APPENDIX B

The Montage Editor

and Basic LDR Information

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The Neuroscan Montage Editor

The purpose of the Montage Editor is to create and modify Linear Derivation (.ldr) and Montage (.mnt) files. Before discussing the Montage Editor, it may be helpful to present some basic information about Linear Derivation files. Montage files are discussed in more detail below.

Linear derivation files in SCAN 4.2 allow you to perform a variety of online and offline analyses with a high degree of flexibility. All of the online analyses - plus more extensive applications - may be performed offline in the EDIT module. The purposes of the next section are to acquaint you more fully with the concept of linear derivation files, and to provide some examples of *.ldr* files that will illustrate their uses.

LDR Bipolar Montage and "Composite" Channel Derivations

Perhaps the easiest way to introduce the basic concept of linear derivation is to look at a simple linear derivation file that converts linked-ear reference recordings to a bipolar montage. Linear derivation

16 20

	Fp1	Fp2	F7	F8	F3	F4	T3	T4	C3	C4	T5	T6	P3	P4	O1	O2	Fz	Cz	Pz	Oz
Fp1-F7	1.0	0.0	-1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F7-T3	0.0	0.0	1.0	0.0	0.0	0.0	-1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T3-T5	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	-1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T5-O1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	-1.0	0.0	0.0	0.0	0.0	0.0
Fp1-F3	1.0	0.0	0.0	0.0	-1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F3-C3	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	-1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C3-P3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	-1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P3-O1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	-1.0	0.0	0.0	0.0	0.0	0.0
Fp2-F8	0.0	1.0	0.0	-1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F8-T4	0.0	0.0	0.0	1.0	0.0	0.0	0.0	-1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T4-T6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	-1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T6-O2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	-1.0	0.0	0.0	0.0	0.0
Fp2-F4	0.0	1.0	0.0	0.0	0.0	-1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F4-C4	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	-1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C4-P4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	-1.0	0.0	0.0	0.0	0.0	0.0	0.0
P4-O2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	-1.0	0.0	0.0	0.0	0.0

files will have *.ldr* extensions, and may be created, reviewed and edited with the Montage Editor, or a standard text editor, such as Notepad. In a text editor, the first line will consist of 2 numbers: "16 20" in this example. This indicates that you will be creating 16 new channels from the existing 20 channels that are recorded. This is the essence of the linear derivation approach - *to create new data channels from weighted linear combinations of existing channels*.

Let's say that you are recording 20 channels using the standard 10-20 montage placements, and that you are using a linked-ears reference for each. The next line in the *.ldr* text file (when viewed with a text editor) contains electrode labels for the standard 10-20 system. These do not have to be in any particular order, but they do have to agree in number and label with the information contained in the corresponding setup file that was created in ACQUIRE. The first column contains the labels of the *new* channels that you are creating. The labels are created manually.

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The numbers in the cells are *multipliers,* or scaling factors*,* for the data in the original file that you are acquiring, or have already acquired. The original data points for each channel are multiplied by the corresponding *multiplier*, and the data in the newly derived channels are simply the *linear sums* of these "weighted" values. For a simple conversion to a bipolar channel, for example, Fp1-F7, the data points from the Fp1 channel are multiplied by "1", the data points for the F7 channel are multiplied by "-1", and data points from all other channels are multiplied by "0". All of the data values for a single time point are then summed linearly across channels, and the result is the difference between Fp1-linked ears and F7-linked ears, or Fp1-F7. The remainder of the bipolar conversion is then simply a matter of placing the 1 and -1 multipliers in the appropriate columns. (A simple way to do this is described below).

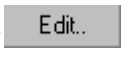
Another example of a simple linear derivation is to create "composite" regional channels, that is, a single channel that is derived from several channels in one region. Using the same recording channels as above, we might create 4 derived channels representing the Front, Back, Left and Right regions, as follows:

```
4 20
        Fp1  Fp2  F7   F8   F3   F4   T3   T4   C3   C4   T5   T6   P3   P4   O1   O2   Fz   Cz   Pz   Oz
Front   .125 .125 .125 .125 .125 .125 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  .125 .125 0.0  0.0
Back    0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  .125 .125 .125 .125 .125 .125 0.0  0.0  .125 .125
Left    .125 0.0  .125 0.0  .125 0.0  .125 0.0  .125 0.0  .125 0.0  .125 0.0  .125 0.0  0.0  0.0  0.0  0.0
Right   0.0  .125 0.0  .125 0.0  .125 0.0  .125 0.0  .125 0.0  .125 0.0  .125 0.0  .125 0.0  0.0  0.0  0.0
```

Notice that the first line was changed to indicate that 4 channels will be created (seen in the text editor, not in the Montage Editor). Eight channels were selected for each of the Front, Back, Left and Right derived "composite" channels. The multiplier is therefore 1/8, or .125. You can use "1s" for the multipliers if you wish - fractions were used in order to maintain the same microvolt scaling as in the original recording. Using "1s" as the multipliers would increase the derived channel amplitudes by a factor of 8.

For more information about Linear Derivation, please refer to the Linear Derivation, Spatial SVD, and the Spatial Filter transforms described in the EDIT manual. With this brief introduction to the basic premise of the LDR files, we will move on to discuss ways to create and edit them, as well as Montage files.

