

Exploratory analysis

Vigilance Project

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Information sources:

- <https://github.com/vhenaoi/Vigilance.git>
- <https://photos.app.goo.gl/PU1hkKenDAAEwb3x5>
- https://drive.google.com/drive/folders/16ExFf1EBw6u6RHHPTn0hB1kD2Rnb68Tv?usp=share_link

1. Justification

This interface was developed as a support element during the exploratory analysis of the data from the vigilance project being developed by the Neuroscience Laboratory of Human Higher Functions at Sapienza Università di Roma under the direction of Professor Claudio Babiloni.

2. Definitions and concepts

- 2.1. Global area:** Refers to the information that is extracted from the 19 channels considering the international standard 10-20. The channels are FP1, FP2, Fz, F7, F3, F4, F8, T7, C3, Cz, C4, T8, P7, P3, Pz, P4, P8, O1, O2 presented in *Figure 1*.

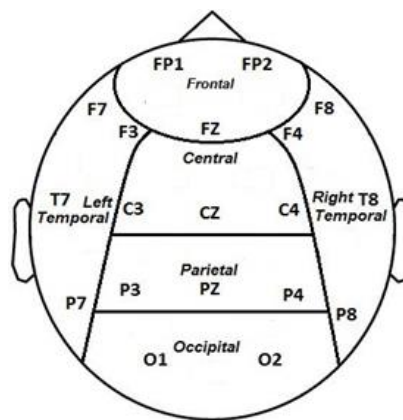


Figure 1. Global area

- 2.2. Posterior area:** Refers to the information that is extracted from the 8 channels of the occipital and parietal zone in a 19-channel assembly considering the international standard 10-20. The channels are C3, Cz, C4, P3, Pz, P4, O1, O2 highlighted in blue in *Figure 2*.

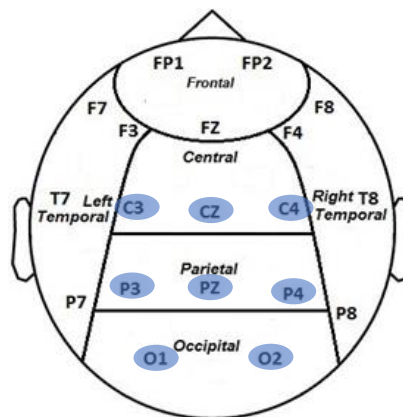


Figure 2. Posterior area.

2.3. True Alpha: This term is used when the reactivity of a subject has the theoretically expected graphic behavior. In *Figure 3.a* a subject with True Alpha is presented and in *Figure 3.b* a subject that is not considered True Alpha.

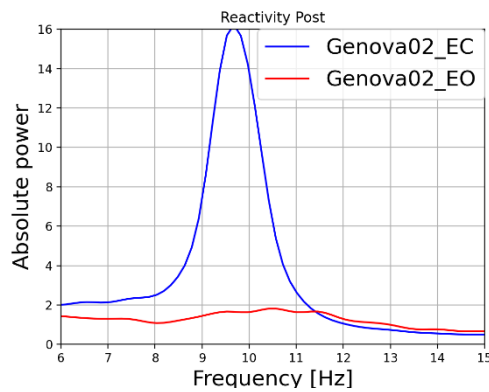


Figure 3.a

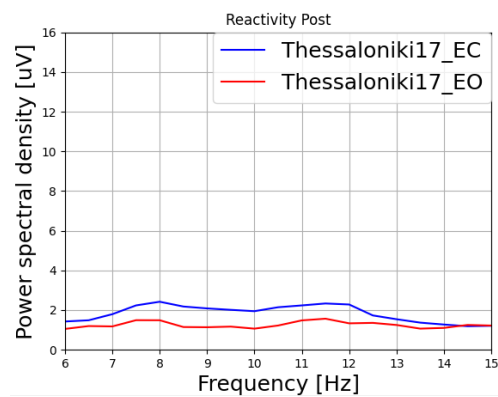


Figure 3.b

2.4. Qualitative analysis: Refers to the inspection and visual analysis of the electroencephalogram performed by an expert. During this analysis, 6 states are initially seen in *Figure 4*.

A: Alert – D: Drowsiness – N1: transition phase to sleep – N2: Sleep – N3: deep sleep

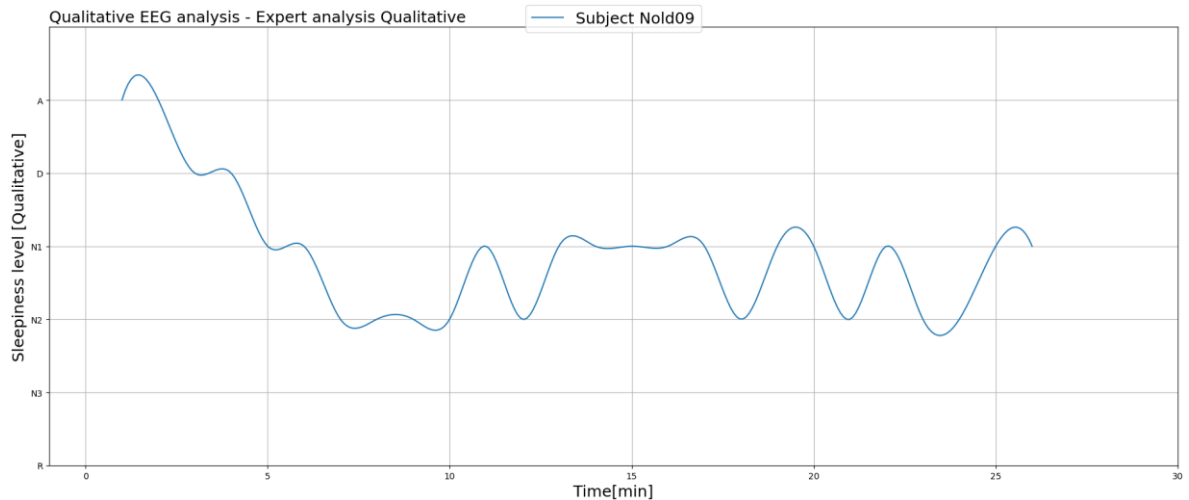


Figure 4. Qualitative

3. Data organization procedure

3.1. Steps to follow having the .txt exported from eLORETA

When carrying out the eLORETA procedure you the following folders are obtained. See *Figure 5* and organize the data in the excel files mentioned below:

1. Normalizzazione. *Figure 6*
2. TF-IAF da CRSS. *Figure 7*
3. MACRO Calcolo. *Figure 8*

- 01 txt
- 02 filter
- 03 CRSS
- 04 eLORB
- 05 eLORN
- 07 ROI
- 08 CRSS TF - AIF

Figure 5. Organizational structure of the information acquired from eLORETA

Figure 6. Represents the powers in rois and considers each segment generated from the processing, it has a first sheet where the data is copied from the .txt and a second sheet where the normalized data output is generated

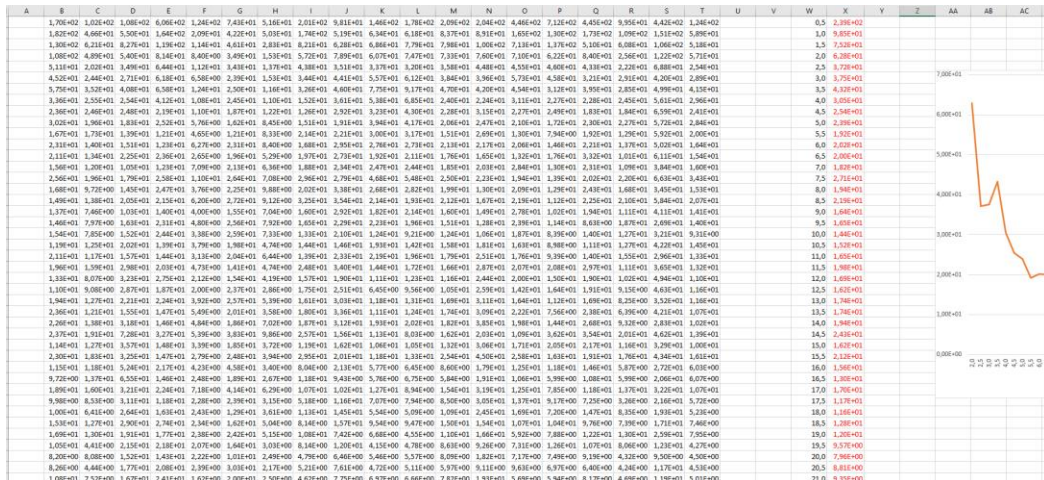


Figure 7. Contains a column with the powers in each of the channels by subject. In the second sheet "TF-AIF" there are the values of the TF and AIF, which are obtained by visual inspection of the generated graph or automatically taking the maximum value in the ranges of interest.

