BMDE 610 – Source Localization Project

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Application of Minimum Norm Estimate for simulated MEG signals

First, the protocol was loaded as a zip filed into Brainstorm and the m file containing the process was placed in the necessary folder.

First a scout was selected at random from the cortex file "Cortex BrainVISA: white_6000V", the first averaged background file was dropped into the process box. A Minimum Norm Estimate solution was implemented (script: MNE.m), with 10 different values of alpha, in order to be able to build a L-curve in order to find a good fit for the alpha parameter (script: L_curve). In order to scale the choice of alpha parameter, the ratio of the traces if GG^T and W^TW was used. The ten alpha parameters selected were: 0.1, 0.0001, 5e-6, 2.5e-7, 5e-8, 5e-9, 2.5e-9, 5e-10, 5e-11, 1e-12. An SNR of 4 was used for these simulations.
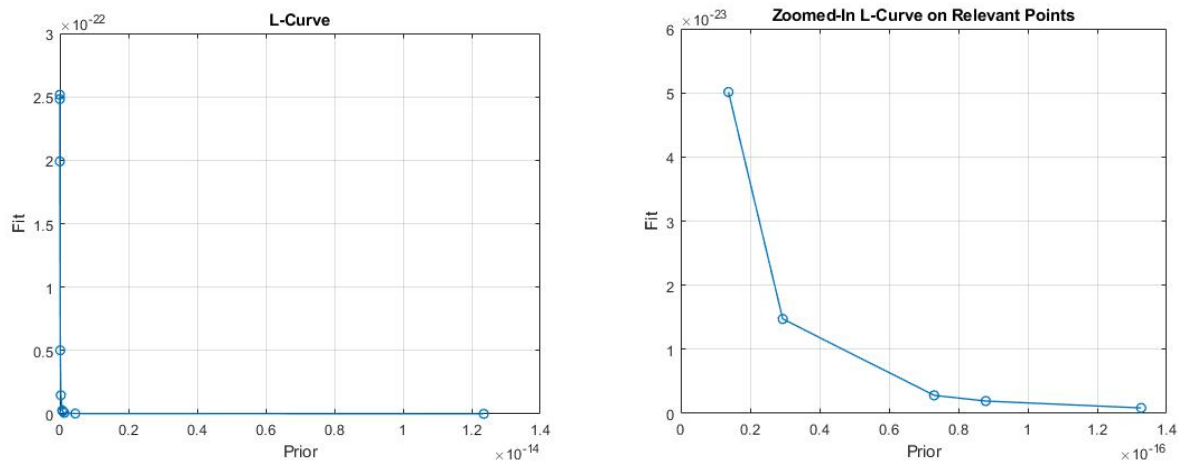