The Montage Editor

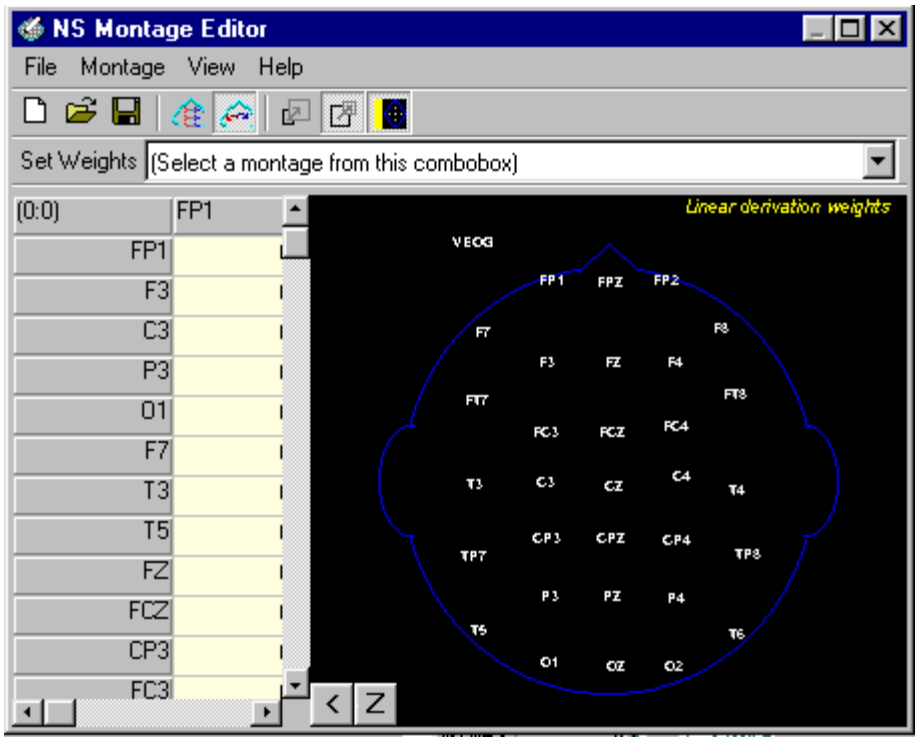
The Montage Editor provides a useful means for creating and editing Montage (.mnt) and Linear Derivation (.ldr) files. It may be accessed most easily from the Toolbar icon  in EDIT and ACQUIRE, and also from several of the Transforms in EDIT, including Linear Derivation, Ocular Artifact Reduction, Coherence, and Spatial Filter. Any Transform that pertains to LDR or MNT files that shows an 

button will access the Montage Editor.

Let's begin by starting the EDIT program and retrieving the P300.eeg file from the \SCAN4.2\Demo\P300s folder. Click the Montage Editor icon  from the Toolbar.

Overview of the Montage Editor. Let's look superficially at the basic sections and functions of the Montage Editor. Note first that the electrodes are arranged on the Head Contour display in the same positions

as in the data file that was retrieved. The electrode labels and position information is retrieved automatically when you open the Montage Editor.



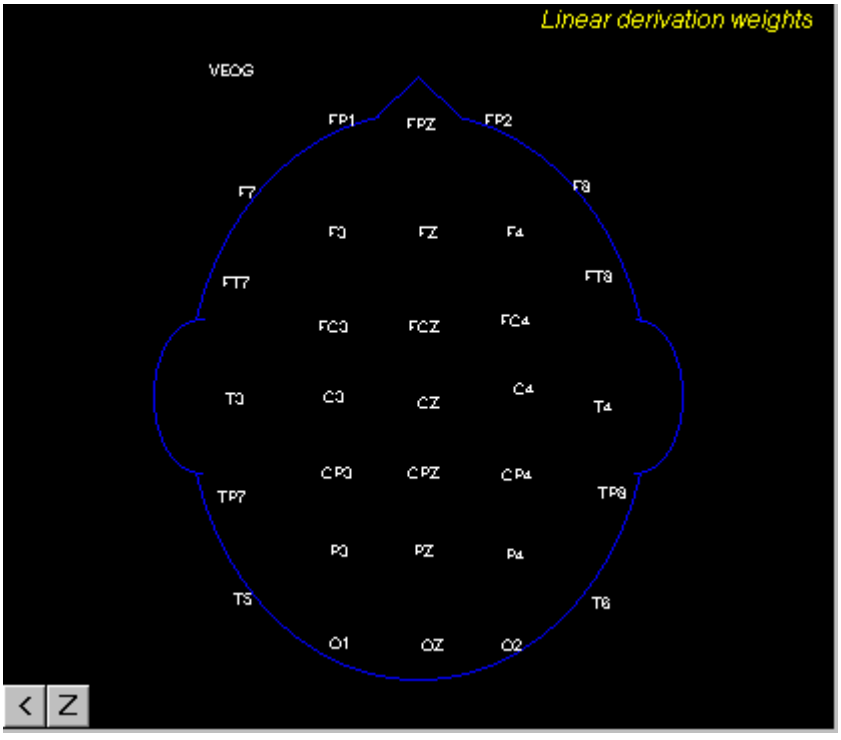
The Main Menu bar File Montage View Help in the Montage Editor has four options: File, Montage, View, and Help. Nearly all of the operations that are listed in these pull-down menus may be accessed more easily from the Toolbar icons, and the features will be described in that section below. If you prefer keyboard controls rather than the mouse, you may access the Main Menu bar options using the standard conventions. For example, press alt-f from the keyboard to access the File pull-down menu, then press the capitalized letter to select one of the options.

Set Weights - The next section on the display, labeled as "Set Weights", provides a list of LDR or MNT files that has been created and stored in the last directory that was accessed. Click the pull-down menu at the far right side of the field to see the list. Whether you see MNT or LDR files depends on which type of file you have chosen to edit. This is typically done using the Toolbar icons, as discussed below.