Figure 8. In the first sheet "TF-AIF" you must paste the values obtained for TF and AIF, in the second sheet "Foglio 3" you must copy the values obtained from the normalization by ROIs for each segment and finally in the sheet "OUTPUT" the values resulting from the procedure are found

3.2. Content of the Sleep.xlsx file

Figure 9. contains the qualitative information of each subject in time, each column represents a subject and the letters A,D,N1,N2,N3 represent the states mentioned in point 2.4 of this manual

Note: It is important that all the subjects are in this excel and it is verified that the name remains in each one of the pages of the book, since the graphs use this information to identify the subjects in the database, it is not essential that if there is quantitative information, likewise the name must be in the first row, an example of this is the subject Brescia33, his name is in the first row, but he does not have a reported qualitative analysis.

3.3. Content of the Gp.xlsx file

3.3.1. Vigilance eLoreta

The first 3 pages of this book contain the information that is extracted from the book presented in Figure 8.

The procedure consists of copying the same information. See Figure 10.

Note: Do not change the name of any of the sheets in this book

SBJ	TF	Delta_F	Delta_C	Delta_P	Delta_L	Delta_I	Delta_K	Delta_L	Delta_M	Delta_N	Delta_O	Delta_P	Delta_Q	Delta_R	Delta_S	Delta_T	Delta_U	Delta_V	Delta_W	Delta_X	Delta_Y	Delta_Z	Delta_AA	Delta_AB	Delta_AC	Delta_AD	Delta_AE				
1	seg1	5.8	5.67247	3.28047	4.81314	3.9728	5.20236	3.25015	1.87816	1.23014	1.87353	1.44639	1.76549	1.18375	1.28487	0.81532	1.55115	1.00955	1.20117	0.8514	1.36341	0.81491	1.55646	1.12708	1.20716	0.89168	1.30881	1.28855			
2	seg2	5.5	5.1494	2.09441	5.13336	2.44647	2.95488	1.95028	1.53258	0.97410	1.5343	1.17928	1.42562	0.97171	1.44517	0.80803	2.3469	1.00224	1.09996	0.51089	1.43781	0.80819	1.97168	1.30029	1.23841	0.98303	1.30123	0.71039	1.55896		
3	seg3	5	4.39001	2.90788	4.19961	5.11602	3.93344	2.65396	1.70064	1.08501	1.71509	1.33243	1.55284	1.07553	1.25896	0.7957	1.2585	0.99452	1.0819	1.40647	0.80437	1.29547	1.31182	1.58386	0.95009	1.15029	0.62625	1.58716			
4	seg4	5	8	3.9129	2.72068	3.98711	2.82113	3.51177	2.43004	1.4917	1.059	1.61554	1.24944	1.39997	0.99808	1.63433	0.81884	1.27474	1.09168	1.05488	0.78624	1.32371	0.7882	1.14673	0.99428	1.03084	0.83434	1.44748	0.79785	1.29518	
5	seg5	5.5	5.30252	2.07707	5.13956	2.97518	2.78958	1.9007	1.41317	1.0053	1.44226	1.25145	1.59598	0.97181	1.22116	0.82813	1.33475	1.0283	1.07823	0.92611	1.3004	0.82514	1.54181	1.13095	1.01339	0.88071	1.32137	0.75737	1.40251		
6	seg6	5	5.94289	3.18831	4.77409	3.47392	4.14471	2.89038	1.83583	1.10549	1.77505	1.42164	1.58389	1.10146	1.48373	0.90738	1.40418	1.10444	1.20128	0.93681	1.5524	0.88802	1.43184	1.34767	1.27708	1.39304	1.41102	0.73279	1.55814		
7	seg7	4.5	5.30215	5.6222	5.53061	4.04572	5.0059	3.86398	1.94879	1.54141	2.08239	1.57082	1.84922	1.12424	1.30255	0.89157	1.24639	1.13008	0.89182	1.38829	0.86485	1.36438	1.12546	1.16424	0.95142	1.35546	0.74061	1.44886			
8	seg8	5	5.24358	1.87927	3.04384	2.21514	2.40812	1.89122	1.47464	1.16132	1.95214	1.34491	1.46008	1.0499	1.23508	0.96792	1.44246	1.10477	1.10881	0.87782	1.44746	0.77946	1.3919	1.17899	1.17413	0.93161	1.42158	0.74337	1.42396		
9	seg9	7	5	1.67044	1.17159	1.57384	1.50722	1.80783	0.85557	0.70091	0.62695	0.76618	0.79021	0.87569	0.46687	0.5791	0.52136	0.65838	0.81213	0.81964	0.42821	0.61409	0.57462	0.78445	1.05665	0.80248	0.50386	0.74608	0.59778	0.86284	
10	seg10	7	10.5	1.82224	1.00889	1.22852	1.18779	1.04663	0.82746	0.67466	0.5722	0.77745	0.88357	0.88024	0.84445	0.56273	0.57876	0.88645	1.32601	0.84928	0.59597	0.86428	0.86907	1.5127	2.66812	1.27176	0.93723	0.5739	0.58802	1.01567	
11	seg11	4.5	10.5	1.95463	1.08321	1.1592	1.15294	2.13558	0.95549	0.81105	0.60404	0.70388	0.83561	0.3694	0.49618	0.51701	0.50375	0.71017	1.0347	0.82232	0.45484	0.64114	0.70203	1.24905	2.05312	1.41718	0.801	0.56708	0.57786	0.96882	
12	seg12	7	10.5	1.28802	0.83686	0.81602	1.09740	1.47927	0.71218	0.59188	0.5304	0.86663	0.87372	0.80723	0.45118	0.48061	0.47488	0.7481	1.39732	0.82343	0.48513	0.67978	0.80724	1.53095	2.78699	1.65133	0.86237	0.56604	0.62445	1.15356	
13	seg13	7	9.5	1.30254	0.81647	0.9149	1.11694	1.55028	0.70986	0.61887	0.53167	0.6458	0.80773	0.80594	0.45229	0.46622	0.44584	0.68383	0.9963	0.76308	0.42583	0.59122	1.23954	2.27158	1.45431	0.76751	0.59013	0.64817	1.15951		
14	seg14	7	10.5	1.27854	0.84915	0.97997	1.1679	1.52886	0.73157	0.58448	0.50123	0.67517	0.87792	0.82354	0.4761	0.49996	0.48893	0.81468	1.30623	0.89427	0.51121	0.62084	0.77506	1.44027	2.26623	1.49973	0.60528	0.54477	0.65009	1.17726	
15	seg15	4.5	10.5	1.59985	0.99447	1.11074	1.40102	1.95082	0.86328	0.71005	0.59392	0.80323	0.85306	0.86112	0.47621	0.45396	0.45456	0.69566	1.20132	0.79024	0.61022	0.58248	0.71271	1.25344	2.30159	1.44727	0.6086	0.49773	0.61364	1.05456	
16	seg16	4.5	5	3.28289	1.75501	2.16064	2.77947	4.13089	1.54761	1.10642	0.63899	0.67275	0.81365	1.24729	0.58202	0.44783	0.38704	0.54572	0.78902	0.68823	0.53271	0.4993	0.47263	0.94009	1.84903	1.18943	0.91985	0.465	0.47286	0.79005	
17	seg17	4.5	8	3.60277	3.69884	4.5436	6.50126	3.48336	0.57067	1.55878	1.54083	1.80525	2.65908	1.36533	1.25725	1.17205	1.075	1.79259	3.95947	1.95521	1.25114	1.7658	1.56282	4.49885	8.4492	3.81878	2.99887	1.55162	1.47997	3.97708	
18	seg18	4	7	4.80234	4.71433	5.97407	4.87922	4.3489	0.57965	1.49391	1.47071	1.574	1.57858	1.09082	1.14068	1.20929	1.17171	1.44496	1.13289	1.57174	1.44496	1.13289	1.57174	1.44496	1.13289	1.57174	1.44496	1.13289	1.57174	1.44496	
19	seg19	4.5	7	3.62676	3.76675	4.88825	7.12384	3.83491	3.57953	1.49697	1.54025	1.72998	2.61134	1.17299	1.21387	1.29537	1.21831	1.86503	3.45288	1.49948	1.3217	1.26452	1.95182	5.42876	11.6469	3.68872	2.28418	2.19889	0.85966		
20	seg20	4.5	7	4.021	3.57023	5.12623	7.83682	4.24135	3.82787	1.97339	1.51939	1.88021	2.8461	1.3874	1.32952	1.26488	1.16813	1.75869	2.81809	3.86084	1.22417	1.82116	1.53761	4.01281	3.76164	2.81556	2.86708	2.126	1.87222		
21	seg21	4.5	8	5.79495	4.0002	5.0602	7.16439	3.00482	3.35354	1.83955	1.93187	2.05982	2.81451	1.41239	1.21812	1.32885	1.4558	1.1831	3.86741	1.54997	1.42639	1.52728	1.35753	6.08822	11.7704	5.9394	3.98888	1.84951	1.80214	4.00942	
22	seg22	4	7	4.27144	4.69315	5.88834	8.05346	3.83307	3.83313	1.6119	2.08948	2.18972	3.05251	1.41361	1.35022	1.18971	1.26436	1.80905	3.08736	1.25318	1.20739	1.468	1.39801	8.80122	8.61721	3.17718	2.89212	2.129	1.80473	1.18472	
23	seg23	4.5	7.5	3.86154	4.73429	5.61056	7.76415	3.84923	3.51077	1.54167	2.02671	2.15645	2.97794	1.98212	1.29933	1.25919	1.65876	2.07782	3.29146	1.36872	1.26566	1.31793	1.23908	5.67393	11.2527	5.00141	3.76414	2.07609	2.06749	4.88737	
24	seg24	4.5	8	2.35151	2.87383	2.80385	3.47579	1.82108	1.71888	1.28895	1.55613	2.07093	2.79740	1.40322	1.19903	1.58604	1.44939	3.70387	7.88814	2.79915	2.61788	3.74985	1.87668	1.78781	9.04376	6.00023	2.11902	1.71511	1.48842		
25	seg25	4.5	10	1.40818	0.58337	0.90028	1.50989	1.62206	1.03507	0.89136	0.43953	0.70402	1.17813	0.96142	0.72021	0.72164	0.42052	0.91899	1.24832	0.61625	0.76021	1.38424	1.18521	7.001	5.71568	2.69602	3.10205	1.45406	2.79025	0.94592	
26	seg26	4.5	10	2.71839	1.15277	1.55485	2.01288	1.62097	1.42387	0.62344	0.98427	1.5112	1.8187	1.04349	1.17732	0.53975	0.9819	1.4182	1.28984	0.98477	1.66489	1.63897	0.94887	4.9162	2.71229	2.58089	1.78127	2.52337	0.84832		
27	seg27	4.5	10	2.64885	1.02567	1.31034	1.99116	2.717	1.40578	1.35334	0.53522	0.77029	1.37154	1.04582	0.83105	1.02442	0.45124	0.74446	1.20387	1.14	0.80821	1.05945	1.33528	3.54276	2.56591	2.60077	2.10886	1.68005	1.49644	4.97325	
28	seg28	4.5	10	1.56409	0.44035	0.68935	1.17279	1.2328	0.81644	1.06413	0.48887	0.74863	1.33916	1.1678	0.83201	0.81214	0.4212	0.87054	1.38025	1.17633	0.56237	1.22494	1.92119	0.83768	0.67849	3.94688	3.86261	1.77645	1.7818	1.73804	
29	seg29	4.5	10	1.41795	0.78264	1.36837	2.52797	1.85409	1.13584	1.02544	0.56475	0.97975	1.64655	1.25726	0.84487	1.00238	0.48711	1.01816	1.72396	1.44425	0.92481	1.40527	2.24507	7.48833	1.32924	4.47785	0.41242	1.67938	1.85445	1.17398	
30	seg30	4.5	5	7.26882	0.61769	0.72378	0.73079	0.9873	0.76549	0.7284	0.2804	0.35783	0.46785	0.06883	0.52735	0.27938	0.37585	0.62194	0.53589	0.3219	0.60523	0.63247	1.03782	1.12974	0.17295	0.81161	0.60167	0.80896	1.41486		
31	seg31	4.5	9	0.90461	0.502	0.64203	0.59828	0.76208	0.57736	0.41834	0.25557	0.32485	0.30642	0.3394	0.26835	0.4359	0.53706	0.38681	0.48536	0.40596	0.23967	0.74388	0.89847	1.95125	1.61306	1.0421	0.81816	0.85559	0.92912	1.54131	
32	seg32	4.5	9	0.90439	0.50366	0.61793	0.59844	0.82052	0.55566	0.44531	0.24584	0.33295	0.40508	0.37122	0.29743	0.55939	0.4024	0.41185	0.40446	0.52168	0.39735	0.79318	0.76756	1.25953	1.62997	1.10228	0.87804	0.85961	0.93514	1.63006	
33	seg33	4.5	9	1.0233	0.5599	0.70711	0.74726	0.91289	0.62424	0.45884	0.24036	0.34493	0.40495	0.42116	0.30996	0.45176	0.28818	0.32886	0.4655	0.39908	0.3085	0.76794	0.7174	1.19583	1.64926	1.10528	0.8268	0.7816	0.71993	0.82023	1.58982
34	seg34	4.5	9	0.90292	0.48802	0.59911	0.65778	0.71698	0.55378	0.42777	0.25666	0.31233	0.24291	0.25273	0.28547	0.51421	0.36886	0.41374	0.57632	0.47713	0.7										

