Practicum: Performing ERP analysis in BCILAB

EEGLAB Workshop 2016, Track B

Christian A. Kothe
Intheon

Questions welcome any time! ☺

Outline

1. Preparations
2. Offline ERP Analysis
3. Online ERP Analysis
4. Customizing Approaches

5. Optional analyses: Using an Advanced ERP Paradigm

1 Preparations

Preparations

- … please start unzipping your BCILAB distribution file to some directory on your disk if you haven’t done so already.
- Should take 5-10 minutes (if you’re on Windows, try to use 7-zip or WinZip/WinRAR).
- Don’t put it inside the EEGLAB folder (BCILAB includes an EEGLAB distribution).

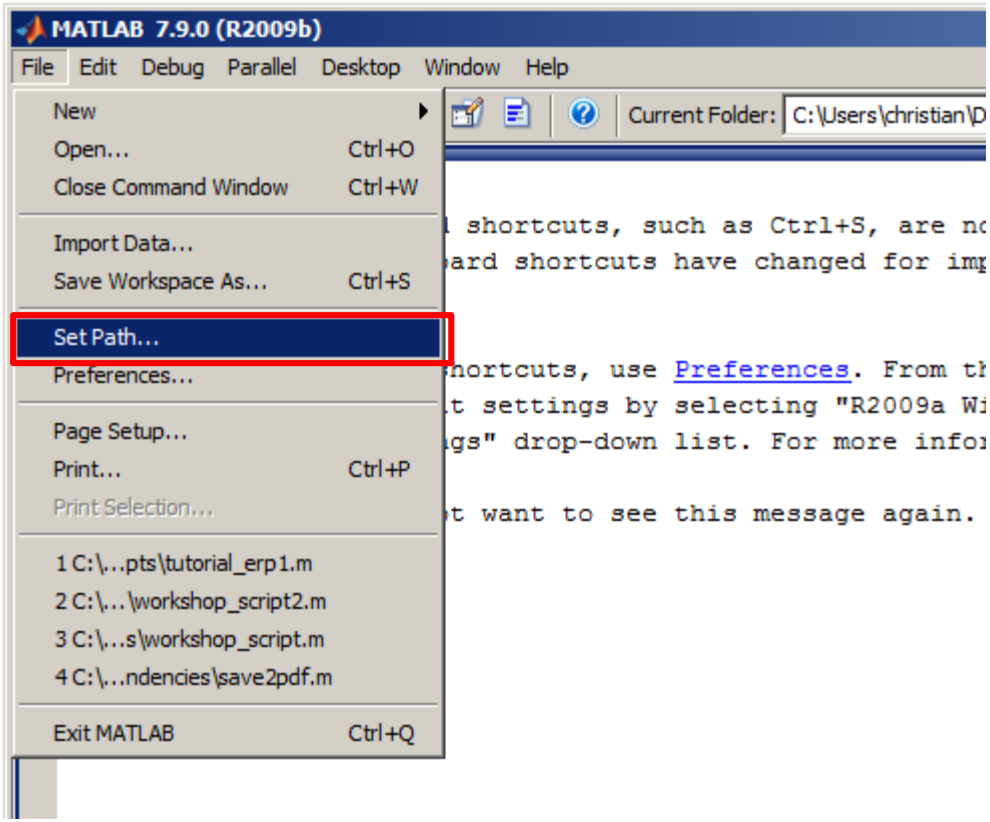
System requirements

- MATLAB 2008a+
- 1GB+ RAM (better: 2GB+)
- Windows, Linux, or Mac
- For smooth workshop: **No** toolboxes in MATLAB path other than Mathworks toolboxes (or EEGLAB)
- To use certain additional features (not covered today): Signal Processing Toolbox, Statistics Toolbox
- To use certain advanced features (also not covered today): Correct MEX compiler setting (this requires Microsoft Visual C++ Express under Win64 and Xcode/gcc under Mac)

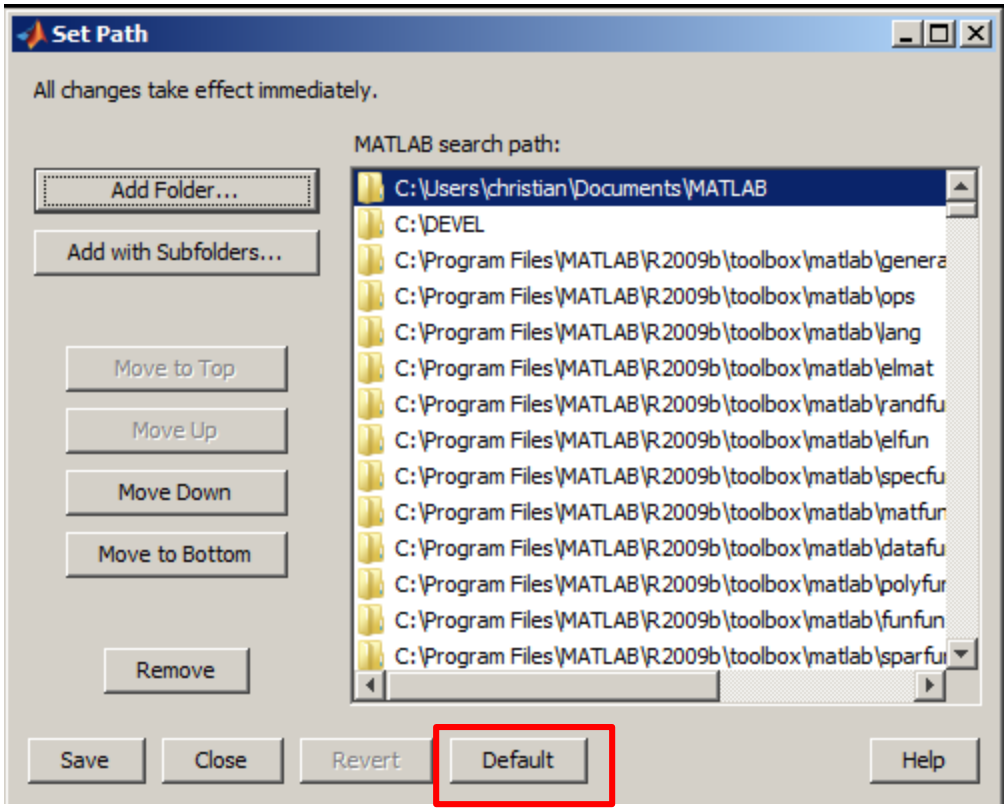
Note: When Processing your own Data

- Note the following requirements:
  - You need proper channel labels (usually the 10-20 labels); 3d locations not necessary
  - You need event markers in your data at time points where the BCI should predict outputs
  - BCILAB needs raw (unprocessed) data
  - Make sure you have a file format supported by EEGLAB

Clearing the Path



Clearing the Path



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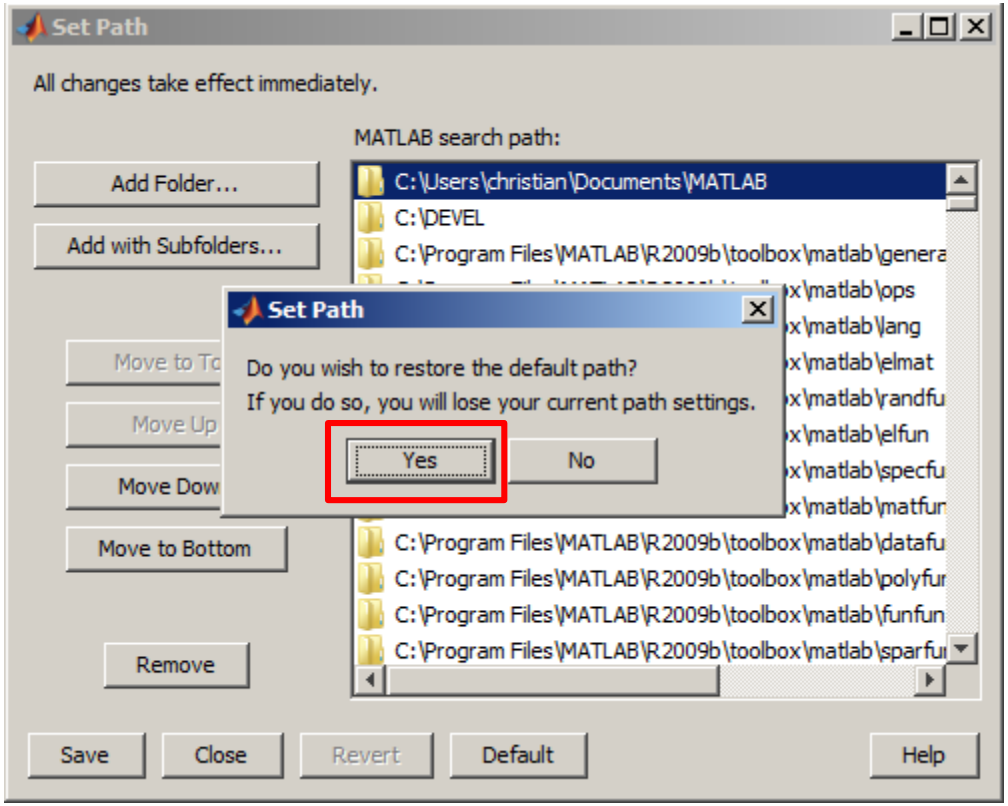

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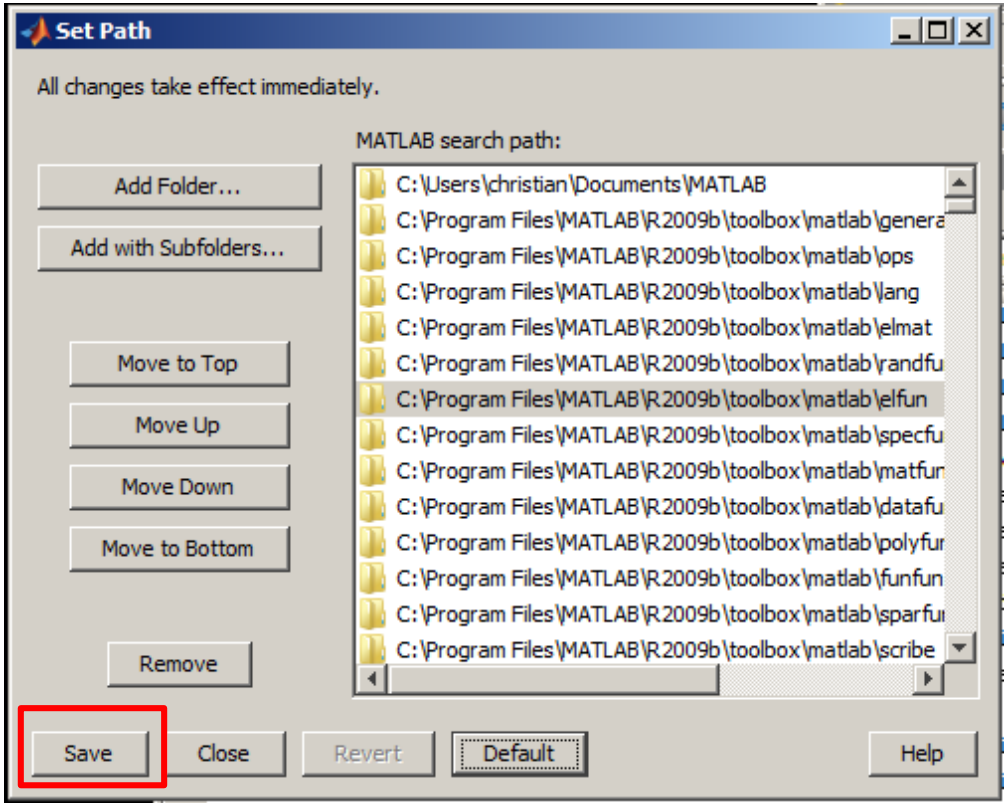
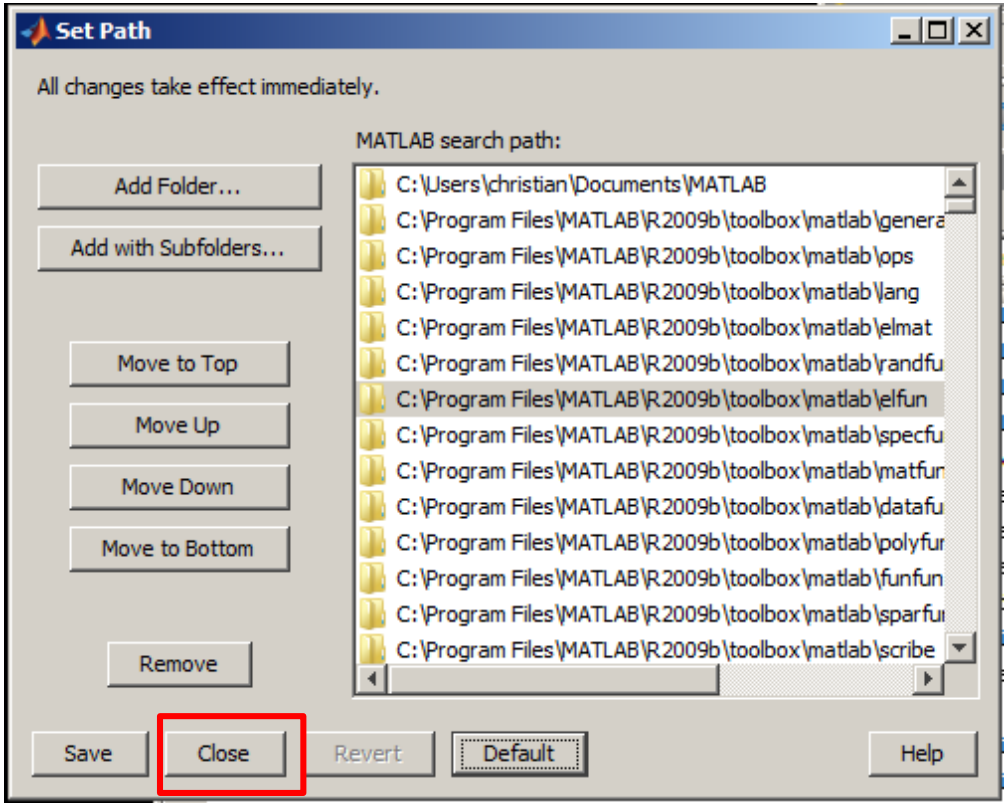
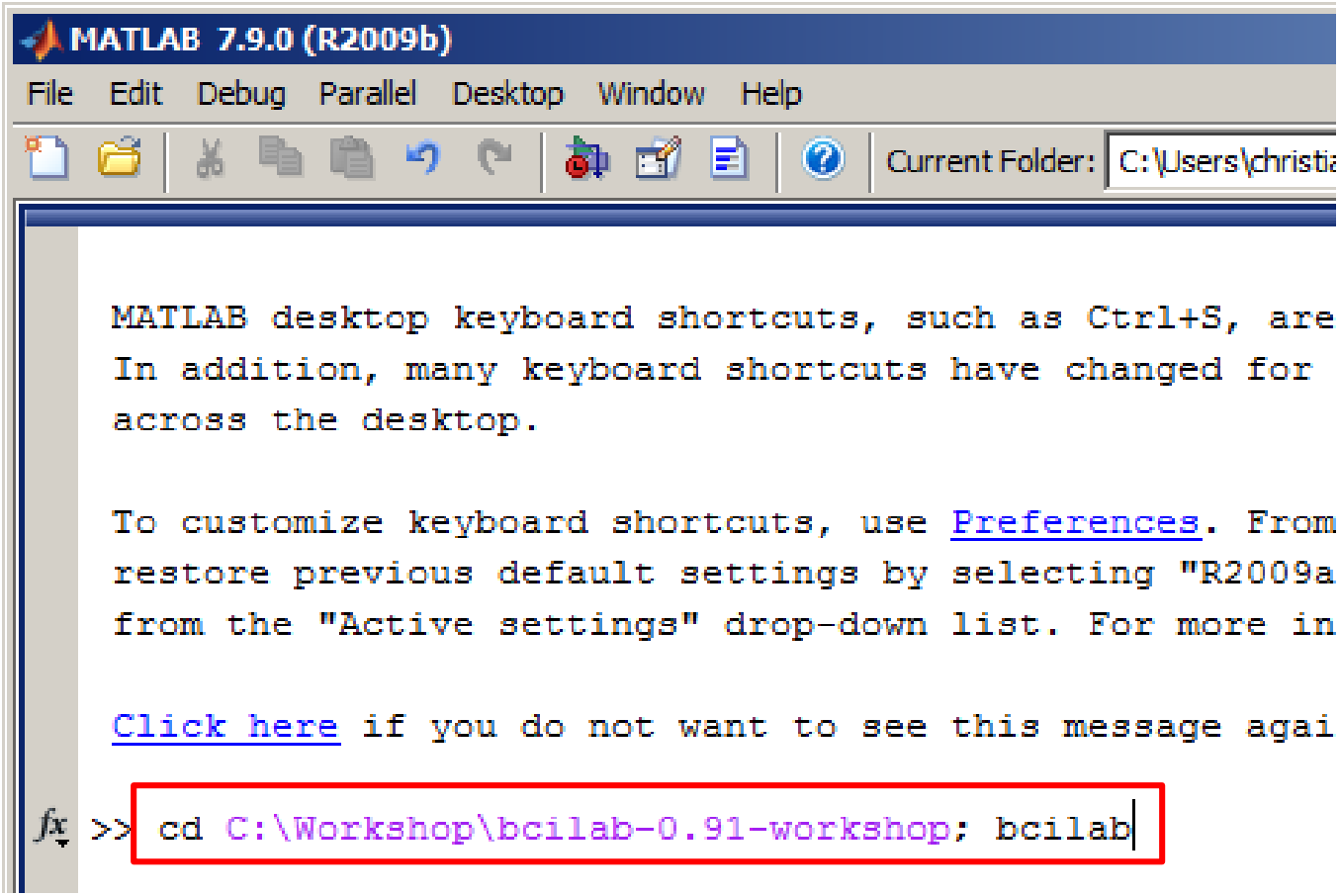


Clearing the Path



Starting the Toolbox

- Type: cd C:\your\path\to\bcilab; bcilab



Starting the Toolbox

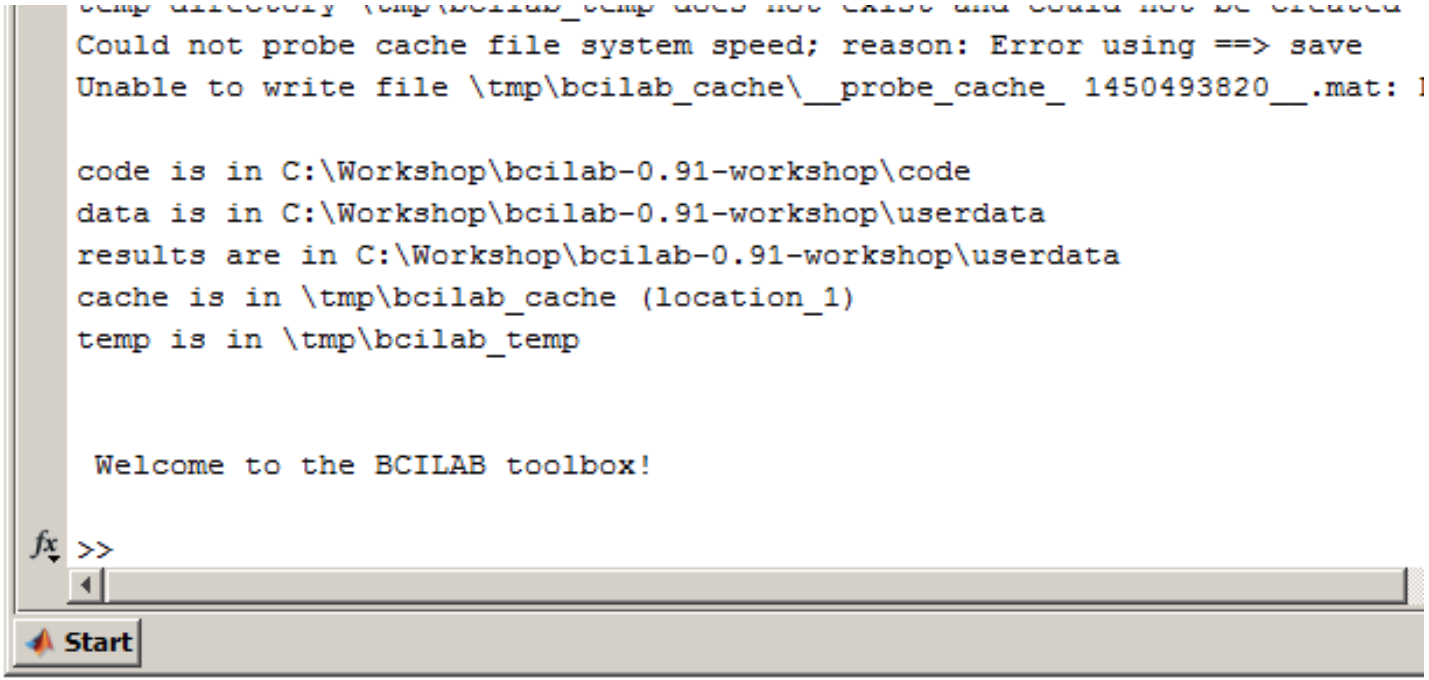
- Or if your path contains spaces, type: cd('C:\your\path\to\bcilab‘); bcilab

Starting the Toolbox

- If you have an unsupported OS/MATLAB combination, BCILAB might ask you some question about compiling functions
  - Just type n (for no) to continue
- If you have things on your MATLAB path that override BCILAB function names, you will get some warnings about it (it's best to remove them from the path)

