

**Operating Manual for**

**Adaptive Signal Analysis & Processing (ASAP) for ERPs**

**2017-11-25**

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Web: [http://www.escience.cn/people/cong/AdvancedSP\\_ERP.html](http://www.escience.cn/people/cong/AdvancedSP_ERP.html)

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# Introduction

## Why do we write this code?

This code demo is written for processing and analyzing One-factor, Two-factor and Three-factor ERP/EEG data. The specific flow chart is as below:

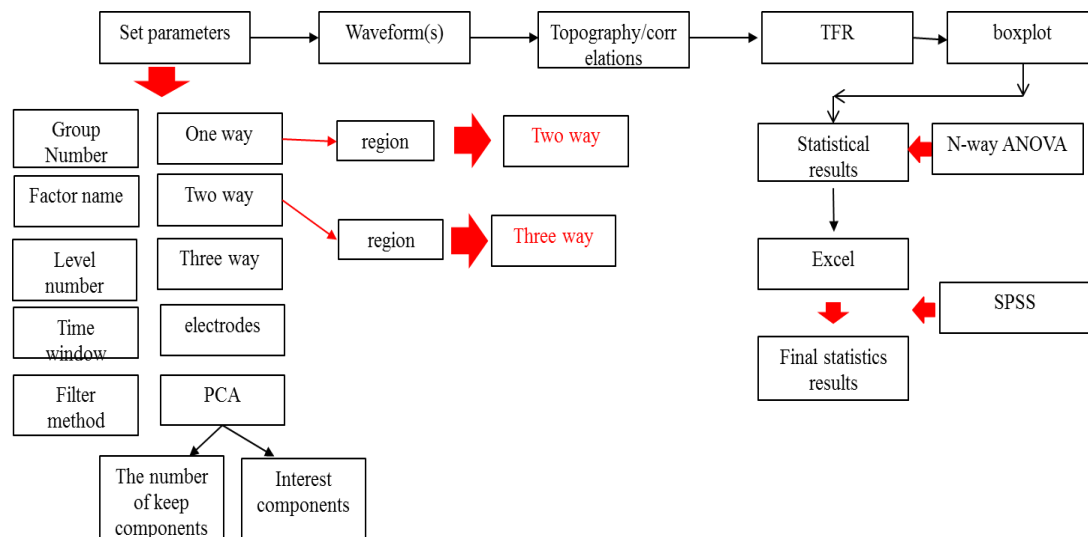


Figure 1.The flow chart of processing and analysis ERP data

## The information of demo data

In order to best understand how to use this code demo for processing and analysis EEG/ERP data, two demo data can be used.

The first demo data was collected by Pro. Peng Li, from College of Psychology and Sociology, Shenzhen University(within subjects analysis test, two factors [2\*2]. It can also be used to one-factor [4\*1] analysis).

- 22 subjects; Epoch Start is -200 millisecond; Epoch End is 1000 millisecond; the sampling rate is 500 Hz.

The second demo data was collected by Dr. Guoliang Chen, 215th Clinical Division, 406th Hospital of PLA, Dalian (between subjects analysis test, two factors [2\*2].

- Two groups: Control (20 subjects); Patient (20 subjects); Epoch Start is -200 millisecond; Epoch End is 1000 millisecond; the sampling rate is 1000 Hz.

# How to use this code demo

## 1. Forming a struct:D

A struct D should be obtained, including a four-order tensor, epoch start time, epoch end time, sampling rate, and group label. Specific steps are as follows.

- Step1: forming a four-order tensor (channel\*time\*stimulus\*subjects).

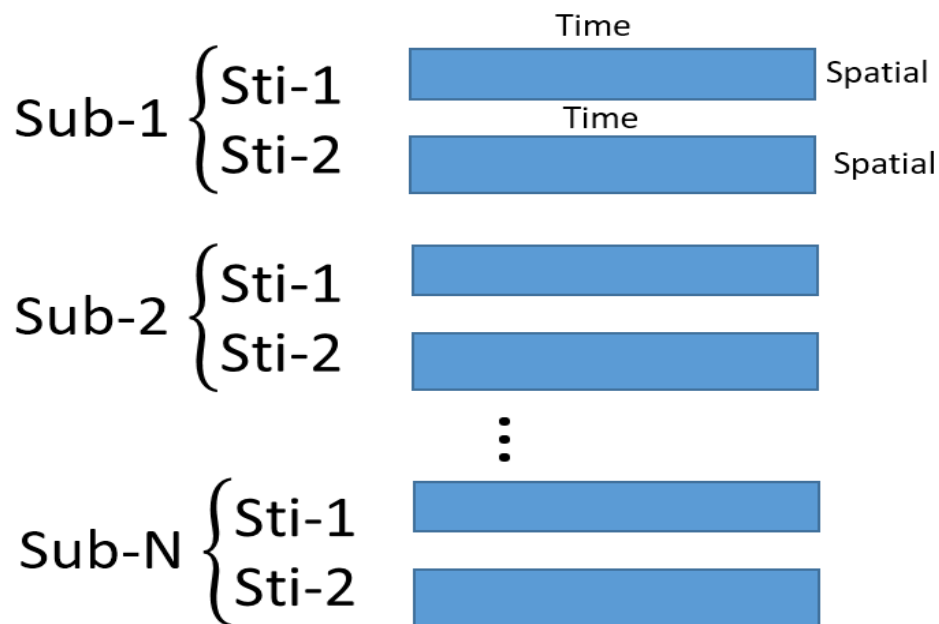
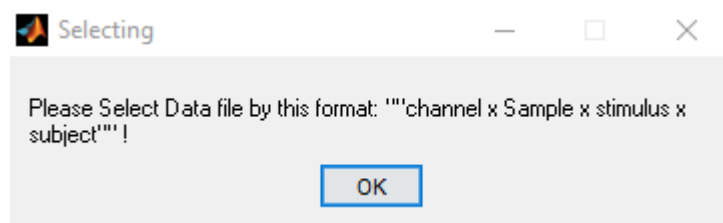
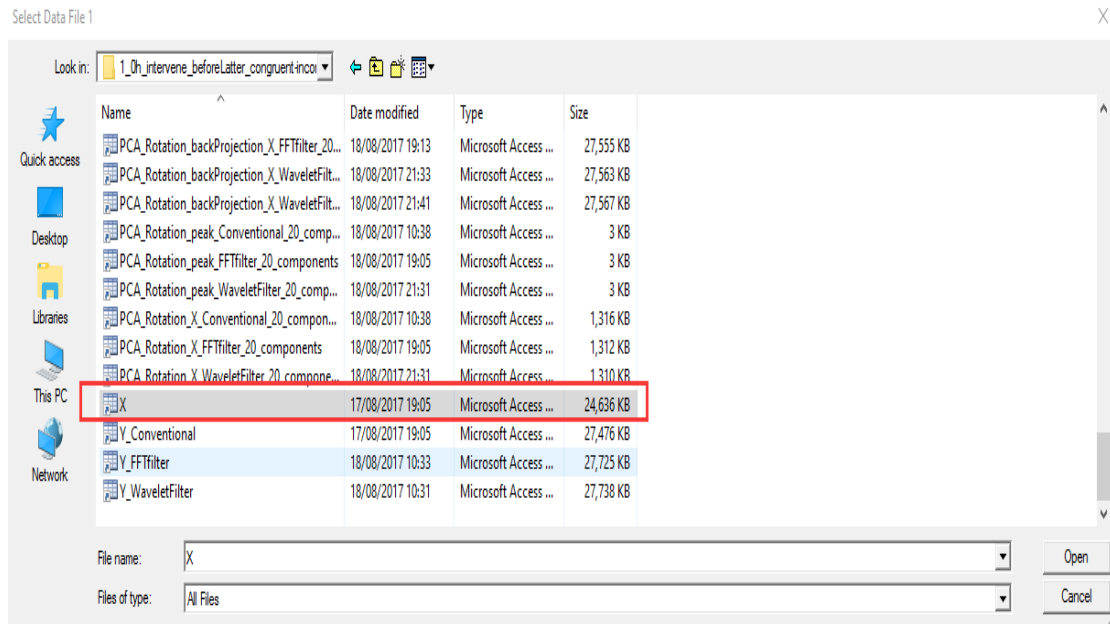


Figure 2. Take one-way test data (two level) forming four-order tensor as example.

- Step2: forming the struct D.
  - run the code: **m\_0\_forming\_theStruct\_D**, then follow the prompts, as shown below:
  - select the four-order tensor data

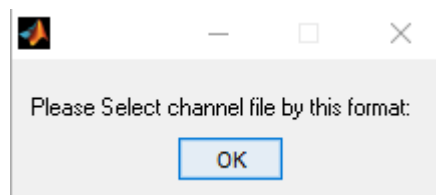


Click 'OK'.