It is not necessary to manipulate this sheet if you have already made the changes in the other 3, just verify that the subject you added is in the sheet and if not, analyze the logic before making any changes.

Note: Do not change the name of any of the sheets in this book

3.3.5. Vigilance activity

Sheets 13 and 14 contain information by channels, in eyes closed and eyes open state, to analyze reactivity or surveillance activity through specific channels.

3.3.6. States

In this case, the states previously analyzed in the qualitative analysis change.

Going from A, D, N1, N2, N3 to the following the Hori states:

Wakefulness

Ripples

Diffuse Theta

Diffuse Theta After N1

Diffuse Theta Before N1

Diffuse Theta + Vertex

K complexes +-

The qualitative analysis is carried out, but it is only used to identify the moment of the trace and find the behavior of the frequency peaks.

The information of the states is reported in the reference presented in *Figure 11*.

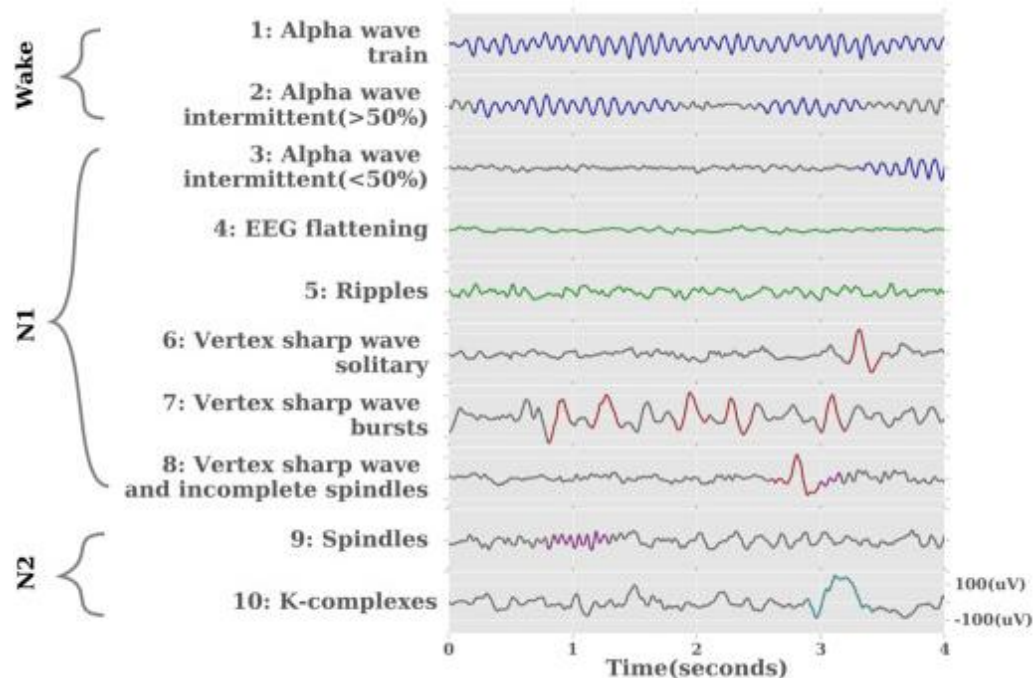


Figure 11. Jagannathan SR, Ezquerro-Nassar A, Jachs B, Pustovaya OV, Bareham CA, Bekinschtein TA. Tracking wakefulness as it fades: Micro-measures of alertness. *Neuroimage*. 2018 Aug 1;176:138-151. doi: 10.1016/j.neuroimage.2018.04.046. Epub 2018 Apr 23. PMID: 296

Sheets 15, 16 and 17 contain 3 methodologies to present the states of transition from vigilance to sleep.

