Spectral and TF analysis

Fourier, wavelets, multitapers

EEGLAB

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EEG Analysis

Goals

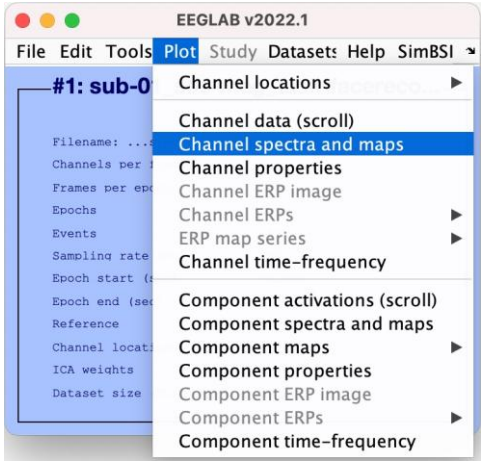
- Describe dynamic characteristics of brain activity
- Describe relation between different regions of brain

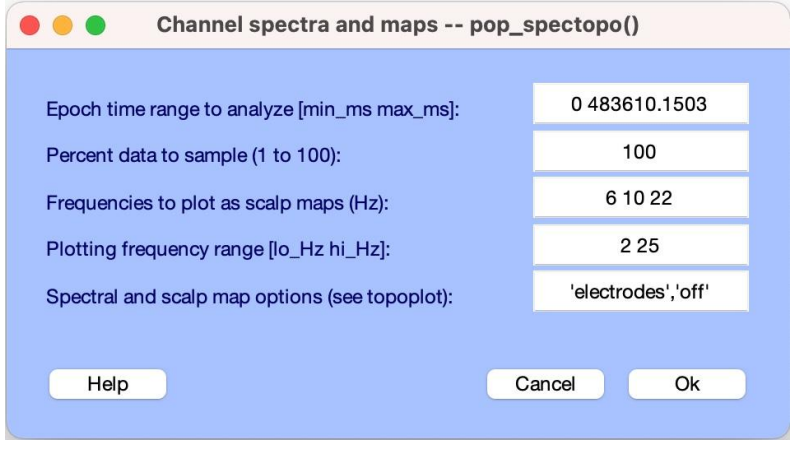
Approaches

- Time domain
- Frequency domain
- Time/Frequency

Spectral and TF analysis
Part 3: Practicum

Plot spectrum using Welch's method





`topoplot()` and `spectopo()` options

Exercises : Plotting spectrum

From EEGLAB, Load data :
wh_S01_run_01_preprocessing_data_session_1_out.set

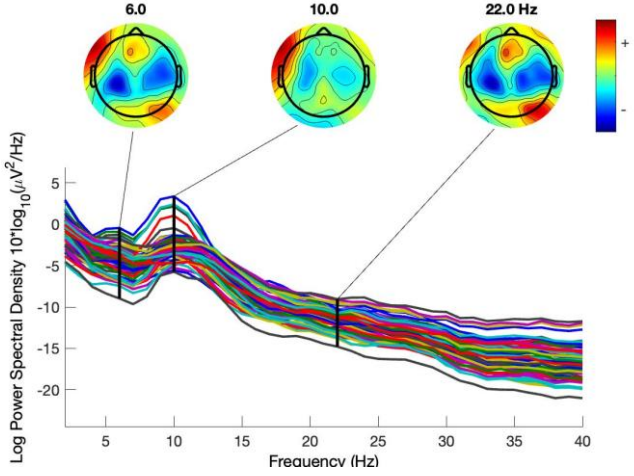
1. From the EEGLAB GUI
    1. Plot spectral decomposition with *windows size of 200* and no overlap.
    2. Plot spectral decomposition with *windows size of 300* and no overlap.
    3. Plot spectral decomposition with *windows size of 300 and 50 overlap.*
2. Use the command line call to the pop_*spectopo()* function and replicate (3) above.
    Hint: Use GUI then history to see a standard call (“eegh”).
3. Plot the spectrum for the channel EEG065