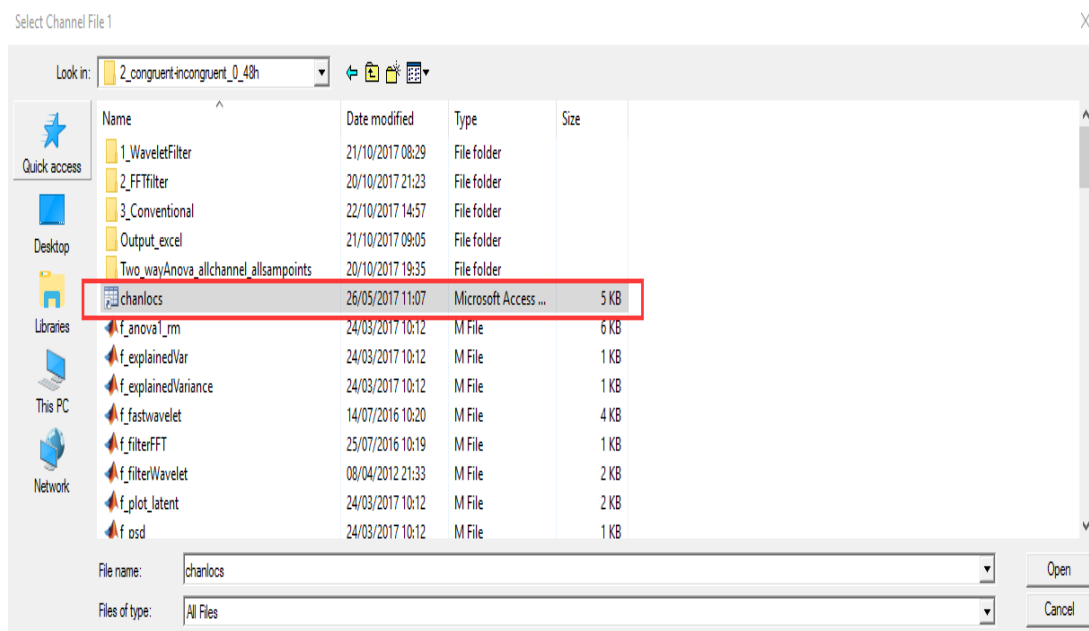


Select the data obtained according to step1.

- select the channel file

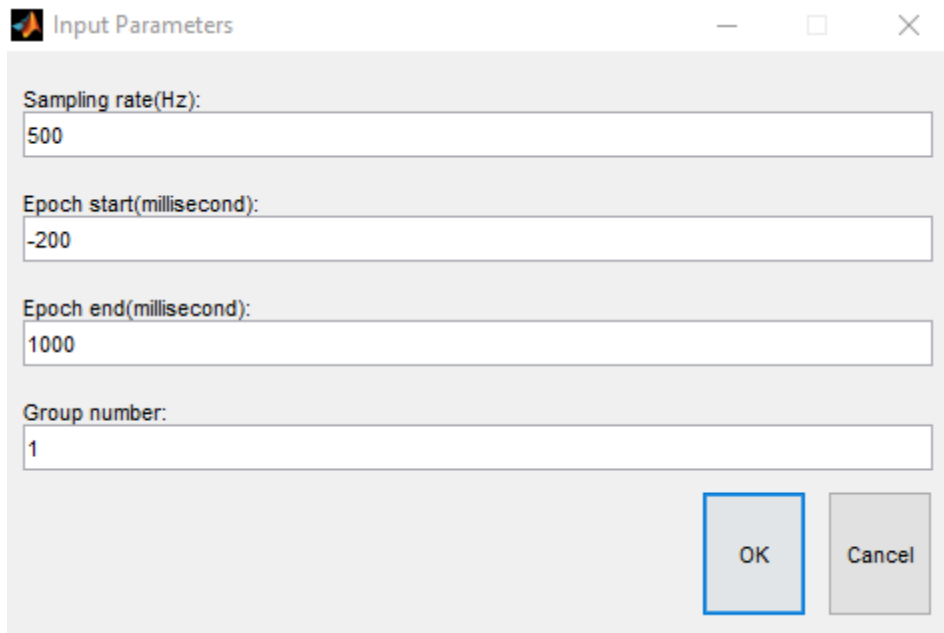


Click 'OK'.

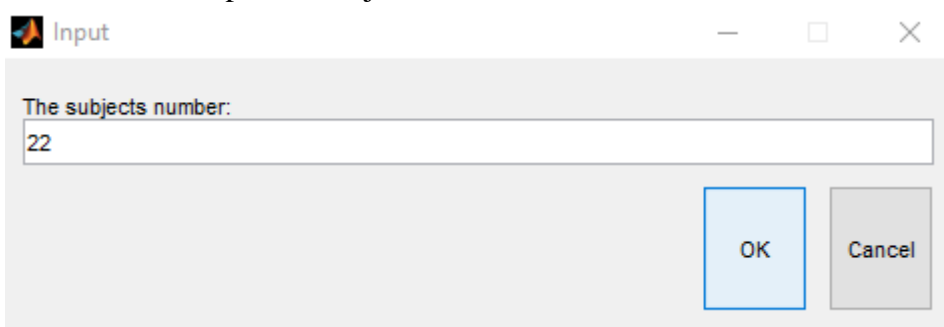


Select the channel file

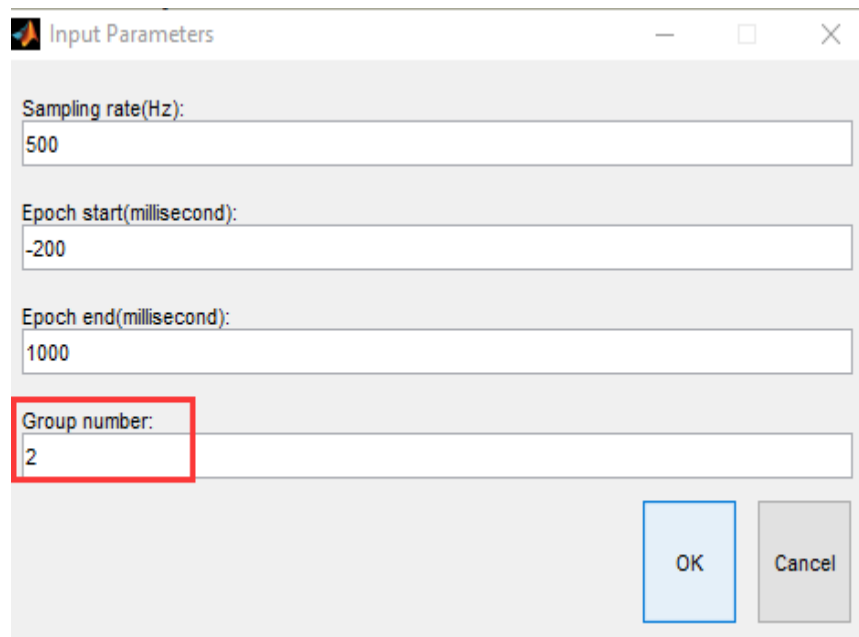
- set the parameters
- One group



click 'OK', then input the subjects.



- If the group number is more than 1, you should input the subjects number of each group respectively. The steps are as follow.



Click 'OK'.

Input Parameters

The subjects number of first group:  
25

The subjects number of second group:  
26

OK Cancel

## 2. Within subjects analysis

### 2.1 Conventional method

- Firstly, you should run the code: **m\_1\_ERP\_Analysis**, then set the parameters, the grand average waveform of interest electrodes, the topography, the topo the topography correlation between subjects, time frequency representation, box plot of the data, and the statistical analysis results obtained.

Input Parameters

The name of first factor =:  
wait time

The name of second factor =:  
feedback

The name of third factor =:  
0

The level of first factor =:  
2

The level of second factor =:  
2

The level of third factor =:  
0

Filter (1.Wavelet filter & 2.FFT filter & 3.None)  
3

PCA (1.Yes & 2. No)  
2

Measure method (1.Mean value & 2.Peak value):  
1

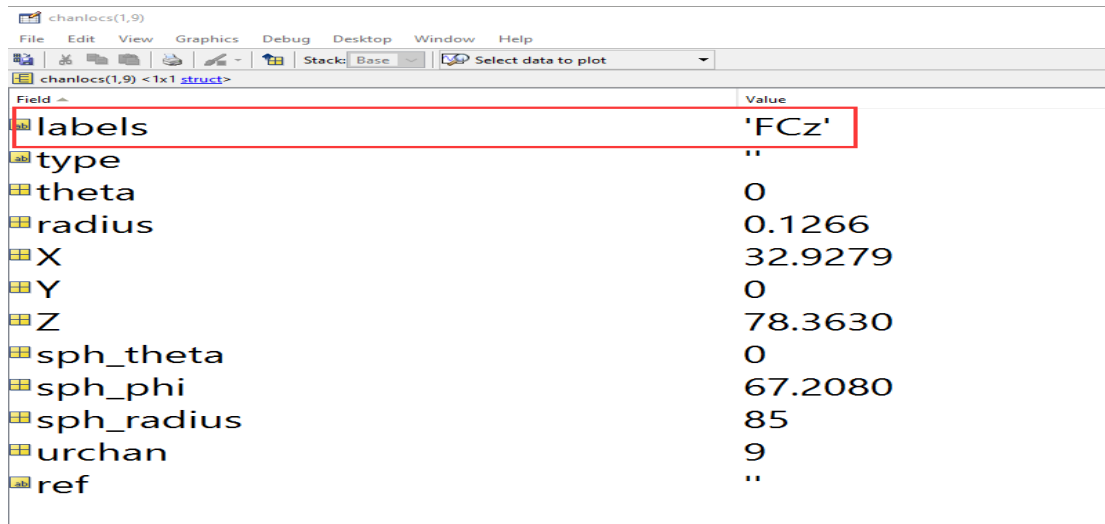
ERPStart=:  
300

ERPEnd=:  
400

OK Cancel

Set the parameters: the name of first factor is wait time, the name of second factor is feedback; the name of third factor is 0; the level of first factor is 2; the level of second factor is 2; the level of third factor is 0; filter method is none; PCA is not used, measure method is mean value; the start time of time window is 300 millisecond; the end time of time window is 400 millisecond.

