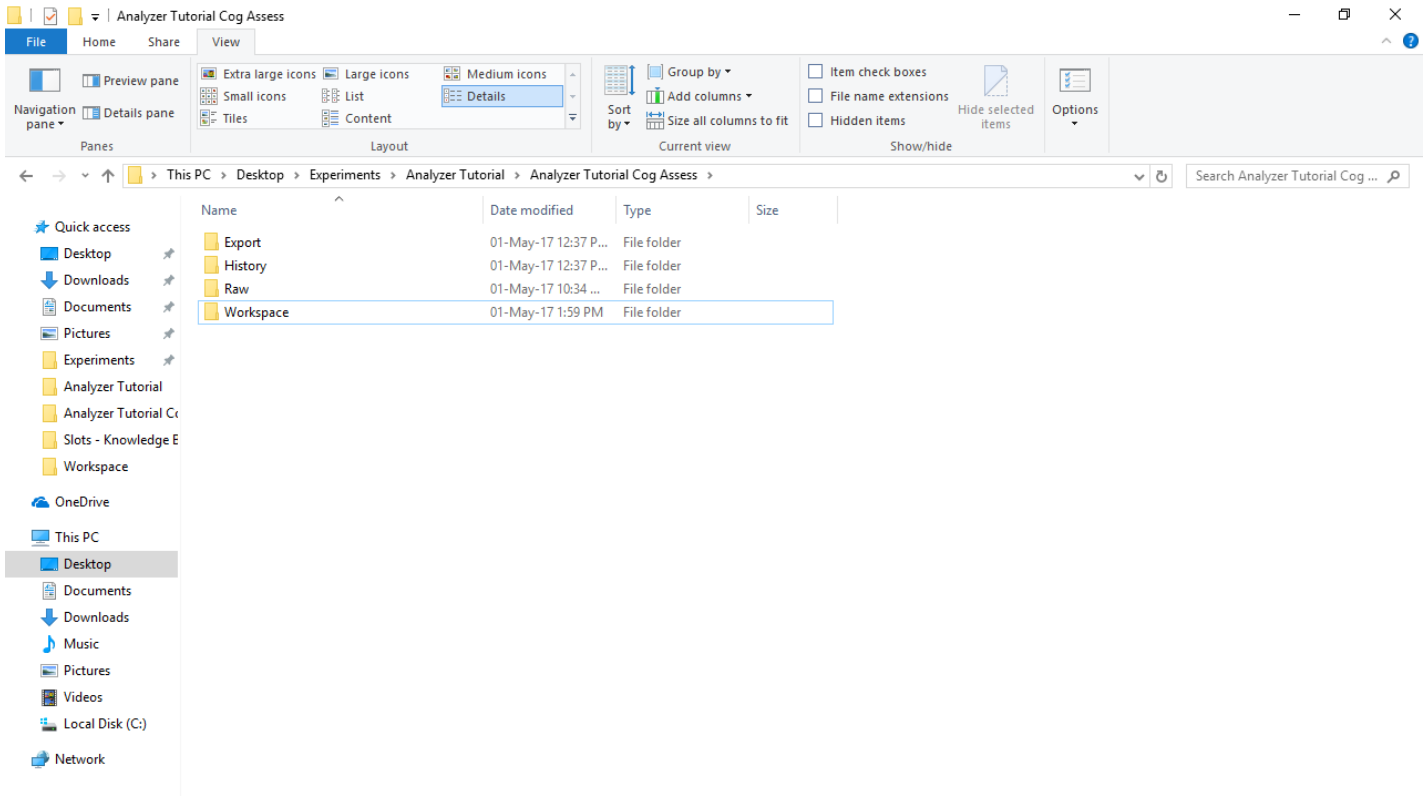
ERP Analysis Tutorial

Reward Positivity

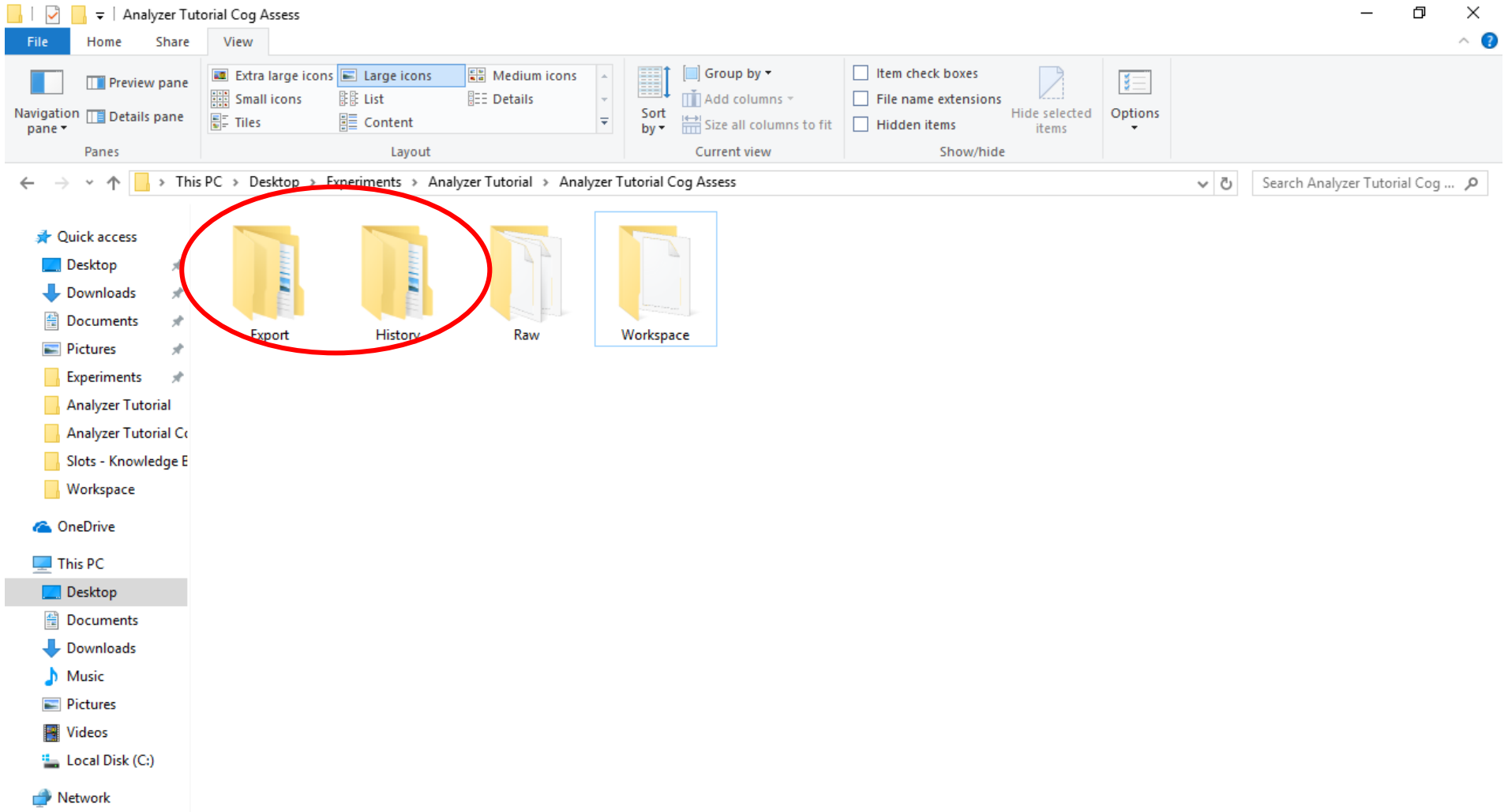
Created by the Krigolson Lab, 2017

Creating Files

- First, navigate to the tutorial folder. For example:
  - **This PC > Desktop > Experiments > Analyzer Tutorial > Analyzer Tutorial Cog Assess**

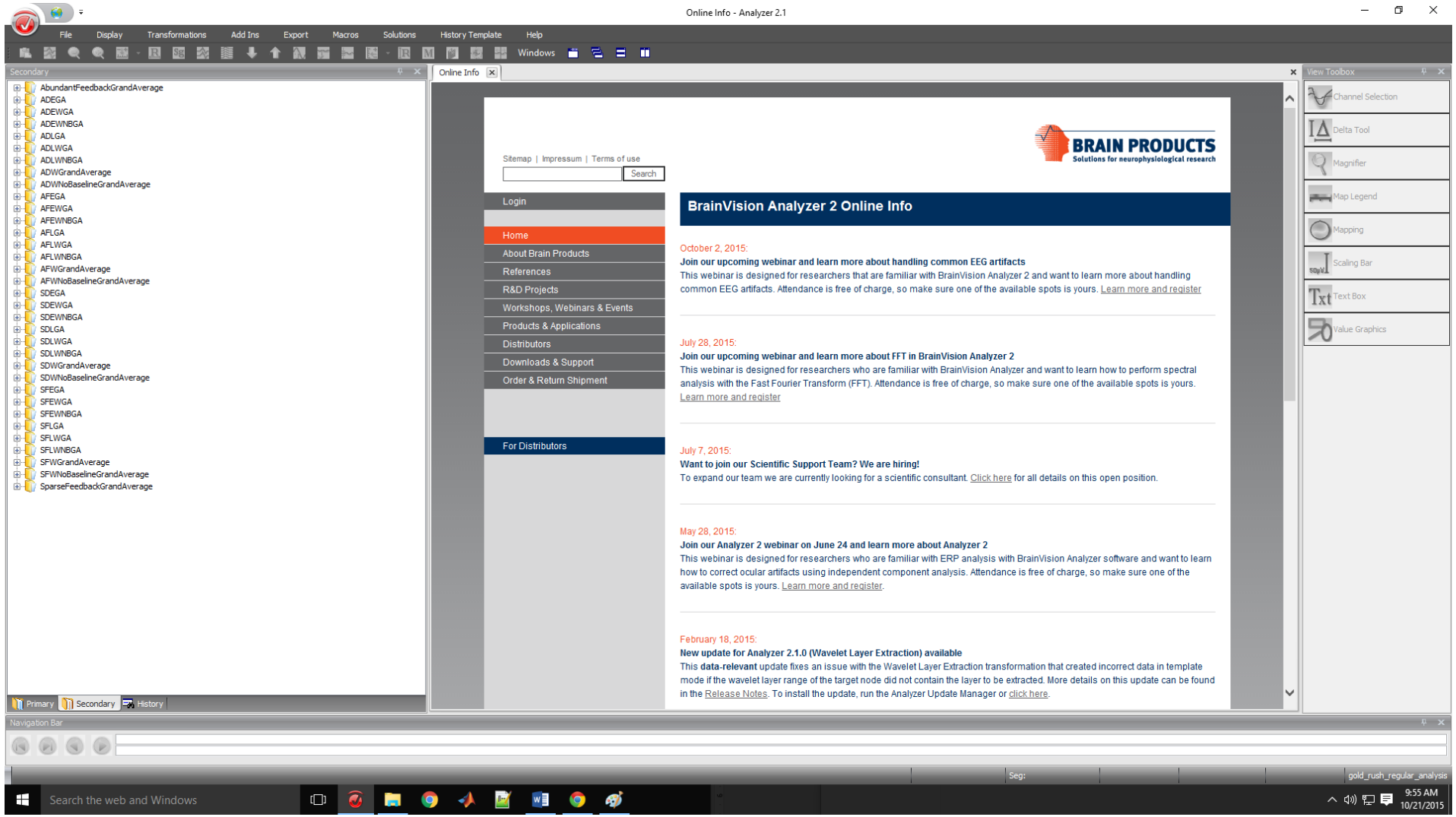


- Create a new History Folder and Export Folder in the respective “History Files” and “Export Files” folders. Name the files “**History_LastName**” and “**Export_LastName**” (e.g. ‘History_Krigolson’ and ‘Export_Krigolson’).

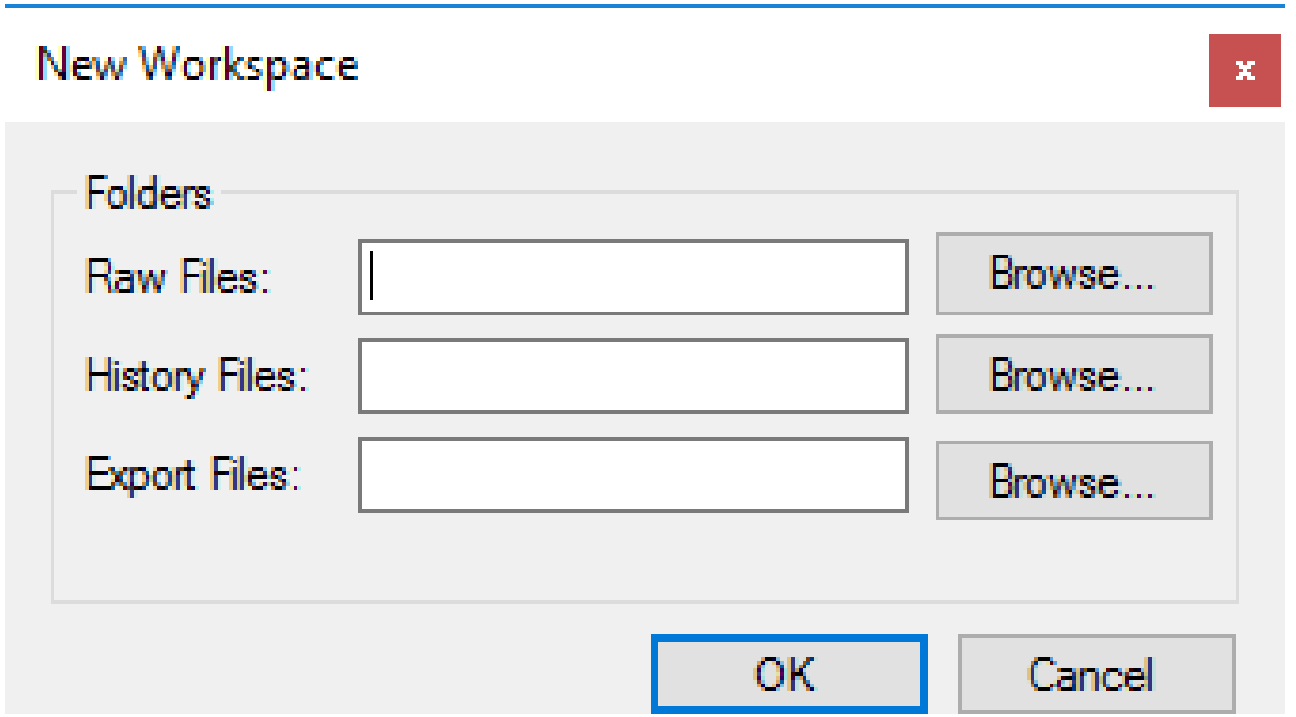


Setting Up the Workspace

- Open up BrainVision Analyzer 2.1



- Create a new workspace by clicking on the “**File**” tab on the top toolbar and click **“New”.**
- A “**New Workspace**” window will appear asking for **Raw, History and Export** Files (pictured below).



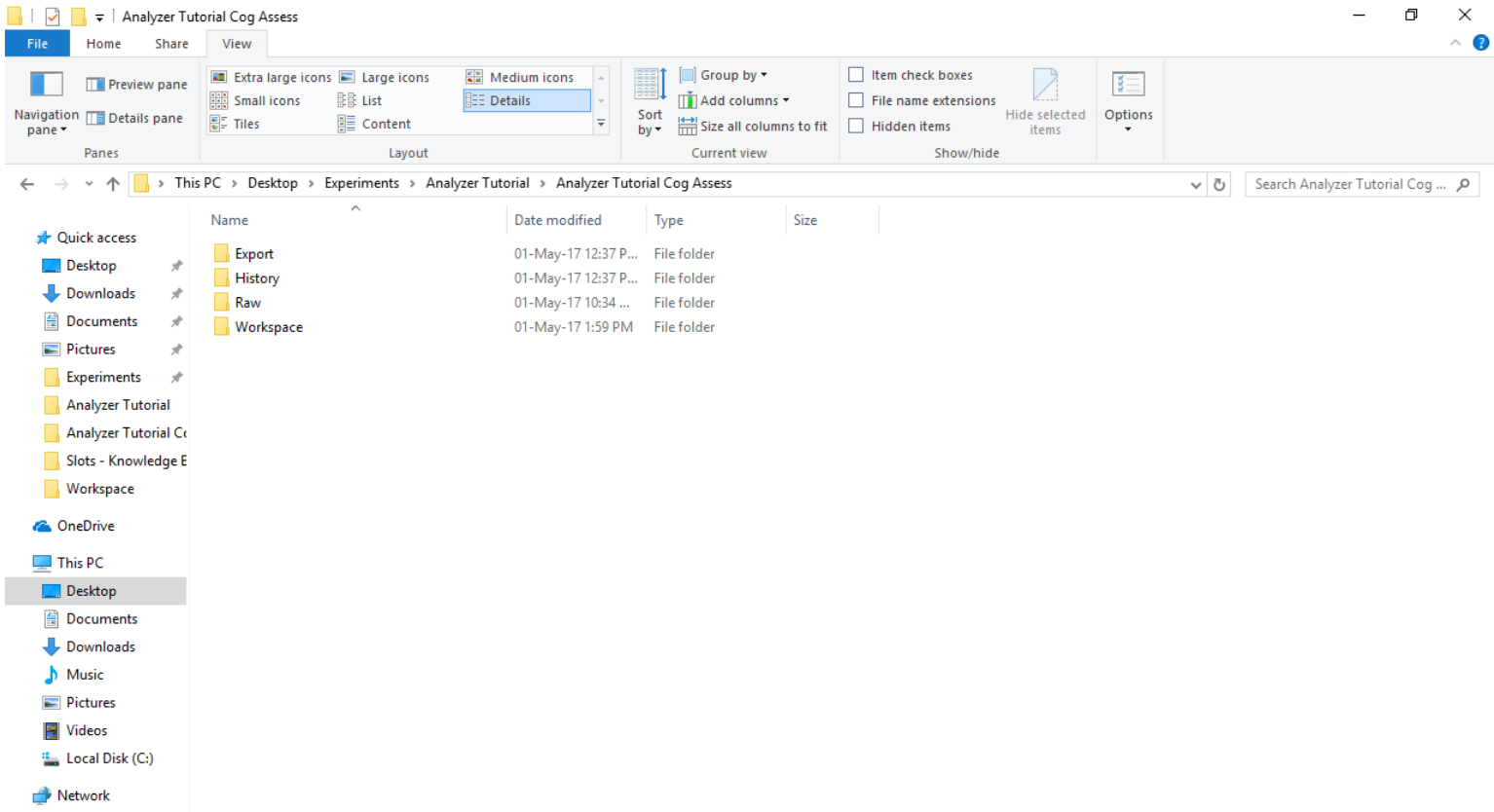
Selecting Raw, History and Export Files…

- Raw Files: click on "**Browse…**" and navigate the following pathway to find the folder: "**This PC\Desktop\Experiments\Analyzer Tutorial\ Analyzer Tutorial Cog Assess\Raw**". Alternatively, type this entire pathway into the text box.

- History Files (pathway): Navigate to the history file you have just created "**This PC\Desktop\Experiments\Analyzer Tutorial\ Analyzer Tutorial Cog Assess \History\History_LastName".**

- Export Files (pathway): Navigate to the export file you have just created "**This PC\Desktop\Experiments\Analyzer Tutorial\Analyzer Tutorial Cog\Export\Export_LastName".**

- Click “**Ok**” and then save workspace to the **“Workspace”** folder. Name the workspace **“LastName_Analysis”** (or something you will recognize). This is what you will open every time you analyze this set of data. Your final folder should mirror the image below.



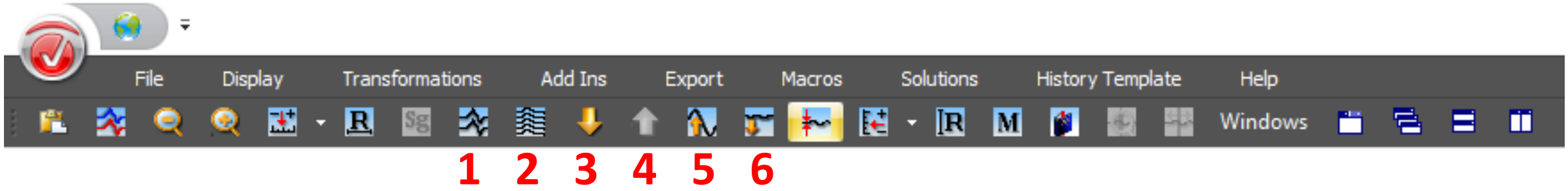
- You are now ready to navigate the workspace.

