In the name of God

Sharif University

Electrical Engineering Department

Sharif Brain Center

Advanced Neuroscience Course

Dr. Ali Ghazizadeh

Homework 4

Traveling Wave

By Amirreza Bahramani

May 2023

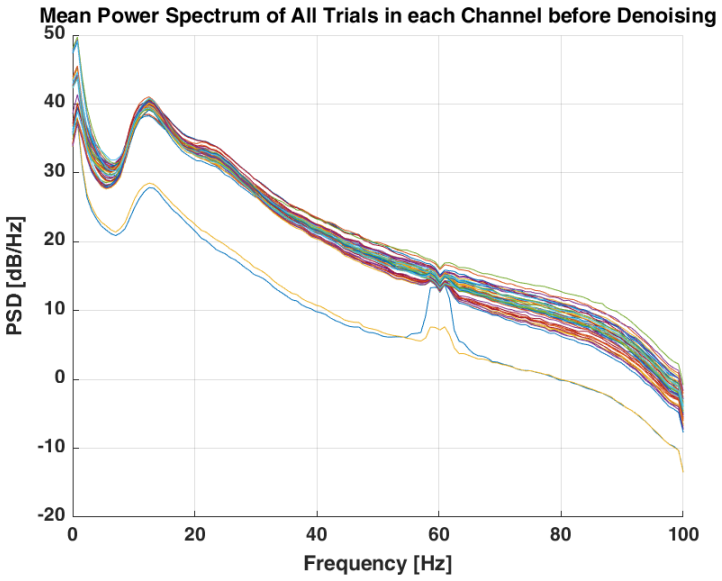
In this homework, we want to do some analysis on LFP data and investigate traveling waves and their properties.

All codes and demos are available in the directory.

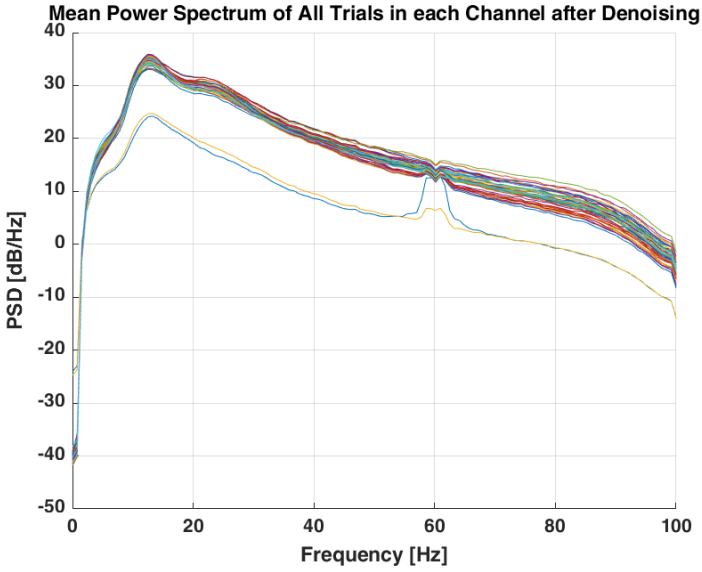
Part 1 (LFP Analysis):

At first, we choose clean trials so I removed bad trials from the original data.

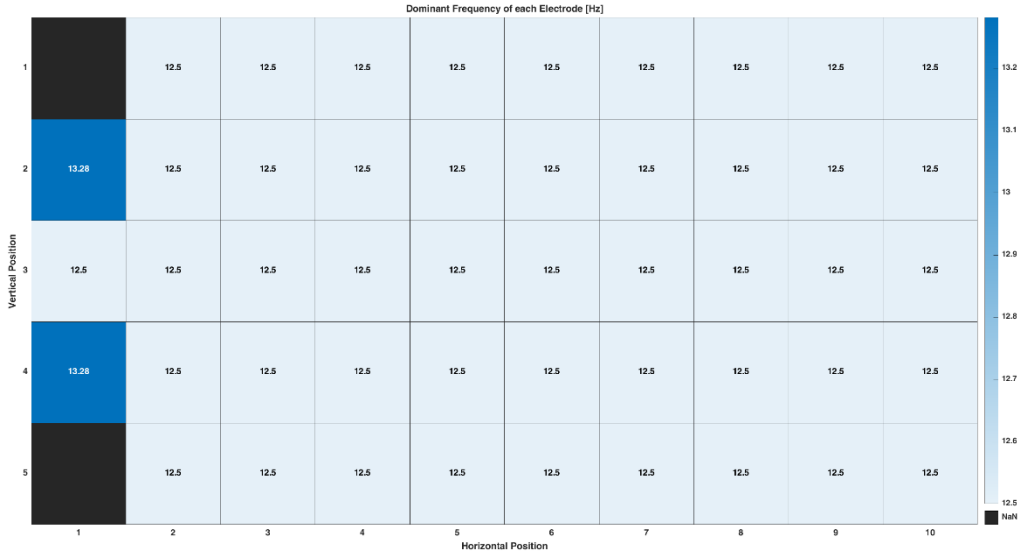
a) In the first step we should denoise our signal from the Pink Noise aka 1/f noise.



