Quantitative and Functional Imaging

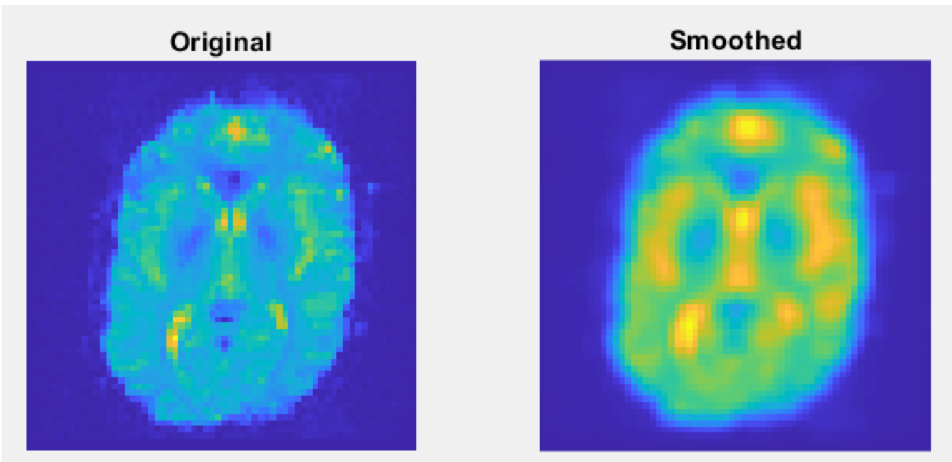
BME 4420/7450

Project #7

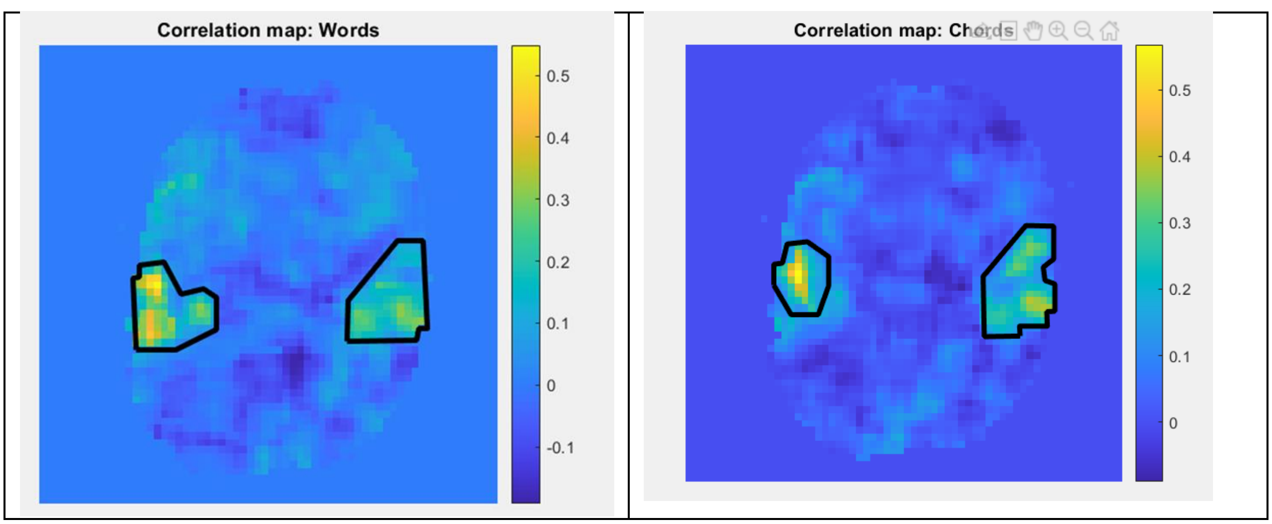
Functional Brain Mapping

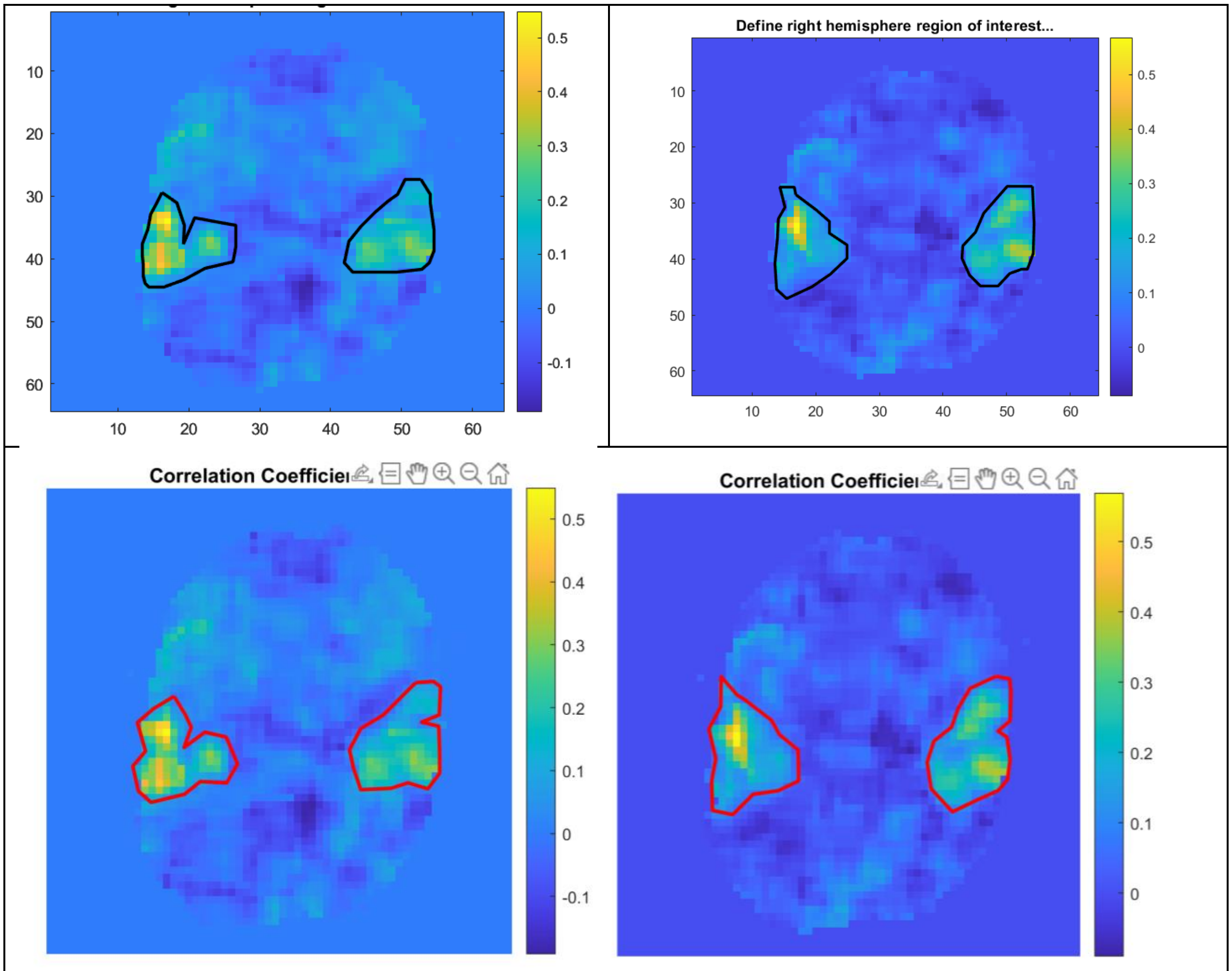
Deliverables:

1. A figure of an original and smoothed image.



2/3. A figure showing the ‘word’ correlation coefficient map with your ROIs (use the *line* command to show the border of your region). A figure showing the ‘chord’ correlation coefficient map with your ROIs.