The Workspace

- The workspace should be set up for analysis now. Before you begin analyzing, take some time to orient yourself with some basic controls.

- **Important Keyboard Controls**
- “Crtl + left/right arrow keys” = scrolls through the data
- “Crtl + up/down arrow keys” = increases/decreases amplitude

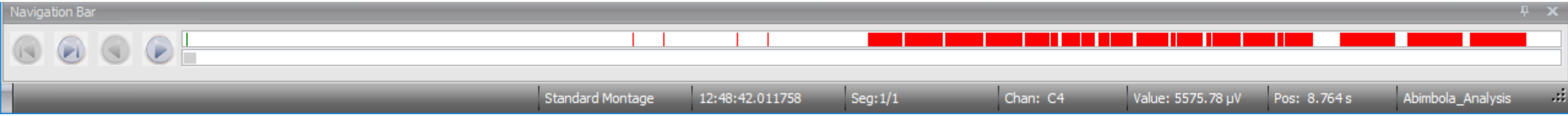
Important Toolbar Controls



1. Decreases the # of electrodes shown
2. Increases the # of electrodes shown
3. Scrolls down through electrodes (when not all are shown)
4. Scrolls up through electrodes (when not all are shown)
5. Increases EEG amplitude scale
6. Decreases EEG amplitude scale

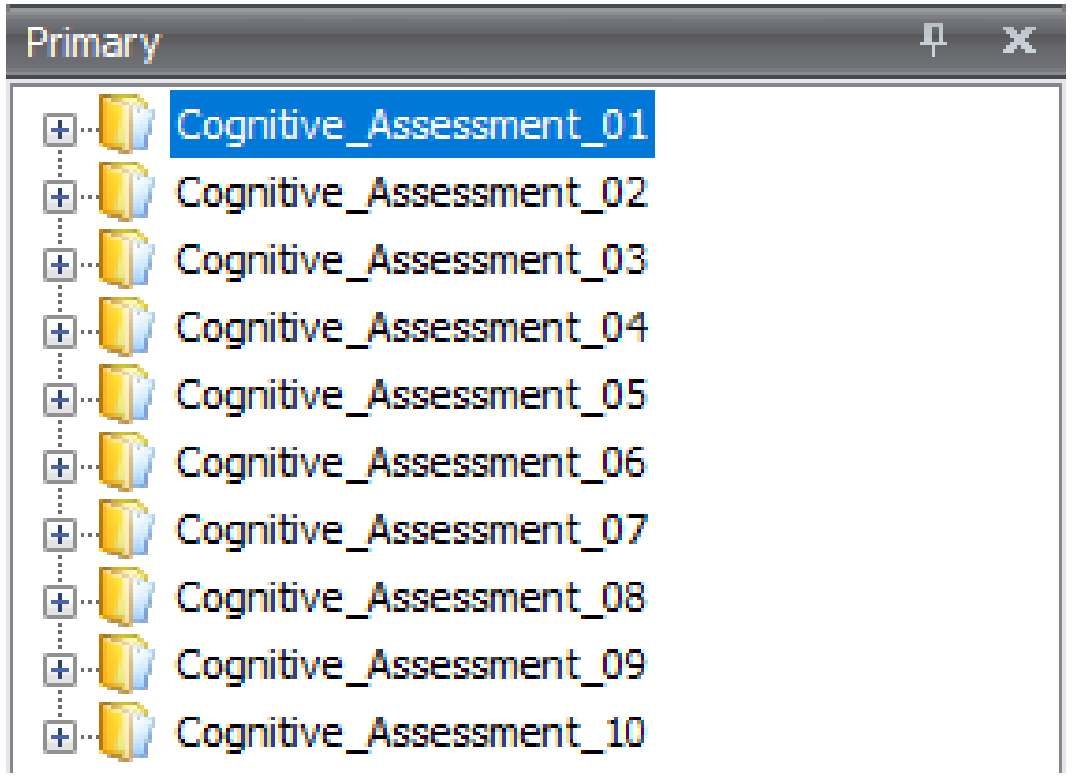
Navigation Bar

- This bar shows the progress of the experiment.
- The red markers indicate certain events during the experiment.
- Blank gaps between these markers indicate a rest break (or no events of interest).



Additional Navigation Tips

- The Primary task window is used for navigating between participants. Stored within each folder is the raw data for that specific participant and each processing step that we will complete on the data.



Short Description of the Experiment

- The experiment you will be analyzing is called Cognitive Assessment. This experiment consists of two paradigms: Decision Making (reinforcement learning paradigm) for the analysis of the reward positivity ERP component and Oddball for the analysis of the P300 ERP component. Here, we will work with the decision making paradigm and the analysis of the reward positivity.

- In decision making, participants had to choose between two stimuli (a blue and green square on either side of a central target) and were given feedback on whether they had “won” or “lost” (referred to as ‘hits’ and ‘misses” for the purposes of this analysis). One of these stimuli will result in “win” feedback more often than the other, thus the participant must learn which square is more rewarding through trial and error.

- You will be finding the average neural response to the ‘hits’ and ‘misses” of data from 10 participants.

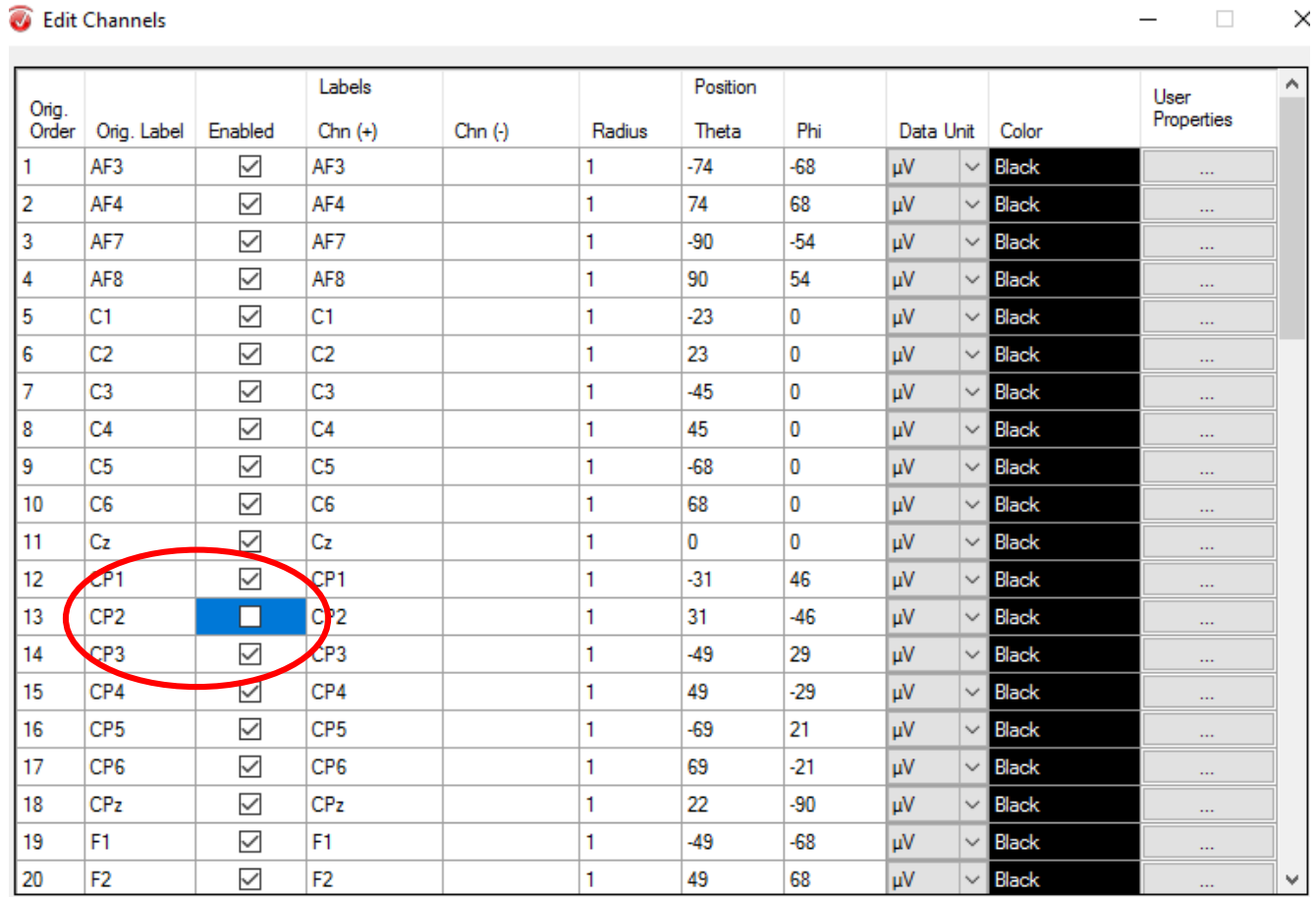
Starting Analysis

- Open “**Cognitive_Assessment_01**” folder and double-click on “**Raw Data**”.
- Each folder contains the EEG data for one participant.
- Click on **Increase Channels** to view all channels.
- Scroll through the data and look for noisy or dead channels.
- **Noisy** = typically recurring, unpatterned, large spikes that have no relation to other channels (*rest breaks may appear wacky; this is acceptable as we don’t use data from rest breaks).
- **Dead** = signal is a flat line. Note down any dead/noisy channels.
- When looking for noisy channels, focus your search to areas with events of interest (e.g., where there is a a red line or bar on the navigation bar at the bottom of the screen).

*The following steps all occur under the **Transformations** tab

1. Edit Channels

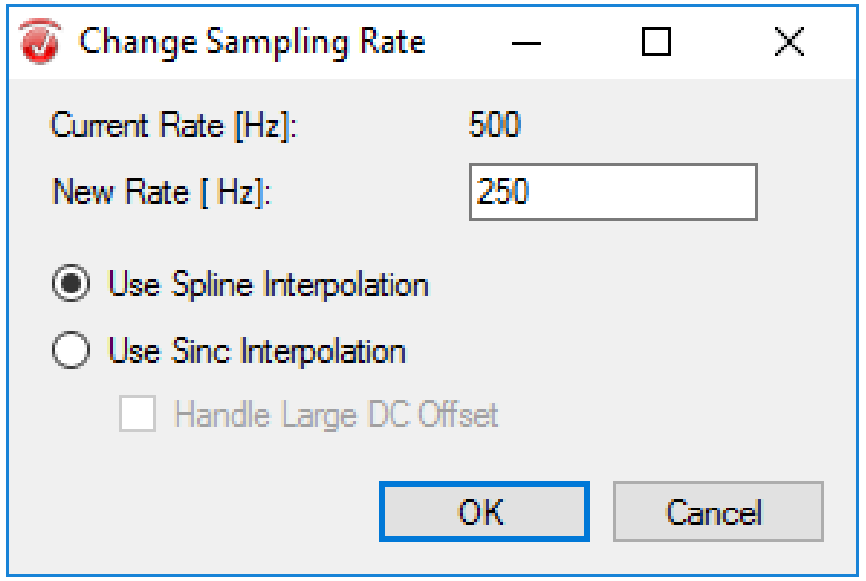
Open the **Transformations** tab and click **Edit Channels**. In the pop-up window, uncheck the noisy or dead channels previously noted. Click **OK.**



Orig. Order	Orig. Label	Enabled	Labels Chn (+)	Chn (-)	Position Radius	Theta	Phi	Data Unit	Color	User Properties
1	AF3	☑	AF3		1	-74	-68	µV	Black	...
2	AF4	☑	AF4		1	74	68	µV	Black	...
3	AF7	☑	AF7		1	-90	-54	µV	Black	...
4	AF8	☑	AF8		1	90	54	µV	Black	...
5	C1	☑	C1		1	-23	0	µV	Black	...
6	C2	☑	C2		1	23	0	µV	Black	...
7	C3	☑	C3		1	-45	0	µV	Black	...
8	C4	☑	C4		1	45	0	µV	Black	...
9	C5	☑	C5		1	-68	0	µV	Black	...
10	C6	☑	C6		1	68	0	µV	Black	...
11	Cz	☑	Cz		1	0	0	µV	Black	...
12	CP1	☑	CP1		1	-31	46	µV	Black	...
13	CP2	☐	CP2		1	31	-46	µV	Black	...
14	CP3	☑	CP3		1	-49	29	µV	Black	...
15	CP4	☑	CP4		1	49	-29	µV	Black	...
16	CP5	☑	CP5		1	-69	21	µV	Black	...
17	CP6	☑	CP6		1	69	-21	µV	Black	...
18	CPz	☑	CPz		1	22	-90	µV	Black	...
19	F1	☑	F1		1	-49	-68	µV	Black	...
20	F2	☑	F2		1	49	68	µV	Black	...

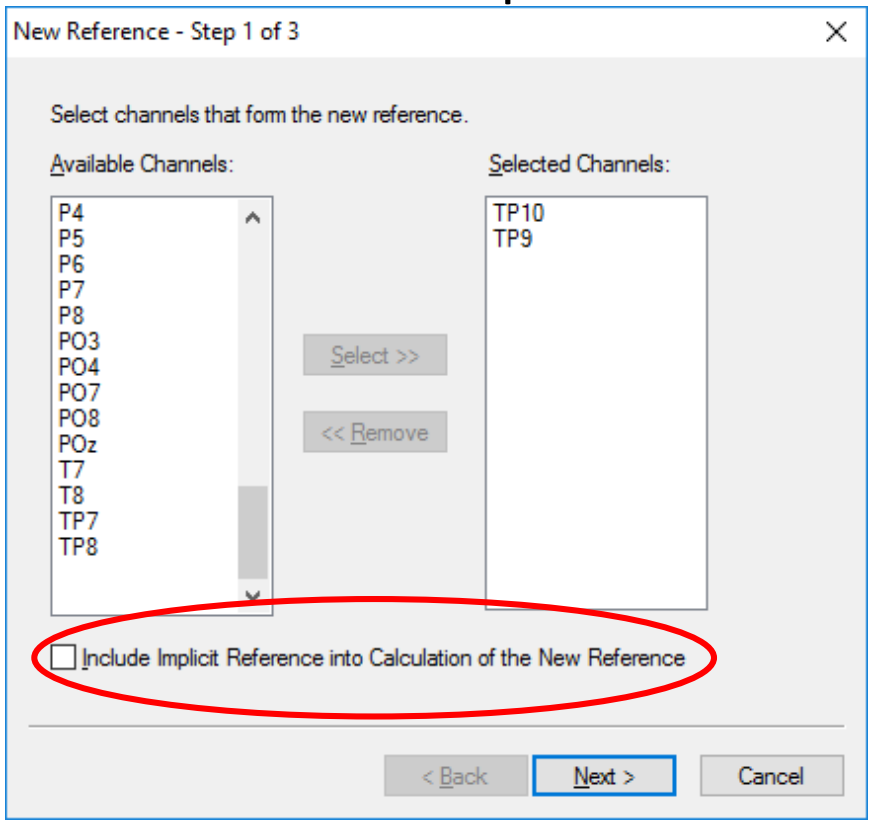
2. Down Sample

- **Transformations > Dataset Preprocessing > Change Sampling Rate**.
- In the pop-up window, insert **250** as the **New Rate**. Select **Use Spline Interpolation**.

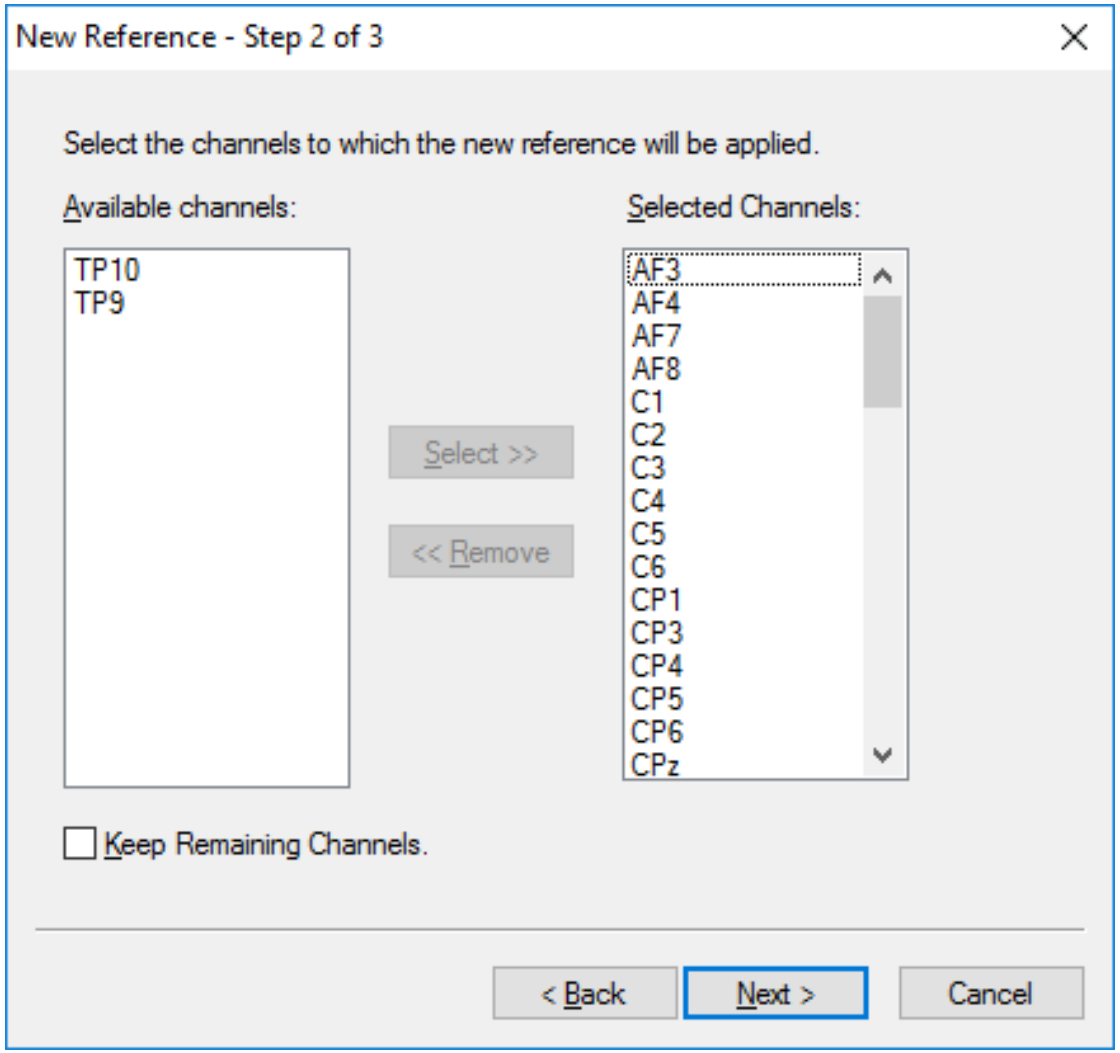


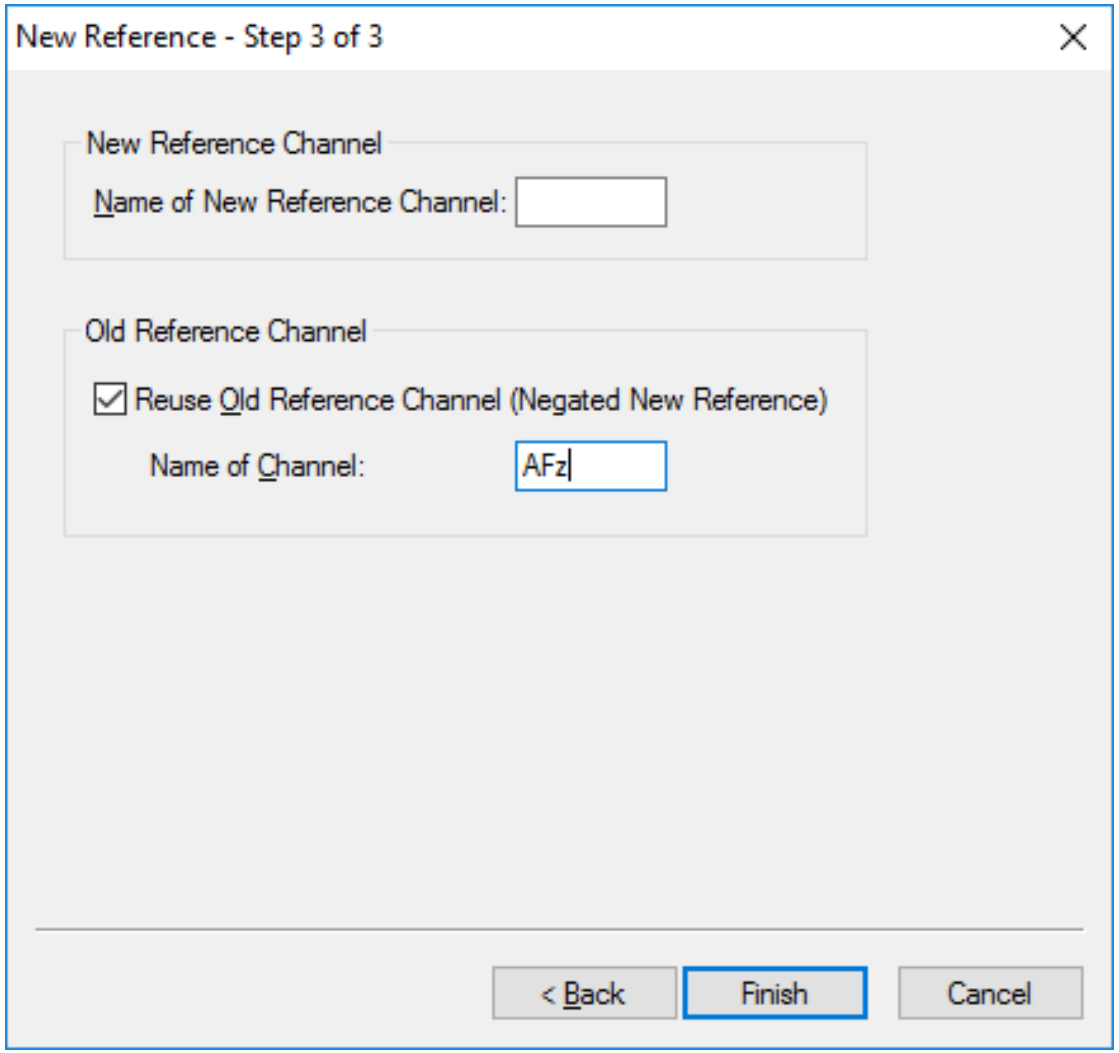
3. Re-Reference

- Click **Channel Preprocessing** and **New Reference**.
  - 1st Window - select TP9 and TP10 (left mastoid and right mastoid) and add them to the **Selected Channels** list. The mastoid channels form the new reference. Click **Next**.
  - Note: Ensure that you **do not include** implicit reference's into the new calculation.