The section on the left hand side of the screen displays a text matrix of the LDR or MNT file.

(0:3)	FP1	F3	C3
P3	0	0	
O1	0	0	
F7	0	0	
T3	0	0	
T5	0	0	
FZ	0	0	
FCZ	0	0	
CP3	0	0	
FC3	0	0	
TP7	0	0	
FPZ	0	0	
FT7	0	0	
FP2	0	0	
F4	0	0	
C4	0	0	
P4	0	0	

The large display area on the right hand side of the screen displays the Head Contour with the current montage, using the electrode label and position information from whatever file you have retrieved.



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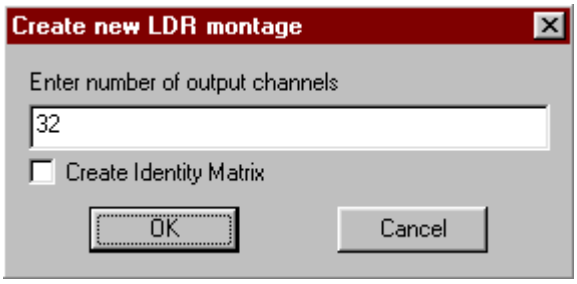
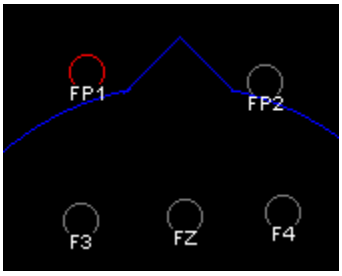
Toolbar icons - Now, let's look at the basic functions accessed from the Toolbar icons. Notice also there are two additional icons in the lower corner of the Head Contour display area.

Create New Montage - This option will remove any current contents from the displayed MNT or LDR file, allowing you to create a new montage from scratch. This will not affect the saved MNT or LDR file (as long as you don't overwrite the existing file).

When you click the icon, you will see the following display.



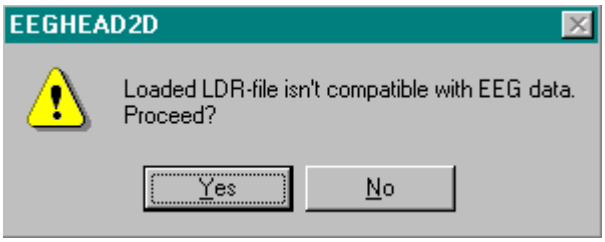
You will be asked to enter a number for the number of output channels that you want to create. You will also be asked if you wish to Create an Identity Matrix. If you enable this option, an LDR file will be created that has 1's going down the diagonal, with all other cells set to 0. The output file will be the same as the original file (the number of input and output channels must be the same). This is useful in cases where, for example, you want to create a new file that has fewer channels. Just delete the channels that you don't want from the y-axis list - the 1's are already in place along the diagonal (see below for instructions on deleting output channels). If you elect to create an identity matrix, you will see loops appearing for each of the output channels on the Head Contour display.



Note: if you enable the Create an Identity Matrix option, it will remain enabled the next time you enter the Montage Editor.

Open Montage File - This option allows you to open an existing MNT or LDR file. If you have selected the Edit Bipolar Montage icon, the Open File list will show MNT files. If you have selected the Edit LDR File icon, you will see a list of LDR files.

Note: The Montage Editor program is accessed after you have retrieved a data file. If you want to retrieve an LDR file that does not match the data file, select the file using Open Montage File. You will then see the following message.



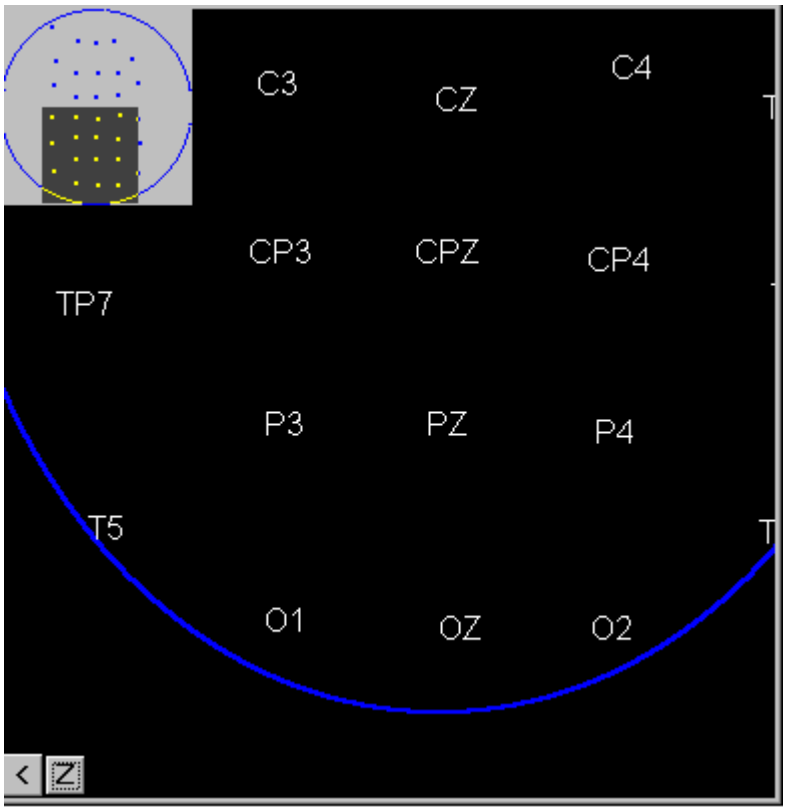
Click Yes to continue, and the new LDR file will be retrieved.

