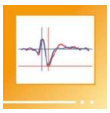
EOG correction in EEProbe: a case study



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Contents

1. Introduction

For some types of ERP experiments, the correction of ocular artifacts is necessary to obtain good average ERP waveforms. This case study explains how this can be applied in the EEProbe signal processing software. In this case study, we will use some standard pre-processing programs and use the interactive viewers to classify, inspect the EOG events, and to assess their influence on the data.

The procedures described apply to EEProbe version 3.2-4.

The example data as used in this document can be downloaded from

http://213.201.130.98/download/EEProbe/Examples/EOG/EEProbe-EOGcasedata.tgz

2. Preparation

2.1. New Experiment

Before we start the real work, you have to decide where the case study will be processed. From within the EEProbe databrowser, you could use **File → Create Project**, or skip this and work in your default project.

Choose **File → New Experiment** and create the experiment "eog-testcase"**:**

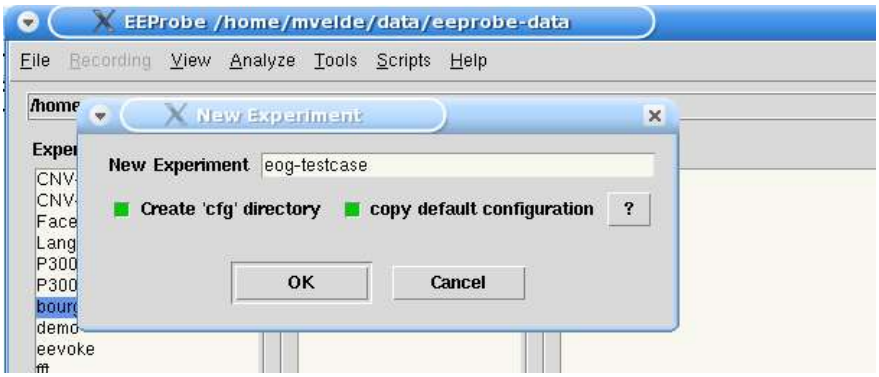

Figure 1. Create the experiment directory for processing the data of the case study.

Use the default options for **New Experiment**: create a `cfg` directory especially for this experiment, and to copy the default configuration files from the project level. This restricts the use of the configuration files to this experiment only and does not interfere with other experiments in the same project.

2.2. Install example data

The example data that will be used in this case study is available in the file `EEProbe-EOGcasedata.tgz`. Go to **Tools → Install / Update** as indicated below.

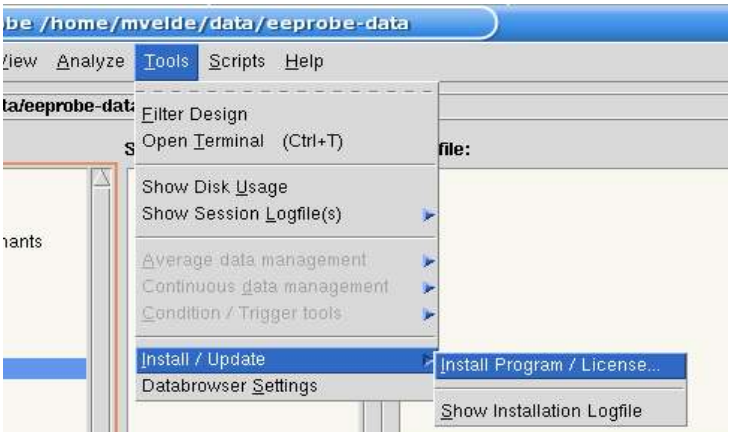

Figure 2. Install the example dataset.

Perform the installation procedure by following figures 2 and 3, and install relative to the experiment directory ("eog-testcase").

Figure 3. Select the compressed archive for installation.

Click on the **Install** button; this unpacks the files `koch01.cnt` and `koch02.cnt`, containing two runs of a typical auditory P300 measurement.

3. Preprocessing

3.1. Review continuous data

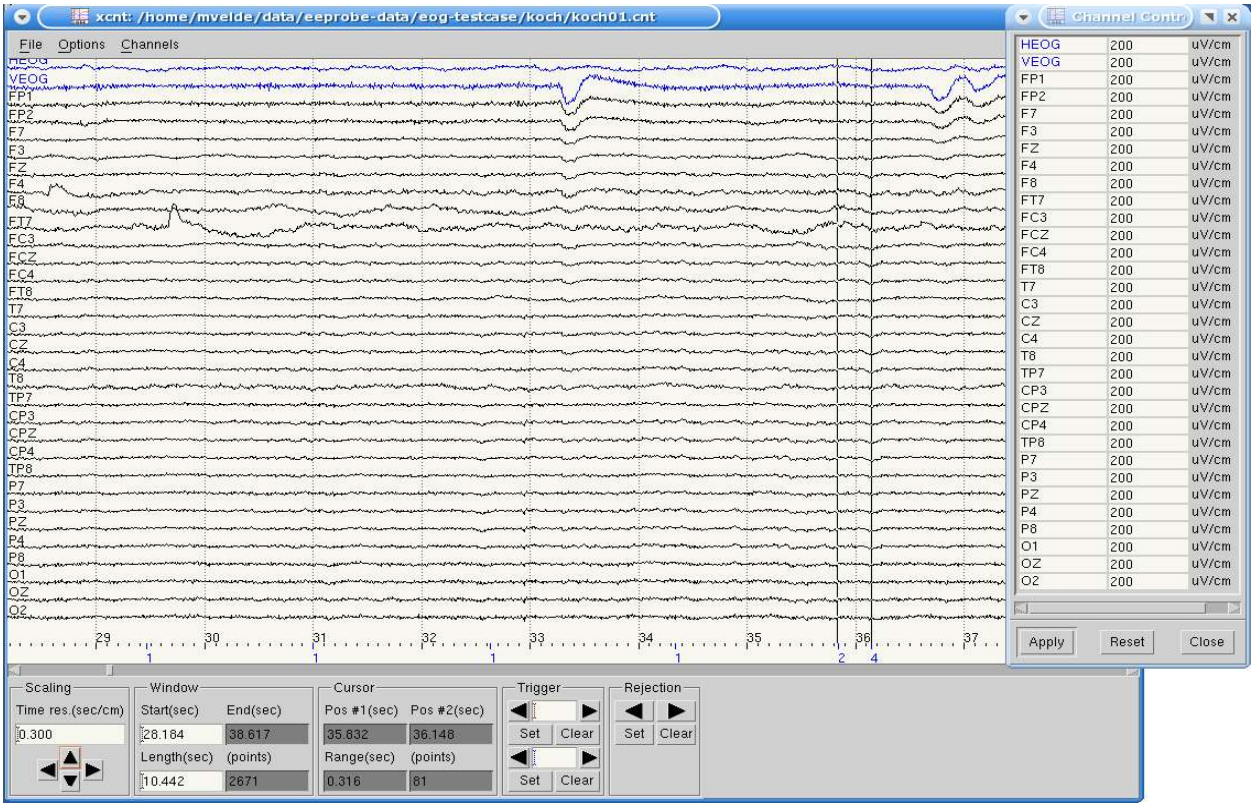

Figure 4. Open and review the continuous data.

The files contains 30 EEG and 2 EOG channels, recorded at a sample rate of 256Hz. The data are already referenced to the 'linked-ear' reference. Double-click on the `cnt` file in the **Workset** to start the continuous data viewer. When reviewing the data, we can observe the triggers 1, 2 and 4 below the time axis; these event codes correspond to the different conditions in an 'active' P300 paradigm, respectively representing the 'standard', 'deviant' tones, and 'subject response'.

3.2. Filtering

The default pre-processing includes filtering; we select both data files in the **Workset**, and apply an adequate filter by defining **Highpass** to 0.3 and **Lowpass** to 30 (Hz). You can use the **?** button to read a brief explanation on how the databrowser uses these settings to generate a FIR file.

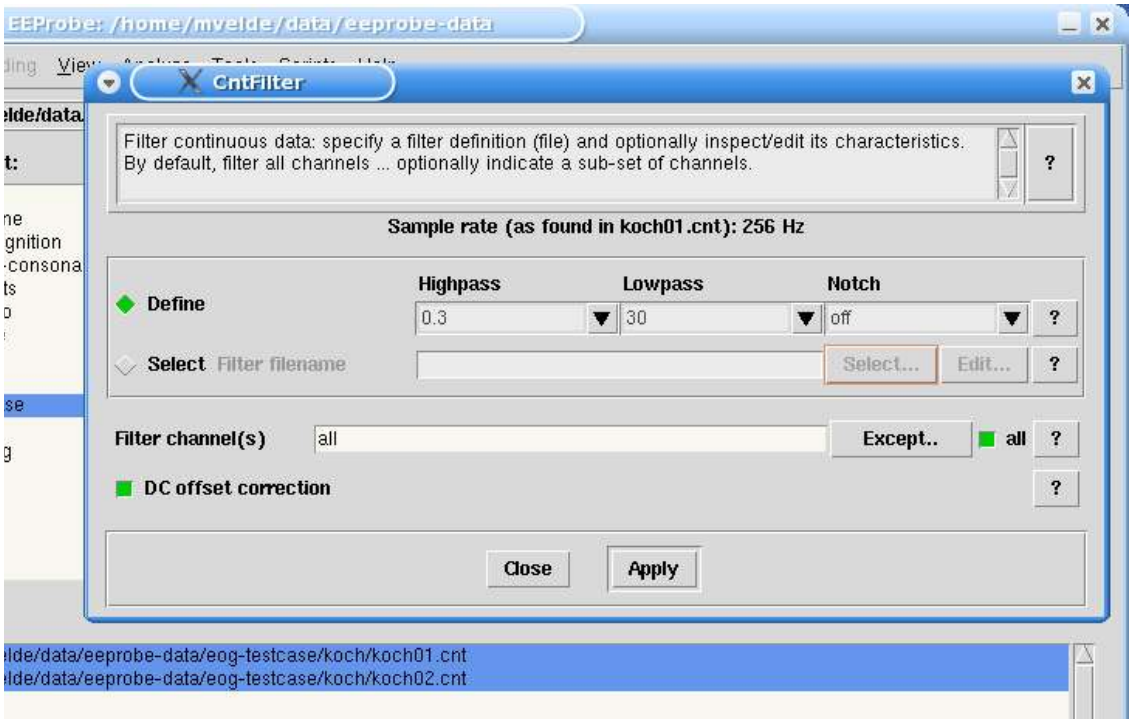

Figure 5. Apply a bandpass filter: use the Define *option to automatically create a fir file (FIR coefficients are calculated in the background, through the* firfilter *program).*

Click the **Apply** button to start the filtering process. This may take some minutes, depending on the speed of your computer. After filtering, the output files `koch01f.cnt` and `koch02f.cnt` are automatically selected in the Workset, which you may review using one of the continuous data viewers.

