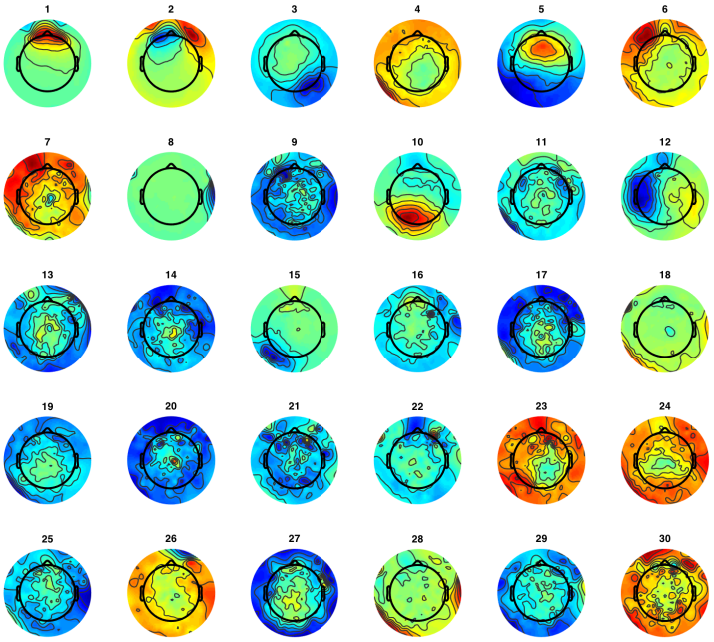
Filtering and ICA

Following my theoretical work on filtering, that I hope you followed restlessly, I choose to use a butterworth filter order 2 (i.e. 12dB/octave roll-off) with low and high cut-off frequencies of 0.1 and 50Hz defined at -6dB (i.e. with the half-amplitude). For the filtering vocabulary cf. Widemann review paper or Luck's book "An introduction to the ERP technique", chapter 7 for filtering, available online with UW library and maybe easier to read.
I choose this filter from ERPLAB as it is what are using the big guys from ERPs as Luck, besides the ERPLAB interface for filtering is nice, you can see in live your filter responses and can adjust easily the roll-off, etc. But I might try other filters later, like the windowed sinc with a kaiser window that Widmann advises, and test which one affects the least my data. I choose 50hz as a low pass to remove the line noise without being too agressive, I can still get lower after.

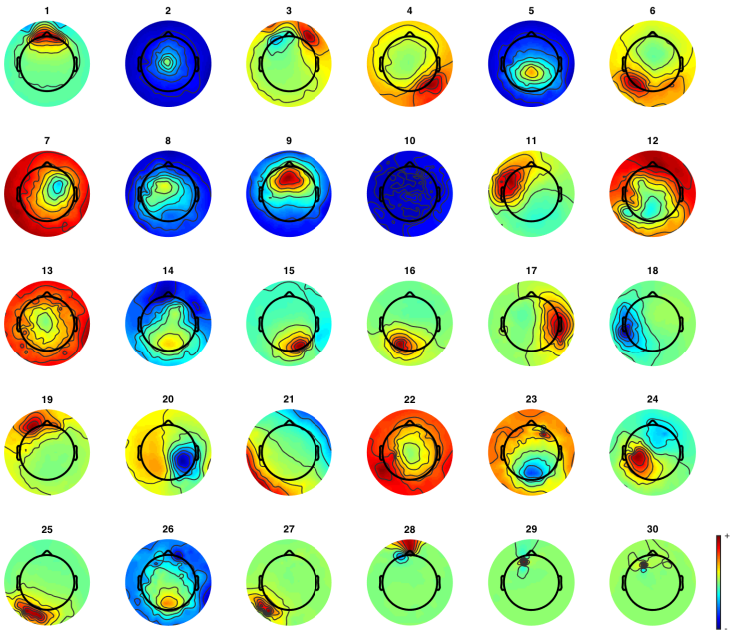
I then ran the ICA after channel and bad epochs rejection, on the epoched data indeed (-1.5 to 1.5 s around my events), with binica (without downsampling to have more datapoints, and without pca reduction for now). The first problem is that ICA is not very good if I high-pass filter (HP) at 0.1Hz…

ICA after 0.1 or 1Hz high-pass filtering

So following the recommendations on an eeglablist discussion https://sccn.ucsd.edu/pipermail/eeglablist/2011/004417.html , I tried to run ICA on 1hz and then apply the weights on 0.1hz.
Following Armand's idea of screenshots here you can compare the ICA decompositions : 0.1hz on left, 1Hz on right, just the 30 first components, after they are not very informative.