Save Montage File - This option allows you to save a MNT or LDR file. A Save File utility window will appear, allowing you to enter a file name and path (the .MNT or .LDR extension will be added automatically).

Edit Bipolar Montage - This option allows you to edit a bipolar montage. An example of this process is presented below.

Edit LDR File - This option allows you to edit an LDR file. An example of this process is presented below.

Zoom In - This option allows you to zoom in on the Head Contour display. When selected, you will see a diagram in the upper left hand corner of the display, with a darker shaded



region. Using the left mouse button, grab and drag the shaded region to a new location. That location will be shown in the zoomed display. This is particularly useful when you are working with files that have large numbers of electrodes. *Note: Double-clicking the left mouse button in an area will also zoom into that area.*

Zoom Out  - The Zoom Out icon will return the display to the original size (see Zoom In above).

Show Head Contour  - This button toggles the Head Contour display on and off.

Full Size Display  - Clicking this option will enlarge the electrode display to the full screen size, and will hide the text portion of the display. Clicking it again will return to the split display.

Zoom Display  - The Zoom Display button performs the same function as the Zoom In and Zoom Out icons.

Creating and Editing a Bipolar Montage - The following steps illustrate the procedure for creating and editing a bipolar montage. The result of these operations will be a bipolar MNT or LDR file. MNT files are used only with the Coherence transform. The LDR file can be used any time you want to apply the Linear Derivation Transform.

The first step is to retrieve a data file for which you would like to create a bipolar montage. For this demonstration, retrieve the P300.eeg file in EDIT. Then click the Montage Editor icon  . Click the Edit Bipolar Montage icon  , if needed. You will see a display similar to the following:

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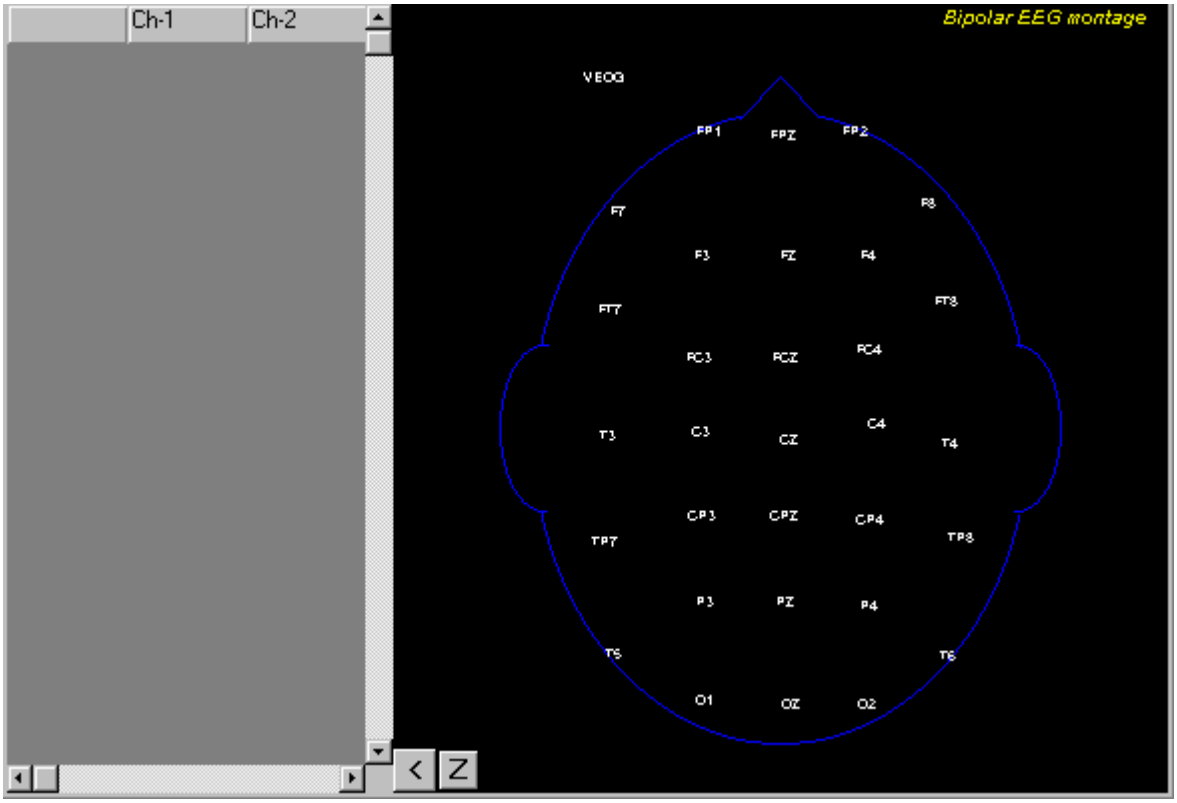
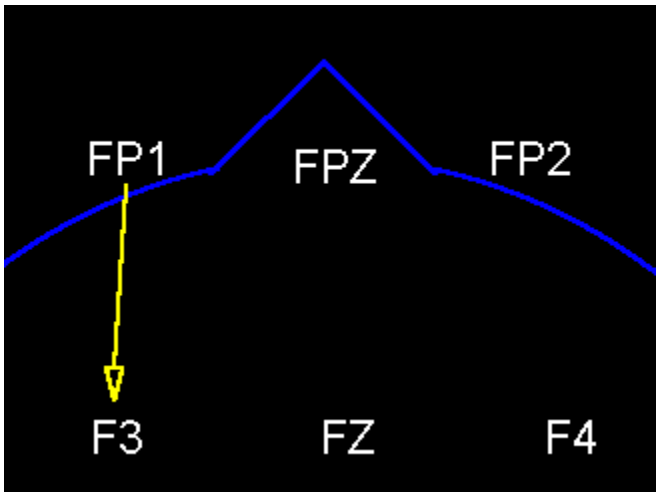