3.3. Conditioning (optional)[1]

In order to obtain optimal average waveforms for both conditions, we want to perform the averaging on all deviant trials only on *correct* trials. This means that we want to check on the correct response of the subject, within a certain time window after the 'deviant' tone.

For this pre-processing step we select the trigger files `koch01f.trg` and `koch02f.trg` that are associated with the `cnt` files, and choose **Tools → Condition / Trigger tools → Trigger / response validation**.

The **Target** and **Response** triggers should be set to 2 and 4 respectively, and we make use of the **Inter-Stimulus-Interval criteria** to limit correct triggers pairs within the time interval of **150** to **800** milliseconds (see figure 6). We will change the target trigger code to 22 for the trigger pairs that meet the 'search criteria'.

1 For experiments where no response dependent averaging is performed, this step can be skipped. The trigger code associated with the 'response' trials is then kept unchanged (in this case code '2' for condition 'deviant'). This results in a different averaging configuration file for starting the EOG detection program (see section 4.2. Edit configuration files).

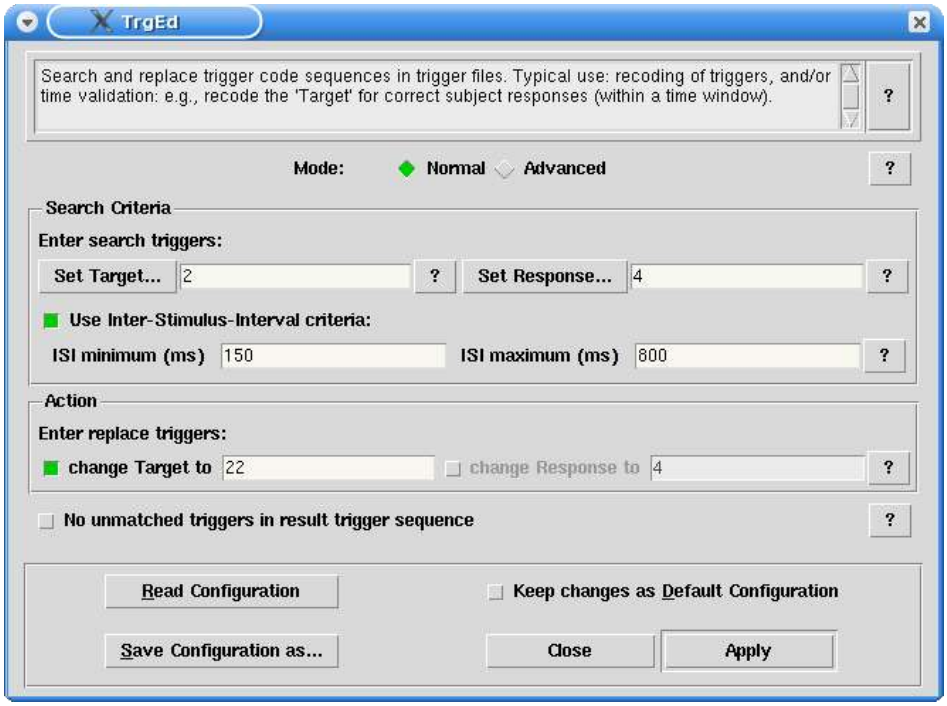

Figure 6. Recode the correct trials for the 'deviant' condition.

After clicking the **Apply** button, the trigger files are updated according to the above parameters. The corrected 'deviant' trials can be identified with the new trigger **22**.

Use the **Tools → Condition / Trigger tools → Trigger count / ISI inspection** tool to quickly review the triggers as present after the conditioning step:

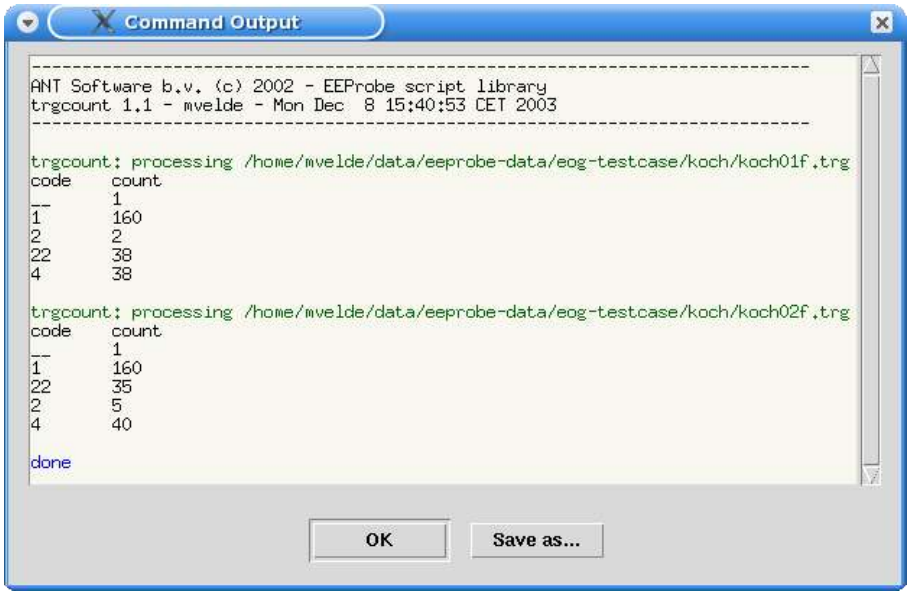

Figure 7. Review triggers using the 'trgcount' script (via the databrowser).

4. EOG classification

The EOG classification step should always be the last action taken before averaging. The *propagation factors* as needed for the correction (which is performed during averaging), are calculated for a specific channel layout and will be invalid for data that is re-referenced to a different channel setup.

The EOG classification is performed interactively using the 'xeog' viewer program. This viewer can be started via the EEProbe databrowser in its 'Classification mode' using some configuration files (for details, see the on-line reference manual). The databrowser will check some *dependencies* before actually starting the program: the *trigger file* and the *rejection file*. Both need to be present (having the same basename as the `cnt` file). If the `trg` file is not found it will be created automatically using 'cntevents' program; for a non-existing `rej` file an error message will be shown.

The EOG classification consists of two stages:

1. Prototype scoring, for which we have to perform rejection analysis, and
2. Trial classification, which depends on proper setup of your trial definitions.

Below, the paragraphs present the various steps in a logical order, as performed in practice.

4.1. EOG detection: rejection analysis

Before the EOG activity can be inspected, the data is scanned for the 'candidate' EOG events. This is performed using one of the rejection procedures as available via the EEProbe databrowser, **Analyze → Reject Continuous**. Start this analysis with the output file(s) of the filtering step selected in the **Workset**: `koch01f.cnt` and/or `koch02f.cnt`. You can choose to perform the rejection analysis only on the first file, or on both files in one run.

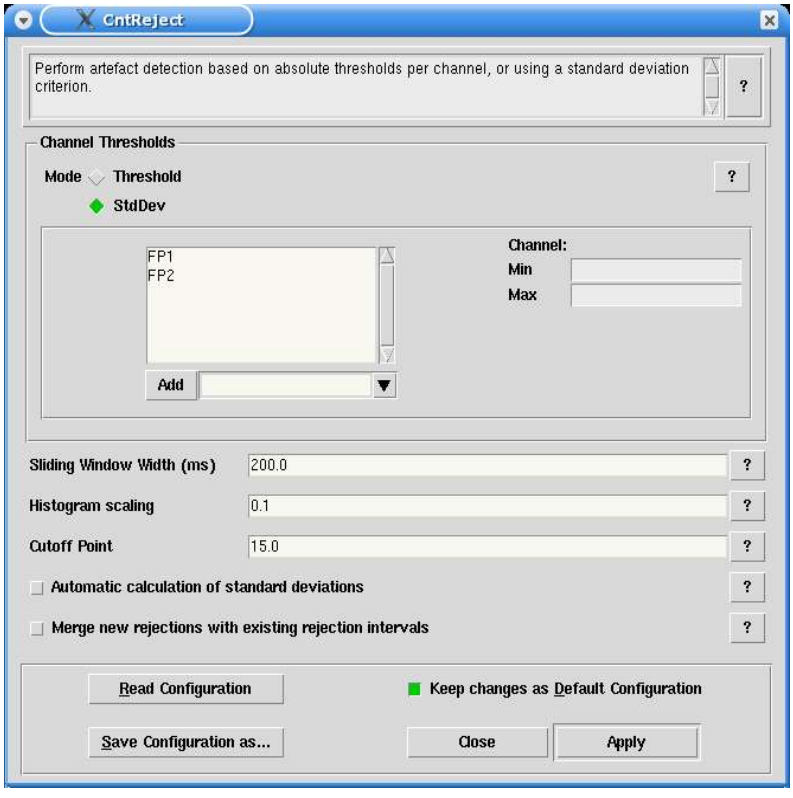

Figure 8. Start the "Reject Continuous" dialog.

The parameters for rejection as shown in this dialog, specify that channels `Fp1` and `Fp2` are used to detect signal outliers using the “Standard deviation” criterion. However, we would rather include the EOG channels of the current data set. Follow the steps described in the figures below to make the detection specific to these channels.

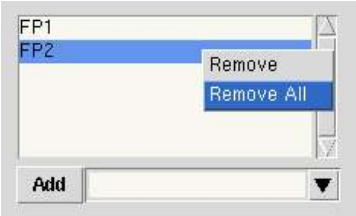

Figure 9. Click in the channel listing, and right-click to select "Remove All" in the popup menu.