- 2nd Window – Add all channels to the **Selected Channels** list **EXCEPT** for TP9 and TP10.

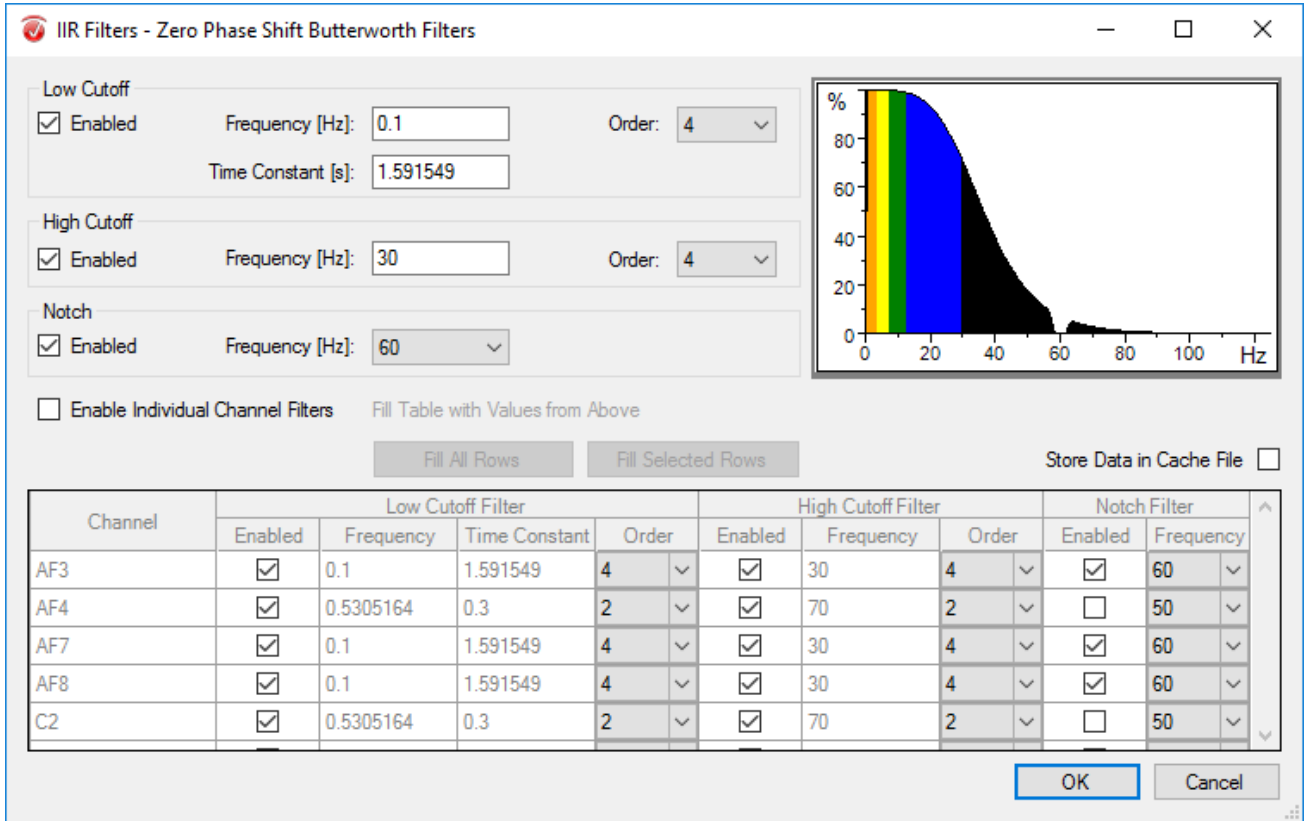




3rd Window – Replicate the image of Step 3 (this will interpolate the channel AFz, which was the reference channel when recording) and then click **Finish.**

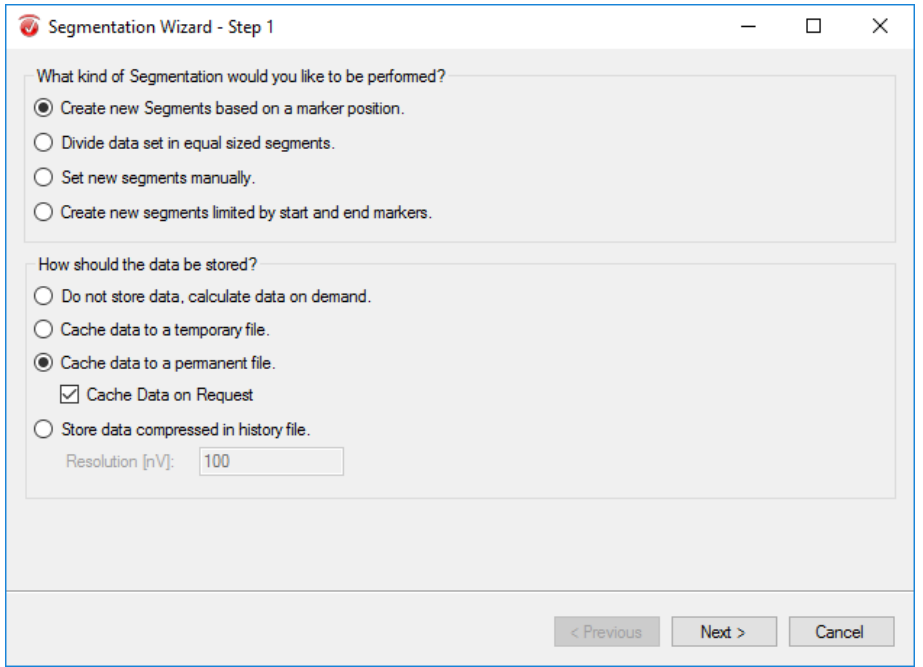
4. Filter

- **Transformations > Artifact Rejection/Reduction > Data Filtering.**
- At **Data Filtering**, select **IRR Filters**.
- Set **Low Cutoff** to enabled, and insert **0.1** as the frequency. Enable **High Cutoff** and insert **30** as the frequency. Enable **Notch** and select **60** notch frequency. Click **OK**. This removes some unwanted electrical noise.

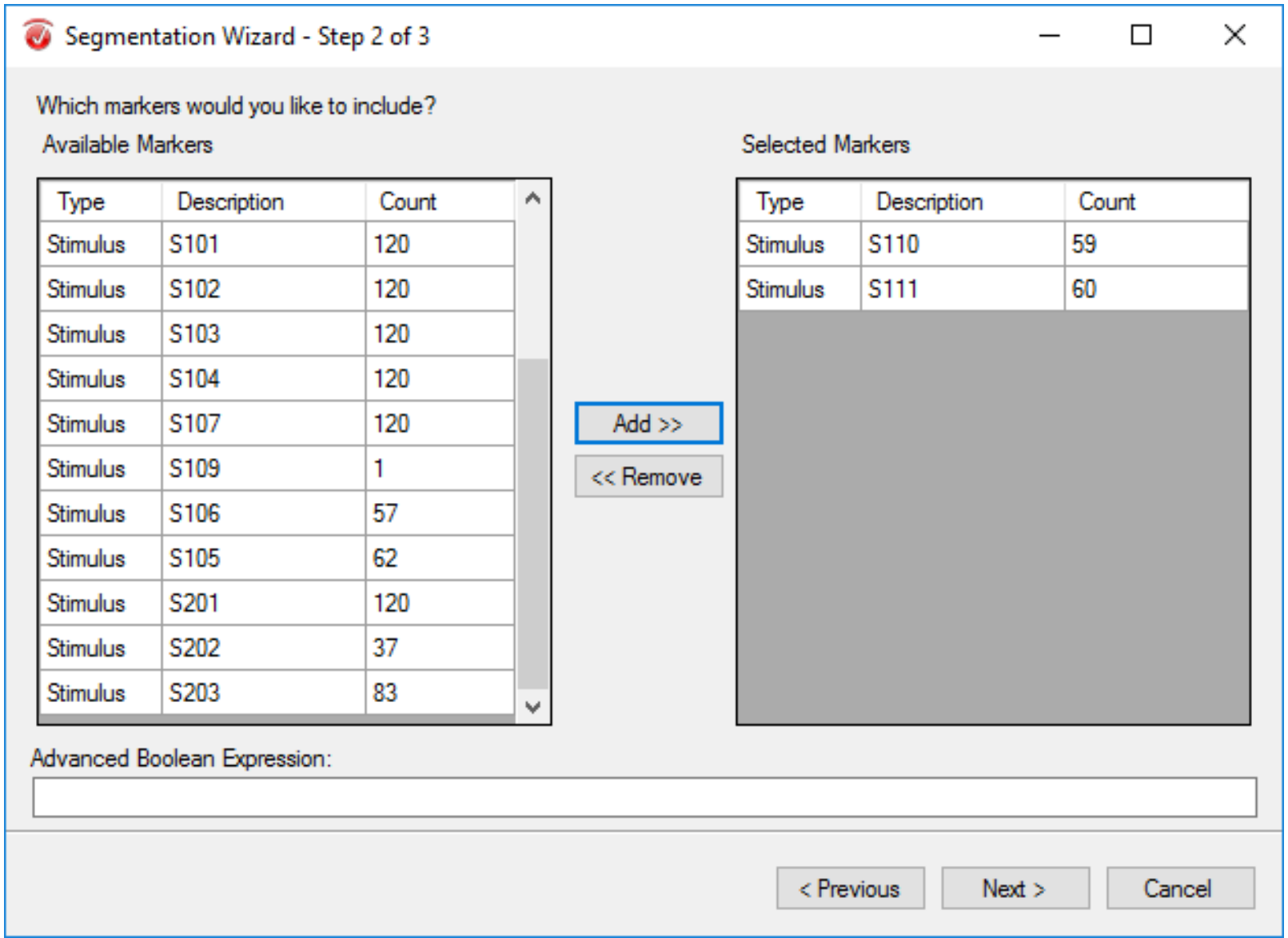


5. Segmentation

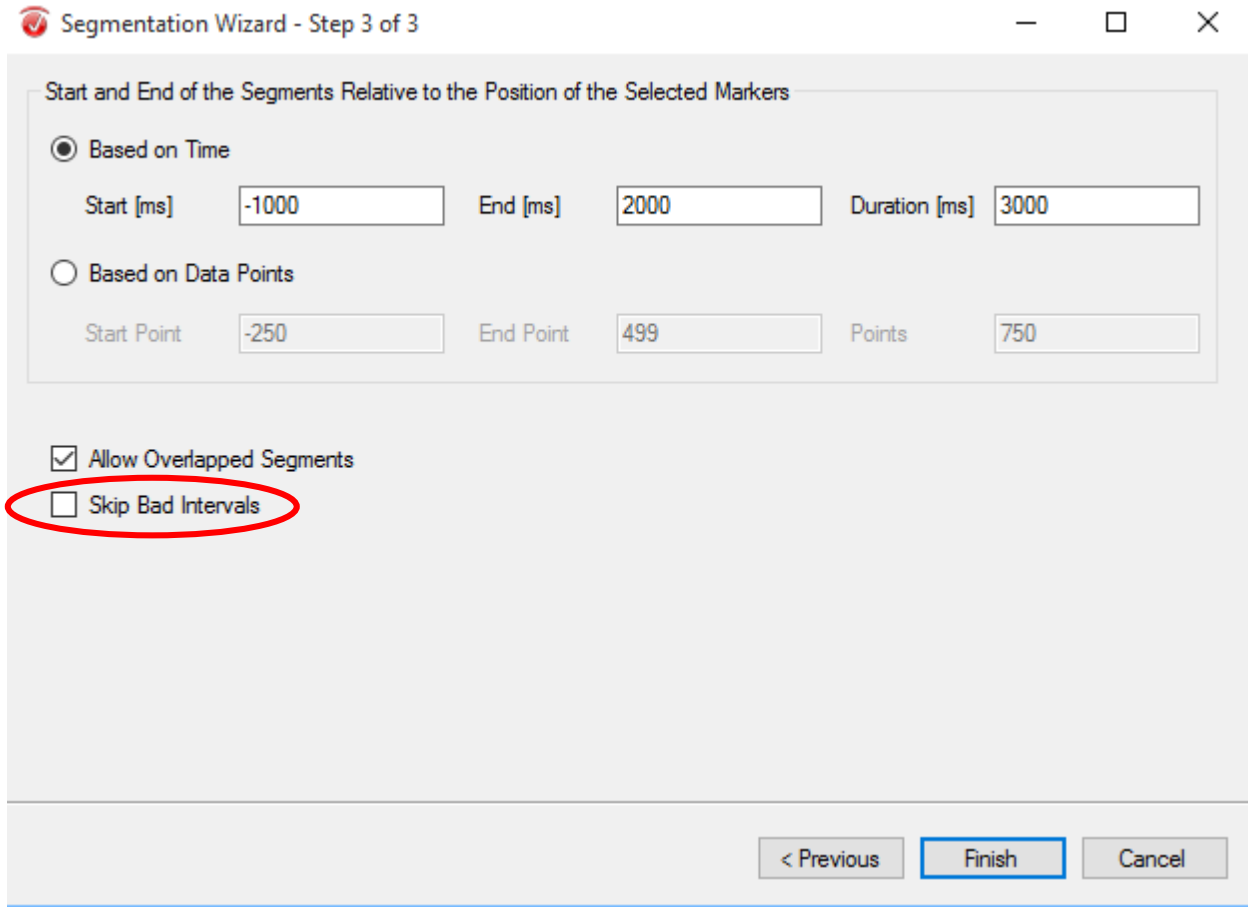
- This step will extract the hits and misses from the rest of data so we can analyze them.
- Find Segment Analysis Functions
- Click **Segmentation**
  - 1st window – select **Create new Segments based on a marker position.** Select **Cache data to a permanent file** with **Cache Data on Request** checked. Click **Next.**



- 2nd window – Select the segment markers **S 110 & S 111** from the list of ‘Available Markers’ and add them to ‘Selected Markers’. Click **Next.**



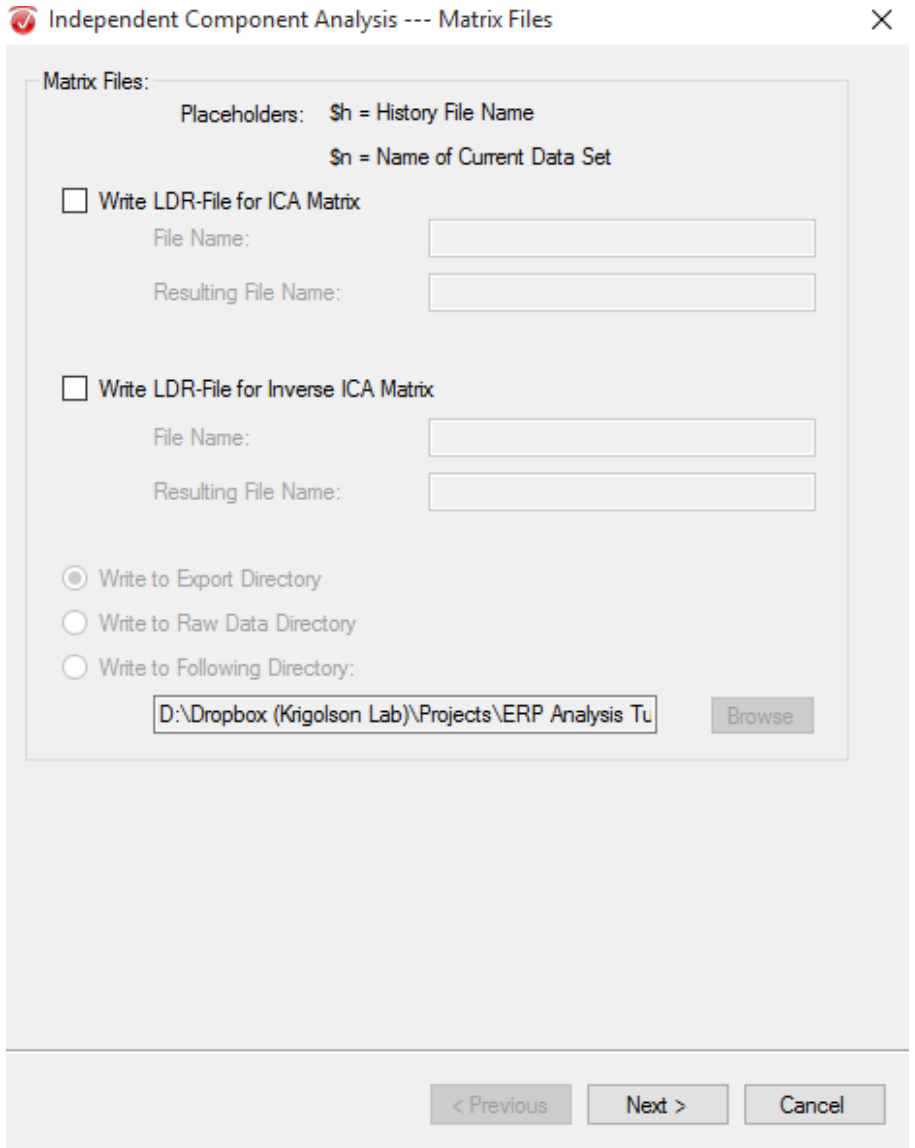
- 3rd window – select **Based on Time**. Insert **-1000** for **Start** and **2000** for **End**. Ensure **Skip Bad Intervals** is **unchecked**. Click **Finish**