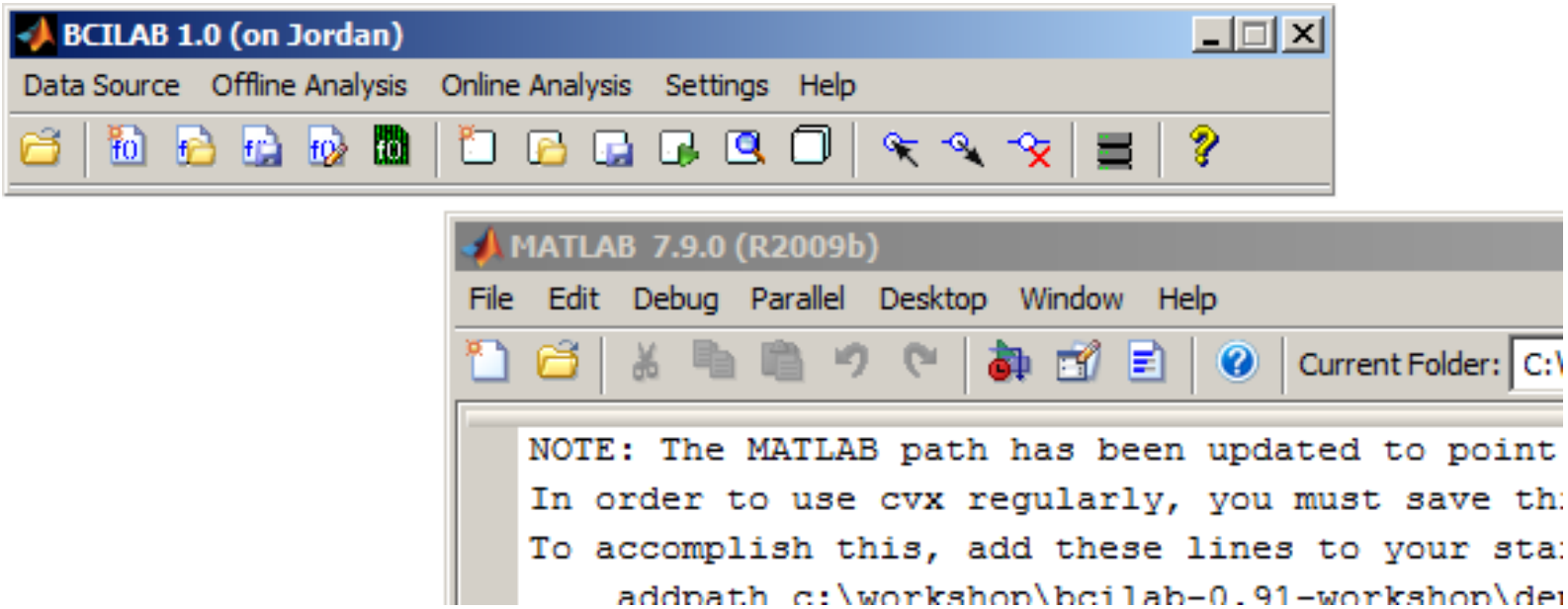
Starting the Toolbox

- You should now see the welcome message

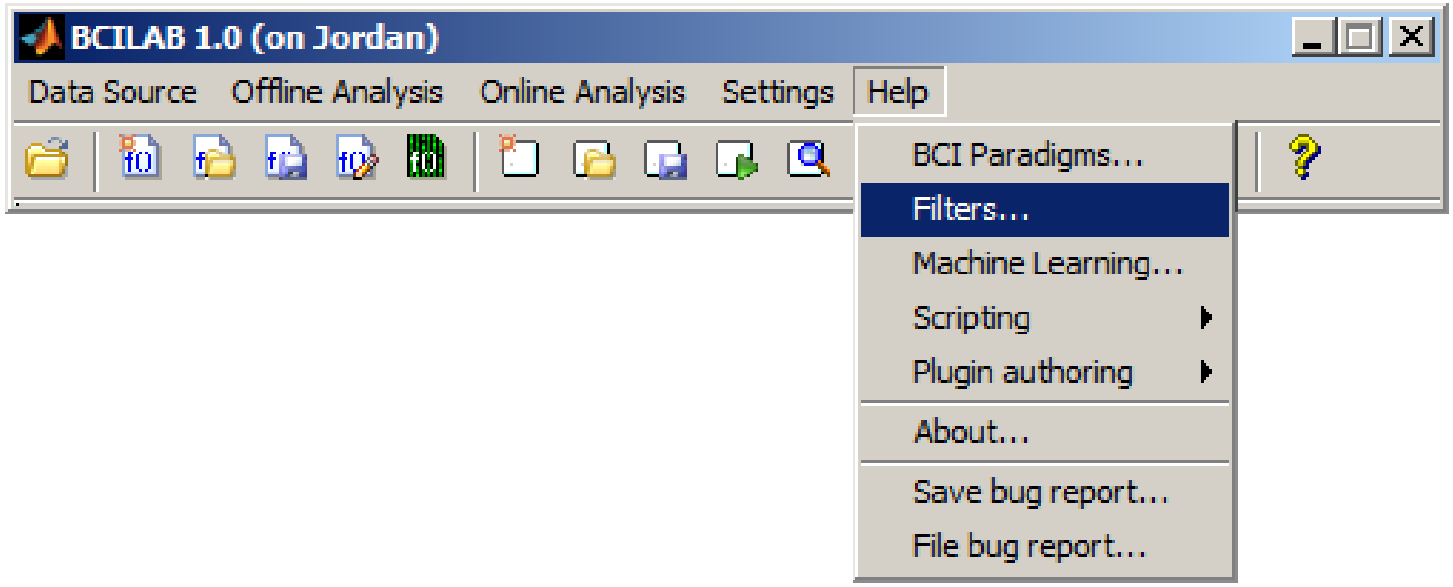


Starting the Toolbox

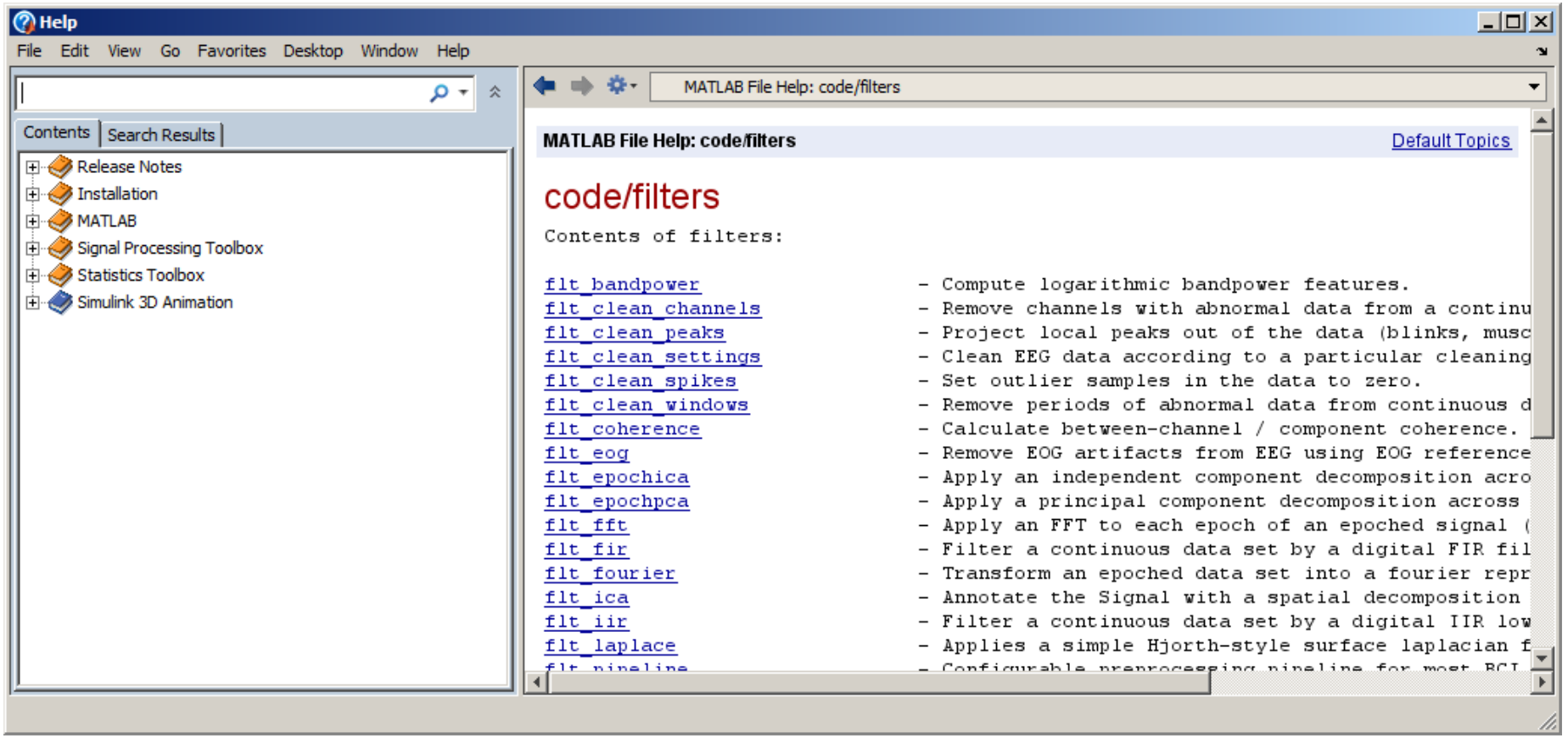
- … and the main menu



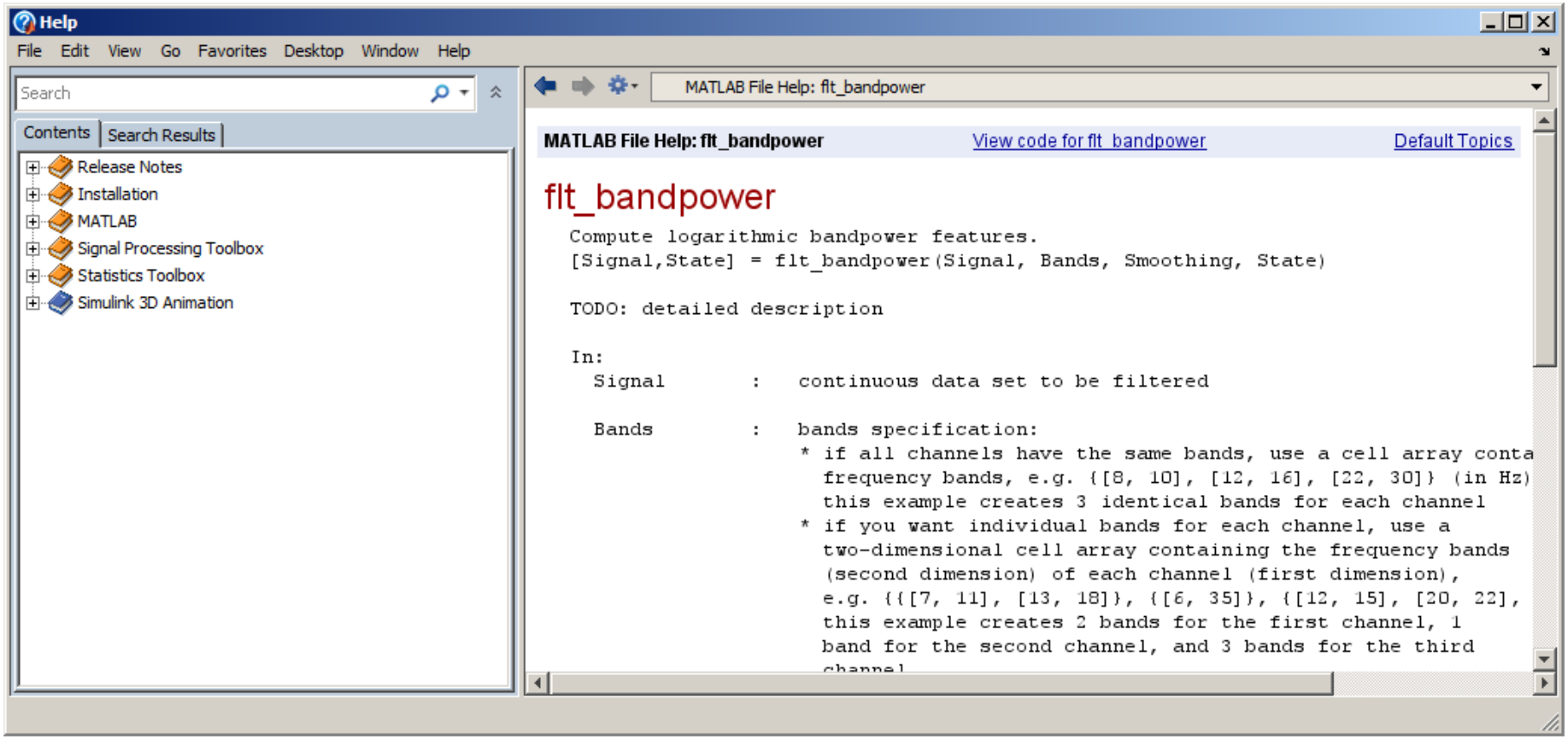
Getting help (if needed)



Getting help (if needed)



Getting help (if needed)



2 Offline ERP Analysis

The Data

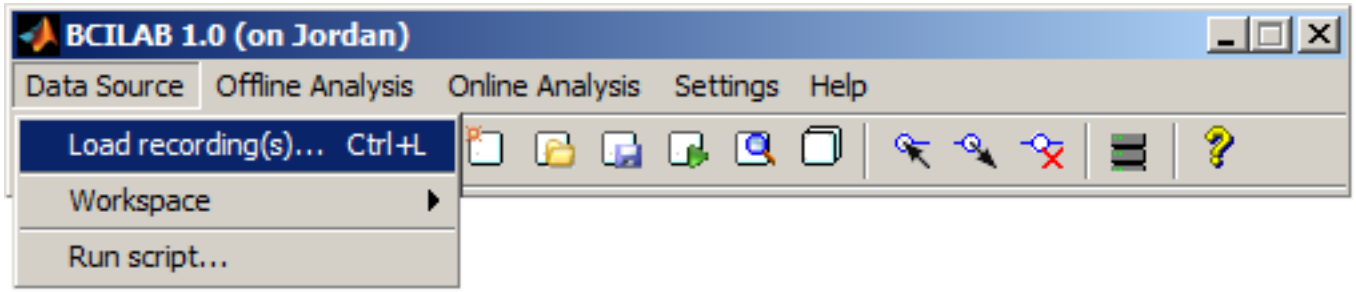
- Provided by Grainne McLoughlin
- Contains data from a Flanker task
- Two groups of markers:
  - S101, S102: person presses a button and **commits no error**
  - S201, S202: person presses a button and **commits an error**

Experimental Task

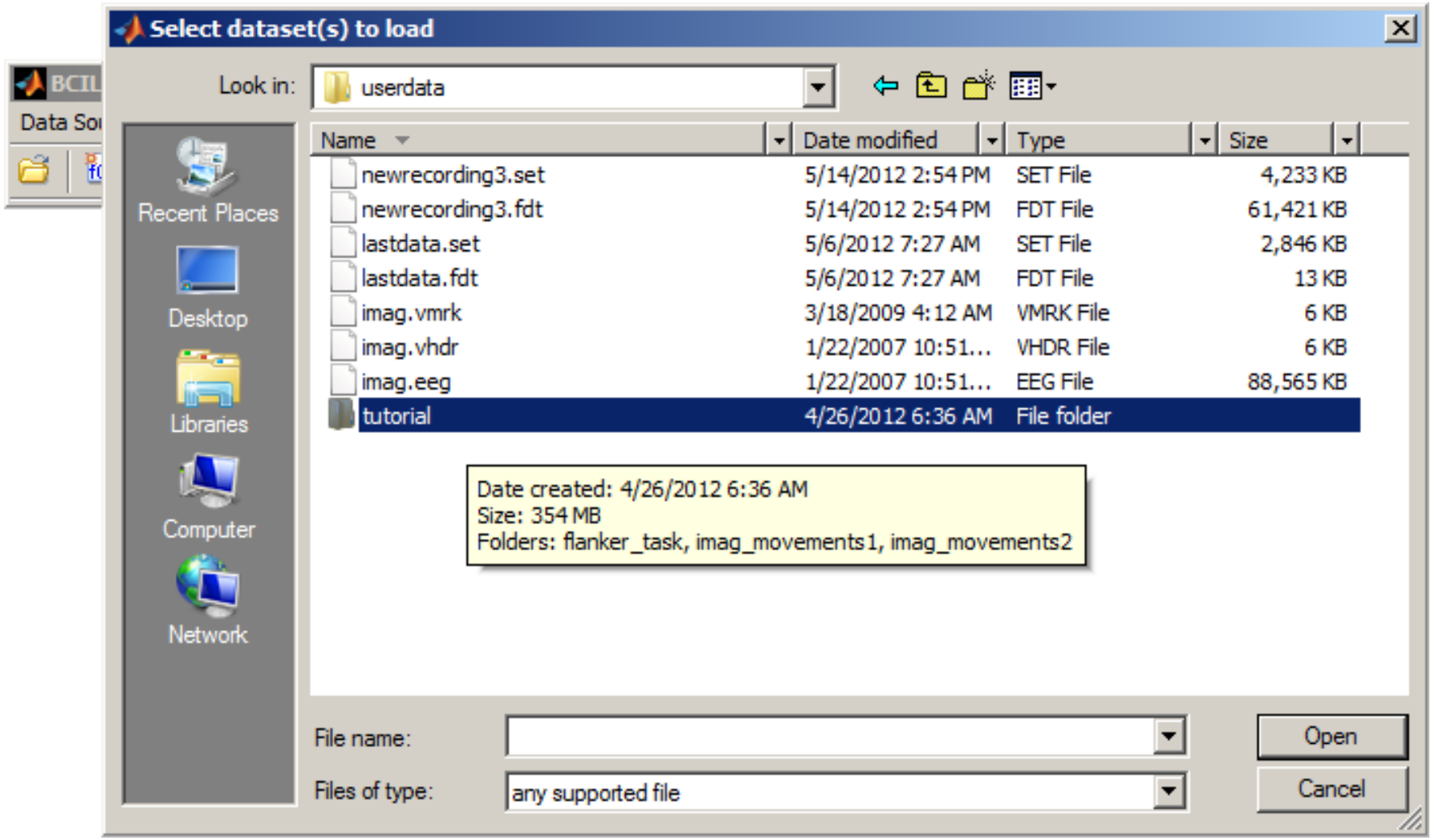
- **Flanker Task:** The experiment consists of a sequence of ca. 330 trials with inter-trial interval of 2s +/- 1.5s
- At the beginning of each trial, an arrow is presented centrally (pointing either left or right)
- The arrow is flanked by congruent or incongruent “flanker” arrows:

- The subject is asked to press the left/right button, according to the central arrow, and makes frequent errors (25%)