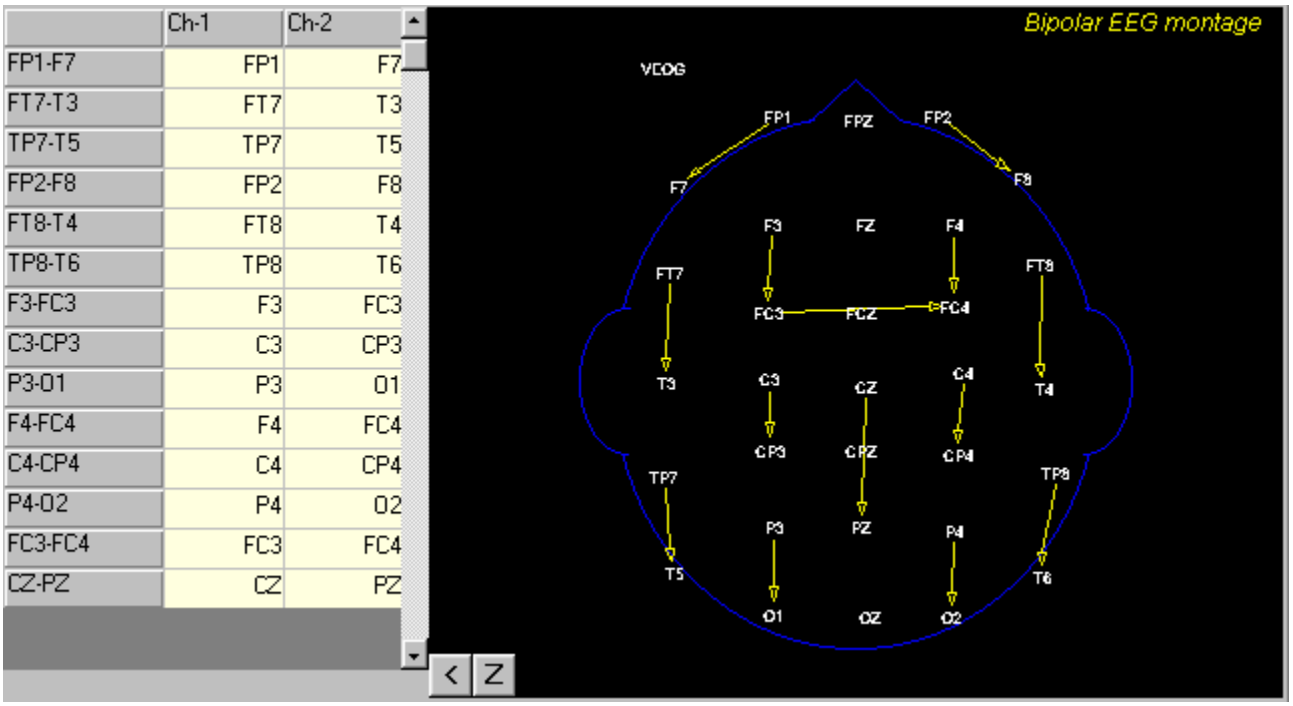
To create a bipolar channel from the original linked ears recording, the basic process is a subtraction of one monopolar channel from another monopolar channel. In other words, to create the bipolar FP1-F3 channel, the program subtracts F3-A1/A2 from FP1-A1/A2. The user interface for this instruction is very simple. Click and hold the left mouse button on FP1, and drag the resulting arrow to F3, and release the mouse button. The arrow will attach itself to F3.



The creation of the new channel will be listed in the text display on the left hand side of the screen.

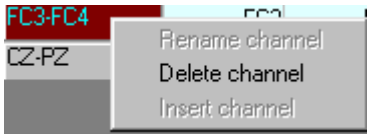
	Ch-1	Ch-2
FP1-F3	FP1	F3

Now go back and create as many bipolar channels as desired. Your final bipolar montage might appear similar to the following.

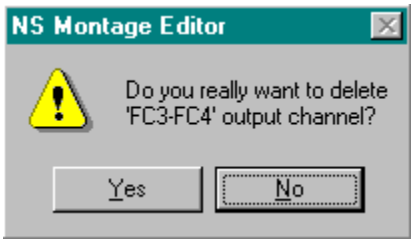


As you draw the lines for the bipolar montage, you will see the channels being added to the text matrix (the .MNT file) on the left side of the screen. Continue creating the desired bipolar channels.

Now, let's say you mistakenly created a channel, and you would like to delete it. In the above example, let's delete the FC3-FC4 channel. Position the mouse on the FC3-FC4 label, and click the right mouse button. You will see a small option window with the Delete Channel option. Select



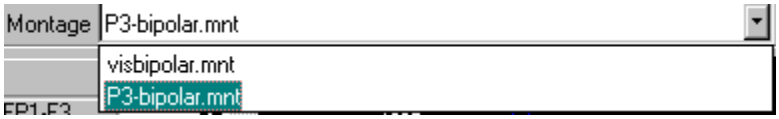
it and you will see a window confirming your desire to delete the channel. Click Yes to delete it.