Figure 1. *Show the L curve that was built with the 10 alpha values chosen*

From that L curve, we see that the corner of the L curve corresponds to some point between the alphas 5e-9 and 5e-8, that alpha value used corresponds to a value of 2.5e-8. The sources were calculated again with the alpha value that was obtained.
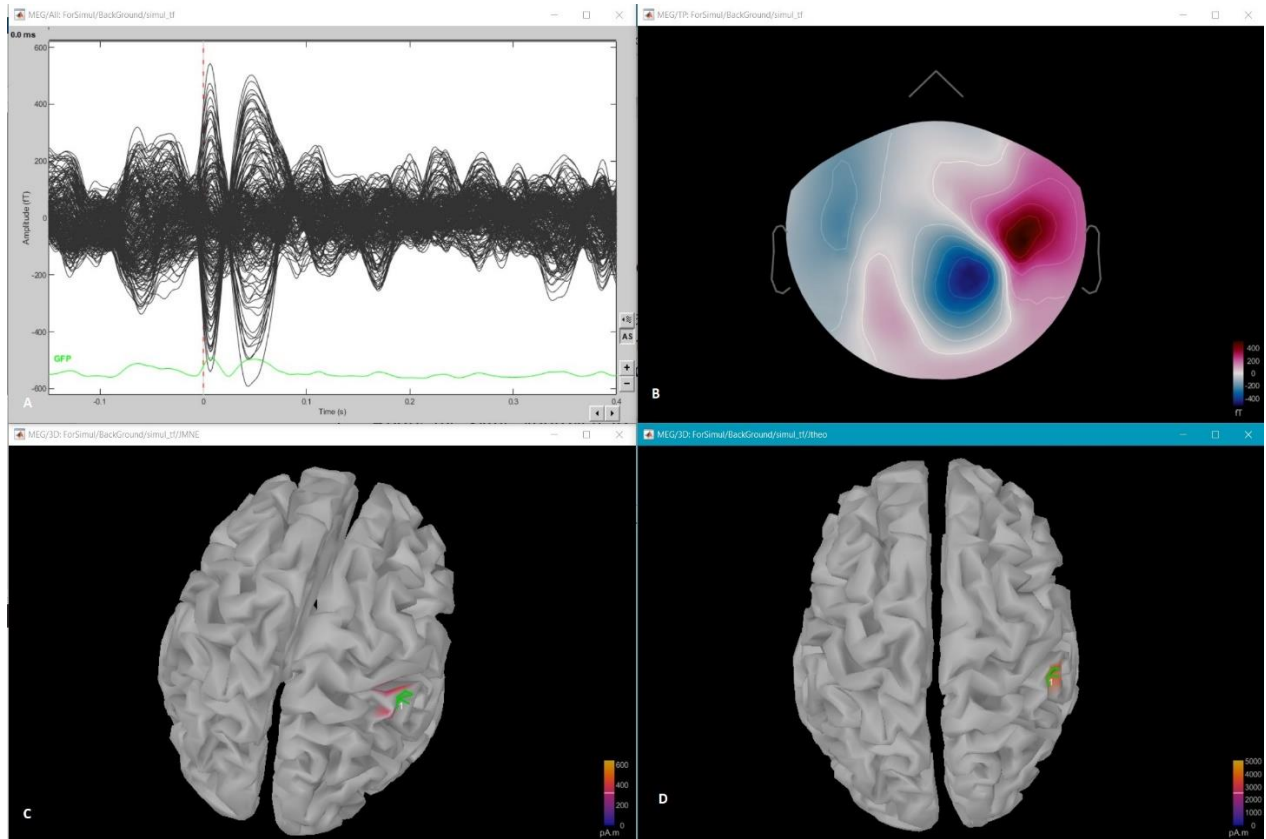
Figure 2. A) shows the MEG signals that were simulated, B) Shows the MEG topography, C) The sources estimated with the Minimum Norm Estimate, D) The theoretical source obtained from the scout selected

Effect of different SNR for the source estimation

For this part of the project, a similar approach was used, however, the SNR was changed in order to explore the effect of the amount of noise in the data. An SNR of 3 was used for this approach. The same scout was used, and the same background file was used. The five alpha values that were used to build the L curve were: 2.5e-7, 5e-8, 2.5e-8, 2.5e-9, 2.5e-11.
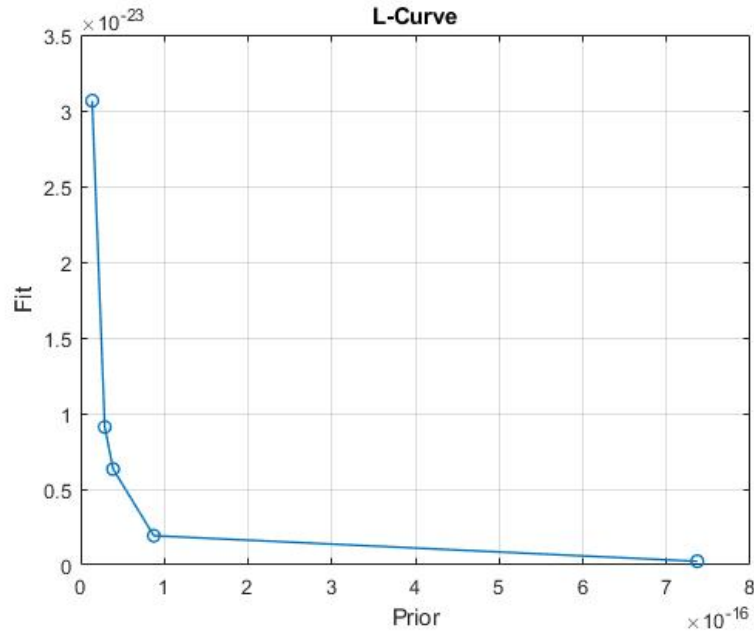
Figure 3. *L curve built using the sources obtained by using a lower SNR*