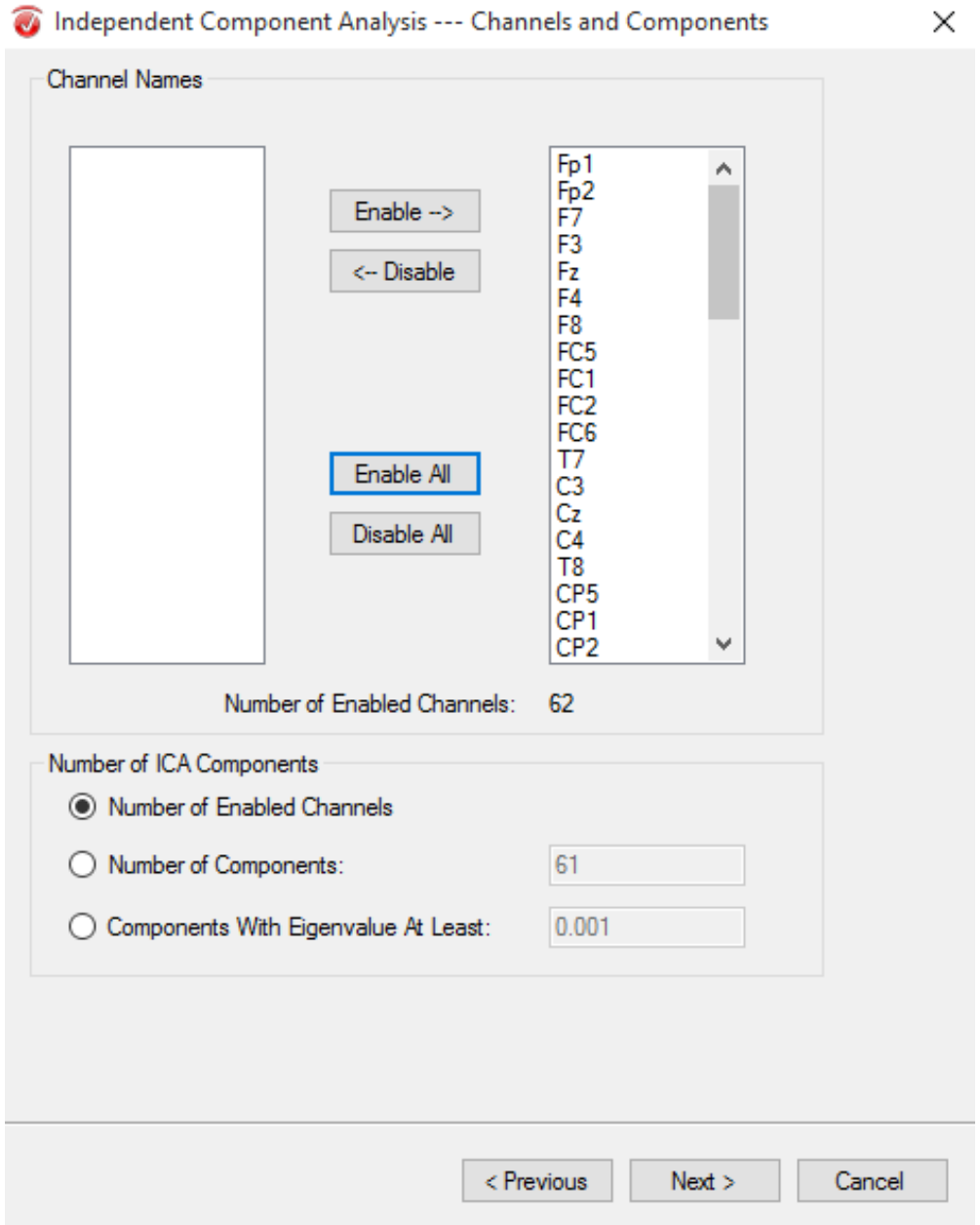
- ***Side Note** – Markers correspond to certain events during the test. The S110 marker represents a 'hit' and the S111 indicates a 'miss'.

6. ICA – Independent Component Analysis

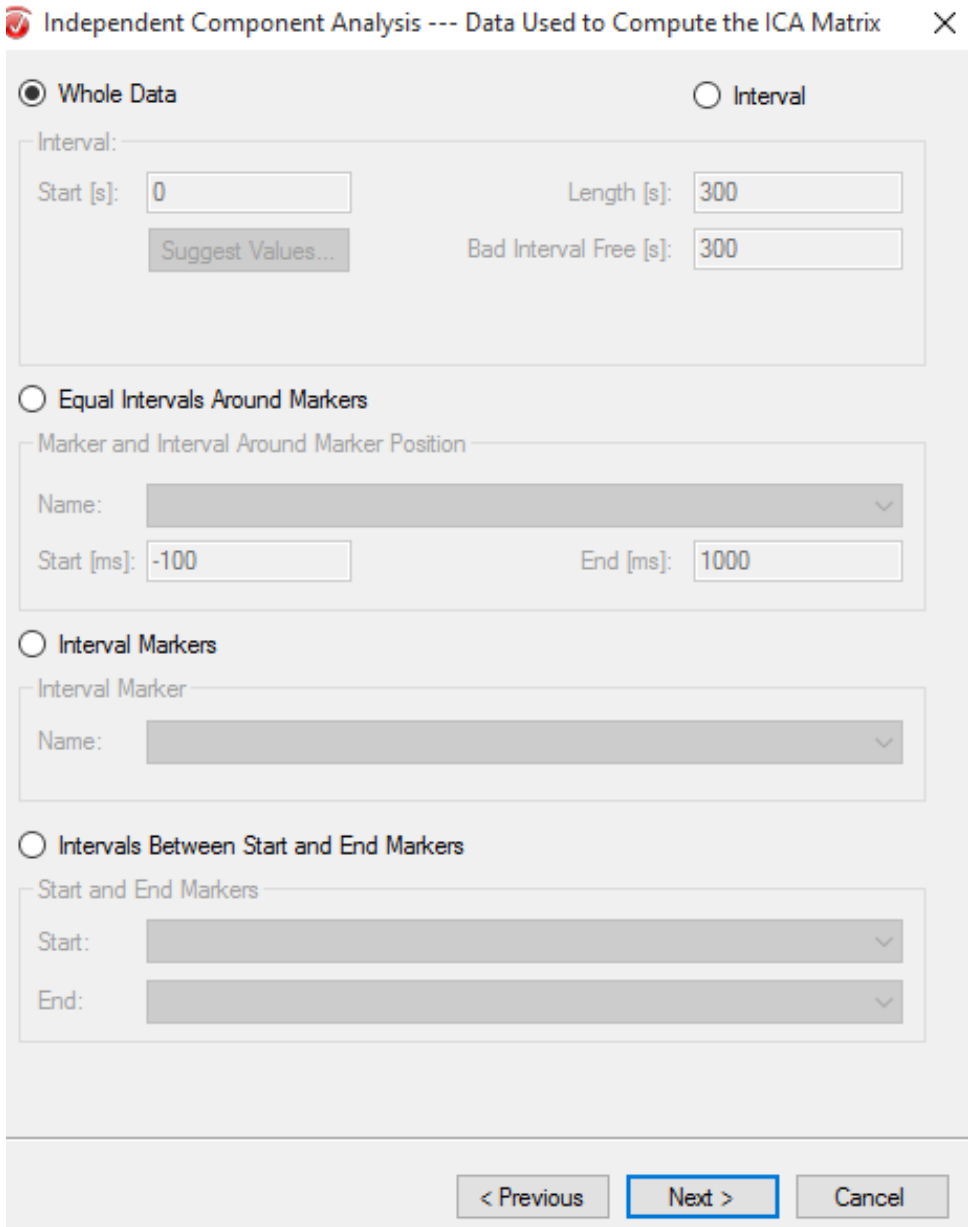
- ICA identifies recurring components of data. We are using this to identify ‘blink’ components.
- In the **Transformations** tab, navigate to **Frequency and Component Analysis** and go to **ICA**.
- 1st Window – Uncheck ALL boxes. Click **Next.**



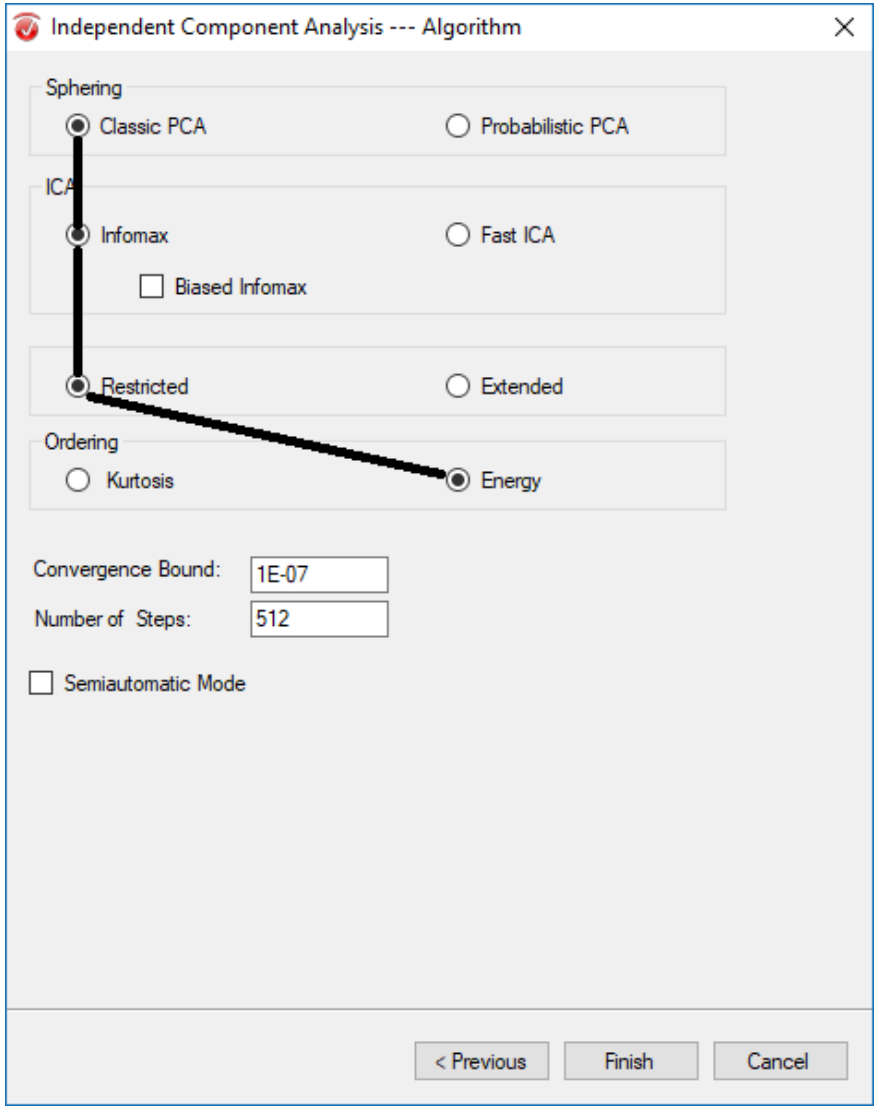
- 2nd Window – Click **Enable All** channels. Select **Number of Enabled Channels**



- 3rd Window – Click **Whole Data**



- 4th Window – Select the following options. 1. **Classic PCA.** 2. **Infomax.** 3. **Restricted**. 4. **Energy.** (Tip: shaped like an “L”). Unselect **Semiautomatic mode** and click **Finish**.

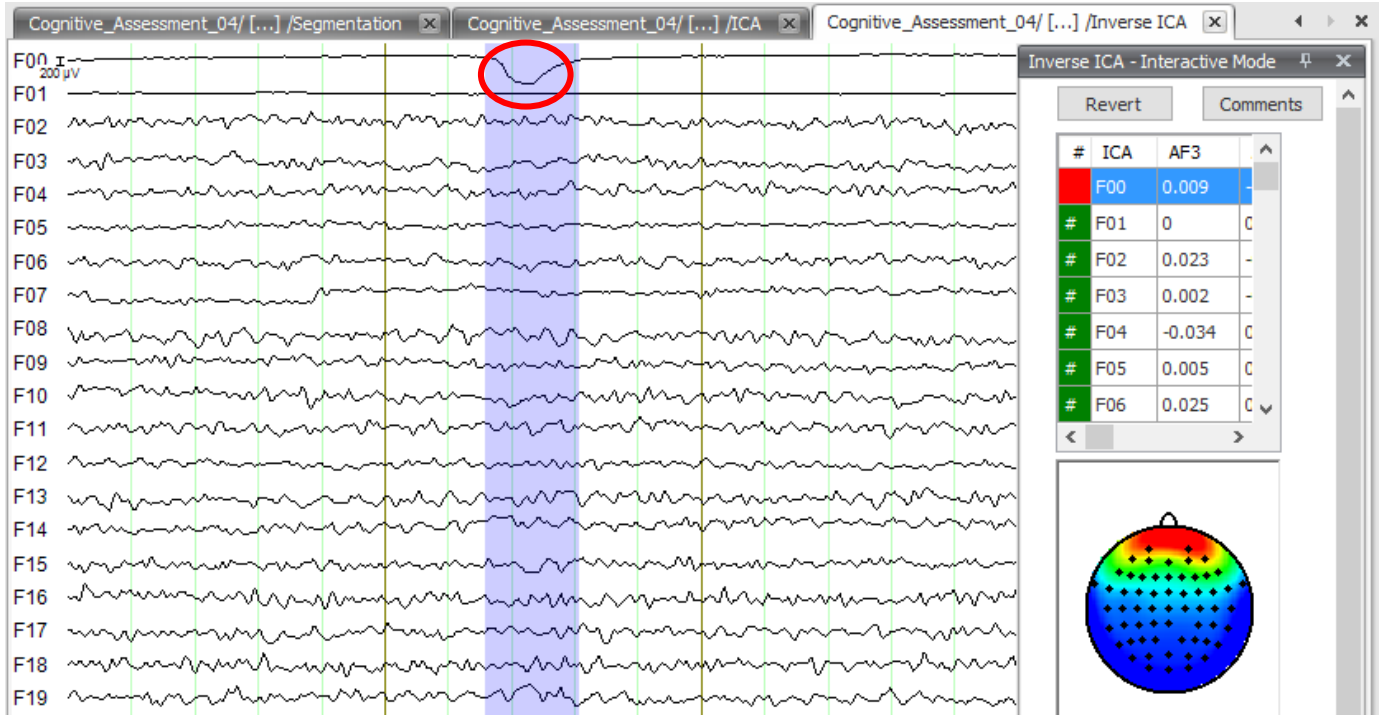


- This step may take a few minutes. Tip: For subsequent data sets, it may be useful to stop before this step for multiple participants and then run ICA for each different participant consecutively via a history template (not discussed here).

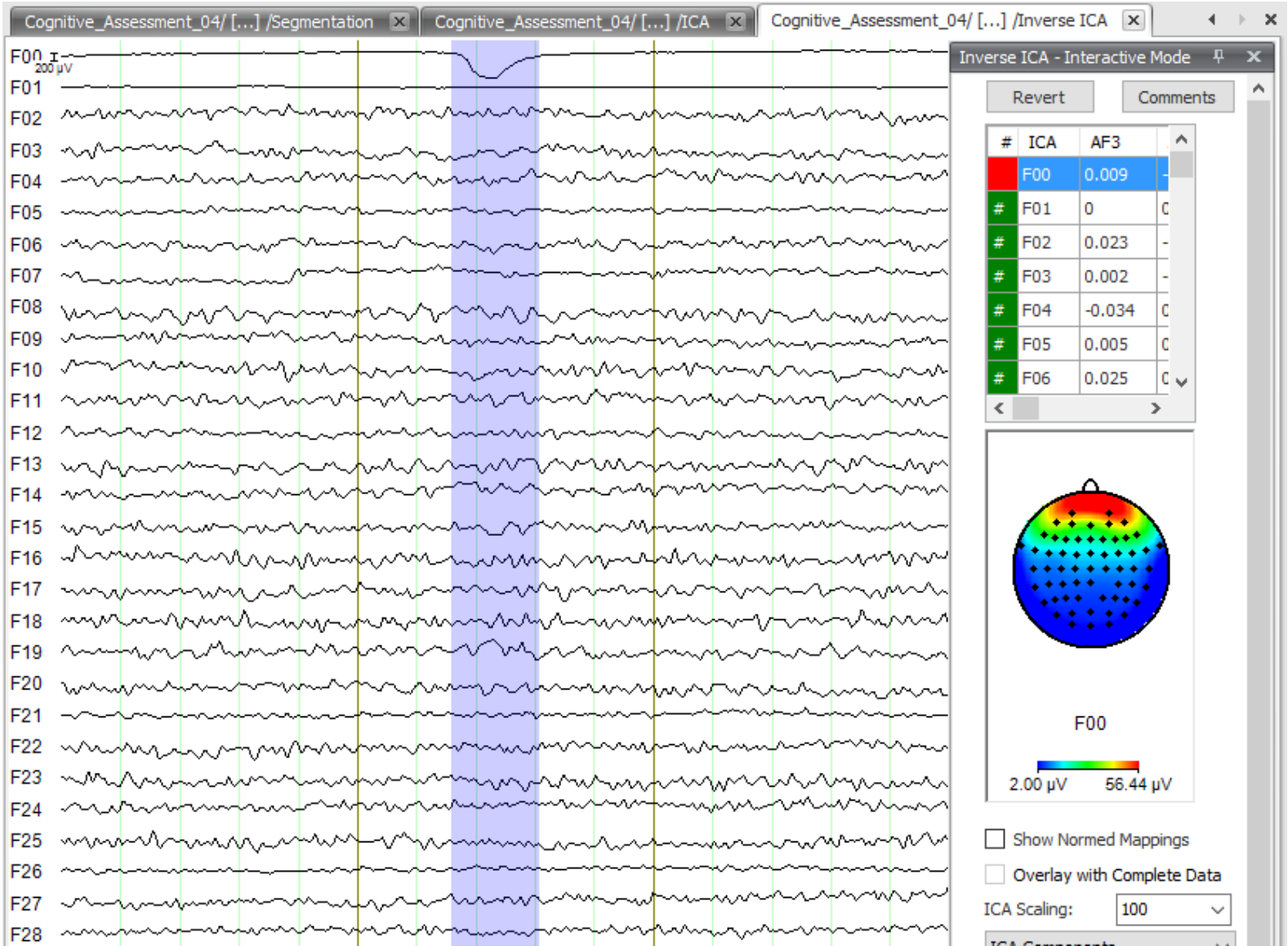
- After ICA is complete, the data shown in the ICA node is no longer EEG data, but individual components that have been extracted from the data.