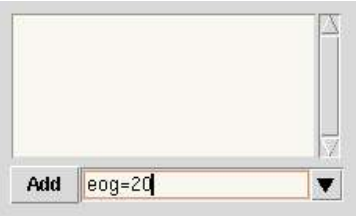

Figure 10. Enter 'eog=20' *to quickly add the EOG channels with a StdDev criterion.*

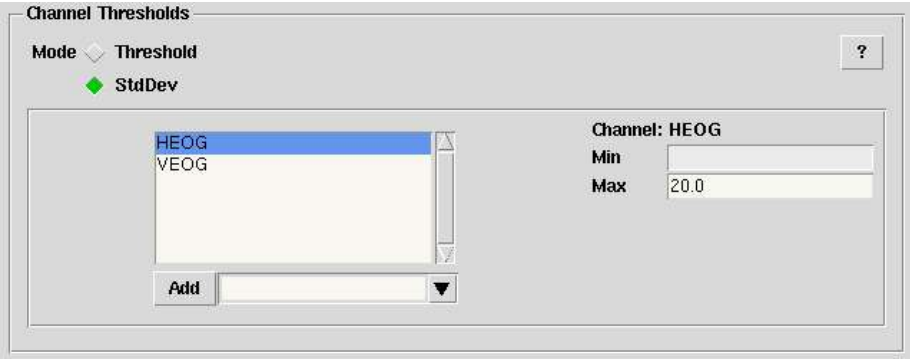

Figure 11. Review the parameters for the two channels by clicking on the channel names.

The 'StdDev' parameter as entered here for the continuous rejection reflects the threshold value above which the corresponding samples are marked as 'rejected'. For EOG channels a good default value for the 'StdDev' parameter would have been 30 μV, however, in the current data the ocular activity is of somewhat smaller amplitude. A value of 30 results in EOG artifacts that are not marked completely by the rejection intervals. Therefore we will use a more restricting boundary of 20 μV here.

Select the option **Keep changes as Default Configuration** (see figure 8) to save to the file `cntreject.cfg`, which holds the rejection parameters for the current **Experiment**.

Now click the **Apply** button to start the rejection analysis. This will create a `rej` file for each `cnt` file as selected.

You can review the results of the rejection analysis in the continuous data viewer 'xcnt' or 'qcnt' (double-click on the `cnt` file in the **Workset**) to inspect the effectiveness of this procedure. Almost all EOG related activity should be marked in the data. Use the arrow buttons ◄► for Rejections to quickly browse the intervals marked as rejected (red line).

The rejection intervals as present in the file `koch01f.rej` (and `koch02f.rej`) are used as 'candidate' EOG events, to facilitate the 'prototype scoring' as explained in one of the next paragraphs.

> *Note:* In a different data set, if you had already performed a rejection analysis at this stage of your data processing, e.g., including *all* channels with a certain threshold, you can choose to **Merge new rejections with existing rejection intervals** (see figure 8). However, you may end up having too many 'candidate' events during the 'prototype scoring' step.
> If desired, you can also perform a custom rejection process later, after performing the EOG classification (and optionally 'merge' with the EOG rejected).

In the following paragraph we will first prepare for the 'trial classification' by defining the proper relations for condition names and trigger codes.

4.2. Edit configuration files

Setting conditions: cntaverage.cfg

In order to display correctly the trials and conditions during the classification step, we must prepare the default averaging configuration file `cntaverage.cfg`. This file is used by the databrowser to start the 'xeog' viewer. This configuration file must therefore contain the correct interval definitions, and should hold all relations for trigger codes and condition names. With a `cnt` file selected in the **Workset**, you can start **Analyze → Average**.

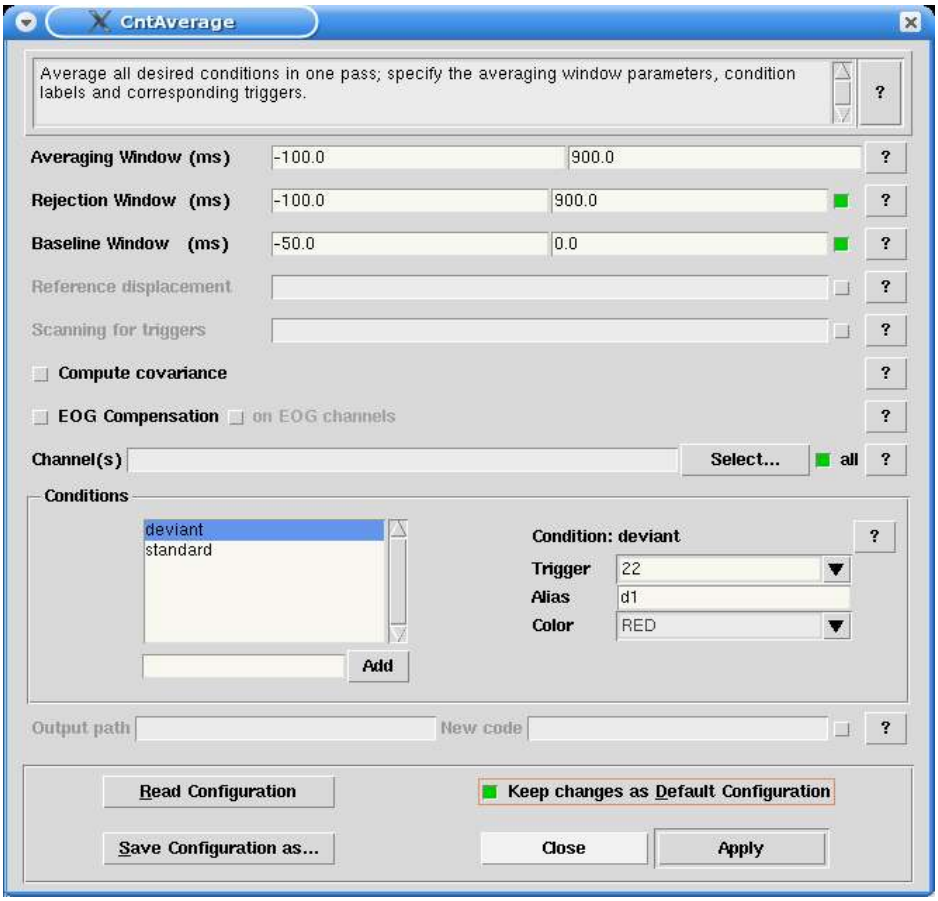

Figure 12. Define the trials in the averaging configuration. Specify the condition names and related trigger codes for all trials in which you may want to correct for EOG artifacts.

The dialog as presented in figure 12 allows you to interactively create the required `cntaverage.cfg` file. Define the condition 'standard' and relate this to trigger '1', and add condition 'deviant' for trigger '22' (which is the trigger code after the response validation). After checking/setting the correct parameters, select the option **Keep changes as Default Configuration** and click on **Close**. This will not start any averaging process, but will save the `cntaverage.cfg` anyway.

If the conditioning step – response validation – is skipped, the 'deviant' code should be '2'.

Setting EOG parameters: xeog.cfg

Some important parameters for the EOG classification/correction process, as well as parameters to control the user-interface of 'xeog', are specified in the `xeog.cfg` file. This configuration file can be edited via the EEProbe databrowser, **Analyze → EOG Detection → Edit Configuration**. This menu item is only accessible when you have one (not more) `cnt` file selected in the **Workset**.

The most important parameters are in the `[eog channels]` section; here you define the two channels that are used to 'build' the *prototype* EOG events (by manual selection) on which the calculation of the

propagation factors is based. These factors define how the EOG activity is subtracted from the each of the other (non-EOG) channels in the subsequent correction procedure.

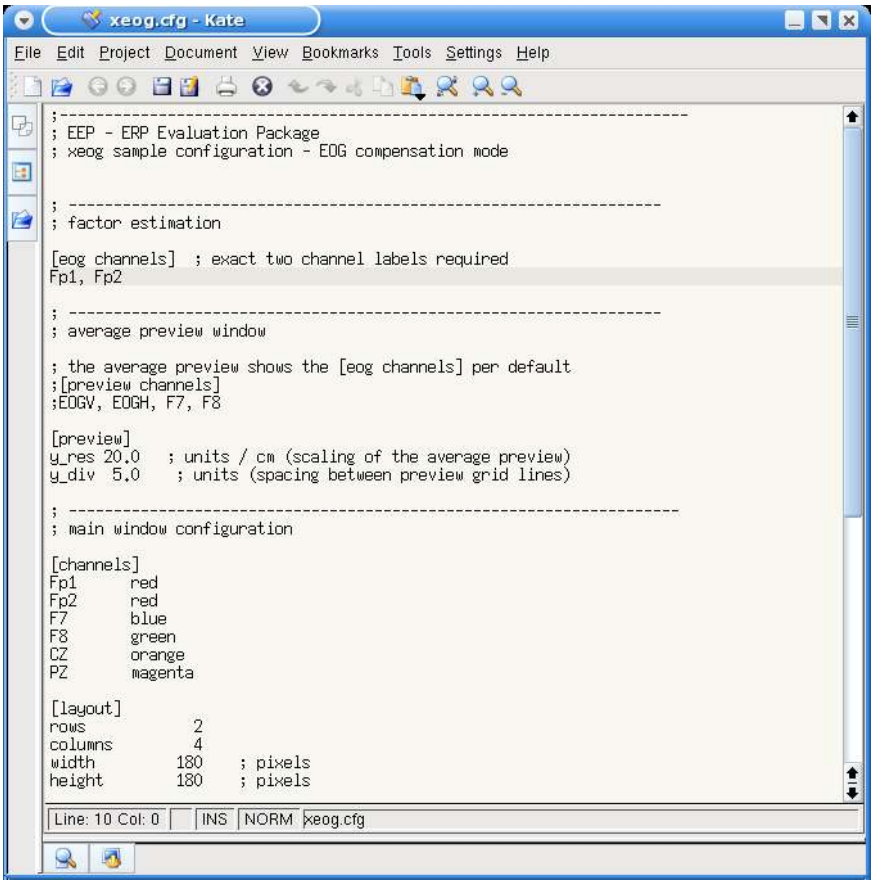

Figure 13. Edit the 'xeog' configuration file to define the EOG channels, and to customize the display layout.