NCCAM_2000_T1_W_AB buttFilt_ord2_0,1-50 chRej epochRej binICA



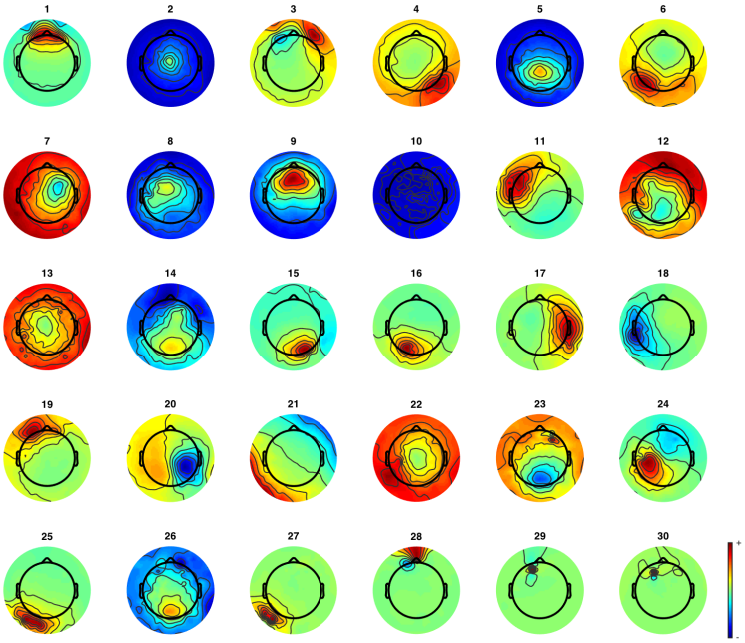
NCCAM_2000_T1_W_AB buttFilt_ord2_1-50 chRej epochRej binICA

Both isolate major components as blinks and lateral eye movement (LEM) (independent components (ICs) 1 and 2 or 3), but the 0.1hz decomposition is not as precise for the others components. For example the 1hz allows to see strange patterns like IC10 and also catches heart pulsation IC21 and muscles ICs 27 and 28 and maybe vertical eye movements IC19.
So I'll definitely keep 1Hz, I tried 2Hz but it's not improving anything and even reducing the isolation quality of the eyes movements.

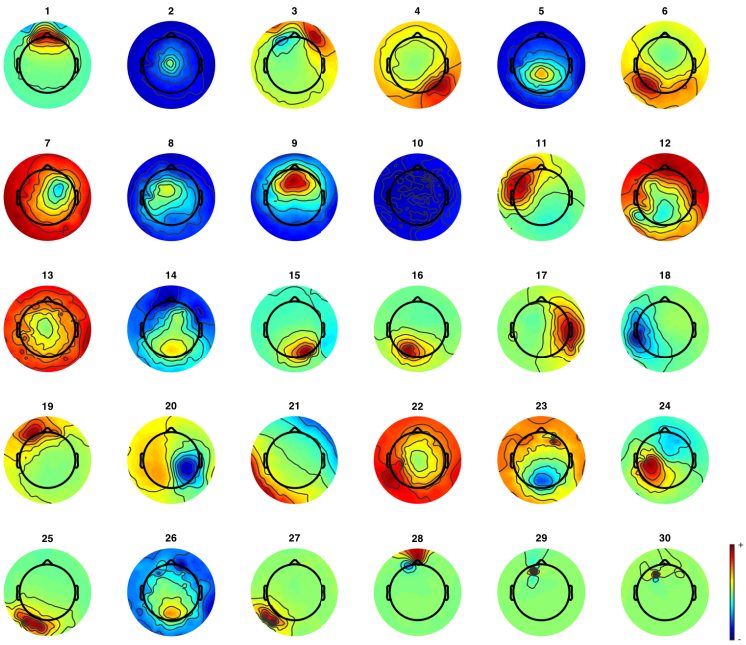
Then according to the papers on filtering, if you are not doing ERPs the HP filter at 1Hz won't change anything to your data. If you are doing ERPs or you want to study low frequencies around 1 or 2 hz, you can do this nice trick described in the eeglablist discussion , which is also the "political line" beyond the people implementing EEGLAB at the SCCN of Scott Makeig, applying the ICA decomposition of your 1hz dataset to your 0.1Hz dataset.
By safety measure I applied the same process to the 2 datasets (same sampling rate, same channels and epoch rejected and same epoching, etc.. except for filtering), but as the ICA weights matrix is just a N by N matrix with N the number of components (in my case the number of channels left), maybe you just need the same number of channels and then when EEGLAB is recomputing the ICA activation matrix with eeg_checkset it is adapting to the number of epochs and datapoints of the new dataset ?…

Anyway the process to do that is pretty simple
_On EEGLAB go on your 1hz dataset with the ICA computed and in the matlab command line
TMP.icawinv = EEG.icawinv;
TMP.icasphere = EEG.icasphere;
TMP.icaweights = EEG.icaweights;
TMP.icachansind = EEG.icachansind;
_ change the active dataset to your 0.1Hz dataset without any ICA run on it
EEG.icawinv = TMP.icawinv;
EEG.icasphere = TMP.icasphere;
EEG.icaweights = TMP.icaweights;
EEG.icachansind = TMP.icachansind;
_ then recompute the ICA activation matrix
EEG = eeg_checkset(EEG);
eeglab redraw

You should see that the decomposition of the 0.1 and 1Hz are now pretty similar as here :