Plot spectrum using Welch's method

Default values

winsize = Sampling Rate; overlap = 0

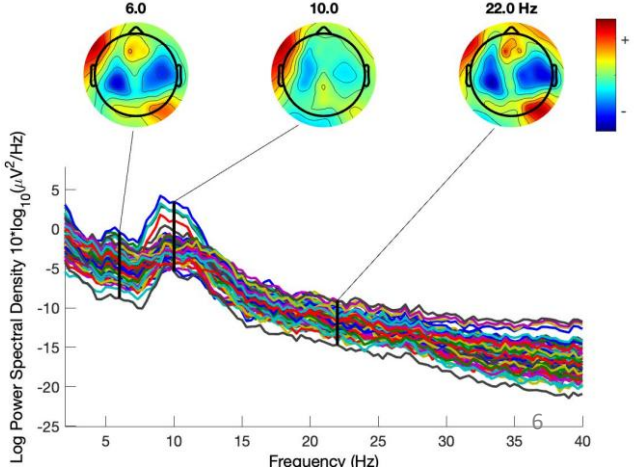
```
pop_spectopo(EEG, 1, [0 EEG.xmax*1000], 'EEG' , 'freq',
[6 10 22], 'freqrange',[2 40],'electrodes','off');
```



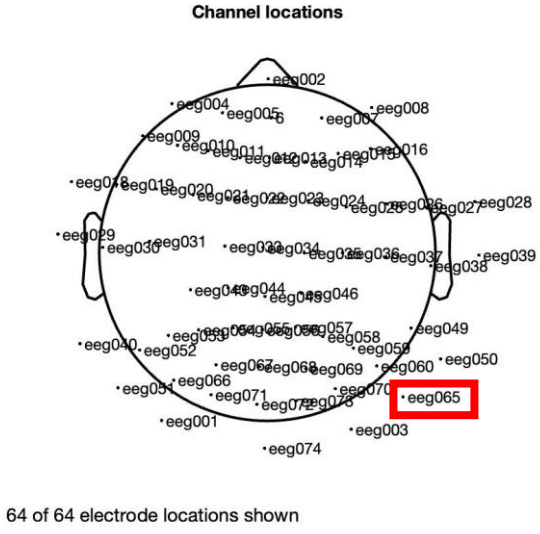
Modifying Window size

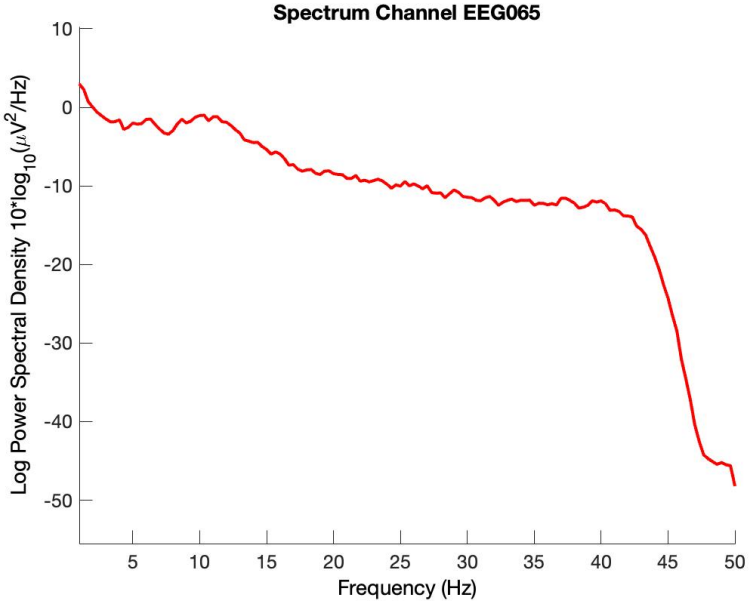
winsize = 300

```
pop_spectopo(EEG, 1, [0 EEG.xmax*1000], 'EEG' ,
'freq', [6 10 22], 'freqrange',[2
40],'electrodes','off', 'winsize', 300);
```



Plot spectrum Channel EEG065






```
spectopo( EEG.data(55,:), EEG.pnts, EEG.srate,'winsize', 300, 'overlap', 50);
```