The default `xeog.cfg` file (as in figure 13) contains 'general' settings that will work in almost all (EEG) data. This takes into consideration that not all measurements will include EOG channels, and therefore specify the pre-frontal electrode labels `Fp1` and `Fp2` as 'EOG' channels. For a proper (optimal) correction the inclusion of true EOG channels is much better, so please edit this configuration and use the following parameters for the example data in this case study (shown are only the changed sections):

```
[eog channels]
HEOG, VEOG

[preview channels]
HEOG, VEOG, F7, F8, Cz, Pz

[channels]
HEOG     gray
VEOG     gray
Fp1      red
Fp2      red
F7       blue
F8       green
CZ       orange
PZ       magenta

[layout]
rows            3
columns         5
width         180    ; pixels
height        180    ; pixels
```

As `[eog channels]` we will of course use the HEOG and VEOG channels as present in the current data set.

The next section `[preview channels]` is optional: when left in comments (line starting with '`;`'), the 'average preview' (see 4.4. Trial classification) will show only the two EOG channels, however, it is much more useful to specify some additional channels here to 'preview' the effect of EOG correction. When using this section, do not forget to *delete the semi-colon* '`;`' before the `[preview channels]` header.

In the `[channels]` section, we also add the EOG channels. The channels in this sections will be used in the 'block wise' display of trials and EOG events. Apart from the EOG channels, we also specify some other electrode locations which we would like to (1) inspect for EOG activity and (2) check the quality of EOG compensation. Include positions for instance far left/right, on the central positions, or occipital locations.

If the display resolution is high, you can change also the number of trials/EOG epochs that are displayed together in the 'xeog' program. Change these details in the `[layout]` section. You may experiment with slightly different settings here to create the optimal display layout on your computer.

4.3. Prototype scoring

When the configuration files as described in the previous paragraph have been checked, the **EOG Detection → EOG/Trial Classification** can be started from the **Analyze** menu in the databrowser. In contrast to almost all other procedures, this procedure only works for one `cnt` file at a time.

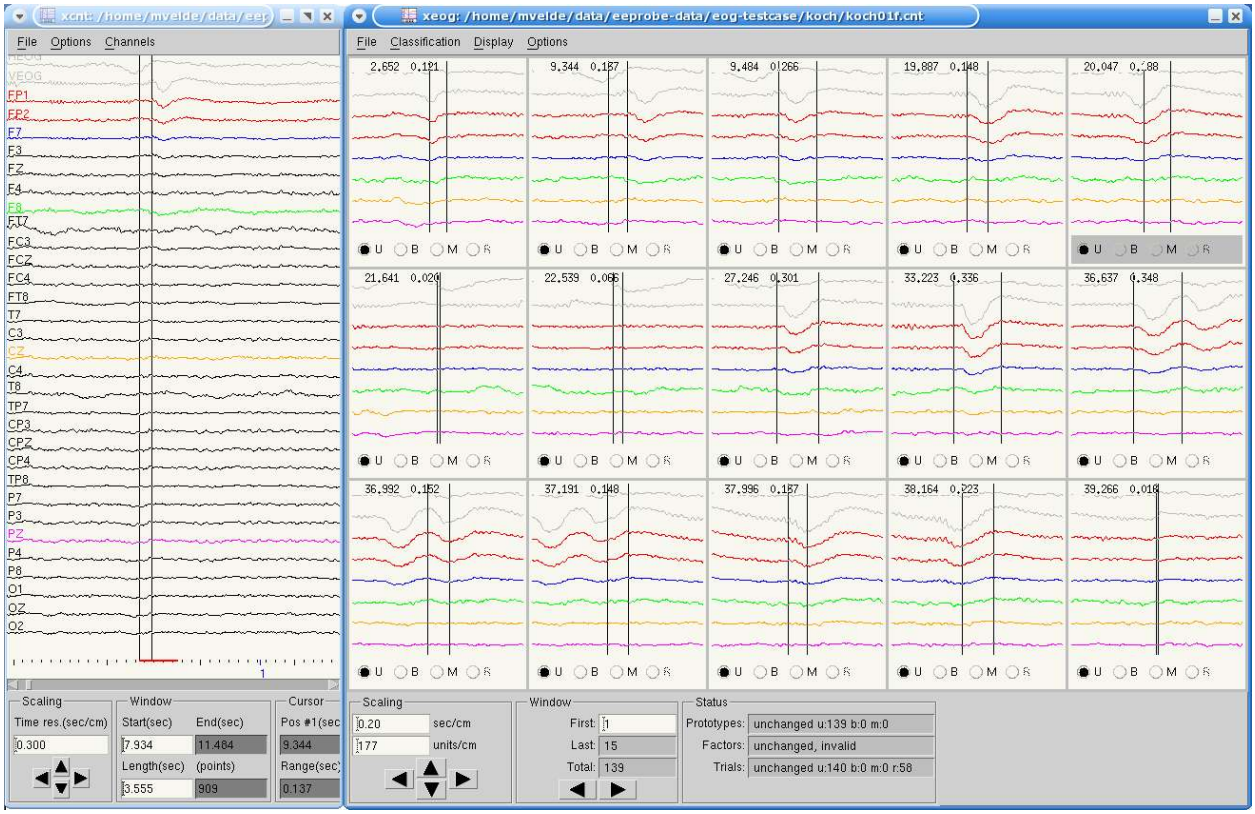

Figure 14. Initial startup of the 'xeog' program, showing the rejections 'block wise' for selected channels. The 'xcnt' viewer shows all channels and is synchronized with the current selection by clicking in each cell.

If the program does not start, you will probably see an error message in the console window from which you started the EEProbe databrowser. This only happens when you have entered a wrong parameter, e.g., wrong electrode label, in one of the configuration files. In this case, please review the procedures as explained in the previous paragraphs.

The 'xeog' program shows you rows/columns of epochs corresponding to the intervals as defined in the rejection file. As in the 'xcnt' program, the interface gives you control over **Scaling** of amplitude and time (buttons ▲▼, ◄►), and using the **Window** buttons ◄► you can quickly browse through all of these 'candidate' EOG events.

The 'xeog' viewer can be used for Prototype scoring (step 1 as in Appendix A. EOG correction workflow) and Trial classification (step 2) without having to restart the program.

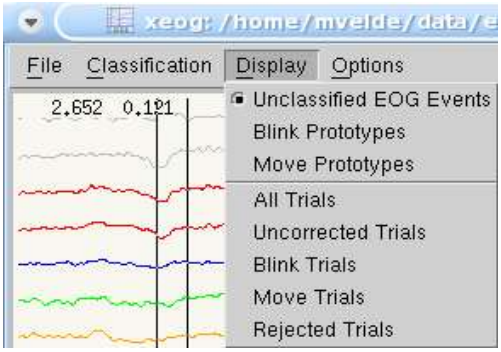

Figure 15. The Display menu controls the scoring/classification mode.

Depending on the selected entry in the **Display** menu, you are either in 'Prototype scoring' (top entries), or 'Trial classification' (bottom entries).

Here we will first describe the *prototype scoring*, and leave the **Display → Unclassified EOG Events** option as it is at the initial startup.

During the manual selection of *prototypes* you should include a number of representative 'Blinks' and 'Move' events. This selection can be made by clicking on the selection buttons 'U', 'B', 'M', to indicate respectively 'Unclassified', 'Blink', and 'Move'. The irrelevant 'R' button ('Rejection') is not available during prototype scoring.

The scoring should aim at including the 'good' blinks/moves. Since the propagation factor sets are calculated from the prototypes, take into consideration that the selection made here greatly influences the quality of the correction. Some general tips are presented below (also see the on-line reference manual):

- Don't use *rare, very large* 'blinks'. They are not typical and would dominate the factor estimation due to their amplitude. At the other hand try not to use the small blinks even if they are frequent. They do nearly not contribute to the factor estimation so you can save your time if you ignore them. A rule-of-thumb is to include 20 to 30 'blinks'.
- The same is valid for 'move', but since good eye-movements are more rare than eye-blinks you may have to use all you can find... You have to include at least 1 move prototype to enable the propagation factor calculation. If you do not find any 'move', you may use any epoch of low amplitude, or use an epoch where a rejection mark overlaps with only half of a 'blink' artifact. If there are not may 'move' artifacts, you can omit the corresponding step in the next step (4.4. Trial classification).
- If you are not sure initially about the specification of your trial windows (as defined in the `cntaverage.cfg` file, see 4.2. Edit configuration files), set a larger time range rather than a shorter one. In doing so, your classification work will be valid in more cases.
- Classify fast rather than careful in a first pass. In a second pass, the options **Blink Prototypes** and **Move Prototypes** in the **Display** menu can be used to review your scoring in the corresponding prototype classes. You will see the mis-classifications from the first pass very fast in the class context.

Some examples for the scoring of 'blink' and 'move' epochs in the current data set are given in the figures below. As described, you should select at least 1 'move', and approximately 20 'blinks'.

In the diagram area you adjust and classify the epochs manually. If you prefer the keyboard to the mouse you can select the current epoch using the keys <←>, <→>, <↑>, <↓>, <PageUp>, <PageDown>, and classify epochs by pressing the starting letter of a class (e.g., 'B' for 'blink'). The <Return> key

synchronizes 'xcnt' to the current epoch. Adjusting prototype epoch limits is possible with the pointer only (left and right mouse buttons). Although this manual adjustment is possible, and may improve the precision and thus quality of the prototype scoring, in most data it is preferred to leave the intervals as defined in the rejection file. This file was created by the rejection procedure and is therefore easy to reproduce, whereas any further manipulation of these intervals is subjective and just more work.