From this L curve we see that the alpha value that provide the best trade off between fit and prior is between 2.5e-8 and 2.5e-9. The alpha value that will be used for the final source estimation is 1.375e-8.
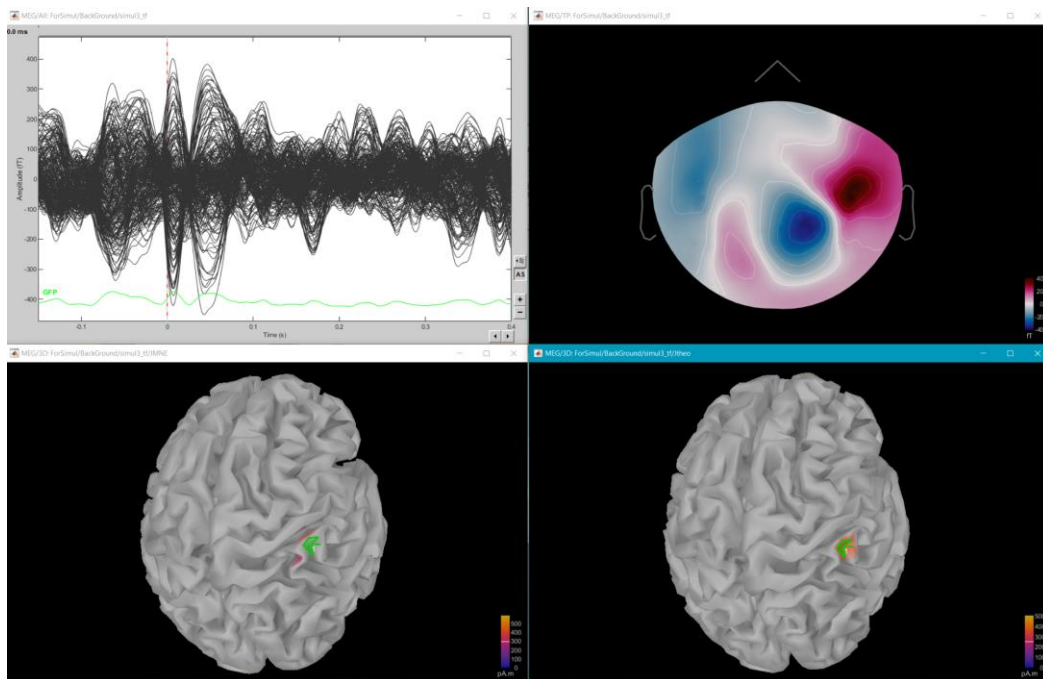

Figure 4. *A) shows the MEG signals that were simulated, B) Shows the MEG topography, C) The sources estimated with the Minimum Norm Estimate, D) The theoretical source obtained from the scout selected*

From performing the same procedure with signals simulated with different SNR, there are two major things we can easily take notice off. First, is that the alpha value that the L curve shows as the better option is lower when we have a lower SNR in the source estimations. The amplitude of the sources estimated were higher in the case were the signal had a higher SNR, as it can be seen while comparing figures 2C vs 4C.