Exercises : Plotting Time-Frequency Decomposition

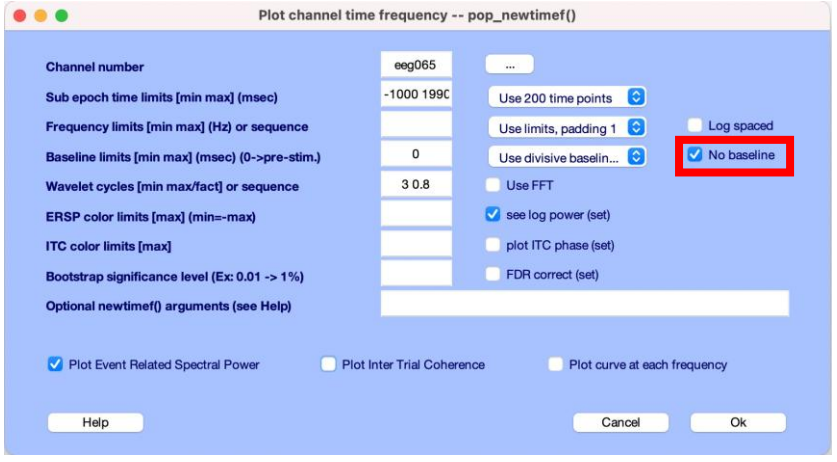
From EEGLAB, Load epoched data for each condition :

```
filename_epoched_famous     = 'wh_S01_run_01_ERP_Analysis_Session_2_famous_out.set';
filename_epoched_unfamiliar = 'wh_S01_run_01_ERP_Analysis_Session_2_unfamiliar_out.set';
filename_epoched_scrambled  = 'wh_S01_run_01_ERP_Analysis_Session_2_scrambled_out.set';
```

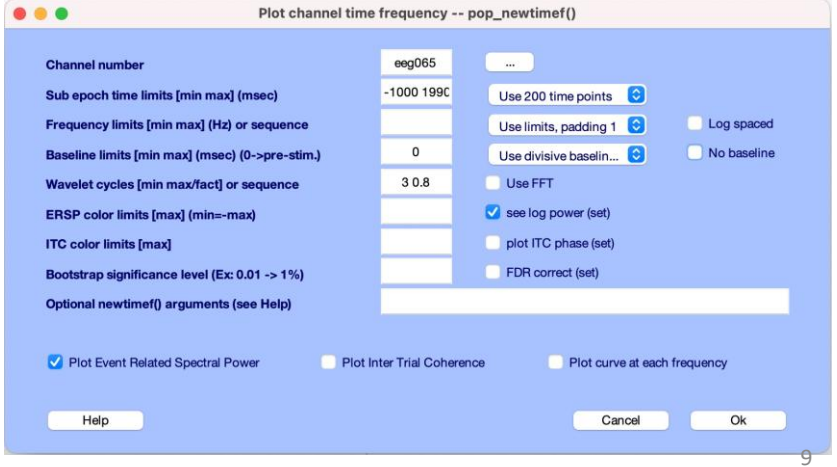
1. From the EEGLAB GUI , plot ERS and ERSP for Famous faces.
2. Plot the ERSP for the three conditions: Famous, Unfamiliar and Scrambled. Did you see any difference?