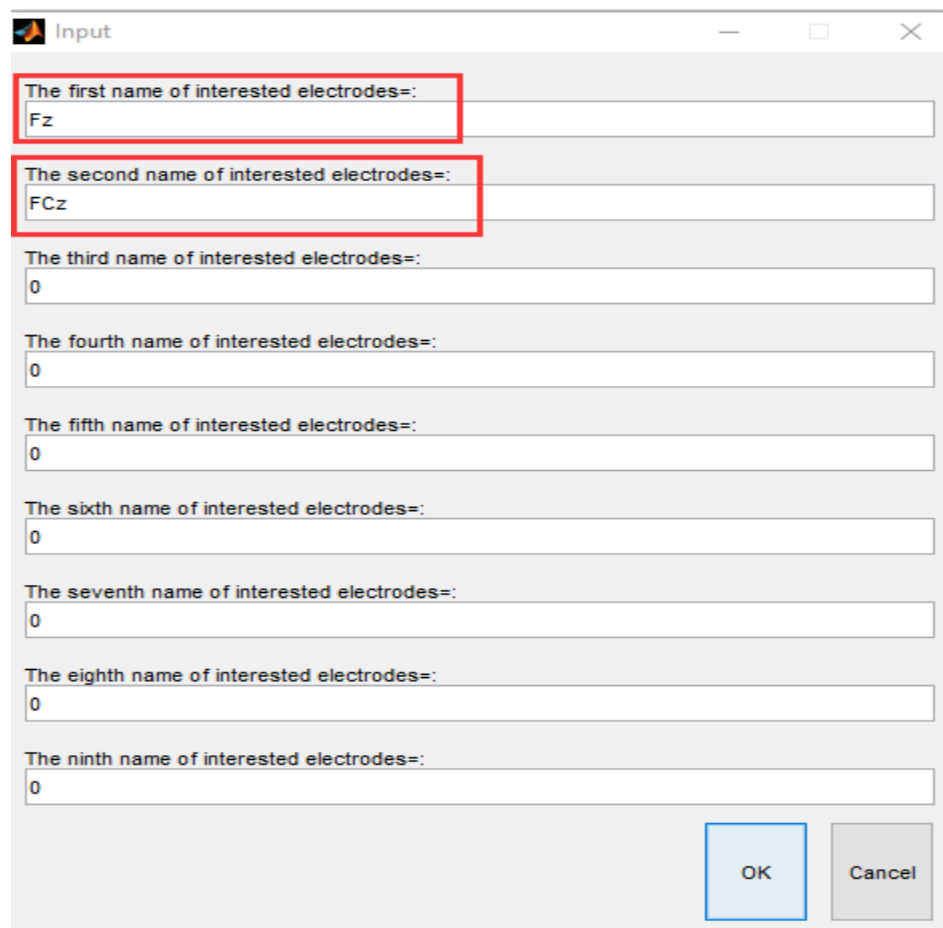
Then, input the name of interest electrodes according to channel file.



Field	Value
labels	'FCz'
type	''
theta	0
radius	0.1266
X	32.9279
Y	0
Z	78.3630
sph_theta	0
sph_phi	67.2080
sph_radius	85
urchan	9
ref	''

Figure 3. An example of one electrode name

Input the interested electrodes name.



The first name of interested electrodes=: Fz

The second name of interested electrodes=: FCz

The third name of interested electrodes=: 0

The fourth name of interested electrodes=: 0

The fifth name of interested electrodes=: 0

The sixth name of interested electrodes=: 0

The seventh name of interested electrodes=: 0

The eighth name of interested electrodes=: 0

The ninth name of interested electrodes=: 0

OK Cancel



Click 'OK'.  
Those results will be obtained.

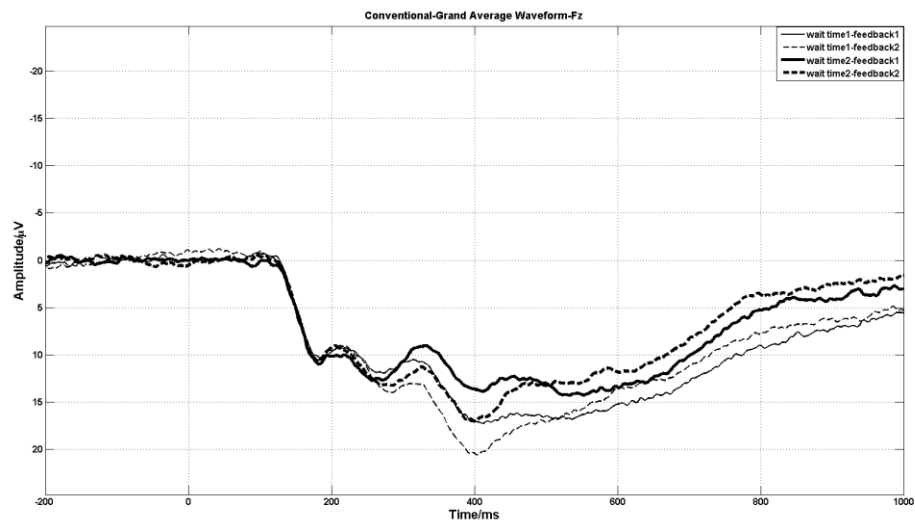


Figure 4.The grand average waveform at Fz

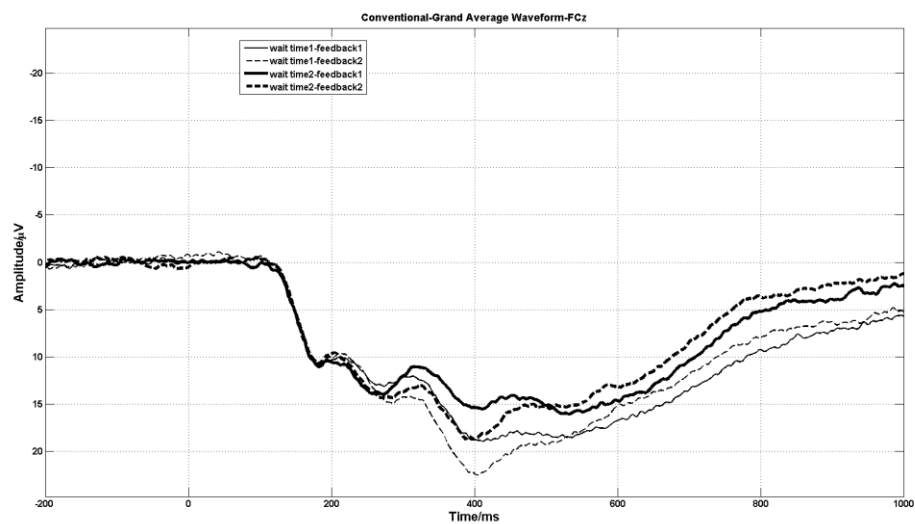
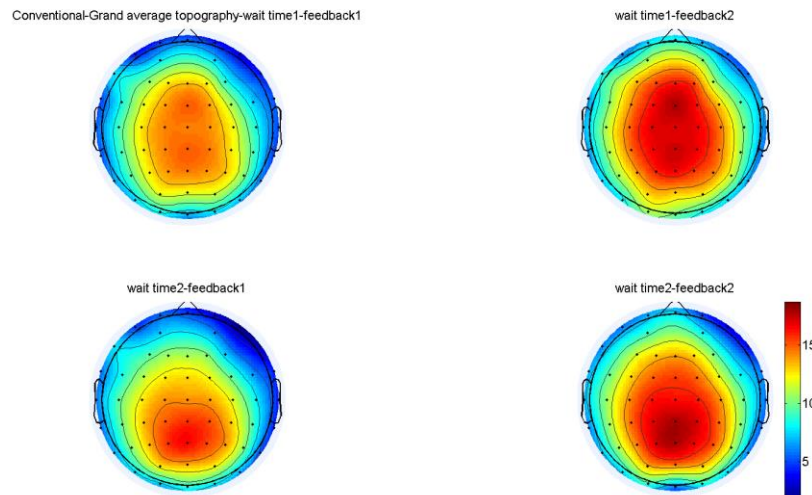
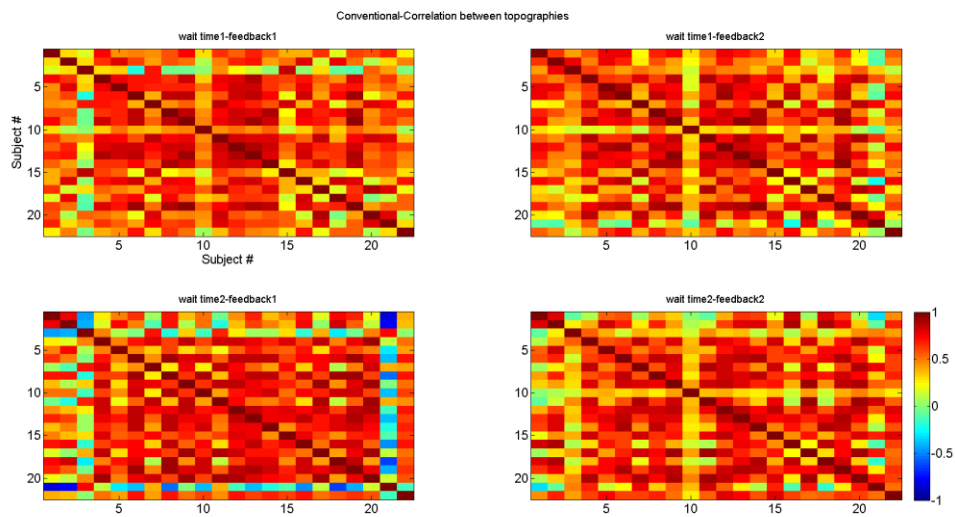


Figure 5.The grand average waveform at FCz



**Figure 6.The grand average topography**



**Figure 7.The correlation between topographies**

Set the parameters for time-frequency analysis, low frequency value and high frequency value of frequency range.

