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**PBIO Project**

**INVESTIGATION OF COCKROACH FLIGHT-CPG BEHAVIOR ACROSS THE AXES**

**Opening statement:**

For my project, I will be using *pearson correlation* & *fourier transformation* to analyze EMG data. The goal of using these statistical methods is to investigate the CPG behavior across the axes in a cockroach.

**Background:**

Central pattern generators (CPGs) are networks of functionally distinguishable neurons that generate and regulate activity in the absence of sensory input. CPG dynamics are largely dependent on events at the intracellular, synaptic, and network level. In cockroaches, if we were to look at the neural circuit involved in the CPG, we would notice that these neurons are interconnect via both excitatory and inhibitory neurons.

A basic explanation of the methodology of this experiment involved recording EMG signals from the forewings and hindwings of the cockroach. The CPG activity was invoked through using artificially generated wind current. We recorded the normal activity of the cockroach suspended in the air and following we manipulated its orientation by adjusting pitch and roll.

Here is the Matlab code how the EMG data was constructed into graphs.

1) Plot the graphs of voltage as a function of time

% the plotter function takes in the time points along the

% x-axis as 't', and then take in the voltage values as 'v'

% and finally 'cutoff' is the number of points we want to

% plot

function [ output\_args ] = plotter( t, v , cutoff)

plot(t(1:cutoff), v(1:cutoff))

xlabel('Time (s)');

ylabel('Voltage (V)');

end

2) Generate the EMG graphs in the command window:

%% generate EMG Data as a function of time

% we will use the plotter function that takes the

% to generate our plots

%% Normal Flight EMG

plotter(Normal1, Normal2, size(Normal1)) % rostral contralateral wing

plotter(Normal1, Normal3, size(Normal1)) % caudal contralateral wing

plotter(Normal1, