artifact waveform is constructed for the EOG channel and for all EEG channels (these waveforms contain a number of points determined by the EOG Points parameter). The transmission coefficient for a given channel corresponds to the slope of a least-squares, best-fit, straight line (through the origin) for a scatter plot of the EOG versus EEG waveforms (each point in time determines one scatter plot point). The standard deviation measures the goodness-of-fit for the estimated straight line through the scatter plot data: Smaller standard deviations are associated with better fits. (As a rough general rule of thumb, standard deviations of 0.05μV or less are acceptable.) Noticeable distortion of the EEG data may result if the correction algorithm is applied in the case of large standard deviations. The large SD is an indication that artifacts other than blinks were averaged, therefore the average is distorted, the coefficients are distorted, and you wind up performing inaccurate subtractions of the artifact.

If the anterior-to-posterior distribution of the averaged artifact looks reasonable, and the weights and SDs are appropriate, click the Finish button at the bottom of the display to remove the artifact. If not, click the Abort button to terminate the routine

.

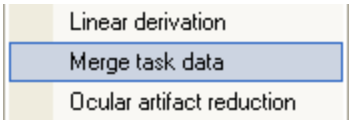
Retrieve the corrected file and compare it to the original one to see the effect of the reduction algorithm.

4. Merging behavioral data into the continuous file - Continuous files created with SCAN version 3.0 and later can be merged with behavioral data such as stimulus/response codes, latency, and accuracy. The advantage of merging behavioral data into the continuous EEG file is that sorting decisions, based on different performance criteria, are facilitated at subsequent processing stages. For example, we might want to look at the difference between averaged responses to correct and incorrect trials. Alternatively, we might want to accept only those trials on which the subject responds within a certain response window. These types of operations can be performed when the behavioral data are included in the continuous EEG file.

In the sustained attention task a behavioral data file named *viscpt.dat* was recorded. This file contains 206 trails of trial-by-trial accuracy and latency data. A section of the DAT file is shown below.

Trial	Resp	Type	Correct	Latency
1	1	2	1	0.399
2	1	2	1	0.292
3	1	2	1	0.251
4	1	2	1	0.270
5	1	2	1	0.359
6	1	2	1	0.295
7	1	2	1	0.270
8	1	2	1	0.280
9	2	1	1	0.390
10	1	2	1	0.299
11	2	1	1	0.492
12	1	2	1	0.272

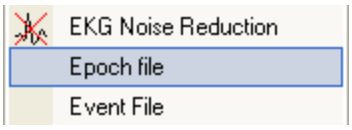
The *viscpt.dat* can be merged with the corrected continuous file with the following steps.



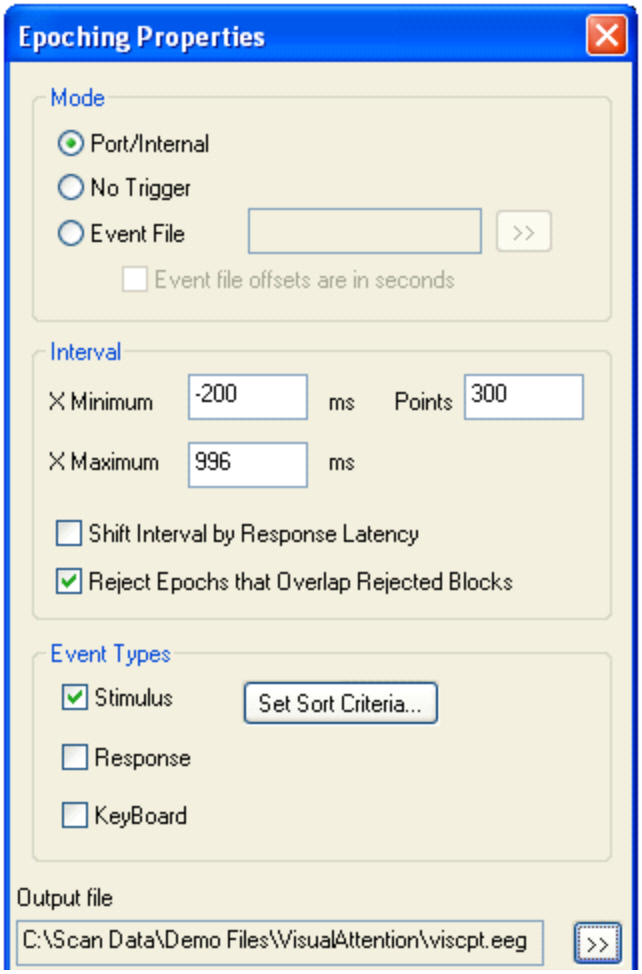
Click on Transforms, and select the Merge Task Data option. A Select Task file display will appear, allowing you to select the DAT file. Select the *viscpt.dat* file, click Open, and the task data will be merged.

5. Constructing single-sweep epochs from the continuous file - There are a number of advantages to recording data continuously. First, epoch windows of any size (limited only by memory) can be defined. If, at some later point, you decide to extend or shorten the epoch length, it can be easily done by reconstructing epochs with new values from the continuous file. Second, the epoch frame relative to the event (i.e., length of pre- and poststimulus interval) can be changed at will. An example of this application might be backward averaging of pre-motor responses. Third, continuous recordings allow for overlapping epochs. There are many instances where it is necessary to examine overlapping epochs as is often the case of complex cognitive tasks. An example of this might be a high-speed sustained attention task in which stimuli and responses occur rapidly.

Follow these steps to construct a single-sweep epoch file:



Click **Transforms** → **Epoch file**. You will then see the Epoching Properties window.



The parameters of this dialog box control the conversion of the continuous file to an epoched single-sweep file. The following is a brief description of each of the fields in this window:

Mode. The Mode fields are used to provide information about the source of the events to be used for determining the zero time point of the epochs.

Port/Internal. These data were acquired with the Port mode, and is the mode used with stimuli from STIM. Select this option for the demonstration.

No Triggers. Use this option for back-to-back epoching (where there are no triggers).

Event File. This option allows you to use an Event File to control epoching.

Interval. These fields set the beginning and ending time points for the epochs.

X Minimum. The X Minimum field determines the prestimulus interval. The value should be set to **-200** in this example.

X Maximum. The X Maximum field determines the poststimulus interval. The value should be set to **996** in this example.

Points. The Points field determines the total number of points allocated to the current epoch size. Click in the field and the number of points will be calculated automatically (**300** points).

Shift Interval by Response Latency. This option is used when you want to perform response-locked averaging. When enabled, epochs will be created around the response triggers, rather than the stimulus triggers. Leave it disabled for this example.

Reject Epochs that Overlap Rejected Blocks. If you reject a block of data in a CNT file, you would normally exclude that section when you Epoch the file. If you enable this option, those epochs that overlap the rejected blocks will be excluded. However, you can opt to include them by disabling the option. Enable the option for this example.

Event Types. Select the type(s) of trigger events to be used for epoching. The Set Sort Criteria button allows you to sort specific events to be used for epoching, such as, trigger types within a certain range.

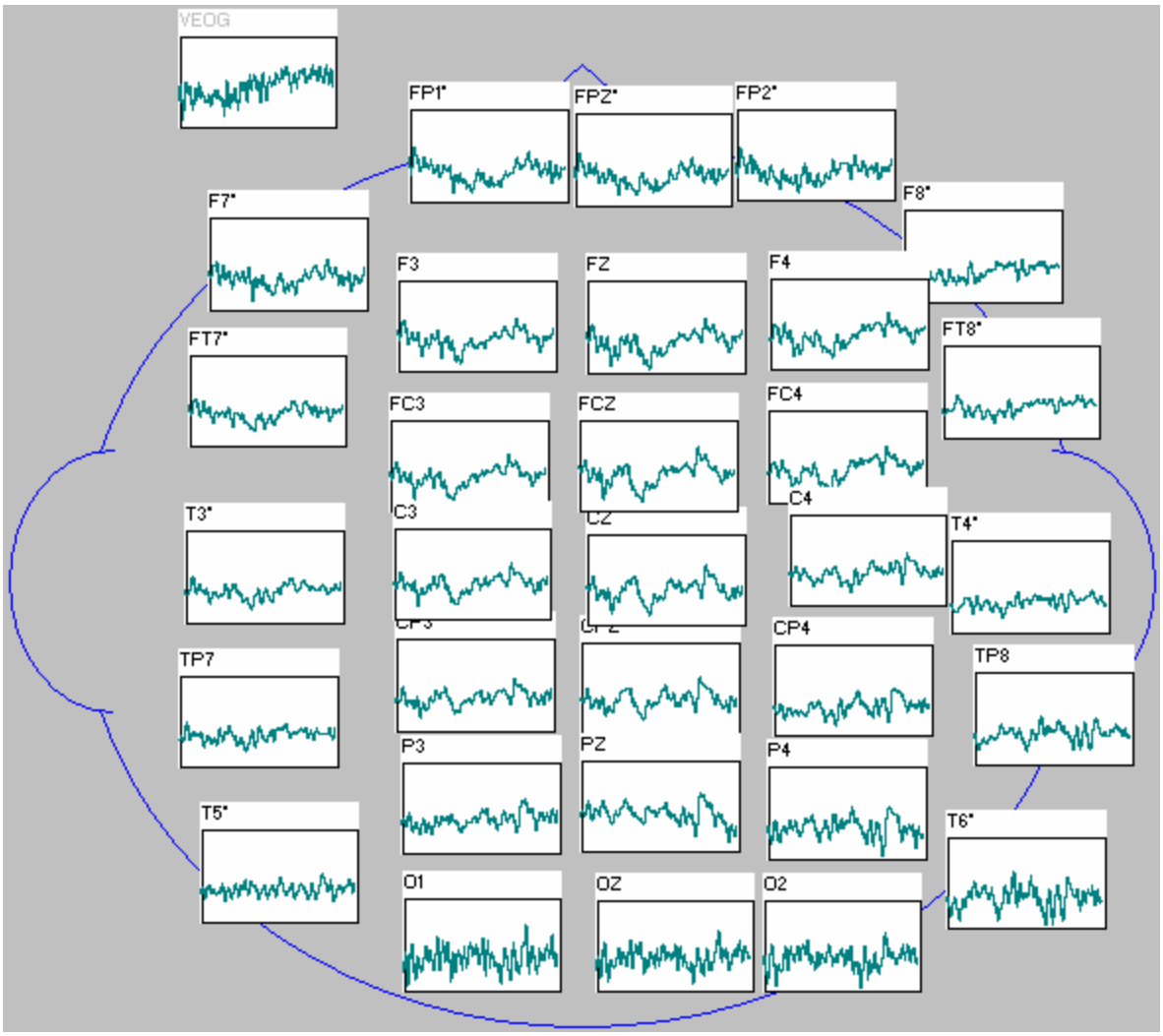
Stimulus. Enabling Stimulus types will create epochs using the stimuli events. Enable the option for this example.

Response. Enabling Response types will create epochs around the Response triggers. Do not enable the option for this example.

Keyboard. Enabling Keyboard types will create epochs using keyboard entered events (as with Function keys). Do not enable the option for this example.

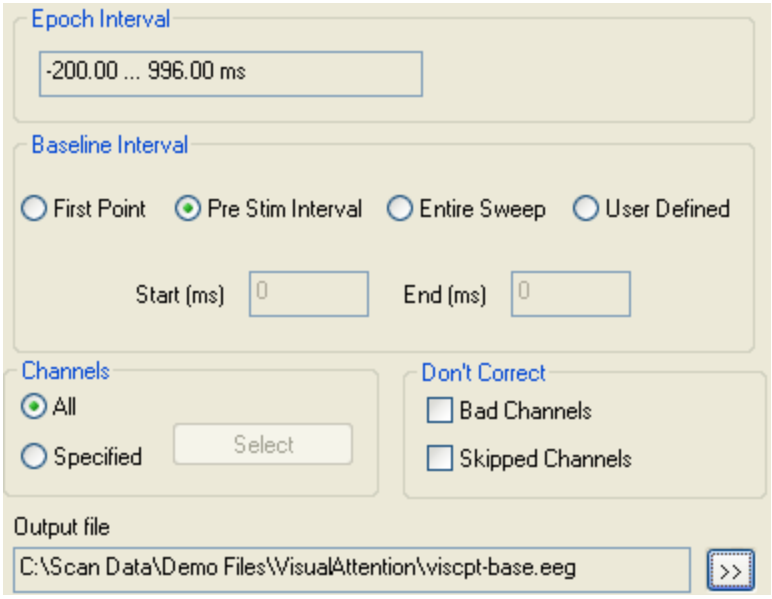
Output file. Click the  button, then select a folder and enter a file name (*viscpt.eeg*) for the output file (the .EEG extension will be added automatically).

Examine your Epoching Properties screen, make sure it matches the above values, and click **OK**. The single-sweep file named *viscpt.EEG* will be created and individual epochs will be written to it. Upon completion, you will see a new Multiple Window containing the first sweep of the epoched file.



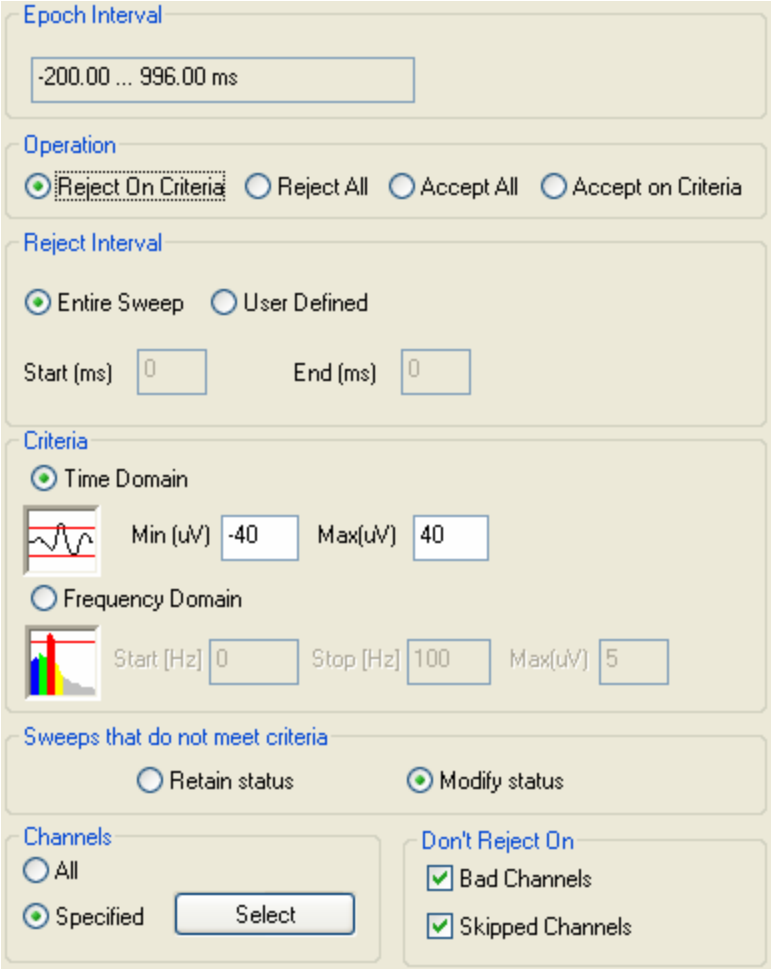
6. Baseline correction and scanning the epoch file automatically for artifact - Now that we have created an epoch file from a continuous file, we can follow the same steps used to prepare the P300 file in the previous tutorial for sorting and averaging.

Make sure the *viscpt.eeg* window has the focus, then click **Transforms** → **Baseline Correct**. The Baseline Correction window will appear.

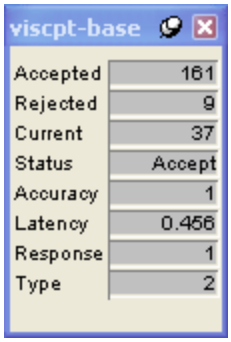


As in the P300 example above, set the Baseline Interval to use the **Pre-Stim Interval**, using **All** channels. Enter an **Output file** name and click **OK**. A bar will show the progress of the transform and new file creation. When it is completed, you will see another Multiple Window Display with the first sweep of the baseline corrected data file.

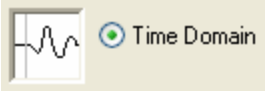
Next, we will scan automatically for any remaining artifact. Make sure the focus is on the baseline corrected epoched file, and then click **Transforms** → **Artifact Rejection**. The Artifact Rejection window will appear. Enter the settings as shown, where we will **Reject On Criteria**, use the **Entire Sweep**, reject any sweeps with voltages in excess of **+/-40** μVs, select **Modify Status**, use **Specified** channels (excluding the VEOG channel), and **Don't Reject On** the basis of **Bad** or **Skipped** channels.



Click **OK** to begin the artifact scan. A bar will show the progress of the scan. When it is completed you will see the number of accepted and rejected sweeps in the status box (your counts may be slightly different from those displayed).



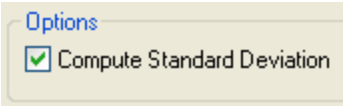
7. Sorting and construction of averaged waveforms - The last step is to sort the different single-sweep types (1 and 2) into separate averages, much as we did in the P300 example above. Follow these steps to construct averaged waveforms:



Click **Transforms** → **Average**, and the Averaging window will appear. Before we begin averaging, we need to set the sort criteria to select the sweeps of interest. This is determined by the values in Sort criteria dialog box. To display this dialog box, click the Sort Criteria... button, and the Sorting Criteria window will appear. These values determine inclusion criteria for the average.

In this example, we need to sort on the different type values corresponding to trial types in the sustained attention task. Type values of 1 correspond to the target stimulus (digit 0). Type values of 2 correspond to the distractor stimuli (digits 1-9). In addition, since this is a behavioral task in which the subject was required to make a decision, we are interested primarily in correct responses that are within a short response interval after the stimulus was presented. Late and incorrect responses may reflect other underlying processes and should be analyzed separately.

We will average the "target" responses first, so enable the **Type** field (so that a check mark appears), and enter a **1**. To set the latency range, enable the **Latency** field and enter the Min. and Max. acceptable latency values (**200** - **500**ms). Only those sweeps that fall within this range will be accepted. Next, enable the **Correct** field and select "**Correct**" from the pull-down menu (if needed). Sweeps that are tagged as correct will be accepted. Set **Sweep Count** for **All** sweeps.

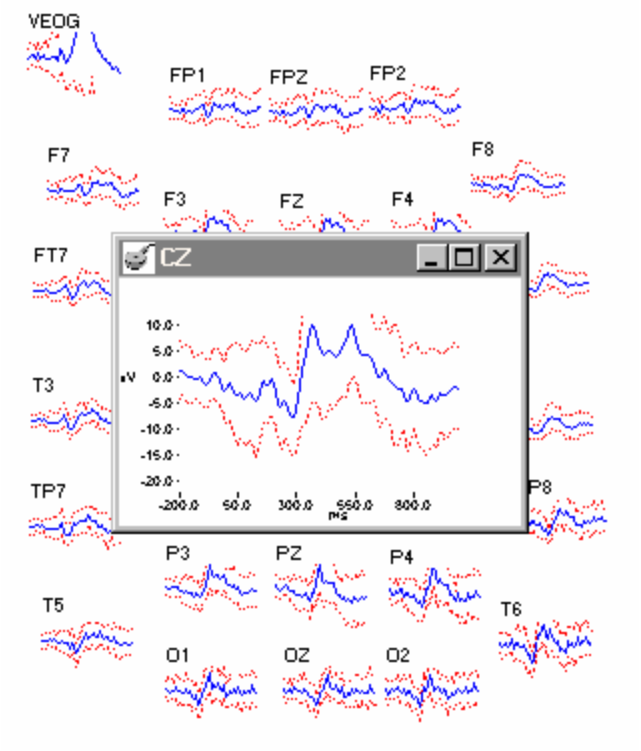


Click **OK** and the Averaging display will reappear. In this example we want the **Compute Standard Deviation** field enabled. This means that the standard deviation will be computed and stored for the average.

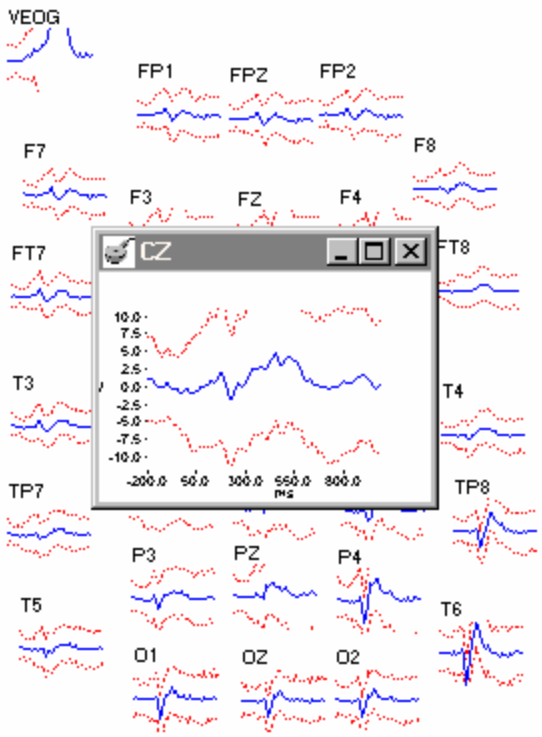
Enter an output file name (*TARGET*), and click the **OK** button to initiate averaging. You will see the progress bar in the center of the screen as the averaging begins. The averaged waveform will appear in a new Multiple Window Display. The averaged waveforms initially may appear to be low in amplitude. This is because the display is still set to the original scale factor used with the single sweep EEG file. The most convenient

method to scale your waveforms is to use the autoscale option located on the Toolbar. Click it, and waveforms for the target stimulus will be displayed with the new minimum and maximum values shown below. If you wish to set your own minimum and maximum values, click the *right mouse* button between the electrode displays, and select the Set Display Min/Max... option. Enter the desired Min and Max values and click OK.

Your screen should now display the target waveform. The dotted lines above and below the waveforms indicate the +/- 1SD values (accessed from **Options** → **Multiple Window Settings** → **General** tab - enable the **Show Standard Deviation** option). The status box will show how many sweeps were averaged.



Finally, we will construct the average to the distractor stimuli. Switch the focus back to the baseline and artifact corrected EEG file (by highlighting its title bar), and repeat the process that you used to construct the *TARGET* stimulus average. Click **Transforms** → **Average** and the Averaging window will appear. Click the **Sort Criteria** button and enter **2** in the **Type** field. The Latency and Correct fields are not relevant, since the subject made no responses to these stimuli. Click **OK** to return to the Averaging window. Enable the **Compute Standard Deviation** option again. Enter *DISTRACT* for the **Output file** name, then click **OK**. A new Multiple Window Display will appear containing the averaged data. Click the autoscale button to scale the data, as needed.



The waveforms displayed are the average responses to the distractor stimuli. In this particular subject there is a larger response on the right than left to the distractor stimulus. Also, the large P300 response that was found to the target stimulus is absent. To see the files together, make sure one of the two average files has the focus, then click the *right mouse* button between electrode displays and select **Load Comparison File**. An Open File display will appear, in which you may select the other average file. The second file will be superimposed on top of the first one. (Disable the display of the SDs, if desired).

8. Subtract the files - Lastly, we will look at the difference between the data files. *Right click* between the windows and select **Delete all Comparison Files**. With the *TARGET.avg* file highlighted, select **Transforms** → **Subtract**.

Select the *DISTRACT.avg* file as the **File to Subtract**, enter an **Output file** name, and click **OK**. You will then see the differences.

This concludes the fifth tutorial. Please save the *TARGET.avg* and *DISTRACT.avg* files for later use.

7 Frequency analysis and mapping - continuous EEG

The spontaneous or ongoing EEG can be recorded in a continuous format and then played back and processed with the EDIT module. This mode could be used, for example, to average around visually recognized events such as motor responses (back averaging), spikes, or alpha onset. Other uses might be spectral (event-related desynchronization) or coherence analyses. The setup for a spontaneous EEG recording is similar to the N400 example given above except that the epoch size and number of points will be

preconfigured for frequency analyses, no sorting is involved, and we will also configure acquisition for online frequency analyses and online mapping.

In this tutorial, you will see how to:

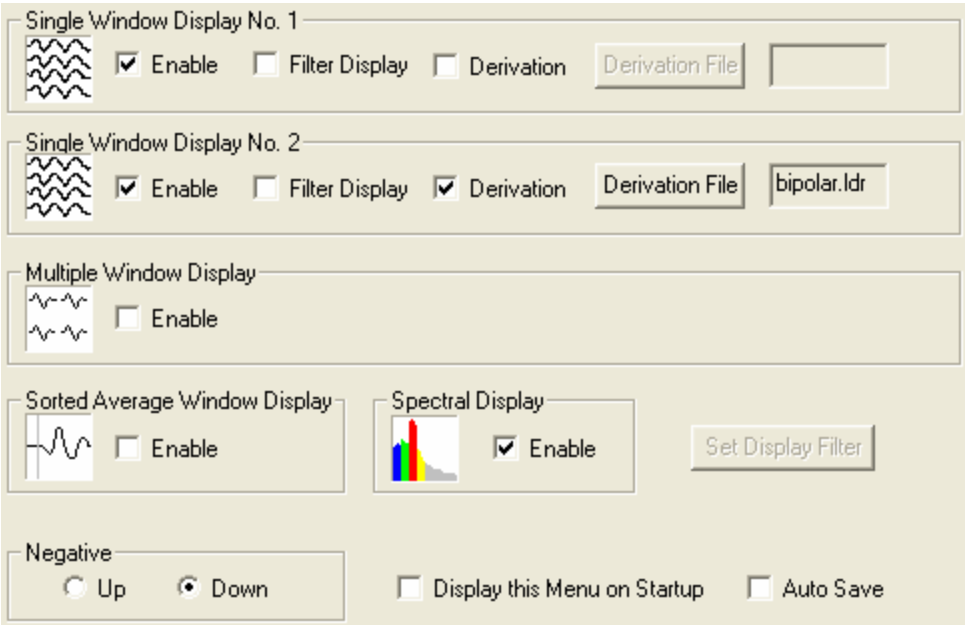
- Use online spectral mapping
- Use online Linear Derivation files
- Add Annotations to the CNT file

7.1 Acquisition

Follow these steps to configure for spontaneous EEG recording:

1. Start ACQUIRE as usual. The next step is to retrieve/create a setup file for continuous recordings. For this example, use the *Synamps2 Quik-Cap64.ast* file. You can use a different setup file, or the **Make Default Setup** option.

2. Select **Edit** → **Overall Parameters** and click the **Startup** tab. For this recording, enable **Single Window Display No. 1** and the **Spectral Display**.

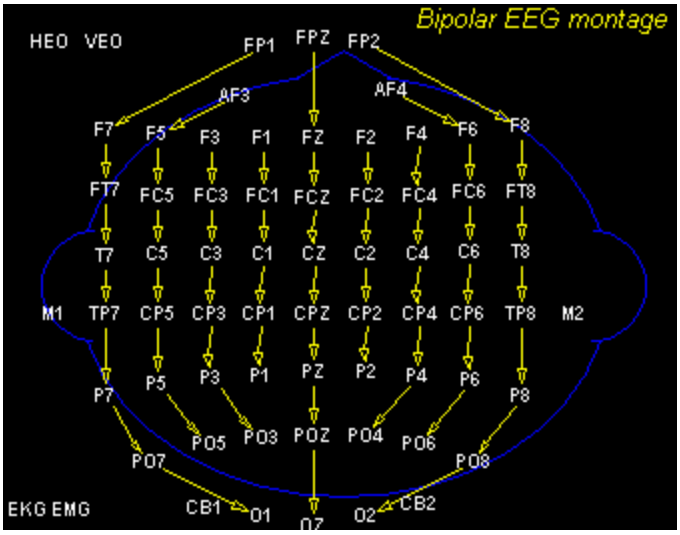


For a more advanced demonstration, let's say that you would also like to monitor the incoming data using a bipolar montage in addition to the unipolar, linked-ears montage that you are using for the recordings. You can do this by enabling **Single Window Display No. 2**, and enabling the **Derivation** field. Then, use the **Derivation File** field to access an Open File utility. Select a linear derivation file (*.ldr* extension) that you created either in the Montage Editor or with a text editor (the *bipolar.ldr* file was selected in the figure), that will allow you to display a bipolar montage as a linear combination of other channels. A portion of such a file is shown below. In this particular example, a 51 channel bipolar montage is created from a 68 channel, extended 10-20 recording.

Note

If you plan to do online mapping of the LDR data file, the labels in both the .map *and* .ldr *files must agree exactly (including case).*

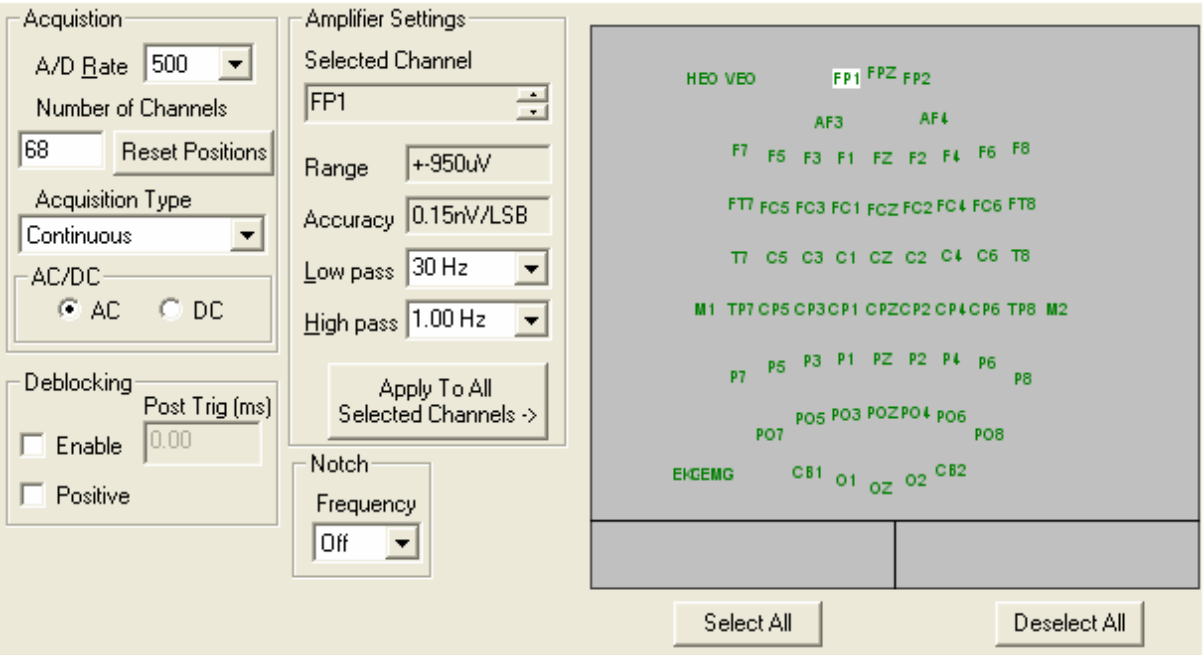
The bipolar montage as seen in the Montage Editor is shown below.



Click Open, and the file will appear in the window on the far right. When you acquire the data you will see the signals in a computed bipolar montage (only the raw data are saved, not the bipolar data). LDR operations are described more fully in the EDIT manual and in the Montage Editor Appendix at the end of the EDIT manual.

Select the polarity as desired (Negative Up or Down).

3. Click the **Amplifiers** tab. Set the **A/D Rate** to **500**Hz (512Hz for *SynAmps Wireless*). Next, enter **68** for the number of channels (if needed; fewer for *NuAmps* and *SynAmps Wireless*). For **Acquisition Type**, select **Continuous**. This setting configures ACQUIRE to store data in a continuous format. If you are using *SynAmps* or *SynAmps*^{2}, under AC/DC select **AC** mode. If you are using *NuAmps*, this section will not be accessible; *SynAmps Wireless* is always AC. Leave the Notch Frequency filter Off; Deblocking will not be needed.



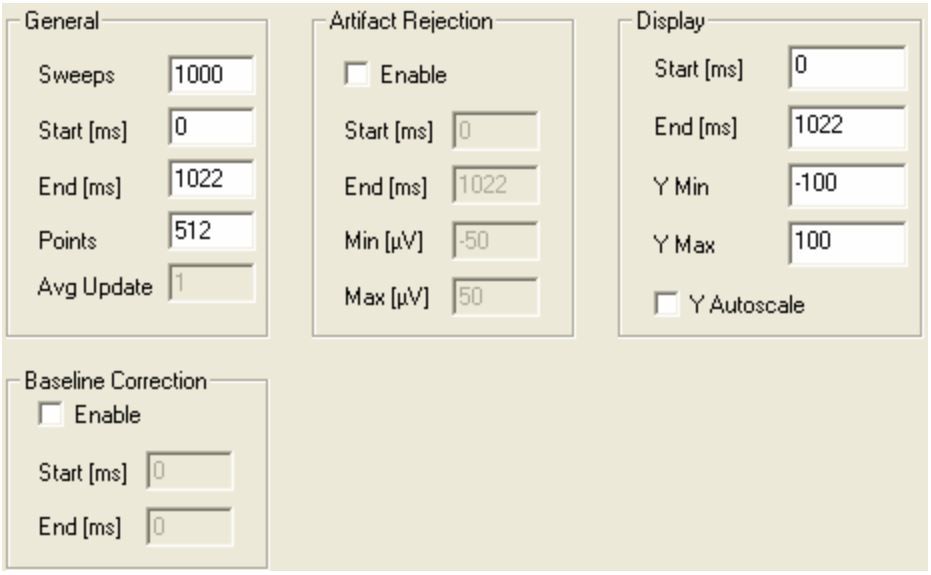
Under **Amplifier Settings**, select a **Low Pass** filter of **30**Hz, and a **High Pass** filter of **1** Hz. (*SynAmps* users select a **Gain** of **1000**, *SynAmps Wireless* use **1500**). Click the

button.

4. Click the **Channel Attributes** tab. Set the VEO and HEO channels as Artifact Rejection channels (as in the previous tutorials).

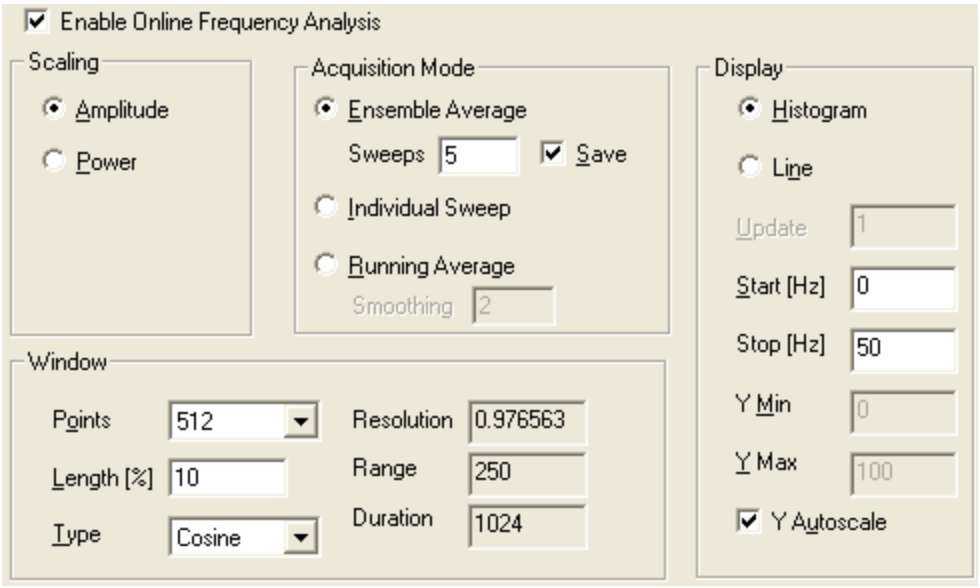
5. No triggering will occur in this recording.

6. Click the **Epochs** tab to set the parameters of the recording epoch. The number of Sweeps in the General section is not relevant in continuous recordings. Set the **Start** time for **0** and the end time for **1022**ms (**998.05**ms for *SynAmps Wireless*). The sample interval has been set so the number of points (512) will be equal to a power of 2. Click on the **Points** field, and enter **512**, if not already set automatically. Again, these settings have no relevance for continuous recordings, but will be useful for offline epoching with the EDIT module.



Disable the **Artifact Rejection** and **Baseline Correction** features.

7. For this recording it might be useful to monitor the online EEG spectral analysis. Click the **Frequency** tab, and enable the **Online Frequency Analysis**. (*Note that these options are only available when you have selected the continuous or epoched modes for Acquisition Type, under Amplifiers*). Under **Scaling**, select the **Amplitude** option. The Amplitude option is approximately the square root of the power spectrum to express the units in microvolts.



Under **Acquisition Mode**, select **Ensemble Average**. Ensemble averaging is more fully explained in the ACQUIRE manual, but is analogous to averaging evoked responses with updated sweeps. Note that when you select the Ensemble option, the **Sweeps** field and the option to **Save** the sweeps become active. Enter **5** for **Sweeps** and enable **Save** to store the online frequency data. You will be asked for a name and path designation for this file as you begin to acquire the data. (You might elect instead to use the **Running**

Average option. Select a Smoothing factor, such as 3, and the online maps should appear smoother).

In the **Display** area, select **Histogram** for the **Display Mode** to have the FFT results displayed in bar form. **Start** and **Stop** set the frequency range for the display. For this recording, enter **0** and **50**, respectively, to have the power in the 0-50Hz range displayed. Enable the **Y Autoscale** field. This will automatically scale the microvolt amplitude according to the maximum value encountered in the epoch.

In the **Window** area, select **512** for the number of **Points**. *Remember, these settings are for the online display only*. Notice the relationship between the number of points and the frequency resolution - the more points you allocate, the finer the frequency resolution (and the longer the Duration). For Type, select **Cosine**, and enter **10** for the **Length (%)** of the epoch to be tapered.

8. It is a good idea with EEG recordings to monitor the activity for indications of severe EOG artifact, floating or otherwise "bad" electrodes, or signs of increasing drowsiness. This can be achieved by inspecting the waveforms alone, but may be facilitated by watching online FFT results in mapping form. To do this, click the **Mapping** tab, to create maps for monitoring delta and alpha. Increased anterior delta will be an indication of increased EOG, and other single electrode increases in delta are indications of possible bad electrodes. Decreasing posterior alpha in an eyes closed recording may be an early indication of drowsiness.

Enable **Map 1** and **Map 3**. Map 1 is labeled "Delta" and Map 3 is labeled "Alpha" by default. For Delta **Minimum** and **Maximum**, enter **0** and **50**; for Alpha **Minimum** and **Maximum** (Map 3), enter **0** and **30**. These set the microvolt scaling limits for the online maps. The **Start** and **Stop** frequencies for both delta and alpha maps have been set automatically. We will not use the linear derivation mapping files at this point. Use the **Map File Name** fields (Map 1 and Map 3) to select an appropriate *.map file (one that matches the setup file). In this case, select the *Synamps2 Quik-Cap64.map* file (from the ... *\Scan4.5\SynAmps2* folder). Leave the **Data Source** set to **Raw**.

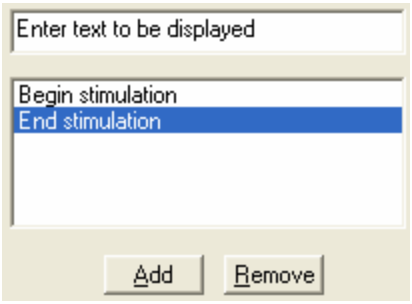
9. It would be a good idea at this point to save the settings that you have made thus far. Click the Save As... button to save the setup file using the file name *CONTSET* (the *.ast* extension will automatically be added). Click OK.

10. Click **Edit** → **Channel Layout**. You may resize and reposition not only the 68 channel array, but also the 51 channel, derived bipolar array. Click the pull down arrow on the **Electrode Array** field, and select the *Single 2 LDR = bipolar* line (if you are following the

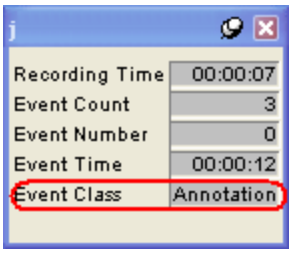
advanced part of the tutorial). Resize and reposition the electrode displays, as desired. Then click OK.

11. Let's say we know that we will want to mark the continuous file at various points during acquisition. There are several ways to do this. One is to insert text strings you have created. You can insert text strings you type in "on the fly". Another way is to use function keys (F2 through F11), or other keys you select, to insert predefined comments.

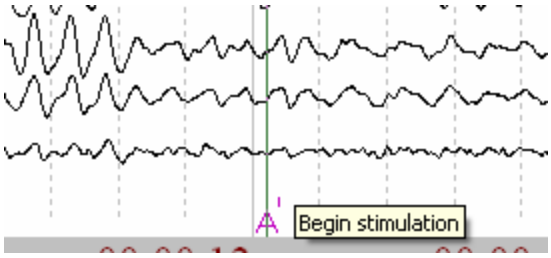
Click the **Events** tab under **Overall Parameters**. In the Annotations section, you can enter text strings that you anticipate using routinely. Type in the text and click the Add button.



When you are recording, and wish to enter one of the annotations, click the A button on the Toolbar. (You must be saving the file to use the button). The same dialog screen will appear. Click the line you want to include, and then click OK. The text will appear at the time point where you first clicked the A button. You will not see it in the ACQUIRE display.



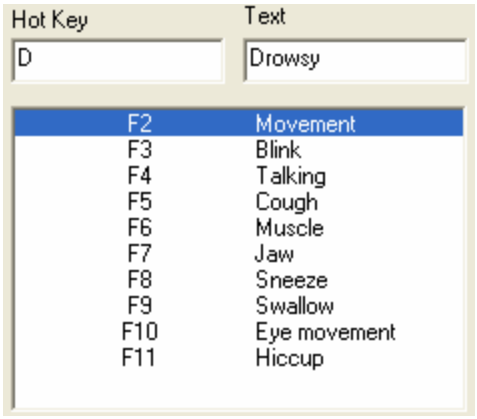
When you replay the file in EDIT, the annotation will be seen as an "A". Move the mouse over the A, and the Annotation will appear in a Tooltip. The Event Class line in the file's Status Box will indicate that event as an annotation (as opposed to a stimulus or response).



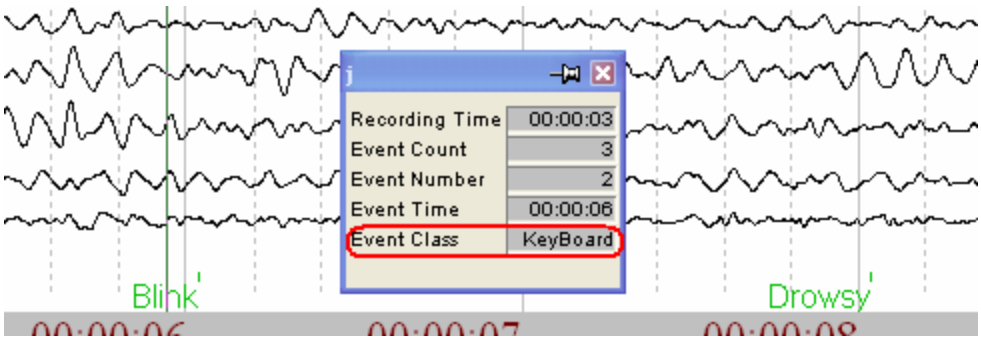
Instead of selecting one of the text strings you had already entered, you could follow the

same procedure except enter an annotation on the text line instead of selecting one, then click OK. In EDIT, you will see the same "A", and the text you entered will be seen in a Tooltip.

You can also use the Events Keys, seen in the **Events** display. ACQUIRE has been preset to use the Function Keys (F2 - F11) as shown.

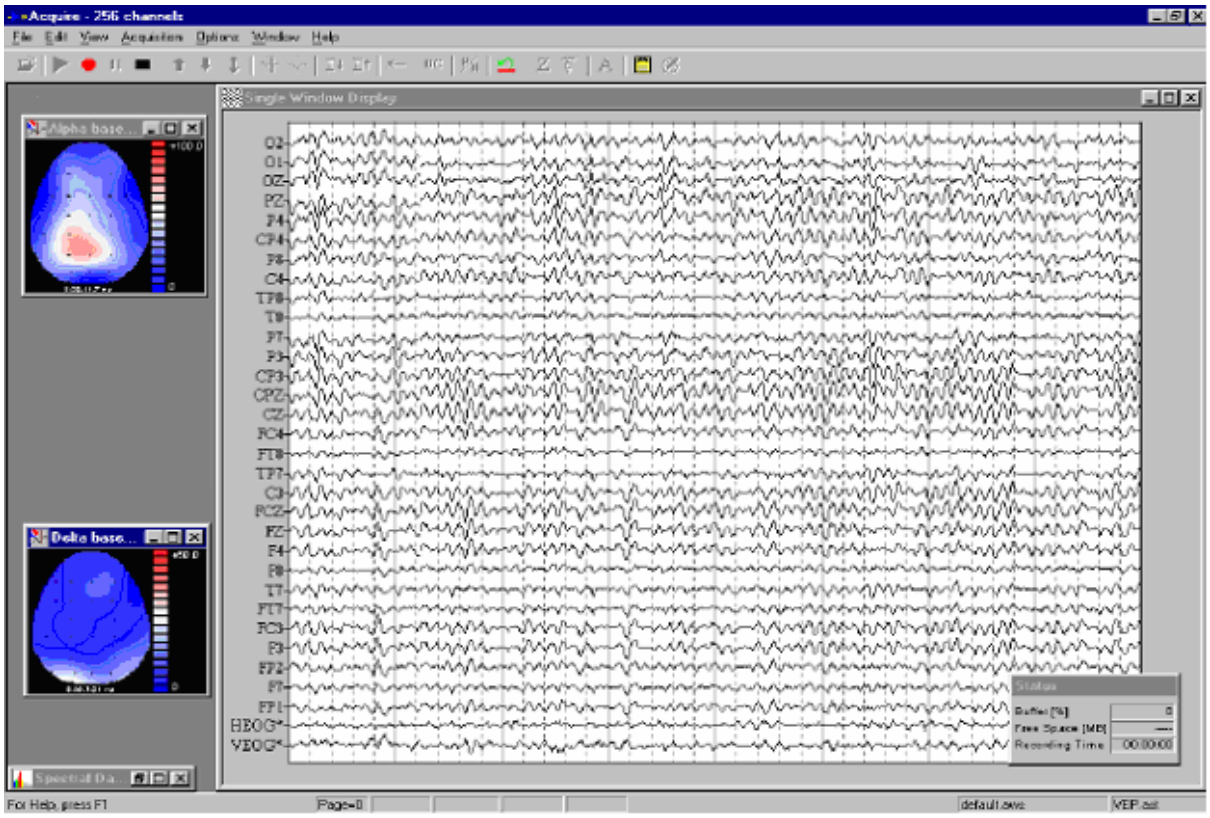


You can change these by highlighting one of the lines in the list, and clicking the Remove button. Then click in the **Hot Key** field and press the **F** button that you Removed. Enter new text in the **Text** field, and click Add to add the new option to the list. You can also use other keyboard keys as Hot Keys. Click in the **Hot Key** field, press the key, enter the text, and Add the new key. When acquiring the data, just press one of the keyboard keys to add the event in the file. You will see the events in the file when you replay it in EDIT. The events are seen as "KeyBoard" in the vent Class field in the Status Box. (You can create epochs around the KeyBoard events by enabling KeyBoard in the Epoching Properties screen).



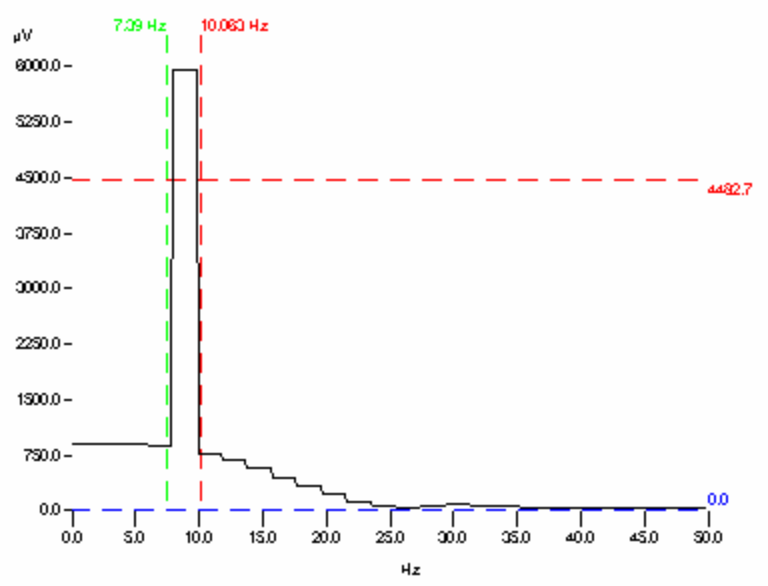
12. Save the Setup file by clicking the Save As... button and overwriting the setup file you have already saved.

13. To begin viewing, click the green triangle on the Toolbar, or click **Acquisition** → **Start Acquisition**. You will see a Save File utility through which you may name the Spectral data file. Enter a file name, and the *.avg* extension will be added automatically. Click Save to continue. You will see a Single Window Display showing the continuous EEG signals, a Single Window Display showing the derived bipolar channels (if you are following this part of the tutorial), map displays for Delta and Alpha, as well as the online Spectral data. Since we set the online FFT for "ensemble", with an update of every 5 sweeps, this will take a few seconds for display. If you do not see any results in the Spectral window, increase the scaling with the Up arrow on the Toolbar.



As soon as you click a scaling arrow, highlight a display, etc., you will see the Active Map display appear. This will have buttons available for each map that is displayed (Delta, Theta, etc.). (You must have at least two online maps for the display to appear).

To understand the function of the Active Map buttons, you should first enlarge one of the channels in the Spectral Data display to full size. You will see in addition to the power spectrum display (displayed as lines rather than a histogram in this example) two vertical dashed lines and two horizontal dashed lines.



You can move the lines by grabbing them with the left mouse button, and dragging them to a new position. If you position the mouse between the two vertical lines, and above the upper horizontal line, you may drag both vertical lines at the same time, thereby preserving the frequency interval between them. With a power spectrum display, the lower horizontal line must remain at zero.

The two vertical lines define the frequency band width that will be mapped. These setting override the ones you made on the Mapping display (under Overall Parameters). By clicking one of the active buttons on the Active Map display, you can direct the frequency band defined by the two vertical lines to the map display of you choice. For example, if you set the vertical lines as shown above, and click the Alpha button on the Active Map display, the Alpha map will display that frequency range. The frequencies shown below the map will change accordingly, and "(Alpha)" will appear to the side of the Spectral Data title, letting you know which map has the "focus" for the selected frequency range.

By moving the horizontal line up and down (grab and drag with the left mouse button),

you can vary the scale on the map that has the "focus" for the new frequency range.

When you are ready to begin recording, click on the *Record* icon (the red dot) on the Toolbar  , and a Windows Save File utility will appear. Enter a file name for the continuous file and any path changes (the *.cnt* extension will be added automatically), and data will begin to be written to the disk when you click OK.

The recording may be terminated by clicking on the Stop icon on the tool bar. Refer to the View section in the *Operating* ACQUIRE details below for description of the Toolbar options for controlling acquisition.

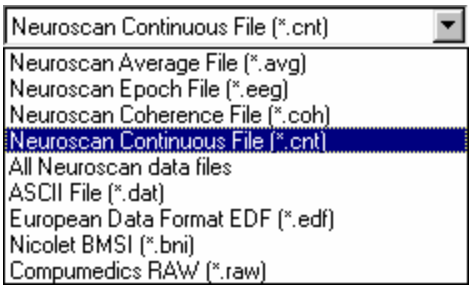
7.2 Post acquisition processing of the CNT file

This section illustrates a variety of different types of spectral transforms that can be performed in EDIT. A 32-channel continuous EEG recording with the eyes closed will be converted from the time to the frequency domain in a number of different ways.

In this tutorial, you will see how to:

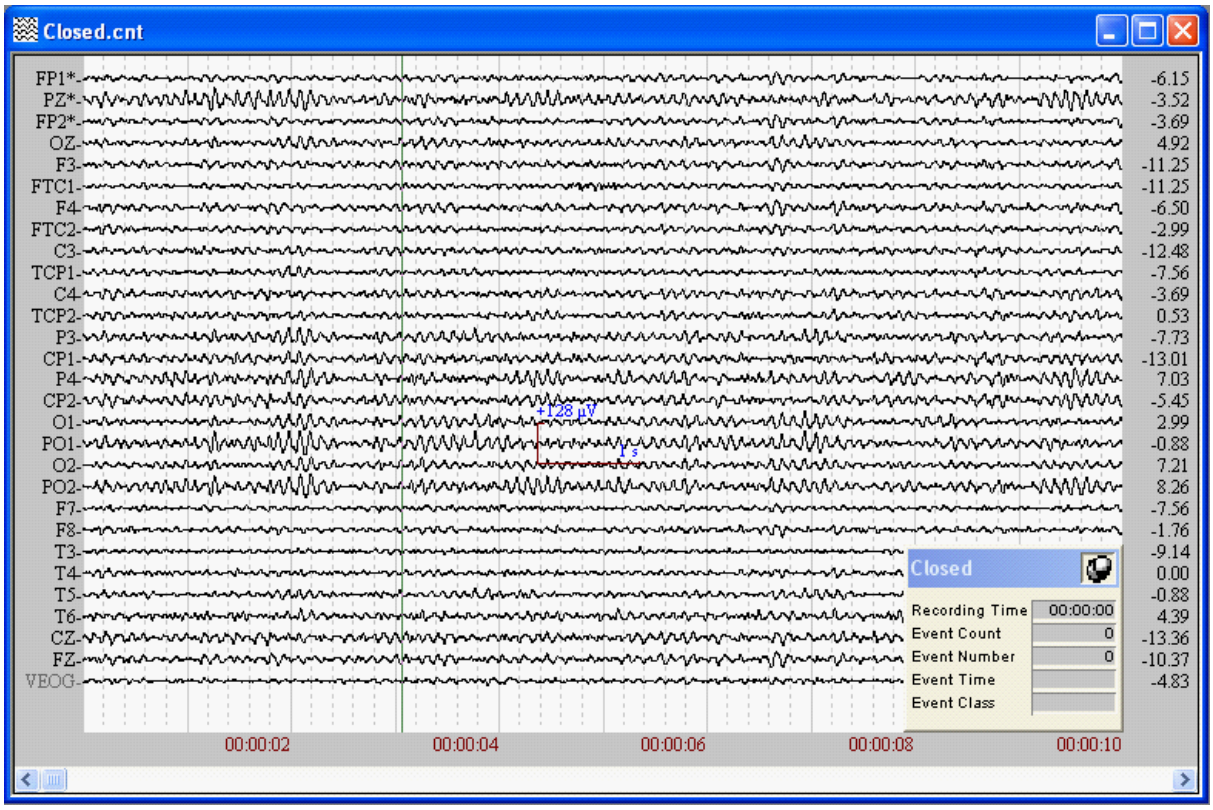
- Perform back-to-back epoching
- Average in the Frequency Domain
- Create epoched files with power spectra (Forward FFT)
- Compute Coherence

We will use a file named *closed.cnt* as a basic starting point for these different types of transforms.
Follow these steps to retrieve the *closed.cnt* data file:



1. Converting from continuous to epochs - Click **File** → **Open data file**, or click the **Open** data file icon  , and select the Neuroscan Continuous File type.

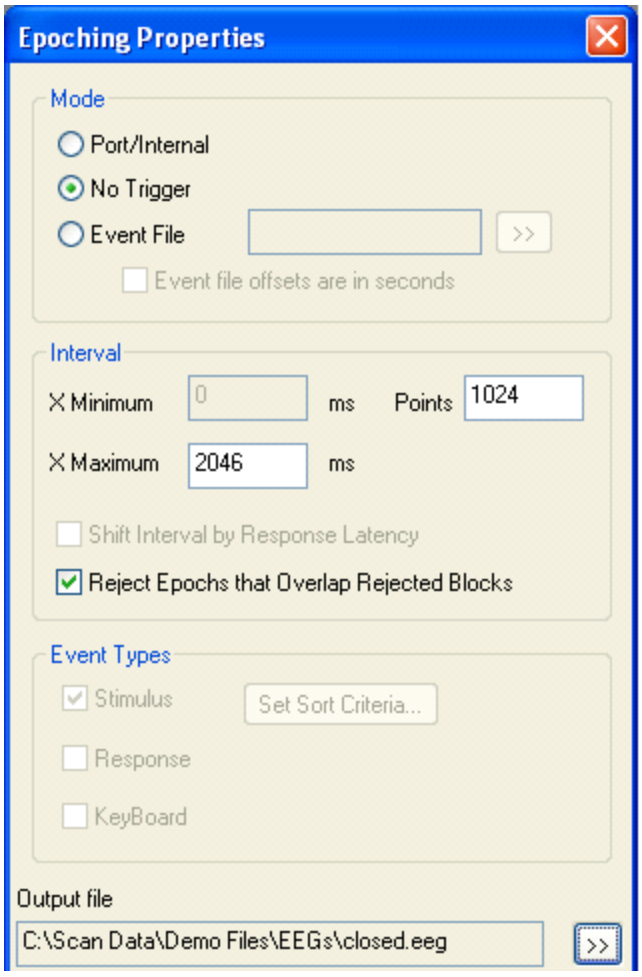
Select the *Closed.cnt* file from the ...*Demo Files**EEGs* directory.
The single window display containing the continuous data will appear. Use the Up or Down arrows  , or the autoscale icon  , as needed to scale the display appropriately.



The *closed.cnt* file was collected from a 25 year-old male with 28 EEG leads and 1 ocular lead to monitor blinks and eye-movement artifact. Amplifier gain was set at 500 (16-bit resolution on a *SynAmps*) with a band pass of 1 to 30Hz and was digitized at 500Hz. The epoch displayed on the screen represents a 10 second section of the continuous file.

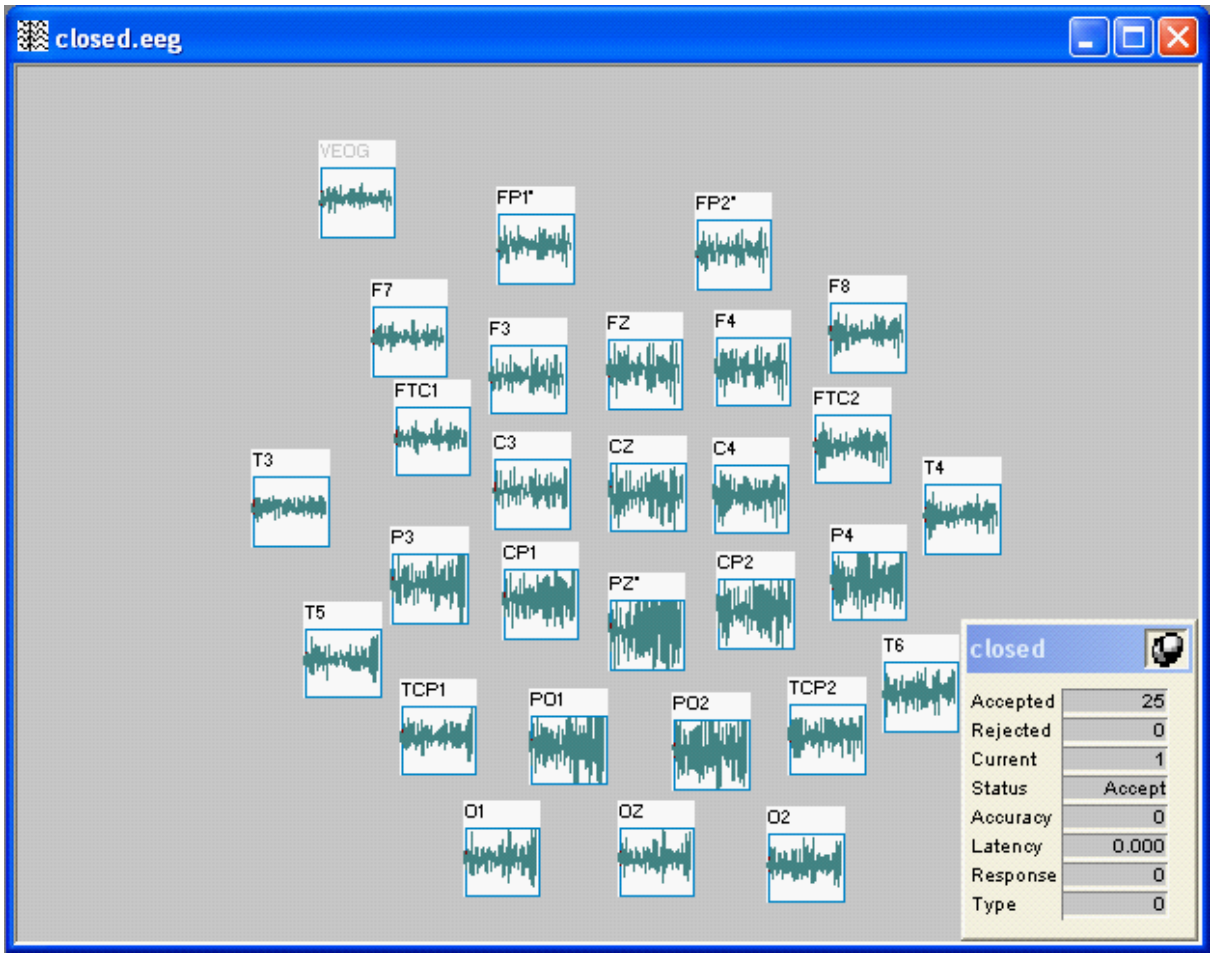
At this point you should go through the ocular correction algorithm and editing that was described in the previous tutorial. This particular file, however, is a short recording that does not contain any obvious artifact. In the interest of expediency we will forego the normal preprocessing steps and immediately convert this file into a single-sweeps epoch file:

Click **Transforms** → **Epoch File**, and the Epoching Properties display will appear.



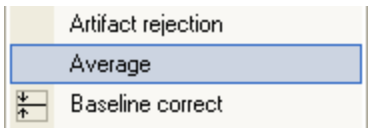
Select the **No Trigger** mode. This option will create back-to-back epochs with no gaps from the continuous file. Set the number of **Points** to **1024**. We have selected a number of points that is a power of 2. This is a requirement of the Fast Fourier Transform (FFT) used to convert data into the frequency domain. We selected this number so that it would provide a long enough interval (2 sec) to resolve the lower frequencies of the EEG. After entering the Points, click in the **X Maximum** field, and the end point of the epoch will be computed automatically (based on the A/D rate). Enter a file name for the **Output file**.

Examine your Epoching Properties display to make sure it matches the above values and click **OK** to begin epoching. A Multiple Window Display will appear showing the first sweep of the epoched file.



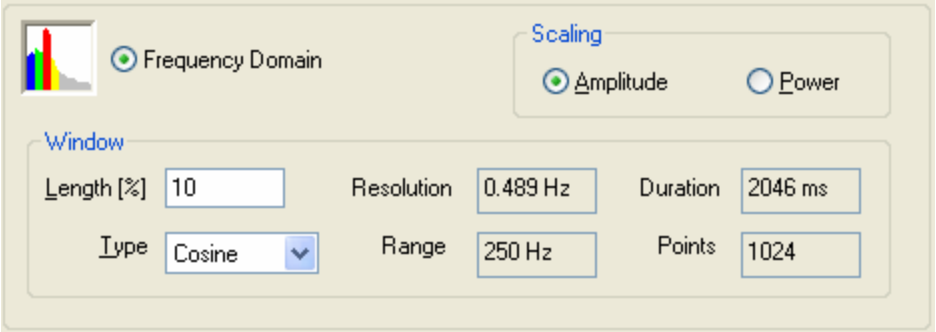
This epoched file can now be submitted to a variety of spectral transforms described below.

2. Ensemble spectral averaging - An ensemble spectral average is created using a series of processing steps. First, time domain EEG epochs are windowed and converted into the frequency domain using an FFT algorithm. Second, power spectral estimates are computed from the real and imaginary results of the FFT. Third, the power spectral estimates are averaged together. Ensemble averaging of spectra generally will improve the accuracy of the estimates of EEG frequency assuming that the EEG spectrum is relatively stable and is not in flux, as is the case of changes in wakefulness. For example, if the power spectrum is computed on a single-sweep, the variability of the estimate will be equal to the estimate itself. Variability decreases proportionally to the number of sweeps in the average. The more sweeps, the better the estimate of spectral composition. If your EEG is relatively stable over a series of discrete epochs, a valid method to estimate EEG frequency content is to average in the frequency domain. Follow these steps to create an ensemble spectral average:



Click **Transforms** → **Average**. The Averaging window will

appear. Select the **Frequency Domain** field. This performs the time to frequency mode conversion at the time of averaging. Below is the Frequency Domain section of the Averaging window.



Note there are additional fields for Scaling, Windowing, and some general information.

Scaling. The scaling field determines how the power spectrum is computed. Two options are supported: Amplitude and Power. The Amplitude option takes the square root of the power spectrum to express the units in microvolts. The Power option computes a standard power spectrum with values expressed in microvolts squared.

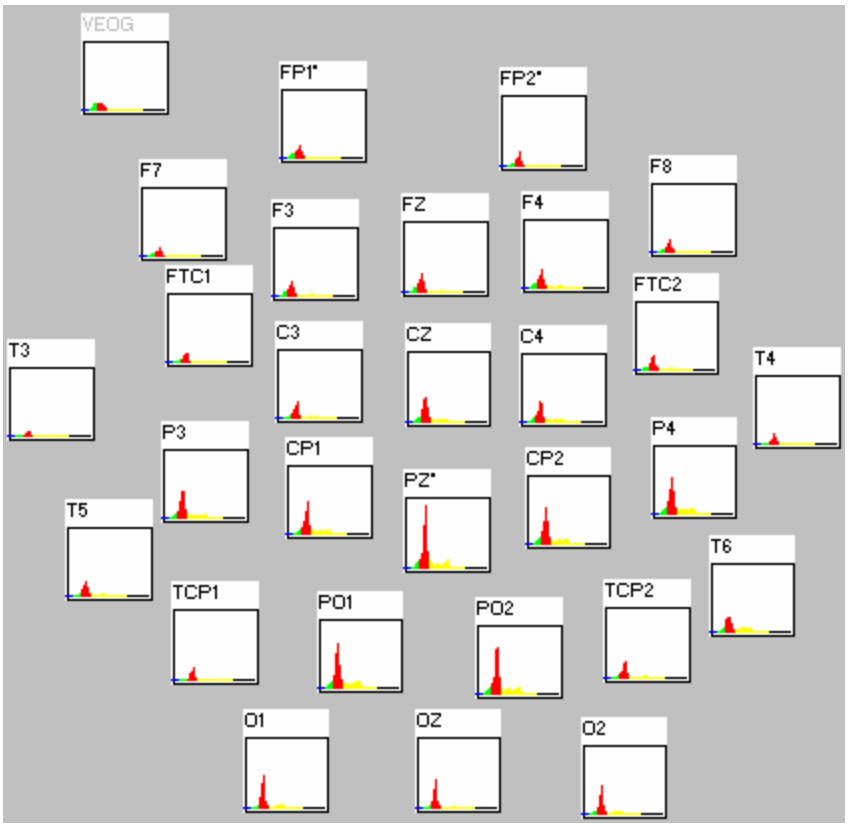
Window. The Window type field is used to taper the ends of the epochs to control spectral leakage. The Window Length [%] determines the extent of the taper (when set to 10%, for example, the beginning and ending 10% of the epoch will be tapered. The Type of windowing determines whether a Cosine, Hamming, Hanning, Parzen, Welch, or Blackman window is employed.

For this example, set the Scaling field to **Amplitude**, window Type to **Cosine**, and set the window length to **10**%. Enter an **Output file** name and click **OK**. You will see a progress bar increment as the transform is applied.

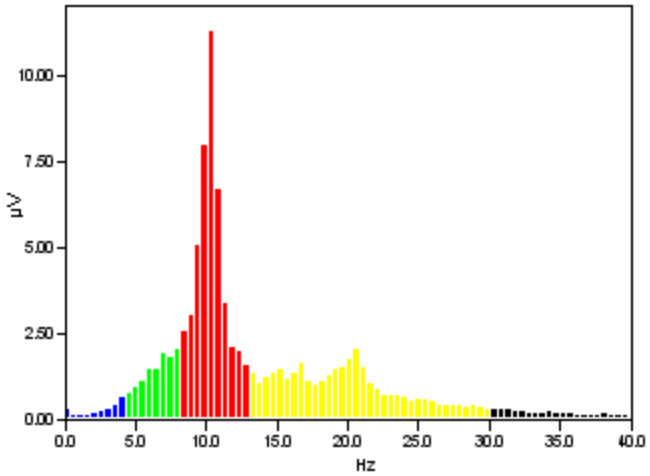
Upon completion of spectral averaging, you will see a new Multiple Window Display with the power spectra displayed at each electrode site. The range in frequency of this spectrum will be from 0 to 250Hz, corresponding to half the sample rate of 500Hz (Nyquist sample theorem). The range of this spectrum (250Hz) is well beyond what is needed for simple EEG and we can narrow the display range by modifying the display range variables located in the acquisition values options, located on the left side of the display (as in ACQUIRE).

Click the **Frequency** tab. Set the **Display Mode** to **Histogram**, the **Stop (Hz)** field to **40**, and **Y Max** to **12**.
You will see something similar to the display below.

Note
The actual data are not affected, only the display is changed.

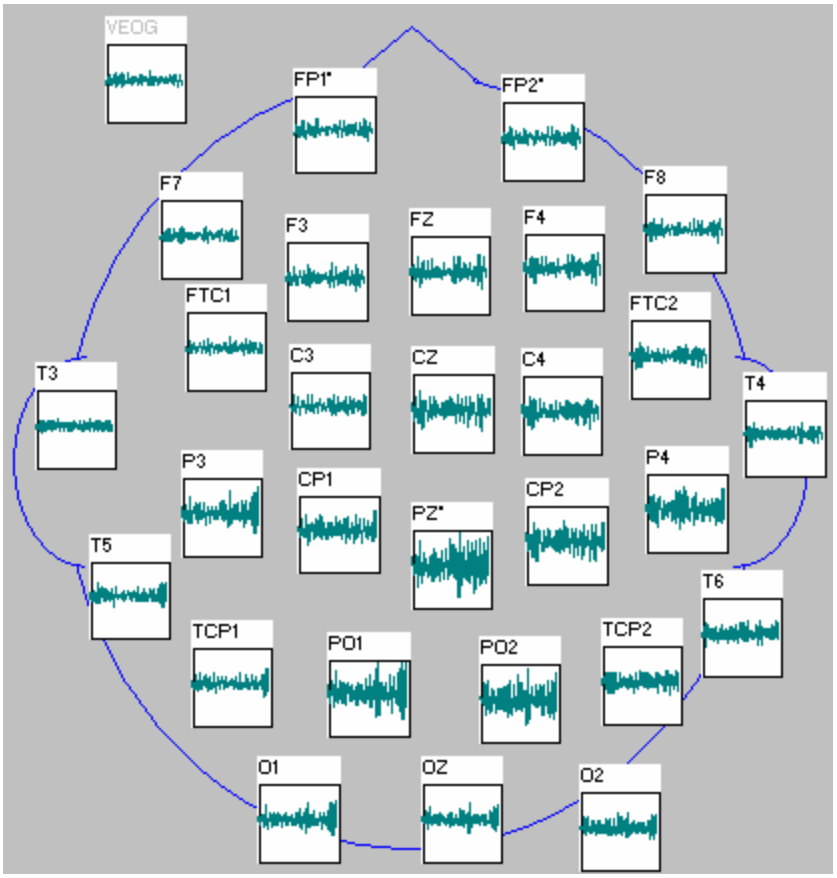


You can examine individual electrodes by clicking on the spectrum just as you have done for waveforms. Try clicking on the Pz electrode display to view the spectrum in more detail. The spectrum will appear as shown (resize the window as desired).



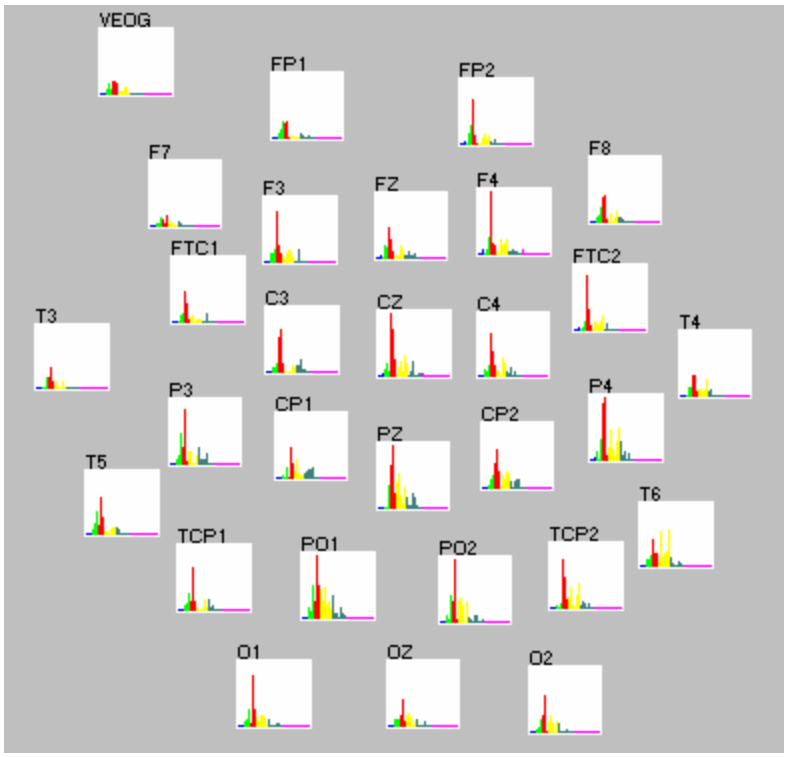
3. Creating a single-sweep (epoched) file in the frequency domain - To create a single-sweep (epoched) frequency domain file, an FFT is computed for each individual electrode and sweep. The results are stored in a manner identical to the time domain file version except that data is displayed and stored in the frequency domain. This transform is useful if you would like to observe changes in EEG spectra over a period of time, such as in a sleep study or an evoked potential following a response.

Follow these steps to convert the *closed.eeg* single-sweep file from the time to the frequency domain:
Change the focus to the *closed.eeg* file (or if needed retrieve it by clicking **File** → **Open**, or click the **Open** data file icon). Select the Files of type field to Neuroscan Epoched (*.eeg), and select the *closed.eeg* file.
The first sweep of the epoched file will appear.



Click **Transforms** → **Forward FFT**. You will then be asked to provide a name and path for the Output File. A progress bar will track the computations, then you will see a new Multiple Window Display with the power spectra for each channel. Use the arrows icons on the Toolbar to step through the file.

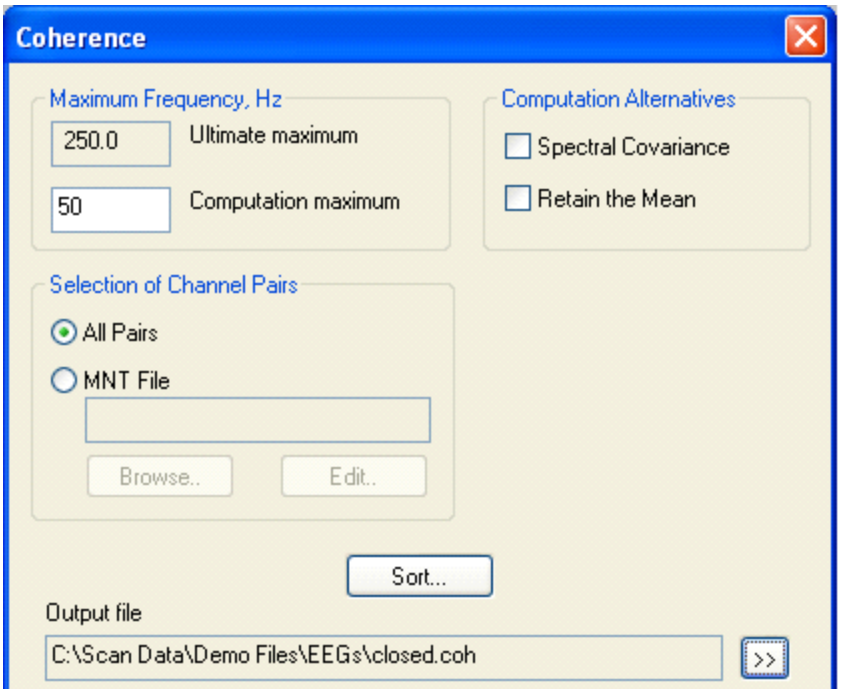
The power spectra are computed for the entire frequency range (250Hz in this example). Use the **Frequency** options as described above to reduce the display of the frequency range. In the Display area, change the **Stop [Hz]** value to **50**. The results should look similar to the figure below.



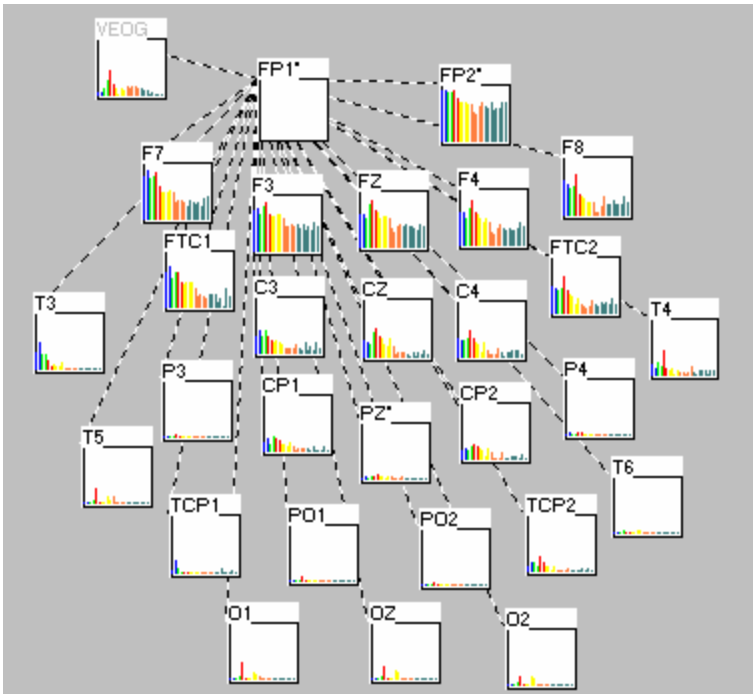
To restore this file to the original time domain file, select **Transforms** → **Inverse FFT**. You will be asked for a file name and path for the restored EEG file. You will see a new Multiple Window Display with the original wave form data in it.

4. Computing the EEG coherence between electrode pairs - Coherence analysis provides a method to examine relationships between the EEG recorded at different electrode sites. It is well known that some proportion of an EEG signal recorded at one electrode can be dependent on the signals recorded at another site(s). Coherence is a measure of this interdependence. A simplified way to view coherence is that it is the correlation between an electrode pair within the frequency domain. The result of a coherence analysis is a complex correlation spectrum. The complex correlation spectrum, when squared, generates the coherence spectrum which has numbers ranging from 0 to 1. For each frequency, this number measures the proportion of variance in the data that can be accounted for by a best-fit linear relationship between two electrode pairs.

We can illustrate the use of coherence analysis by analyzing our *closed.eeg* file. Follow these steps to compute a coherence spectrum:

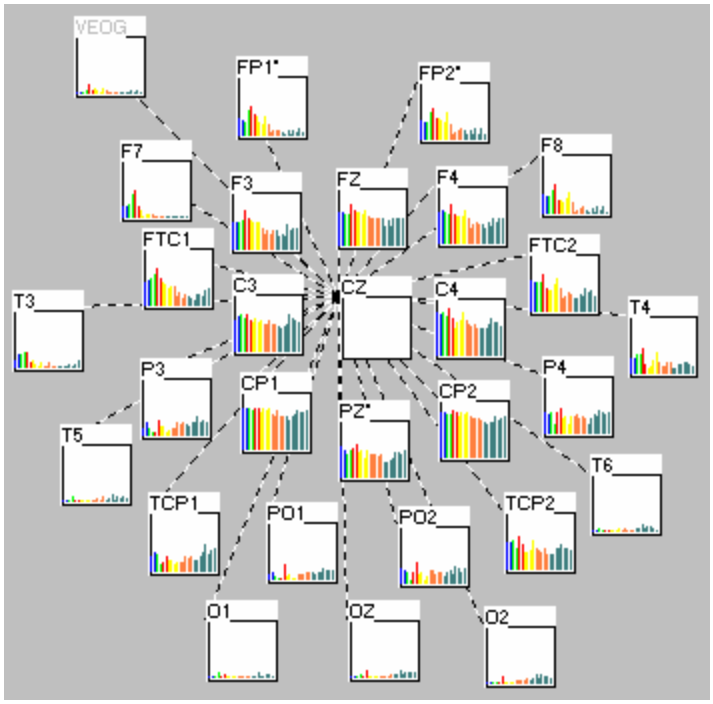


Change the focus to the *closed.eeg* file, and select **Transforms** → **Coherence**. The Coherence display will appear. For this demonstration, we'll use the default values, with one exception. Change the **Computation maximum** to **50** (Hz). This will compute coherence up to that frequency, using all pairs of electrodes. Enter an **Output file** name, and click **OK** to continue. A progress bar will track the computation, and you will then a new Multiple Window Display showing the coherence results.



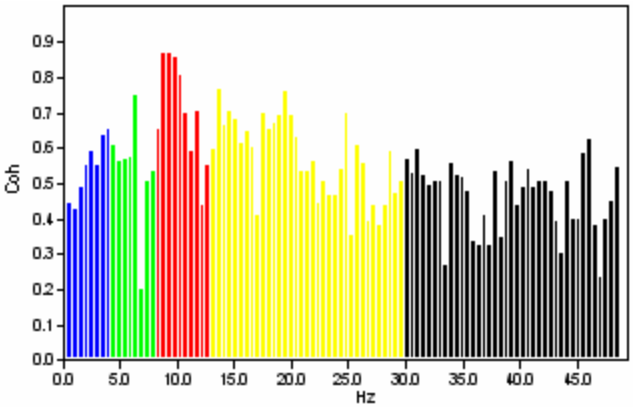
The coherence spectrum is the result of pairwise comparisons between electrodes. To

display this relationship in the data, a series of dotted lines are drawn from the current comparison electrode to all other electrodes to which it has been compared. Since we chose the **All** option above, lines have been drawn to all other electrodes from the current comparison electrode. The starting comparison electrode is the first electrode in the electrode table. In this file that electrode happens to be FP1, so lines are drawn from FP1 to all other electrodes. To change to a different electrode, position the mouse over another electrode, such as CZ, and click the *right mouse* button. Select the **Set Coherence Reference** option, and you will see dotted lines drawn from CZ to the other electrodes. (CZ itself will be blank since it makes no since to correlate an electrode with itself).



As a general rule, coherence values will always be greatest from the electrodes that are closest to the reference electrode.

Now, double-click the left button on an electrode display (such as FZ) to enlarge it to full size.



If your colors look different, these are controlled by settings under **Options** → **Multiple Window Settings** → **General** → **Frequency Bands** button. From this screen you may modify the frequency band limits and colors.

This concludes the sixth tutorial.

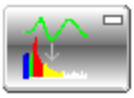
8 2D Topographical mapping and display options

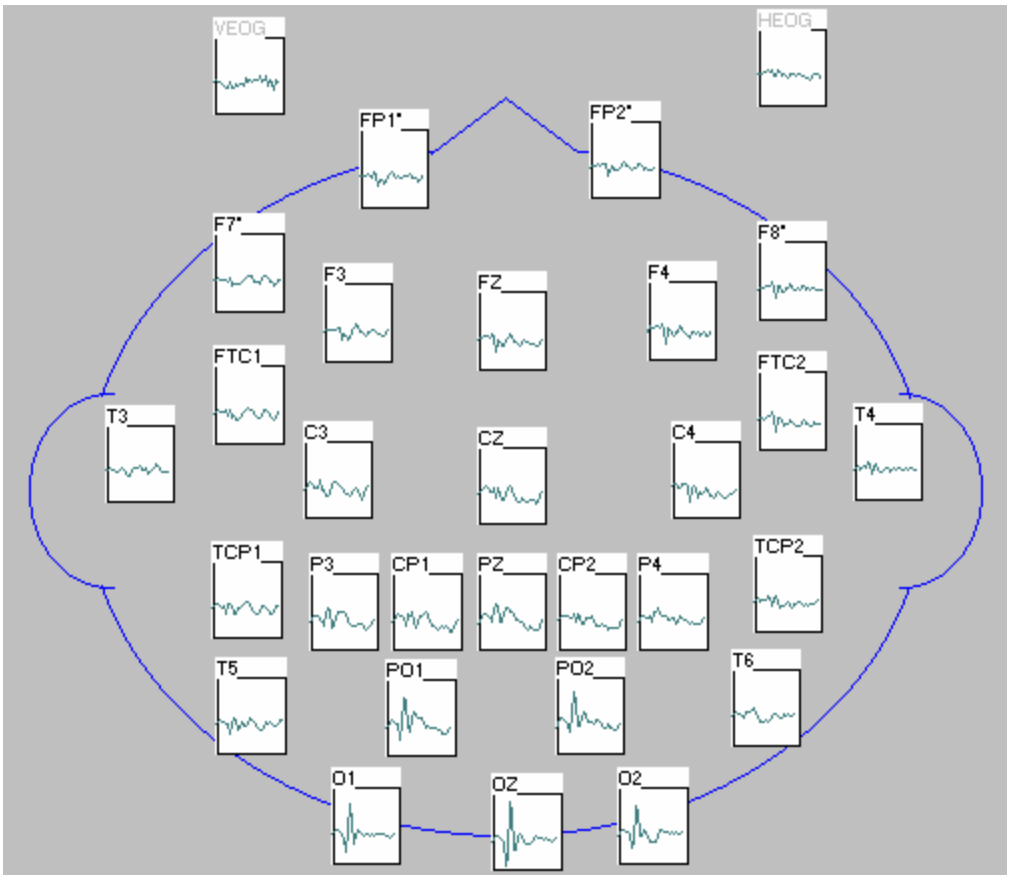
There are several ways to map your data. Mapping can be performed online and offline, although there are more options offline (these are described below). If you are using conventional electrode labels (from the 10-20 and extended system), EDIT will map the data using an internal mapping scheme. If you have different labels, or if you want to modify or create your own mapping template, you should refer to the MapGen appendix at the end of the EDIT manual.

In this tutorial, you will see how to:

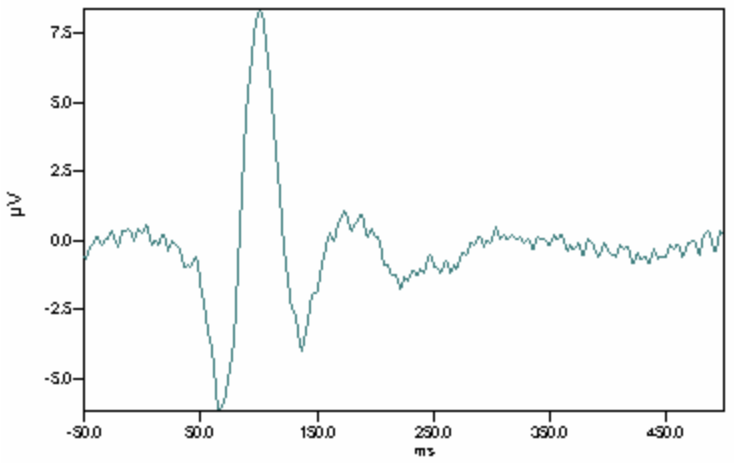
- 2D Mapping of single points
- Create 2D cartoons
- Change scaling and color schemes
- Print results
- Perform 2d Mapping on a 3D head shape
- Set Multiple Window Display options

For this tutorial we will touch upon some of the more common aspects of mapping in EDIT. The EDIT manual contains a complete description of all of the features. In this example we will use the *vep.avg* demo file that is contained in the *c:\ScanData\Demo Files\Veps* directory.

1. Open the EDIT program by clicking the EDIT icon  from the Program Launcher. Click **File** → **Open** data file, and set the Files of type field to Neuroscan Average (*.avg). Go to the ...*Demo Files**Veps* directory, select the *vep.avg* file, and then click open. The VEP average file will appear.

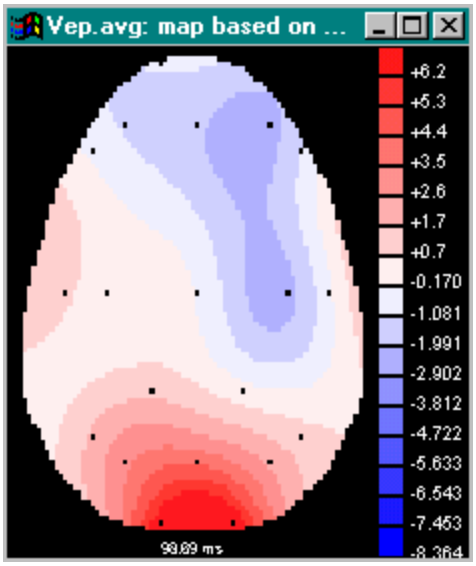


Enlarge the OZ electrode display. If the waveform is clipped, click the Autoscale icon on the Toolbar . The result should appear similar to the figure below. (Click the icon to invert the waveforms, if desired).



On the Toolbar there are two icons that we will be using with this file . The first is used for 2D mapping, and the second for 2D cartoons. Click the **2D mapping** icon. You will see a color scale appear to the side of the OZ waveform, and the 2D potential map window will also appear. (Click **Windows** → **Tile Vertical** to place the waveforms and map

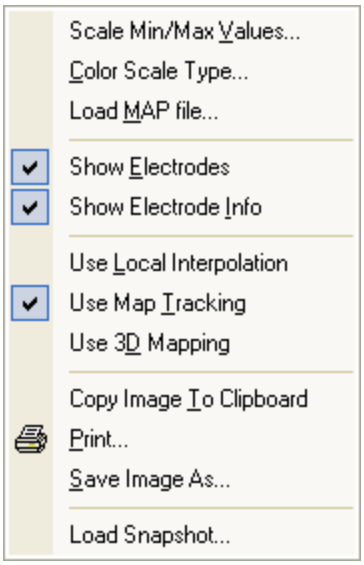
display side by side). Your map may have different colors from the one shown.



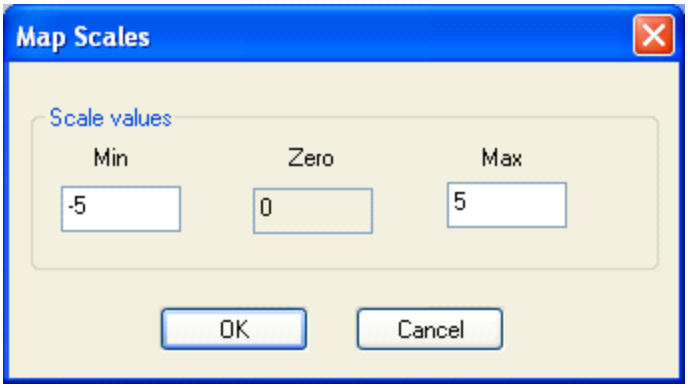
As you move the mouse around in the waveform display window, you will see the map change according to the time point where the mouse cursor is placed. If the map does not change as you move the mouse, *right click* inside the *map* display, and select the Use Map Tracking option.

The default map file that EDIT uses is an internal mapping template consisting of 77 electrodes from the 10-20 system and extended system. This file does not contain all of the positions used in the *vep.avg* file; however, it will map the channels that have labels that match the internal mapping template. To map all of the channels, you would need to create a *.map* file in MapGen (see the appendix at the end of the EDIT manual) where the labels in the .map file match the labels in the data file. There can be fewer channels in the map file, but the labels that you use must match labels in the data file.

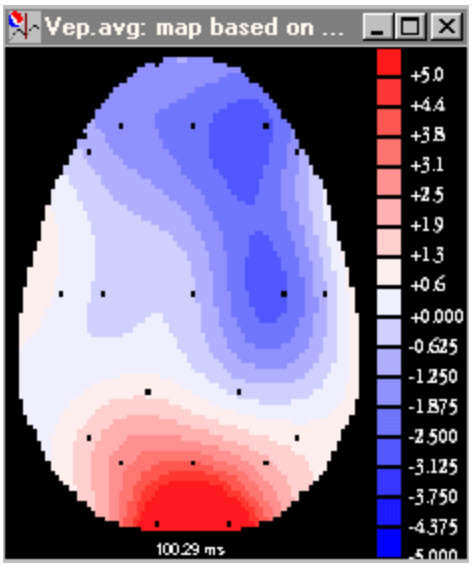
Position the mouse anywhere in the 2D map display, click the *right mouse* button, and see the displayed list of options.



Select the **Scale Min/Max Values** option. This will allow you to change the scaling of the map to get a better range for the colors. Entering -5 and 5 will give a better display.

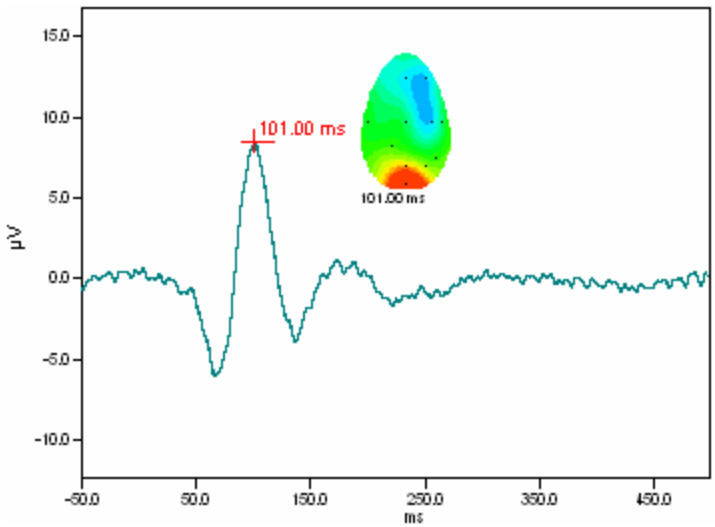


The rescaled map will look like the display shown. You will need to reposition the mouse over the waveform to see the new scaling.



2. Now move the mouse into the waveform window again. As you move the mouse near the waveform, you will see an additional "head" drawing become part of the cursor. You will also see a vertical hash line appear on the waveform, showing the exact location of the point being displayed.

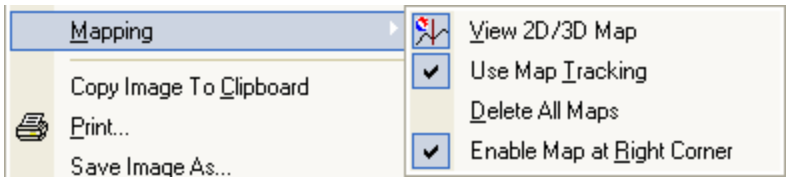
Now we'll create a 2D map of the peak P100 response. This occurs at approximately 101ms in this subject. Position the mouse at the peak of the P100 component, so the additional "head" indicator appears, and click and hold the left mouse button. A black rectangle will appear. Holding the left mouse button down, drag the rectangle to a clear part of the display, and release the left button. A 2D map will be dropped at that position. We will demonstrate how to change the color scheme shortly.

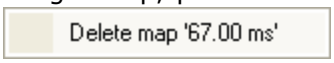


If you scaled the waveform using the Autoscale feature, the top of the millisecond marker will be above the display. Click the down arrow on the Toolbar to reduce the display scale. You can map additional points as you desire (up to 25 maps).

To remove the maps that you have created, click the *right mouse* button inside the

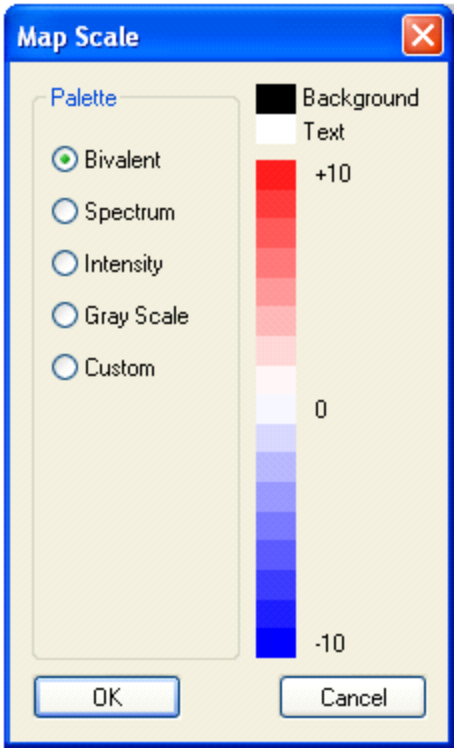
waveform display, and select the Mapping option.



Click the **Delete All Maps** option, and the maps will be deleted. To deactivate the 2D mapping feature, click the *right mouse* button again, and deselect the **View 2D/3D Map** option. Reselect it to reactivate it. To delete a single map, position the mouse over the map and click the *right mouse* button. Select 

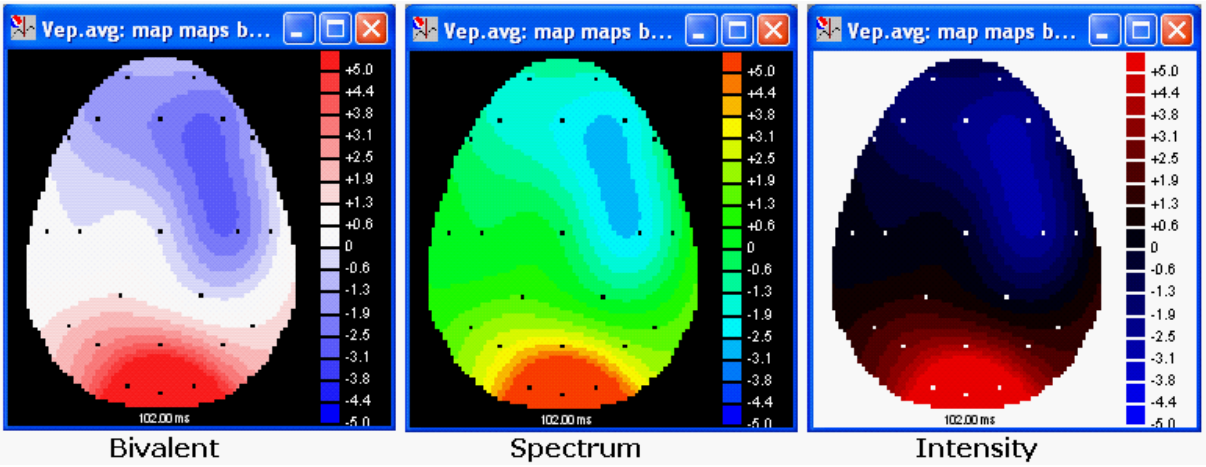
.

Shown above are a couple of the color schemes for mapping. There are several others. Change the focus to the 2D maps window, position the mouse cursor anywhere in the display, and click the *right mouse* button to access the context menu as shown above. Select **Color Scale Type**, and you will see the Map Scale screen.

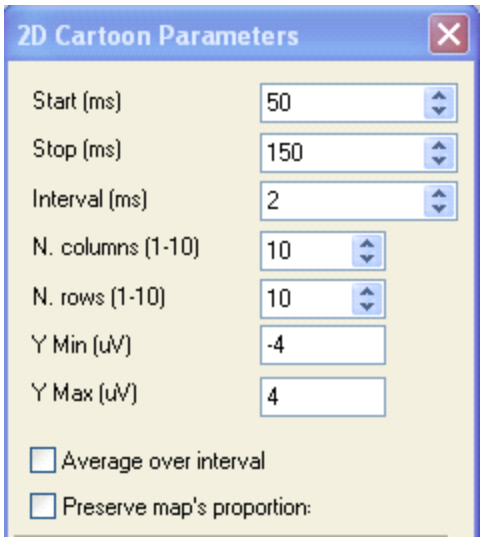


The Bivalent palette uses variations of two colors: red to blue. The Intensity palette also uses red to blue, with black and white being reversed. Spectrum uses a spectrum of colors, and the Gray Scale varies from black through gray to white. You can create you own color scale by clicking the Custom option. Then double-click any of the colors to see the colors palette, from which you may assign any desired color. When you select the Custom option, you will also have the option to change the color of the Background and Text (double-click each to see the Colors palette).

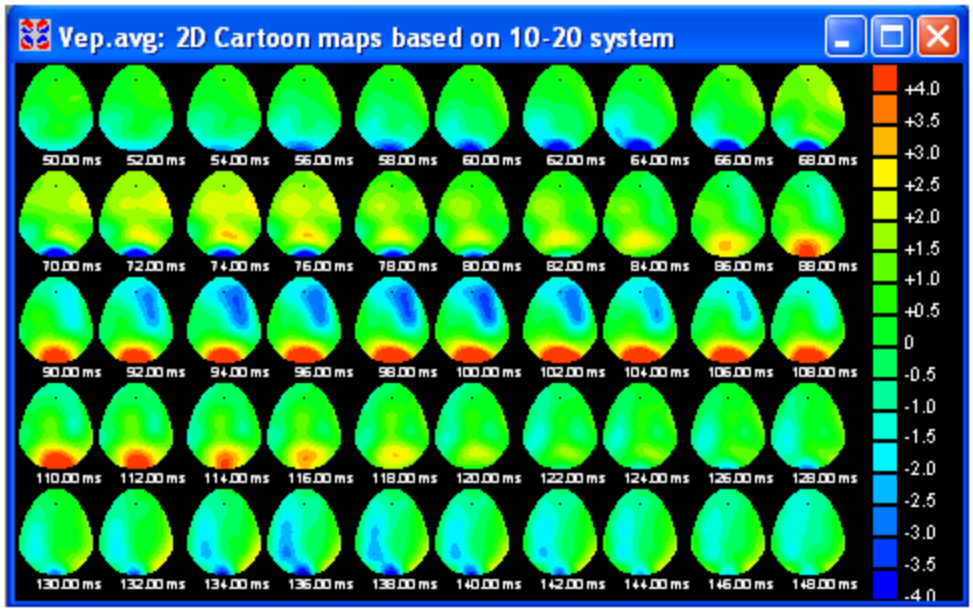
Select a Palette option, then click **OK**. Some of the color schemes are displayed below.



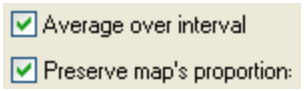
3. Next, will create some cartoon maps. First, let's clear all the maps so far. Click the 2D mapping icon to close its function, and delete all maps (*right click* and select **Delete All Maps**). Now click the 2D cartoon icon from the Toolbar. A series of maps will appear based on the default values in the **2D Map Cartoon Parameters** display, which also appears.



Set the **Start** and **Stop** times in the 2D Parameters display to **50** and **150**ms, to capture the most interesting part of the response. Set the **Interval** to **2**ms to create a map for each 2ms point. Set **N Columns** to **10** and **N Rows** to **10** to display the maps in a 10x10 grid. Set the **Y Min** to **-4** and **Y Max** to **4**μVs. Then click the **Update 2D** button to make the changes in the maps. The cartoon should like similar to the following (using Spectrum).



In the lower part of the 2D Cartoon Parameters dialog are the following options.



Average over interval. When enabled, the average of the values during the **Interval** will be mapped. Otherwise, single data point map will be displayed. For example, with an AD Rate of 1000Hz, there are data points every ms. Say you have Interval set to 5. If **Average over interval** is enabled, then the average of the 5 data points will be mapped. If not enabled, then every 5th data point will be mapped.

Preserve map's proportion. When enable, the size and shape of the 2D maps will remain constant even though you resize the cartoon display. Sliding tabs will appear, allowing you to see different parts of the display. If you disable Preserve map's proportion, then you can resize the cartoon display as desired. The maps will all be displayed, and subject to the proportioning of the overall window.

4. We will now print the screen and save it for other graphics applications. To print the cartoon screen, make sure it has the focus, then select **Print** from the *right mouse* menu, or select **File** → **Print**, or click the Print icon  from the Toolbar. The regular Print dialog will appear. Note that you have the option to **Stretch output to fit page**. Deselect it if you want the graphic to be displayed in its proportional size. Included with the printout will be subject, date and file information at the top.

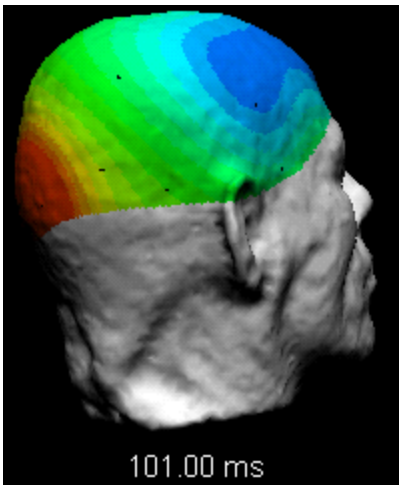
You may wish to save the image for inclusion in other applications running in Windows. Click the *right mouse* button in the cartoon display, and select 

. A utility screen will appear allowing you to save the image as a Windows Metafile (the .wmf extension is added automatically). Metafiles may be inserted into a variety of document and graphic software packages.

5. Close the 2D Cartoons by clicking the in the cartoon display, or deselecting on the Toolbar.

6. For the last mapping demonstration, we will map the peak of the P100 component on a 3D head shape. 3D head shapes are created in the 3DSpaceDx programming using a digitizer. If you do not have a digitizer, you can map the data using a head shape provided.

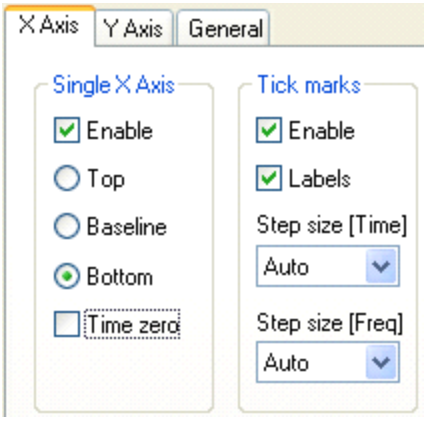
You will first need to select the **2D Mapping** option as described above ( ). *Right click* in the map display, and select **Use 3D Mapping**. The 3D head shape will appear. *Right click* again in the display, and select **Scale Min/Max Values**. Enter **-4** and **4**. *Right click* once more, and deselect **Use Map Tracking**. In the waveform display, position the mouse cursor at the peak of the P100 component (101 ms) and click the mouse. The waveform data will be transferred to the 3D head.



You may grab-and-drag the head shape into different perspectives. You can change the size by using the *right mouse* button. Hold it down while moving the cursor up and down in the display. You can rotate the head by doing a quick grab-drag-release movement (left mouse button). The faster you drag, the faster it will spin.

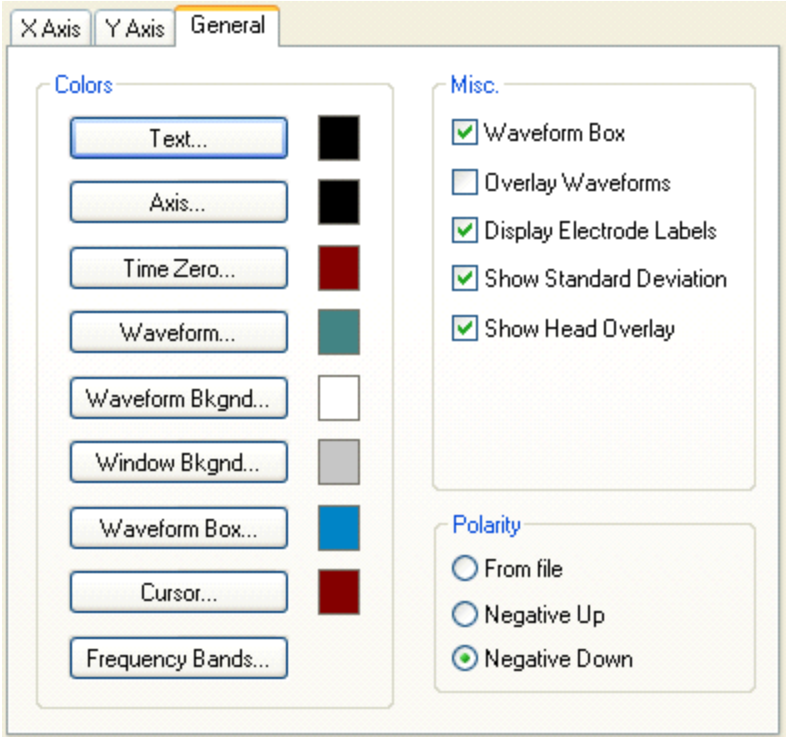
Close 3D Mapping by deselecting the button.

7. We will now look at some of the waveform display options. These are described in complete detail in the EDIT manual. With the *vep.avg* file still open, click **Options** → **Multiple Window Settings**. You will see the screen below.

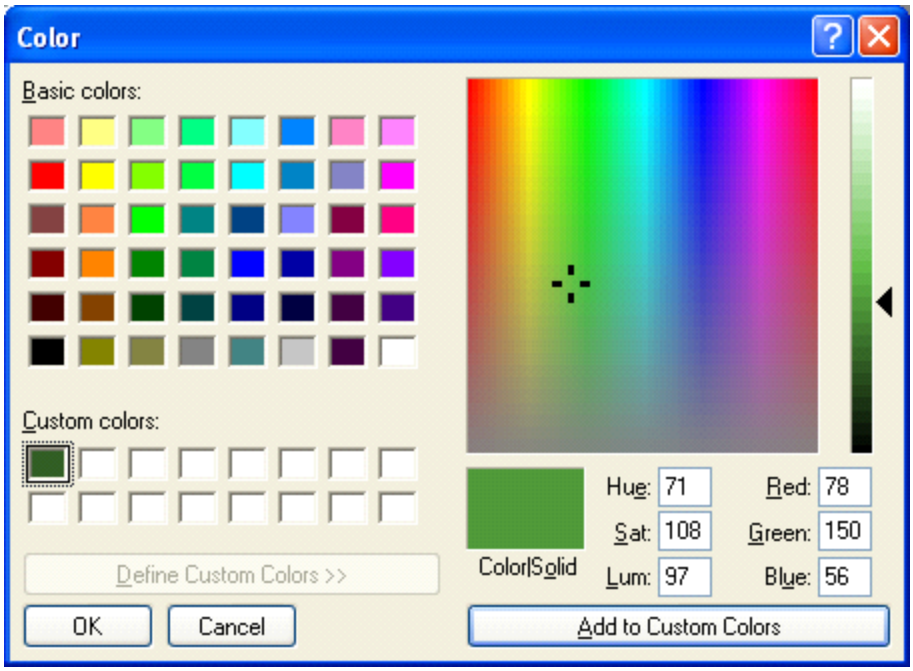


Again, a Multiple Window Display, in EDIT and ACQUIRE, is the type of display in which each electrode has its own window (e.g., AVG, EEG and COH files). Continuous (CNT) files are displayed in a Single Window Display (all channels are in the same window).

For now, click the **General** tab to see the following screen.



In the **Colors** fields you can select colors for the Text, the Axes, the Backgrounds, and so forth. As a quick demonstration, click the Text bar, and a standard color palette will appear (shown with the Custom Color display). Select a color, and press **OK**. If you want to create your own color, click the **Define Custom Colors>>** bar, and select the color from the spectrum matrix. Click the **Add to Customs Colors** bar, and click **OK**. Then go through in a similar fashion and choose colors for the Waveforms, Waveform Background and Window Background. Click **OK** when finished to apply the changes.



Click the Save As... button, and you will see a standard Output File display. The changes you make are stored in the **.aws* (**workspace**) file. Save the changes to the *default.aws* file, unless you wish to create a new one. Click **OK** when you are through. If you save the changes to the **.aws* file, they will be applied the next time you enter EDIT as well. You can also save changes to the *.aws* file from **Options - Save Workspace**. You may have more than one workspace file. Use **Options** → **Load Workspace** to select a new one.

In the tutorial above we demonstrated some of the mapping features in EDIT. Additional options are described in the mapping section in the EDIT manual.

This concludes the seventh tutorial.

9 Scripting

You will likely find when you are processing data files that you repeat the same operations over and over with different files. Beginning with SCAN 4.2, there are two ways to automate processing - Script files and Batch files. Batch files are described in the Tcl Batch Commands manual. In general, Scripts are adequate for many types of repeated analysis operations. Scripts cannot be used for automating acquisition. Batch files with Tcl (Tool Command Language) offer almost unlimited flexibility, and, although, somewhat more complex to master, many users gravitate toward Batch files as the preferred method for automating acquisition and analysis procedures. *In future versions of Scan, scripting will likely be eliminated and we therefore strongly recommend that you use batch files rather than script files*. (See also the Batch Tutorial manual, accessed from **Help** → **Batch Tutorial**. It exists as a PDF file only).

There are at least three advantages in using script or batch files.

1. They save time. Set the programs to run, and the steps you would be performing

by hand are automated.

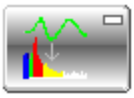
2. They increase accuracy. When you are performing the same steps, in the same order, on subject after subject, it's easy to make a mistake. Script and Batch files will perform the same operations, in the same order, on every subject.

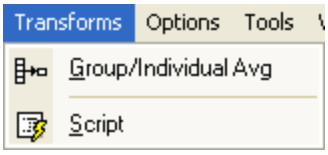
3. They provide a record of the operations that were performed. When you archive data, save a copy of the script or batch file along with the data files. You will then have a record of the operations that were performed and the parameters that were used.

In this tutorial, you will see how to:

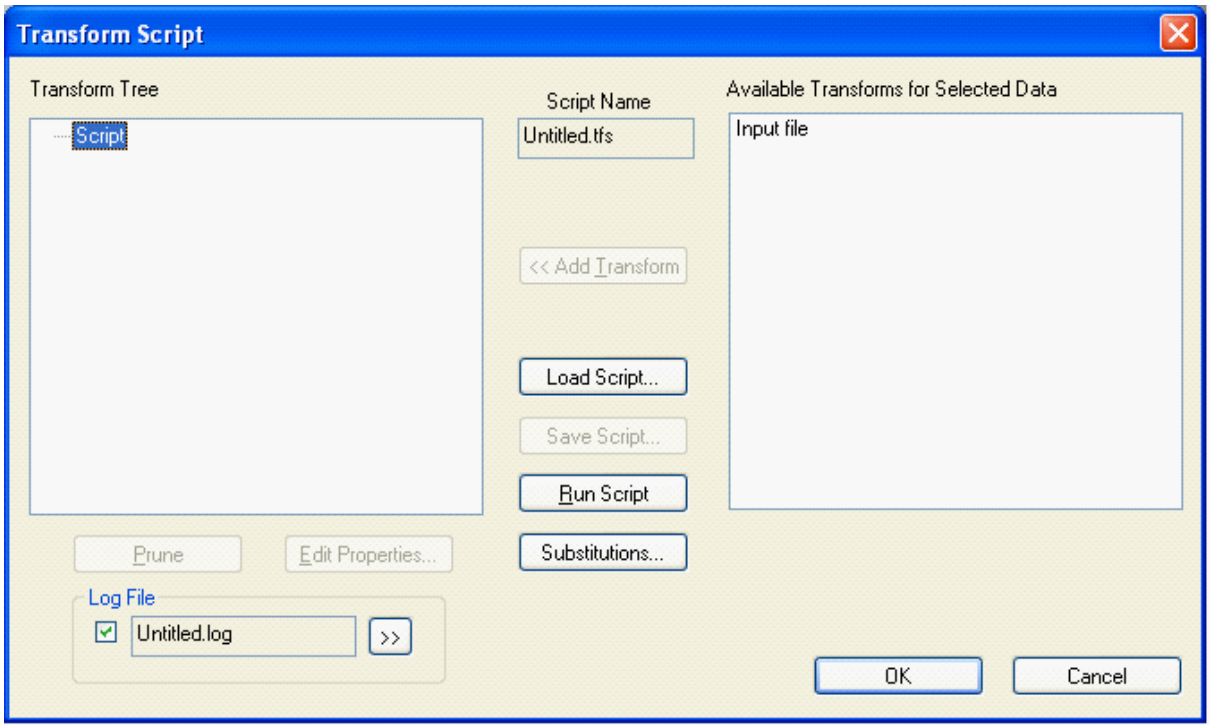
- Create a simple Script
- Edit scripts
- Save Transform Reports

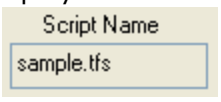
In this Script example, we will create a simple Script file that will be used to retrieve a continuous file, and then epoch it. We will then perform a Baseline Correction, Filter it, perform Artifact Rejection, and save the transformed .EEG file.

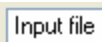
Open the EDIT program by clicking the EDIT icon  from the Program Launcher. Then click **Transforms** → **Script**. The Transform Script window will appear.

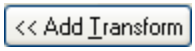


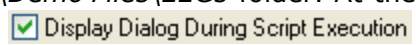
The **Transform Tree** area will display the Script as we create it.

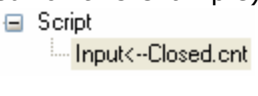


The **Available Transforms for Selected Data** area will display which transforms can be used at each step along the way. The **Script Name** field 

will display the name of the loaded Script file. To start, click 

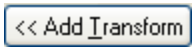
. It will become highlighted, and the 

button will become activated. (Double-clicking a transform avoids having to click the Add Transform button). Double-click **Input file** and an Open Files utility window will appear. Change the Files of type field to Neuroscan Continuous (*.cnt), and select the *closed.cnt* file from the ...*Demo Files**EEGs* folder. At the bottom of the window, you will see an option called 

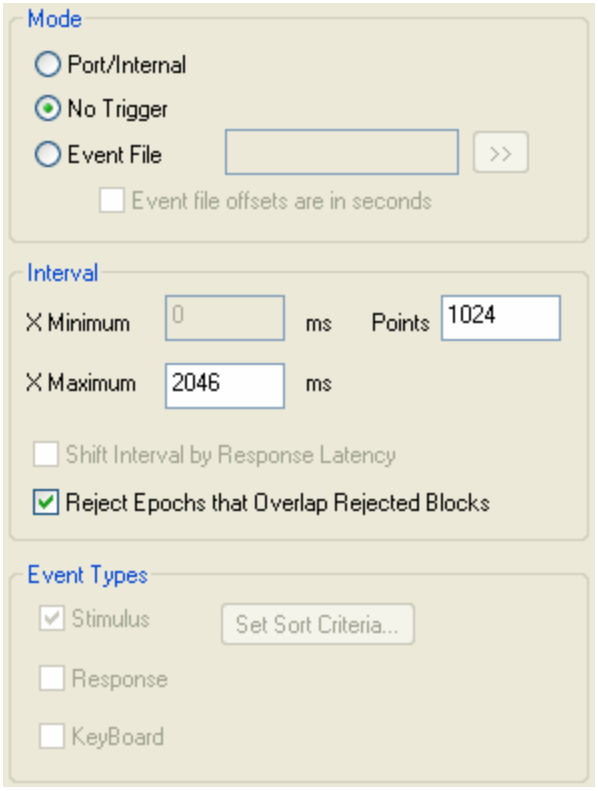
. This option will appear on most Transform screens. When enabled, the dialog will appear during the execution of the script file (leave it disabled for this example). Then click **Open**. You will see the first step, or branch, of the Tree 

, and the available set of options.

Append recording
DC offset correction
Delete bad channels
Epoch
Event File
Filter
GFP/Reference
Linear derivation
Merge task data
Ocular artifact reduction
Output file
SCD/Interpolate
Spatial filter
Spatial SVD
Splitter
Transform Report
Voltage threshold

Next, to epoch the file, click **Epoch**, then the 

button (or double-click **Epoch**). The Epoching Properties window will appear. As in the previous tutorial where we used the *closed.cnt* file, set the Mode to **No Trigger**, the number of Points to **1024**, and then click in the **X Maximum** field. This will automatically compute the length of the epoch. The output file name is ignored in scripting; you will need to specify the output file in a later step, as described below.

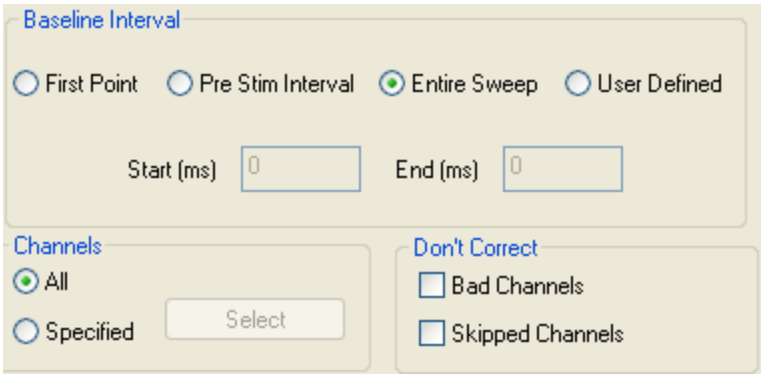


Then click **OK**, and you will see a new set of options on the right side display.

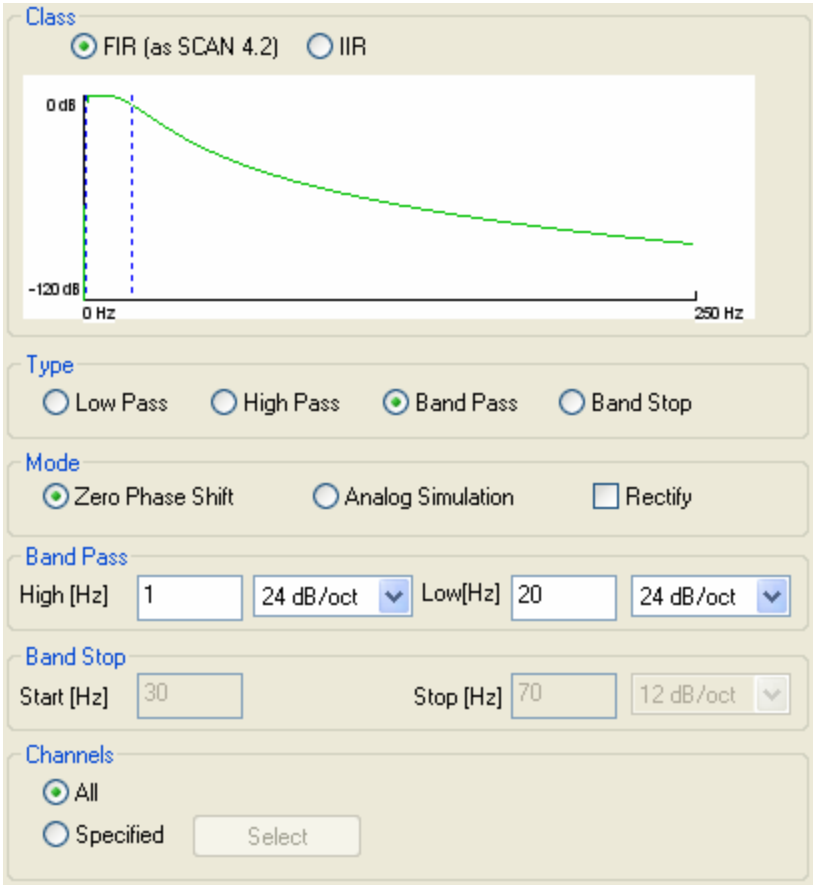
Note

You may return to any transform screen by highlighting the transform in the Transform Tree and clicking the Edit Properties... *button.*

Select the **Baseline Correct** option, click << Add Transform, and the Baseline Correction window will appear. Select the **Entire Sweep** and **All** channels. (The output file line is, again, ignored). Then click **OK**.

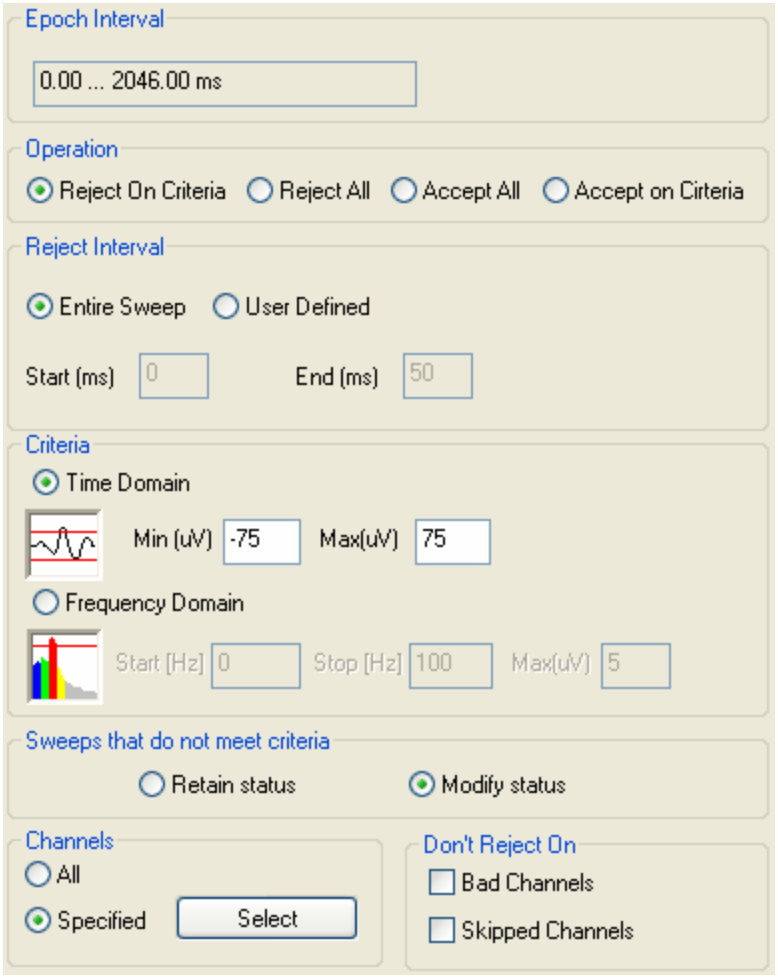


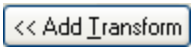
Now click the **Filter** option, click << Add Transform, and the Filter display will appear. For the current purposes, select **FIR** Class, the **Band Pass** filter Type, the **Zero Phase Shift** Mode, **High Pass** filter settings of **1**Hz and **24**dB, **Low Pass** settings of **20**Hz and **24**dB, and **All** channels. Then click **OK**.This will perform a digital band pass filtering between 1 and 20Hz (for demonstration purposes).



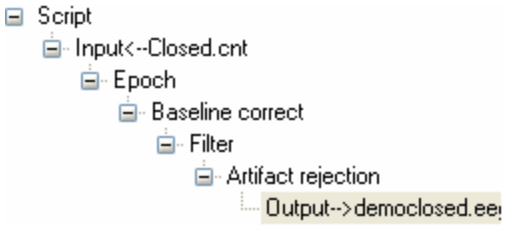
Next, click **Artifact Rejection**, click 

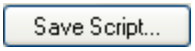
, and the Artifact Rejection window will appear. Set the Operation Window to **Reject On Criteria**, **Entire Sweep**, set the Criteria to **+/-75**μVs, select **Modify Status**, **All** channels, and **disabled** both fields under **Don't Reject on**. Then click **OK**.



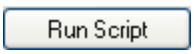
Lastly, click the **Output file** option, then 

. A Save File utility will appear. Enter a file name and path (*democlosed* in this example; the *.eeg* extension will be added automatically), and click the **Save** button.



Save the script file by clicking the 

button on the script screen, entering a file name (*demoscript* in this example; the *.tfs* extension will be added automatically), and clicking the Save button.

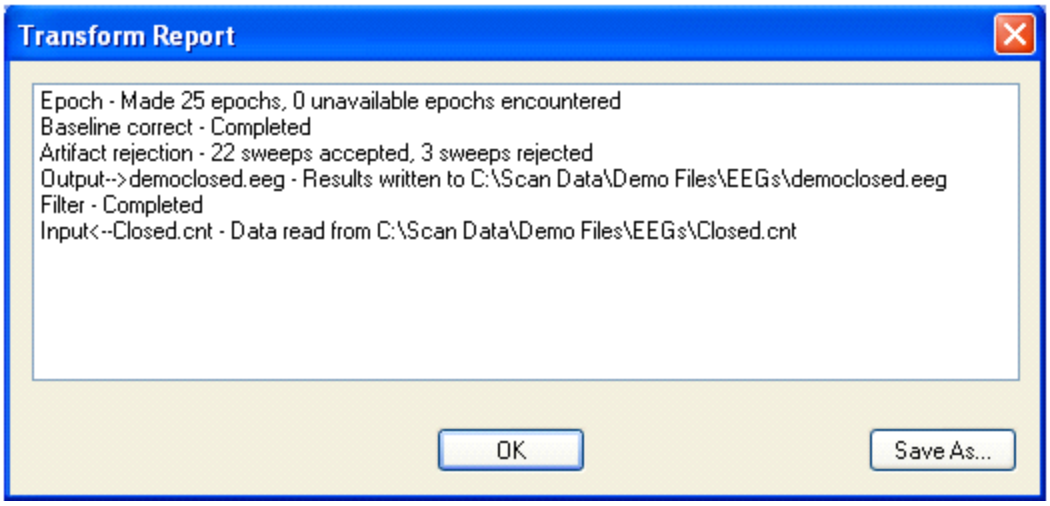
Run the script file by clicking 

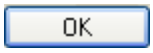
.

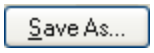
If we had enabled the 

option for each screen, you would

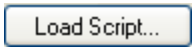
see the screens appear one at a time while the script program is being executed. This would give you the opportunity to modify the settings as the programs runs. For maximum automation, however, you should leave the option disabled. An incrementing bar will show the progress of the transform process. When completed, you will see a **Transform Report** screen, saying, in this example, how many epochs were made, how many were accepted/rejected, and the path and name of the output file.



Click 

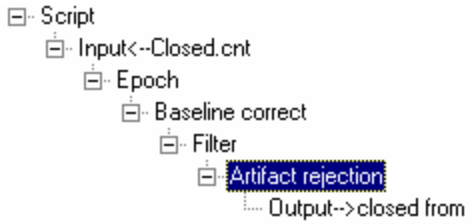
to continue. If you click the 

button, you can save the report as a text file (with a **.log* extension). Retrieve the file you created by clicking the **File → Open data file** option, setting the file type to .EEG, and double-clicking the file from its folder.

To retrieve a saved script file, click the 

button from the main script screen.

Let's say we want to modify the existing script file we just saved by decreasing the artifact rejection criteria. Retrieve the script file, then click the Artifact rejection step to highlight it.



Now click the 

button. You can also click the *right mouse* button on the transform, and go directly to the properties display. The Artifact Rejection screen will appear, and you may modify the threshold criteria. If you want this file to be stored with a different file name or path, you may modify the Output file line accordingly.

Save the new script file, if desired.

The last feature we will discuss here is the 

function. Pruning will simply remove a branch from the script tree. Highlight a step on the tree, click Prune, and that step as well as everything below it will be removed.

There are other features used with Script files that will be discussed more fully in the EDIT manual. Just to mention two of them, you will see the **Splitter** function appear as an option with many transform operations. This allows you to add branches to the tree. For example, as in the P300 demonstration above, we sorted for the RARE, the FREQuent, or the distractor stimuli. In the script file, you can split the line of operations to allow you to, for example, perform multiple sorted averages within the same file. Another useful feature is the Substitution option. This allows you to run the same script file on multiple data files.

This concludes the Scripting tutorial.