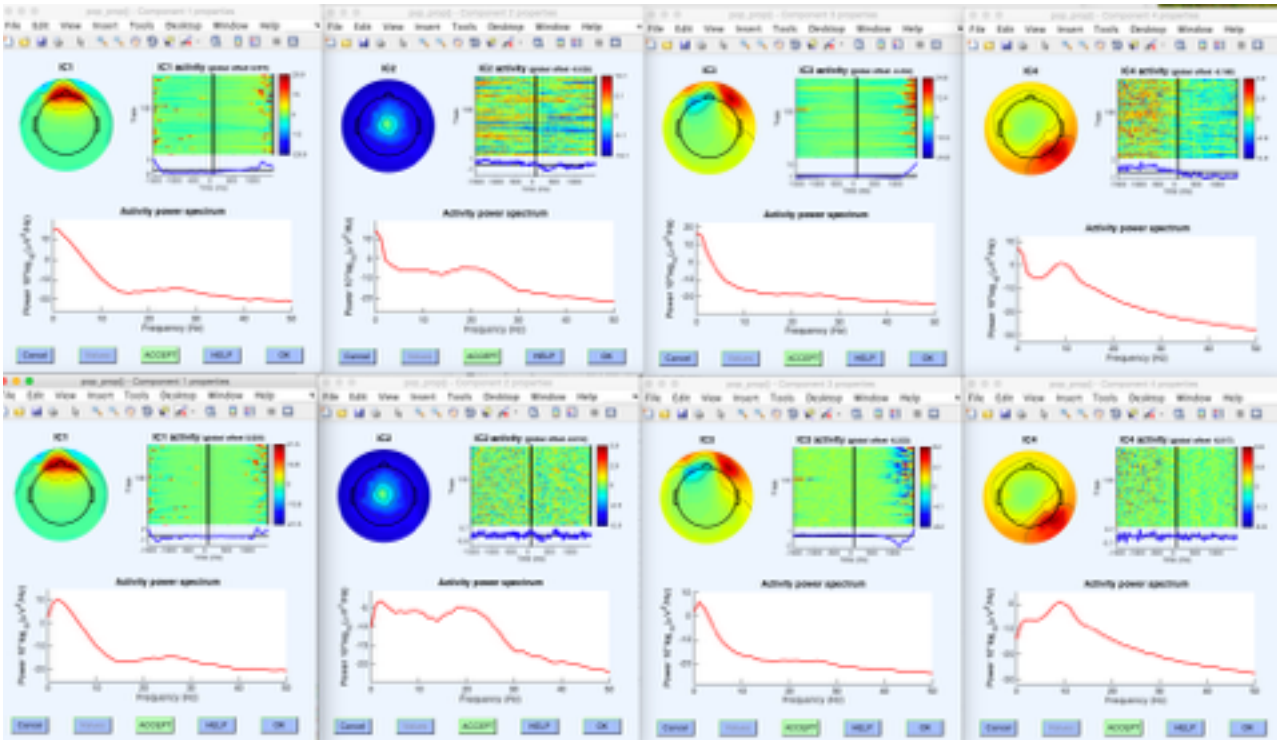


NCCAM_2000_T1_W_AB buttFilt_ord2_0,1-50 chRej epochRej 1HzbinICA

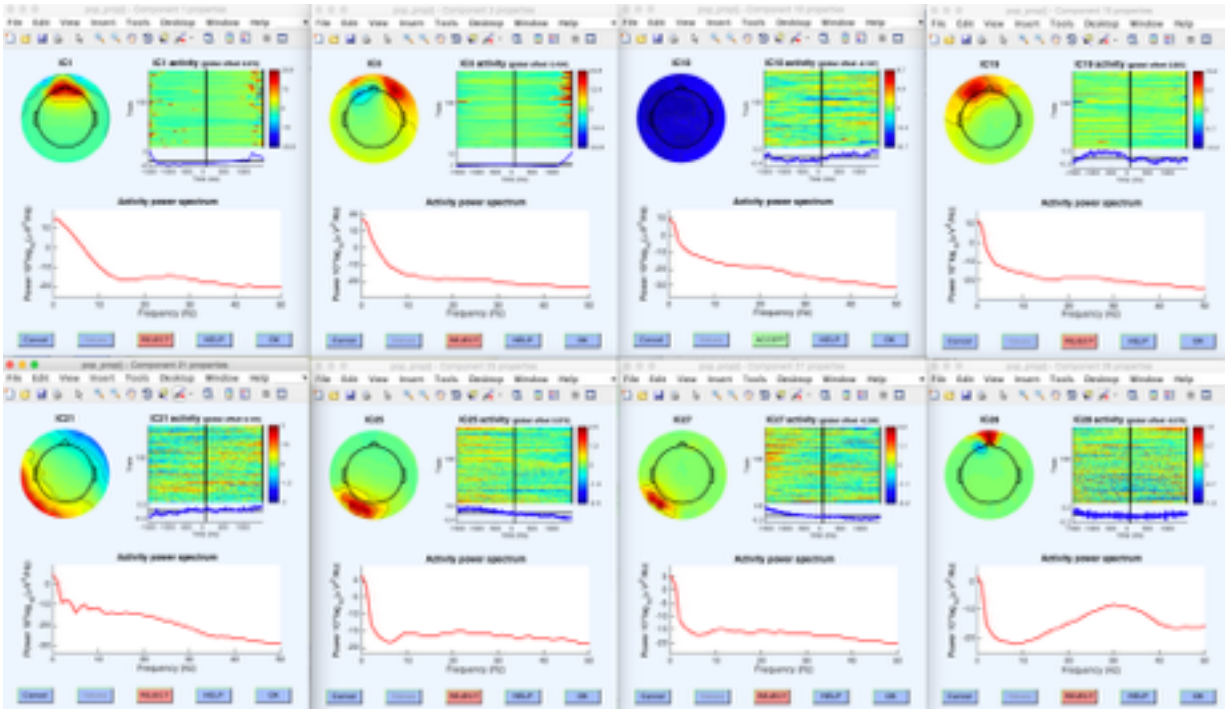


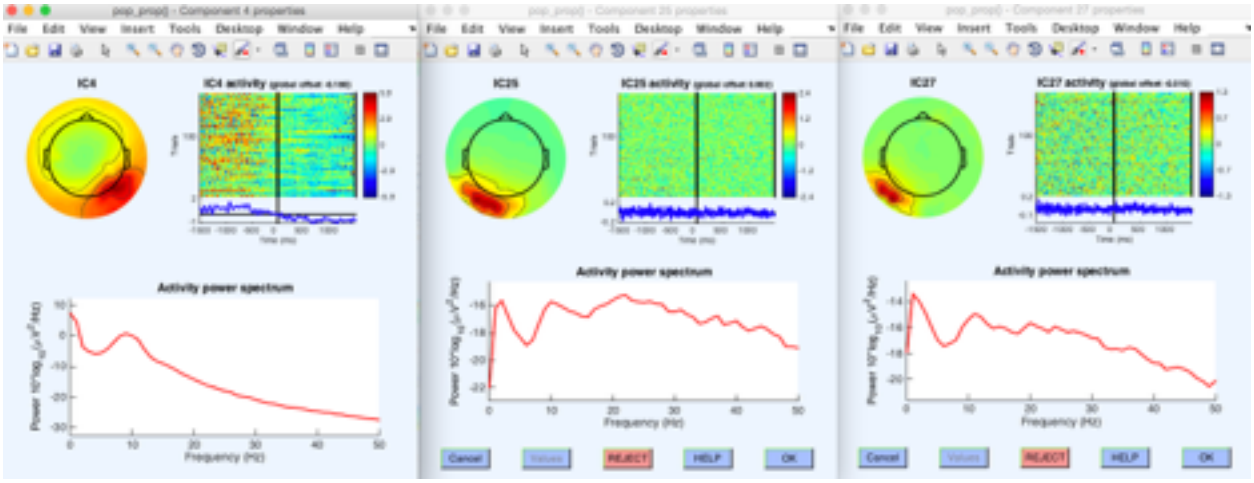
NCCAM_2000_T1_W_AB buttFilt_ord2_1-50 chRej epochRej binICA

At least for the topographic map, if you look in details the component properties, they are different because not based on the same data, the 0.1Hz activation are noisier due to the low frequencies noise. 0.1Hz above, 1Hz below.