Input

low frequency:

high frequency:

OK

Cancel

Then, click 'OK'.

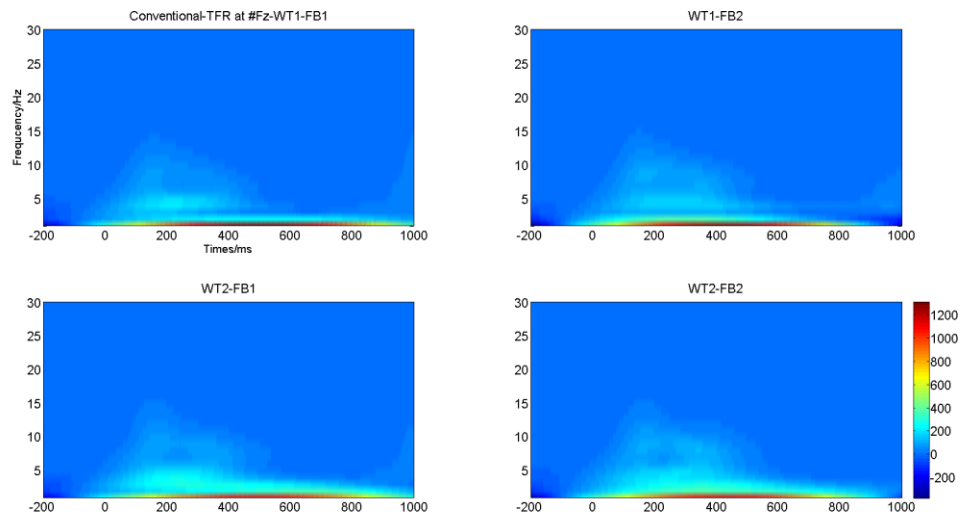


Figure 8.The time-frequency representation at Fz

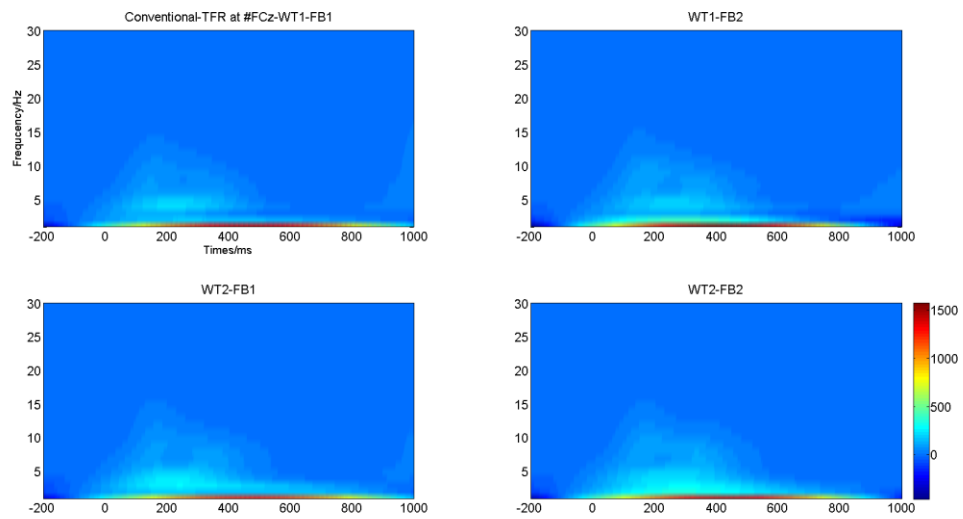
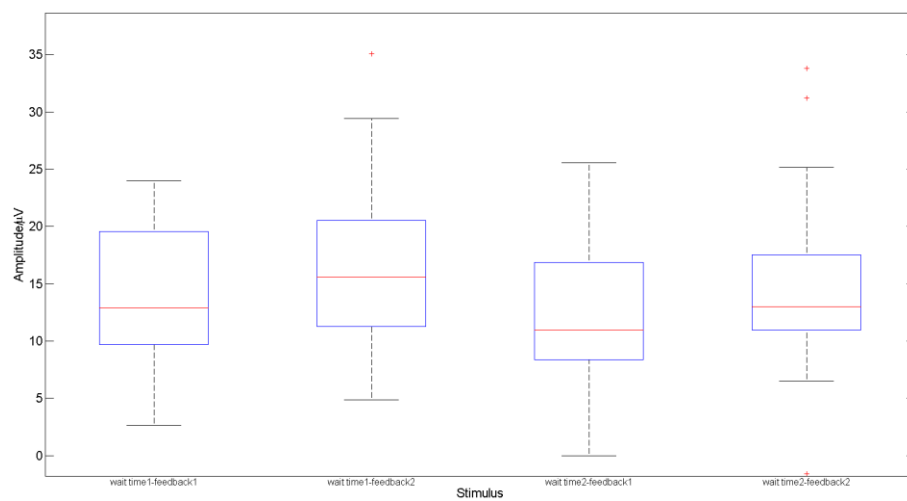


Figure 9.The time-frequency representation at FCz



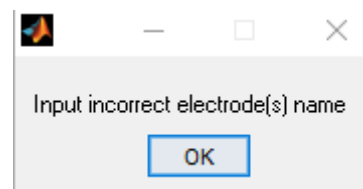
**Figure 10.**The boxplot of the data (the window is from 300 to 400 millisecond, the interest electrodes are Fz,FCz)

Analysis of Variance					
Source	Sum Sq.	d.f.	Mean Sq.	F	Prob>F
wait time	1.43	1	1.428	0.03	0.8551
feedback	571.15	1	571.153	13.42	0.0004
wait time*feedback	447.59	1	447.587	10.52	0.0017
Error	3574.3	84	42.551		
Total	4594.47	87			

Constrained (Type III) sums of squares.

**Figure 11.**The results of statistical analysis (the window is from 300 to 400 millisecond;the interest electrodes are Fz,FCz)

If you input incorrect electrode(s) name or do not input anything, the following tips will be given:



Please, click 'OK'. Other input window will appear. Input interested electrode(s) name again.

- Output the data

Run the code: **m\_4\_outputdata\_excel**. Output the data of interested component at interested electrodes, and then use SPSS for further analysis. The steps are as follow:

Set the parameters:

**Input Parameters**

The name of first factor =:  
wait time

The name of second factor =:  
feedback

The name of third factor =:  
0

The level number of first factor =:  
2

The level number of second factor =:  
2

The level number of third factor =:  
0

Filter (1.Wavelet filter & 2.FFT filter & 3.None)  
3

PCA (1.Yes & 2. No)  
2

Measure method (1.Mean value & 2.Peak value)  
1

ERPStart=:  
300

ERPEnd=:  
400

OK Cancel

Input interest electrodes' name:

**Input**

The first name of interested electrodes=:  
Fz

The second name of interested electrodes=:  
FCz

The third name of interested electrodes=:  
0

The fourth name of interested electrodes=:  
0

The fifth name of interested electrodes=:  
0

The sixth name of interested electrodes=:  
0

The seventh name of interested electrodes=:  
0

The eighth name of interested electrodes=:  
0

The ninth name of interested electrodes=:  
0

OK Cancel

Click 'OK'.