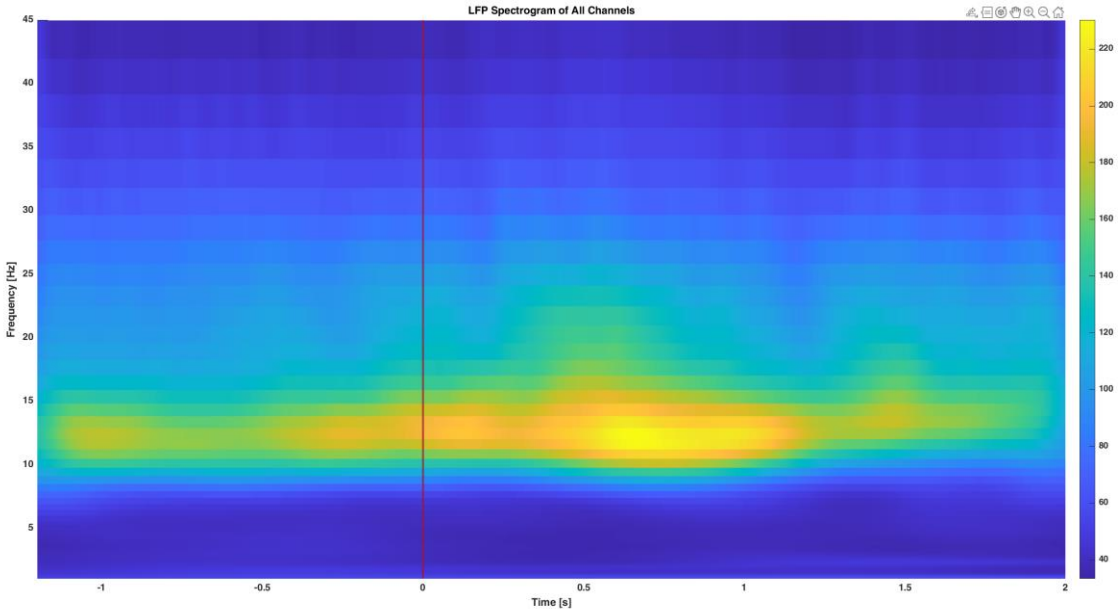
Above you can see the frequency domain (by Welch) of all trials -stacked together- of each channel before denoising. Below you can see the same after denoising.



b) In the next step I calculated the dominant frequency of each electrode in all trials. As you can see the dominant frequency for almost all of them is the same and around 12.5 Hz. This shows the possibility that the same wave is propagating through all of them.