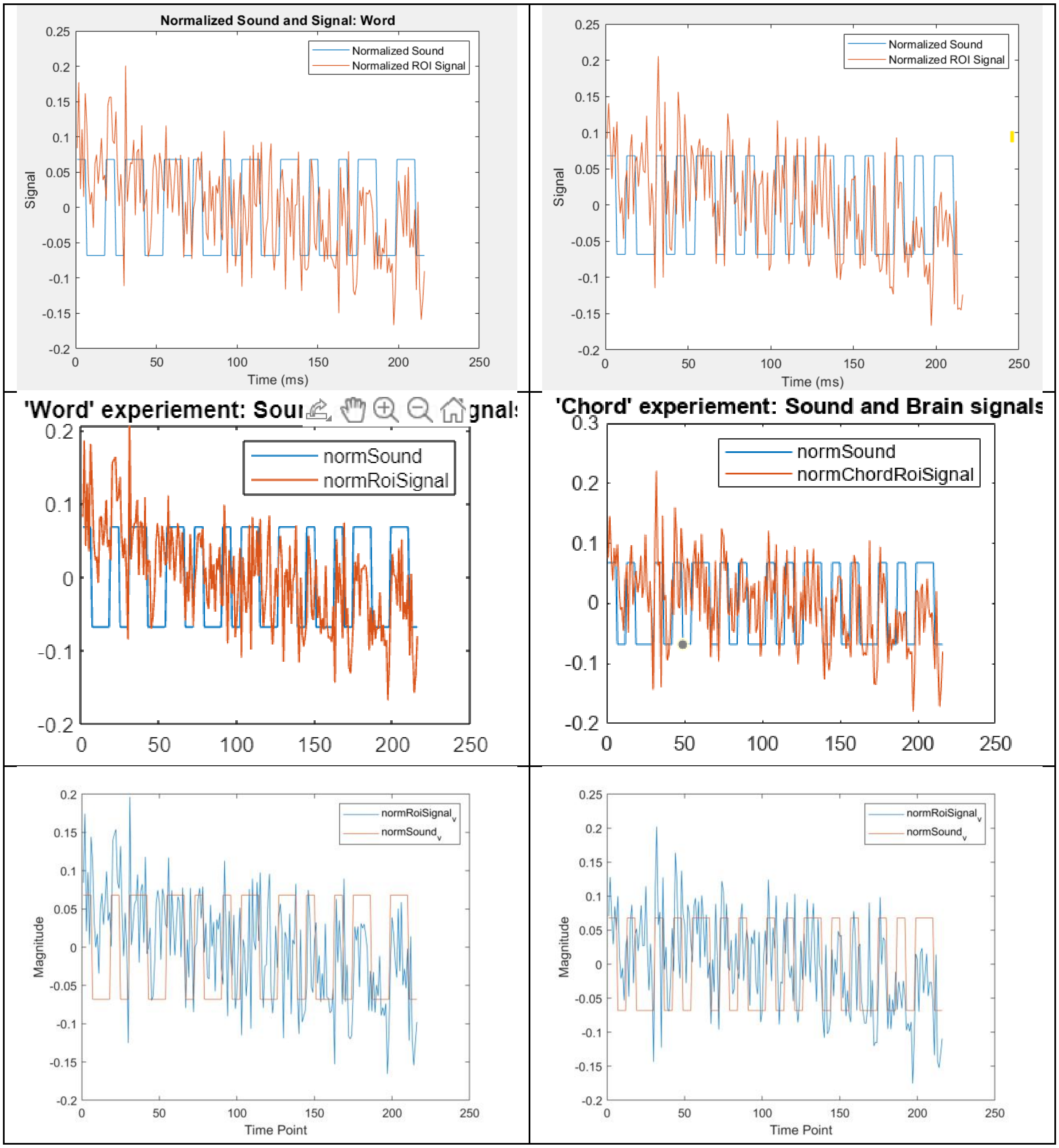
Word stimulus

Chord stimulus

4. Your plots of ROI signal intensity versus time for both stimuli.

Depending on our region of interest, we will have the corresponding plots as below

word	chords



CNR was calculated using the equation:

$$CNR = \frac{meanStim - meanRest}{\sqrt{\left(\frac{1}{2}\left(\sigma_{Stim}^{2} + \sigma_{Rest}^{2}\right)\right)}}$$

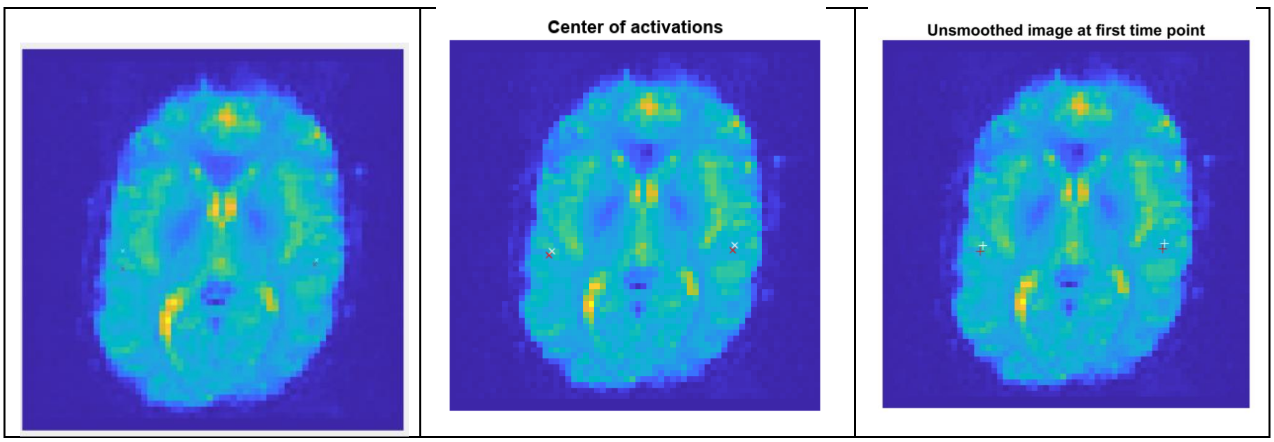
Word stimulus

meanStim	1.7556e+07	1.9101e+07	2.3169e+07
meanRest	1.7468e+07	1.9014e+07	2.3073e+07
CNR (before drift-subtraction)	0.6772	0.6445	0.6421
CNR (after drift-subtraction)	0.9298	0.8436	0.7673

