

# Coding Neuroimaging Masks to Improve Mice Brain Imaging Analysis

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# Introduction

There is an ongoing state of activity that spans all across the brain. This activity is called *spontaneous activity or resting state activity*.

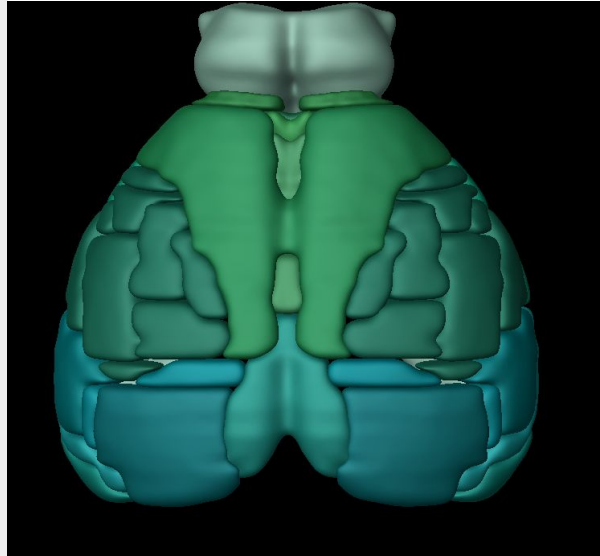
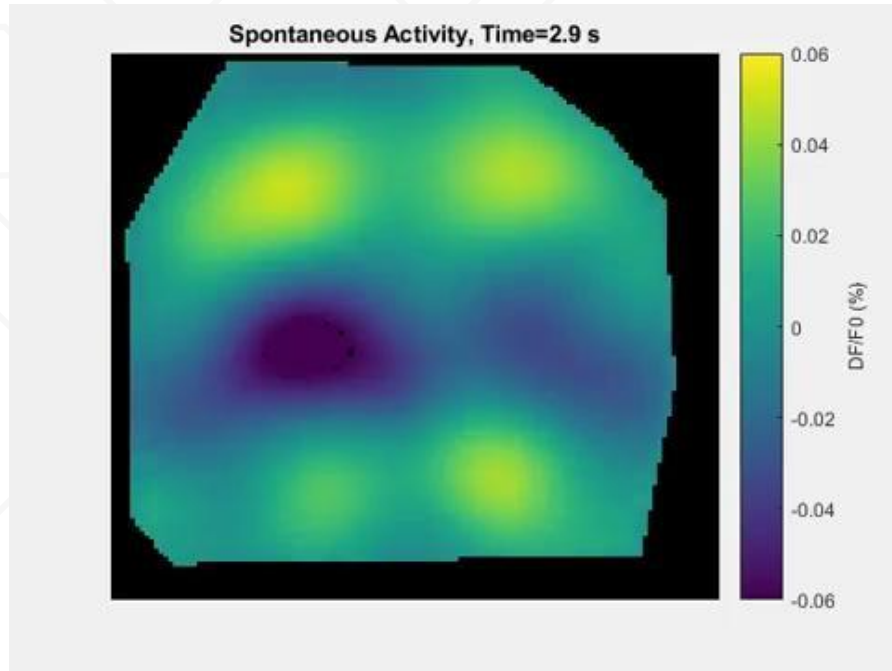
People have used this activity to study the functional organization of the brain by observing and trying to discover possible connections from one part to another. Scientists are attempting to better understand the connections between the different parts of the brain to identify what parts of the brain are affected or changed by mental disorders and diseases to better diagnose and treat them. Scientists do so by comparing how similar to one another these regions are. Highly correlated brain regions are inferred to be connected (Dr Allen Chan, 2021).



## Background

Scientists and laboratories, including the Allen Chan Neuroimaging Lab, use fluorescence biosensors in transgenic mice for their experiments in mice neuroimaging. The fluorescence biosensors are used to get clearer coloured pictures of the brain activity. They are apart of a special lab generated species of mice called C57B16-Thy1-GCamP6s that are used to minimize external factors (Dr Allen Chan, 2021).