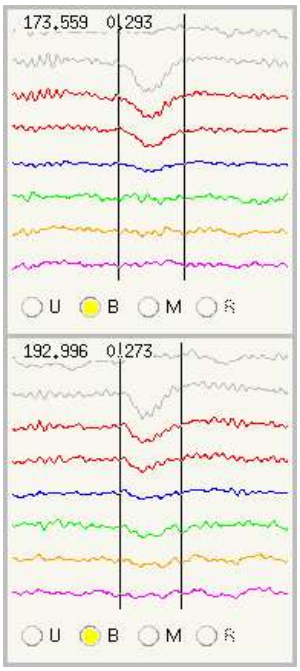

Figure 16. Examples of blink *prototypes.*

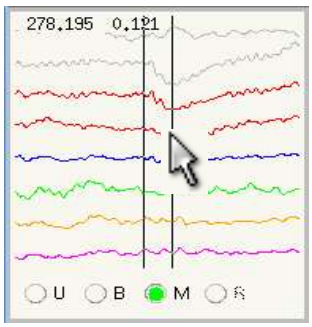

Figure 17. Example move *prototype.*

For detailed adjustment, the left and right mouse buttons can be used to change the epoch limits, between which the propagation factors are calculated.

Figure 16 shows two examples for 'blink' prototypes that were marked initially by the rejection process for the full duration of the blink. The propagation factors are calculated from the data in the rejection interval as indicated. Some other 'blinks' may not have been marked completely (see figure 14); do not select these as prototype.

In the analysis as performed for this document, 20 blink prototypes and 4 move prototypes were selected. The **Status** display will show the progress of the scoring (figure 18).

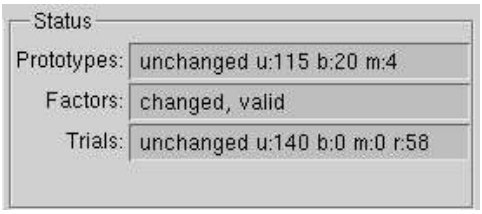

Figure 18. The Status *display shows the details on prototype scoring, factor calculation and trial classifications.*

When you have sc*ored a sufficient* number of 'blink' and 'move' prototypes, select **Classification → Calculate Propagation Factors** in the menu. You will see that the **Status** now indicates 'Factors: changed, valid'. Now make use of the 2nd and 3rd options in the **Display** menu (as in figure 15) to review the prototypes by class. As mentioned before, review here, adjust the epoch limits, or change your scoring to 'unclassified' if you find that one or more of the prototypes should not be included in the calculation.

> If you make changes to the prototype scoring, you again have to **Calculate Propagation Factors** (in the **Classification** menu).

Because the propagation factors have been calculated at this point, the 'xeog' program also shows the resulting corrected signals in the display as a dotted line (if not shown, choose **Options → Show Correction**). Use this to assess the quality of the EOG compensation: signal traces from electrodes relatively far from the EOG electrodes should *not* show much change between the original and 'corrected' trace (as is the case for channels Cz, Pz – the two bottom lines orange, magenta). If necessary, enlarge the amplitudes (or time scale) to enhance the display of the overlay of original and corrected signals.

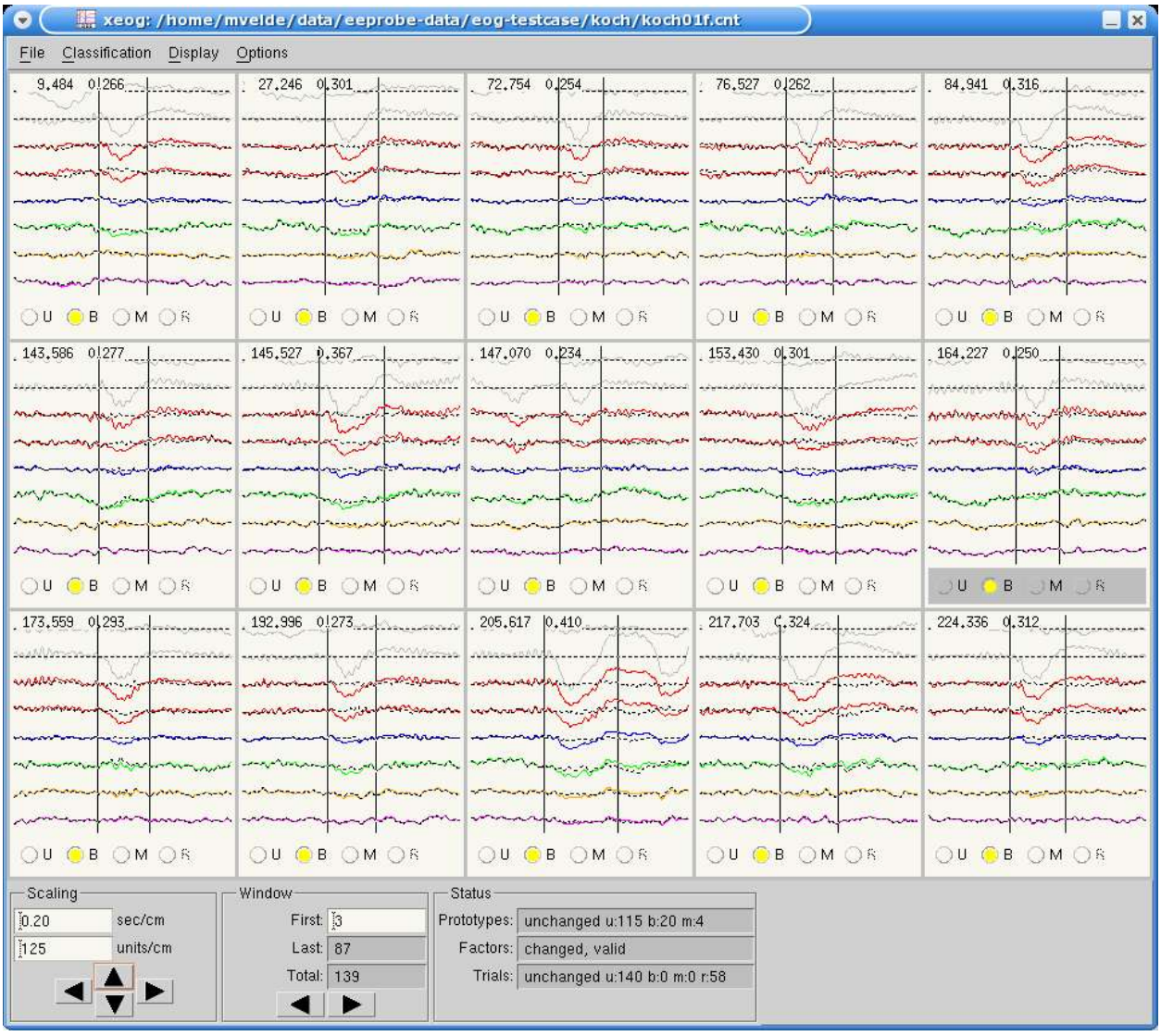

Figure 19. Review the blink *prototypes.*

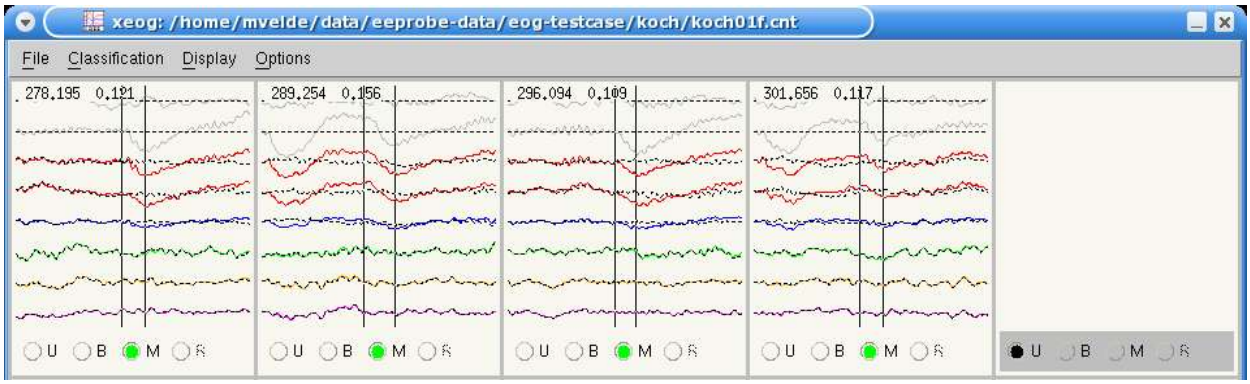

Figure 20. Review the move *prototypes.*

Save the results

To conclude the *prototype scoring* step, save your work:

1. The *propagation factors* are used during the averaging procedure (see Appendix A. EOG correction workflow, file relations). It is therefore important to save these parameters to a `pfc` file. Choose **File → Save Propagation Factors**. The program asks for a filename: you should use the same *basename* `'koch01f'` as in the name of the `cnt` file (see figure 22); this allows the 'cntaverage' program find it automatically.

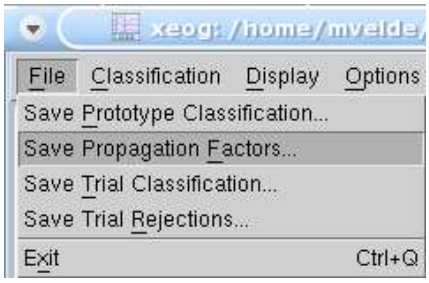

Figure 21. The File menu is used to save all work as performed during EOG classification.