Then, the data of the time window 300-400ms and interest electrodes were

imported into excel as shown in figure 12.

	wait time1-feedback1	wait time1-feedback2	wait time2-feedback1	wait time2-feedback2
1				
2	5.559942592	4.892975658	-0.034007352	-1.604017693
3	13.59754728	15.11314073	8.35611875	13.03624674
4	18.12222851	13.24727698	10.12511959	11.94992744
5	8.229799446	11.98082454	11.13041595	12.96222205
6	12.74391173	11.91424574	7.289813658	10.96095858
7	5.616828777	8.836184928	8.18290422	7.231415237
8	17.87280772	20.34327672	16.90528599	13.35448377
9	12.64478801	13.73555039	9.872050005	15.60136149
10	11.10733538	17.05754501	13.82617256	15.94076294
11	2.630242538	6.061902244	2.966013157	6.503776074
12	23.74954989	27.84338496	19.06123768	25.16335193
13	22.10258569	26.72755104	25.54351495	33.80483879
14	22.33392649	35.08289627	12.29419849	20.2554984
15	15.15969405	20.50756067	10.0314783	11.27086617
16	19.54930569	17.18631152	13.58982647	12.96389031
17	13.02535008	16.09033757	16.88000233	10.99830198
18	20.5452699	29.41146674	20.61972324	31.17620688
19	11.99591296	9.9258263	8.666429602	7.924248386
20	10.45313239	19.69905225	11.2762523	14.39468026
21	23.95938855	27.17721218	19.41782923	21.10729015
22	9.63054688	10.18664747	4.802277119	8.767951759
23	9.701472041	11.27713333	10.81494372	17.54484471

Figure 12. An example for importing data into excel\

- The operations for different brain regions: run **m\_1\_ERP\_Analysis**. Set the parameters. Especially, the third factor name must be **Region**.

The screenshot shows the 'Input Parameters' dialog box for the 'm\_1\_ERP\_Analysis' function. The dialog contains the following fields and values:

- The name of the first factor =: WT
- The name of the second factor =: FB
- The name of the third factor =: **Region** (highlighted with a red box)
- The level of the first factor =: 2
- The level of the second factor =: 2
- The level of the third factor =: **3** (highlighted with a red box)
- Filter (1.Wavelet filter & 2.FFT filter & 3.None): 3
- PCA (1.Yes & 2.No): 2
- Measure method (1.Mean value & 2.Peak value): 1
- ERPStart =: 300
- ERPEnd =: 400

At the bottom right, there are 'OK' and 'Cancel' buttons.

Click 'OK', then input the name of interest channel, the grand average waveform of interest electrodes, the topography, the topography correlation between subjects, and time frequency representation obtained.

Next, three user interfaces will appear respectively for inputting the name of the first region/second region/third region.

input

The first channel name of the first Region:-

Fz

The second channel name of the first Region:-

0

The third channel name of the first Region:-

0

The fourth channel name of the first Region:-

0

The fifth channel name of the first Region:-

0

The sixth channel name of the first Region:-

0

The seventh channel name of the first Region:-

0

The eighth channel name of the first Region:-

0

The ninth channel name of the first Region:-

0

OK

Cancel

input

The first channel name of the second Region:-

Cz

The second channel name of the second Region:-

0

The third channel name of the second Region:-

0

The fourth channel name of the second Region:-

0

The fifth channel name of the second Region:-

0

The sixth channel name of the second Region:-

0

The seventh channel name of the second Region:-

0

The eighth channel name of the second Region:-

0

The ninth channel name of the second Region:-

0

OK

Cancel

input

The first channel name of the third Region:-

Pz

The second channel name of the third Region:-

0

The third channel name of the third Region:-

0

The fourth channel name of the third Region:-

0

The fifth channel name of the third Region:-

0

The sixth channel name of the third Region:-

0

The seventh channel name of the third Region:-

0

The eighth channel name of the third Region:-

0

The ninth channel name of the third Region:-

0

OK

Cancel

Input the name of each region.

Regions Name

The first region name =:

F

The second region name =:

C

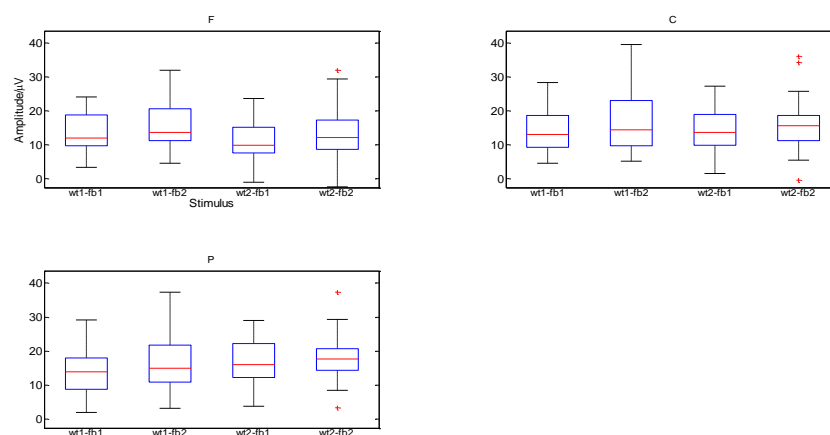
The third region name =:

P

OK

Cancel

Click 'OK'.



Analysis of Variance					
Source	Sum Sq.	d.f.	Mean Sq.	F	Prob>F
wt	370.2	2	185.087	3.53	0.0307
fb	370.3	1	370.259	7.07	0.0083
Region	15.3	1	15.266	0.29	0.5898
wt*fb	12.8	2	6.4	0.12	0.885
wt*Region	170.9	2	85.456	1.63	0.1977
fb*Region	3.1	1	3.056	0.06	0.8093
wt*fb*Region	1.2	2	0.616	0.01	0.9883
Error	13199.6	252	52.38		
Total	14143.3	263			

Constrained (Type III) sums of squares.

## 2.2 FFT filter & Wavelet filter

- Step1, Run the code: **m\_2\_Filter\_ERP** -to filter the average ERP data.

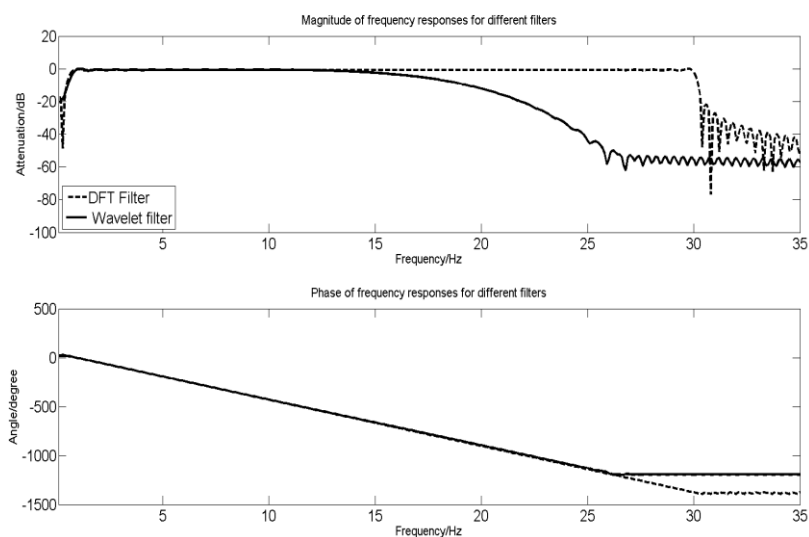


Figure 2.1 frequency responses for different filters

- Step2, Run the code: **m\_1\_ERP\_Analysis, the fileter**; the filter method is 1 or 2 and the rest parameters setting are similar to the conventional method, shown as below.



The name of the first factor =:  
WT

The name of the second factor =:  
FB

The name of the third factor =:  
0

The level of the first factor =:  
2

The level of the second factor =:  
2

The level of the third factor =:  
0

Filter (1.Wavelet filter & 2.FFT filter & 3.None):  
2

PCA (1.Yes & 2. No):  
2

Measure method (1.Mean value & 2.Peak value):  
1

ERPStart =:  
300

ERPEnd =:  
400

OK Cancel

- Step 3, run the code : **m\_4\_outputdata\_excel**, output the data of interested component, then use SPSS to further analysis.

## 2.3 Conventional method/FFT/Wavelet Filter + PCA

- Step1, Run the code: **m\_3\_PCA\_rotation\_ERP\_multipleGroups**, determine how many components should be retained, then select the interested component(s) to back projection. Filter method can use 1,2, and 3.

The name of the first factor =:  
WT

The name of the second factor =:  
FB

The name of the third factor =:  
0

The level of the first factor =:  
2

The level of the second factor =:  
2

The level of the third factor =:  
0

Filter (1.Waveletfilter & 2.FFTfilter & 3.None):  
3

OK Cancel

Next, select the reserved components according to explained variance of

accumulated lambda.

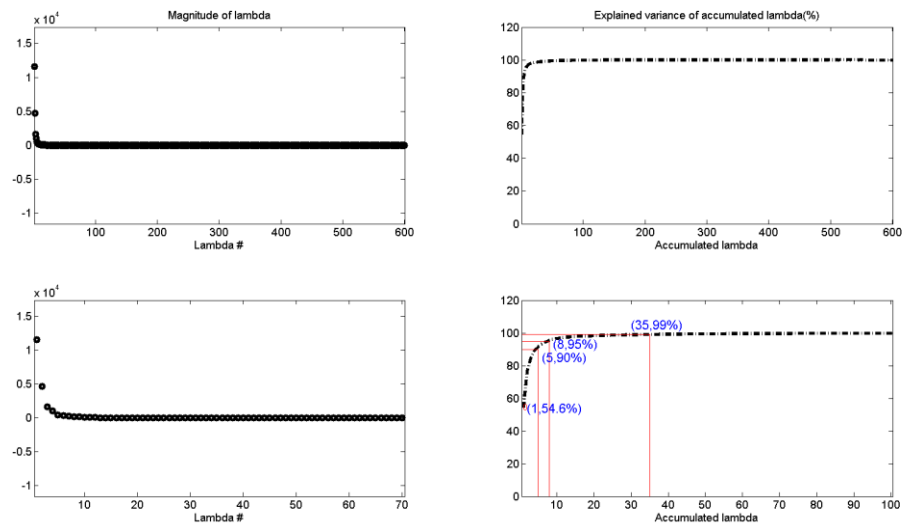


Figure 2.3.1 explained variance of accumulated lambda of conventional method  
Here, 10 was reserved, then select the interested component(s) to back projection.