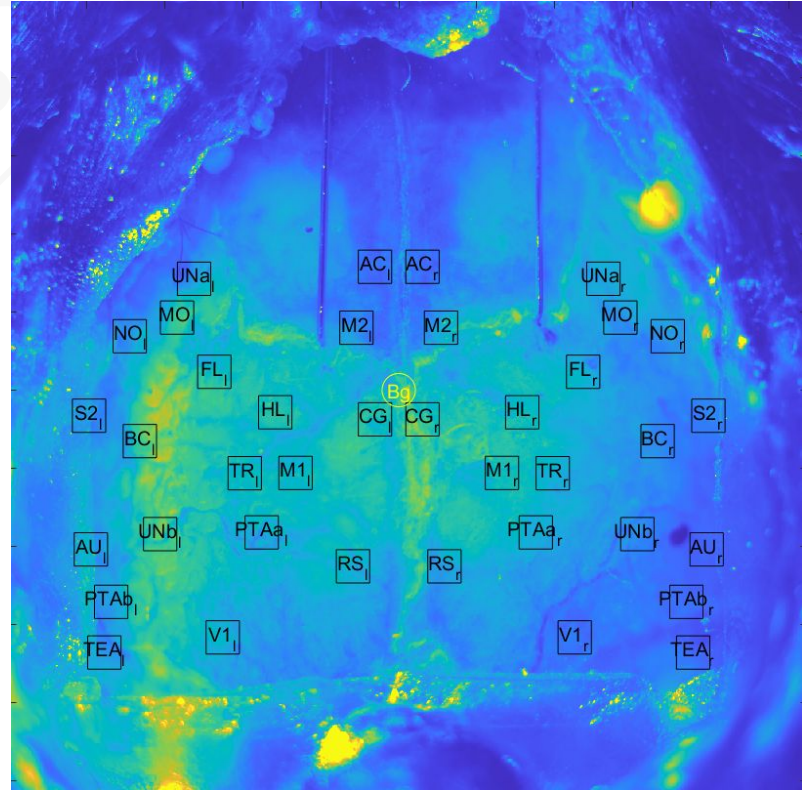
# 01.



An example of what spontaneous brain activity looks like using fluorescence biosensors.

# Introduction

The regions of the brain are irregularly shaped. (Dr Allen Chan, 2021). The irregular shape makes it difficult to gather data from the entire region. Often researchers use *region of interest* (boxes) method to measure spontaneous brain activity (Dr Allen Chan, 2021). This method allows scientists to gather measurements from within the parameters of the box. They can place the box in whichever region they are interested in (hence region of interest) to gather data from the specific region to utilize in the experiment they are conducting.



## Introduction

The other method, referred to as the *region of function*, is the outlining of the irregular shapes of the regions of the brain. **This method gathers information from the entirety of the functional region instead of solely in the box shaped region of interest that is typically used.**

# Brief history of discoveries in brain mapping and function.



## Gage

Gage was a railroad worker who was impaled in the head with an iron rod, but survived and seemingly recovered.

Later it was discovered that his mood had changed drastically. It was the first discovery made about mood being linked to the brain (Guy-Evans, 2020)

## H.M.

H.M. was a famous psychology case of a man suffering from epilepsy went through a lobotomy, where his hippocampus was removed, but ended up not being able to make new memories. This is how scientists and doctors discovered that the hippocampus was the part of the brain that made memories (Squire, 2009).

## Penfield

Penfield was a Canadian neurosurgeon who experimented on awake patients to map brain activity (Brown, 2018).