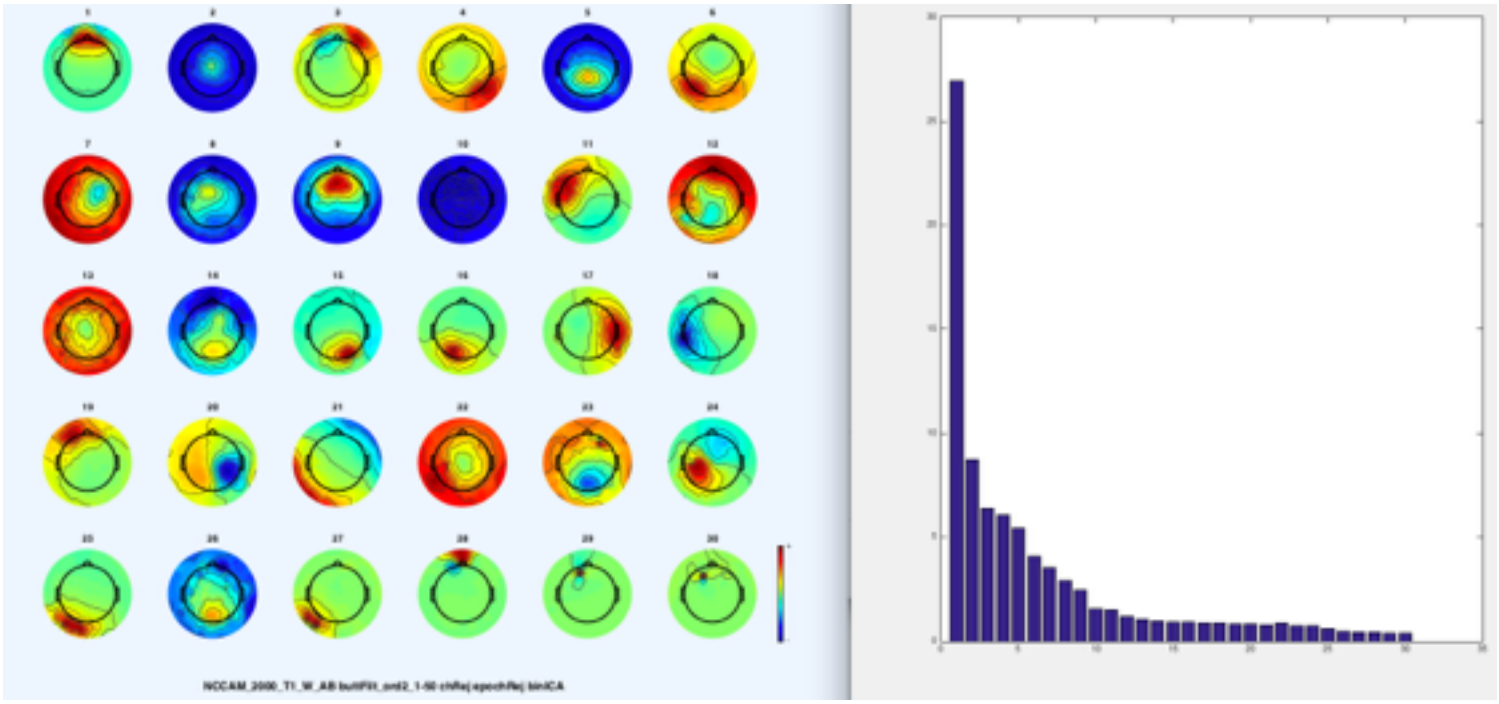
Then, now you can reject the artifact components on your 0.1Hz dataset, DO NOT reject them before, in the 1Hz dataset, before to apply the weights to the 0.1Hz dataset. The rejection will be specific of the 0.1Hz dataset. Here I removed components (see below for figures) : 1=blink, 3=Lateral eye movements, 10 I didn't remove it but it's very strange, someome has an idea ?, 19 = vertical eye movements I think but it's less obvious than 1 and 3 so I'm not sure, it might be mixed with neural activity, 21 = heart pulsation, 25 and 27 seem to be neck muscles but not obvious they might be mixed too, it's clearer in the 1Hz components, see figures next page, they are clearly muscles with high oscillation activation and high power spectrum above 20Hz compared to a neural component as 4(see next page). So it can be helpful to have a look to the 1Hz components too. Finally 28 seems to be eye muscles with high frequency power, localized and with a nice dipolarity.