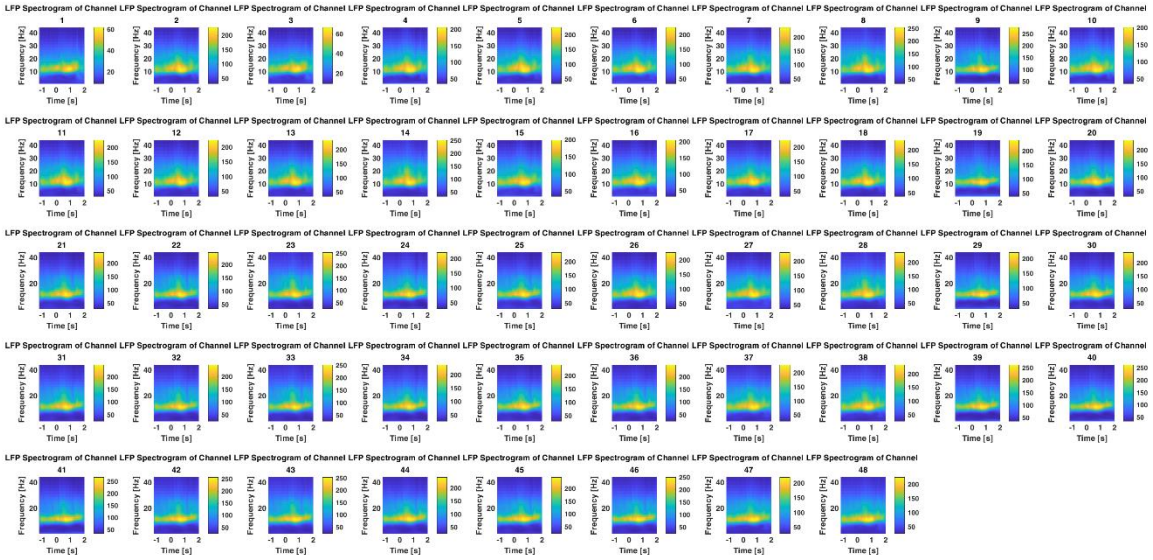


c) Now we have to do the time-frequency analysis by plotting the spectrogram of LFPs. To do so I used CWT (Continuous Wavelet Transform).

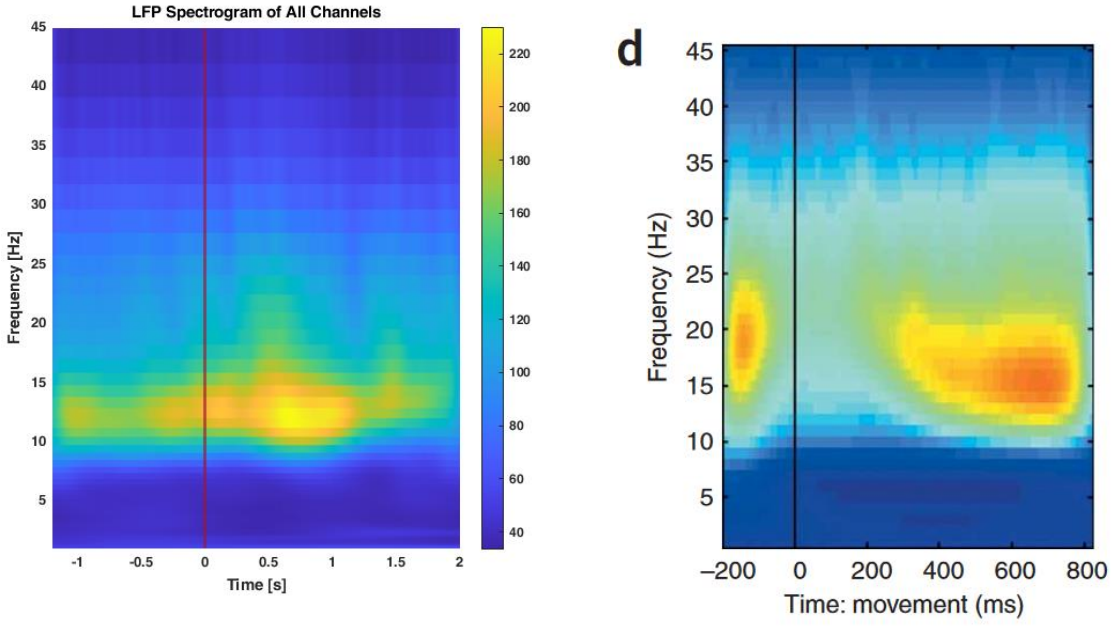


Above you can see the mean spectrogram of all trials.