## History

1800s

Phineas Gage

1940s

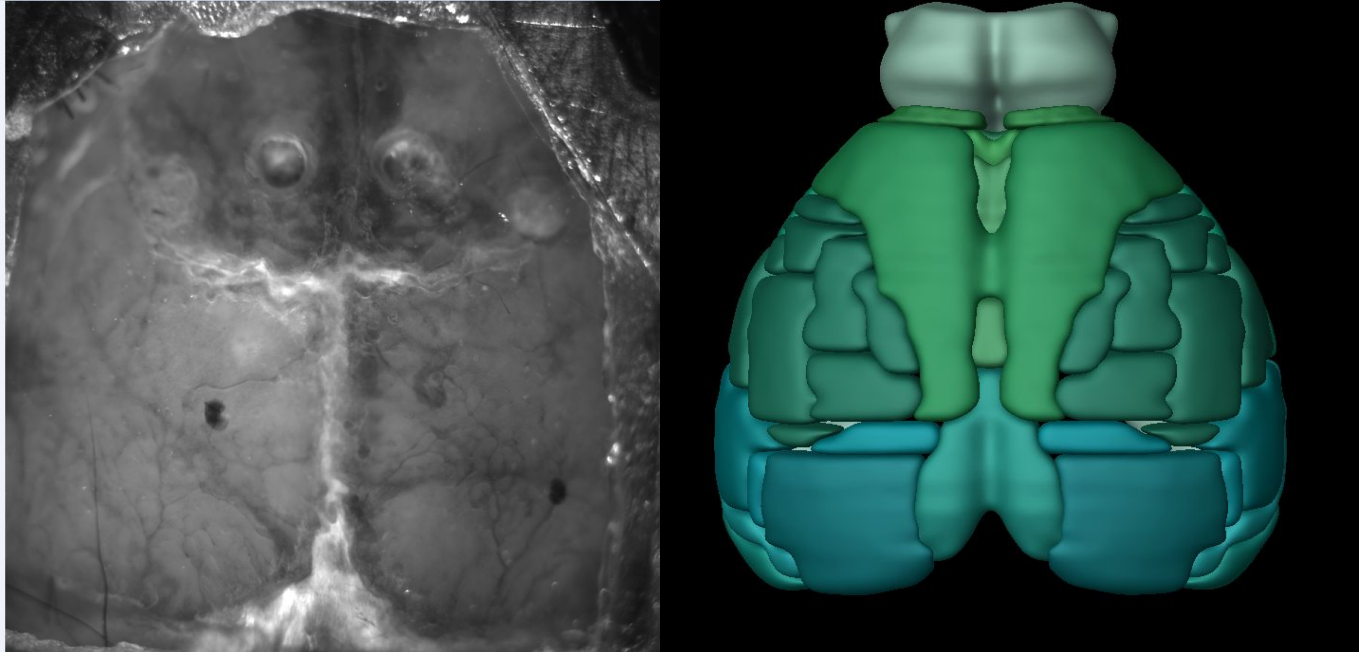
H.M.

1920s -1960s

Wilder Penfield

# 02.

On the left is an image of a mouse brain and on the right is a graphical depiction of the brain. In the right image the functional regions are outlined so that we can see where they are and what they look like.