7. Inverse ICA

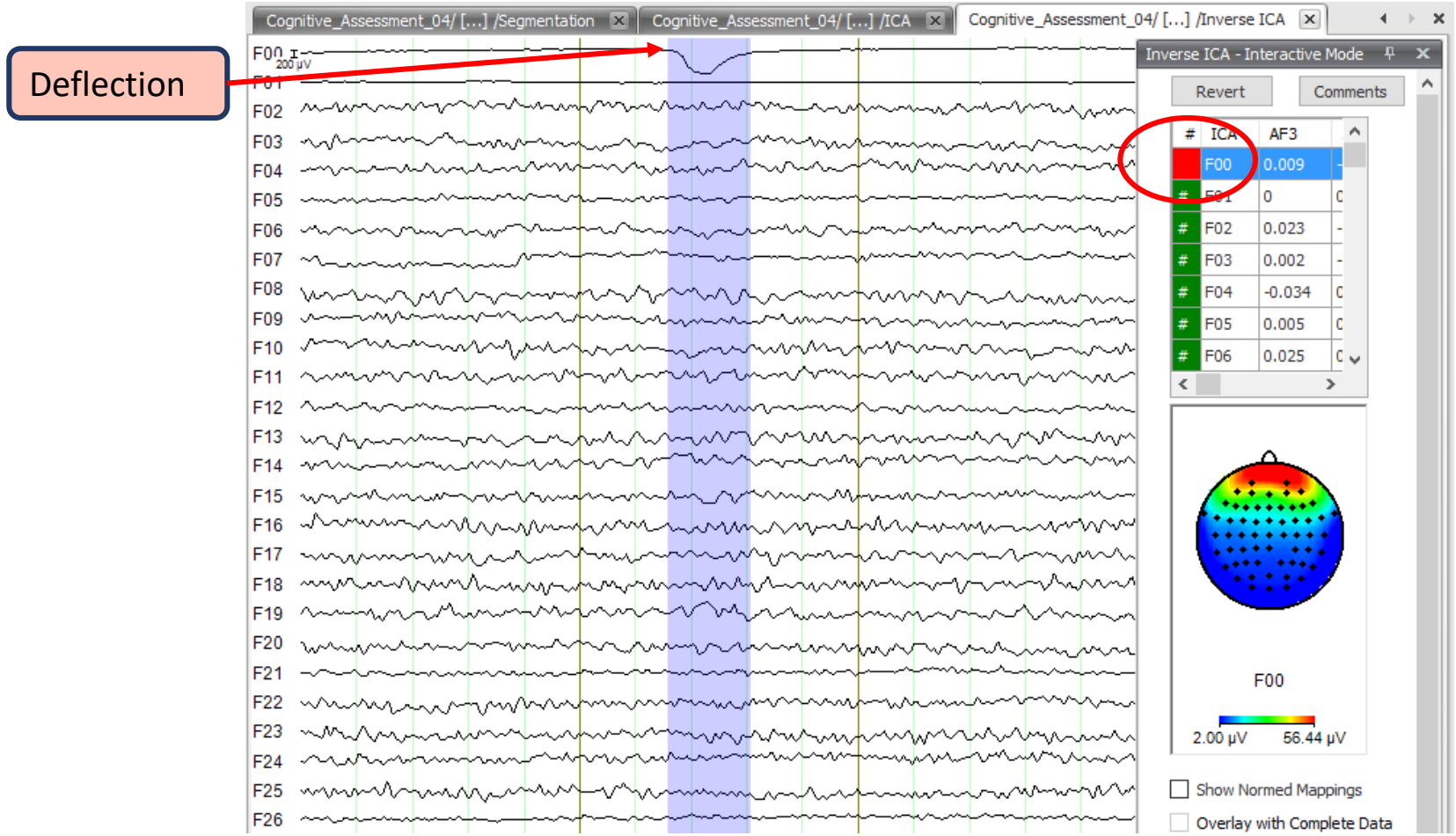
- Under the **Frequency and Component Analysis** tab select **Inverse ICA**
- Select **Semiautomatic mode.** Click **OK.**
- Now you must choose the components that are contributing to the “blink” effect. Blinks appear as negative deflections. **Note which segment the blink is in.**



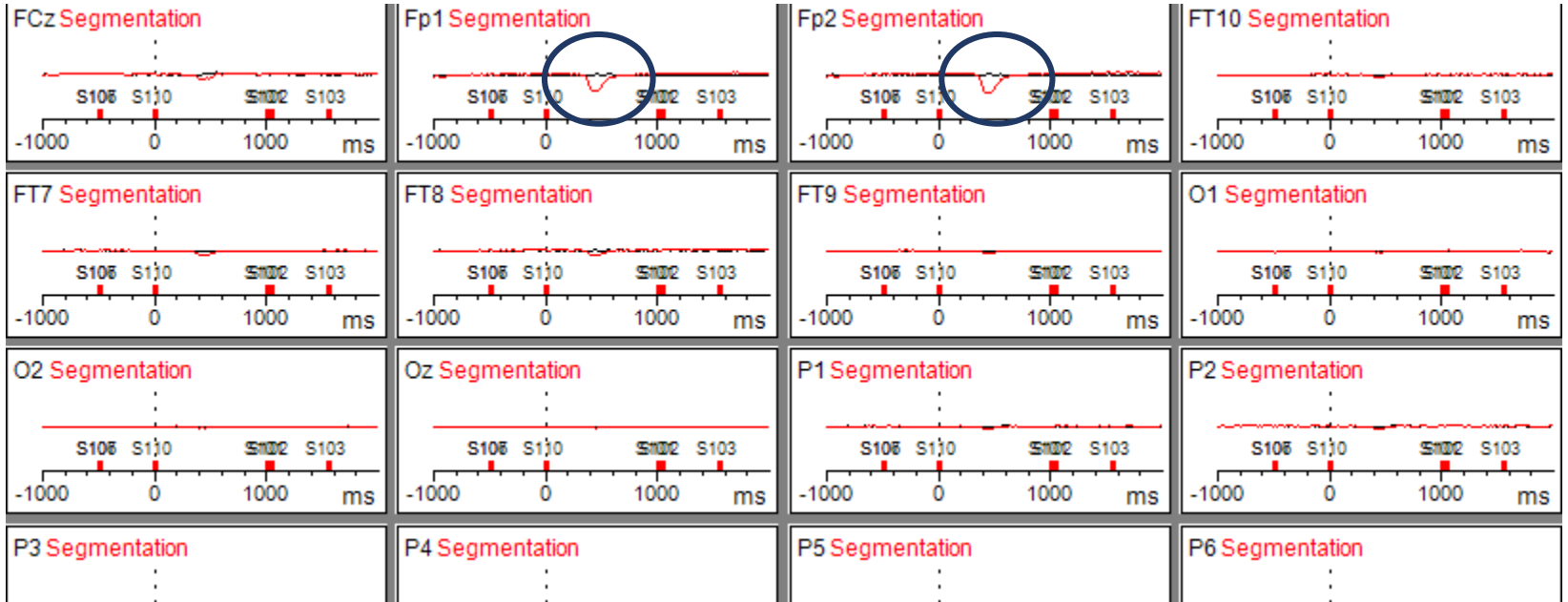
- You should notice a corresponding deflection in certain components. *Blinks are typically found between F00-F10 and they may be a combination of negative and positive deflections.



- As shown, **F00** has a strong negative deflection. Click on F00 in the right-hand toolbar. The topographic map may indicate activity in the frontal region. This is the classic display of a blink. Double-click on **F00** (The box should now be red) and click finish.



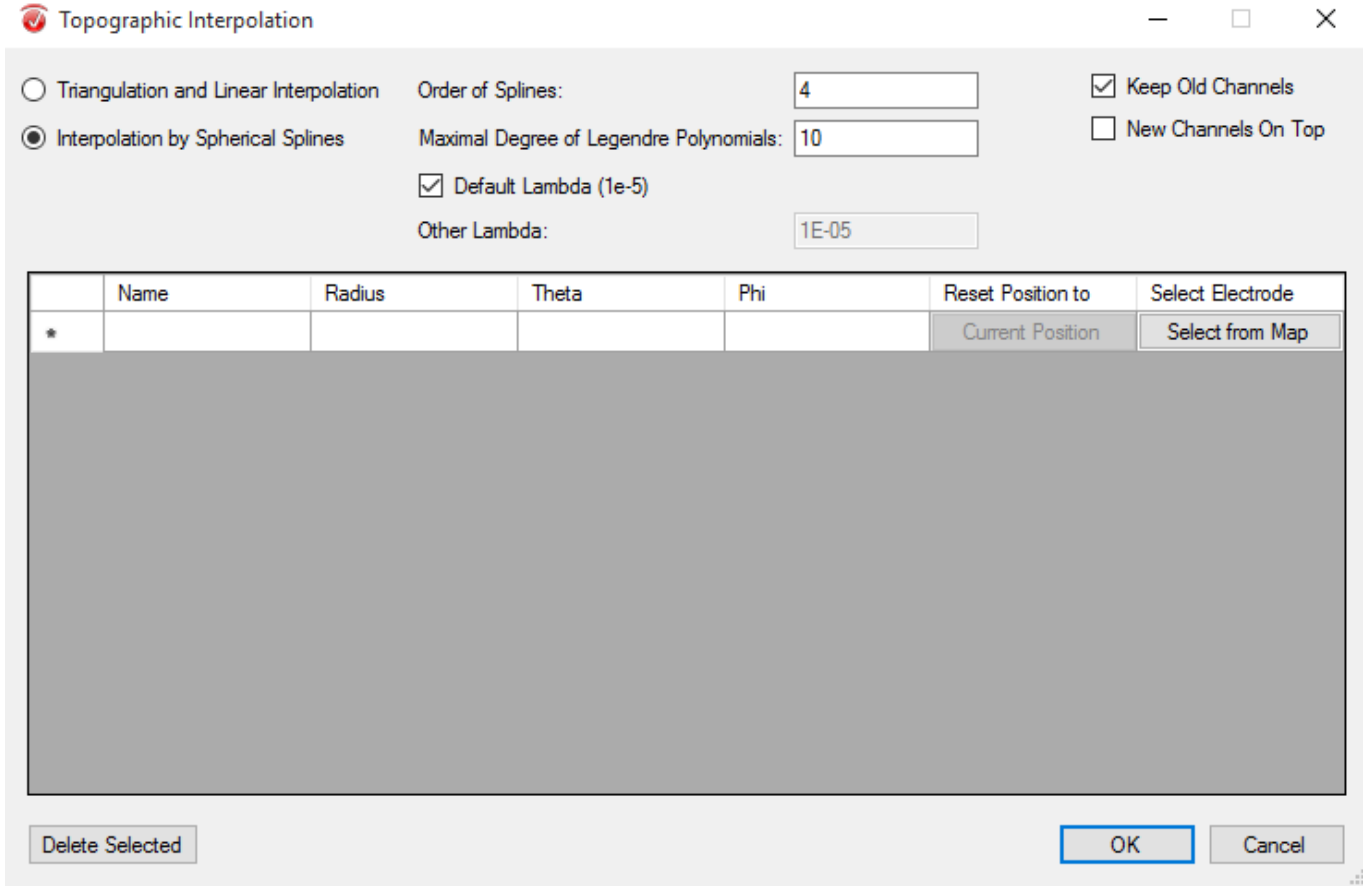
- You may check your work by overlaying the **Segmentation** node on the **Inverse ICA** node. Click and drag the **Segmentation** node directly onto the **Inverse ICA** EEG data (not the node). The difference should show a significant decrease in the negative deflection of the blink.
- Note: To find this deflection you may have to scroll through the data (Ctrl + right arrow key) until a deflection appears. If you have noted the segment number of a previous blink, you can simply scroll through to that same segment to see the difference after blink component removal.



- This process of choosing components and checking your work may have to be repeated several times (Note: When you are learning, this **should** be repeated several times) in order to get the cleanest data possible.
- Sometimes more than one component will have to be removed.
- The (or combination of) component(s) removed may be different for each participant.

8. Topographic Interpolation

- Under **Dataset Preprocessing**, choose **Topographic Interpolation**.
- Select **Interpolation by Spherical Splines, Default Lambda** and **Keep Old Channels**. Enter the names of the channels you deleted in the Edit Channels phase and click **OK** (Note: One channel was deleted from participant 1).



8. Topographic Interpolation

- When identifying deleted channels, you can select them from an electrode map. Choose **Select from Map** (see Image 1). Once the Electrode map has opened, change its configuration to **64 Channels** (see Image 2) from the drop down menu.

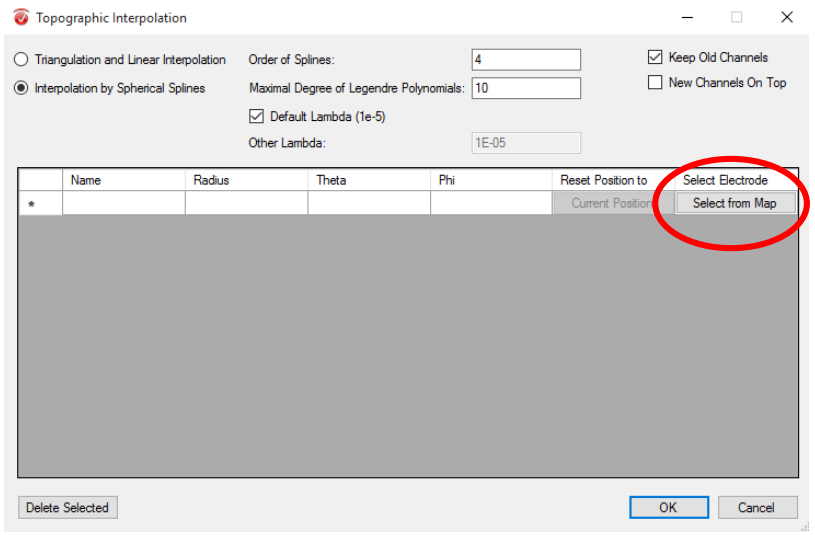


Image 1

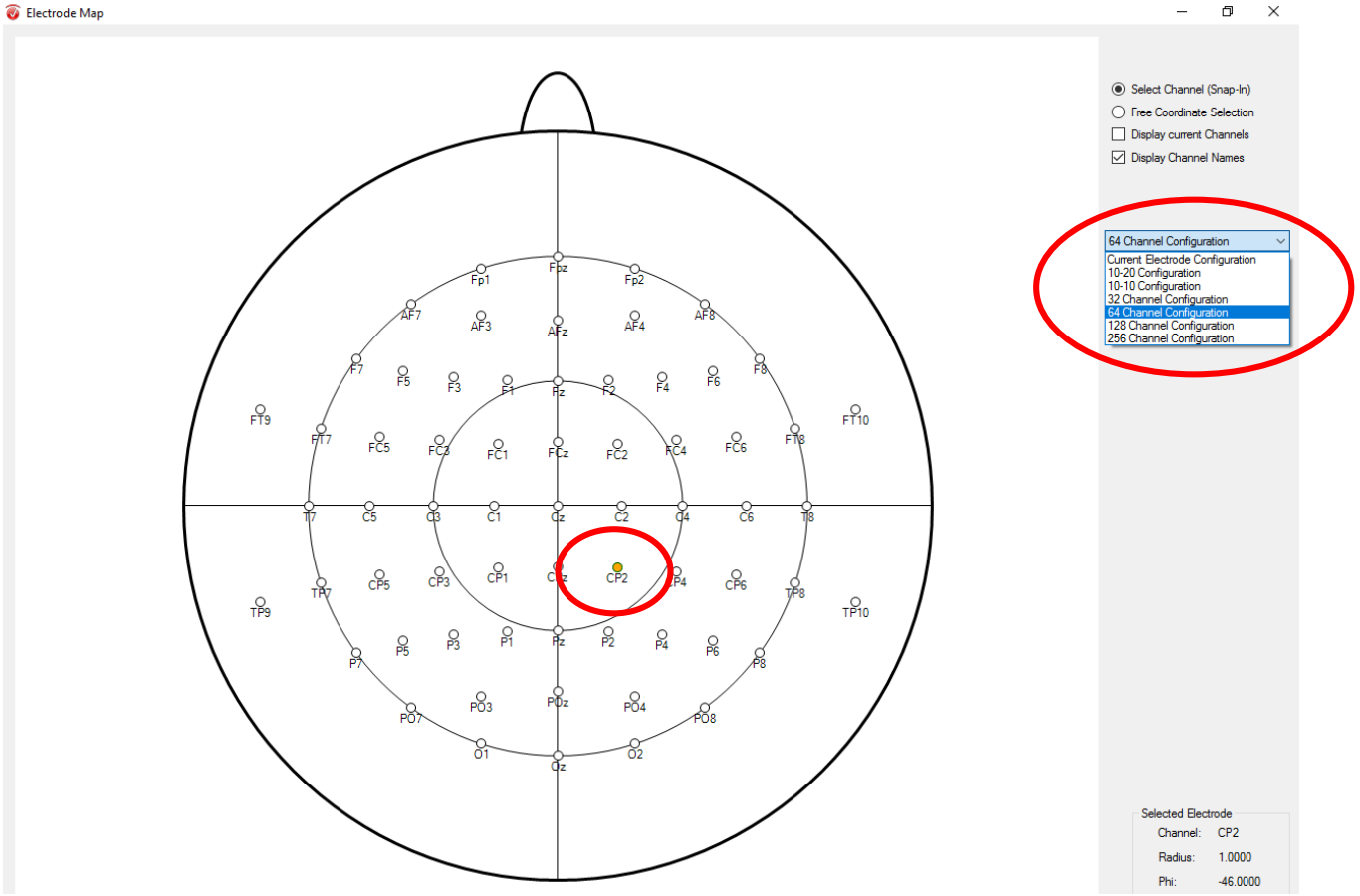
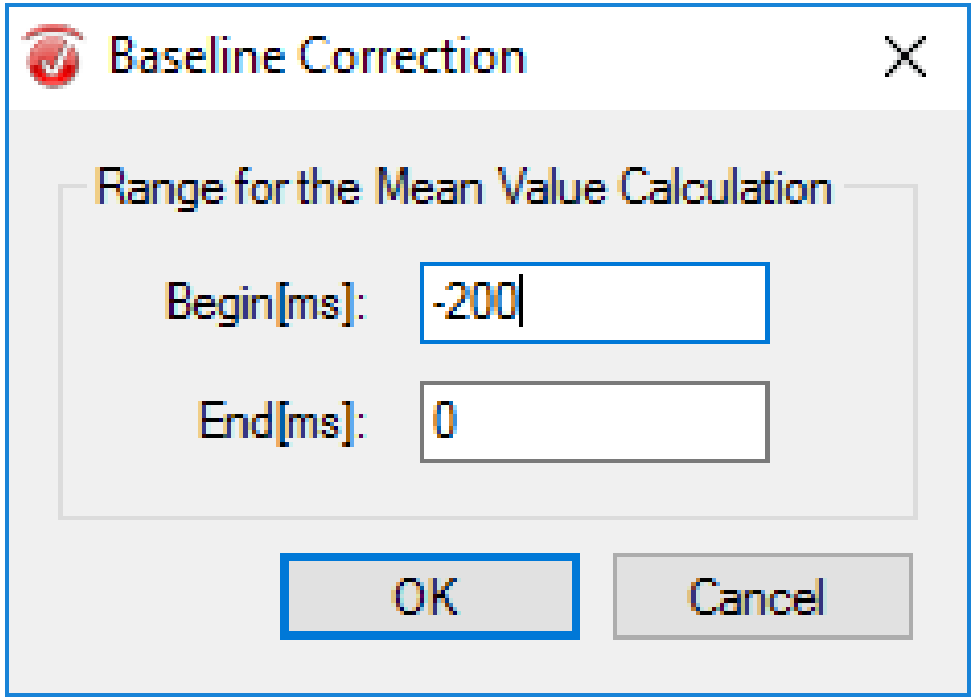


Image 2

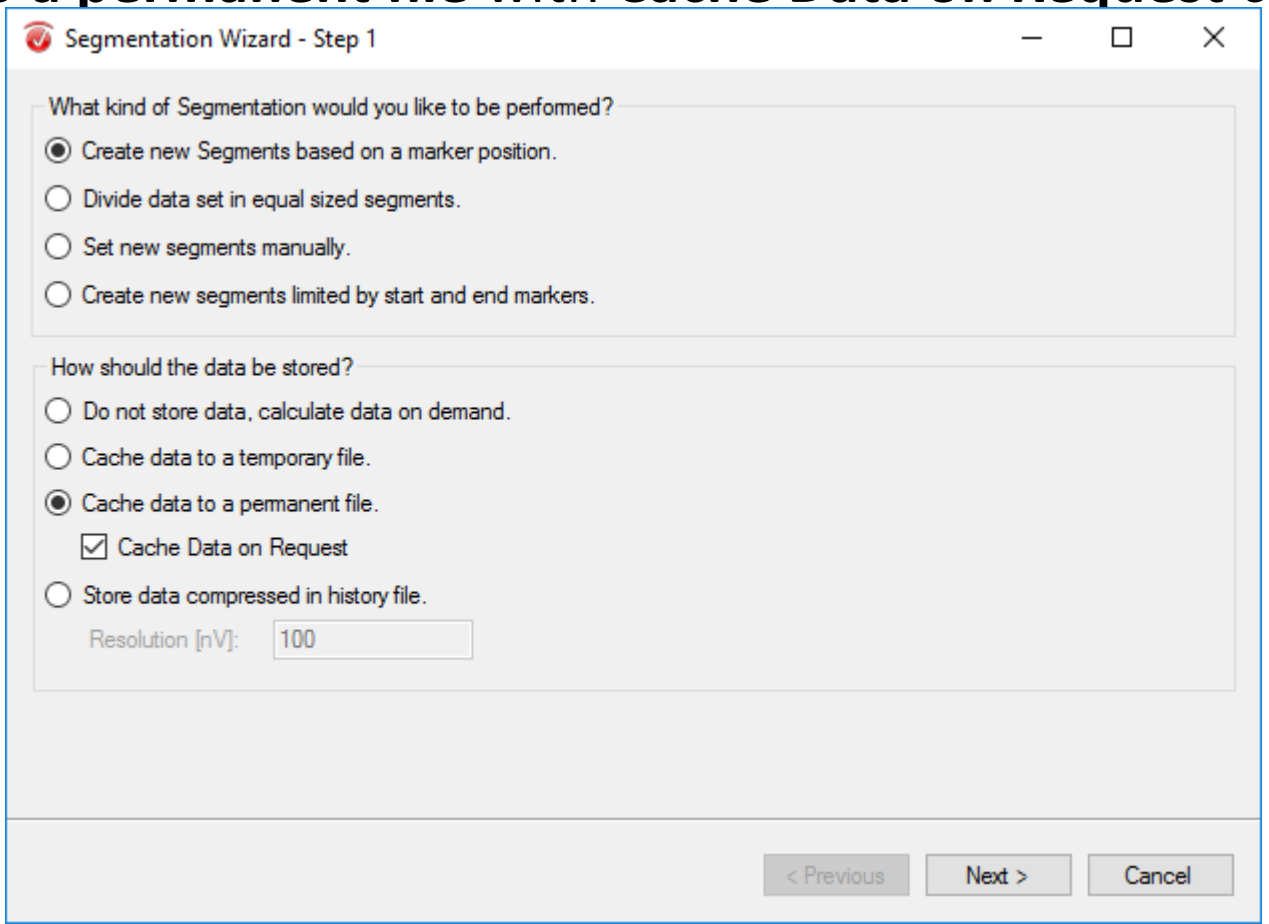
9. Baseline Correction

- **Segment Analysis Functions** > **Baseline Correlation**
- Select Baseline correction with -200 to 0