Below is the spectrogram of each electrode. They are very similar. Confirming the wave propagation.



d) At last you can see that the calculated spectrogram is much like the spectrogram reported in (Rubino et al., 2006)

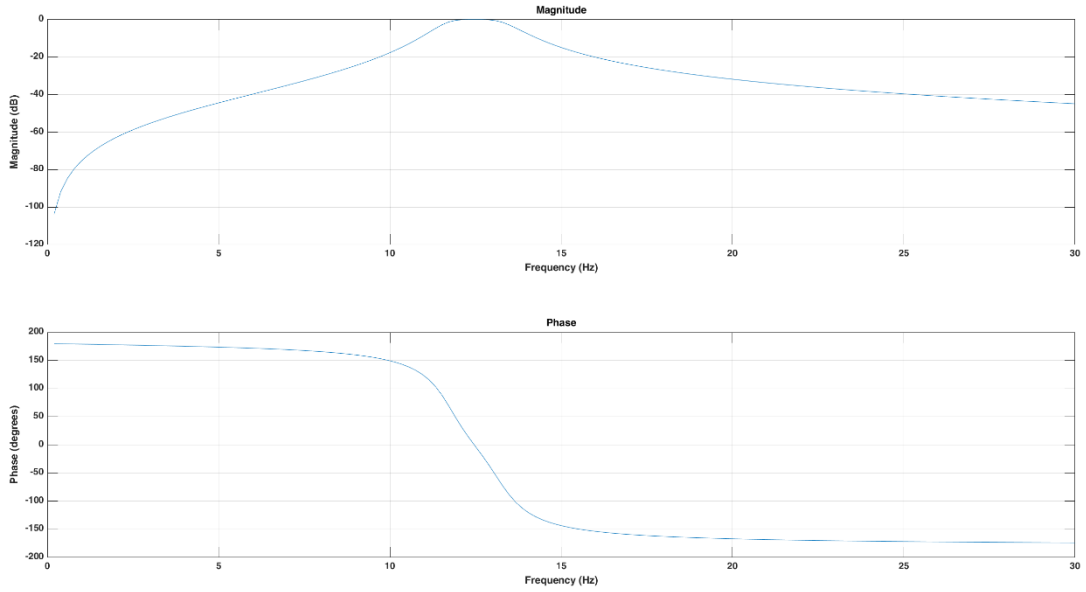


It's obvious that our LFP signal is mostly in the Beta band and a little in the Alpha.

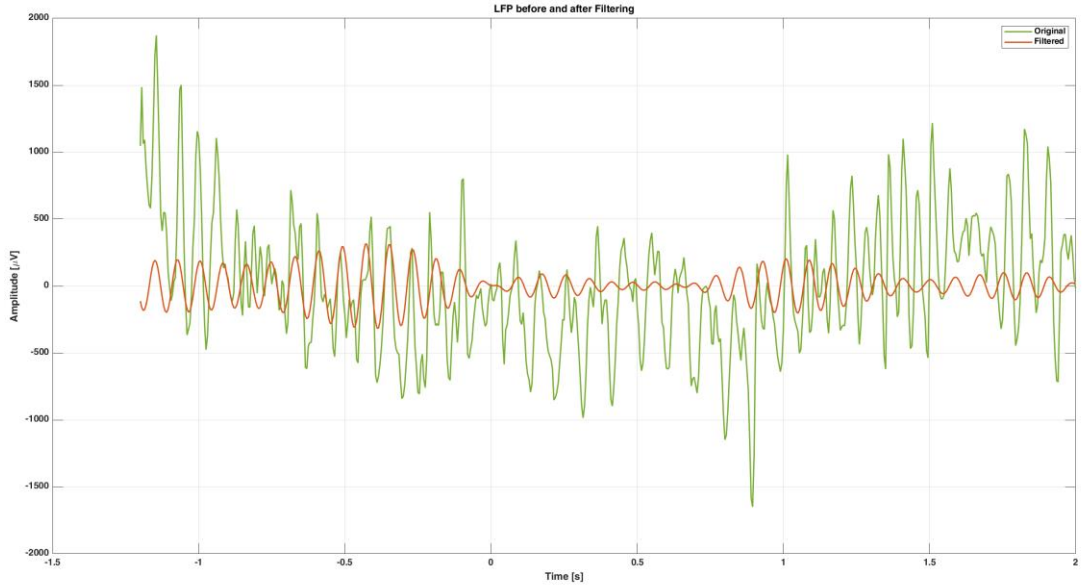
Part 2 (Phase Propagation):

In this part we investigate the propagating properties of LFP waves.