Effect of deeper source in source estimation

The goal of this section is to explore how the depth of the region selected influences the source localization; in order to do this, a new scout was selected. This new scout has the same x and y coordinates as the one used in the previous part; however, the z coordinate was changed so that the region of interest in deeper in the brain. The coordinates of the first scout used were [143,91,116], the coordinates of the second scout used for this section were [146,92,90]. The area of the second scout was approximated to be similar to the area of the first one, with the scout used on the previous section having an area of 2.43 cm^2 and the second scout having an area of 2.32 cm^2. The SNR used was 4.
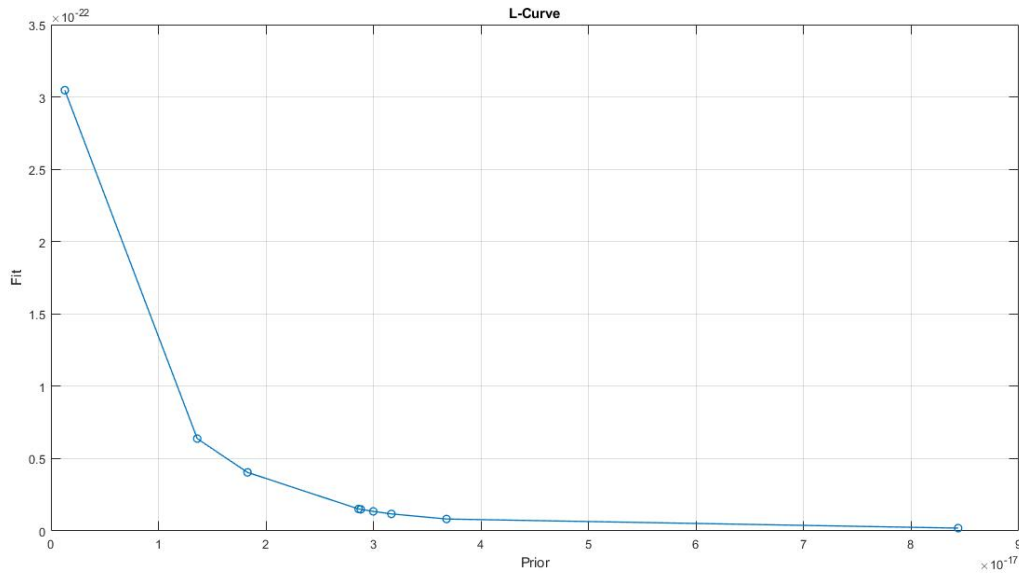

Figure 5. *L curve obtained using the different values of alpha for the deeper scout.*

In order to build this L curve, the values of alpha used were: 2.5e-6, 2.5e-7, 1.5e-7, 5e-8, 4.9e-8, 4.375e-8, 3.75e-8, 2.5e-8, 2.5e-9, 2.5e-11. From this curve we can see that the best trade off occurs when the value of alpha is set to be around 2e-7.
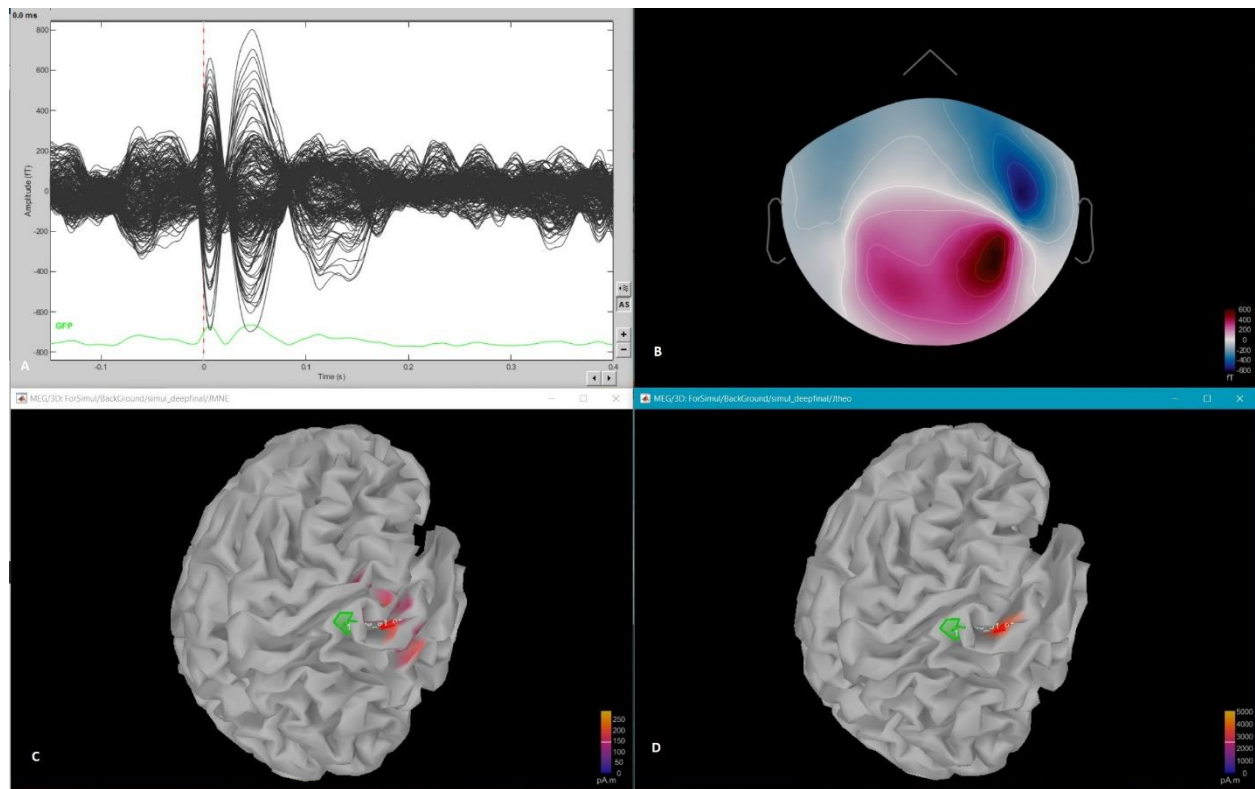
Figure 6. *A) shows the MEG signals that were simulated, B) Shows the MEG topography, C) The sources estimated with the Minimum Norm Estimate, D) The theoretical source obtained from the scout selected*