Chord stimulus

meanStim	1.4845e+07	2.6519e+07	2.6449e+07
meanRest	1.475+07	2.6393e+07	2.6319e+07
CNR (before drift-subtraction)	0.8361	0.8491	0.8040
CNR (after drift-subtraction)	1.0706	0.9367	0.9375

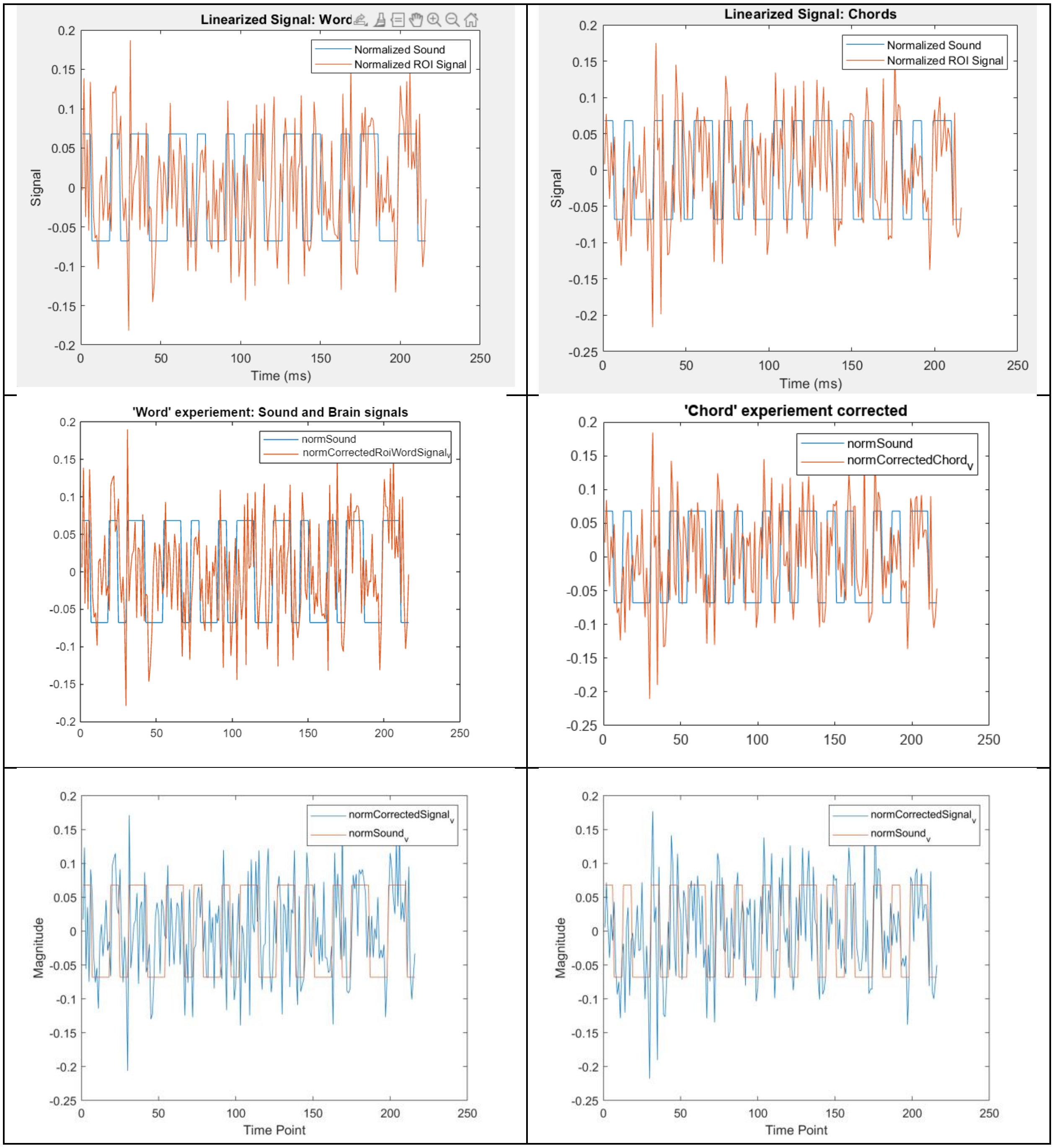
2. A figure showing the location of the center of Word and Chord activations in each hemisphere. Display these as dots (or crosses) on a single, unsmoothed image of the brain.