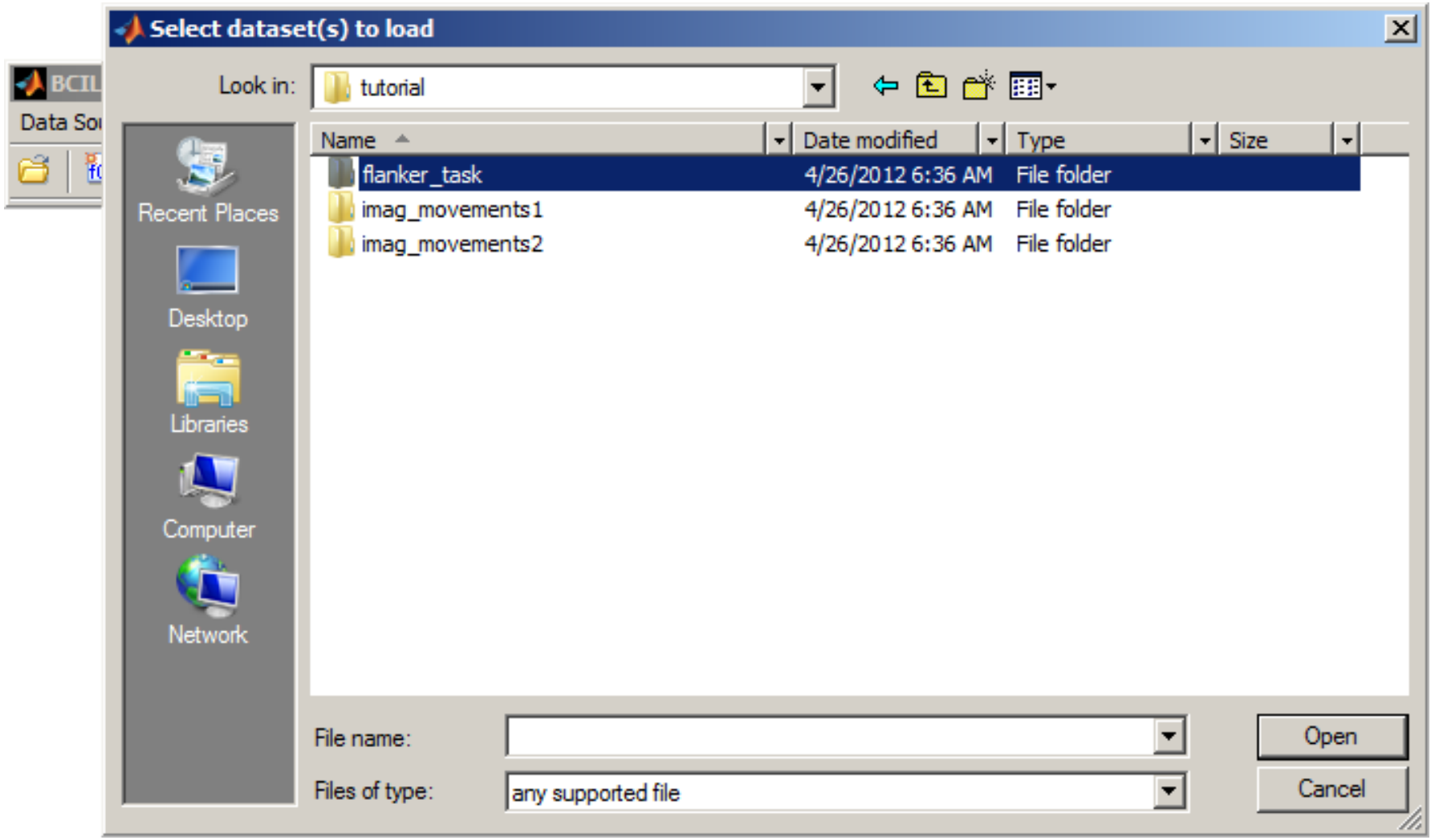
Loading the Data



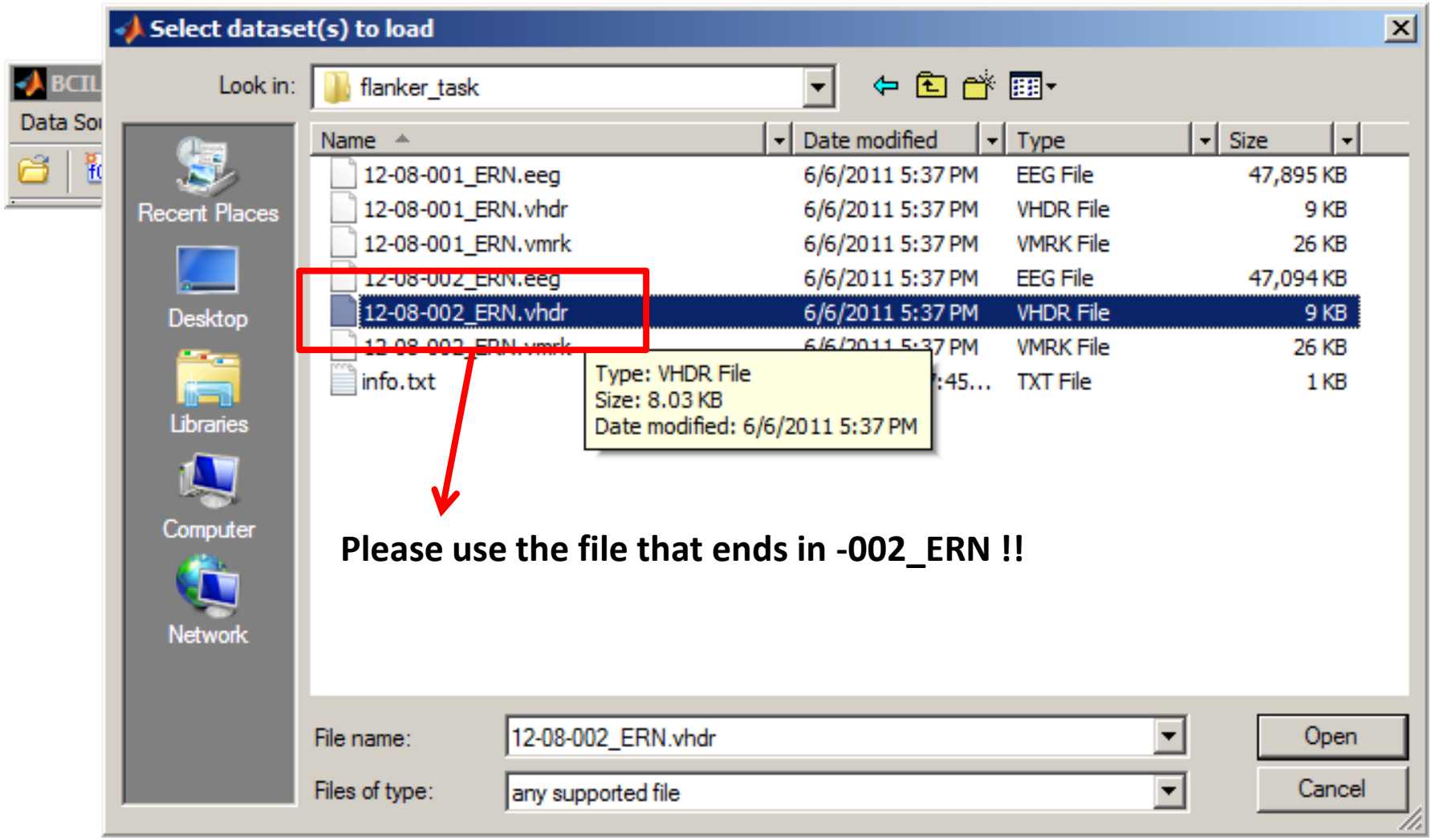
Loading the Data



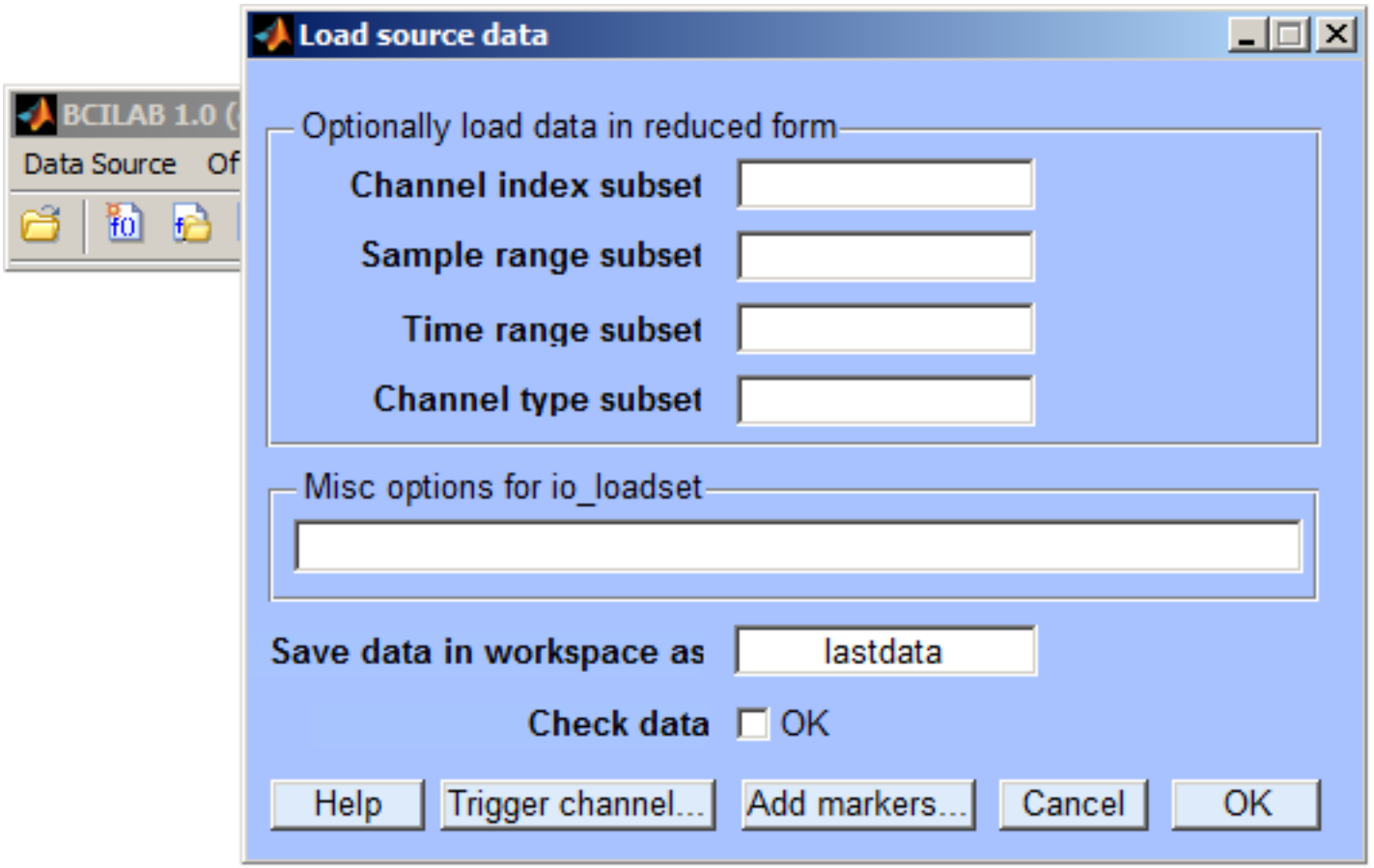
Loading the Data



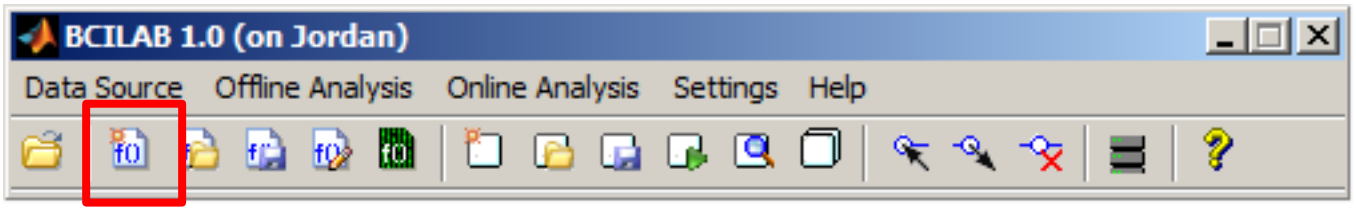
Loading the Data



Confirming Import Options



Creating a New Approach



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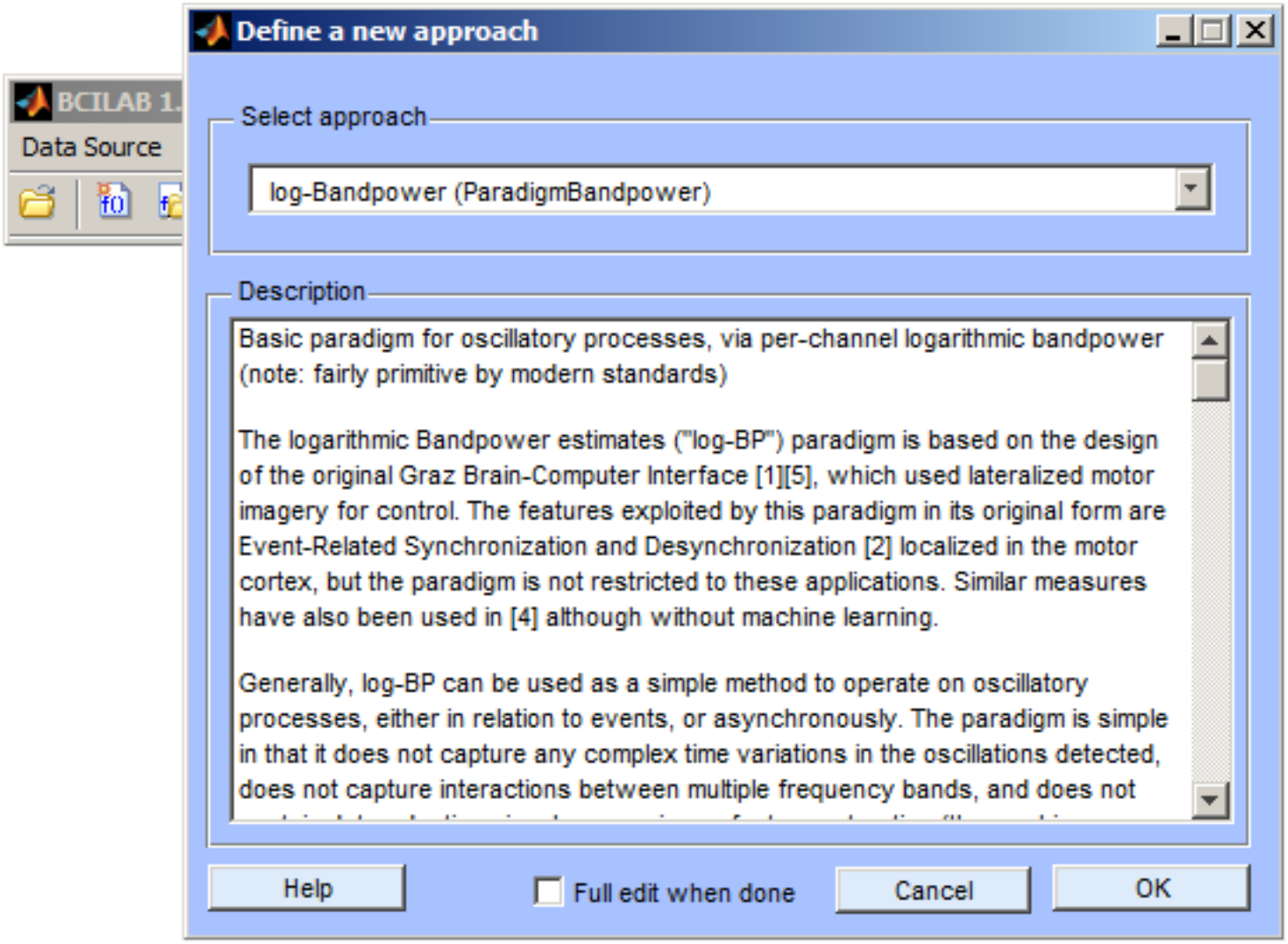
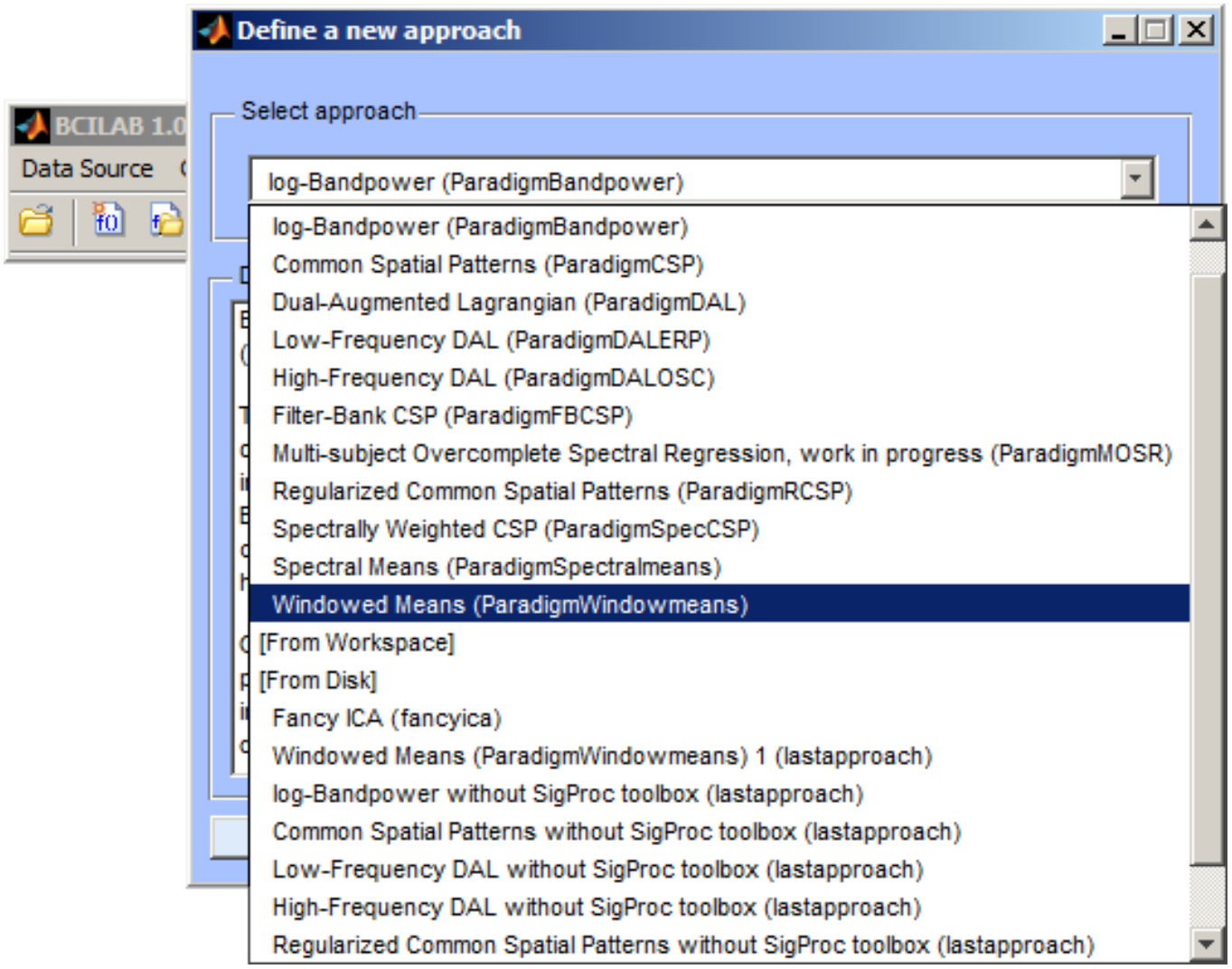
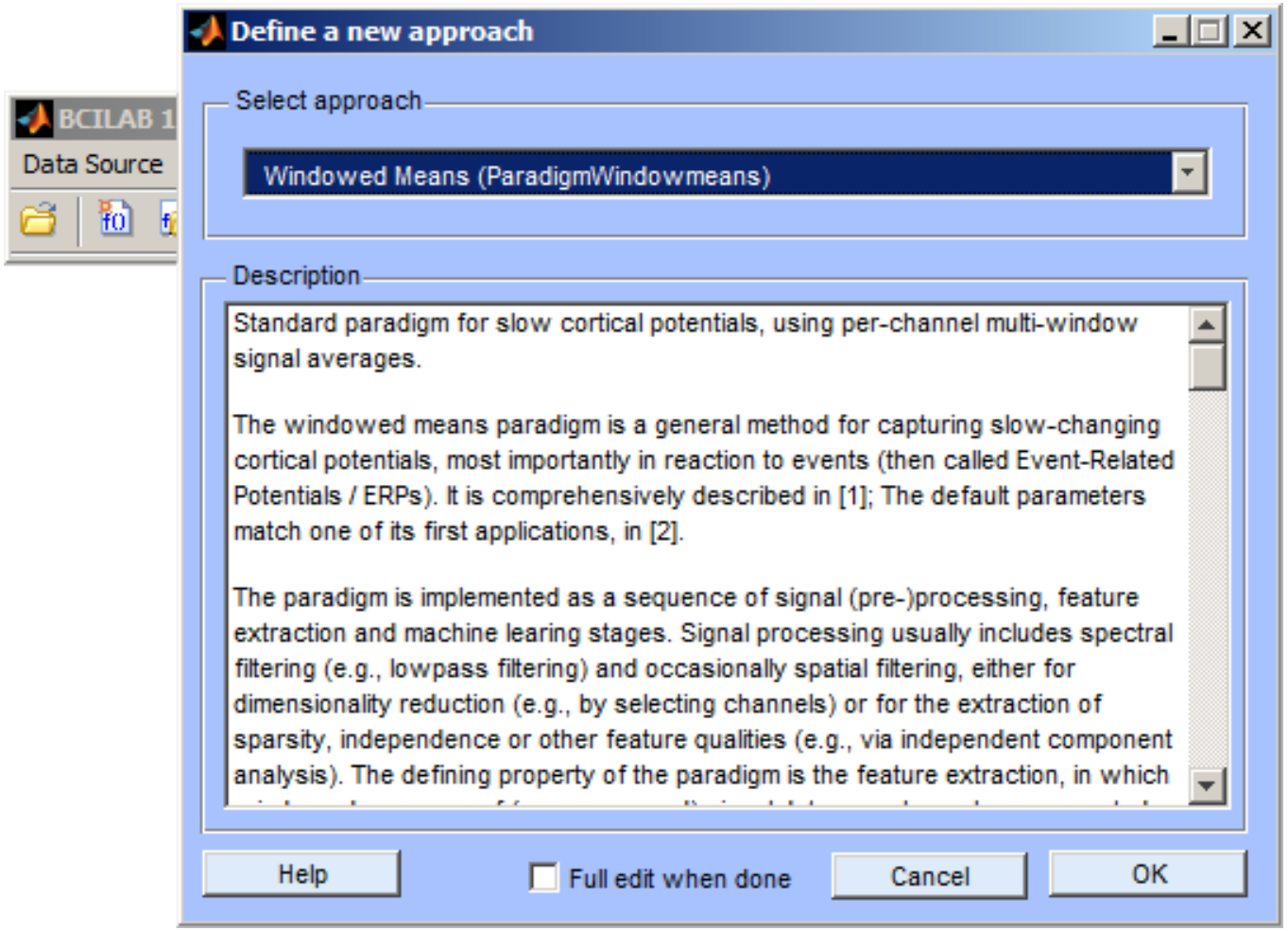