- **Sheet 15 WDN** contains the states:

Wakefulness, Ripples, Diffuse Theta, Diffuse Theta + Vertex, K complexes +/-

- **Sheet 16 WDN1** contains the states:

Wakefulness, Ripples, Diffuse Theta After N1, Diffuse Theta + Vertex, K complexes +/-, Diffuse Theta Before N1

- **Sheet 17 WRD** contains the states:

Wakefulness, Ripples, Diffuse Theta

Inside the leaves, 3 channels can be characterized using the color identification of *Figure 12*.

Fz	Green
Cz	Red
O1O2	Blue
Relevant	Yellow

Figure 12. Color characterization for channels

3.3.7. Vertex

The last sheet "Vertex" contains the difference between the Fz-Cz channels of some subjects, to observe the behavior of the Vertex as presented in the *Figure 13* and following the reference found in it.

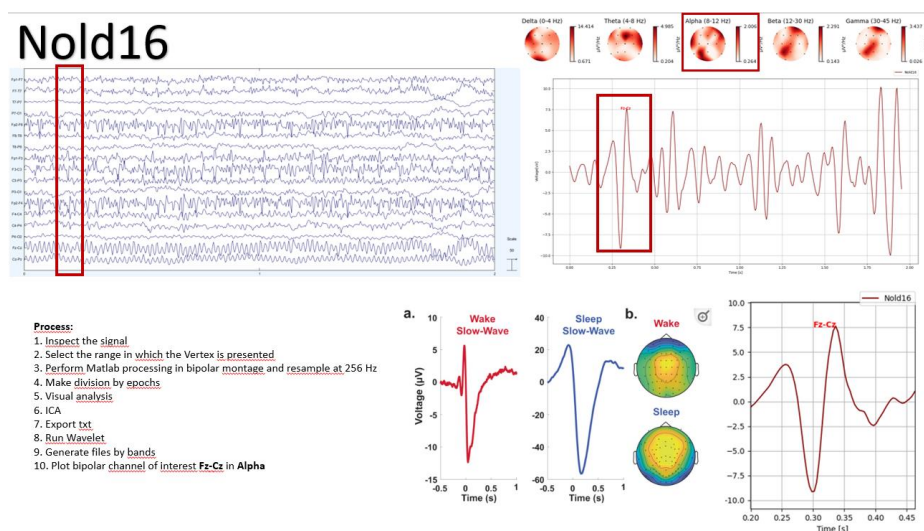


Figure 13. Own results contrasted with Andrillon T, Burns A, Mackay T, Windt J, Tsuchiya N. Predicting lapses of attention with sleep-like slow waves. Nat Commun. 2021 Jun 29;12(1):3657. doi: 10.1038/s41467-021-23890-7. PMID: 34188023; PMCID: PMC8241869.

Process:

1. Inspect the signal
2. Select the range in which the Vertex is presented
3. Perform Matlab processing in bipolar montage and resample at 256 Hz
4. Make division by epochs
5. Visual analysis
6. ICA
7. Export txt
8. Run Wavelet
9. Generate files by bands
10. Plot bipolar channel of interest **Fz-Cz** in **Alpha**

4. Run graphics interface

You can download the application directly from the link:

https://drive.google.com/drive/folders/16ExFf1EBw6u6RHHPTn0hB1kD2Rnb68Tv?usp=share_link

To run the interface, you only must look for the application folder in the place where you have downloaded and unzipped it.

Note: the folder should always be in the same location as the __main__.exe file

1. If you need to add data by modifying some data, enter the files folder, remember not to change the name of the files or the folder.
2. Double click on the __main__.exe file
3. A window will appear as shown in *Figure 14* (This may take a few minutes)

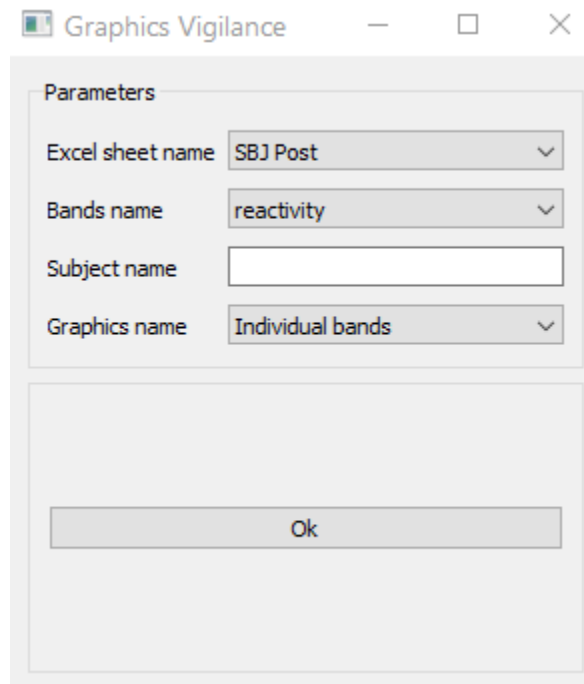


Figure 14. Interface

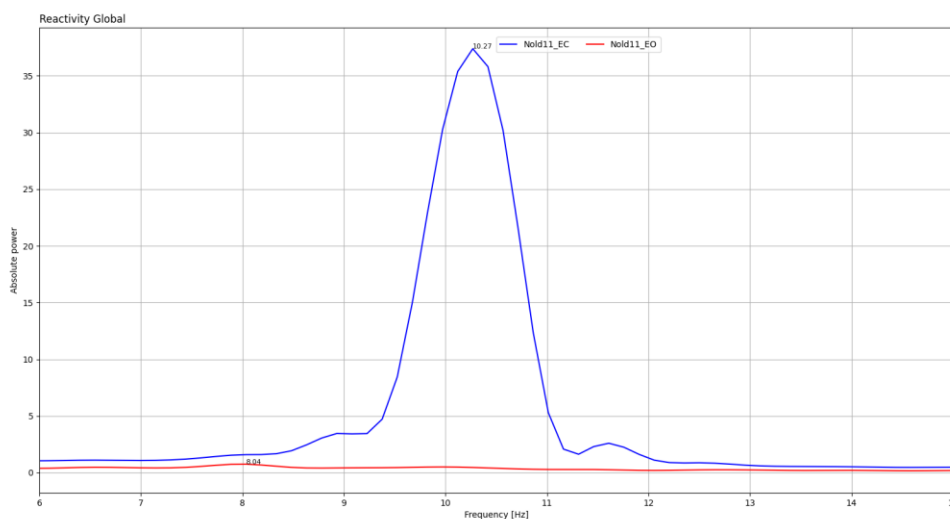
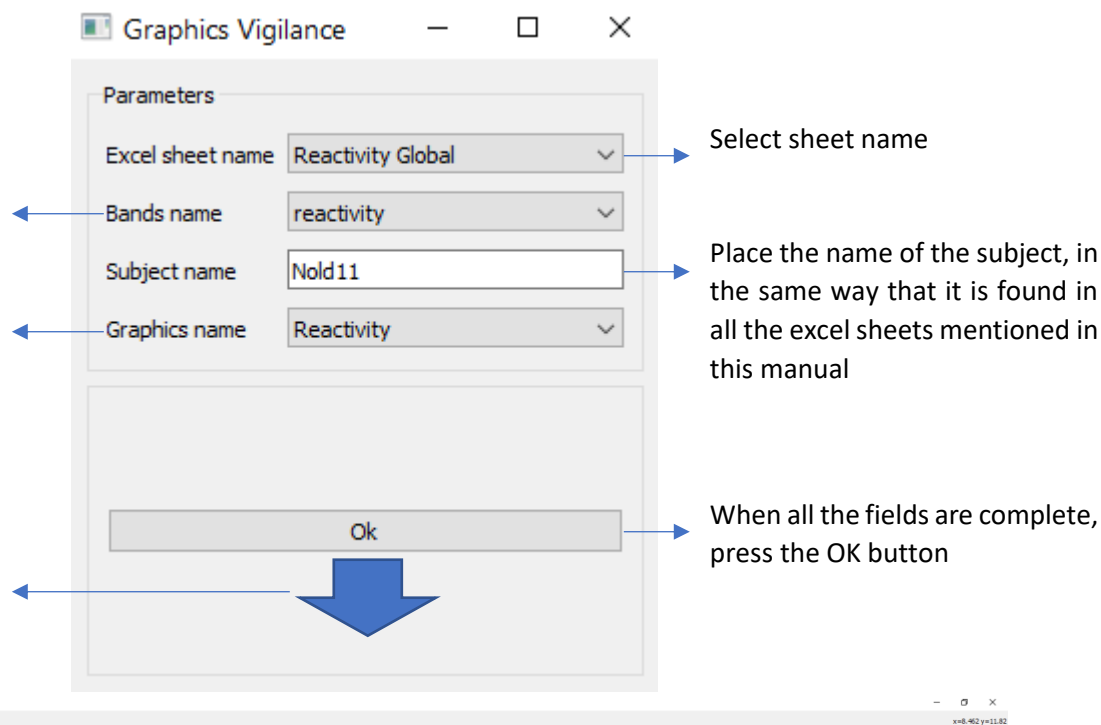
The application consists of 3 dropdown menus and a line of editable text. The use of the application with each of the menu options is presented below.