When comparing the source localization for deeper sources, the first thing that becomes very clear is the fact that the amplitudes of the source detected are much smaller compared to the theoretical ones. Another important thing to take notice of is how spread out the localization of the sources is. The area of sources found is much higher compared to what the theoretical region should be for the deeper scouts.

Effect of scouts with longer spatial extent for source localization

For this section, the effect of localizing sources of larger regions was examined. In order to do this, a scout was created centered around the same coordinates as the first scout used, however the area that this scout covers was increased. The area covered by the scout was changed from 4.43 cm^2 to 27.18 cm^2. SNR of 4 was used. The L curve for this scout was obtained using the alpha values of: 1e-6, 2.5e-7, 2e-7, 1e-7, 3e-8, 5e-9, 1e-9.
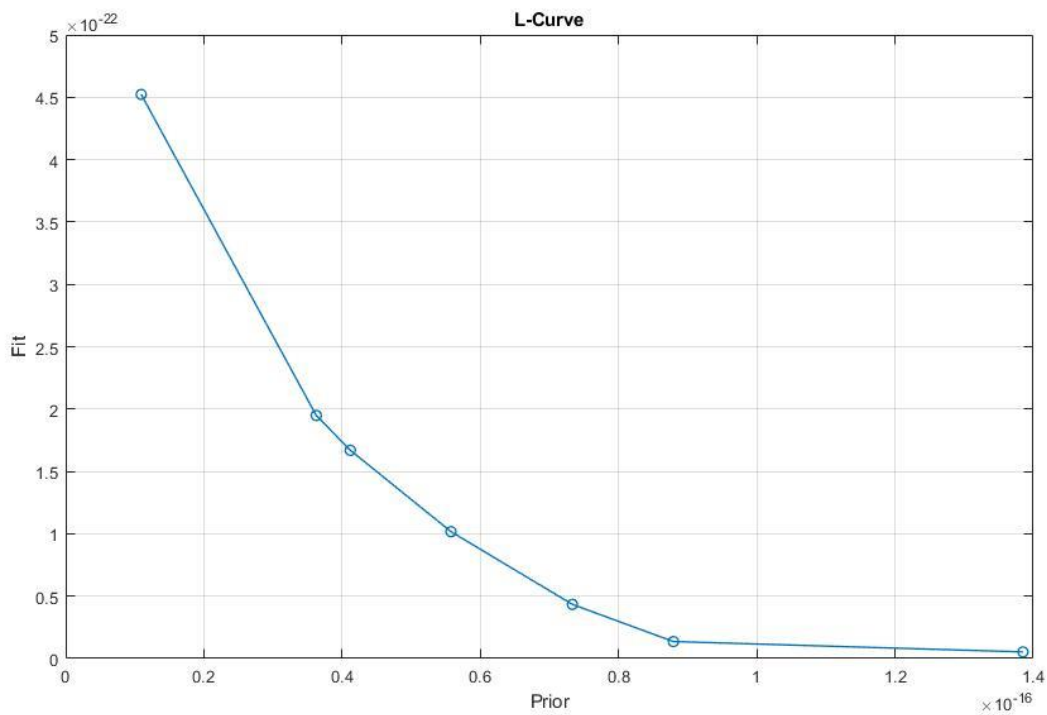