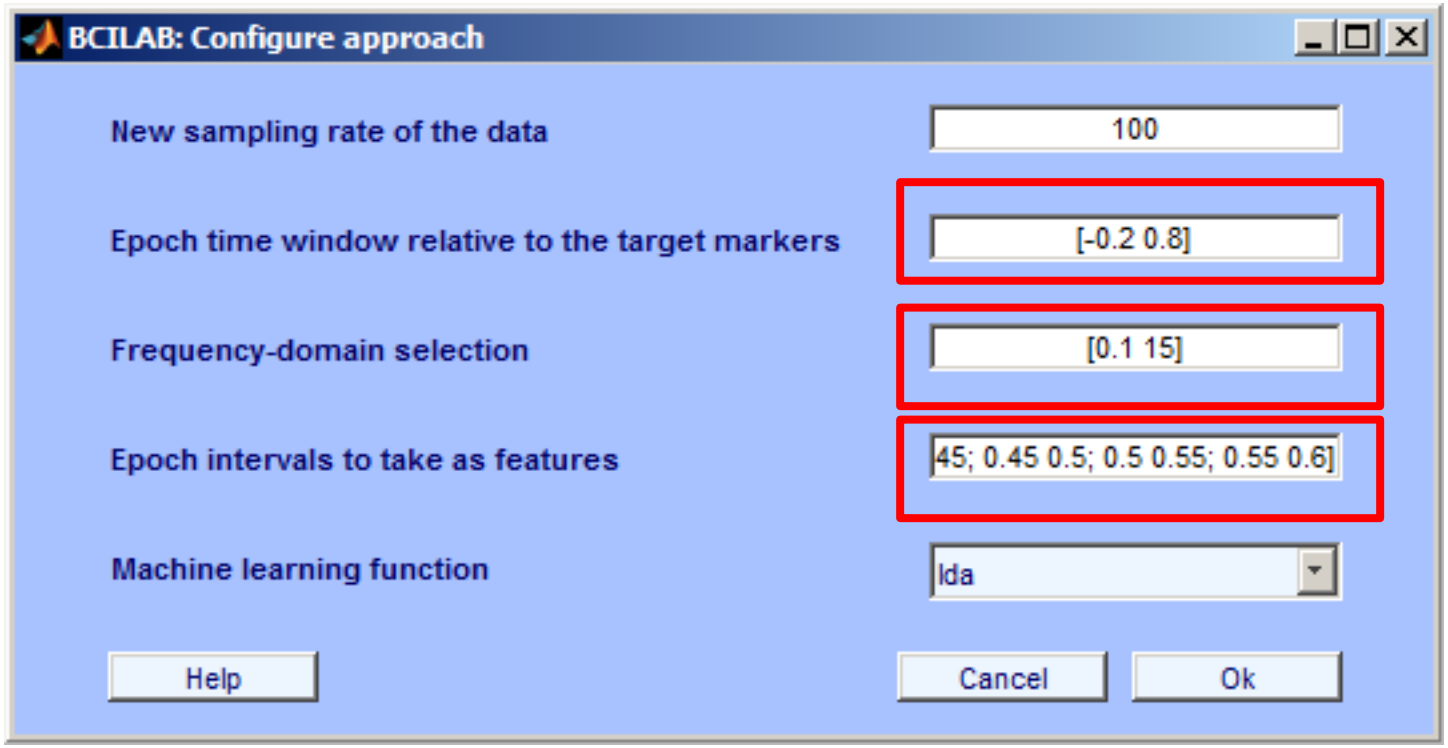
Select an ERP Paradigm



Select an ERP Paradigm



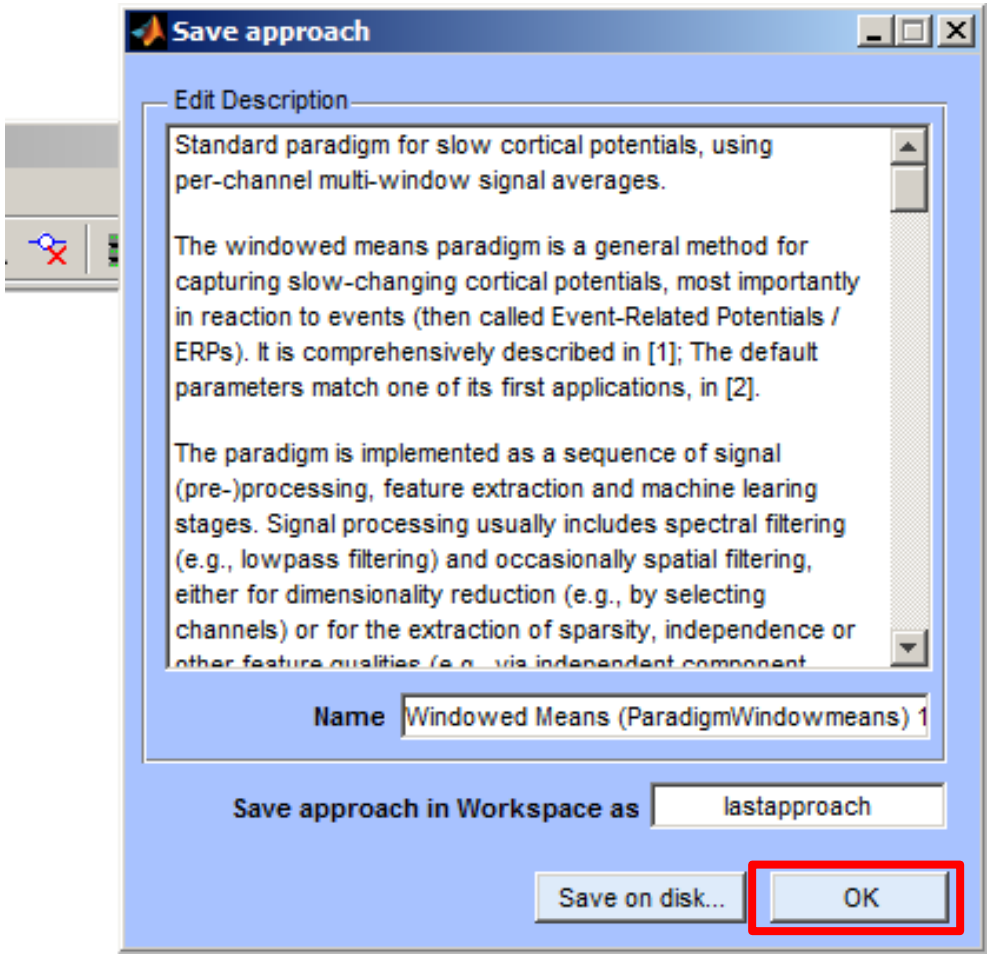
Configuring the Approach



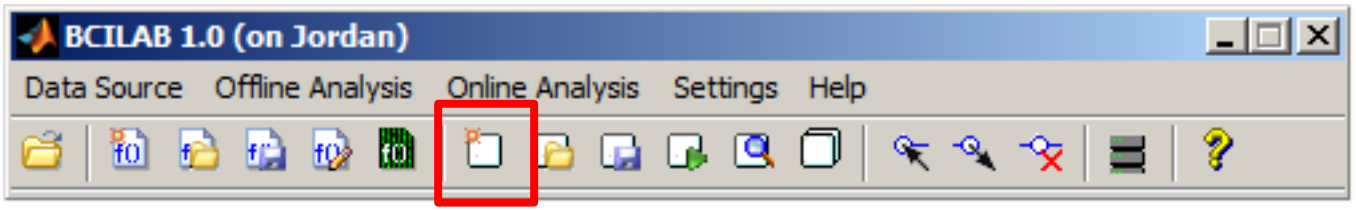
Type into the lowest of the 3 highlighted fields:
[0.25 0.3; 0.3 0.35; 0.35 0.4; 0.4 0.45; 0.45 0.5; 0.5 0.55; 0.55 0.6]

Note: On macOS, the latest MATLAB version likes to pop up this window in full screen; For the time being it is best to resize it to something similar to the above

Saving to the Workspace



Calibrating a New Model



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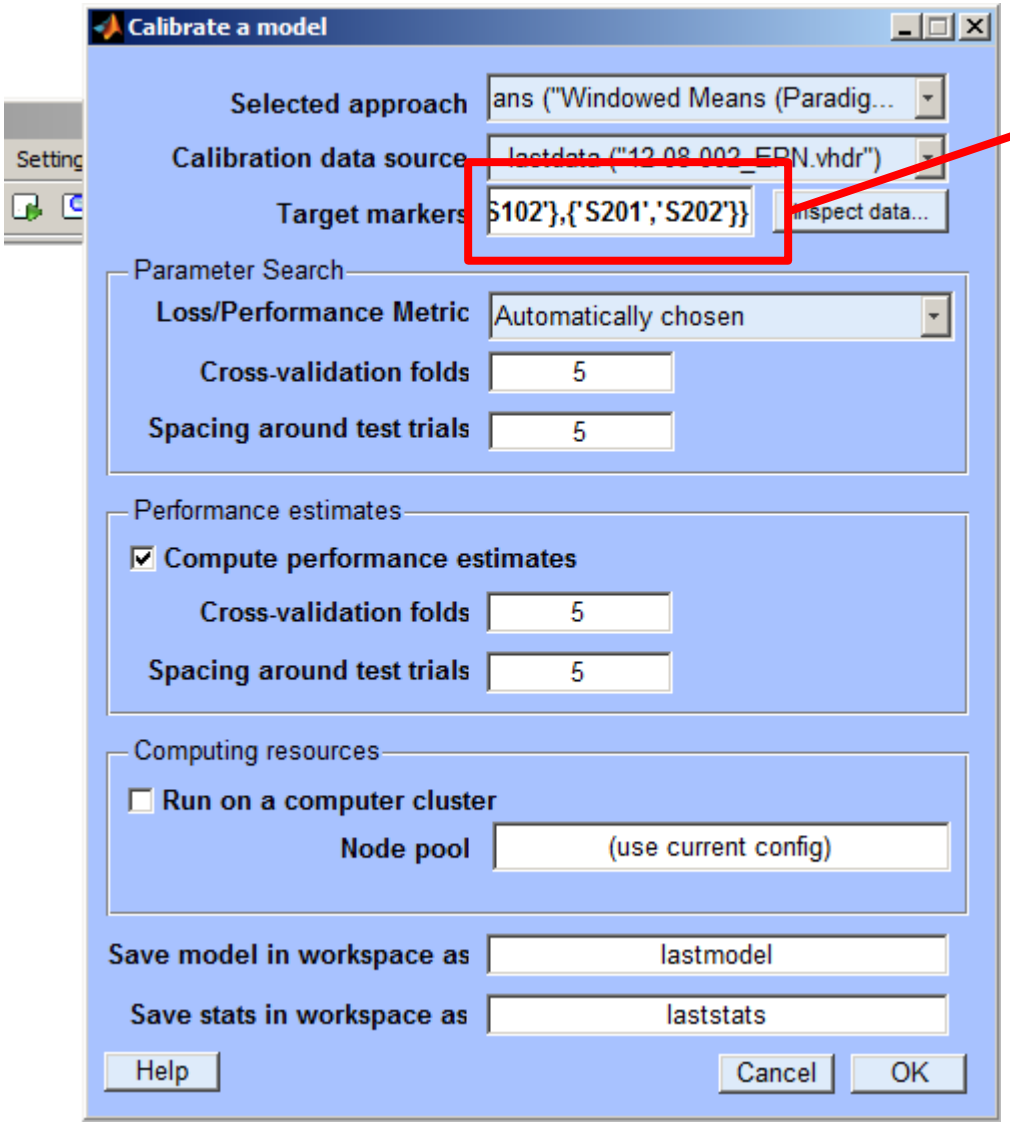
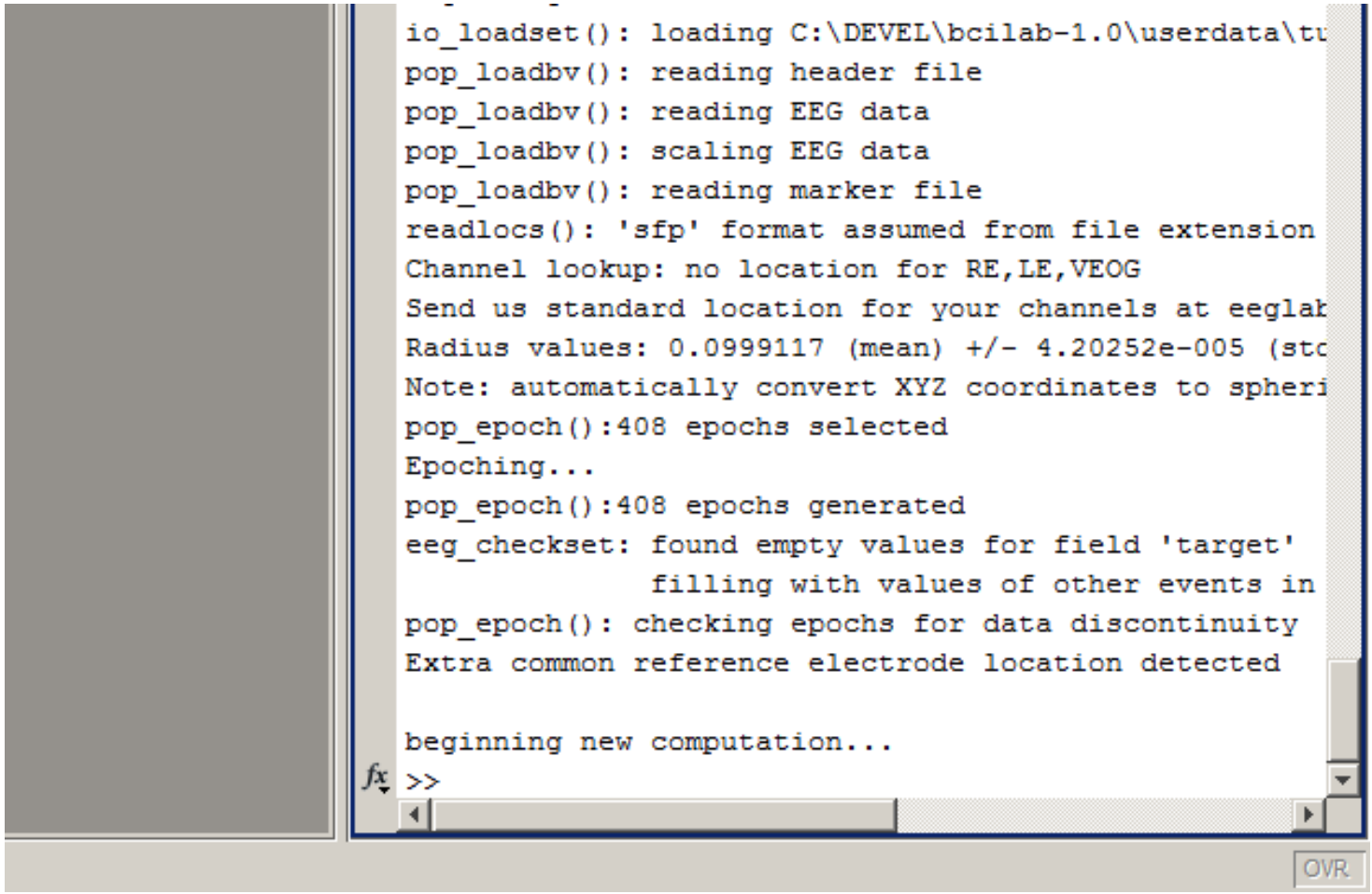


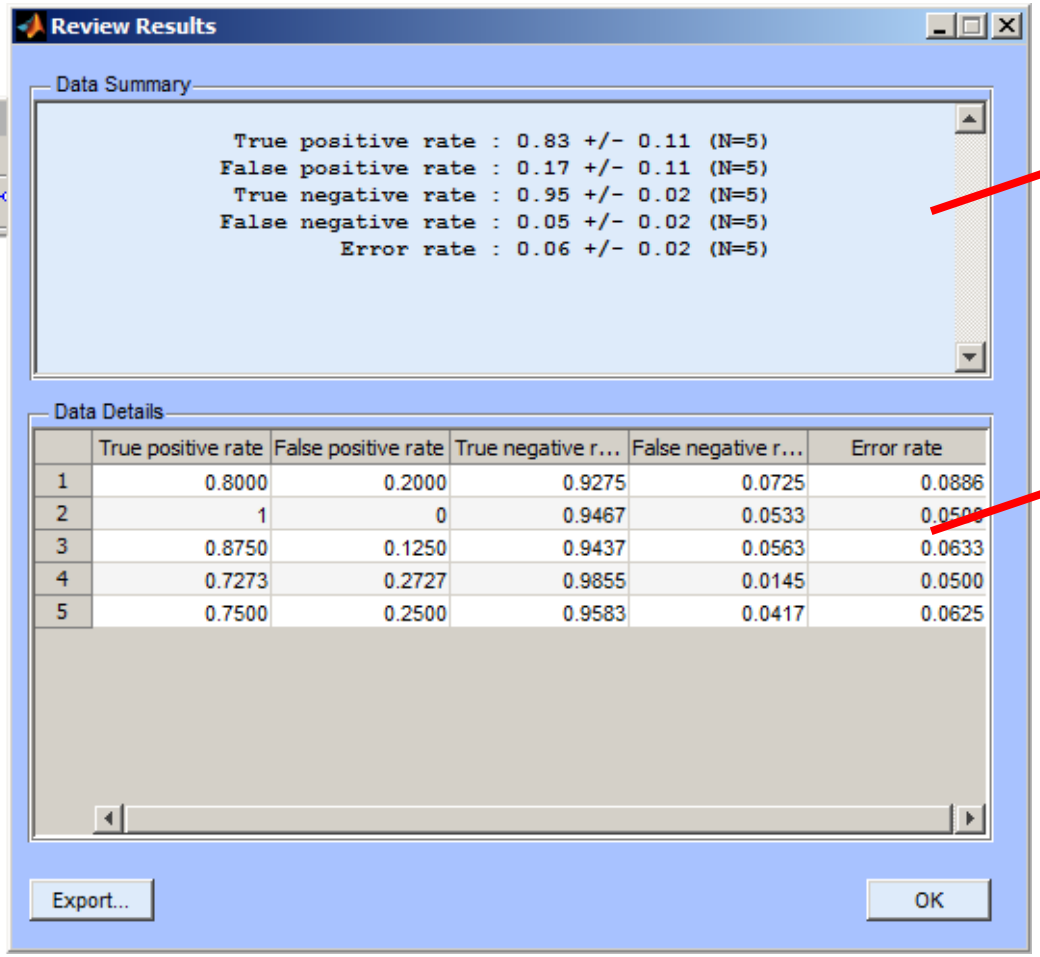
This is the set of marker labels that determine our two possible error conditions. For each of the two conditions, there is a group of multiple markers (different types of errors and non-errors).

Type the following here:
{{'S101','S102'},{'S201','S202'}}

Watching the Computation…



Reviewing Results

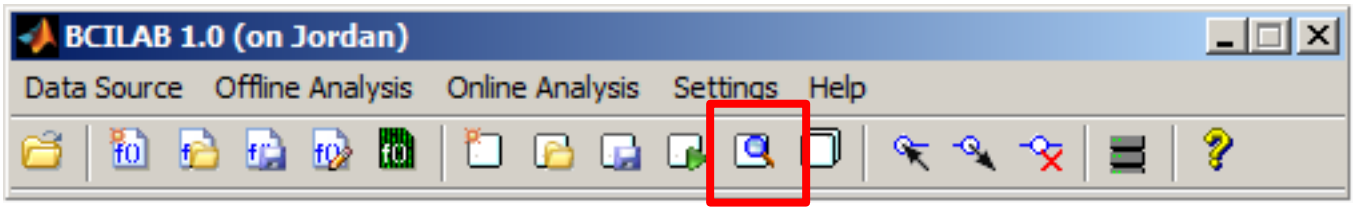


	True positive rate	False positive rate	True negative r...	False negative r...	Error rate
1	0.8000	0.2000	0.9275	0.0725	0.0886
2	1	0	0.9467	0.0533	0.0500
3	0.8750	0.1250	0.9437	0.0563	0.0633
4	0.7273	0.2727	0.9855	0.0145	0.0500
5	0.7500	0.2500	0.9583	0.0417	0.0625

Summary Statistics

Statistics for each fold of the Cross-Validation (here 5x).