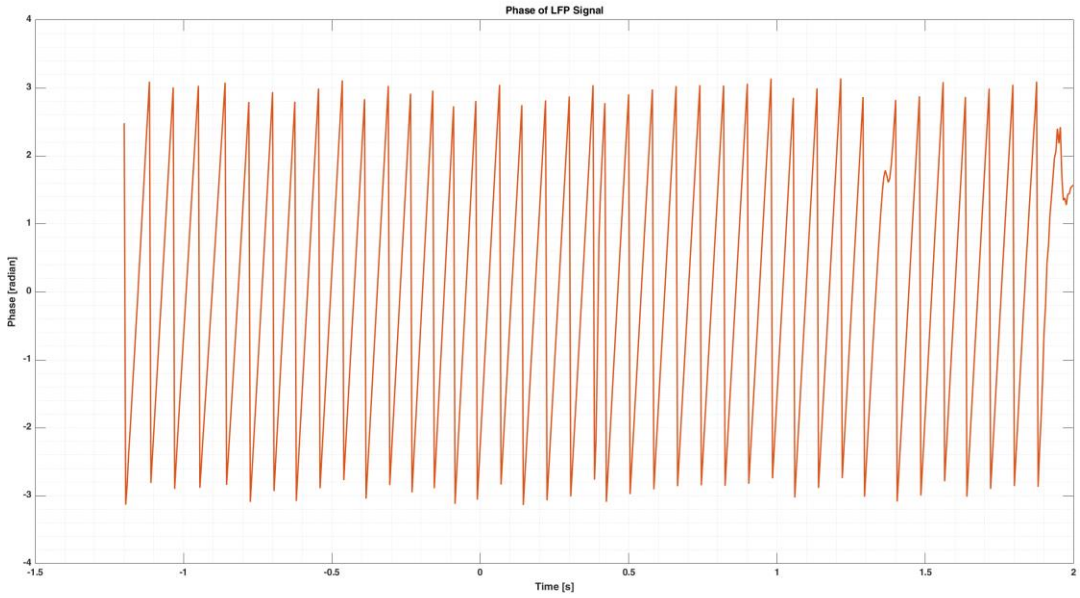
a) At first we passband filter the signal using a 2nd order Butterworth filter shown below.



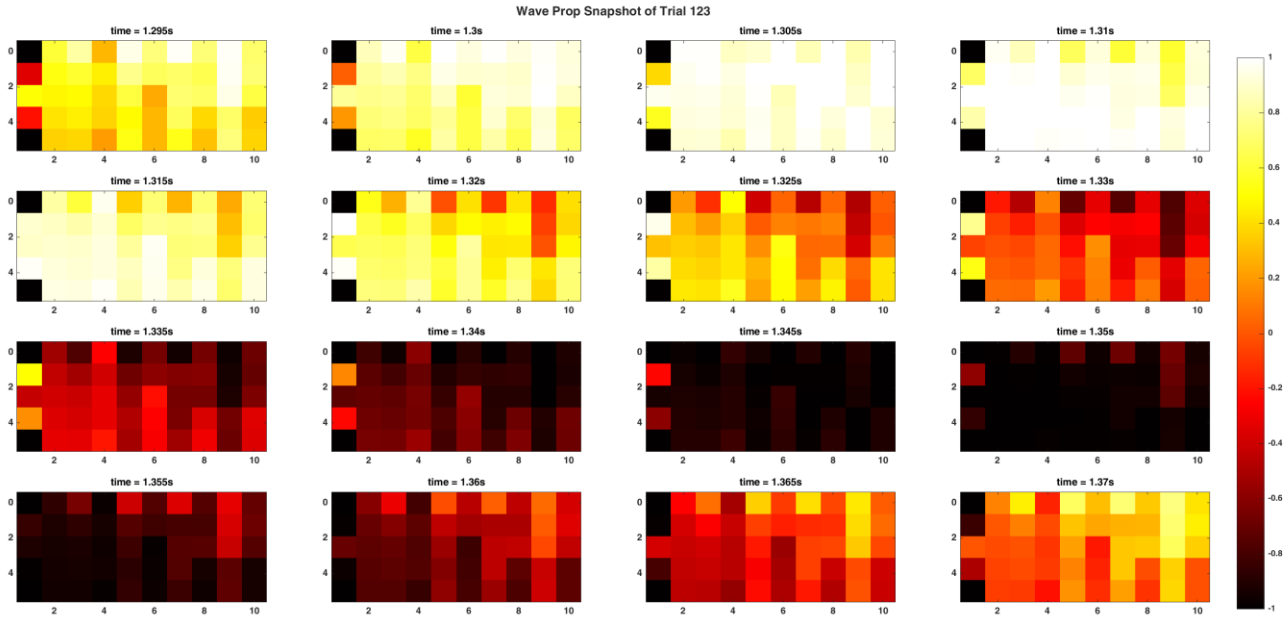
You can see the effect of filtering on a sample tial of one of the electrodes.