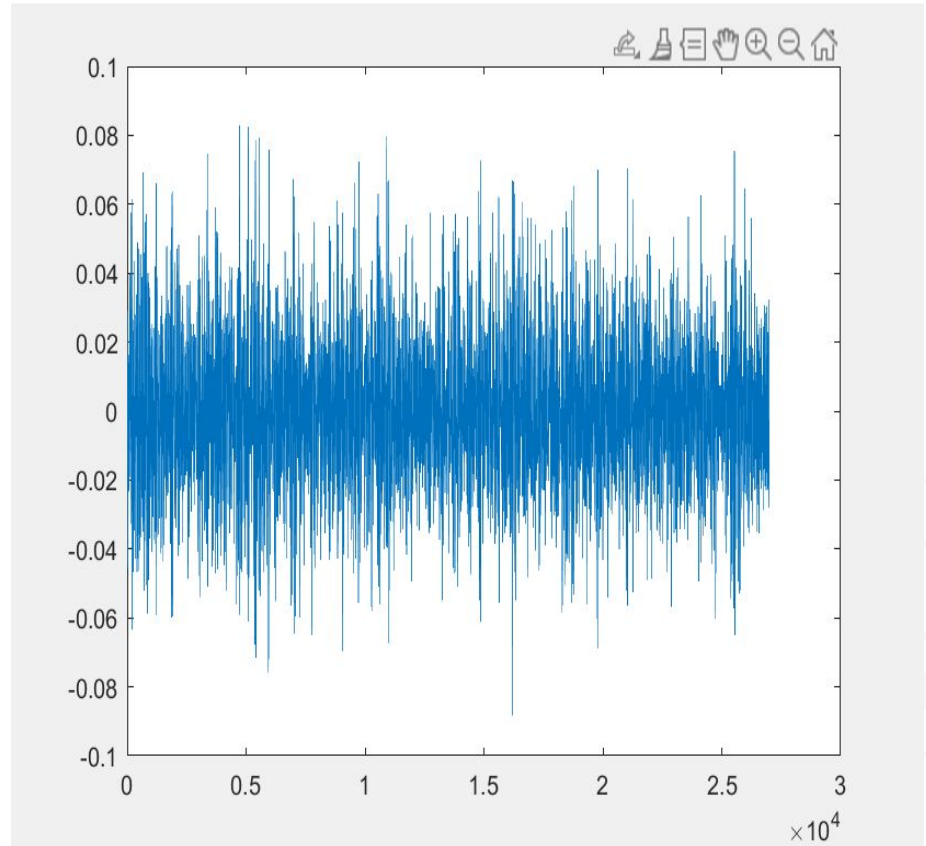


# Objective

**The main objective of the experiment is to determine the differences, if there are any, between the region of interest method and the functional region method.** This will be achieved by testing functional organization of the cortex by using both methods and generating a correlation matrix to compare them (Dr Allen Chan, 2021). Through this we may infer what method is more effective in measuring brain activity. If scientists can figure out which method is more effective, then they will be able to have more accurate results when gathering data. Which can be applied to researching neuro diseases and disorders.

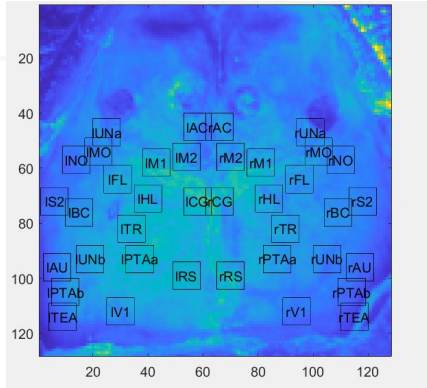
# What is a Time Course?

A time course is a plot of how brain activity changes over time during spontaneous activity. It is measured by the fractional change in fluorescence intensity (Dr Allen Chan, 2021) on the y axis ( $\% \Delta F/F$ ) to time on the x-axis (min or frames)