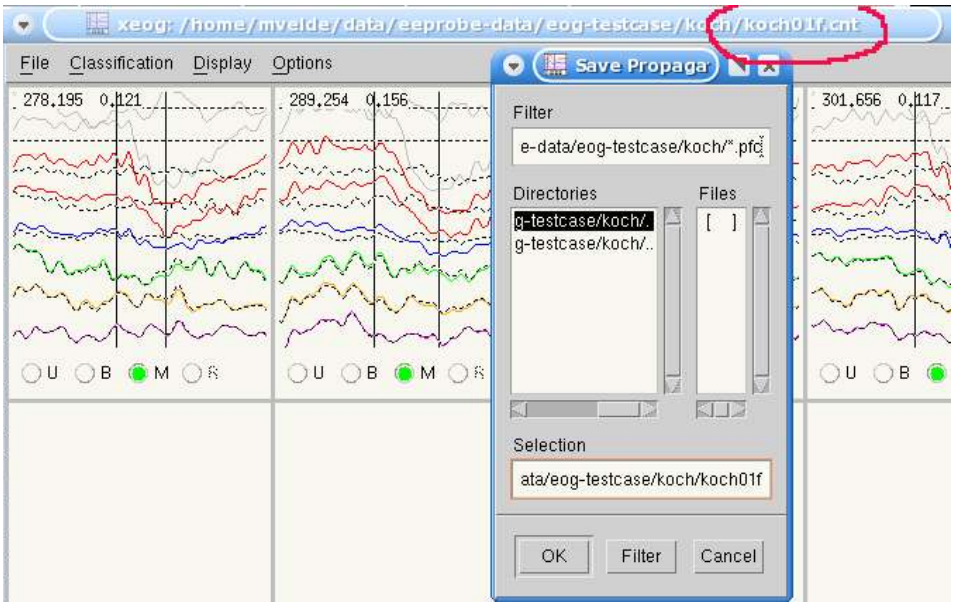

Figure 22. Save the `pfc` *(and* `cls`*) file with the same* basename *as the* `cnt` *file, which is indicated in the title bar. Type the* basename *in the* Selection *field.*

2. Also the *prototype scoring* should be saved to a file. This file has extension `cls` and contains the prototype classes as indicated for the 'candidate' EOG events (epochs as initially specified by rejection file, possibly adjusted manually). Go to the **File** menu, and **Save Prototype Classication**. The program again asks for a filename; use the *basename* from the `cnt` file, to allow the 'xeog' program to find it automatically when you want to review the EOG classification later.

4.4. Trial classification

The next step in the EOG procedures involves the classification of all trials as predefined in the `cntaverage.cfg` (see 4.2. Edit configuration files). During this step, you have to indicate which trials will be corrected for 'blink' and 'move' artifacts. This classification is saved to the trigger file for use by 'cntaverage' (see Appendix A. EOG correction workflow, file relations).

To enter the *trial classification* mode, you do not have to restart the 'xeog' program, but simply go to the Display menu and select **Display → All Trials** (or any of the other entries below – see figure 15). The rows/columns in 'xeog' now show all trials together with the time and condition information (if not shown, choose **Options → Show Legend**).

You can go through all of the trials and indicate manually the 'blinks' and/or 'moves', however, the **Classification** menu provides some options to automate the most common actions. The options are explained below. You may perform the actions presented in 1 to 3 as you read along, however, **do not perform option 4**.

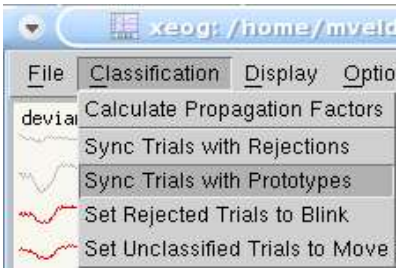

Figure 23. Use the options from the Classification *menu to speed up the trial classification.*

1. When using **Sync Trials with Rejections**, the program checks the *trial rejection windows* (as defined in `cntaverage.cfg`) for overlap with rejection intervals and will classify the trial accordingly. This action is performed at startup by default if no trial classification is found (from a **classified** trigger file, see below: *Save the results*).
2. The action **Sync Trials with Prototypes** checks the *trial average windows* (`cntaverage.cfg`) for common time ranges with prototypes; it sets the classification of corresponding trials to the correct prototype class as scored in the previous step. If a trial contains more then one prototype, the last one is used.
3. **Set Rejected Trials to Blink** is the option that saves a lot of time. Because nearly all rejections in trials are caused by eye blinks, you can better start with 'blinks' and reclassify within this class. After selecting this option, choose **Display → Blink Trials**, and remove the (few) non-blinks (set 'unclassified', 'move' or 'rejected').
4. The option **Set Unclassified Trials to Move** should be used with care. The rejection process as performed by 'cntreject' (see 4.1. EOG detection: rejection analysis) usually marks only "large" EOG events. You may find a lot of your trials infected by EOG but not marked as 'rejected'. You can either leave these trials uncorrected – as would have been done before running the 'xeog' program – or go through the data trial by trial manually and classify to 'blink' or 'move' for all such trials. If you do use this option, all trials that would not have seen any correction previously will now be treated as 'move'. You cannot harm much in applying the 'move' compensation to low EOG amplitudes, however, this approach is not always valid.

In this case study action 1 has no effect at this point in the case study, as described above. When performing action 2, you will change a few trial classifications, which can be seen in the **Status** change. Next, perform action 3, and review using **Display → Blink Trials**.

You can undo the options 2, 3, 4, by selecting again option 1.

Save the results

After the *trial classification* step, save your work! Go to the **File** menu, **Save Trial Classification**, and save the `trg` file. For the `koch01f.cnt` file, select and overwrite the existing trigger file `koch01f.trg`; the classification results are added to the file to transform the trigger listing into a '**classified** trigger file'. The original trigger file contains three columns, the classified version contains additional columns to indicate the 'unclassified', 'blink', 'move', or 'rejected' class. You can easily add the trigger file to the **Workset** in the databrowser, and inspect its contents by double clicking on the file.

The classification as present in the 'classified trigger file' is *only* used for EOG Compensation, and is *only* active when the corresponding option is used in the 'cntaverage' program. You can always revert to the original trigger file (and undo changes from EOG classification or Conditioning) by selecting the `cnt` file in the **Workset** of the EEProbe databrowser, and choosing **Analyze → Extract Events** in the menu.

In 'xeog', the option **File → Save Trial Rejections** can be used to save a new rejection file (overwrite the existing file) that reflects the new (reduced number of) rejections. This is optional and we do not use this in the current case study.

4.5. Review classification results

When starting the EOG detection again for the same `cnt` file, the 'xeog' viewer will automatically use the saved results, allowing you to review the prototypes and trial classification. The most important file in this respect is the `cls` file, which holds the prototype classification. If you have this file (`koch01f.cls` for `koch01f.cnt` in this case) you can quickly go through xeog's **Classification** menu, recalculate the propagation factors, and perform the trial classification as explained in the previous paragraph.

A very useful tool to assess the quality improvement achieved by the EOG compensation algorithm, is the **Options → Preview Averages** tool. Corresponding to the `[preview channels]` section in the `xeog.cfg` configuration file (see 4.2. Edit configuration files), you will be able to review the resulting average waveforms after EOG compensation (see figure 24).

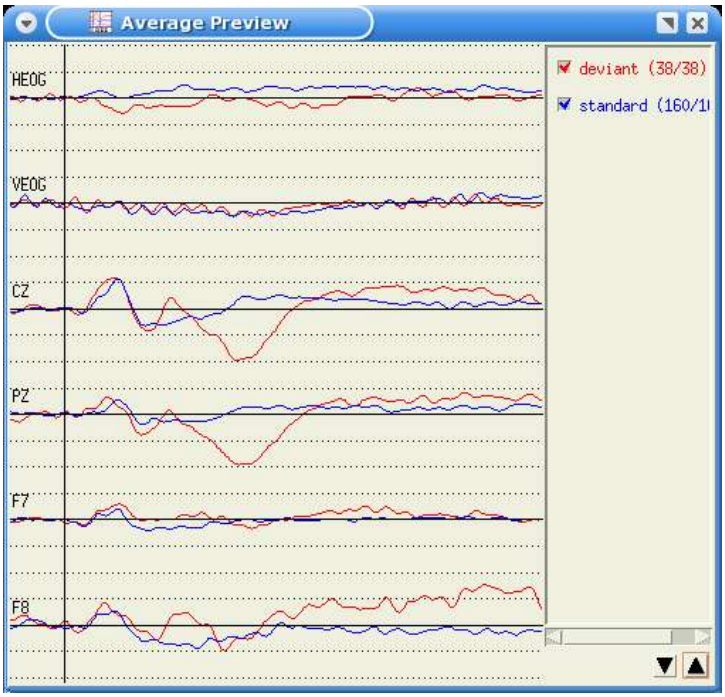

Figure 24. Average preview for selected channels in the current data set (negative plotted downwards).

The **Average Preview** window shows the desired channels on the left, and the condition names on the right. Resize the window to accommodate for the number of channels shown. Include a condition in the preview display by clicking on its checkbox; the averaging may take some time for the initial display of the average waveforms. However, then it allows you to interact much more direct: the average preview is updated immediately when changing any of the *trial classifications*. This allows you to review in detail the impact/improvement/deterioration of the correction in relation to the changes you make.

If you have made changes to the trial classification, do not forget to save the new '**classified** trigger file' via **File → Save Trial Classification**.

5. EOG correction

5.1. Averaging

After performing all steps as explained in the EOG classification chapter, we can calculate the EOG-corrected averages for the P300 data as available for this case study.