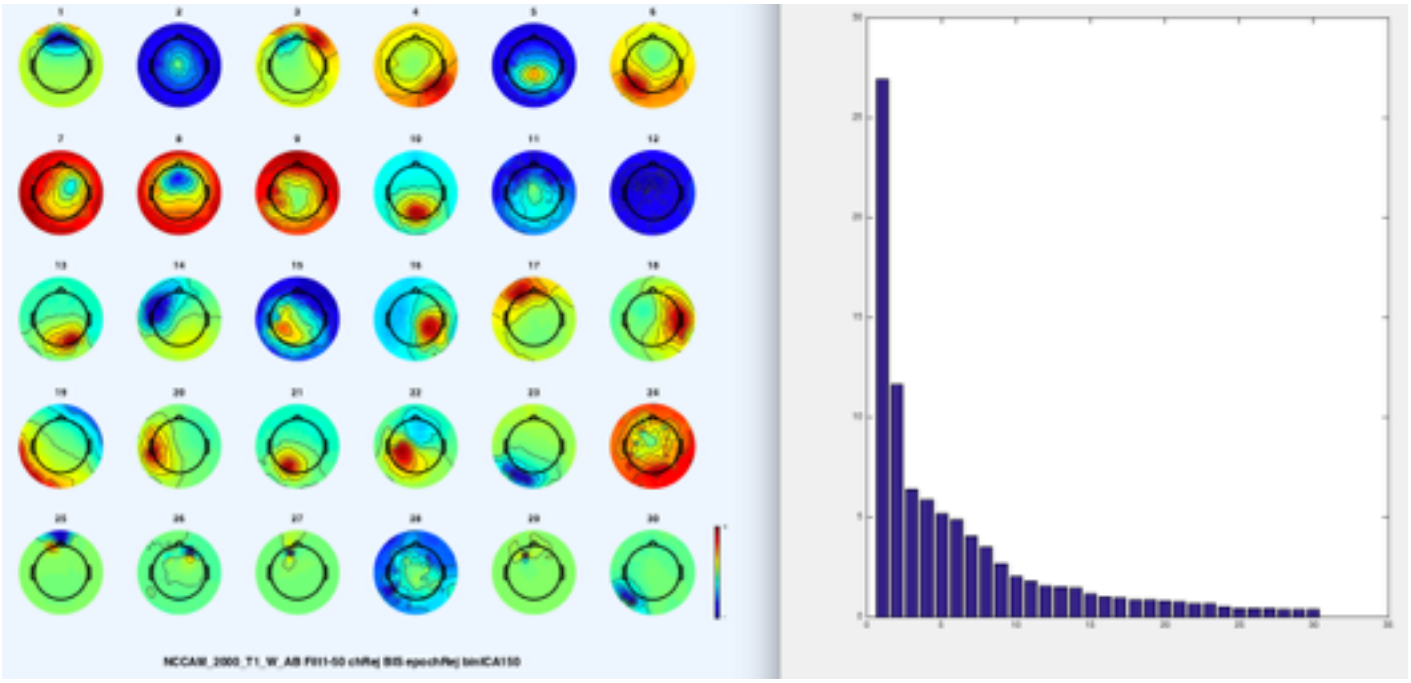


Tests different ICA parameters

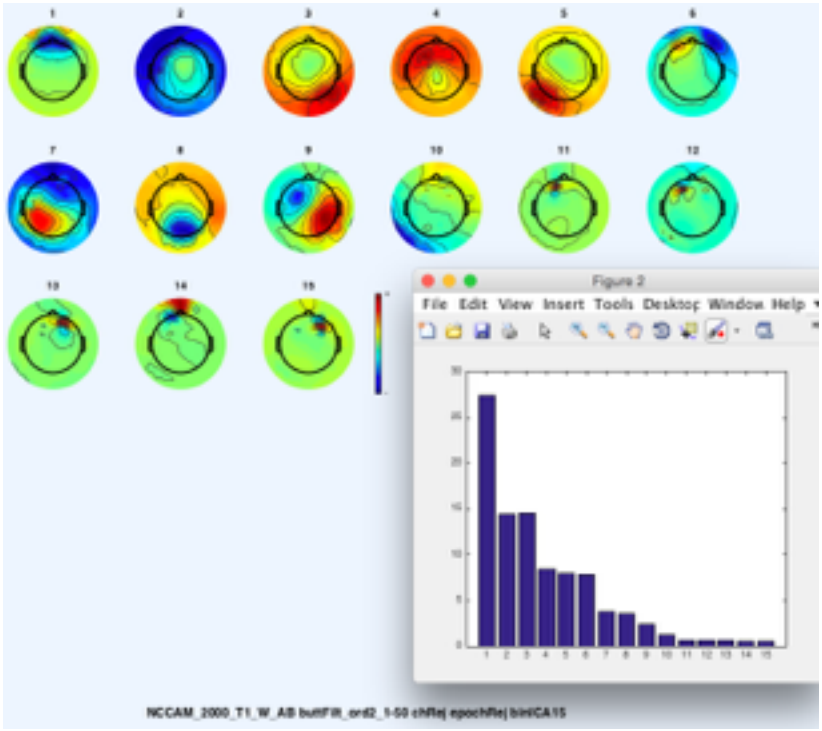
I then tried different ICA parameters on my 1Hz dataset to see if I could improve my decomposition: _binica without pca reduction, I plot the 30 first components and the graph of the percentage of variance each component account for (that you can obtain for each component with :
[proj, variance] = compvar(EEG.data, {EEG.icasphere EEG.icaweights}, EEG.icawinv, componentNumber);
You can see that the blink component account for a lot of variance.