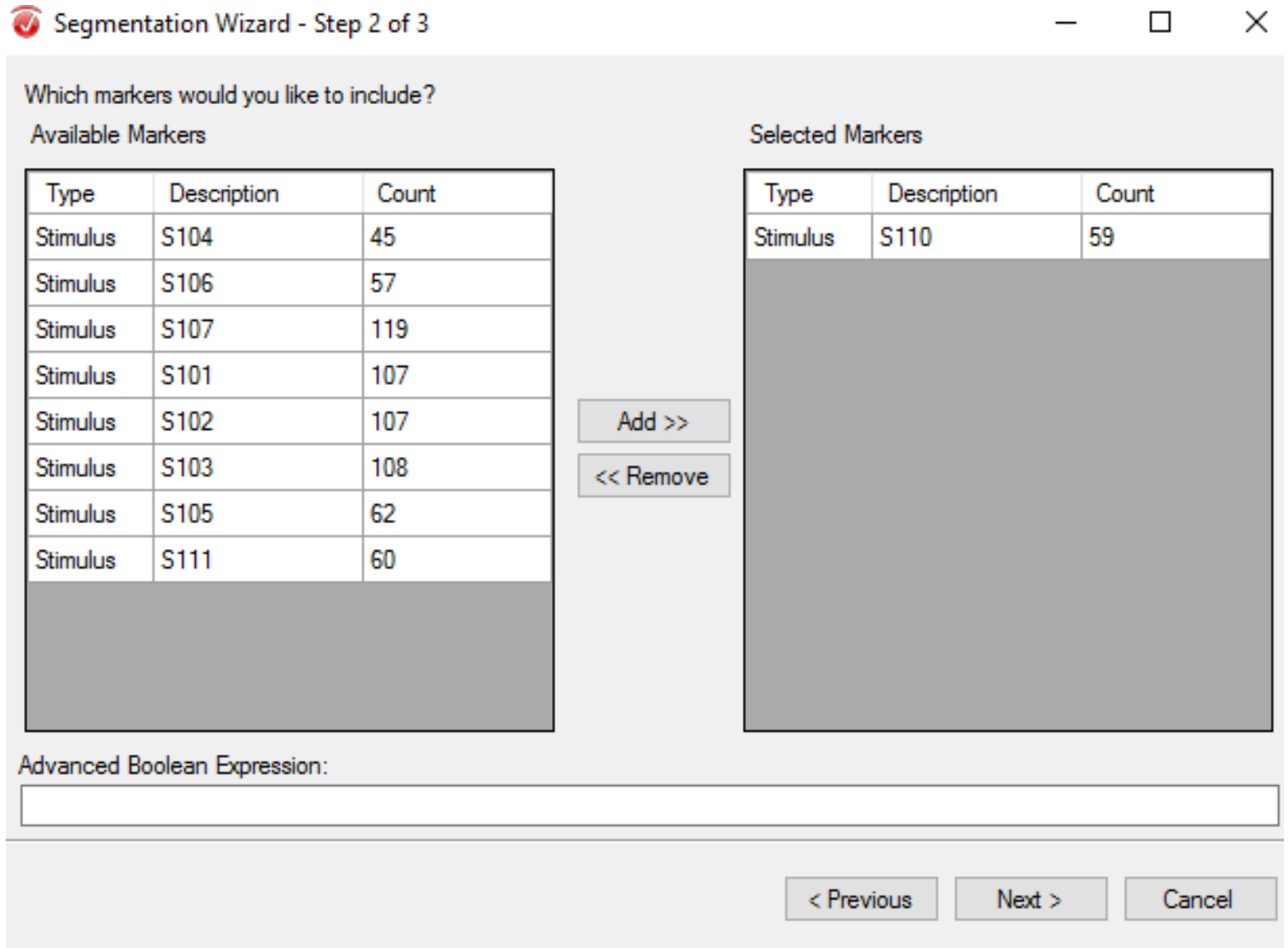


10. Condition Segmentation

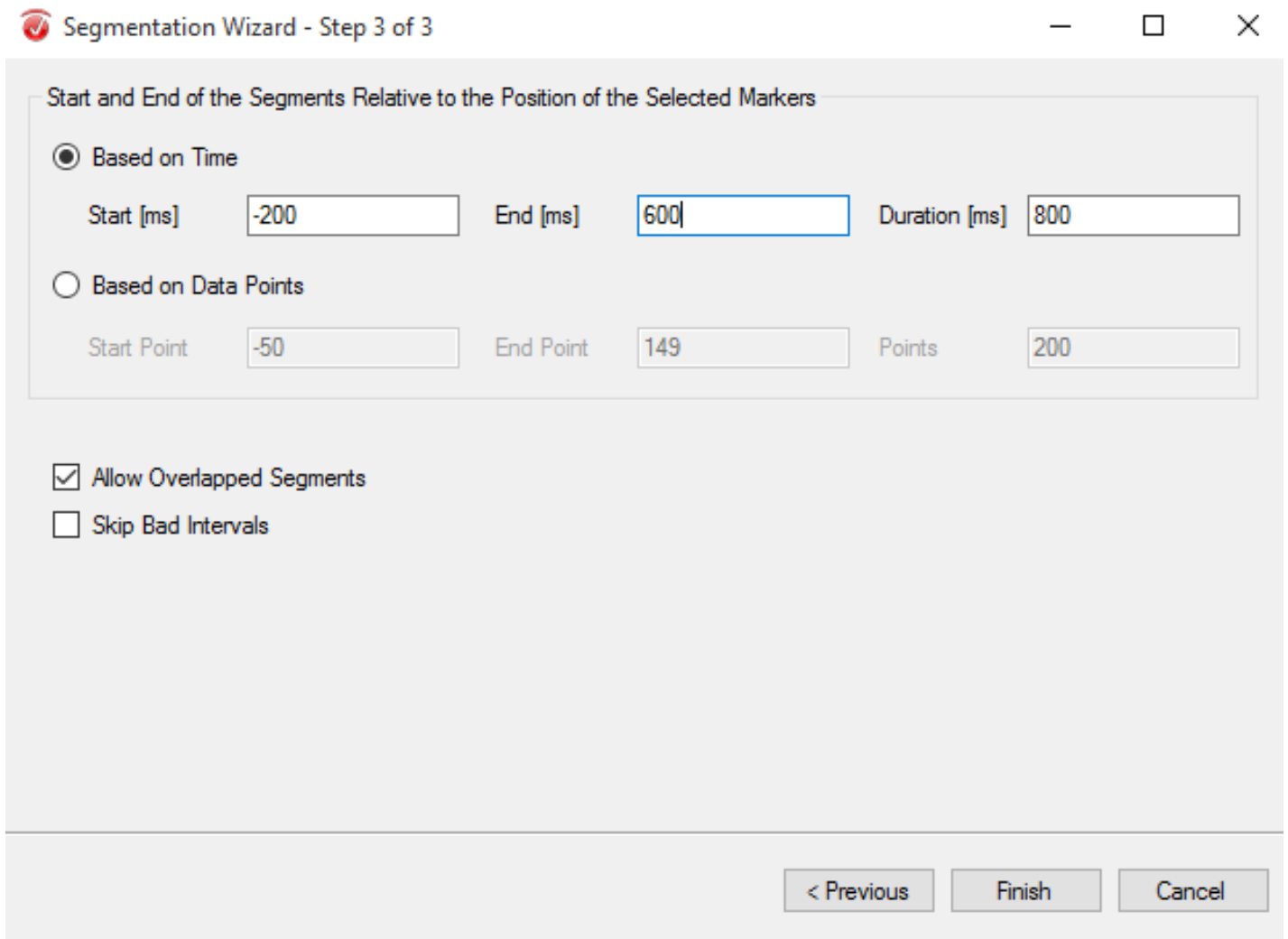
- This step separates **Hit** segments and **Miss** segments.
- Click **Segmentation**
  - 1st Window - select **Create new Segments based on a marker position.** Select **Cache data to a permanent file** with **Cache Data on Request** checked. Click **Next**.



- 2nd Window – Add the **hit** marker (**S 110**) and click **Next**.



- 3rd Window – Change the **Start** time to **-200 ms** and the **End** time to **600 ms**. Click **Finish**.

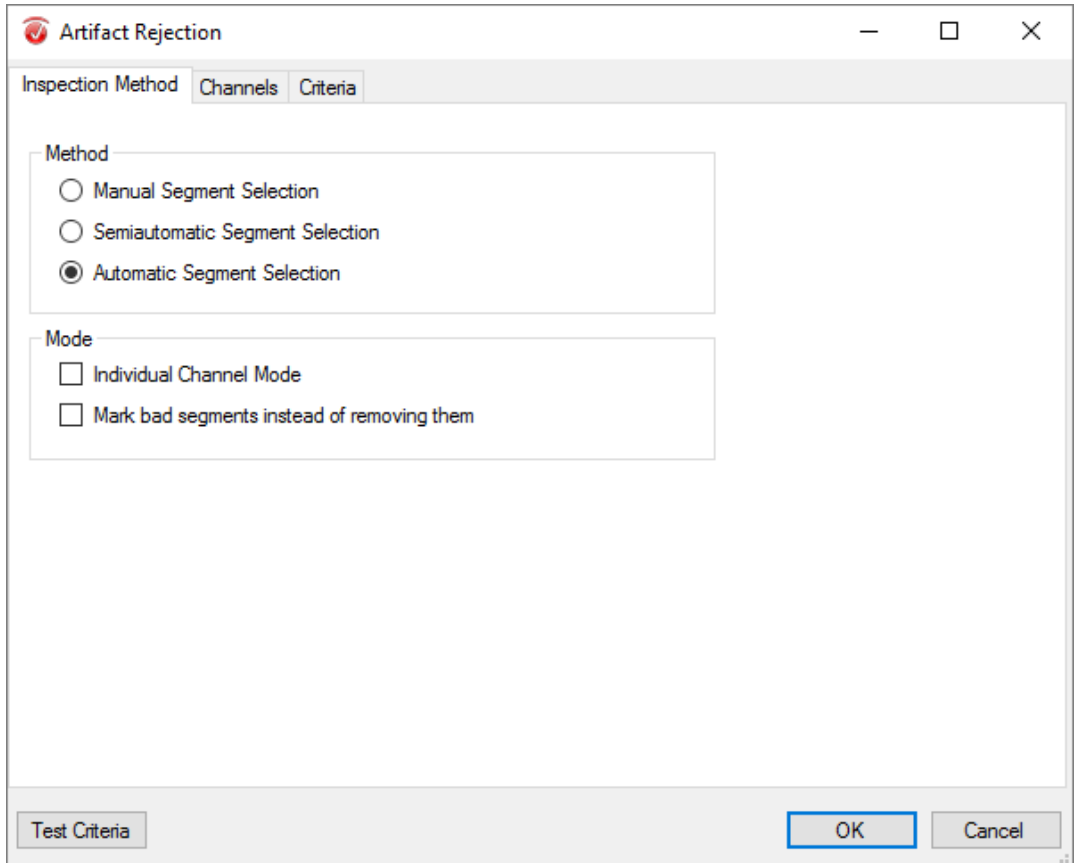


- Rename the **Segmentation** node to **Segmentation Hits** as these segments contain only **Hits**.

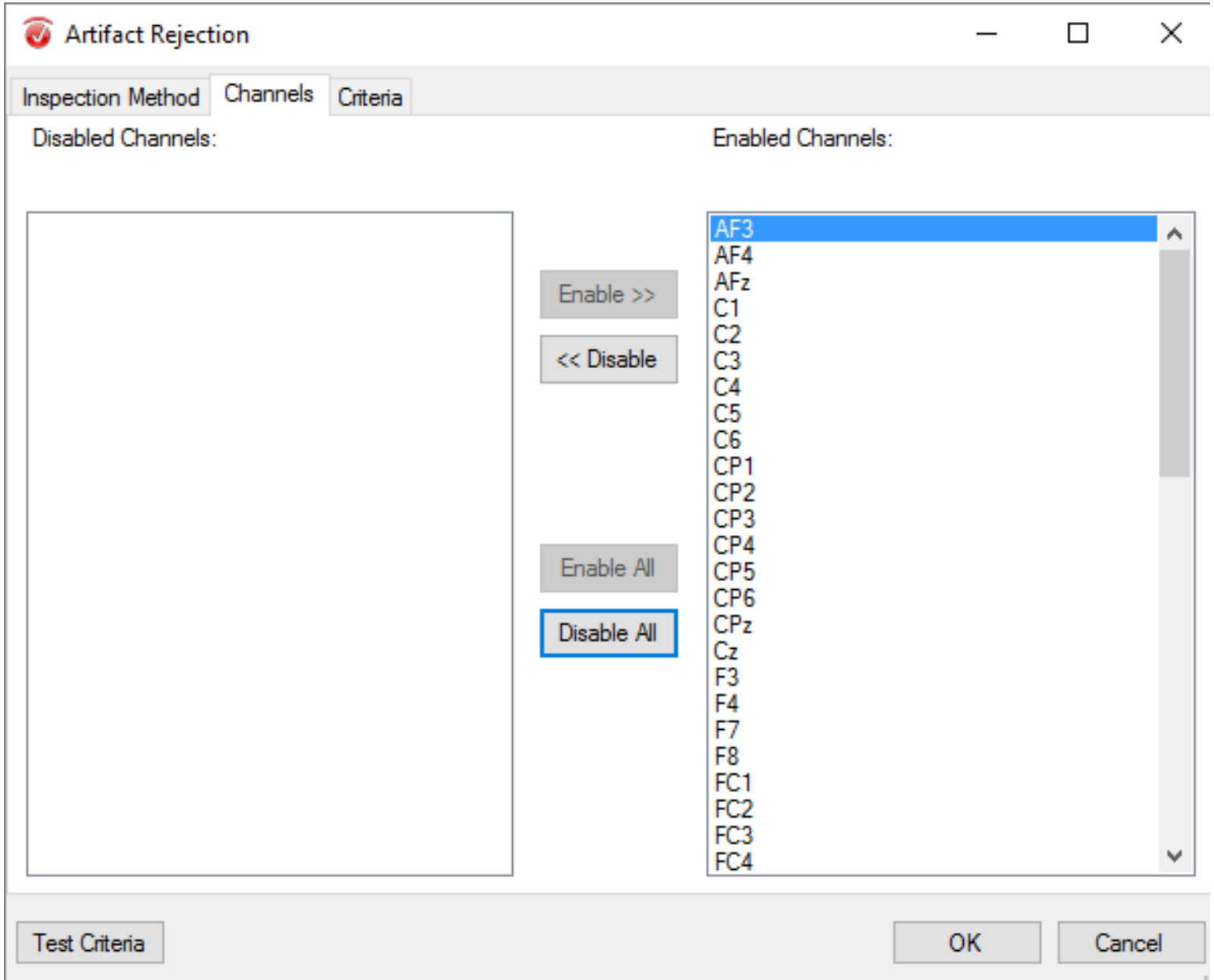
- Repeat this step for all **Misses** by adding **S 111** instead of **S 110** in the 2nd window. Rename the node to **Segmentation Misses**

11. Artifact Rejection

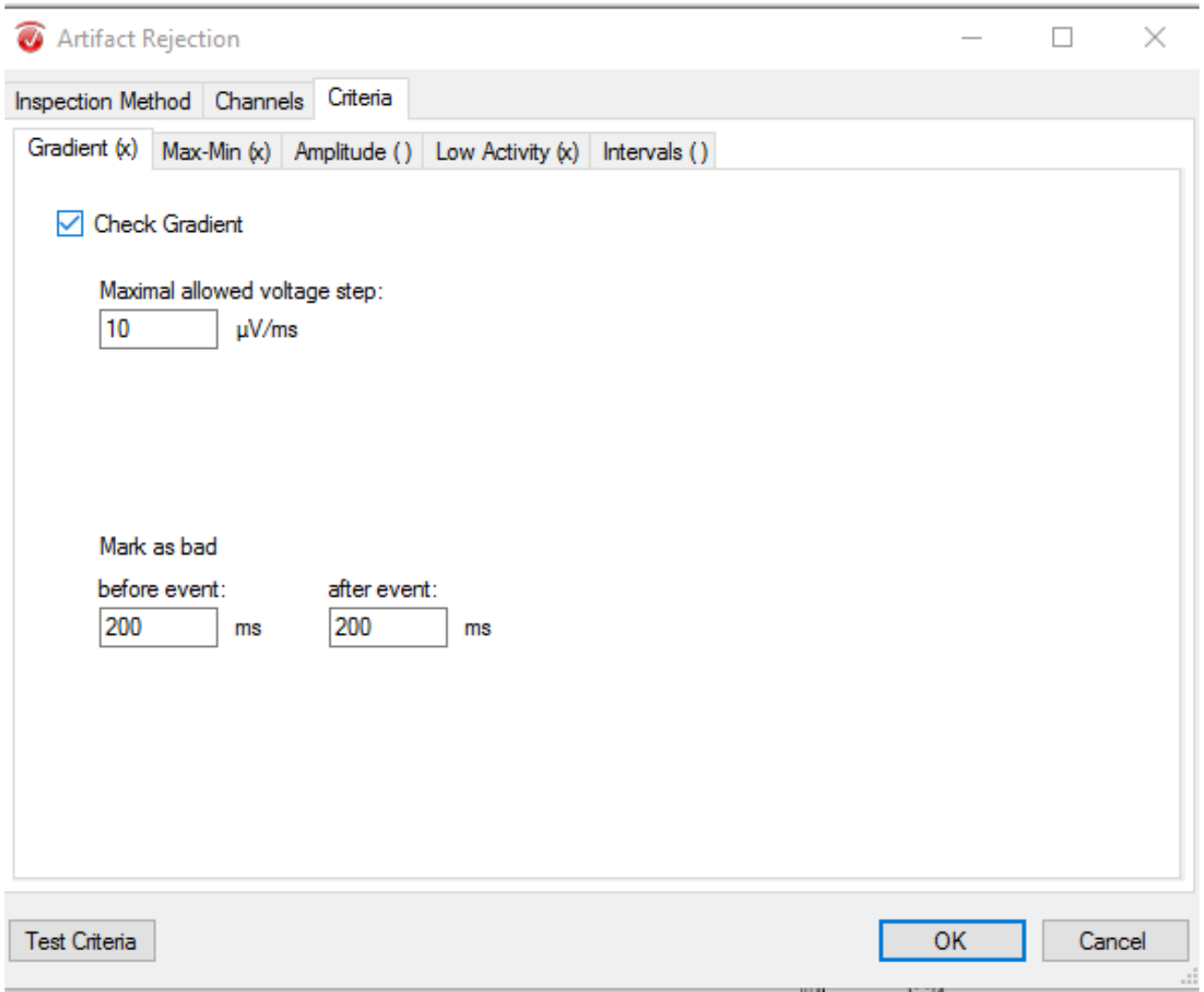
- **Transformations** > **Artifact Rejection/Reduction** > **Artifact Rejection**
- The following Artifact steps (A – C) should **ALL** be completed before pressing ok
  - A) Inspection method tab – Select Automatic Segment Selection and unselect all other options.