Exercises: Display ERS Vs ERSP

Event-related Spectrogram



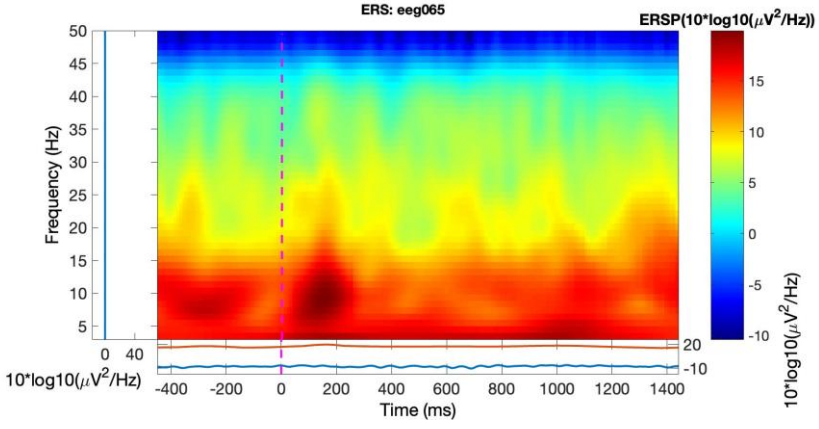
Event-related Spectral Perturbation



Exercises: Display ERS Vs ERSP

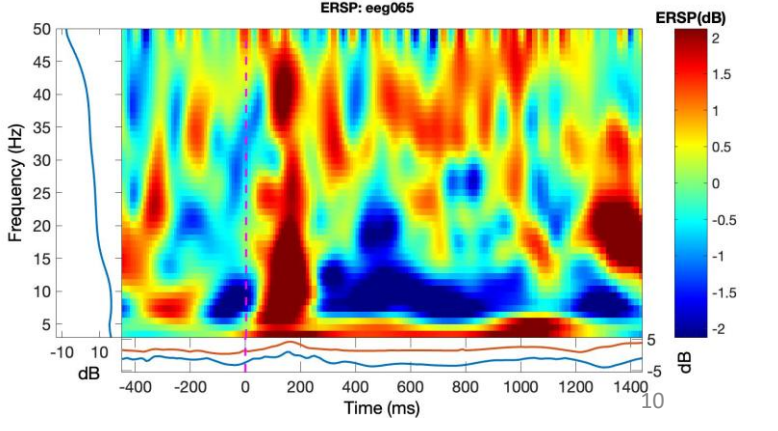
Event-related Spectrogram

```
figure;
pop_newtimef( EEG, 1, 52, [-1000 1990], [3 0.8] , 'topovec', 52,...
                                                  'elocs', EEG.chanlocs,...
                                                'chaninfo', EEG.chaninfo,...
                                                  'caption', 'eeg065',...
                                                  'baseline', 0,...
                                                  'plotitc' , 'off',...
                                                  'plotphase', 'off',...
                                                  'padratio', 1,...
                                                  'winsize', 100);
```



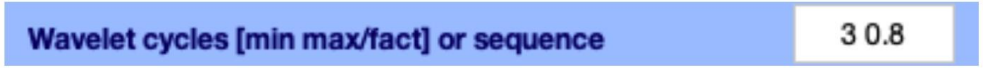
Event-related Spectral Perturbation

```
figure;
pop_newtimef( EEG, 1, 52, [-1000 1990], [3 0.8] , 'topovec', 52,...
                                                'elocs', EEG.chanlocs,...
                                                'chaninfo', EEG.chaninfo,...
                                                   'caption', 'eeg065',...
                                                   'baseline', 1,...
                                                   'plotitc' , 'off',...
                                                   'plotphase', 'off',...
                                                   'padratio', 1,...
                                                   'winsize', 100);
```



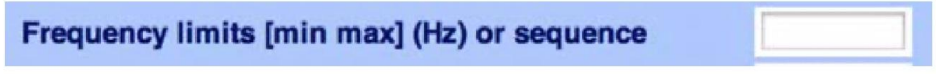
Exercises: pop_newtimef() parameters

- Try different wavelet specifications



  - Default: 3 0.8
    - 3 cycles. Try 2. How do the time limits of the plot change?
    - What is the 0.8? Try 0. Try 1…what do you observe?