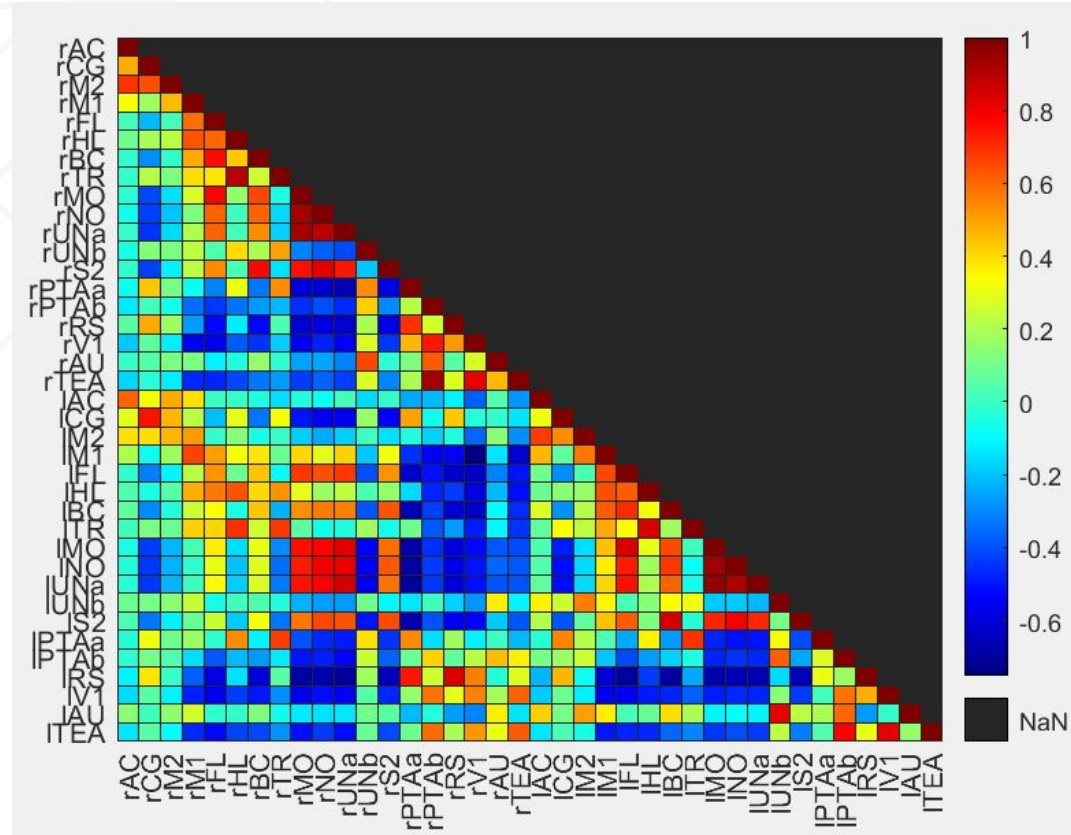
# The Region of Interest Method

MATLAB code (The Allen Chan Neuroimaging Lab) is used to run the spontaneous brain activity imaging. A time course is produced from the data within the region of interest.