The image shows a software window titled 'Input'. Inside the window, there is a text box with the label 'The number of reserved components=:' and the value '1' entered. Below the text box, there are two buttons: 'OK' and 'Cancel'.

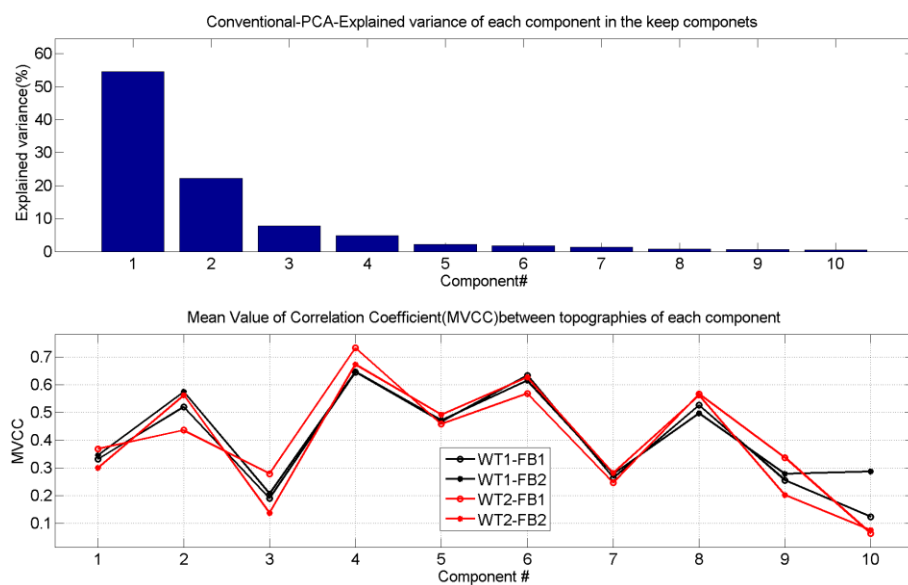


Figure 2.3.2 Explained variance of accumulated lambda of conventional method and Mean Value of Correlation Coefficient (MVCC) between topographies of each component