- Try different low-frequency limit

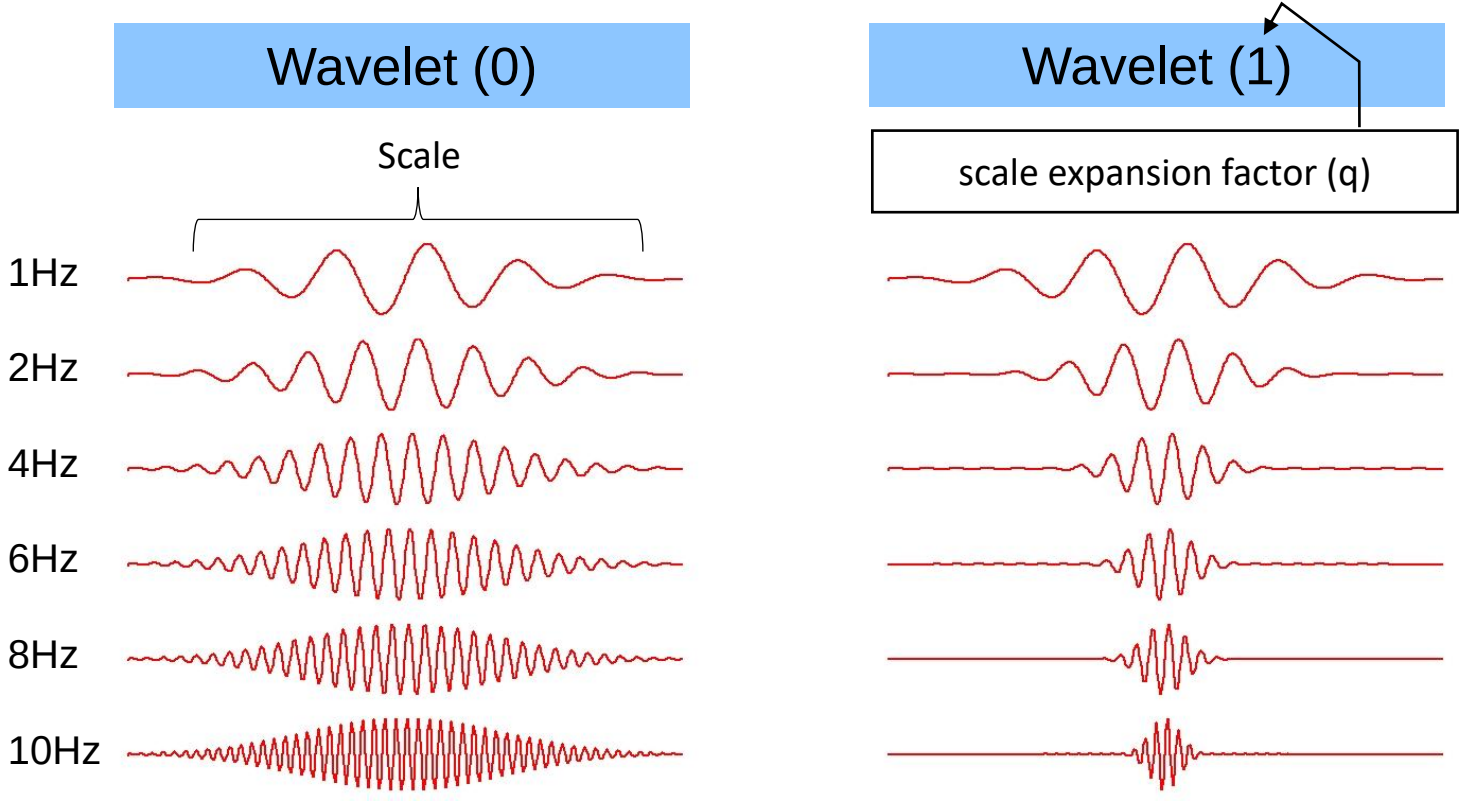


  - what is the effect on the time limits of the ERSP?

- Try different baseline methods
  - divisive
  - standard deviation (express spectral perturbations in #sd relative to baseline sd)