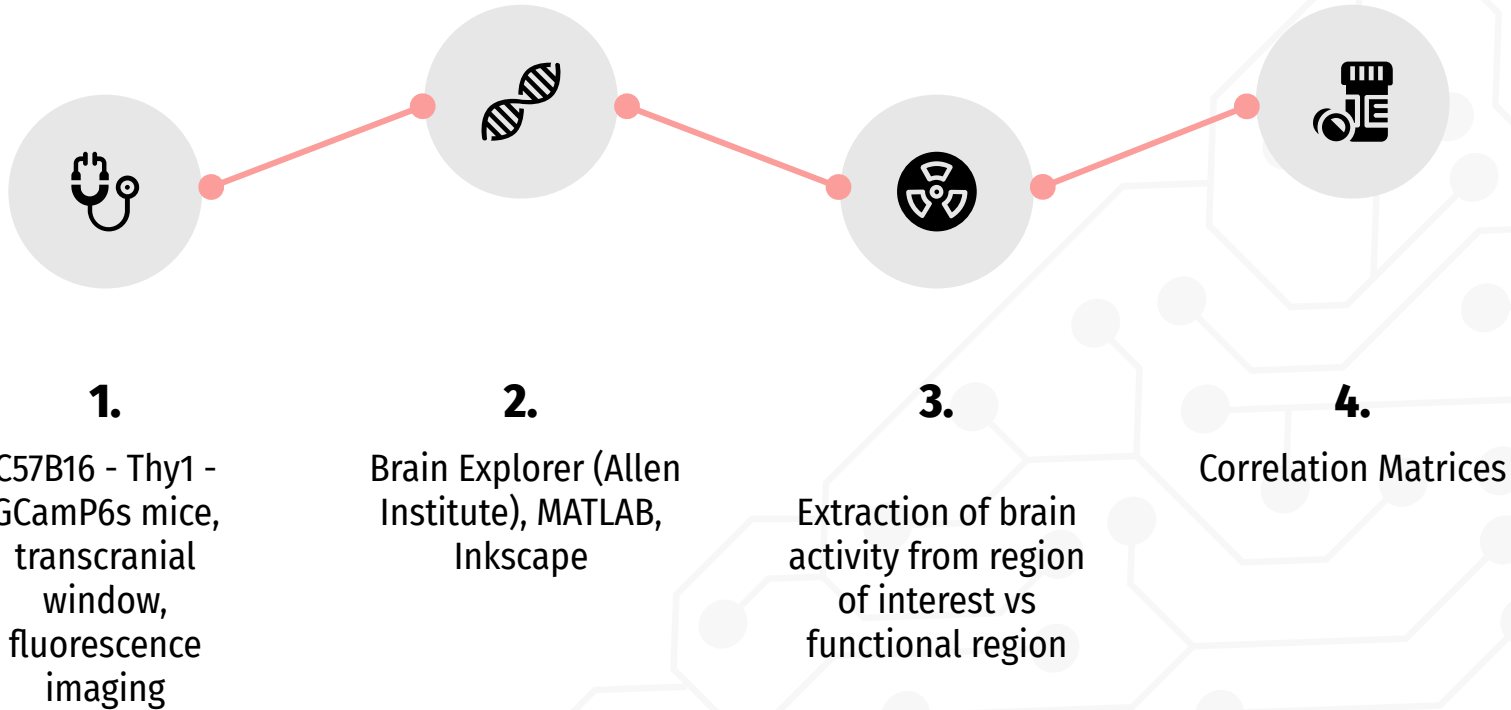


# 03.

This is the Correlation matrix for the Region of Interest Method. The graph ranges from -1 (blue) to 1 (red) to depict the similarities and differences. If one region of interest is similar as another it ranges from 0 to 1 depending on how similar. If one region of interest time course is the opposite of another region of interest time course then it ranges from 0 to -1 depending on how close. 0 means they have nothing in common at all.



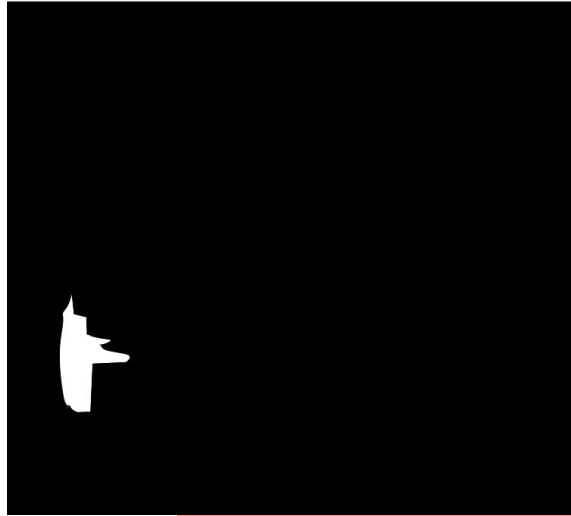
# New Method



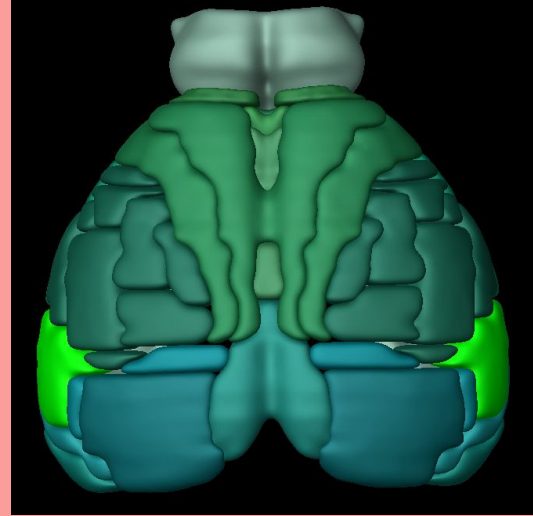
# Functional Region Method

Using graphics from The Allen Institute Brain Explorer and using the Inkscape software I am able to make outlines of the entire functional region that is required.