4.1. Reactivity analysis in the global area.

When selecting reactivity, how the conditions eyes closed and eyes open are evaluated, the name of the bands would be the same way reactivity.

Analysis to be carried out

Another window will open with the requested graph, if the required analysis generates several graphs they will open simultaneously



4.2. Reactivity analysis in the posterior area.

When selecting reactivity, how the conditions eyes closed and eyes open are evaluated, the name of the bands would be the same way reactivity.

Analysis to be carried out

Another window will open with the requested graph, if the required analysis generates several graphs they will open simultaneously

Graphics Vigilance

Parameters

Excel sheet name: Reactivity Post

Bands name: reactivity

Subject name: Nold11

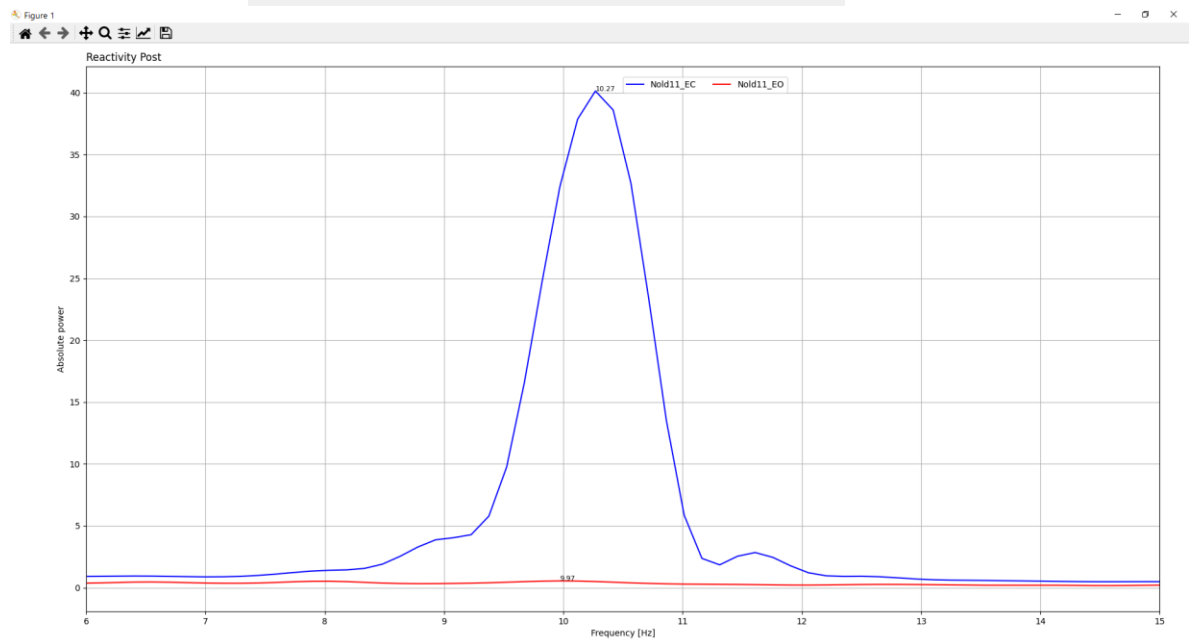
Graphics name: Reactivity

Ok

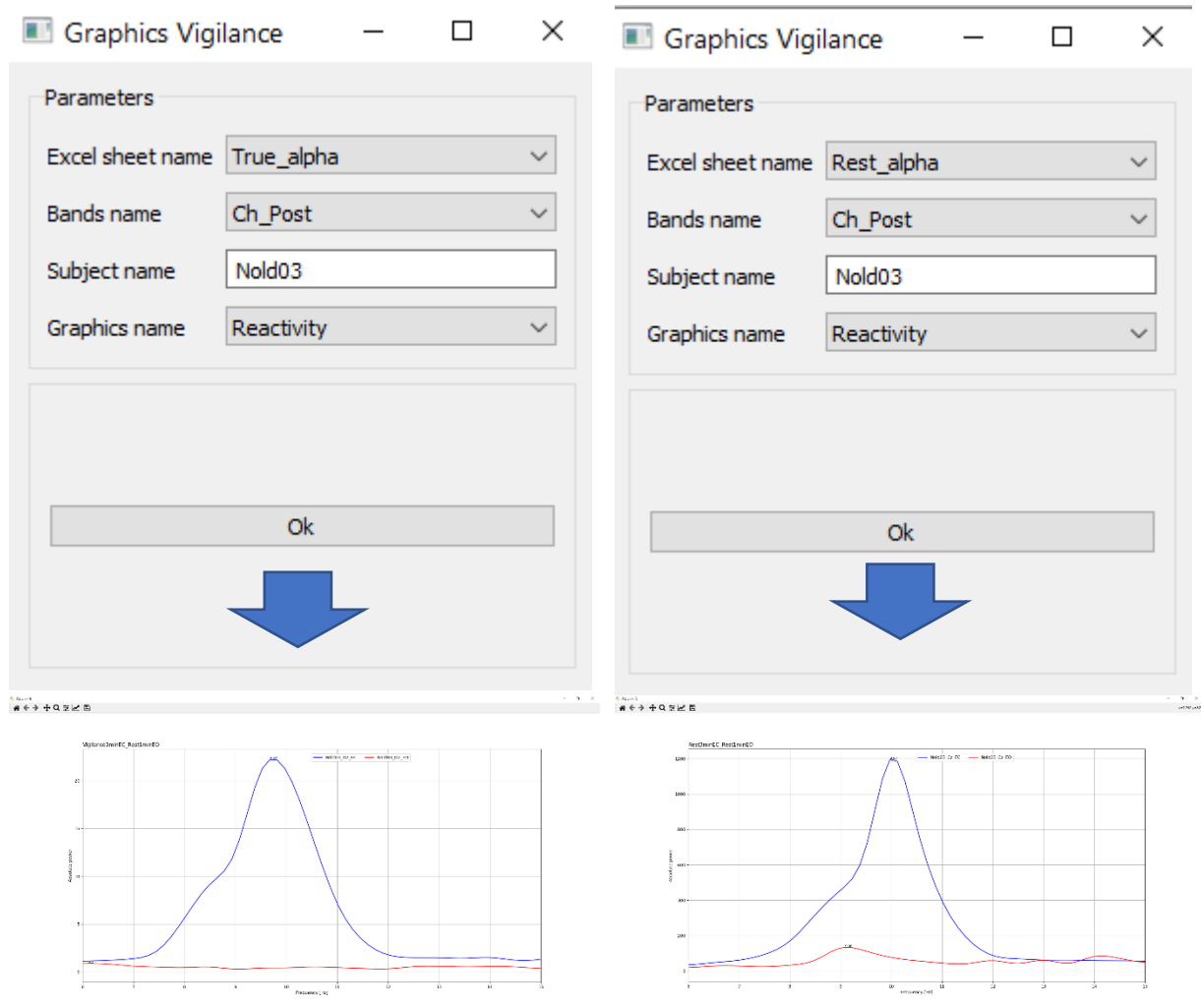
Select sheet name

Place the name of the subject, in the same way that it is found in all the excel sheets mentioned in this manual