courtesy of John Iversen

Wavelet scale expansion factor

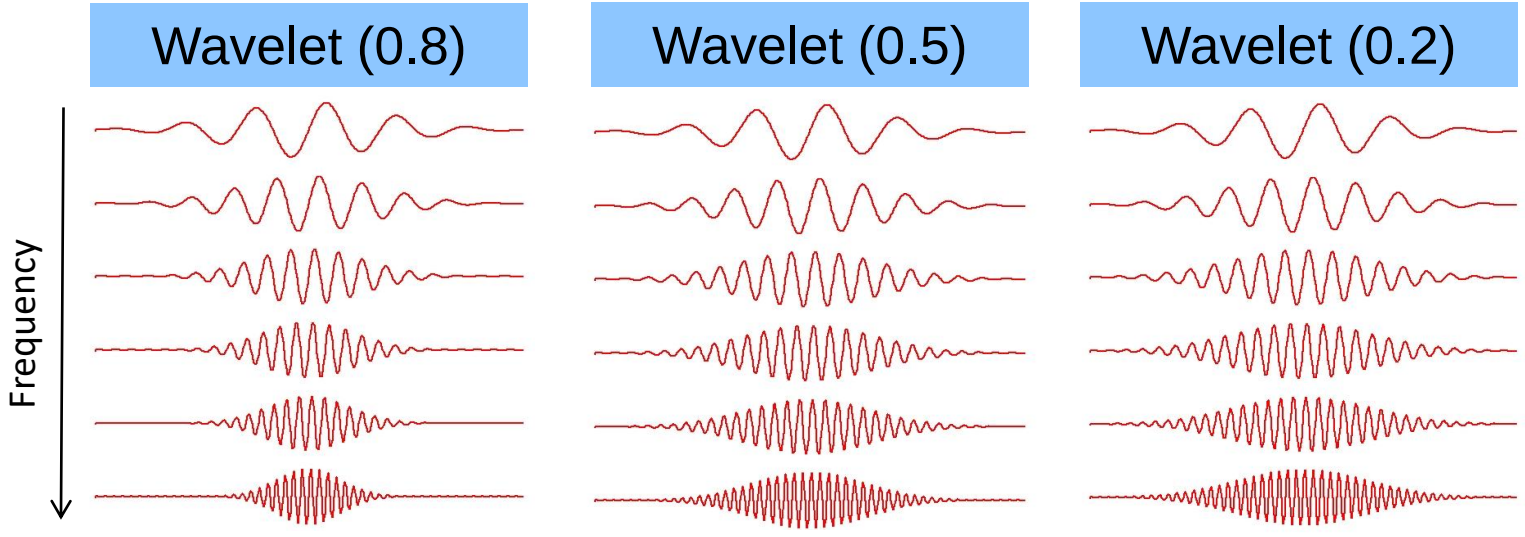


constant window size (time resolution) for increasing frequency → increasing # cycles with frequency.

window size decreases by a factor of 2 for each octave (power of 2) → constant # of cycles at each frequency

Wavelet scale expansion factor

Larger expansion factor produces larger scale decrements (increased time resolution, lower frequency resolution) for increasing frequency



Number of cycles at highest frequency for an expansion factor of *q:*

$$C_{\text{fmax}} = \frac{f_{max}}{f_{min}} C_{\text{fmin}} (1 - q)$$

Exercises: Wavelet specifications

Wavelet cycles [min max/fact] or sequence	3 0.8

Answer: The first #cycles controls the basic duration of the wavelet in cycles.

The second factor controls the degree of shortening of time windows as frequency increases

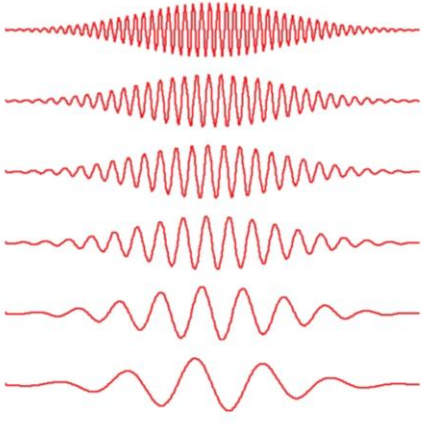
0 = no shortening = FFT (duration remains constant with frequency)

1 = pure wavelet (#cycles remains constant with frequency)

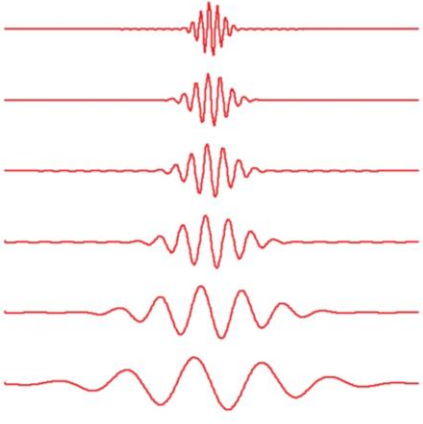
0.5 = intermediate, a compromise that reduces HF time resolution to gain more frequency resolution.