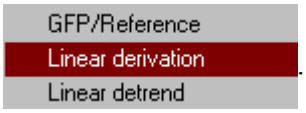
If you want to start over from scratch, select the Create New Montage option under File.

To save the bipolar montage, click the Save Montage File icon . A Save As utility window will appear allowing you to enter a file name (e.g., P3-bipolar). Click the pull-down arrow at the end of the "Files of type", and select whether you want to save the file as an .MNT or .LDR file.

Then enter a file name and path (the .MNT or .LDR extension will be added automatically). The next time you enter the Montage Editor, and click the Edit Bipolar Montage icon, you will see the MNT file listed in the Montage pull-down display.



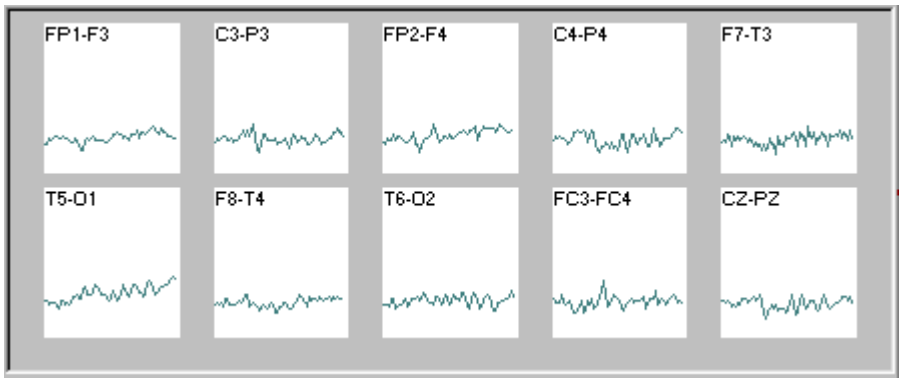
The bipolar montage that you have created can be applied in the calculation of Coherence. An option on the Coherence screen allows you to select an .MNT file. Coherence will be calculated for those channels only. (If you want to try this with the P300.eeg file, you must first perform a Spline Fit where you force the number of points to be a power of 2. To see the results in the final Coherence display you will need to set one of the bipolar electrodes as the Coherence Reference using the right mouse button. See the Coherence description in the EDIT manual for more details).

The *bipolar LDR* file can be applied anytime the Linear Derivation option is available on the Transform or Script options list. For example, save the bipolar montage created above using the LDR file type, and exit the Montage Editor. With the P300.eeg file still displayed in EDIT, select Linear Derivation from the Transform menu 

. When the Linear Derivation display appears, use the >> button to retrieve the LDR file 

.

Click the OK button to continue. The LDR file will be applied and you will see the derived bipolar channels.



For those familiar with earlier versions of SCAN software, the Linear Derivation feature is now used to display your data as bipolar channels, rather than having separate bipolar options.

Creating and Editing an LDR File - This section will demonstrate how to create and edit Linear Derivation files. Perhaps the simplest illustration of an LDR file is one used to create a new data file that has fewer channels than the original file. To illustrate this, retrieve the *closed.cnt* file from the \scan4.2\demo directory, and click the Montage Editor icon from the Toolbar. In the Montage Editor, click the Edit LDR Montage icon, if needed. The Head Contour display will have no links, and the LDR text display, on the left, will have all zeros. Let's take a closer look at the LDR text display. Unclick the Head Contour icon.

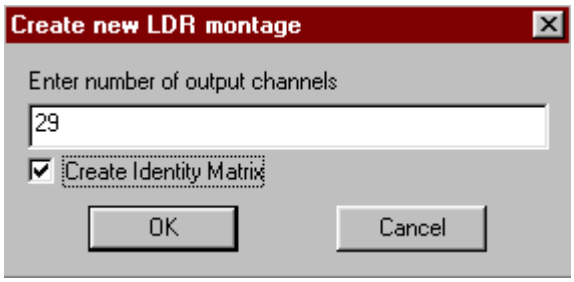
(0:0)	FP1	PZ
FP1	0	0
PZ	0	0
FP2	0	0
OZ	0	0
F3	0	0
FTC1	0	0
F4	0	0
FTC2	0	0
C3	0	0
TCP1	0	0
C4	0	0
TCP2	0	0
P3	0	0
CP1	0	0
P4	0	0

In the upper left hand corner of the matrix you will see (0:0). This is the cell identifier. Each cell in the matrix may be identified by its row and column number (row, col). The numbers correspond to whatever

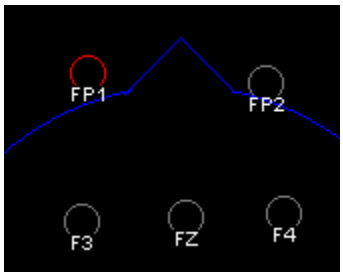
cell is in the top left corner of the section of the matrix being displayed.

All of the electrodes are listed across the top of the matrix, as well as down the left side of the matrix. The arrows and sliding buttons will let you look through the entire matrix. The channels across the top are the existing channels. The channels going down the left side are the new channels being created. The numbers within the matrix are the LDR weights. Each data point for each existing channel is multiplied by the respective weight, and the weighted data points are then summed linearly and written to a new channel in a new data file.

In the simplest example, let's create a new data file that contains only the four midline channels. The easiest way to do that is to create an Identity Matrix, and then delete the unwanted channels. Click the Create New Montage icon , and enable the Create Identity Matrix option.