Figure 7. *L curve obtained using the different values of alpha for the scout with the larger area*

From figure 7 we can see that the alpha value that should be used is approximately 2e-7.
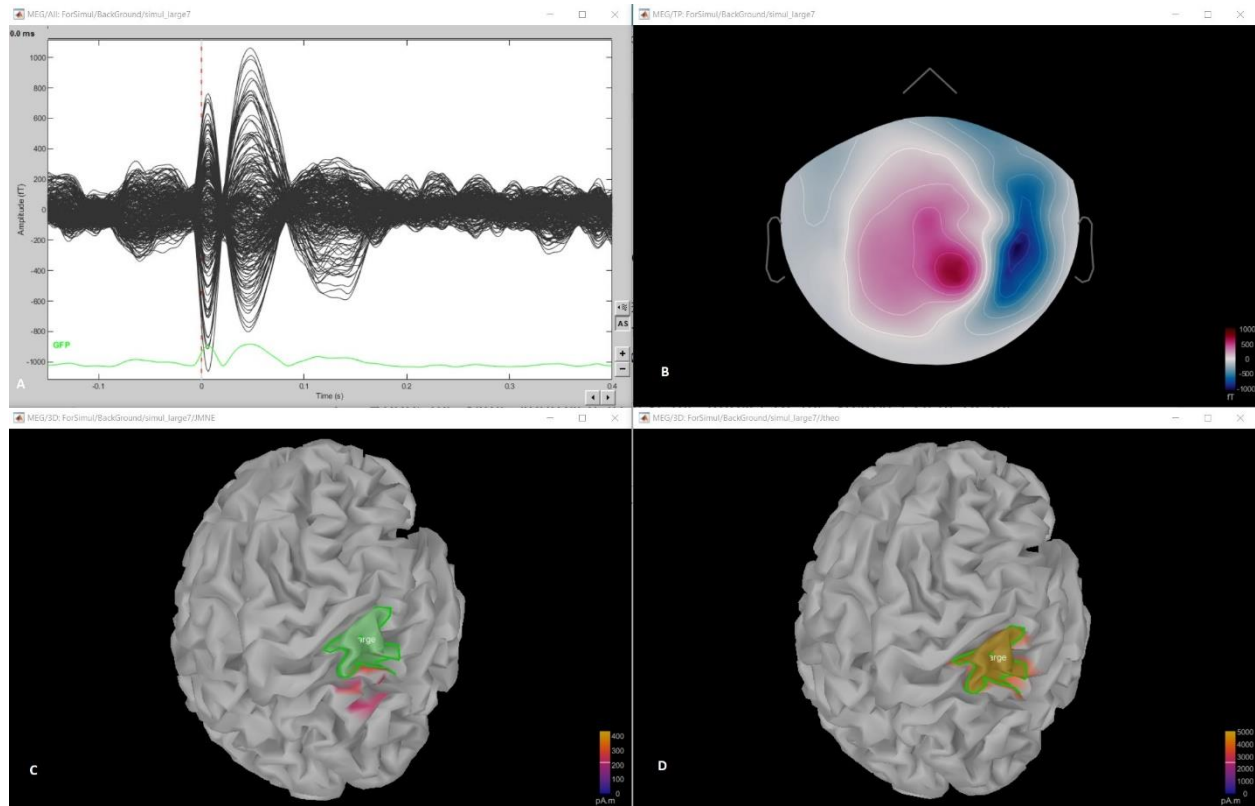
Figure 8. *A) shows the MEG signals that were simulated, B) Shows the MEG topography, C) The sources estimated with the Minimum Norm Estimate, D) The theoretical source obtained from the scout selected*

From the results that I obtained while performing source localization in scouts with bigger areas, it was harder to identify the specific area that the sources were coming from. While comparing the J obtained from my minimum norm estimate, and the theoretical one, it can be seen that the source estimation was not as accurate. The amplitude of the sources estimated was considerably lower as well. The alpha value obtained through the L curve, was higher for the larger scout than for the smaller scout.