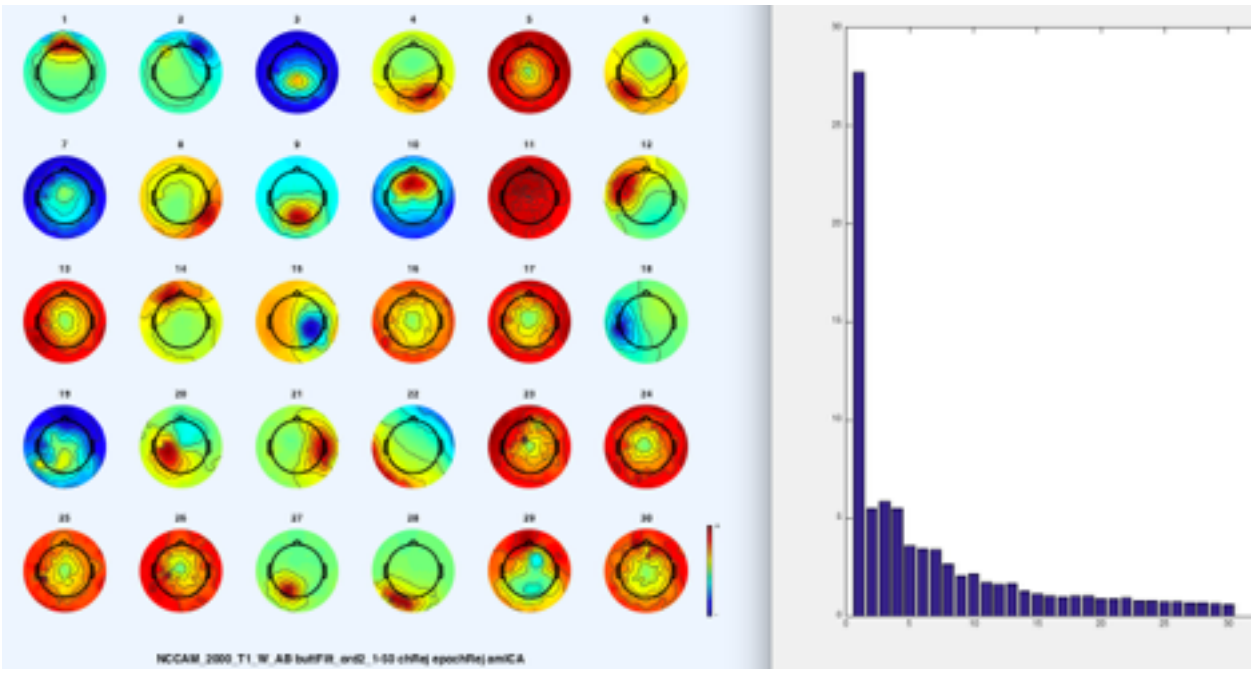
_ binica with pca reduction to 150 components as advised by Arnaud Delorme for hdEEG 256 channels somewhere in the eeglablist, almost the same decomposition so it can be helpful to do some quick tests because it's a bit faster than without pca (I had 236 channels left after rejection so 236 components). But as advised by Armand and Ben told me the same, it's better not reducing with pca if we can avoid it. Variance wise it's also quite similar except for the 2nd component which accounts for more variance.



_binica with pca reduction to 15 (or less) components as advised by Leo. Very different from without reduction, for example lateral eye movement explaining much less of the variance, less muscle components (no 25 and 27 from original ICA), no vertical eye movement (potentially 19 on the original ICA). But maybe it's actually a better decomposition with components being really independents and so you have less mixed ones as the 19 25 and 27 in the original ICA. I'm not expert enough on ICA to judge on that, maybe Leo can argue if he thinks it's a better decomposition ? At least it's much much faster… Variance wise, the neural components account for more variance than previously.



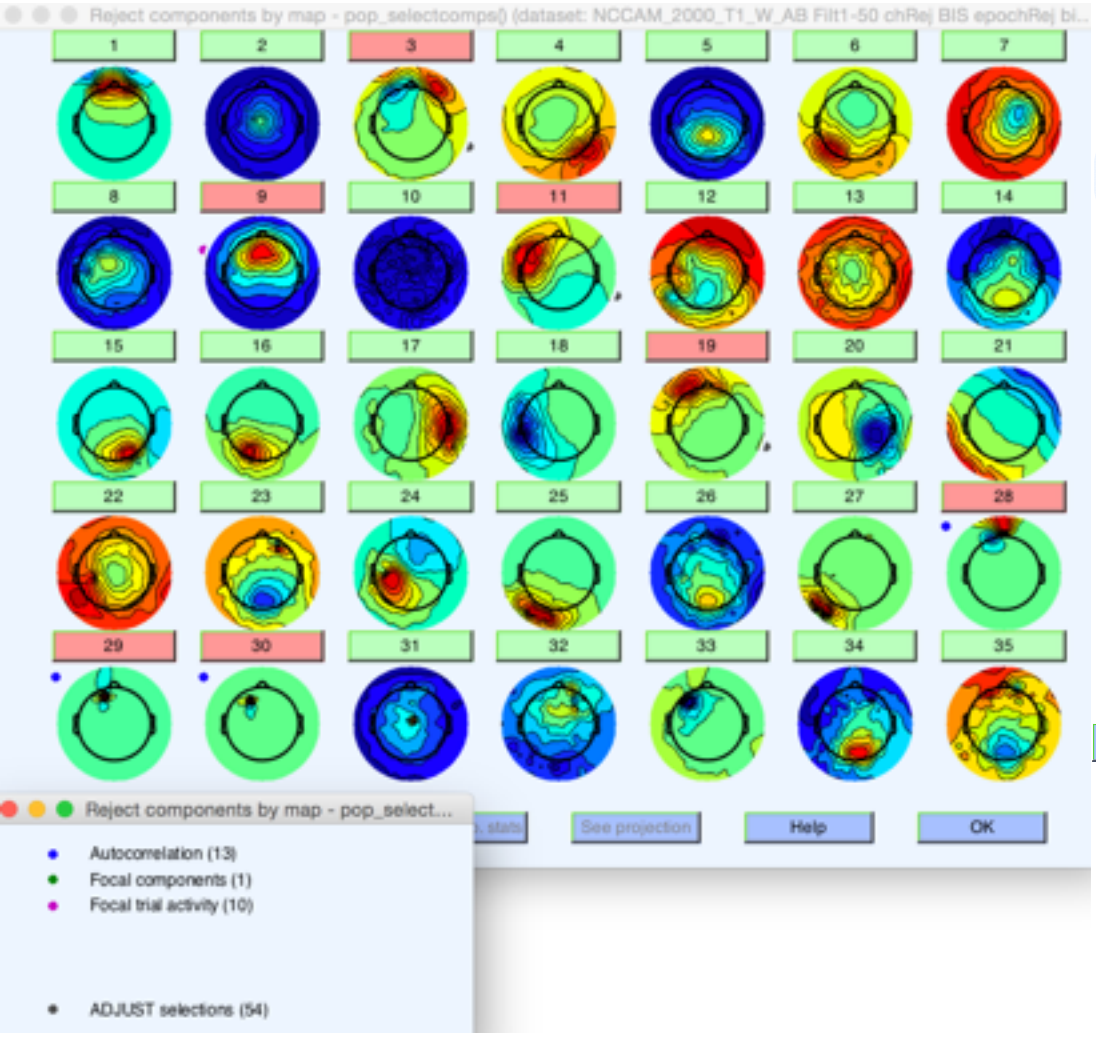
_ amica as advised by Ben, not much difference from binica for me, the lateral eye movement is in second position instead of third. I don't feel like there is a real improvement with fewer and more precised artifact components not mixed with neural data, so for me it's not worth the very long time it takes, about 3hrs for me… The same if Ben find it's better and wants to argue ?
For the variance the neural components seem to account for less variance.