Visualizing the Model



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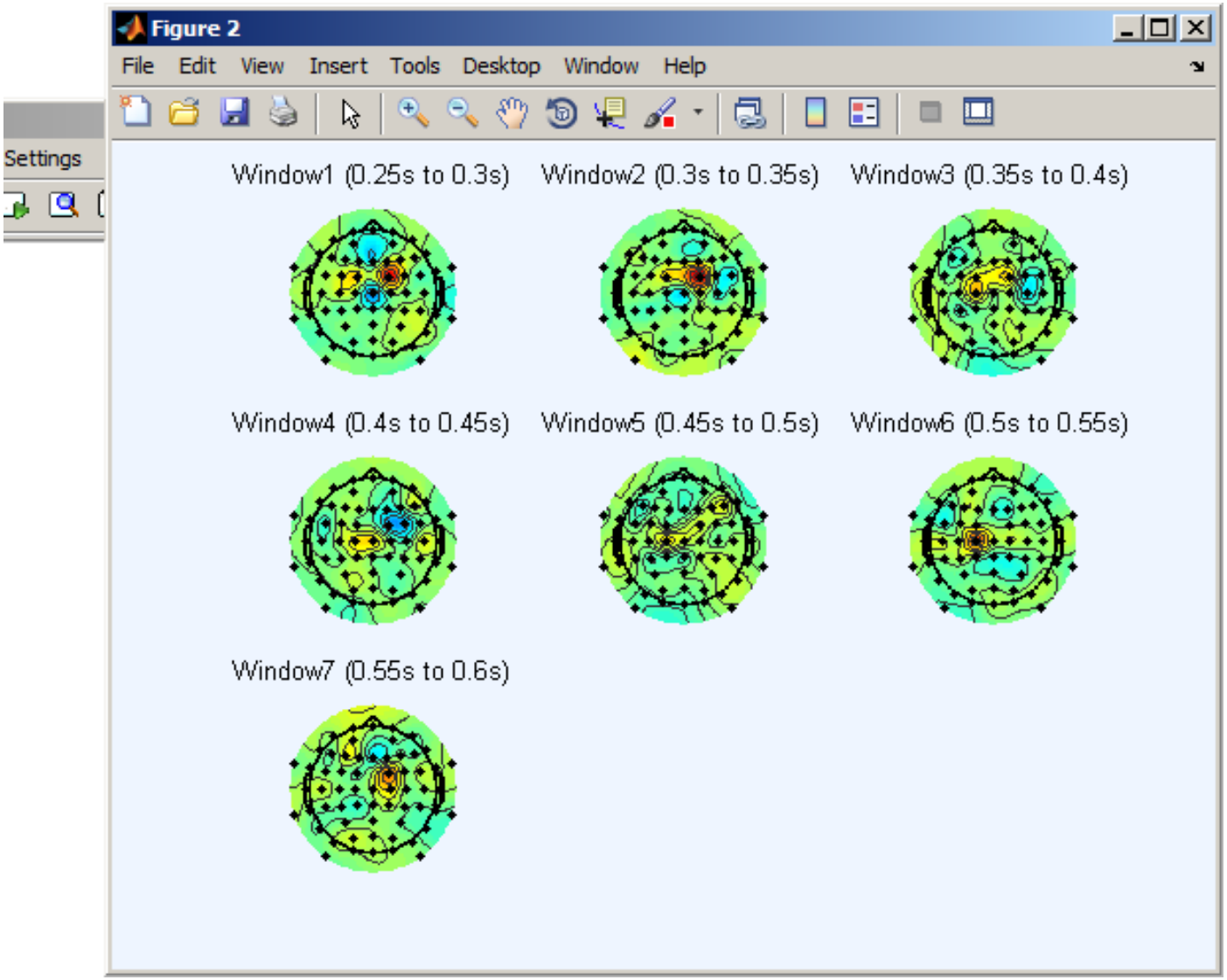
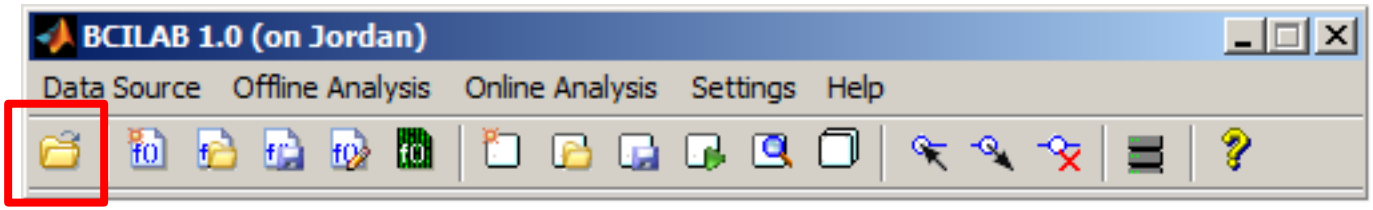
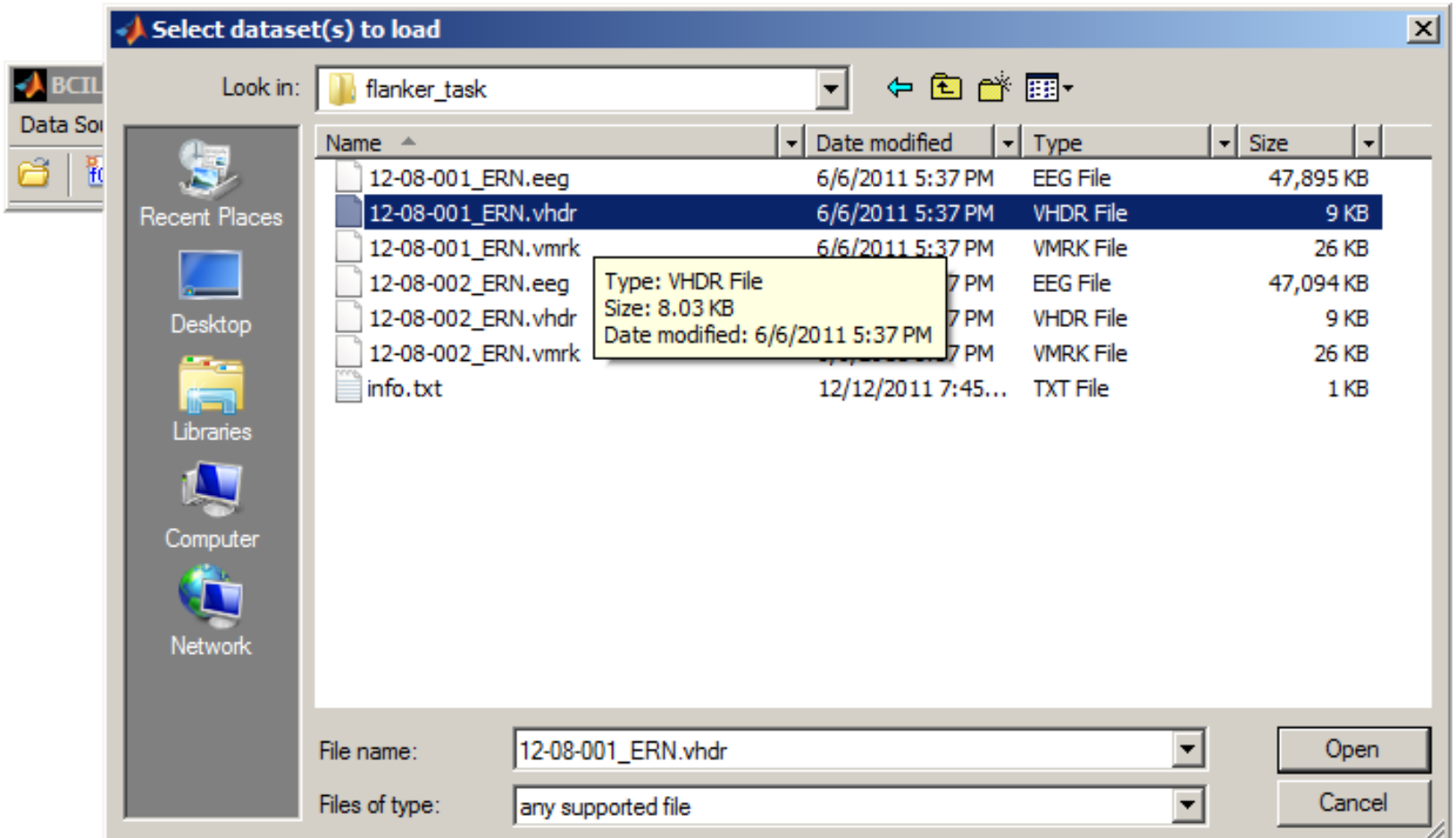


Loading a Separate Test Set

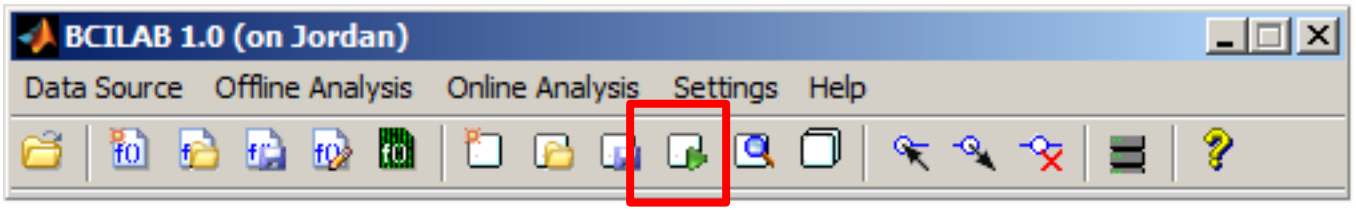


Loading a Separate Test Set

Note: This data set is from an identical twin doing the same task.



Applying the Model to Test Data



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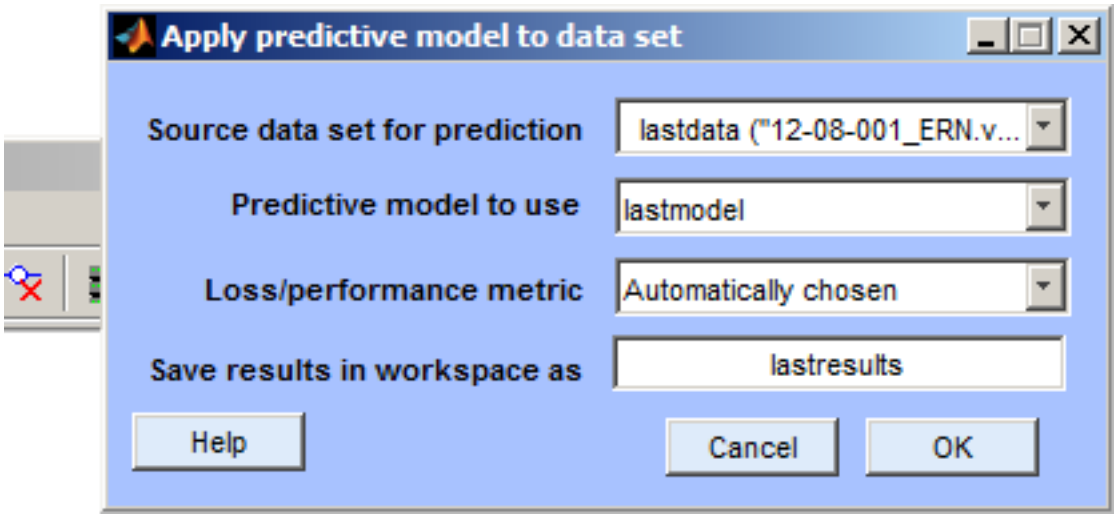
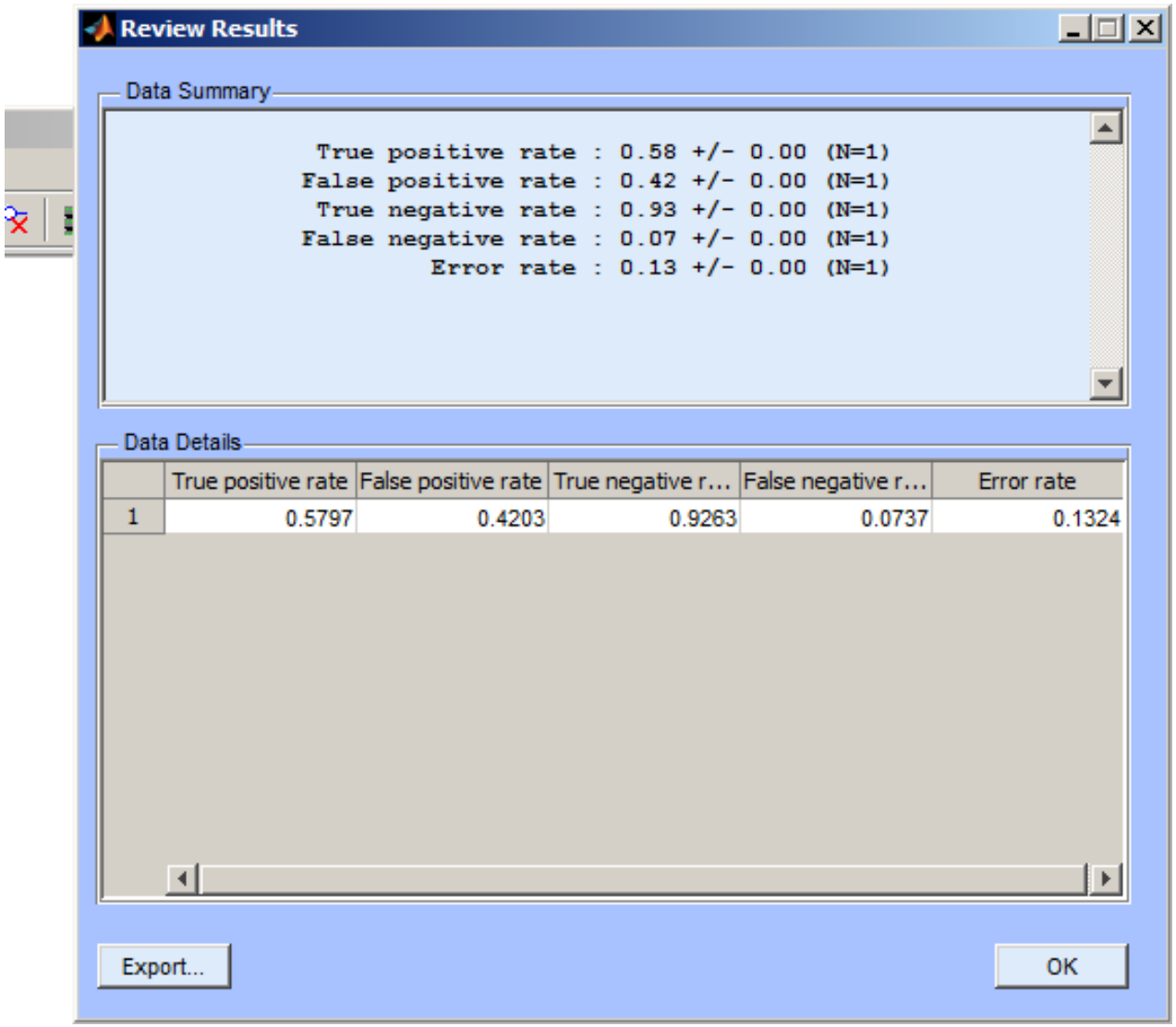
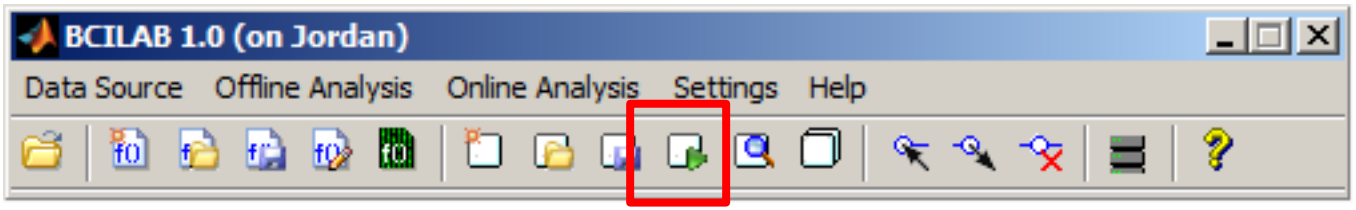


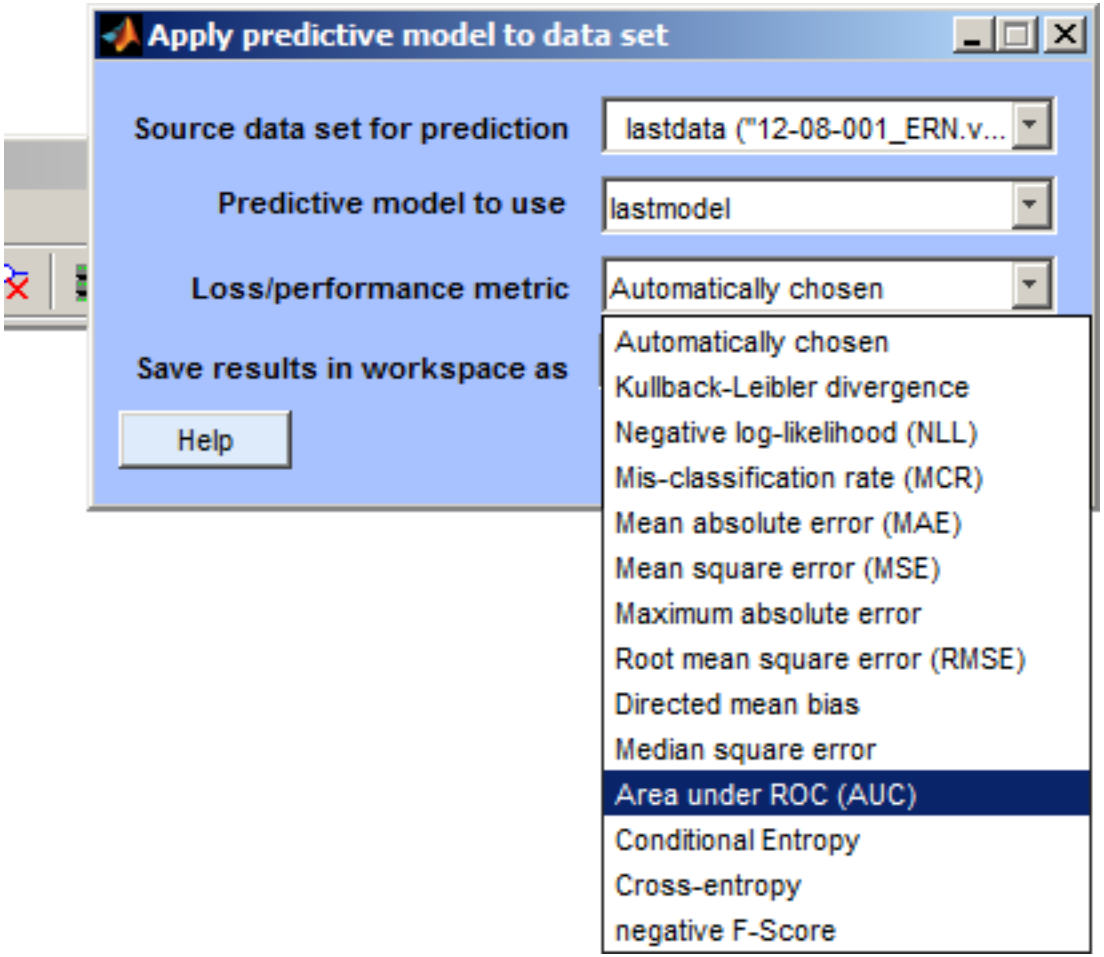
Reviewing Statistics



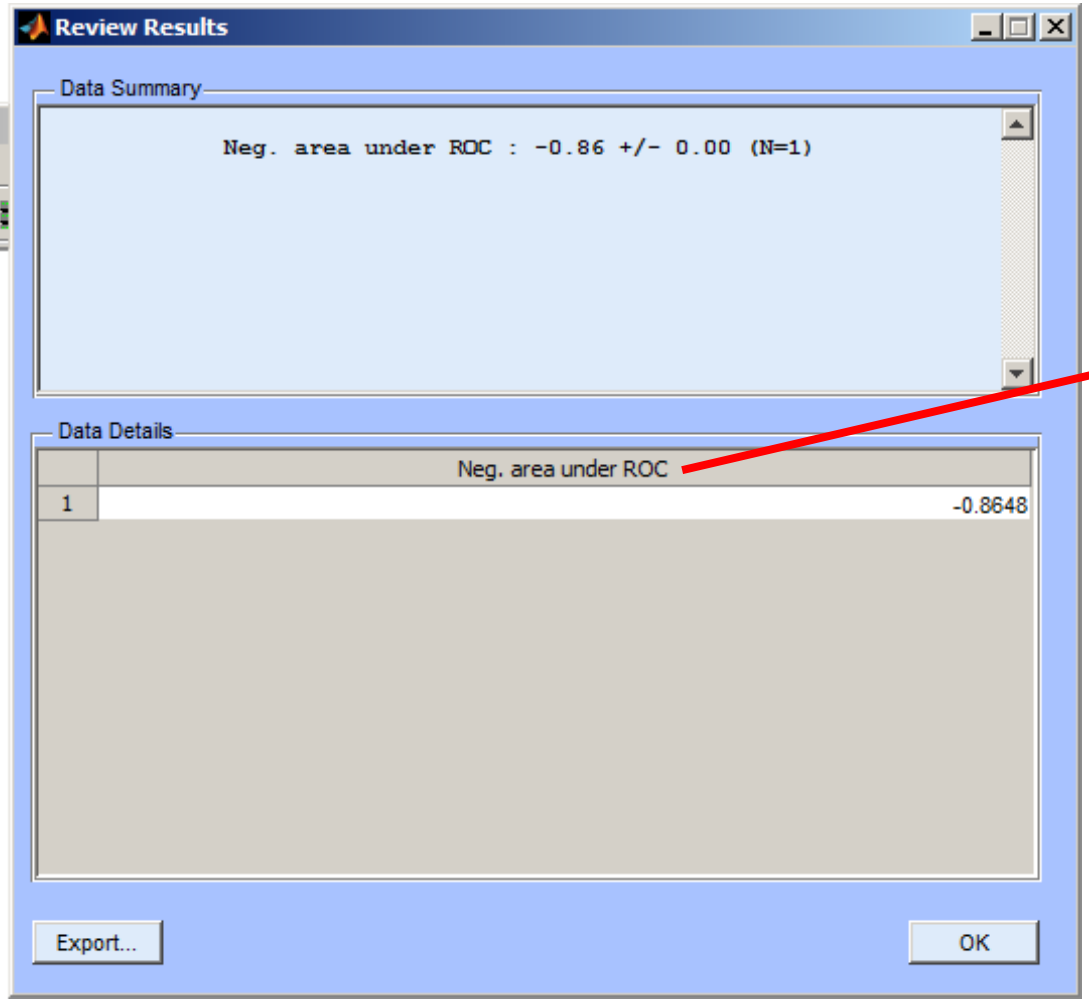
Using Another Loss Measure

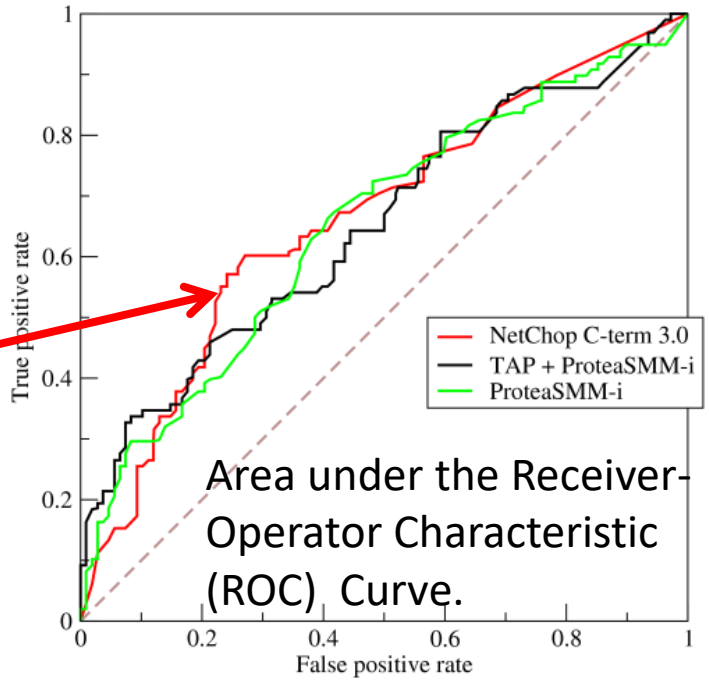


Using Another Loss Measure



Using Another Loss Measure

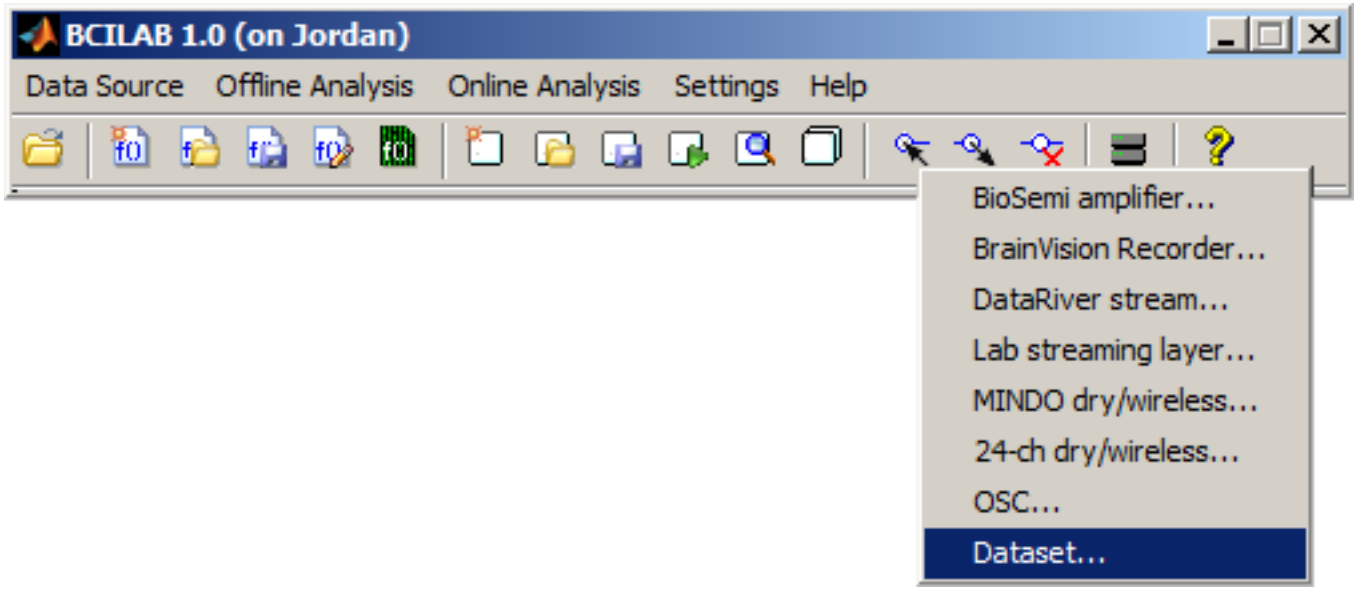




Area under the Receiver-Operator Characteristic (ROC) Curve.