When all the fields are complete, press the OK button



4.3. Reactivity analysis in channels



4.4 Power analysis considering the global area

Graphics Vigilance

Parameters

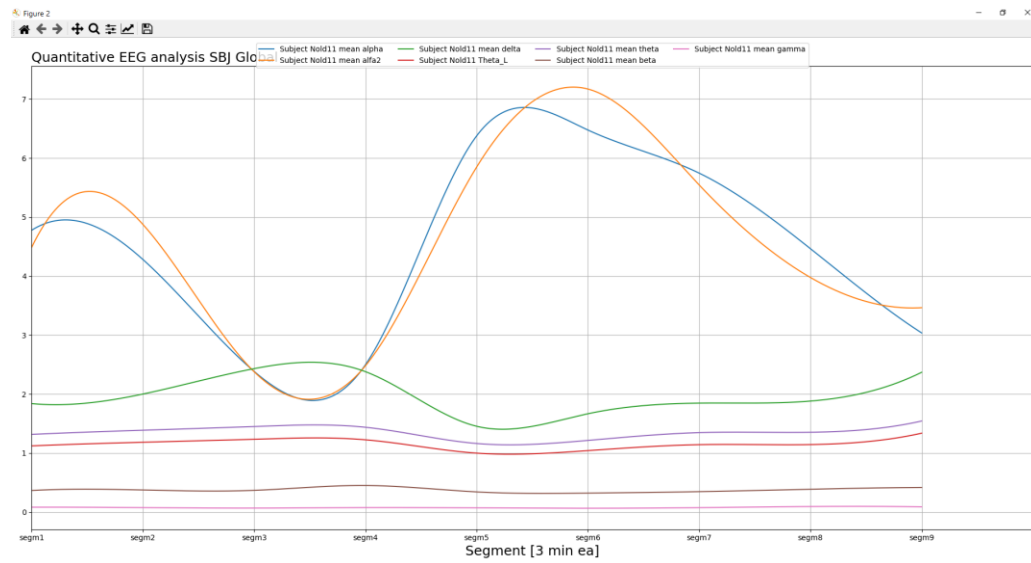
Excel sheet name: SBJ Global

Bands name: all_ind_bands

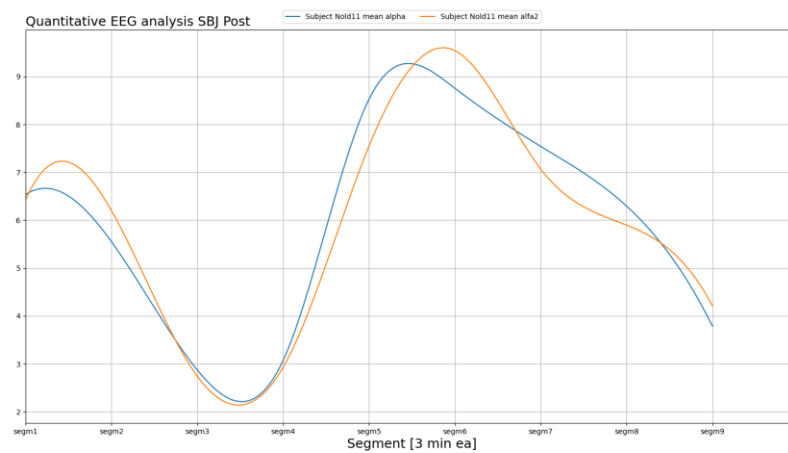
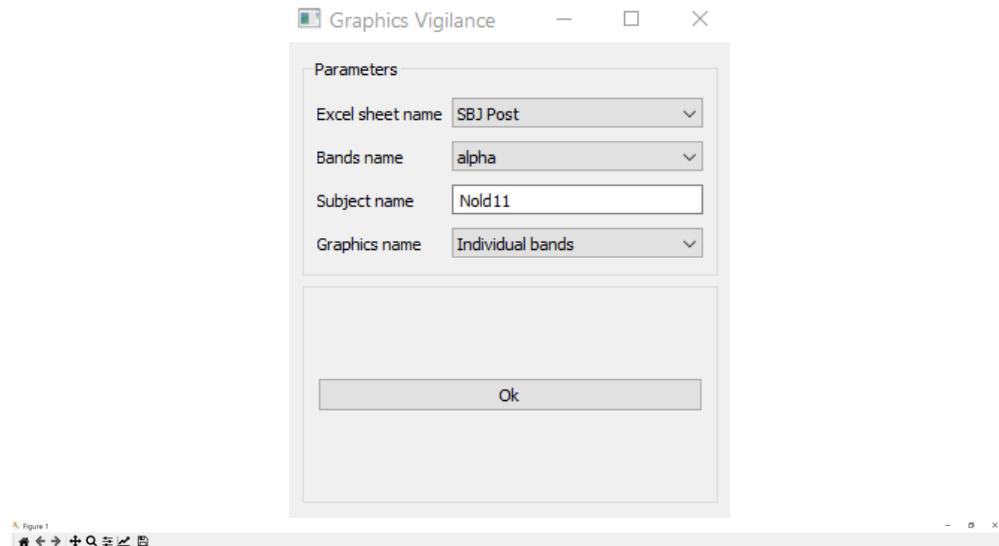
Subject name: Nold11