In this example I've isolated the region depicting the left primary auditory cortex (white region in left image, green images depict left and right hemispheres in right image)

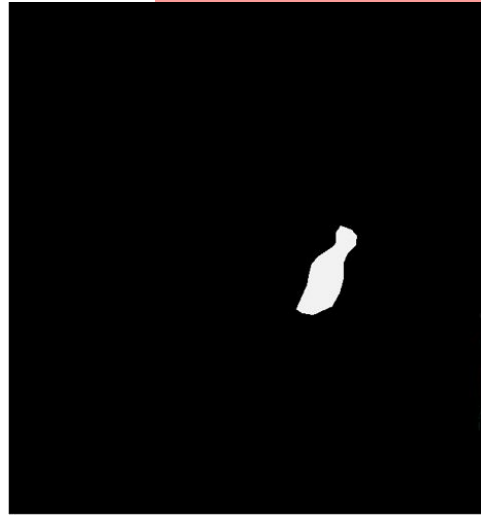


**Left Primary Auditory Mask**

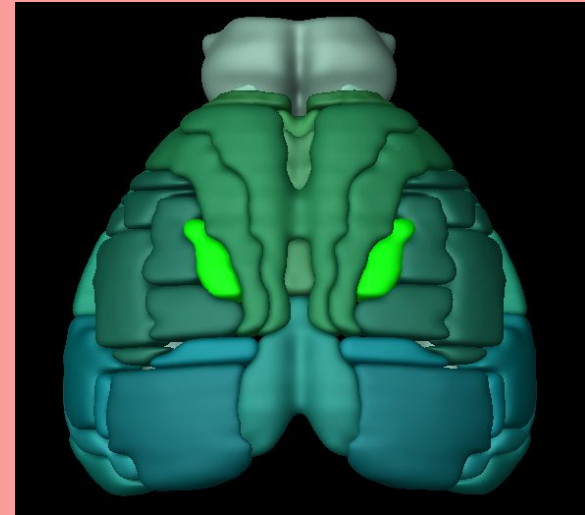


# Functional Region Method

Then the outline, or mask, is placed over the spontaneous brain activity imaging so that data can be collected from the entire functional region using MATLAB software. In this example I've isolated the region depicting the right hindlimb somatosensory region (white region in left image, green images depict left and right hemispheres in right image)



Right Hindlimb Mask

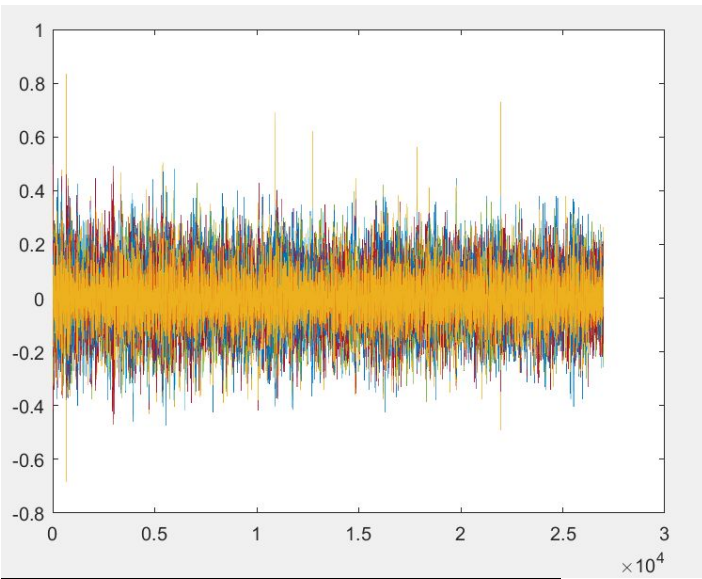


## **MATLAB.**

Using Matlab code I resized the mask being used to fit the dimensions of the spontaneous brain activity. Then using MATLAB code provided by the Allen Chan Neuroimaging Lab, a loop was created to record the data from within the region of the mask over the 10 minutes.