3 Online ERP Analysis

Starting an Online Data Stream

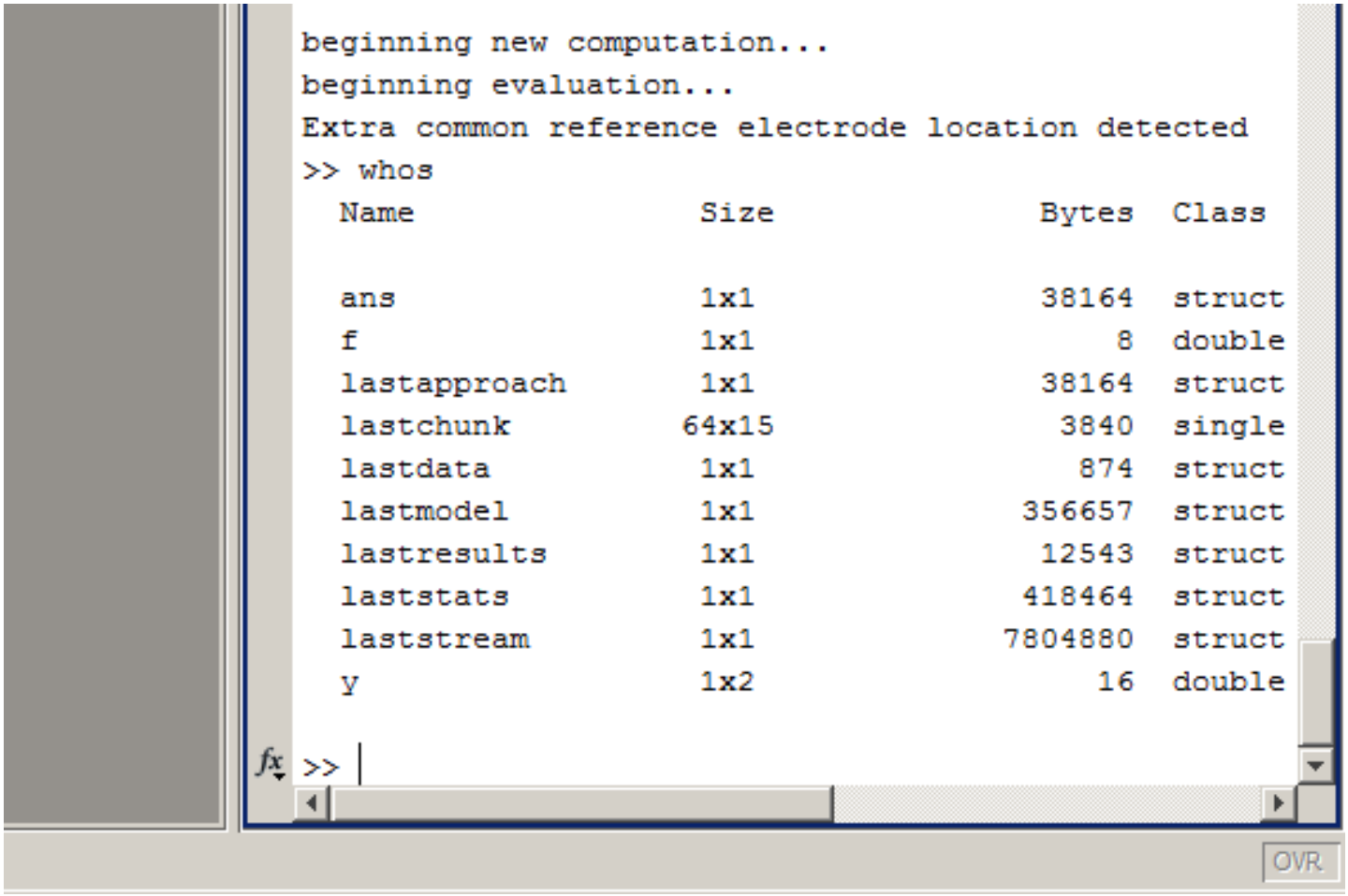


The selected stream will be played back in the background.
In this course we'll be playing back the test data set in real time (instead of reading from an actual device).

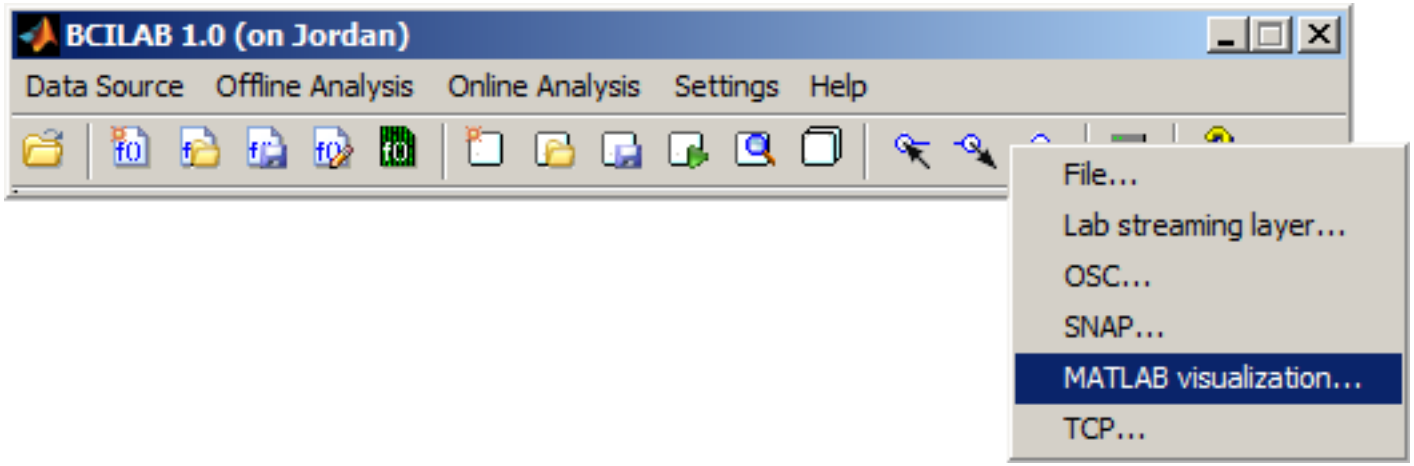
Configuring the Online Stream

Meanwhile in the MATLAB Workspace…

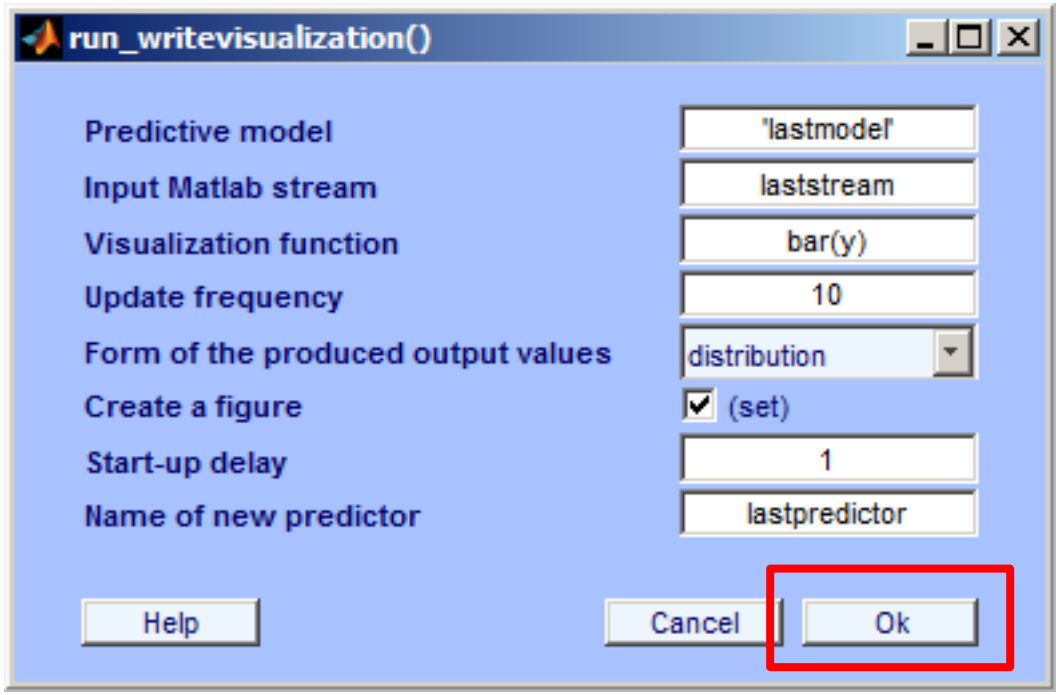
If you type **whos** you could see the data structure (laststream) that is updated in the background.



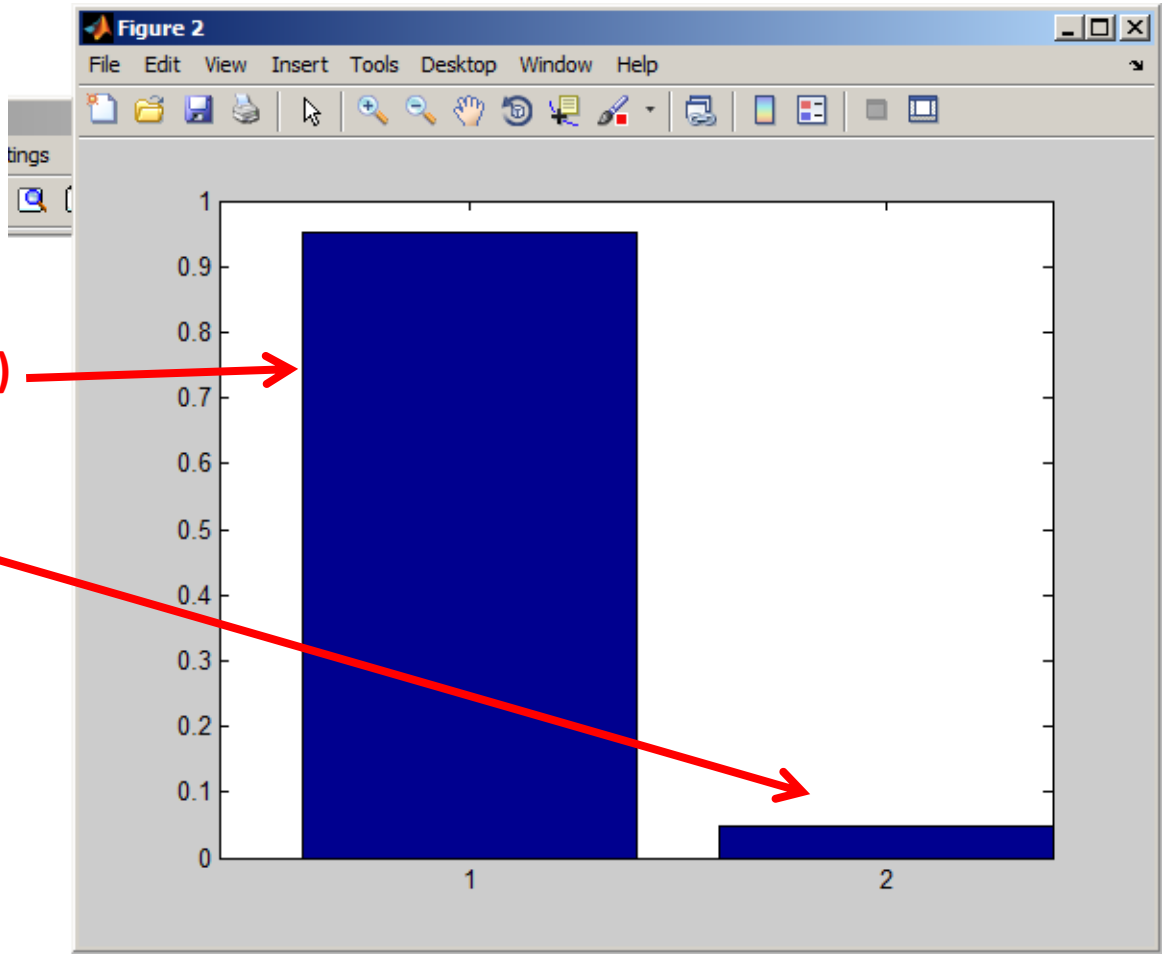
Selecting the Destination for BCI Outputs



Selecting the Destination for BCI Outputs



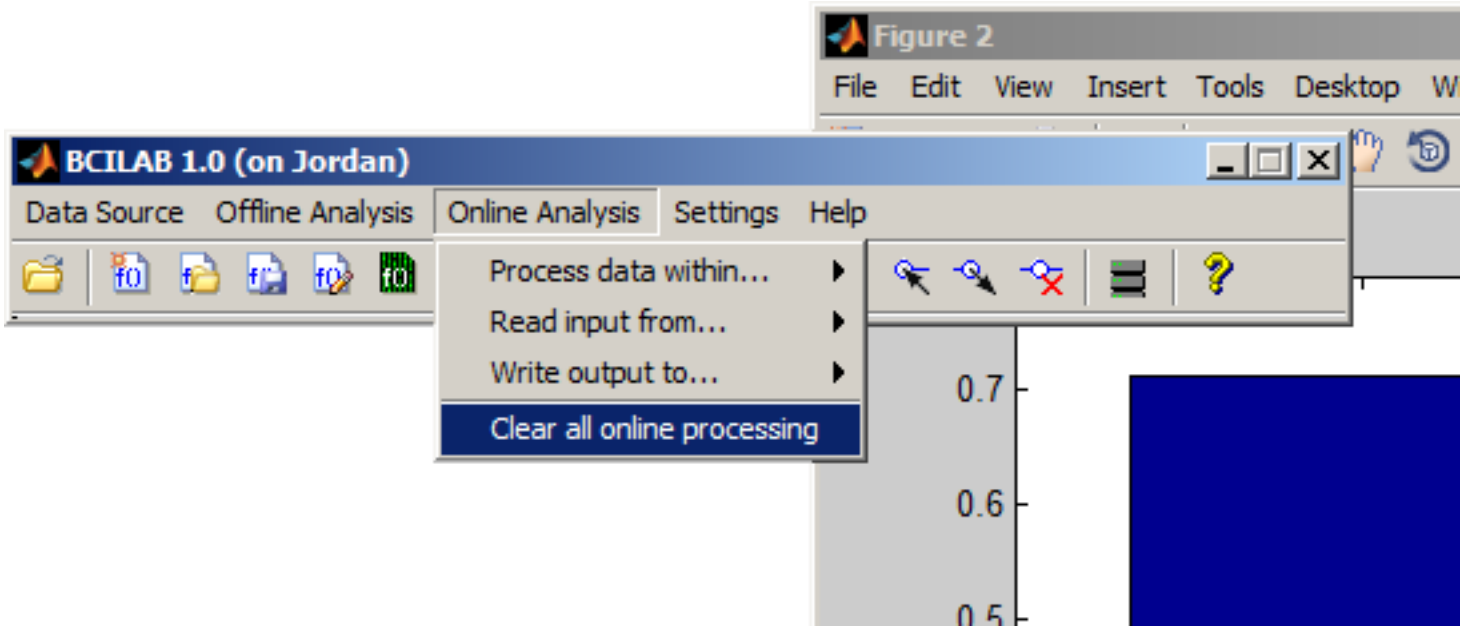
Visualized Real-Time Outputs



Probability of class 1 (no error)

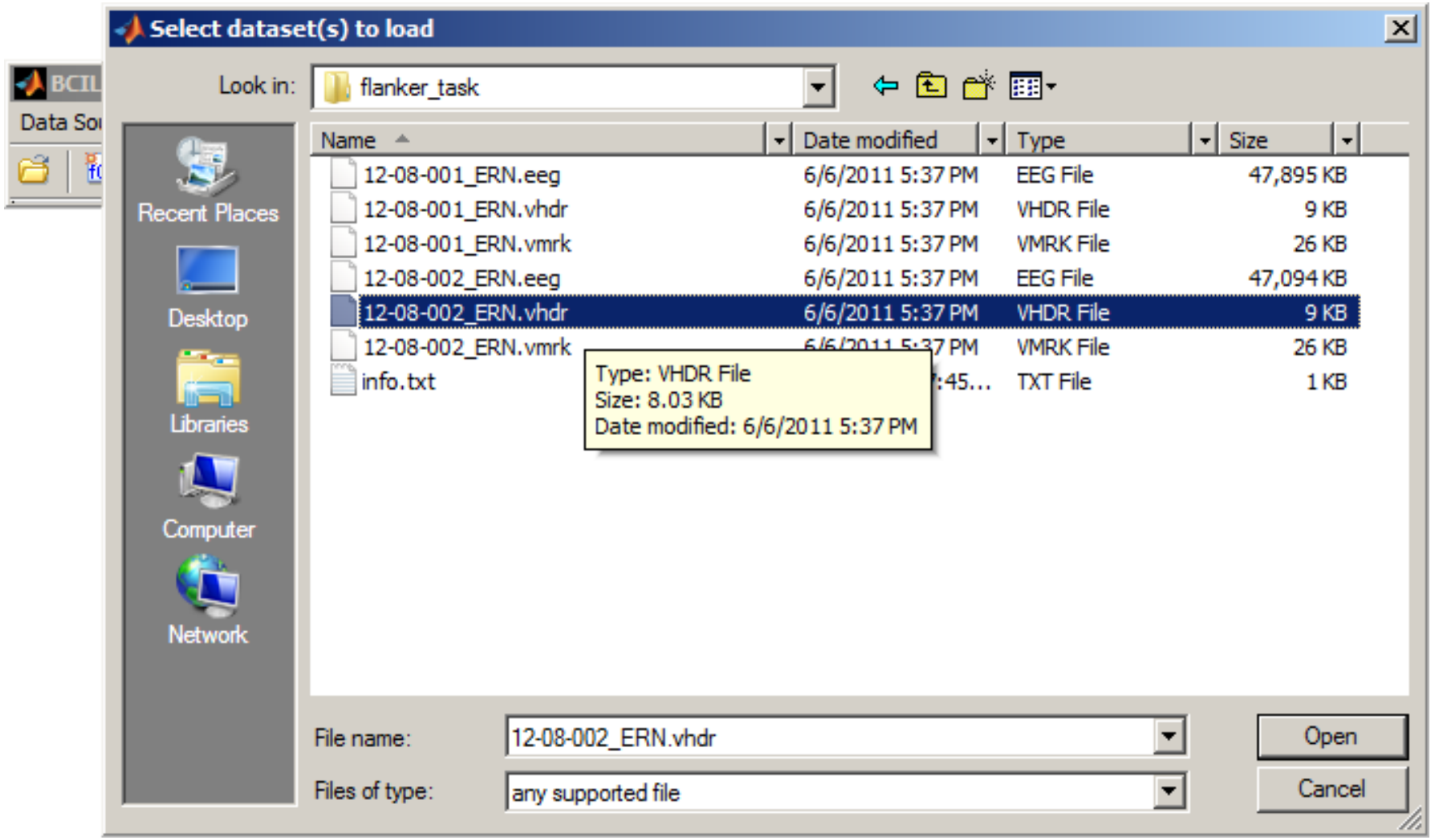
Probability of class 2 (error)