Graphics name: Individual bands

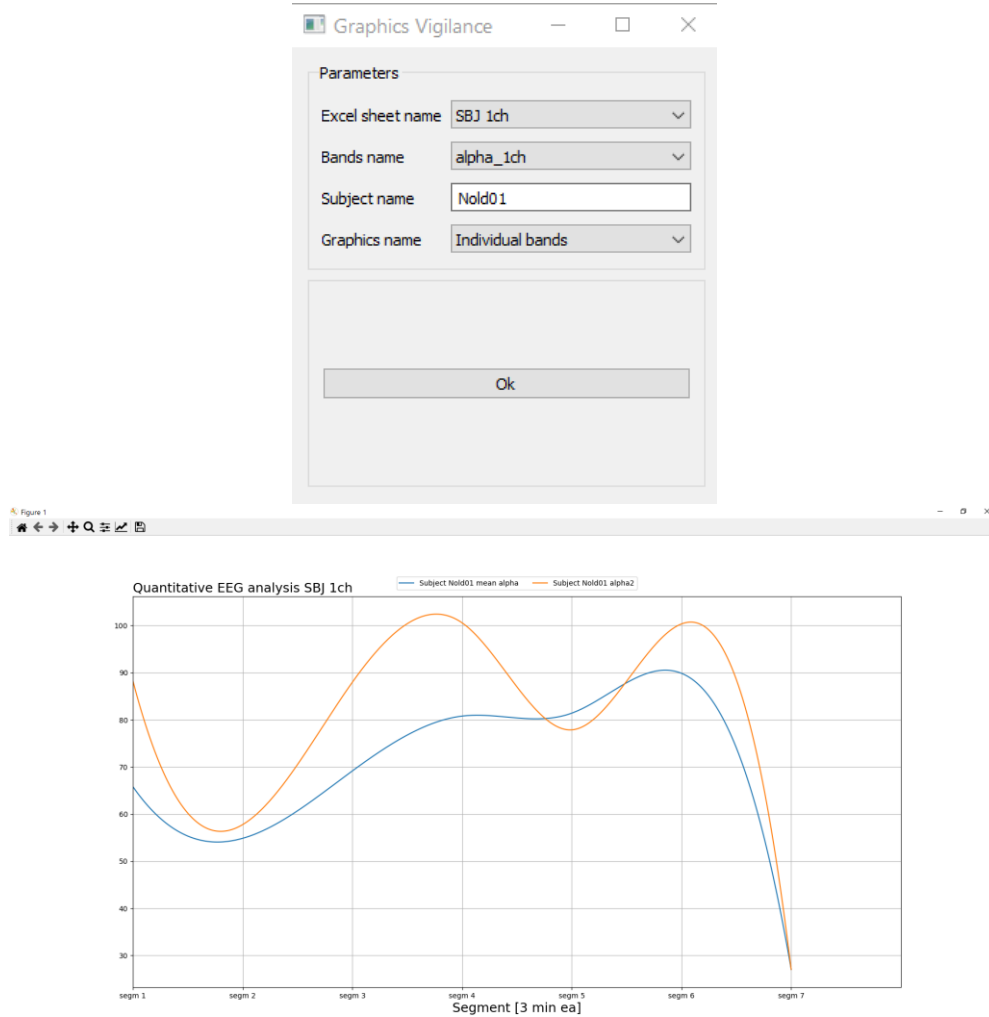
Ok



4.5 Power analysis considering the posterior area



4.6 Power analysis considering the more relevant channel (based relevance on reactivity or True Alpha)

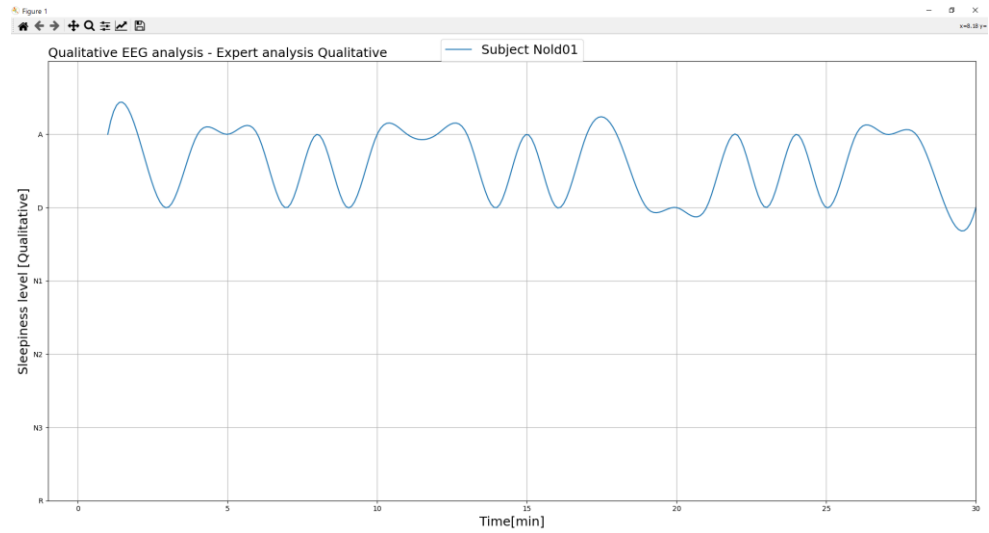


4.7 Qualitative analysis

The figure shows the 'Graphics Vigilance' dialog box configured for qualitative analysis. The parameters are:

- Excel sheet name: Qualitative
- Bands name: Qualitative
- Subject name: Nold01
- Graphics name: Qualitative

An 'Ok' button is at the bottom of the dialog.