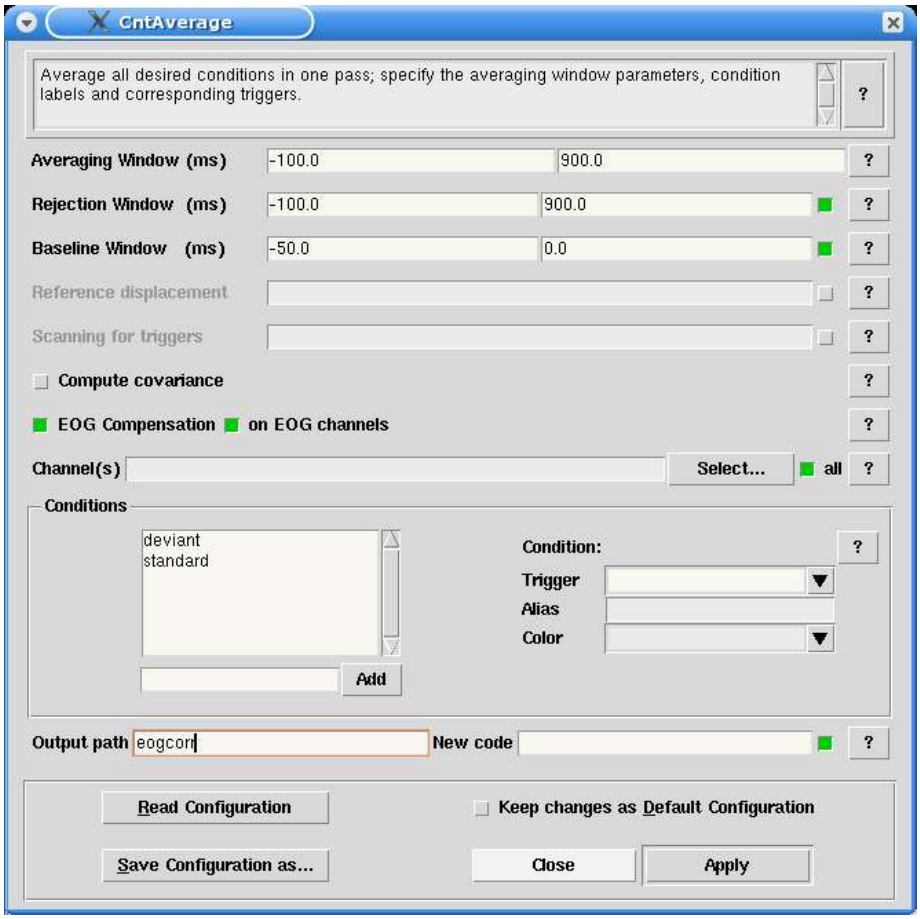

Figure 25. Start the averaging procedure with EOG compensation enabled.

Select the `koch01f.cnt` file in the **Workset**, and start **Analyze → Averaging...**

The parameters shown in the **CntAverage** dialog come from the default `cntaverage.cfg` file as created in 4.2. Edit configuration files. The parameters are already correct for the trial windows (the three entries at the top), and specify the correct **Conditions**. Because we have created the propagation factor (`pfc`) file and have a classified trigger (`trg`) file, we can now use the **EOG Compensation** mode. Perform the averaging **On EOG channels** in order to see how well the EOG signals are corrected. Ideally, the correction should suppress most or all EOG activity (e.g., see figure 24).

We will perform the averaging twice, to allow inspection of the influence of EOG correction. For the first run, when using the EOG correction, set the **Output path** to 'eogcorr' (see figure 25). This means that the 'cntaverage' program will create the subdirectory 'eogcorr' in the Subject directory. You should see a **Command Output** window showing messages similar to this:

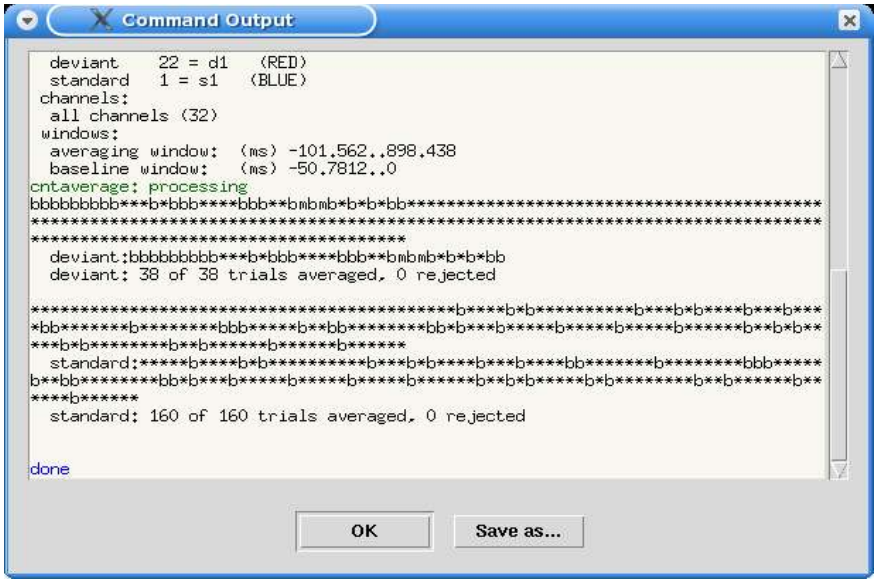

Figure 26. The output of the current averaging procedure shows the applied EOG compensation as 'b' and 'm' for the corresponding blink *and* move *trials.*

For the second run, select again the `koch01f.cnt` file in the **Workset**, go to **Analyze → Averaging**. Now do *not* use the EOG Compensation, and set the **Output path** to 'nocorr' .

5.2. Review

To view the averages resulting from the above processing, select all output `avr` files in the **Workset**, and press <Enter>, or select **View → Average**. Right-click on the diagram showing the Cz channel, **Zoom** in and you can see the effect of averaging with and without EOG compensation.

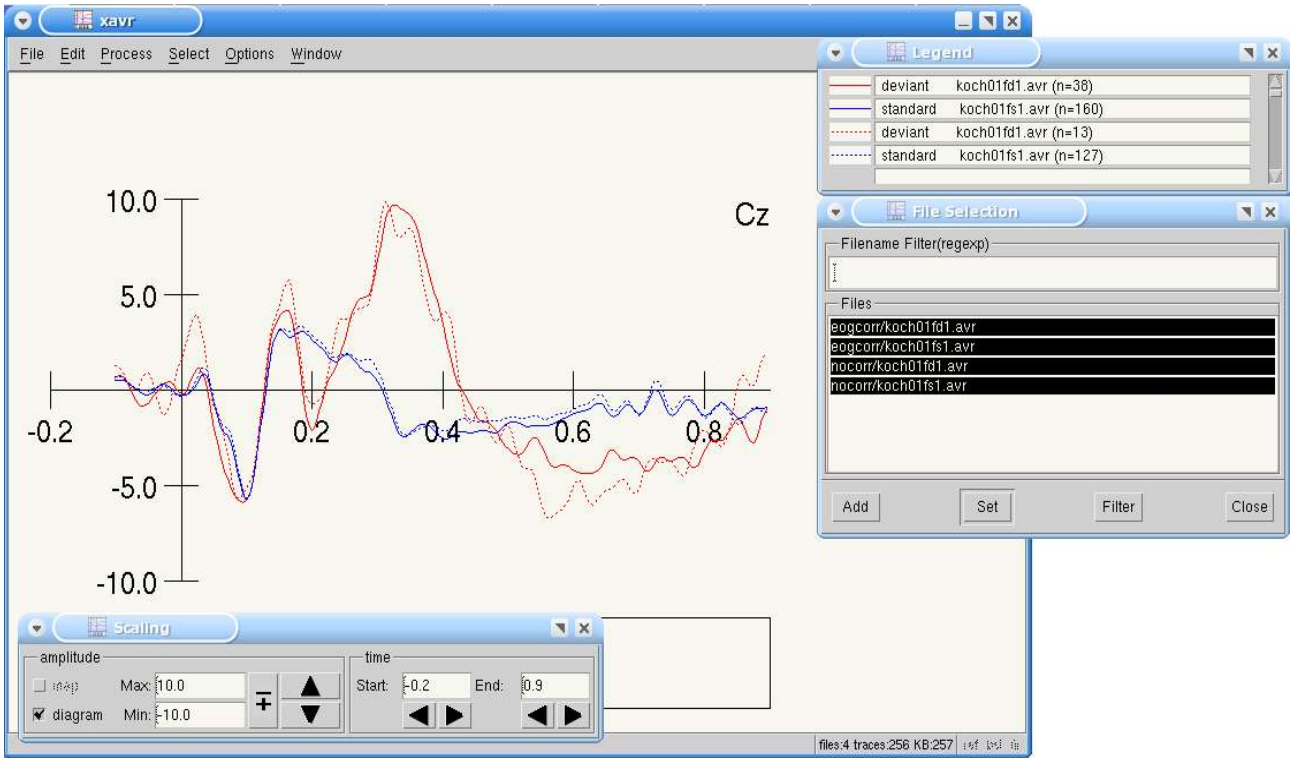

Figure 27. Display of Cz*-average for corrected (solid line) and uncorrected waveforms (dotted line).*

6. Additional notes

6.1. How to re-use propagation factors (within subject)

The example data for this case study contains another file measured in the same subject, using a similar P300 protocol. Since this measurement – `koch02.cnt` – was performed in the same conditions, an obvious question that arises is: how can we reuse the propagation factors for the averaging of this second file?

Still the best procedure would be to go through all of the steps as described in this document. However, a quick way to reuse the work as performed for the `koch01f.cnt` file is the following:

1. Perform all procedures as explained in chapter 3. Preprocessing and paragraph 4.1. EOG detection: rejection analysis for the new file `koch02.cnt`
2. Start the 'xeog' program through **Analyze → EOG Detection → EOG/Trial Classification**
3. Perform the **Classification → Set Rejected Trials to Blink** as explained in 4.4. Trial classification

   > You will not be able to preview the result of the correction (signal overlay of dotted lines – see page 13), because we do not have a `cls` file associated with the current `koch02f.cnt` data file[2]. Even if we copy the `pfc` file as explained below, the preview will not be available because the propagation factors remain invalid without a `cls` file (see Appendix A. EOG correction workflow, file relations for file dependencies).

   You can inspect the **Blink Trials** (from the **Display** menu) and quickly browse and change the trials that you think should not be included for EOG compensation.

4. When done, save the 'classified trigger file' `koch02f.trg`, and quit the 'xeog' program
5. Copy the `pfc` file to the new base name, as explained in the figures below:

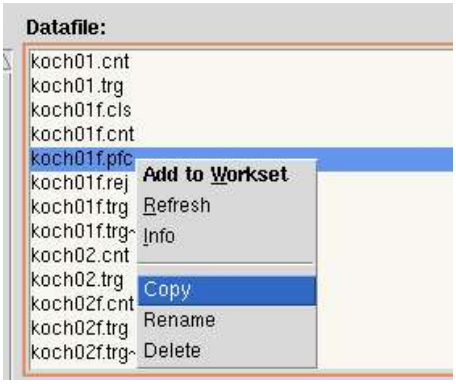

Figure 28. To copy the `pfc` file to reuse it for another data file: select and right-click on the `pfc` file and select Copy *from the popup menu.*

Figure 29. Type the name of the destination `pfc` file (same basename as `cnt` file).