Stopping the Online Processing

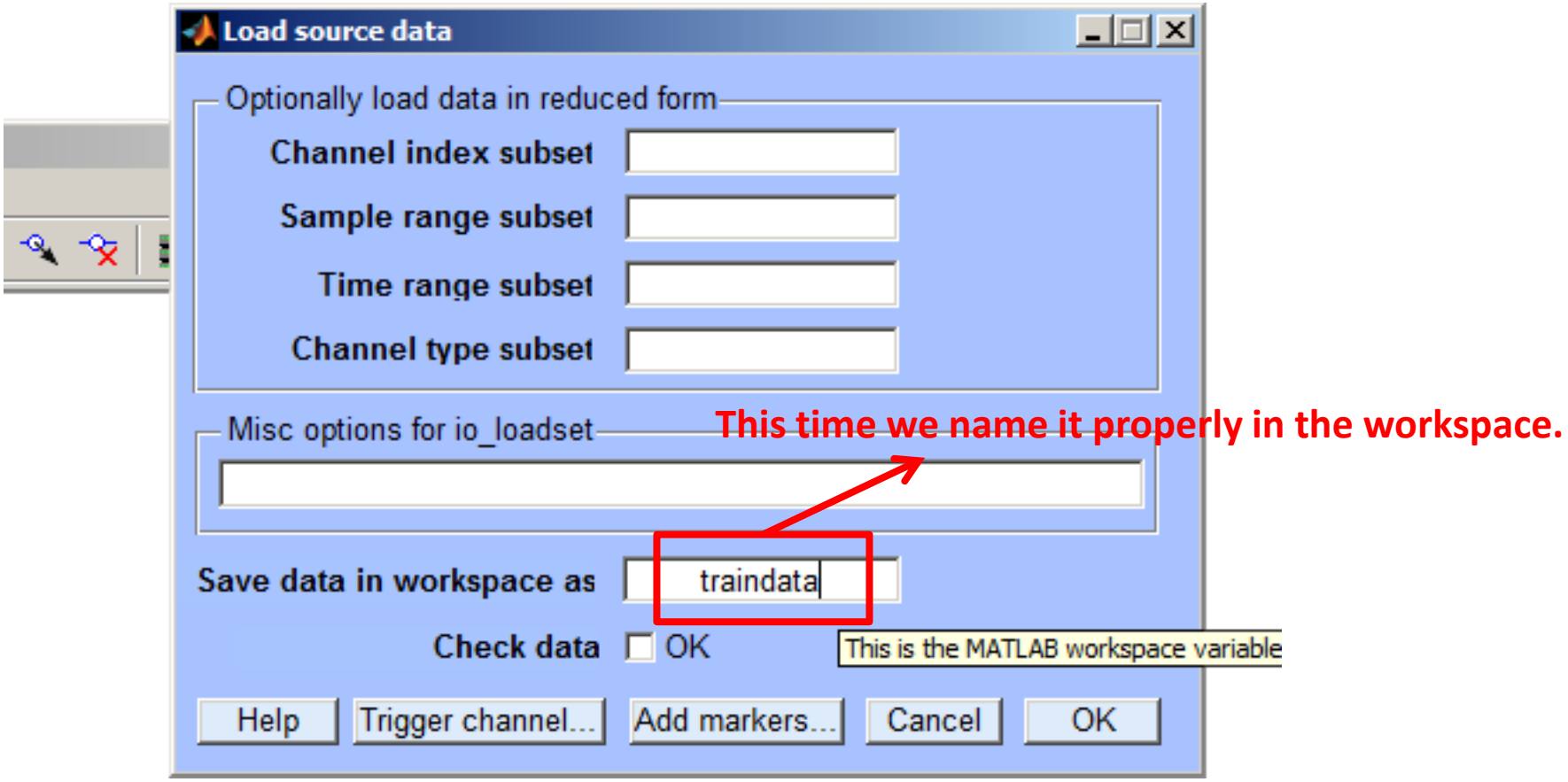


4 Customizing Approaches

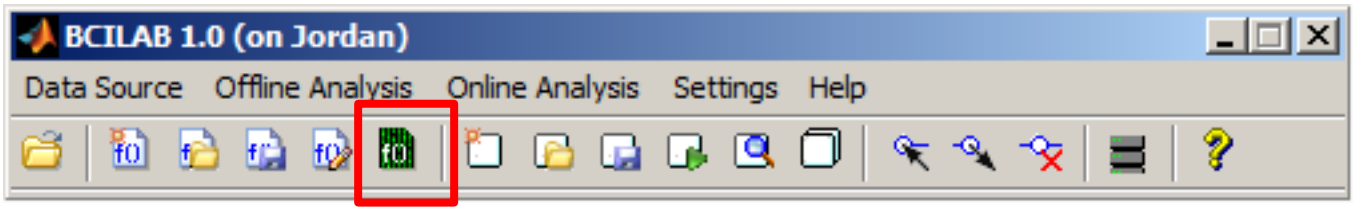
Loading the Training Data Again



Loading the Training Data Again



Editing the Previous Approach In Detail



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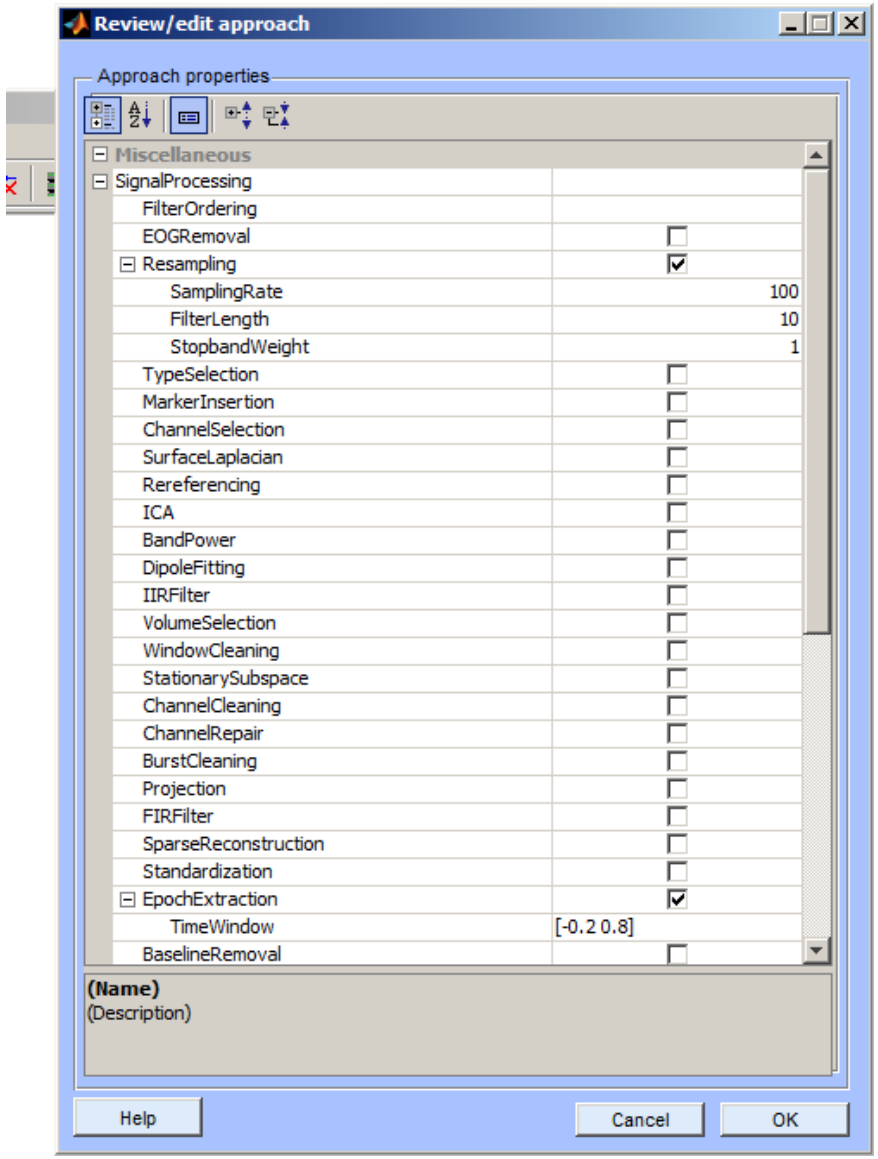
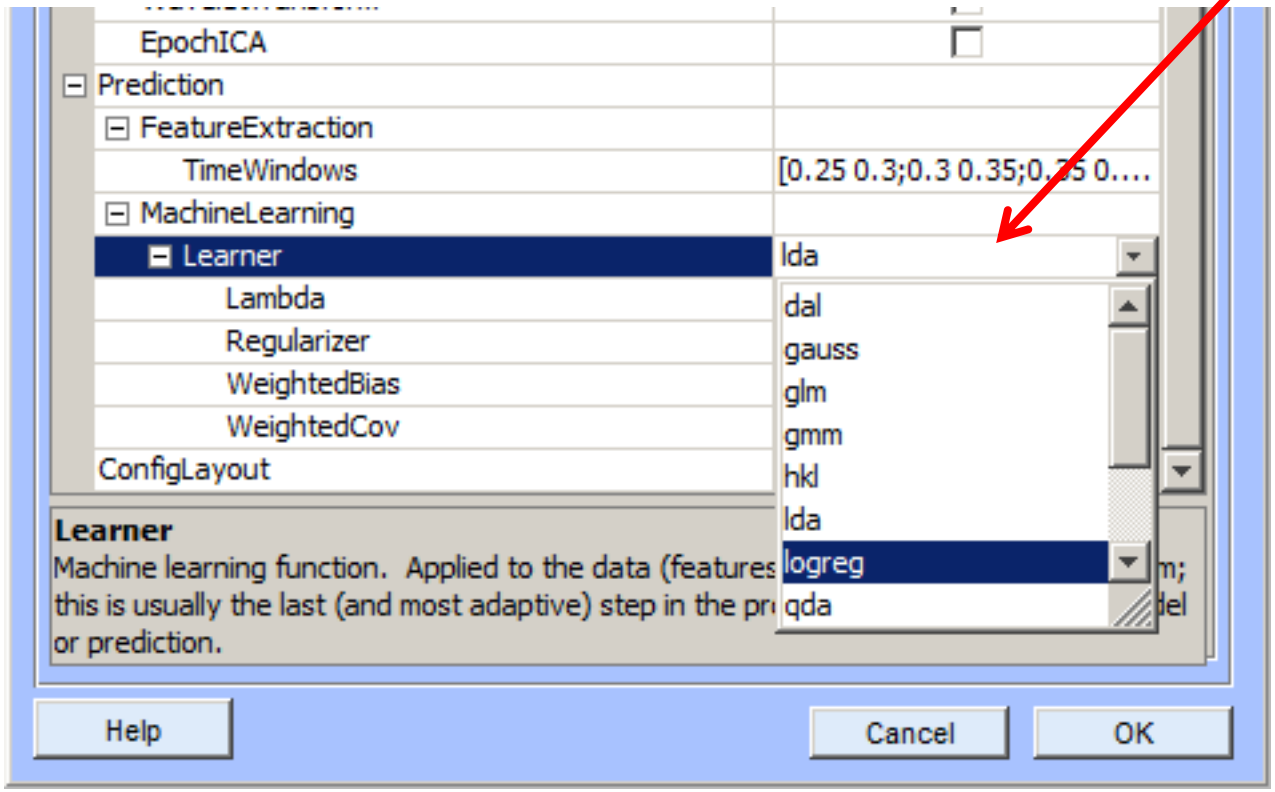


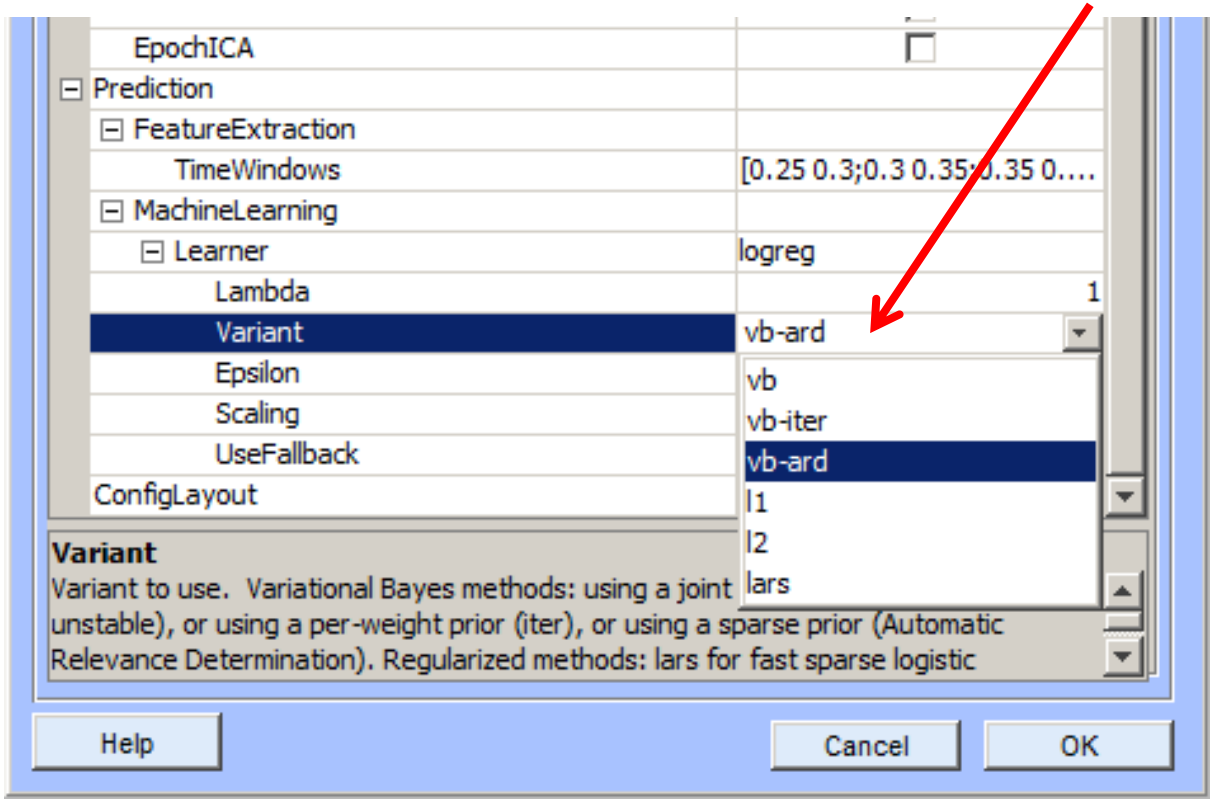
Changing the Classifier

Instead of LDA we choose logistic regression.

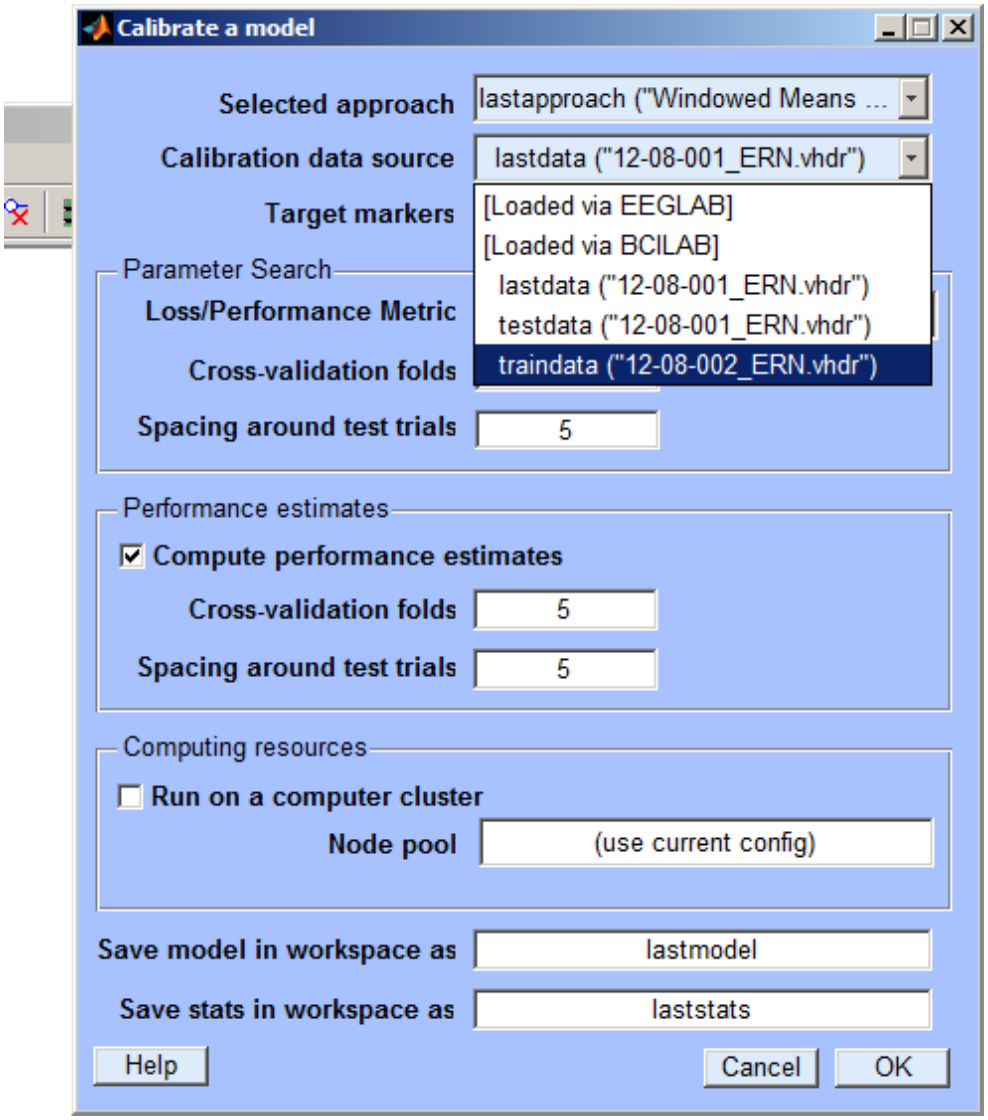


Changing the Classifier

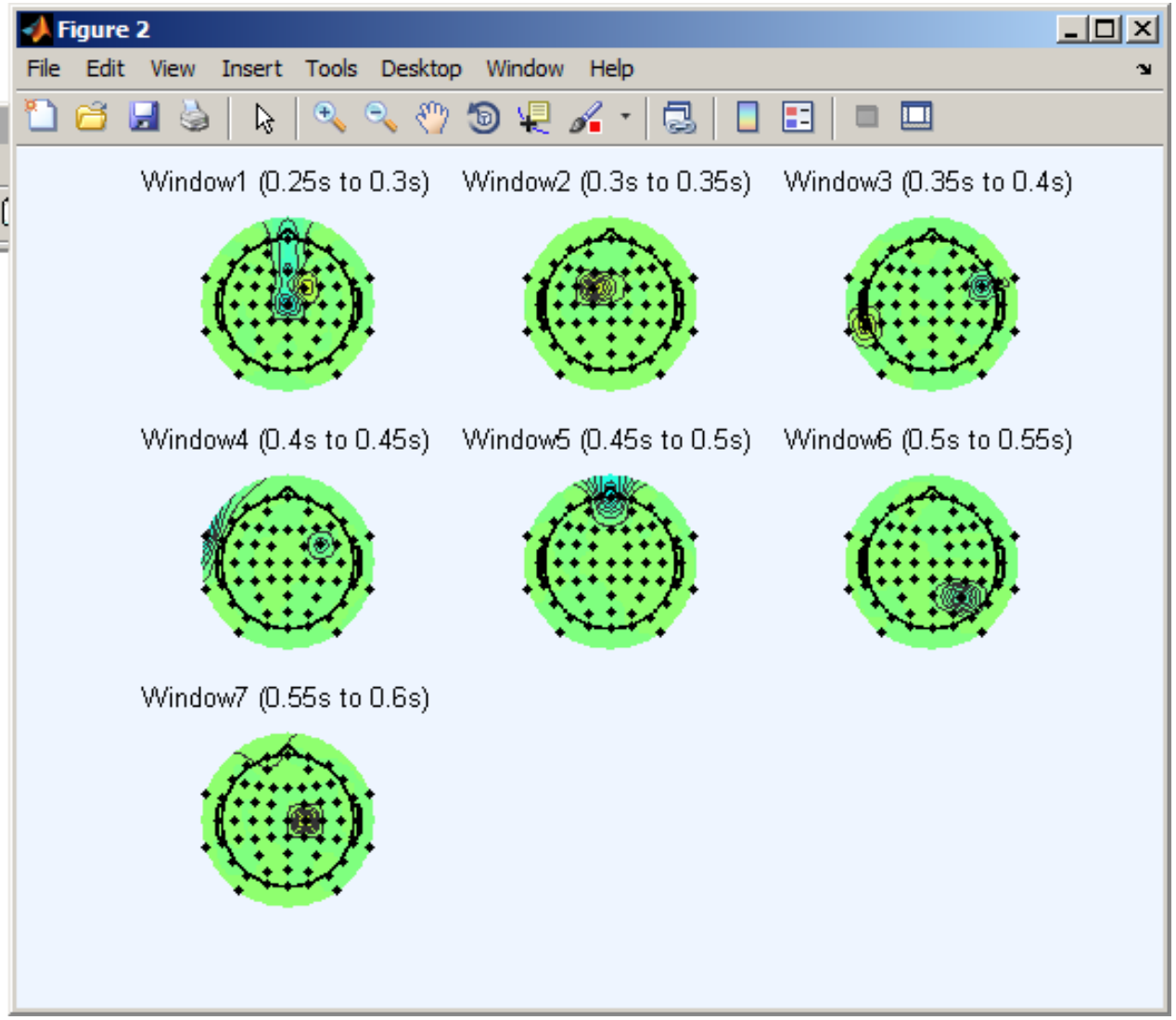
We don't use the VB (Variational Bayes) variant but the sparse version (with Automatic Relevance Determination).