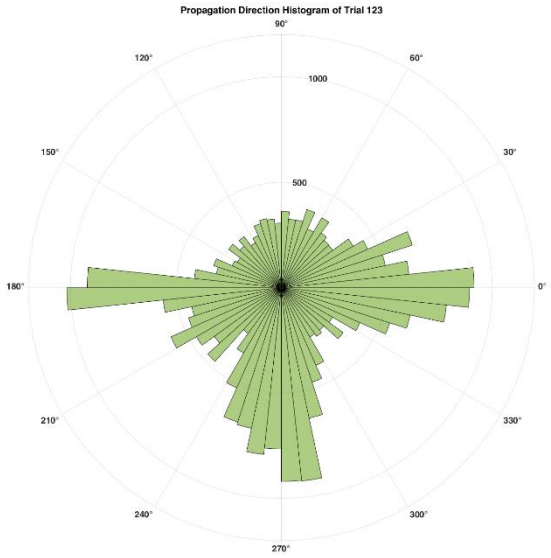
b) Then we calculate the phase at each time point using Hilbert Transform. One sample is shown below.



c) By using the phase at each time point we can create a demo of wave propagation. One Snapshot is shown below and the video is in directory.



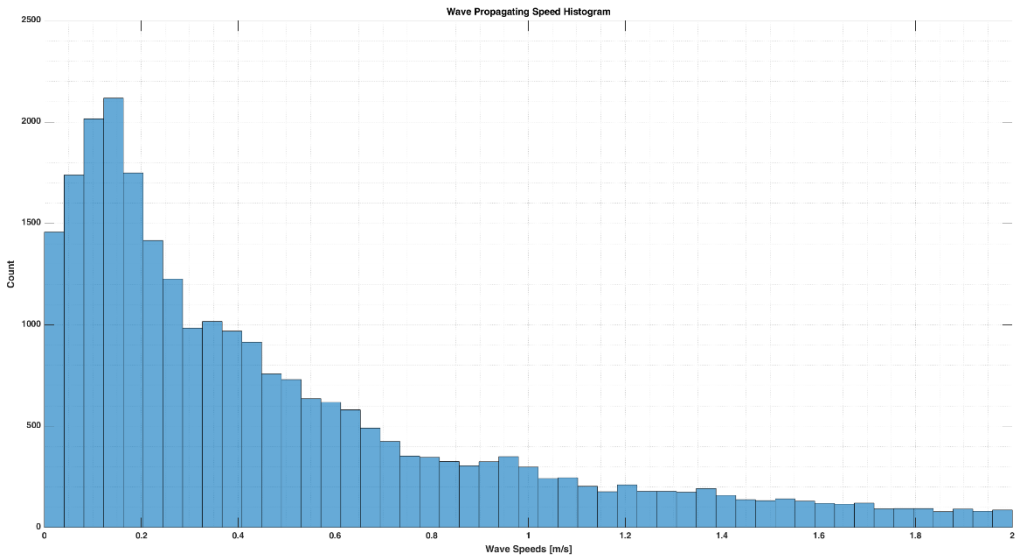
d) Now we use the gradient of phase at each point to see the direction of propagation. Below you can see the histogram of all. As you can see most of the propagation is in horizontal direction and some is going down.



And for some timepoints.

e) The demo is in directory.

g) You can see the hist of speeds. These speeds were calculated in the horizontal direction and they are what had been reported in (Muller et al., 2018)



References:

Muller, L., Chavane, F., Reynolds, J., & Sejnowski, T. J. (2018). Cortical travelling waves: Mechanisms and computational principles. *Nature Reviews Neuroscience*, *19*(5), 255–268. https://doi.org/10.1038/nrn.2018.20

Rubino, D., Robbins, K. A., & Hatsopoulos, N. G. (2006). Propagating waves mediate information transfer in the motor cortex. *Nature Neuroscience*, *9*(12), 1549–1557. https://doi.org/10.1038/nn1802