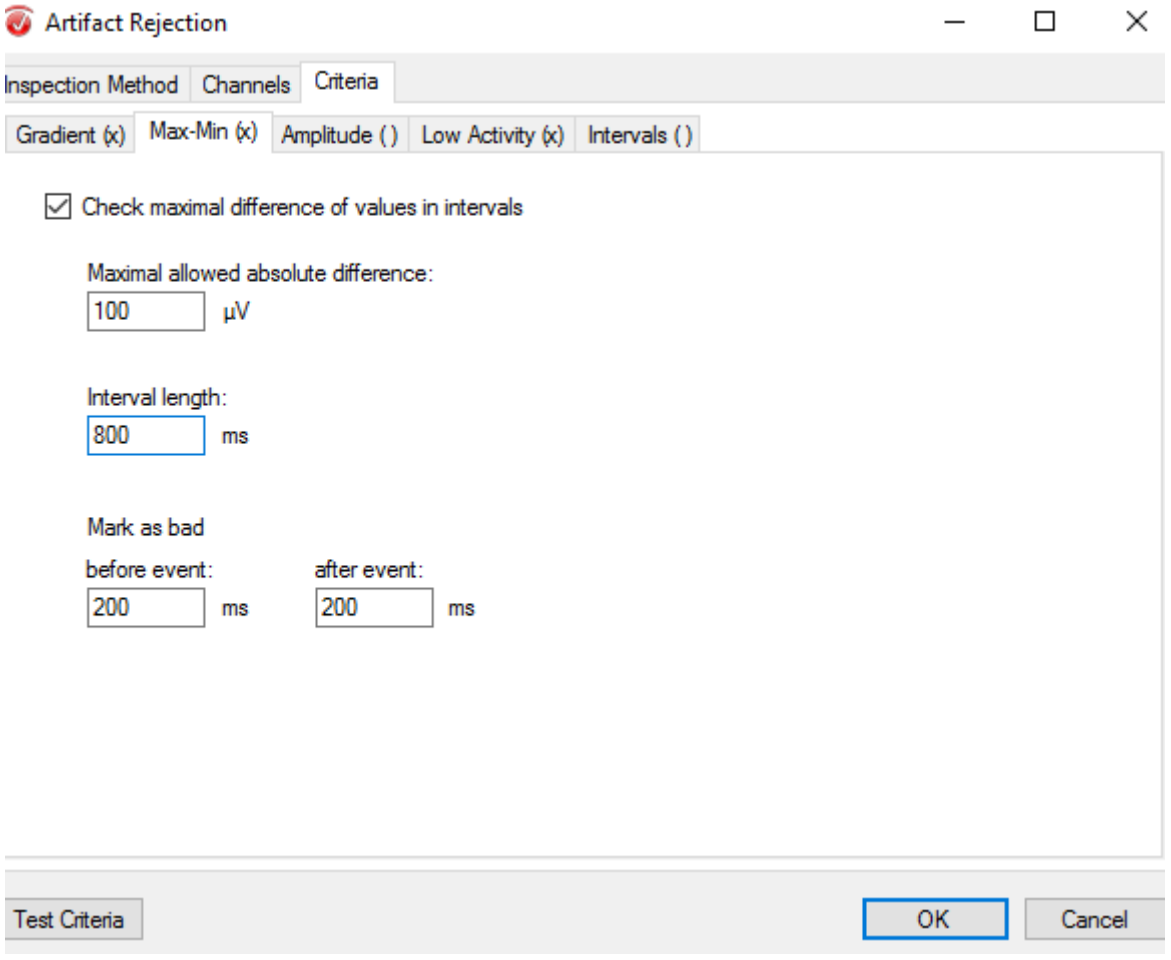
- B) Channels tab – Click **Enable All**



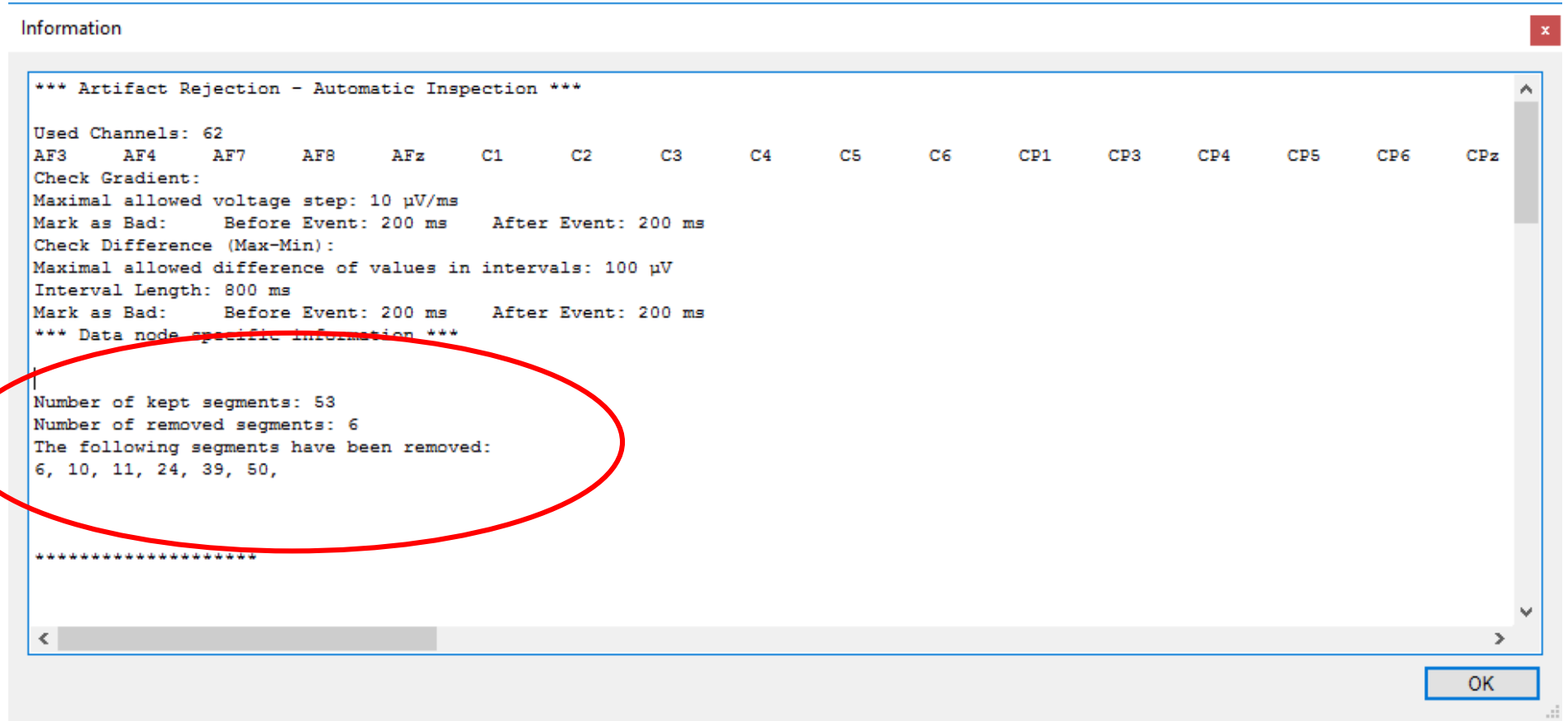
- C) Criteria TabGradient (x) tab – select **Check Gradient** and change **Maximal allowed voltage step** to 10. Change both **before event** and **after event** to **200 ms**.



- C) Criteria Tab
  - ii. **Max-Min (x) tab** – select **Check maximal difference of values in intervals**. Change **Maximal allowed absolute difference** to 100*, Interval length to 800 and **before event** and **after event** to 200. Check to make sure all other sections [Amplitude, Low Activity and Interval] are **unchecked**. Click **OK.**

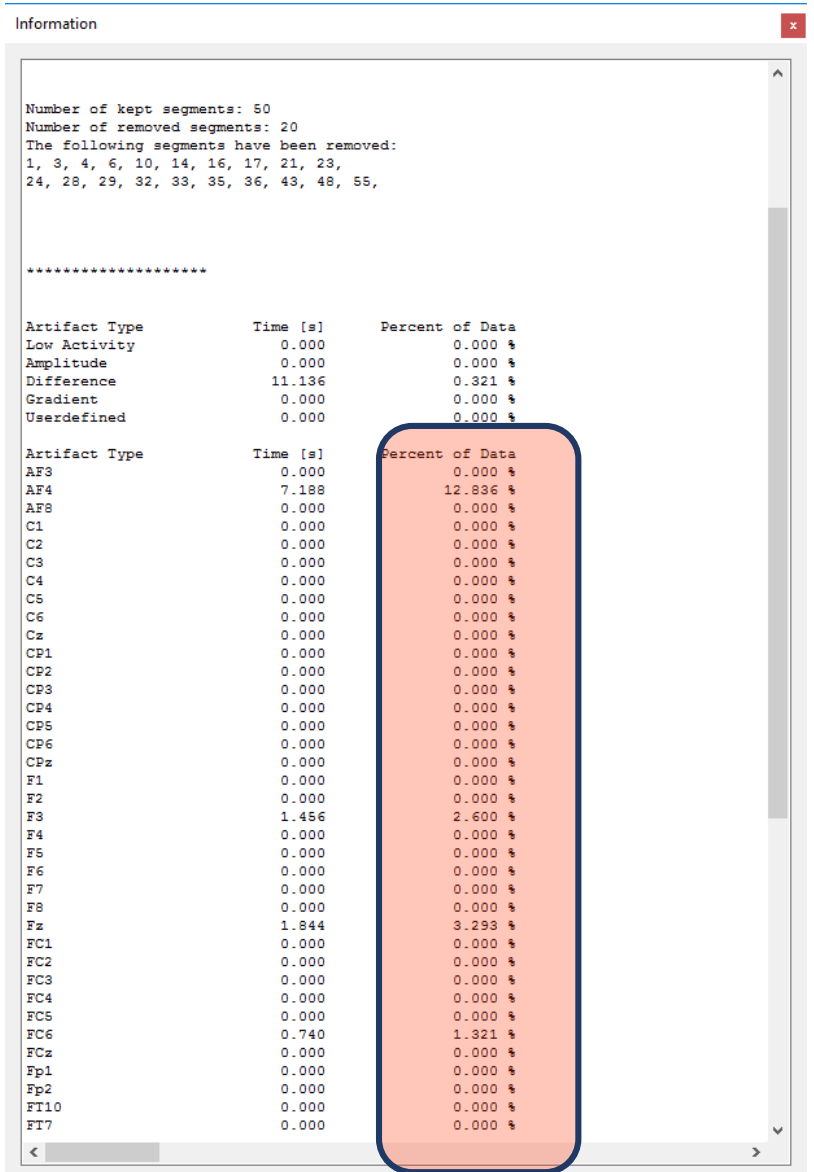


- Right-click the **Artifact Rejection Node** and click **Operation Info…**
- In the pop-up window, it will show the **Number of kept segments:** and **Number of removed segments:**
- The **Number of removed segments** should be low. If it is not, double check that your ICA worked properly and the quality of your data is good



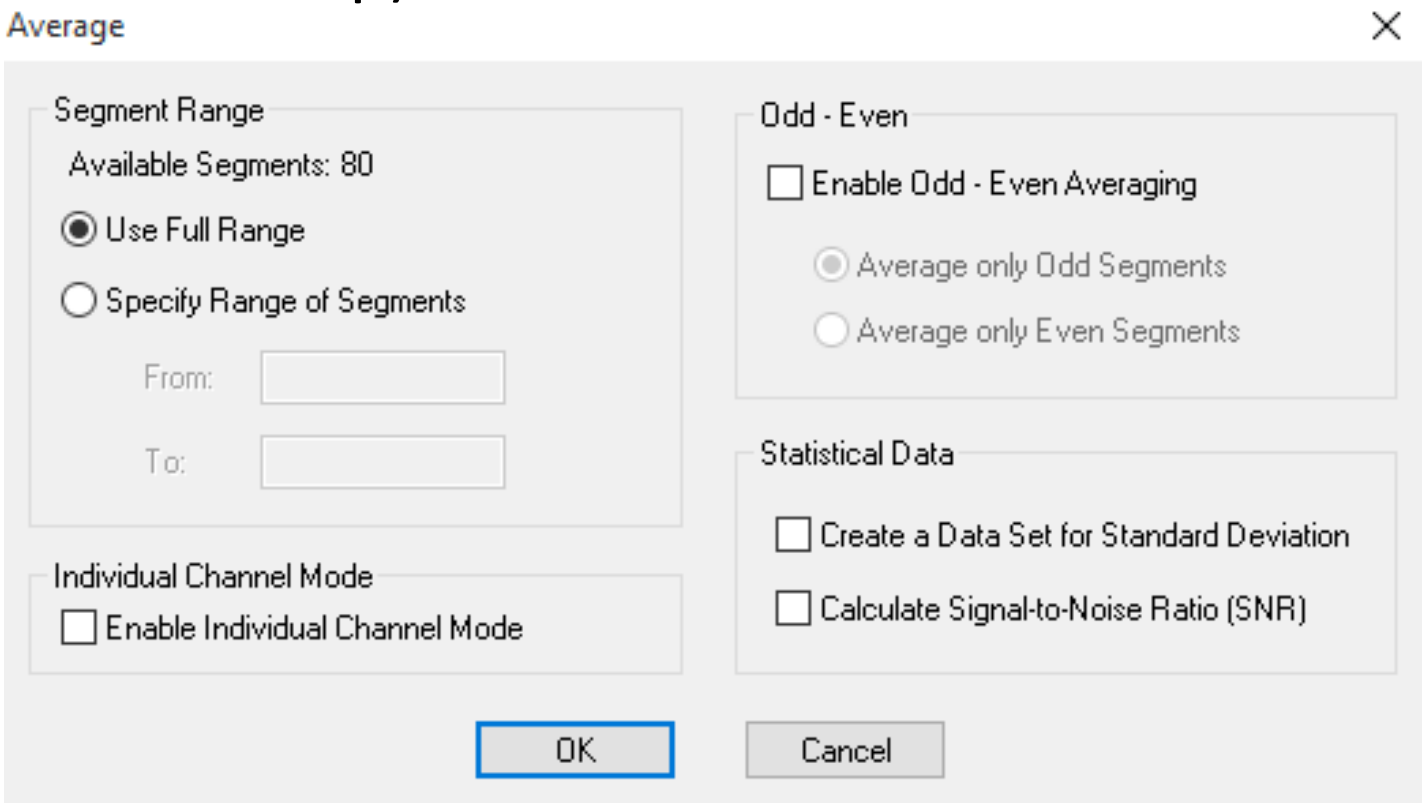
Additional Artifact Rejection information

- If the number of removed segments can not be kept below 10%, there is an alternative method for deciding whether too much information, has been removed.
- The percentage of removed data from each individual electrode (e.g. AF4, Fp1, Pz), can also be used as a guide. This can be found in the same **Operator info** page as before.



12. Average

- **Segment Analysis Functions > Average**. In the pop-up window select **Use Full Range** and leave all other options unchecked. Press **OK**. Name the **Average** node “Average Hits” or “Average Misses” accordingly. (*Ensure spelling and punctuation is consistent across ALL participants as the nodes must be recognized in a further step).



13. Generic Data Export

- In order to export the data collected (amplitude at each time signature for each electrode) it should be saved into a text (.txt) file.
- Navigate to **Export > Generic Data**.
- Leave the base name in its default form, ensure the extension is .txt and make sure no boxes are checked (See Image 1).
- ‘Add Channel Names to Data file’ (Image 3) should remain ticked, along with ‘Export All Channels” (Image 4). Then Press **Finish** and the data should be exported in a txt file to the Export file folder in Analyzer Tutorial {This PC\Desktop\Experiments\Analyzer Tutorial\Analyzer Tutorial Cog\Export}