Red = "Word" stimulus; White = "Chord" stimulus

3. [Grad/extra credit] Your plots of ROI signal intensity versus time after trend removal (both stimuli).

word	chords



Questions:

1. Why does the signal increase when the subject hears the sound (words or chords)?
   - Neurons need energy (in the form of glucose and oxygen) to do work. When the neurons become activated (I.e., when a sound is heard), they require more energy and cerebral blood flow increases locally to meet these demands. As a result, oxygen saturation increases locally. Because oxygen makes the iron in hemoglobin less magnetic, the magnetic field around blood vessels in the brain becomes more uniform

(T2 star increases) and the measured signal increases in turn because there is less dephasing.

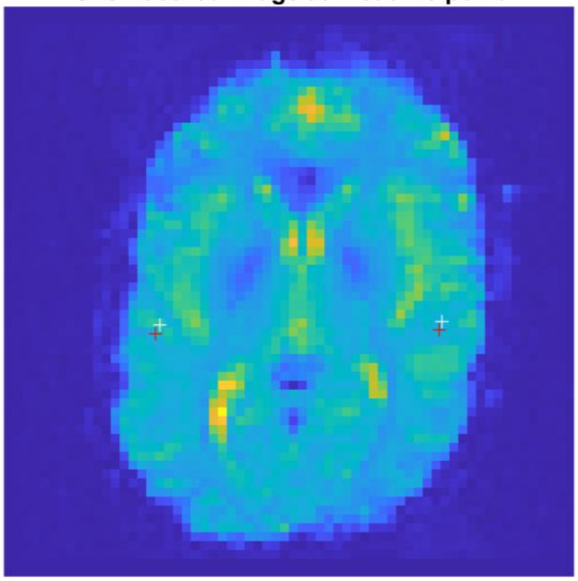
2. What is the contrast-to-noise ratio of the BOLD measurement for each stimulus? What are some strategies (beside step #12) that you could use to improve this?
   - CNR for "Word" stimulation: 0.6421-0.6772
   - CNR for "Chord" stimulation: 0.8040-0.8861

Strategies to improve CNR:

- Improve signal by increasing contrast or resolution
- Improve the ROI fitting to be sure we only include stimulated area by using a thresholding algorithm such as Sobel Edge detection. For example, being more stringent when drawing the ROIs (drawing smaller ROIs) will increase our CNR. Thus, we can choose a higher threshold when using a thresholding algorithm to ensure that only stimulated areas are included in the ROI.
- In this assignment, we remove drift effects from the signal which increases the CNR by decreasing the noise

3. Studies have shown that speech, like all sounds, is processed by the 'primary' auditory cortex, but unlike other stimuli, the information is then fed to a neighboring area farther back (i.e., posterior) in the temporal lobe. Are your measurements of the centers of activation consistent with this model? If the primary auditory area detects the frequency and timing of sounds, what do you think the neighboring area might do? The 'words' used in our experiment are comprised of standard English phonemes (i.e., sounds, for example 'vos'), but have no meaning.
   - Our measurements appear to be consistent with the proposed model, because the centers of activation for the "Words" stimulus are further back in the brain than the centers of activation for the "Chords" stimulus (as shown in image below). This would suggest that posterior areas of the brain have higher activation when the brain hears speech as opposed to when the brain hears other sounds (non-speech).

Unsmoothed image at first time point



Red = “Word” stimulus; White = “Chord” stimulus

- The neighboring area may be involved in the classification of sounds (for example, recognition of phonemes) and the understanding of language. This area may also be involved in remembering speech/verbal information.

4. [Grad/extra credit] What activation CNR did you measure for each stimulus after removing the linear trend in signal? Did this step improve the CNR? Why does your result make sense?
   - CNR for “Word” stimulus: 0.7673-0.9298
   - CNR for “Chord” stimulus: 0.9367-1.0706

   Yes, removing the baseline drift in the signal improved the CNR. This makes sense because the drift itself was a form of low-frequency noise that served to disrupt our signal. Because we eliminated this component of noise, our CNR increased; by reducing the noise, we decrease the standard deviation, making the fraction (signal difference/standard deviation) greater.

<u>Code:</u>