Click OK, and you will see a text matrix that has the same output files as input files, with 1's running down the diagonal. Notice that the Head Contour display will show loops at each electrode (click the Show Head Contour icon , if needed, to see the display). This is to signify that the electrode is linked to itself.



The Identity Matrix could have been created manually by creating an output file with 4 channels, and then clicking on the labels in the Head Contour display. Clicking a label once with the left mouse will cause the loop to appear, and simultaneously will write a 1 in the corresponding cell. It is also possible to enter the 1 in the desired cell in the text matrix. That will cause the loop to appear on the Head Contour display at the corresponding electrode site.

If saved at this point, the LDR file would create an output file that was identical to the input file. Now go down the column of electrodes labels on the left, and do a combination Ctrl + Left Mouse click on all the ones you want to delete (they will all be highlighted). Then click the right mouse button on one of the highlighted labels, and click the Delete selected channel(s) option to delete the channels. In this example, it would have been slightly easier to have highlighted all the channels at once (by highlighting the top label, then using the Shift + Left Mouse click on the bottom label), and then deselecting the 4 channels to be retained.

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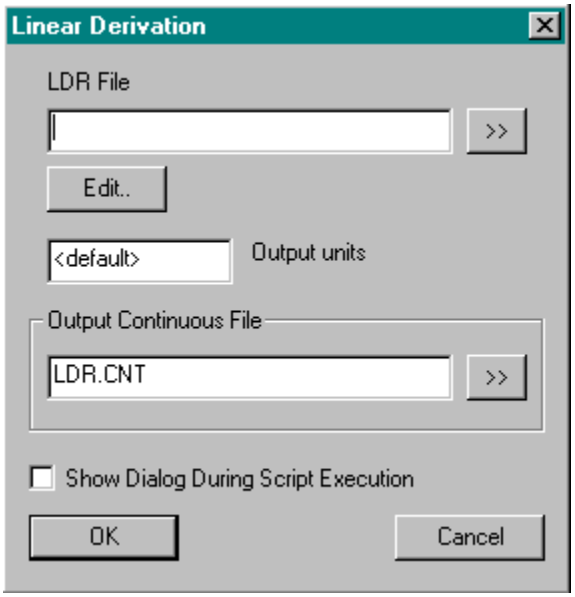
Conceptually, we want to preserve the original data from a given channel. The weight for that channel should therefore be 1, and the weights for all the other channels should be 0. When summed linearly, the result will be no change to the original data. The final matrix should appear as follows (shown in part).

(0:0)	FP1	PZ	FP2	OZ	F3
PZ	0	1	0	0	
OZ	0	0	0	1	
CZ	0	0	0	0	
FZ	0	0	0	0	

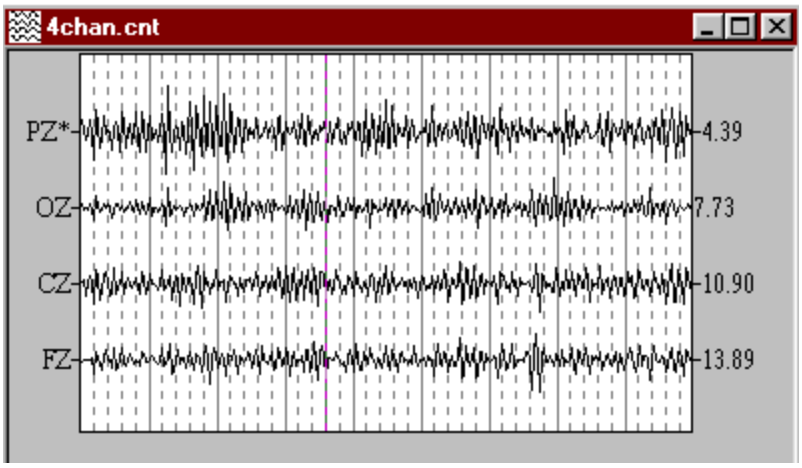
Click the Save Montage File icon  , enter a file name (the LDR extension will be added automatically), and click Save. Then close the Montage Editor.

Back in EDIT, make sure the closed.cnt file has the focus, then select Linear Derivation from the list of Transforms. Use the Browse button 

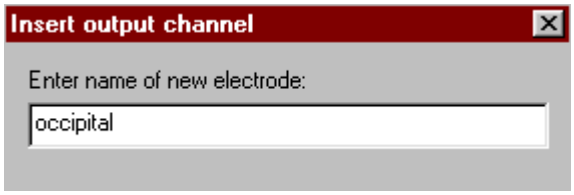
to select the LDR file that you just created. Enter a file name for the Output CNT file, and click OK.



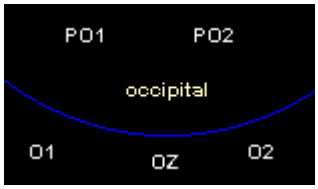
You will then see the Linear Derivation progress bar track the execution of the transform. Since this is a CNT file, you will need to retrieve it. The resulting file will contain the 4 channels.



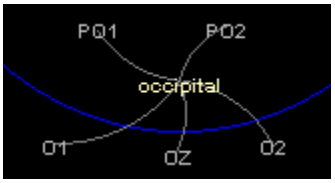
Creating New Channels - In some instances you might wish to create an entirely new channel based upon some combination of existing channels. For example, you could create a linear combination of the occipital channels in the VEP.avg demo file. Retrieve the VEP.avg file, and go into the Montage Editor. Click the right mouse button anywhere on the list of output channel labels. Select Insert channel, and enter a channel name, such as "occipital". You will see the new label on the column of output labels.