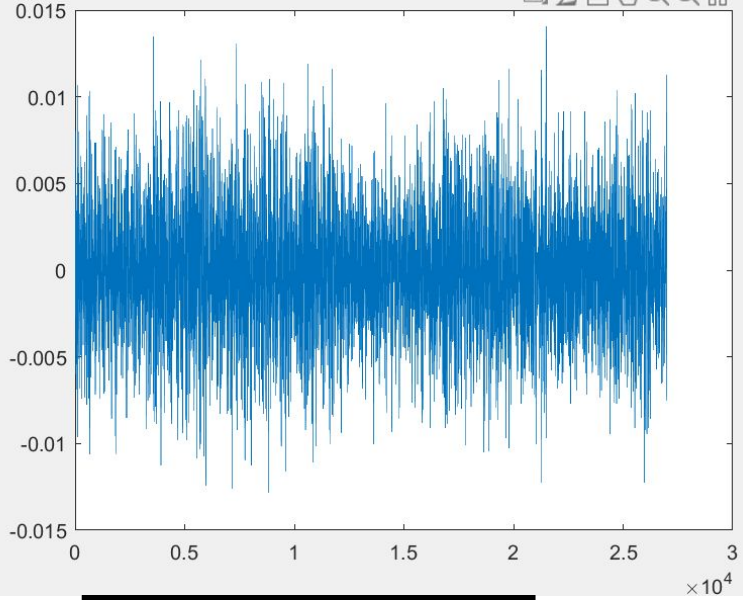




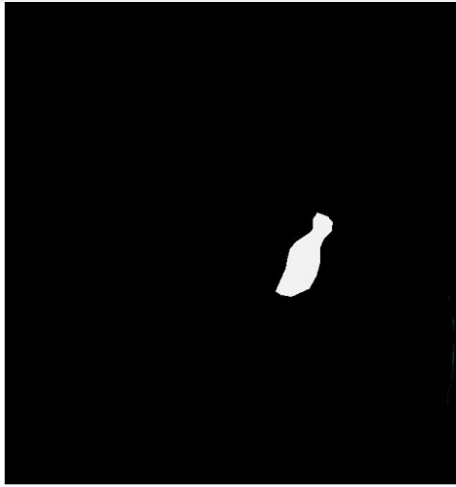
# Time Course Left primary auditory

On the top is the time course that was produced from the left primary auditory region of the mouse brain using a mask (bottom picture) which is the functional region method.





# Time Course Right hindlimb



On the top is the time course that was produced from the right hindlimb region of the mouse brain using a mask (bottom picture) which is the functional region method.



# Comparison.



## Region of Interest

The region of interest correlation matrix had more similarities between its time courses. That is why we saw deeper reds and blues because the cross correlation is or very close to -1 and 1 meaning that they were either almost exactly the same or the exact opposite of each other.



## Functional Region

The functional region correlation matrix has a lot of cross correlations that are or are close to -1 and 1 too but they also have a few that are close to 0 meaning the corresponding time courses are not related.

## Comparison.



In the correlation matrix for the difference between the Region of Interest correlation and the Functional Region Method correlation we see a few cross correlations that are white which means they are close to 0. This means that the two time courses ( of the exact same region) being cross correlated are the same. No difference means that no matter the method used, the results will be most likely the same.



But in the difference matrix there are some cross correlations that are shades of red and blue. These shades of colours indicate that the correlation between pairs of time courses are not the same as each other. The darker the shade of red or blue the bigger the difference between them.

## Conclusion.

In the Correlation Difference Matrix, it is observed that there are differences between the Region of Interest and Functional Region matrices. That means that there are differences in the time courses produced by both methods. Based on this information we know that there is more than one way to gather data from neuroimaging and produce a set of data. To take this experiment a step further, finding out which method is more accurate would be important. Theoretically the Functional Region Method should be more accurate because it gathers data and brain activity from the entirety of the region instead of within a smaller parameter. In conclusion, it is proven that these two methods produce different results.

# Acknowledgements.

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# Citations.

Silasi, G., Xiao, D., Vanni, M. P., Chen, A. C. N., & Murphy, T. H. (2016). Intact skull chronic windows for mesoscopic wide-field imaging in awake mice. *Journal of Neuroscience Methods*, 267, 141–149. <https://doi.org/10.1016/j.jneumeth.2016.04.012>

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