0.8 = EEGLAB default—higher HF time resolution

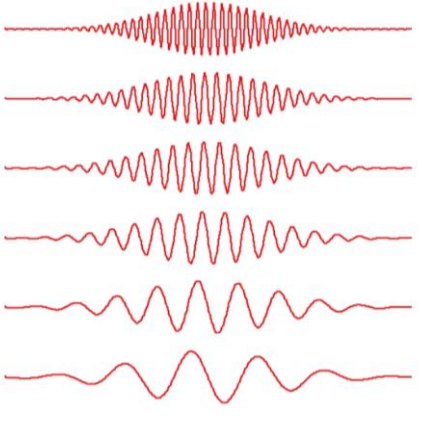
3 0



3 1



3 0.5

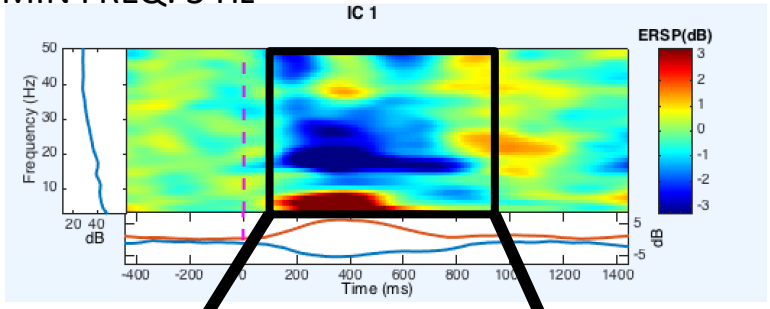


Exercises: Time loss at edge of ERSP

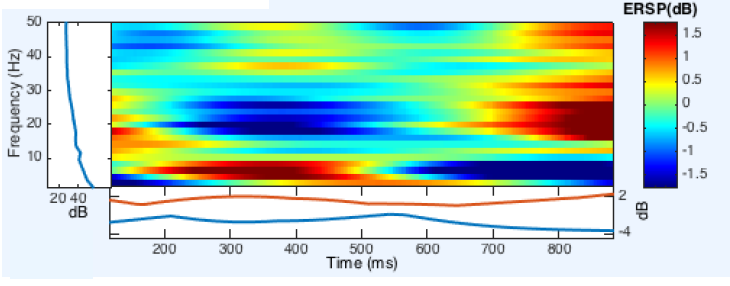
Settings for 1) *wavelet cycles* and 2) *lowest frequency* impact the time limits of analysis

***more wavelet cycles, or a lower minimum frequency loses time at edges of epoch**

MIN FREQ: 3 Hz



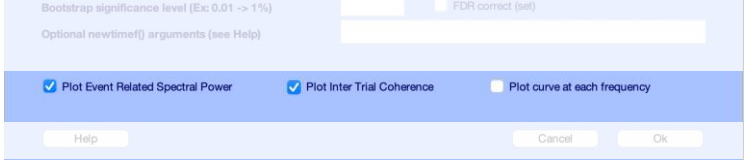
MIN FREQ: 1 Hz



Solution: If you need low frequencies in your ERSP, be sure to extract longer epochs to counteract this. If you can't re-epoch, then try reducing the number of wavelet cycles.