4.8 Relations

Graphics Vigilance

Parameters

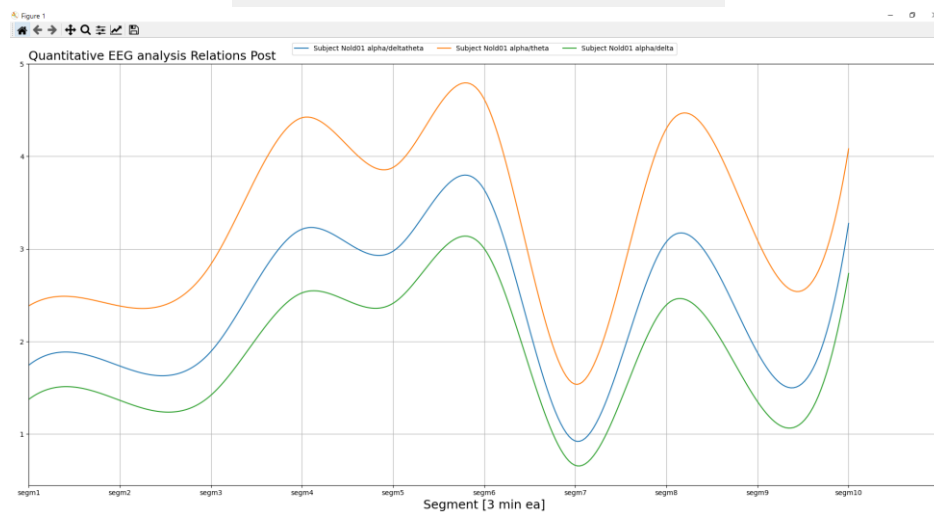
Excel sheet name: Relations Post

Bands name: all_bands

Subject name: Nold01

Graphics name: Individual bands

Ok



4.9 Relations considering the more relevant channel (based relevance on reactivity or True Alpha)

Graphics Vigilance

Parameters

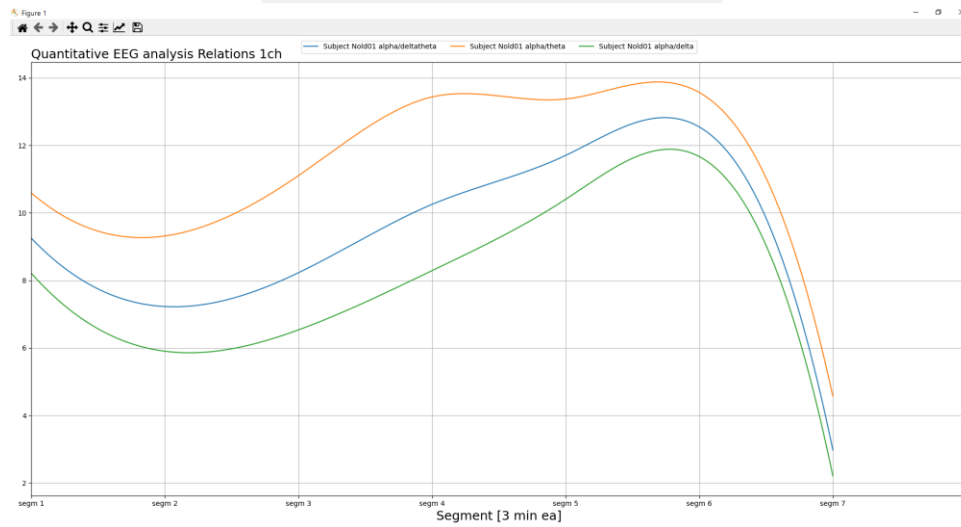
Excel sheet name: Relations 1ch

Bands name: all_bands

Subject name: Nold01

Graphics name: Individual bands

Ok



4.10 Contrast between qualitative analysis and quantitative analysis

Graphics Vigilance

Parameters

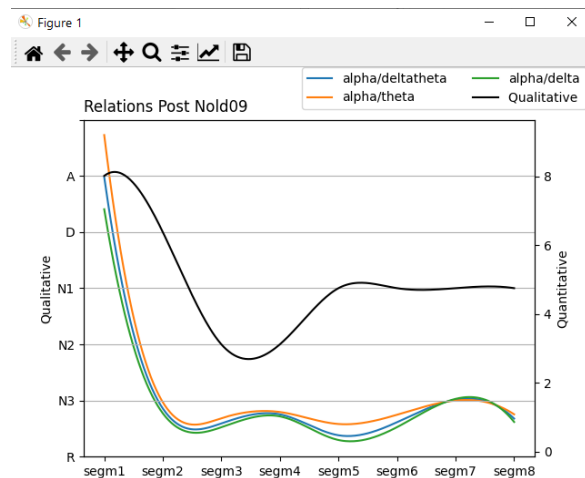
Excel sheet name: Relations Post

Bands name: all_bands

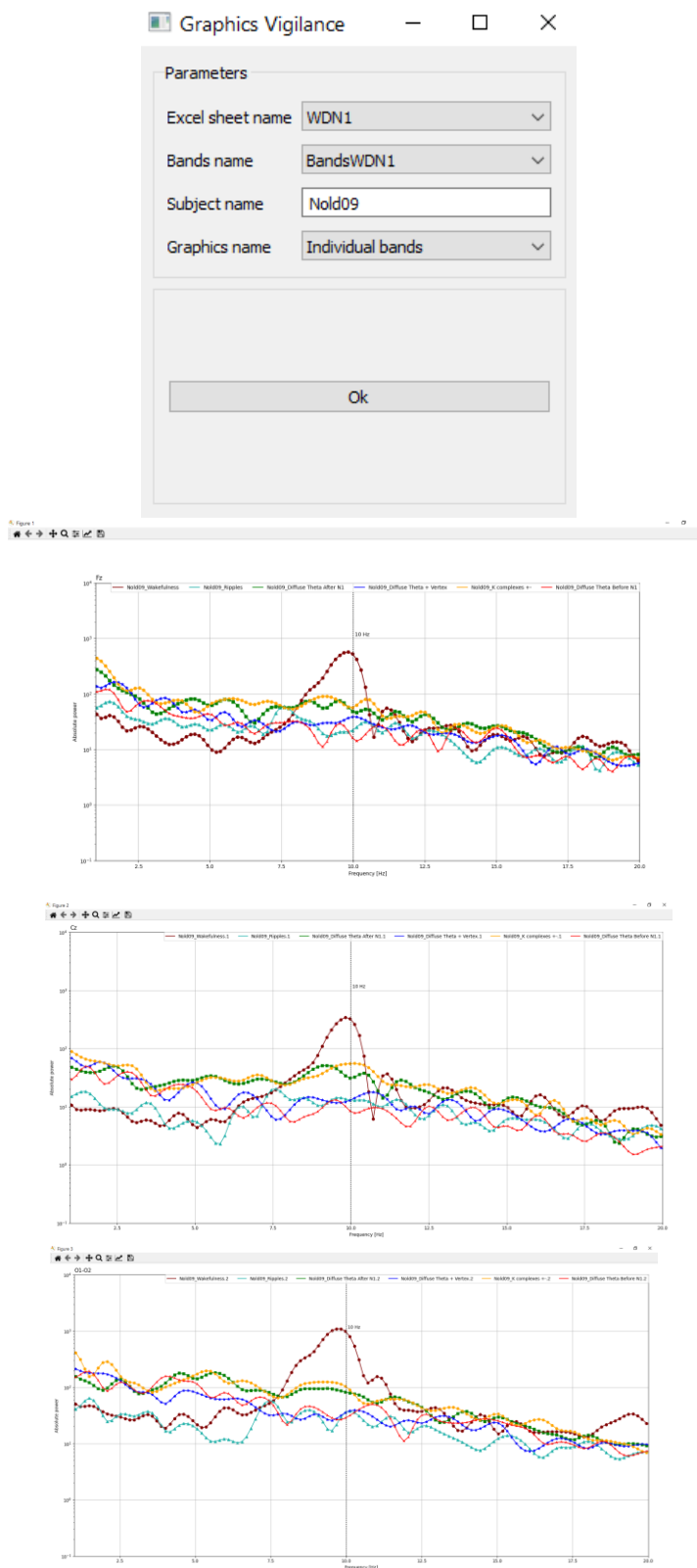
Subject name: Nold09

Graphics name: Quantitative and Qualitative

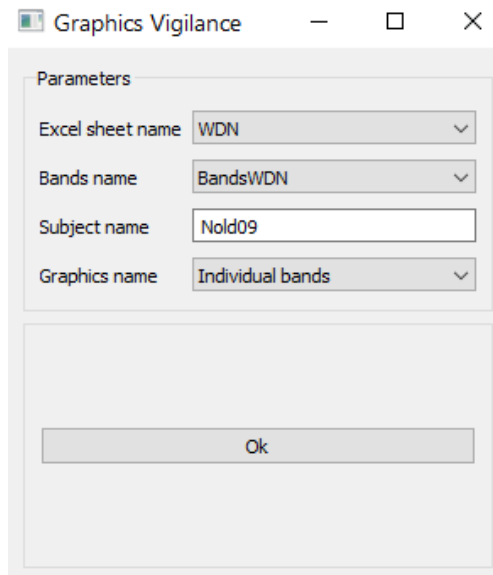
Ok



4.11 States of transition from vigilance to drowsiness WDN1



WDN

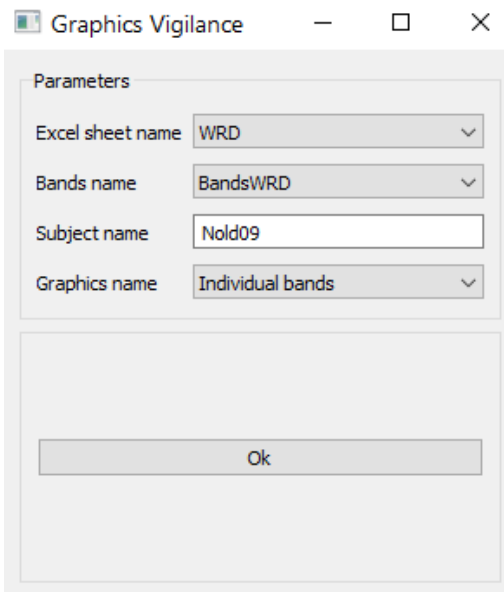


The dialog box titled "Graphics Vigilance" contains a "Parameters" section with the following fields:

- Excel sheet name: WDN
- Bands name: BandsWDN
- Subject name: Nold09
- Graphics name: Individual bands

An "Ok" button is located at the bottom of the dialog.

WRD



The dialog box titled "Graphics Vigilance" contains a "Parameters" section with the following fields:

- Excel sheet name: WRD
- Bands name: BandsWRD
- Subject name: Nold09
- Graphics name: Individual bands

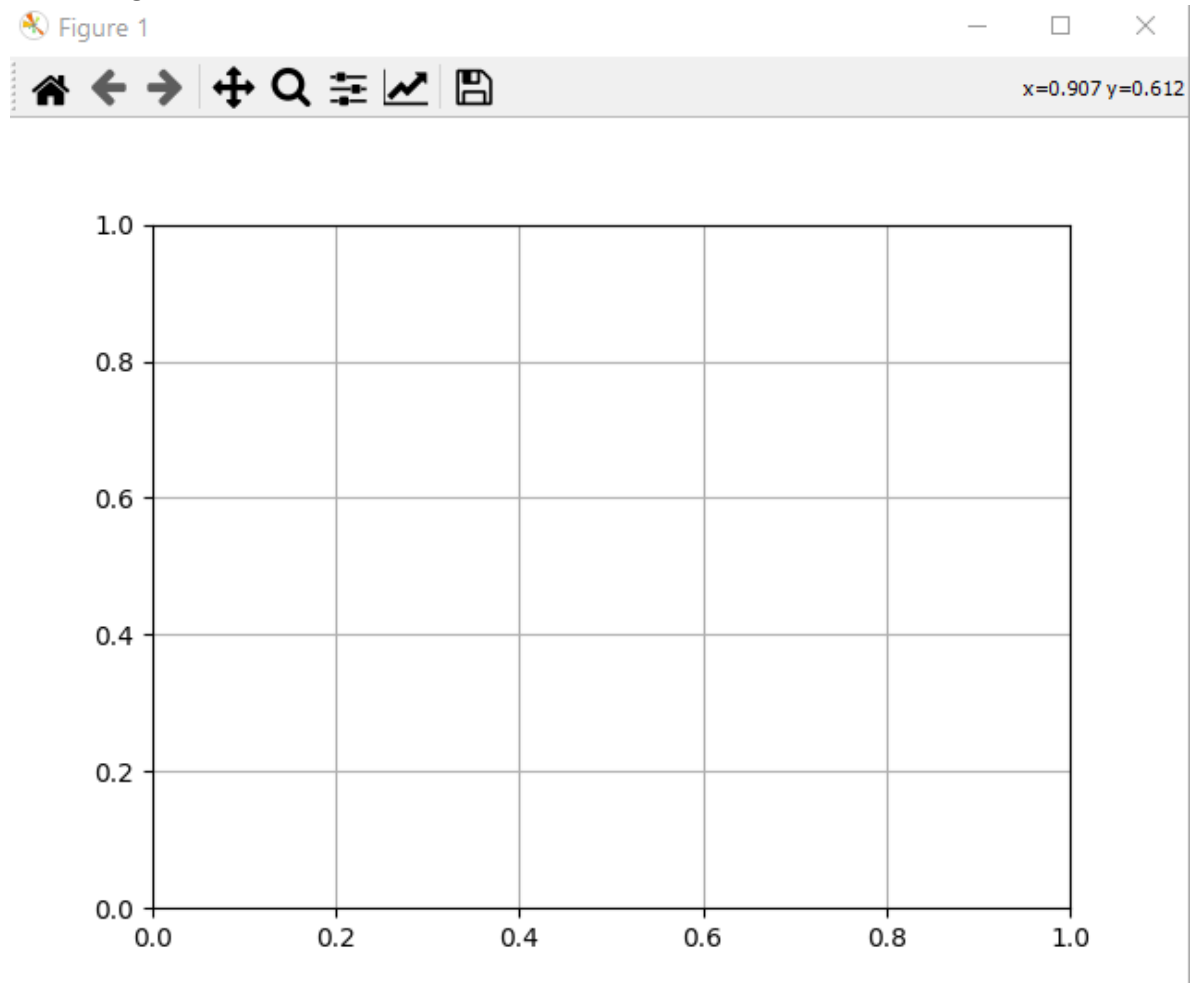
An "Ok" button is located at the bottom of the dialog.

Note: Observe the combinations that are required to generate each graph, that is, each sheet needs certain bands to execute the graph and the name of the graph must correspond to that need.

5 Complementary material

5.1 bug fix

5.1.1 blank image



- It may be due to an error in the combination of items in the menu
- It may be because the subject is not in the database or does not contain the information that is sought to be graphed.

5.1.2 unexpected shutdown

If this happens, try to open the program again, if it happens consecutively, report the error to veronica.henaoi@udea.edu.co

5.2 material for bipolar montage MATLAB

This is a small script to observe the record in bipolar form in Matlab in order to observe the characteristics that in the monopolar assembly are not as evident as the vertex. It is used in the same way as `recdiv` and `detr`, only calling the function from the command window, but it contains an additional file with the order of the electrodes, which must be in the same folder as the function and the processing would be:

1. Load the .set of interest in the eeglab window
2. Launch the bipolar function
3. Continue with the other steps of the current Matlab manual from point (4 Segmentation) with the recdiv function