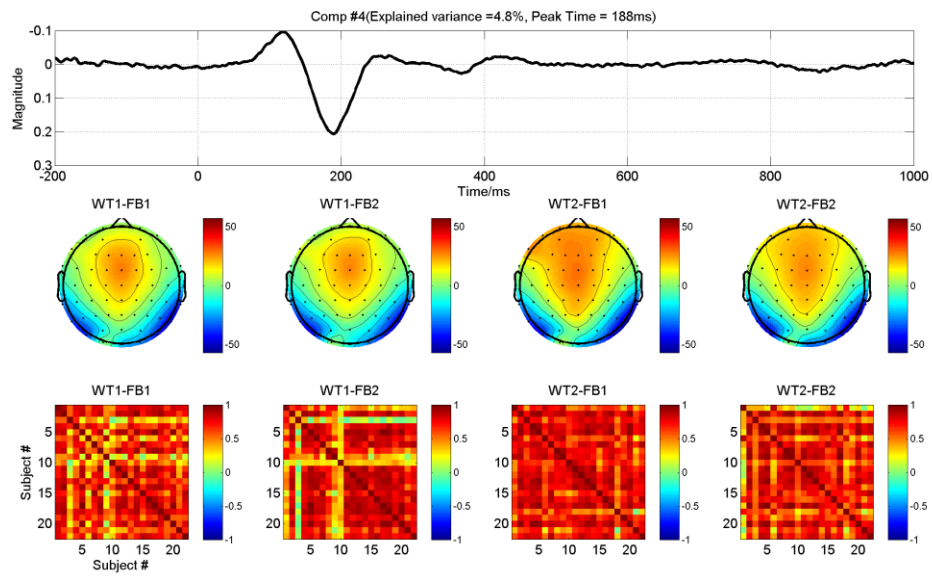


Figure 2.3.3 The 4<sup>th</sup> component

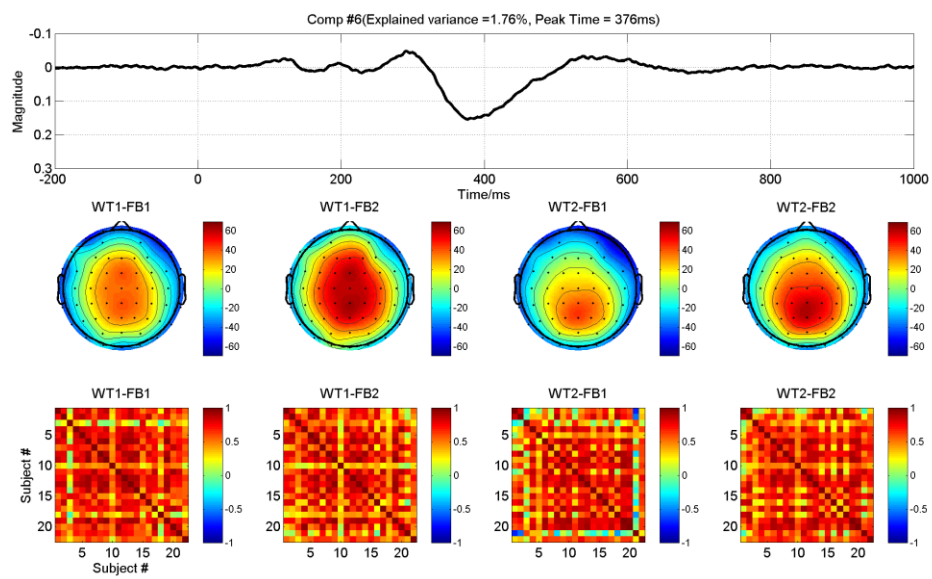


Figure 2.3.4 The 6<sup>th</sup> component

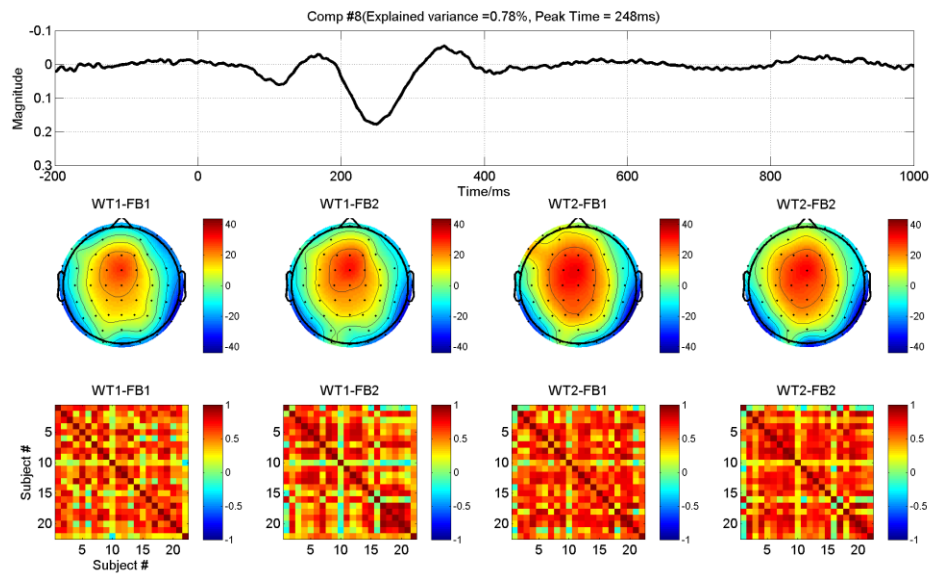


Figure 2.3.5 The 8<sup>th</sup> component

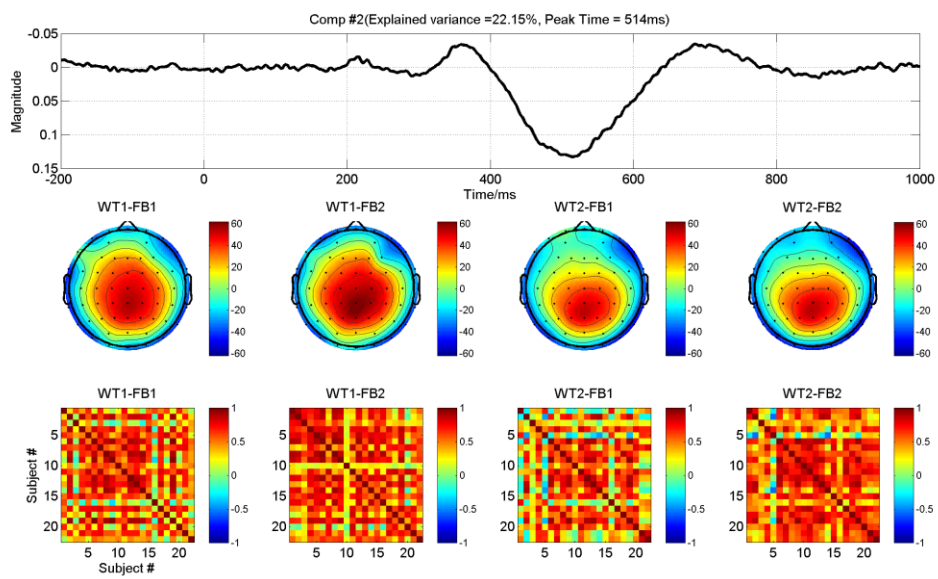


Figure 2.3.6 The 2<sup>th</sup> component

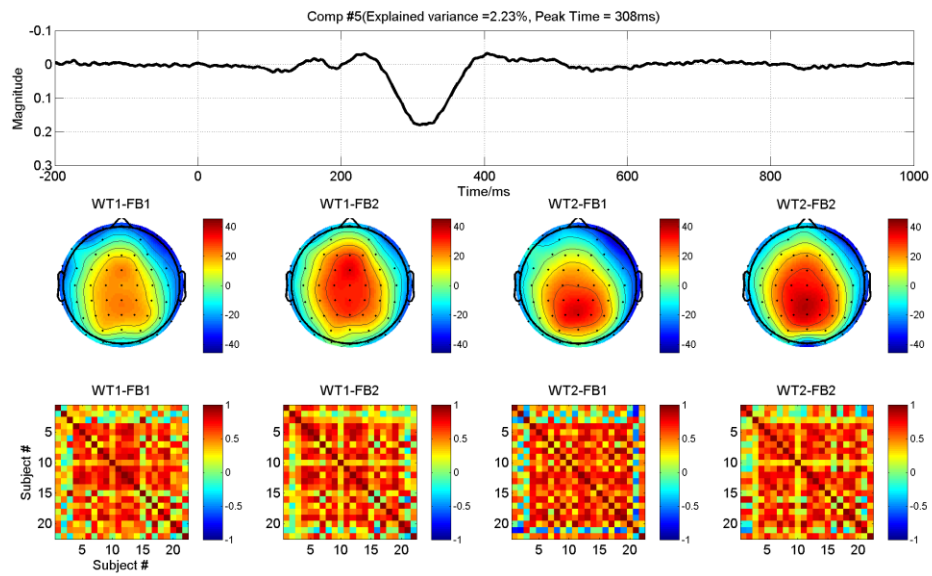


Figure 2.3.7 The 5<sup>th</sup> component

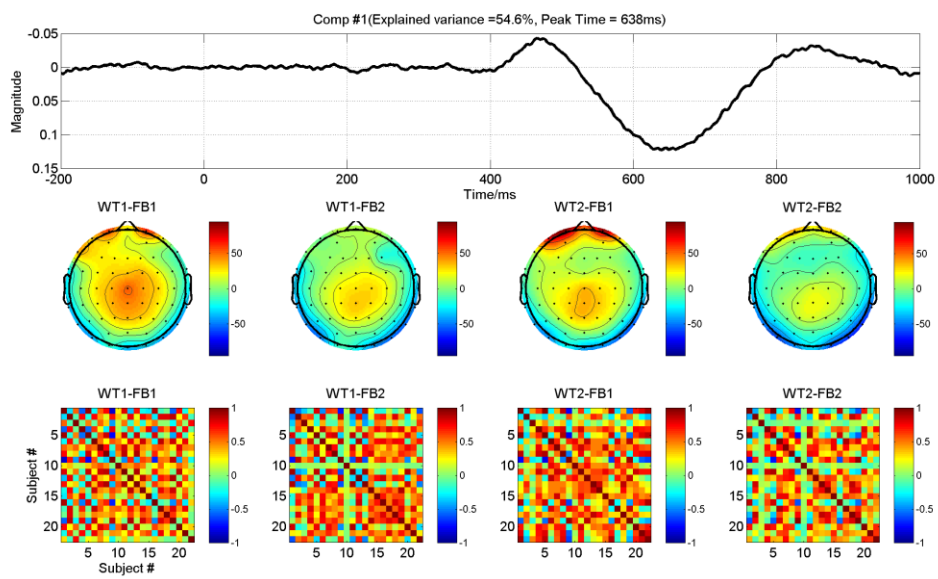


Figure 2.3.8 The 1<sup>th</sup> component

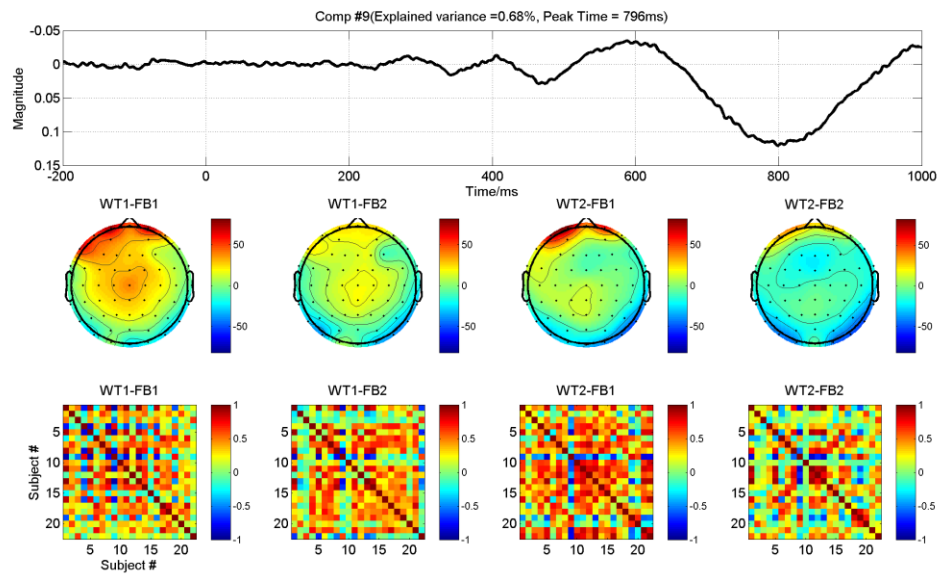


Figure 2.3.9 The 9<sup>th</sup> component

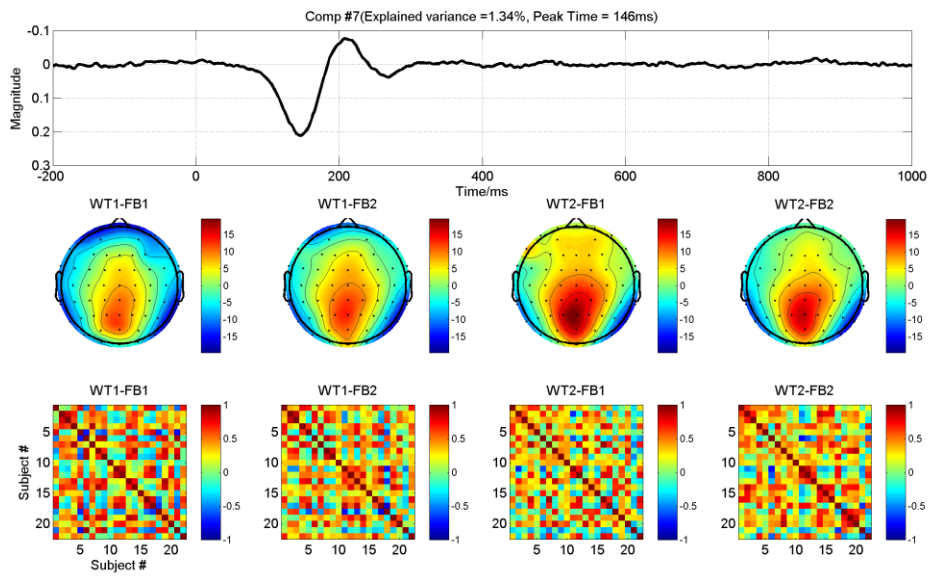


Figure 2.3.10 The 7<sup>th</sup> component

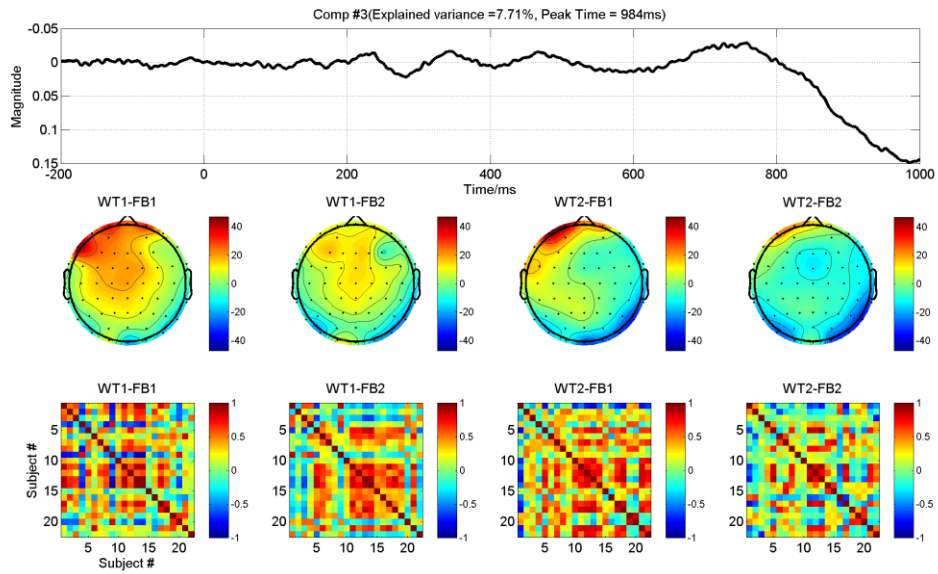


Figure 2.3.11 The 3<sup>th</sup> component

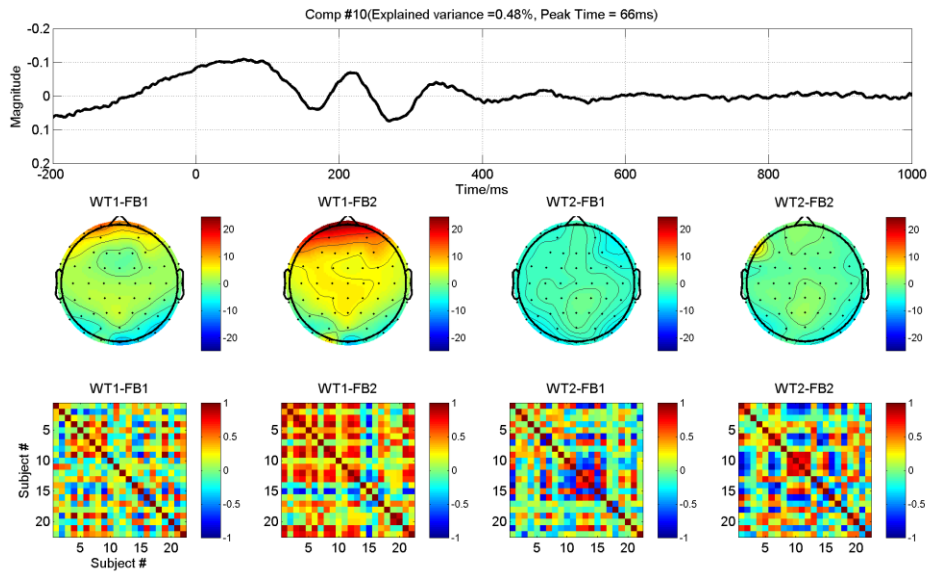


Figure 2.3.12 The 10<sup>th</sup> component

According to the properties of interest component in the time domain and spatial domain and the correlation coefficient between topographies, the 6<sup>th</sup> component was selected to back projection.



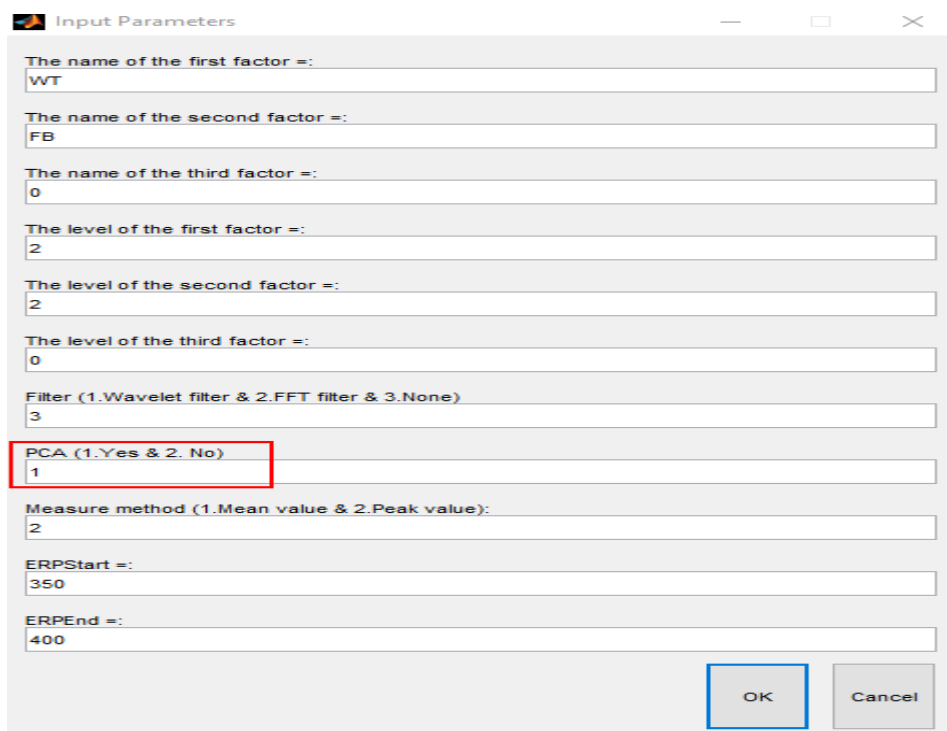
Input

The component(s) number of interest = :

6

OK Cancel

- Second, run the code: **m\_1\_ERP\_Analysis**, then set the parameters, the grand average waveform of interest electrodes, the topography, the topo the topography correlation between subjects, time frequency representation, box plot of the data, and the statistical analysis results were obtained(especially, the PCA method should be 1).



Input Parameters

The name of the first factor =:  
WT