You will also see a cursor and a tooltip box instructing you to place the new label as desired. Position it in the posterior area of the Head Contour display. If you then apply the LDR file to create a new data file, retrieve that file, and enter the Montage Editor, you will see the electrode label.



Now, delete all of the other channels in the output label column, leaving only the "occipital" channel. That row will have all zeros. Create links from each of the 5 surrounding electrodes to the new "occipital" one.

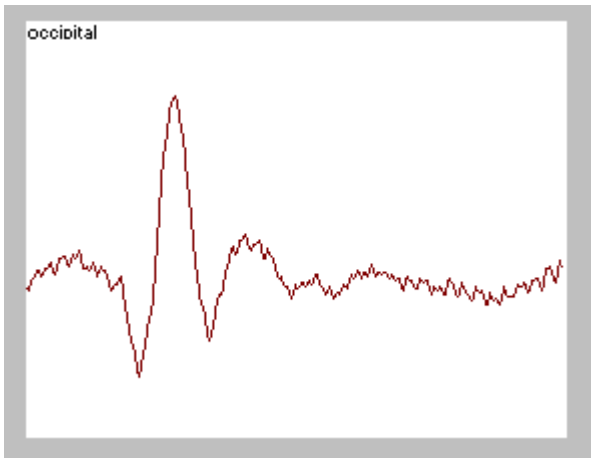


This will place "-1s" in the PO1, PO2, O1, OZ and O2 columns. In the text area, replace the -1's with

0.2's.

	01	02
occipital	0.2	0.2

. Save the LDR file, and exit the Montage Editor. In EDIT, select Linear Derivation from the list of transforms. Select the LDR file you just saved, and apply it. The newly created file will have one channel that is a composite of the 5 channels.



More Complex LDR Files - So far, we have been dealing with simple LDR files that can be created in the Montage Editor. In practice, you may be using more complex LDR files that are created as output files from some of the Transforms in EDIT, such as the Ocular Artifact Reduction, Spatial SVD, Spatial Filter, and so forth. Let's take a look at an LDR file created from the Ocular Artifact Reduction transform.

Below is a section from the lower right hand part of the output LDR file created when the P300.eeg file underwent Ocular Artifact Reduction.

```
0.00000     0.00000     0.00000     0.00000    -0.08171
0.00000     0.00000     0.00000     0.00000    -0.08478
1.00000     0.00000     0.00000     0.00000    -0.12742
0.00000     1.00000     0.00000     0.00000    -0.06659
0.00000     0.00000     1.00000     0.00000    -0.07214
0.00000     0.00000     0.00000     1.00000    -0.11770
0.00000     0.00000     0.00000     0.00000     1.00000
```

The column on the far right is from the VEOG channel. The other columns are from some of the EEG electrodes. Throughout the file, along the diagonal, are 1's. These are the cells where the existing channels intersect with the new channels to be created. If there were no numbers in the VEOG column, the LDR file would have no effect when applied. In other words, the artifact subtraction is based solely on the values in the VEOG column. These values are the linear transmission coefficients computed in the Ocular Artifact Reduction transform, and will have the highest values at the frontal channels. Note that they are all negative numbers (with the exception of the lower right hand 1.0, which is the intersection of the input and output VEOG channel).

It should therefore be apparent how the subtraction part of the artifact reduction works, when using an LDR file. For any given EEG channel, the weight is 1, so the data points for it are unchanged. The points for the VEOG channel are multiplied by the transmission coefficient (i.e., reduced proportionally to the covariance of the artifact in each channel). When summed linearly, that proportion of the amplitude at the VEOG

channel is subtracted from the amplitude at the EEG channel (because it is a negative number). Since this is an LDR file, it may be applied to other files from the same subject (assuming the data were acquired under comparable conditions).

A more complex LDR file is created when you perform a Spatial SVD transform on a data file. The picture below is a section of the LDR file created when applying the Spatial SVD to the P300.eeg file.

	FP1	F3	C3	P3	O1
COMP1	0.43699	0.20500	0.10985	0.06828	0.02145
COMP2	-0.23946	0.00472	0.15519	0.23956	0.22382
COMP3	0.19567	-0.16845	-0.19916	0.02746	0.29918
COMP4	0.10058	0.10182	0.21074	0.22823	0.22688
COMP5	-0.10222	0.01744	0.07632	0.10142	0.13528
COMP6	-0.14268	0.13720	0.00018	-0.10605	0.24251
COMP7	0.05690	0.19437	-0.00590	-0.19876	-0.26663
COMP8	-0.00500	-0.01628	-0.09789	-0.07939	0.13721
COMP9	-0.09013	-0.09859	-0.07059	0.00165	-0.05779
COMP10	-0.07622	0.01450	0.30376	0.01816	-0.42444

As you can see, the LDR files can get fairly complex. In this example, COMP1 is the first component detected in the Principle Components Analysis, and it is the component that accounts for the largest amount of variance. If you look along the row for COMP1, you will see that some channels have relatively larger weights. These are the channels where COMP1 is most clearly distributed. The LDR is essentially preserving the activity from those channels where the component is most evident (larger weights), and minimizing the activity from those channels where the component is less evident (smaller weights). When summed linearly, the result is the clearest, single waveform depiction of COMP1. As with the Ocular Artifact Reduction LDR file above, you may apply the SVD LDR file to a different, but comparable data file.

The Montage Editor can be used to modify these LDR files. For example, you may rename, delete, or insert output channels using the right mouse button options described above. You can, of course, modify the values contained within the cells, however, we do not recommend doing so unless you have a thorough understanding of the effects it will have on your data.

This concludes the Montage Editor Appendix.

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