- See Next Slide For Images

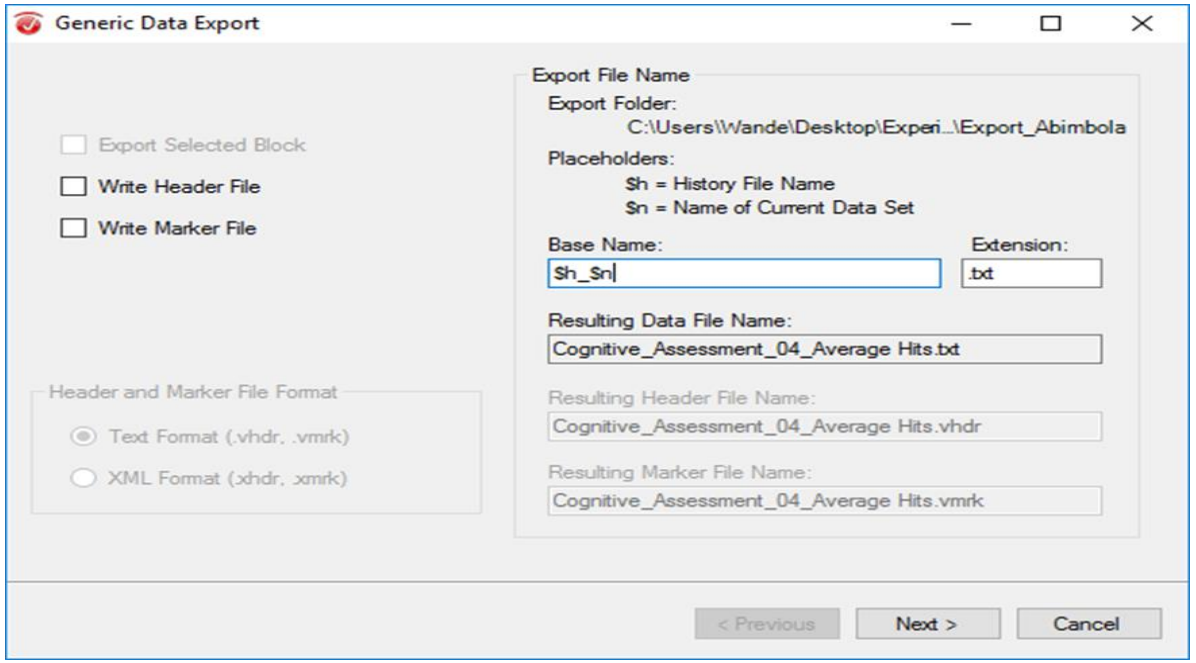


Image 1

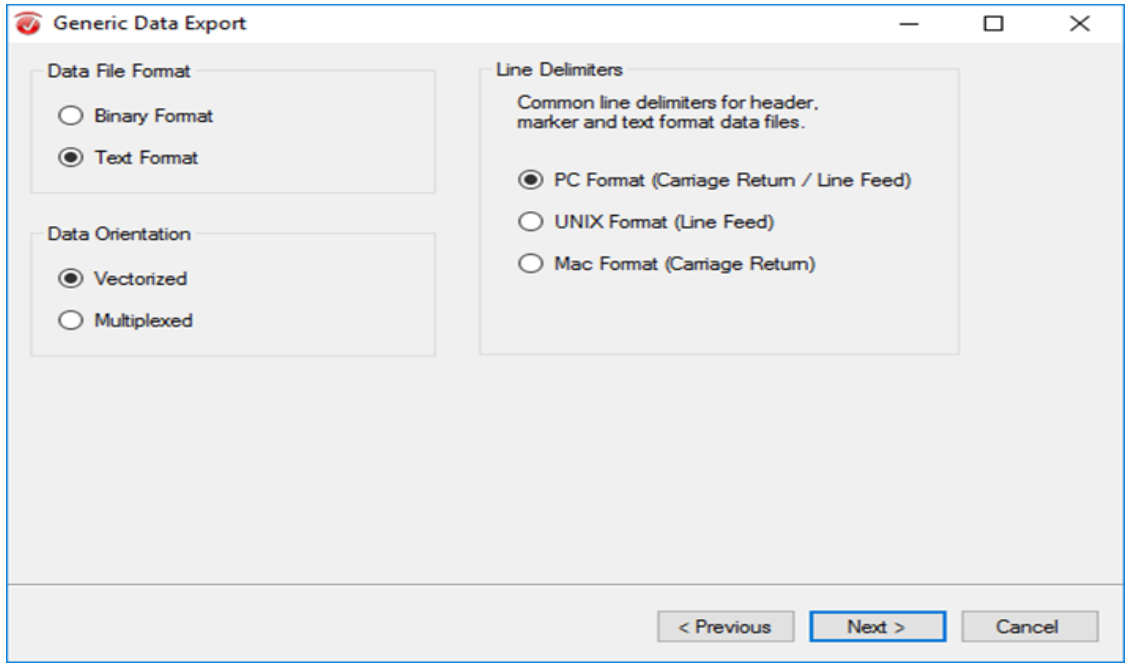


Image 2

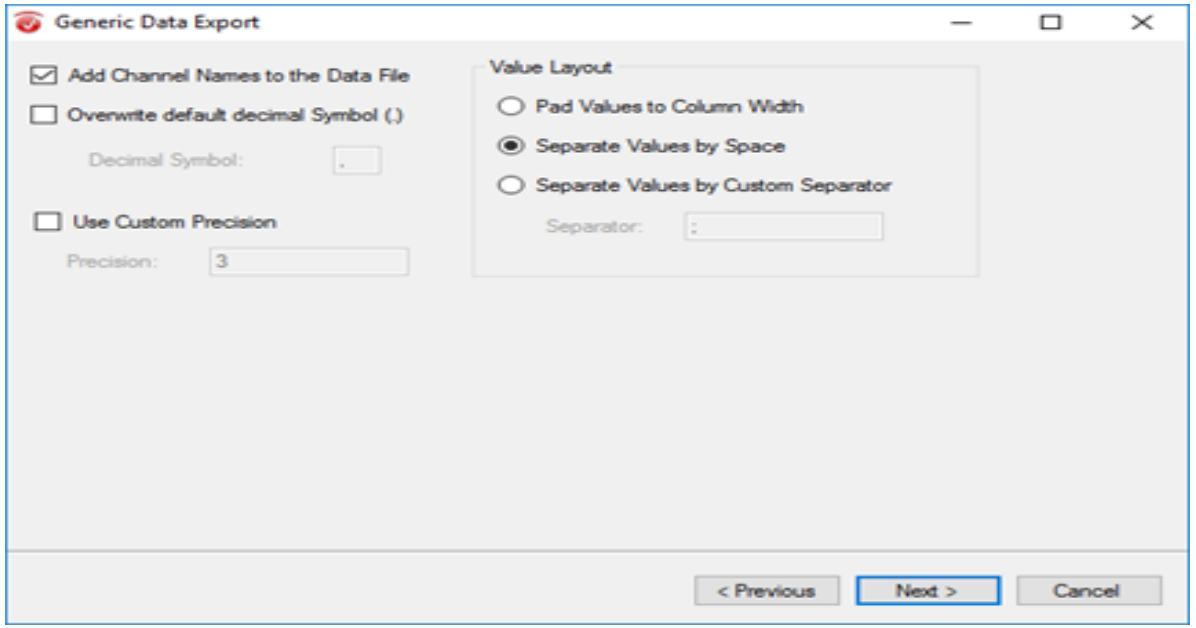


Image 3

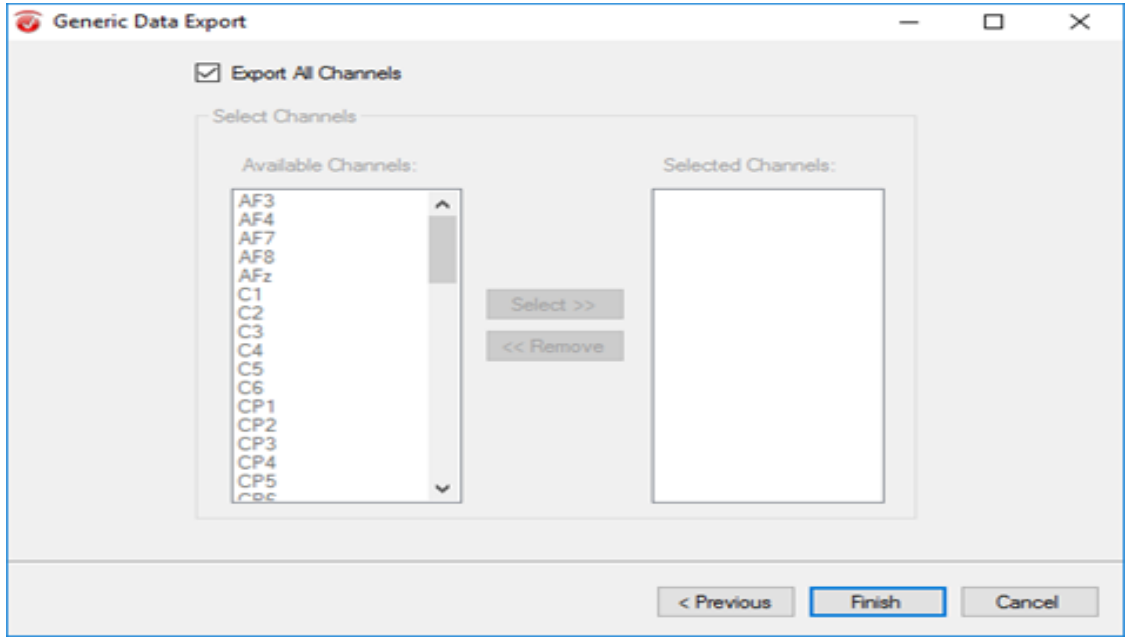
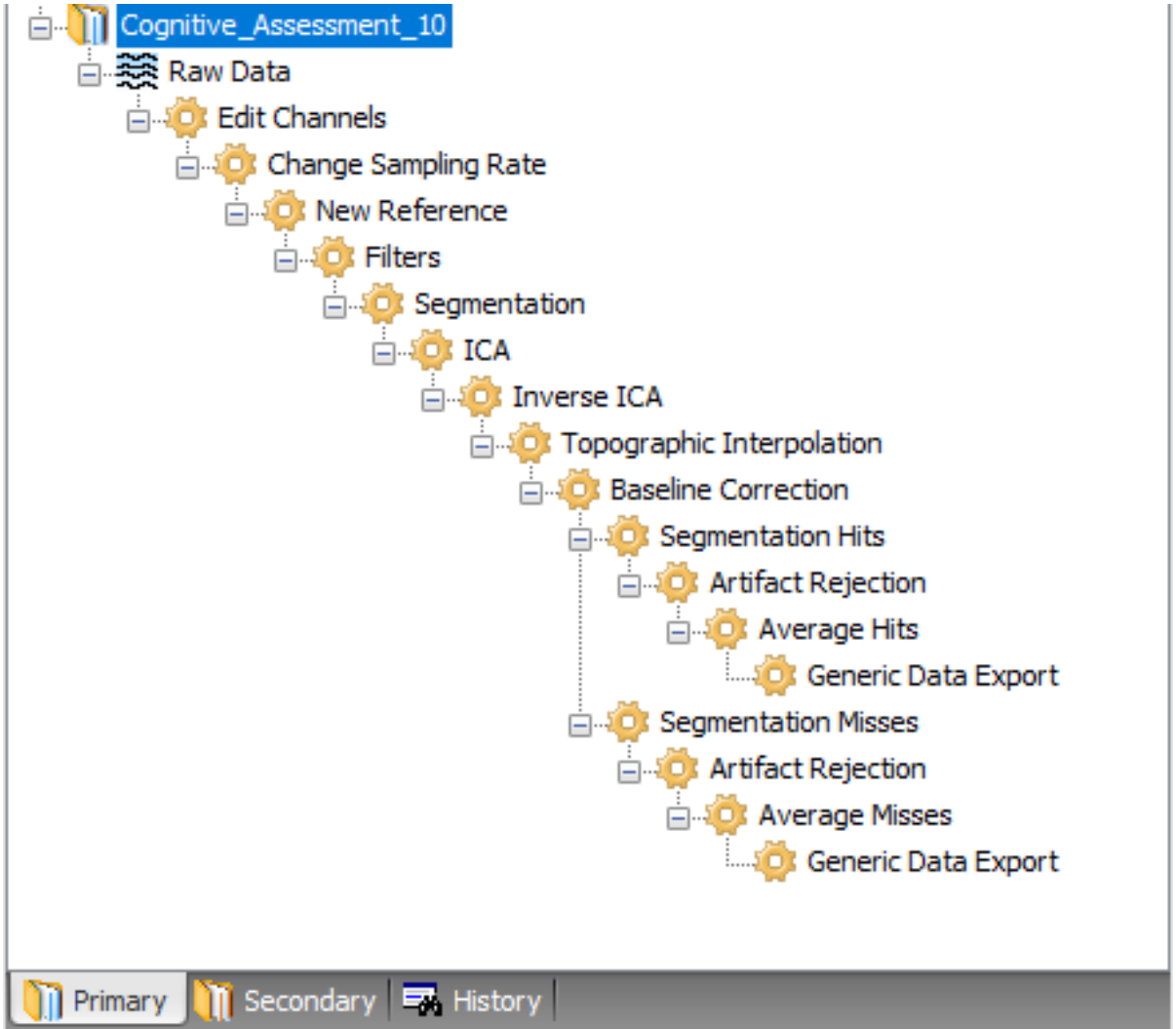


Image 4

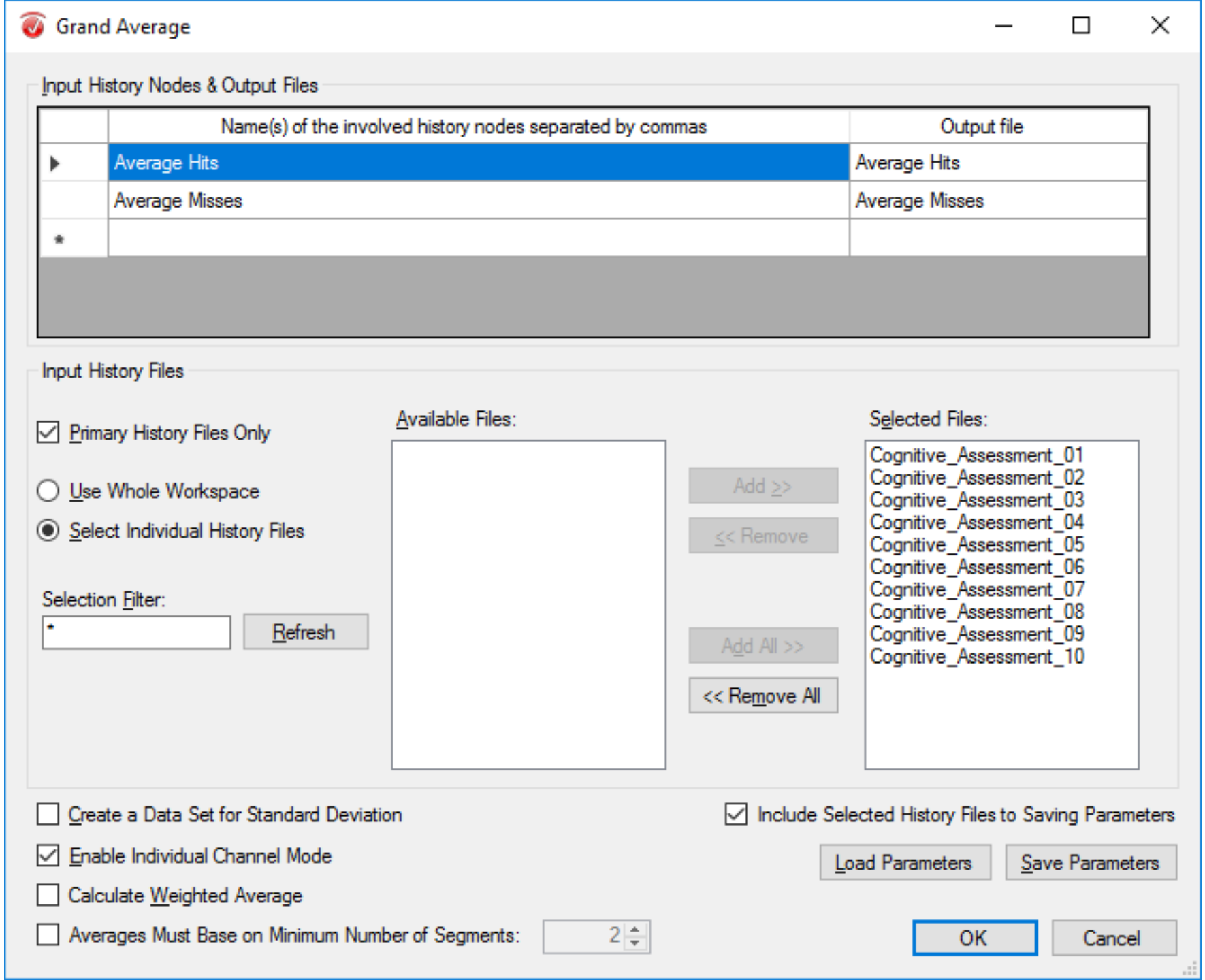
Participant Tree

- Your analysis for one participant is now complete. The tree should look like this:



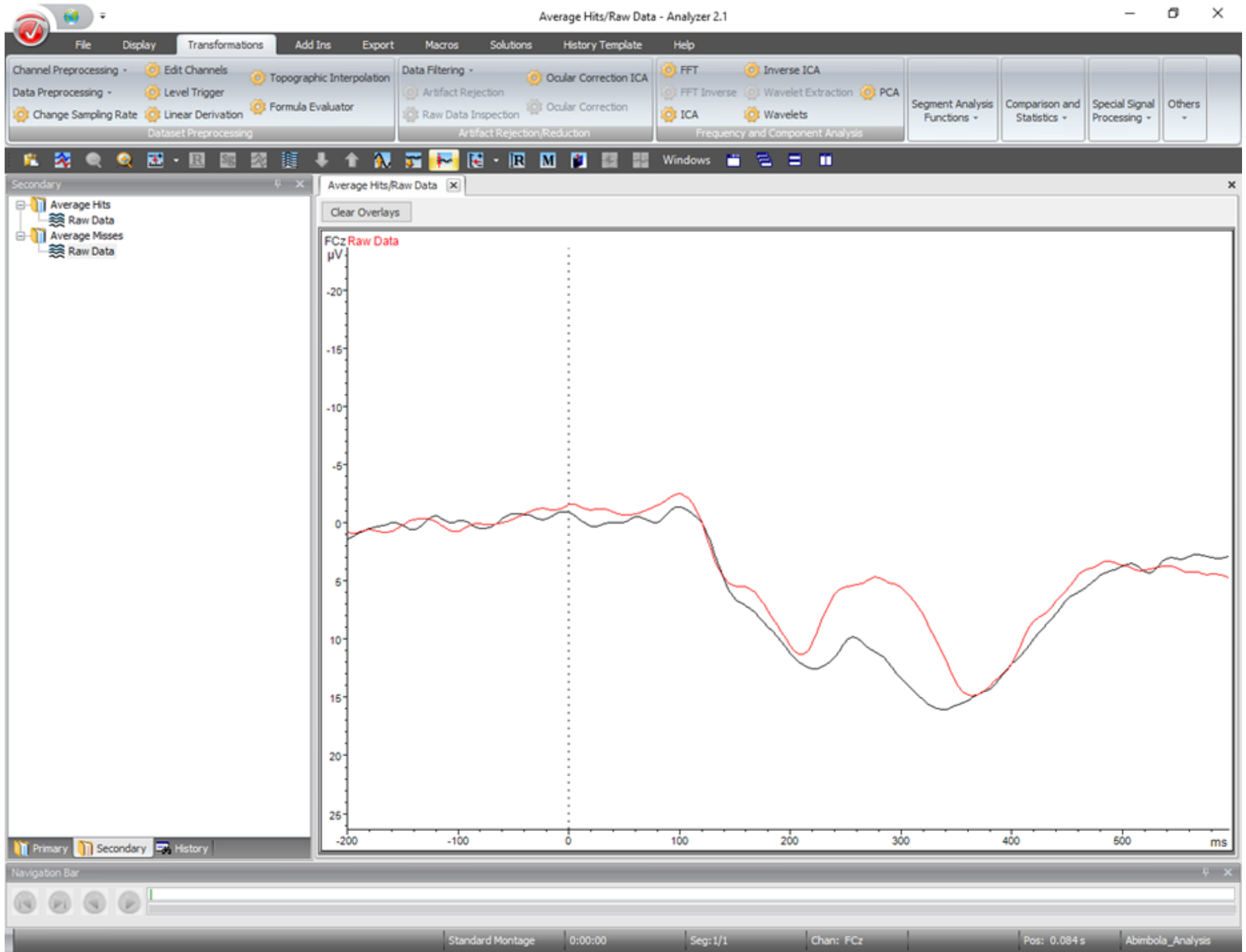
14. Grand Average

- ***This step should ONLY be completed after averages have been calculated for ALL participants/conditions***
- Under **Segment Analysis Functions**, select **Result Evaluation**. Next, select **Grand Average.**
- In the **Input Nodes** and **Output Files** table, enter the name of the conditions in both columns (i.e. “Average Hits” and “Average Misses”) ***To delete previously entered names from the columns, click on the 1st column on the left of the names and press “Delete” on the keyboard (not Backspace).**
- Ensure the spelling exactly matches that of the spelling used in the nodes.
- **Add All** channels to the column on the right and click **OK**.


Grand Average
Input History Nodes & Output Files
Name(s) of the involved history nodes separated by commas
Output file
Average Hits
Average Hits
Average Misses
Average Misses
Input History Files
Primary History Files Only
Use Whole Workspace
Select Individual History Files
Selection Filter:
*
Refresh
Available Files:
Add >>
<< Remove
Add All >>
<< Remove All
Selected Files:
Cognitive_Assessment_01
Cognitive_Assessment_02
Cognitive_Assessment_03
Cognitive_Assessment_04
Cognitive_Assessment_05
Cognitive_Assessment_06
Cognitive_Assessment_07
Cognitive_Assessment_08
Cognitive_Assessment_09
Cognitive_Assessment_10
Create a Data Set for Standard Deviation
Enable Individual Channel Mode
Calculate Weighted Average
Averages Must Base on Minimum Number of Segments:
2
Include Selected History Files to Saving Parameters
Load Parameters
Save Parameters
OK
Cancel

Unifying Data

Navigate to the Secondary tab in Analyzer. From there, open up the raw data for ‘Average Hits’ and find **FCz**. Double click FCz and then drag and drop the ‘Average Misses’ raw data file on to the graph created of average amplitudes at the **FCz** position.


Average Hits/Raw Data - Analyzer 2.1
File
Display
Transformations
Add Ins
Export
Macros
Solutions
History Template
Help
Channel Preprocessing
Data Preprocessing
Change Sampling Rate
Edit Channels
Level Trigger
Linear Derivation
Topographic Interpolation
Formula Evaluator
Dataset Preprocessing
Data Filtering
Artifact Rejection
Raw Data Inspection
Ocular Correction ICA
Ocular Correction
Artifact Rejection/Reduction
FFT
FFT Inverse
ICA
Inverse ICA
Wavelet Extraction
Wavelets
PCA
Frequency and Component Analysis
Segment Analysis Functions
Comparison and Statistics
Special Signal Processing
Others
Windows
Secondary
Average Hits
Raw Data
Average Misses
Raw Data
Primary
Secondary
History
Average Hits/Raw Data
Clear Overlays
FCz Raw Data
µV
-20
-15
-10
-5
0
5
10
15
20
25
-200
-100
0
100
200
300
400
500
ms
Navigation Bar
Standard Montage
0:00:00
Seg: 1/1
Chan: FCz
Pos: 0.084 s
Abimbola_Analysis

Quick Guide

1. Edit Channels
2. Change Sampling Rate [250 Hz]
3. New Reference
4. Data Filtering
5. Segmentation [Start] -1000 -> [End] 2000
6. ICA
7. Inverse ICA – Remove Blink Component
8. Topographic Interpolation
9. Baseline Correction [-200]
10. Condition Segmentation [-200] -> [600] --- Hits vs Misses
11. Artifact Rejection
12. Evaluate Artifact Rejection Data
13. Average
14. Export
15. {After All Participants} Grand Average
16. Final Export

Answer Key

- These show the steps which require the analyzer to remove channels or ICA components.
- Your results may differ *slightly* from these answers – especially the names of the ICA components that are removed (but the number of removed components should be the same)

Participant #	Channels Removed	Inverse ICA Component(s) Removed
01		F00
02	C1	F00
03	C1	F01
04	C1, F4, T8	F02
05	PO4, AF7, AF4	F00
06		F00
07	PO7, C6	F00
08		F00
09	AF3	F00
10	PO4, Cz	F01