The name of the second factor =:  
FB

The name of the third factor =:  
0

The level of the first factor =:  
2

The level of the second factor =:  
2

The level of the third factor =:  
0

Filter (1.Wavelet filter & 2.FFT filter & 3.None)  
3

PCA (1.Yes & 2. No)  
1

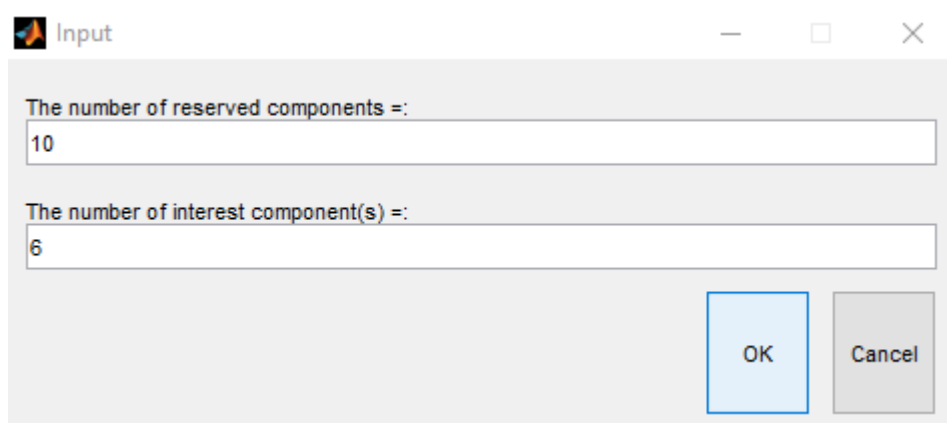
Measure method (1.Mean value & 2.Peak value):  
2

ERPStart =:  
350

ERPEnd =:  
400

OK Cancel

Then, input the number of reserved components (here, it is 10) and the number of interest component (here, it is 6).



Input

The number of reserved components =:  
10

The number of interest component(s) =:  
6

OK Cancel

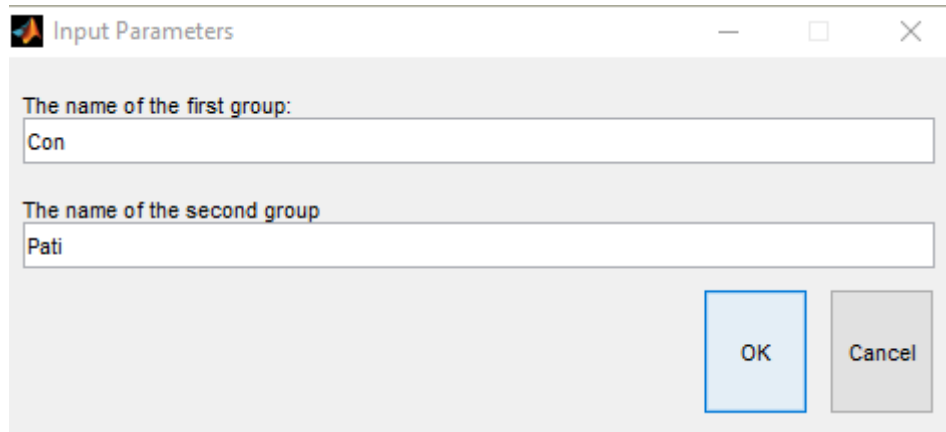


Next, input the name of interest electrode(s) in the user interface.

- Finally, run code: **m\_4\_outputdata\_excel**, the parameters setting are the same as step 2.

### 3. Between subjects analysis

Here, the similar operation should be done except inputting the name of each group.



The screenshot shows a window titled "Input Parameters". Inside the window, there are two text input fields. The first field is labeled "The name of the first group:" and contains the text "Con". The second field is labeled "The name of the second group:" and contains the text "Pati". At the bottom right of the window, there are two buttons: "OK" and "Cancel".

### 4. Acknowledgement

My acknowledgements are to Prof. Peng Li, Dr.Guoliang Chen for providing ERP data. Meanwhile, express my thanks to Tiantian Yang, Xiaoshuang Wang, Jianrong Li, XiaoyuWang, Jianning Du for helping me to improve this code demo.