Now you can perform the averaging procedure exactly as explained in chapter 5. EOG correction. The improvement from the **EOG Compensation** in the averages of this second data file is more dramatic on the P300 waveforms than in the first file, as illustrated in the 'xavr' display (figure 30):

2 The only way to preview the correction without creating a new prototype classification for `koch02f.cnt` is to *concatenate* the file `koch01f.cnt` (for which we have the prototype classification `koch01f.cls`) and `koch02f.cnt` to `output.cnt`, and copy the `cls` file to the same basename `output.cls`. The concatenation can be done using the EEProbe databrowser: select both files in the **Workset**, and go to **Tools → Continuous data management → Concatenate files**. Switch on the option to **Use external trigger files** to include the results of the Conditioning step. You also have to create the associated `rej` file: perform the rejection procedure as in 4.1. EOG detection: rejection analysis. Now go to step 3 on this page.

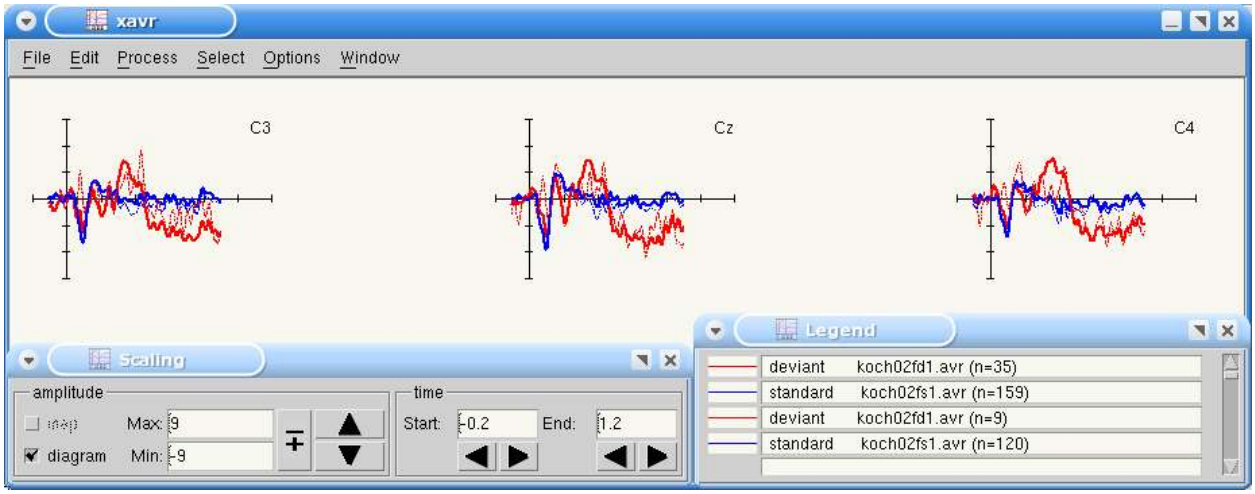

Figure 30. Signal improvement through EOG correction in the `koch02.cnt` *file.*

6.2. How to create an EOG-corrected `cnt` file

For some research purposes it may be necessary to review the EOG-corrected `cnt` file. Also for certain (external) single trial procedures this continuous data file may be required.

As part of the EEProbe programs are available two converters: 'trials2bin' and 'bin2cnt'.

The first converter will build the trials from the `cnt` data, using the configuration and input files exactly the way 'cntaverage' would do before the summation/averaging, including baseline correction and eog correction steps. The output filenames (one file per condition) are built analogous to the conventions of 'cntaverage', creating `bin` files (custom binary format, see the on-line help manual).

The second converter can import the custom binary format to the compressed riff `cnt` format.

The following utility can be downloaded from the EEProbe download web-site[3]: 'trials2bin2cnt'. This downloaded `tgz` file can be installed via **Tools → Install / Update → Install Program / License** (install relative to the project directory). The script/template is then immediately available via the **Scripts** menu: choose its **Edit** option to arrive at the following dialog window:

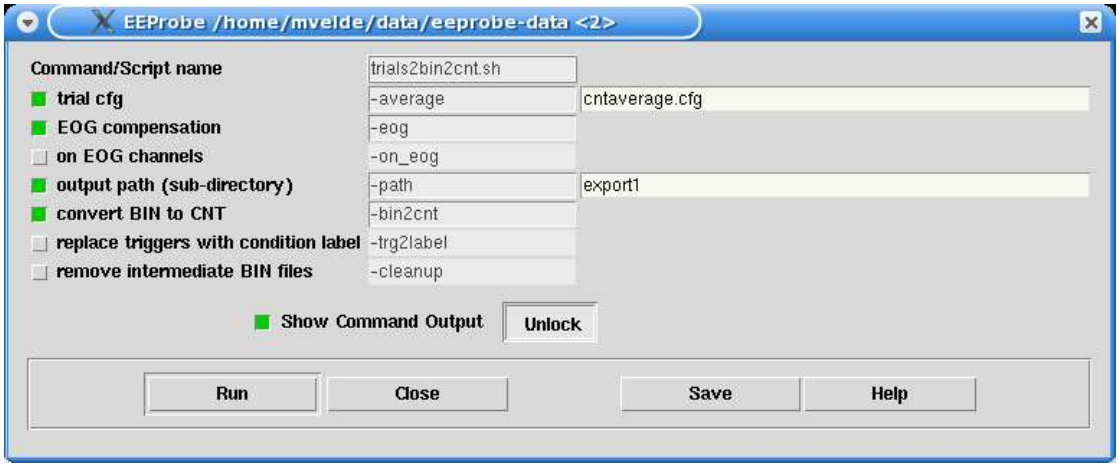

Figure 31. The dialog for the script/template 'trials2bin2cnt'.

The 'trials2bin2cnt' template conveniently combines the use of the programs 'trials2bin' and 'bin2cnt'.

3 http://213.201.130.98/download/EEProbe/scripts/trials2bin2cnt.tgz

Short usage description

Using the default options (as shown in figure 31) will create a `cnt` file for each condition in the subdirectory `export1`. The output files will contain discontinuous data as indicated by 'discontinuity triggers' (see figure 32).

The script will automatically find the `cntaverage.cfg` file in the appropriate `cfg` directory relative to the subject directory. Select the `cnt` file in the **Workset** before going to the **Scripts → template: trials2bin2cnt**. The required `pfc` file, and (classified) `trg` file should be present for the selected `cnt` file.

Optionally you can have the script change the *trigger codes* to the *condition labels* by selecting the corresponding checkbox in the dialog.

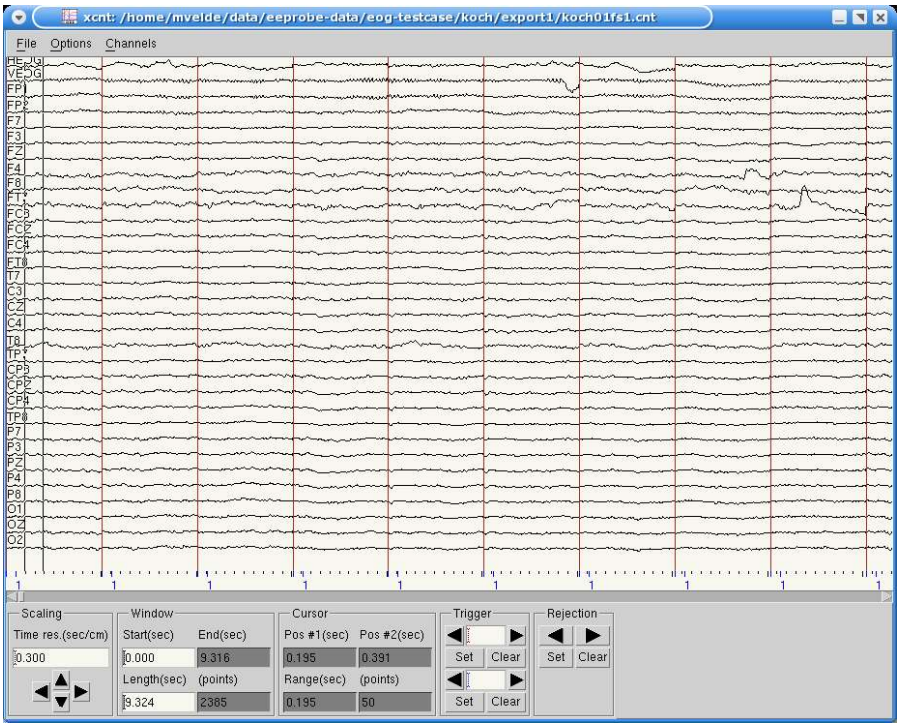

Figure 32. Exported `cnt` file for the 'standard' condition trials.

6.3. Using the results of different rejection procedures

One may argue about the EOG classification/correction procedures as explained that the process in 4.1. EOG detection: rejection analysis does not include all channels and therefore will miss some artifacts.

This little drawback can be overcome by performing again the rejection analysis, now including the desired channels[4]. You may use the option **Merge new rejections with existing rejection file** (see figure 8, page 6) to make sure that you keep the rejections for EOG channels. However, this is not strictly necessary when the classification file `cls` was already created.

With the newly created `rej` file, start **Analyze → EOG Detection**. Probably there will be more rejection intervals than before, however, xeog's **Display → Rejected Trials** will not show anything because the '**classified** trigger file' overrules the rejection file. To include the new rejections you should go through the steps 1 to 3 (and optionally 4) as explained on page 15.

Now you should review with more care the signals as presented by **Display → Blink Trials** since more trials (possibly not contaminated by EOG artifact) will have been marked by the rejection procedure.

4 If your measurement contains a 'bad' channel, you probably have to exclude this from the list of Channel Thresholds, otherwise you may end up with all trials rejected. Bad channels may be interpolated in the `avr` file.

Appendix A. EOG correction workflow, file relations

Procedures 1 and 2 are performed interactively using the **xeog** program, procedure 3 is performed by the **cntaverage** program.