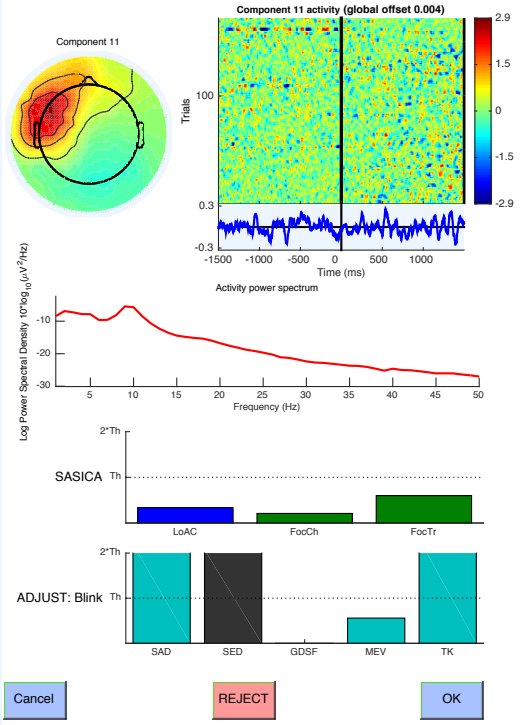


By the way Ben also advised me to use a 185 inside channels montage to keep just the inner channels and remove the outside channels of the EGI 256 channels net that are on the neck, the ears and the face and are very noisy. I didn't use it this time because I might want to keep the maximum channels for future analysis. But it can be helpful to automatically remove a lot of potentially bad channels and doing so having less components for the ICA without performing pca. Also while setting the EGI net on the subjects these channels can be very annoying, so it can be a relief if we know that we will discard them anyway.
Here are the inside channels to keep if you want to try that
[1;2;3;4;5;6;7;8;9;10;11;12;13;14;15;16;17;18;19;20;21;22;23;24;25;26;27;28;29;30;31;32;33;34;35;36;37;38;39;40;41;42;43;44;45;46;47;48;49;50;51;52;53;54;55;56;57;58;59;60;61;62;63;64;65;66;67;68;69;70;71;72;74;75;76;77;78;79;80;81;83;84;85;86;87;88;89;90;94;95;96;97;98;99;100;101;105;106;107;108;109;110;114;115;116;117;118;119;123;124;125;126;127;128;129;130;131;132;136;137;138;139;140;141;142;143;144;148;149;150;151;152;153;154;155;158;159;160;161;162;163;164;168;169;170;171;172;173;177;178;179;180;181;182;183;184;185;186;190;191;192;193;194;195;196;197;198;202;203;204;205;206;207;210;211;212;213;214;215;219;220;221;222;223;224]

ICA classifier to help us decide which components to remove

During the meeting some people talk about ADJUST to detect eye movement components artifact, I tried it in combination with SASICA another plugin that has his own detection algorithms and also use adjust but I don't find it very efficient, it doesn't find the first blink component which is obvious, the heart rate neither. It classes the 19 as a Vertical eye movement but also the 11 as a blink although it has an alpha peak and it should be more a mixed component. Sasica finds not very relevant components (29 and 30) and marks the 9 as bad but it seems to be a neural or mixed component. But it finds the 28 muscle component. So not very efficient neither I think.





Then I tried ICMARC which I think is better, it finds the 1 and 3 eye components, the heart pulsation and the 28 muscle. Bad points it just classifies 19 potential vertical eye movement as mixed and 25 and 27 muscles as neural and the interface is nice, with different classification, for example “mixed” components that contain neural and artifactual signal. But it’s much longer to run than Sasica and Adjust, so if you use it then save the “classtype” variable it creates under EEG.reject, if you don’t want to run it again after.