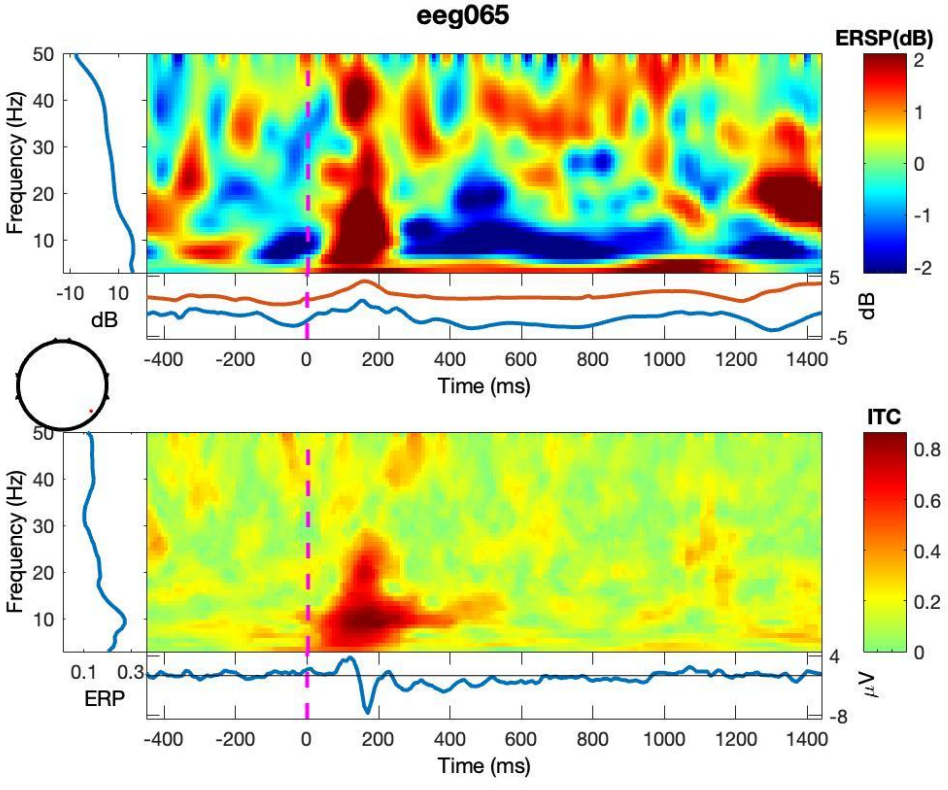
Exercises: Inter Trial Coherence

pop_newtimef GUI



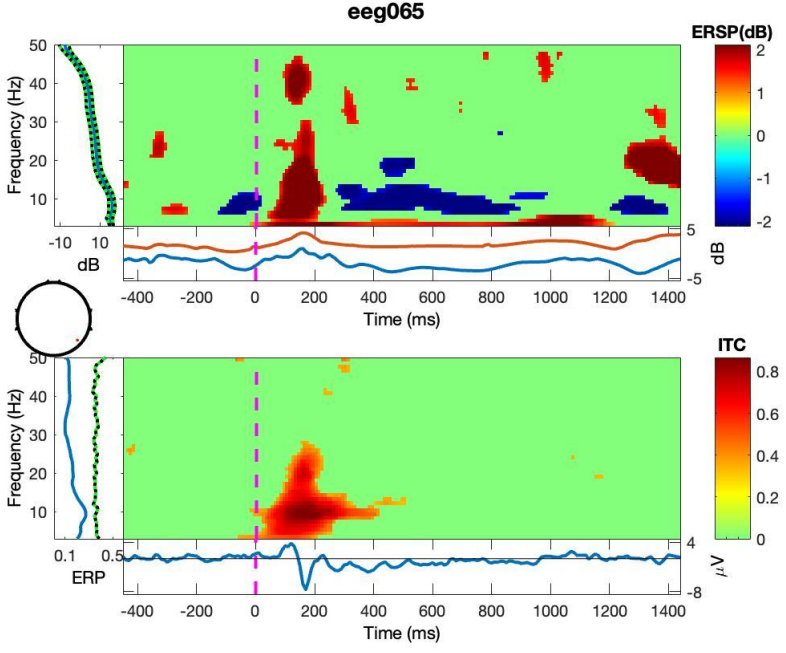
Command line

```
pop_newtimef( EEG, 1, 1, [-1000 1990], [3 0.8] ,
'topovec', 1, 'elocs', EEG.chanlocs, 'chaninfo',
EEG.chaninfo, 'caption', 'eeg065', 'baseline',[NaN],
'plotphase', 'on', 'plotphase', 'off', 'padratio', 1,
'winsize', 100);
```



Exercises: Significance testing

Keep in mind: "is this significant?"



Method: Bootstrap
Green areas are not significant.

Scale of ERSP & ITC vales also give a clue:
Large values are often encouraging of a significant effect
(Large ≈ > 1dB for ERSP; > 0.5 for ITC)

For exploratory purposes, can try 0.01 without FDR correction