Learning a New Model…

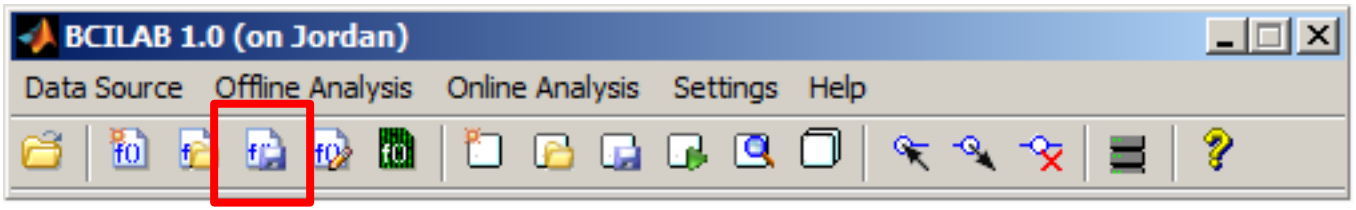


Visualizing The Model

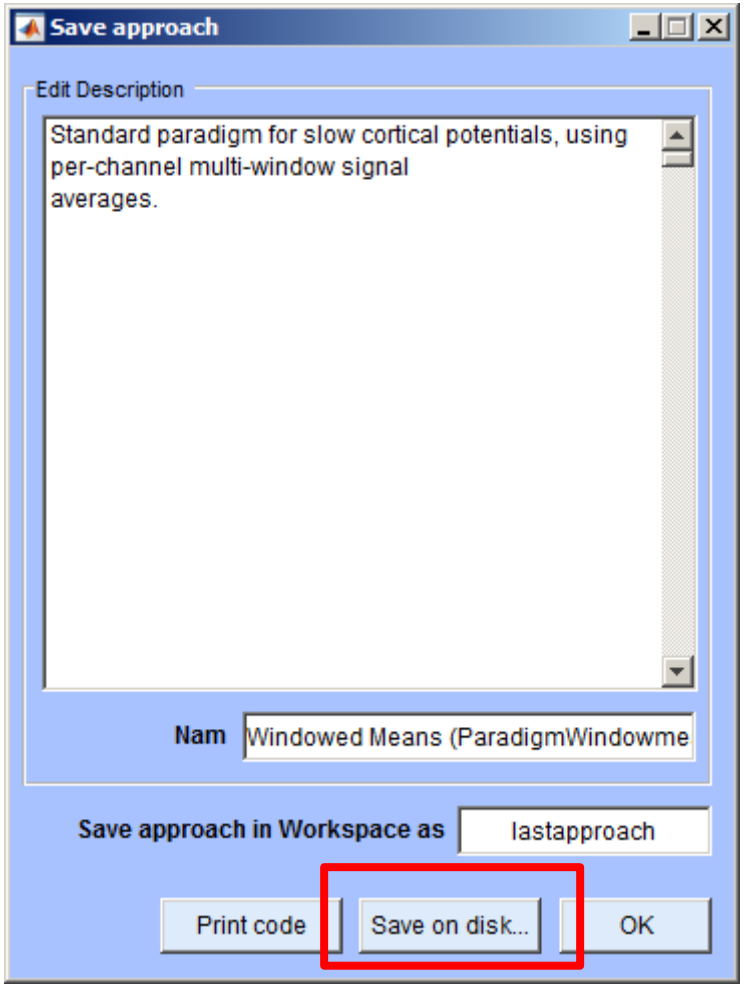


This model uses a minimal subset of channels.

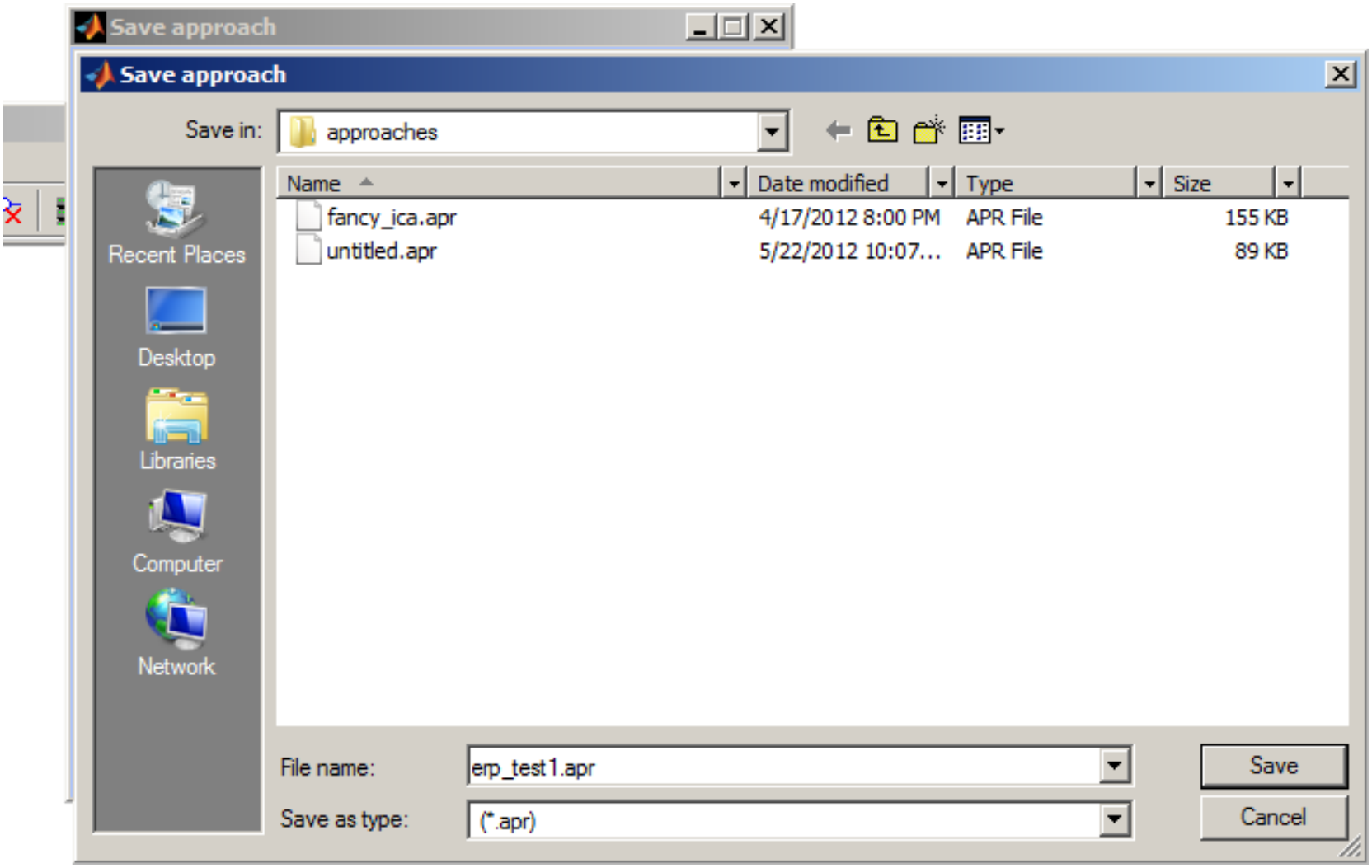
Saving the Approach for Later



Saving the Approach for Later



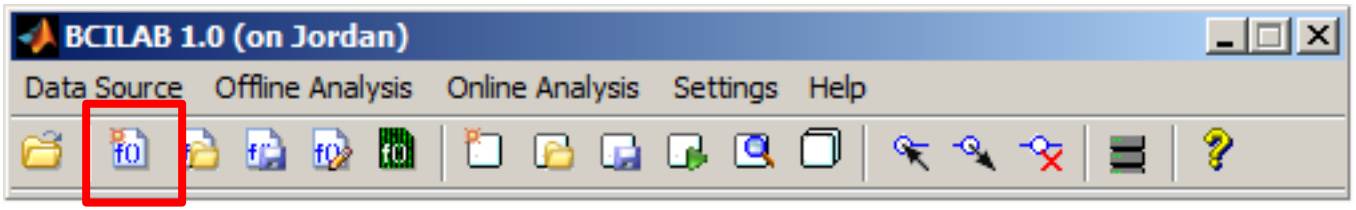
Saving the Approach for Later



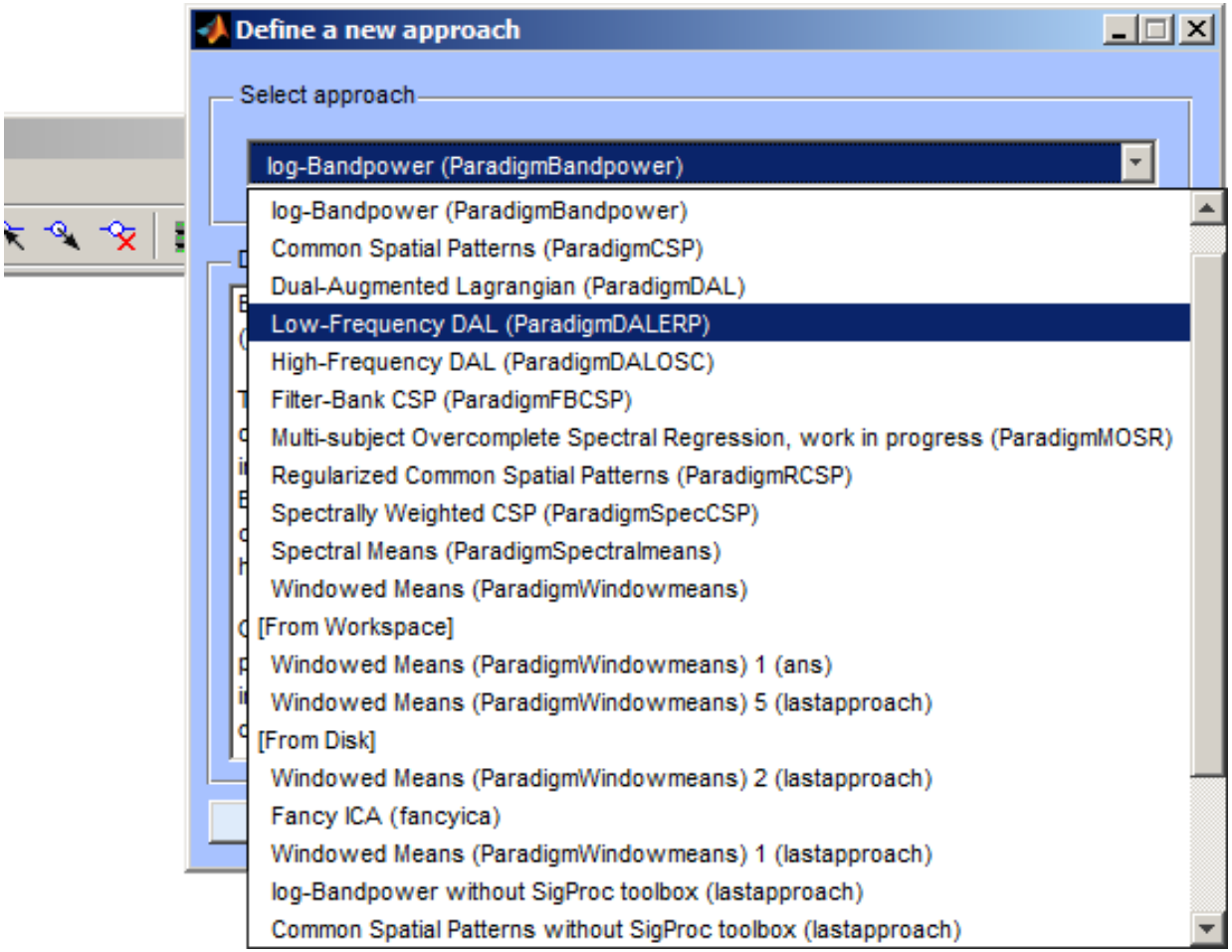
5 More Analyses: Using an Advanced ERP Paradigm

Note: this computation uses a method that will run for up to 15 minutes.

New Approach….

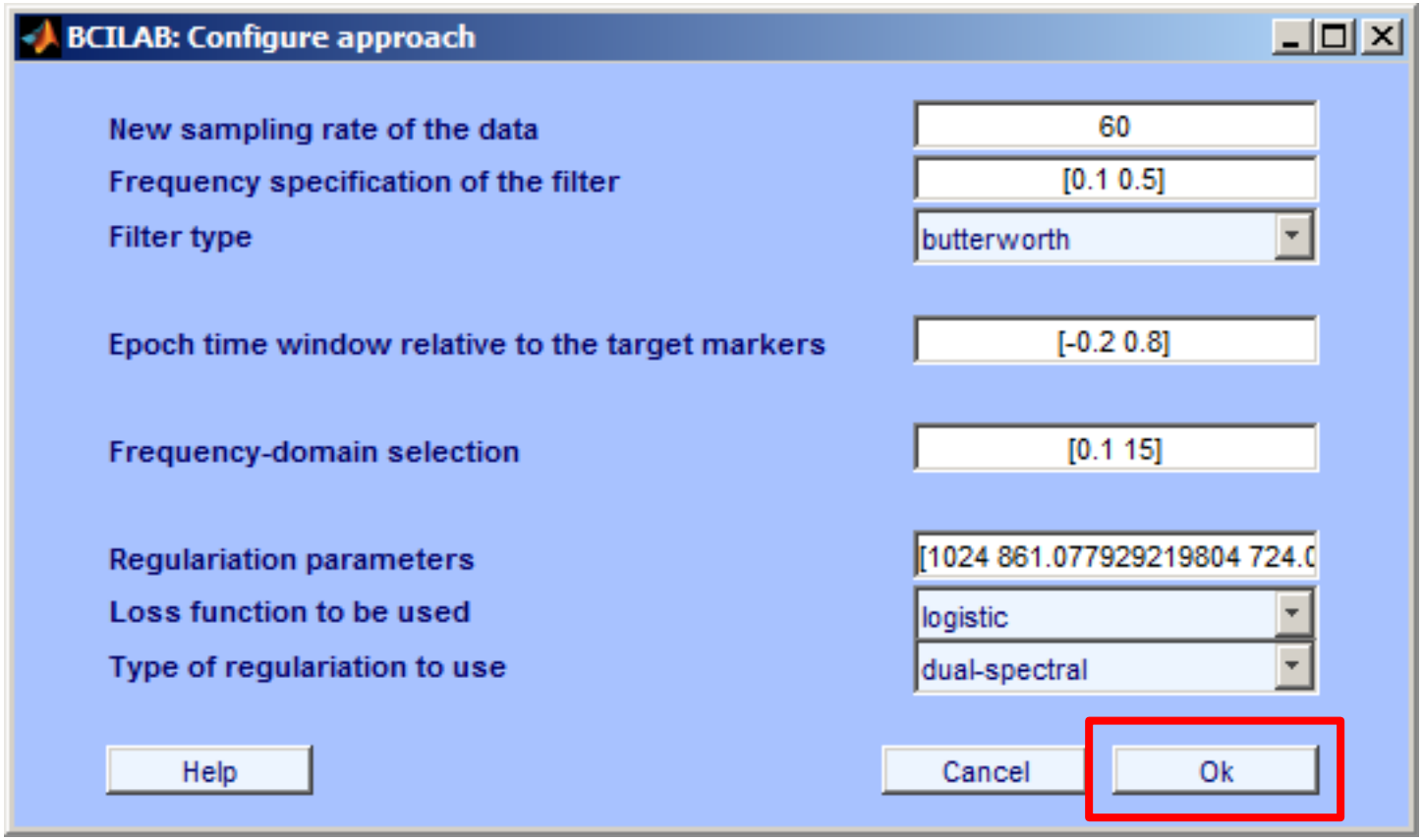


Selecting DAL-ERP

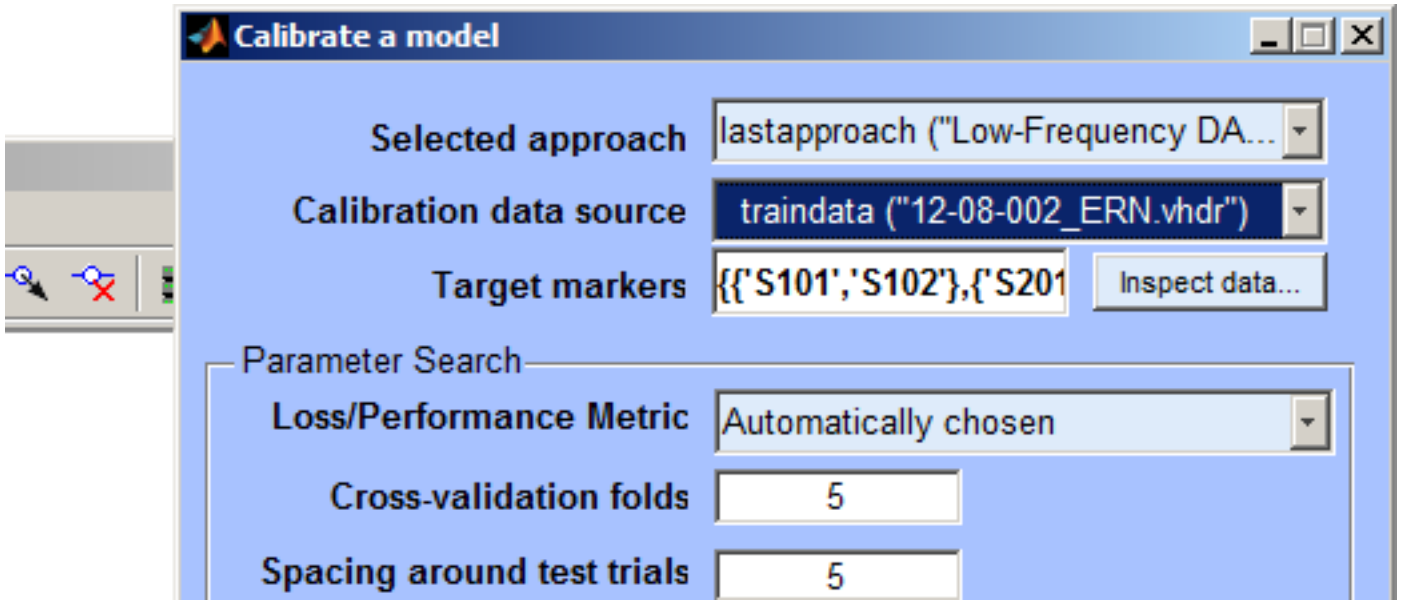


This is one of the best known approaches for ERP-based BCIs. It assumes that there is a small set of latent spatial sources with their own characteristic time course weights, and learns *both simultaneously*.

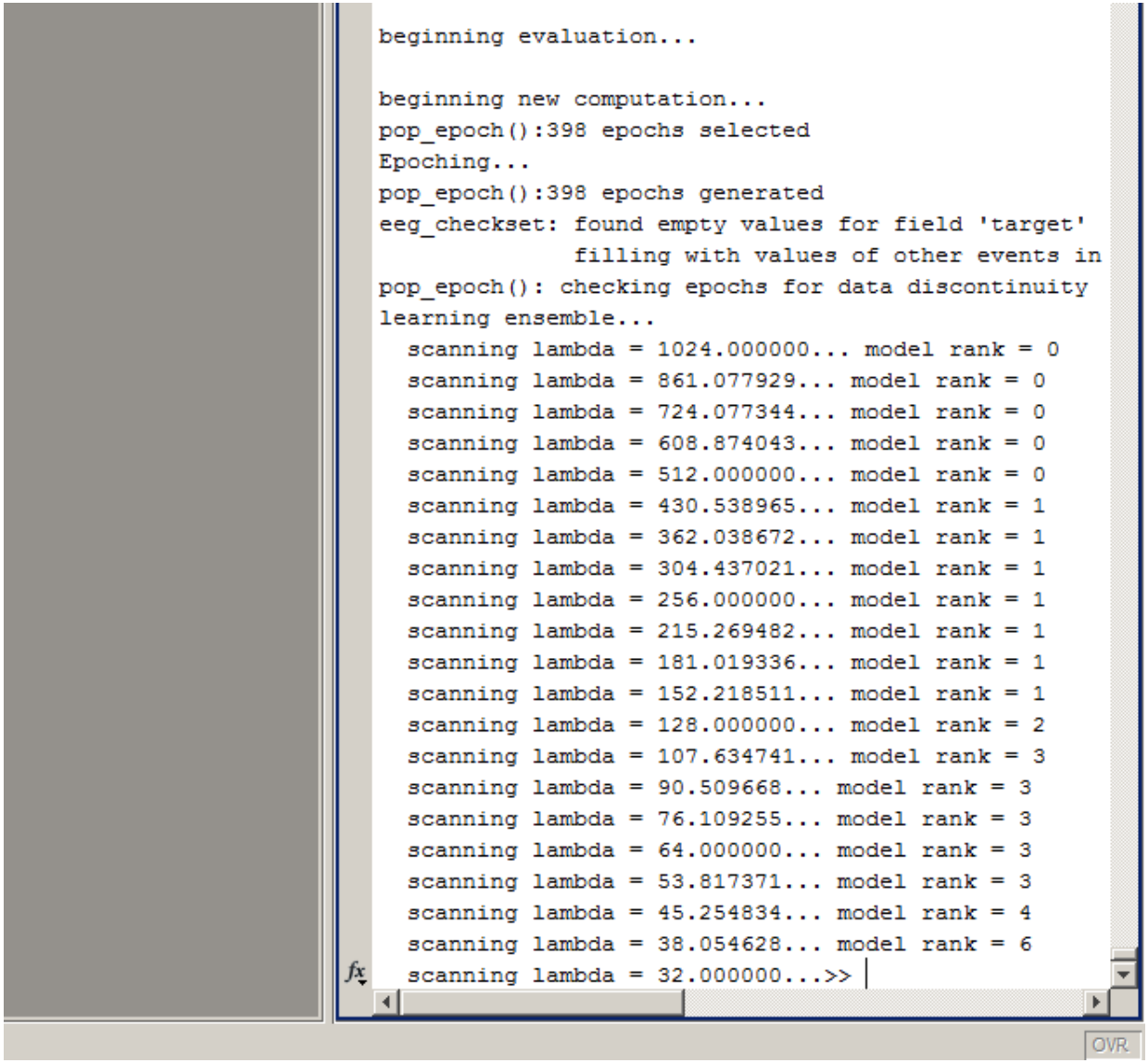
Configuring DAL-ERP



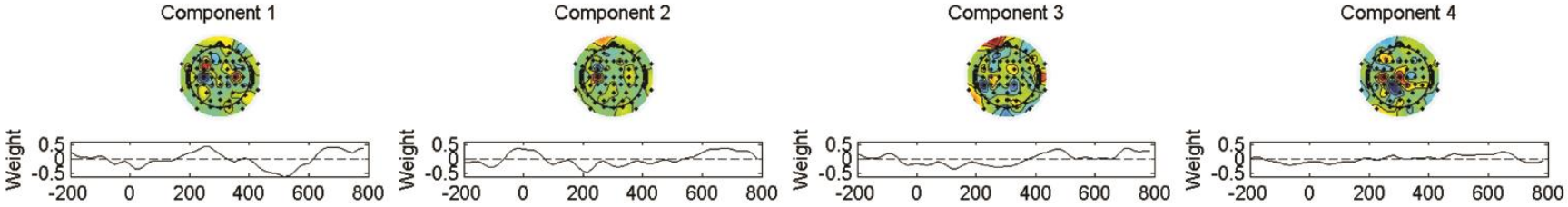
Calibrate Model…



Wait for a Few Minutes…



Visualizing the Model



Note that these are the spatial filters rather than the forward projections!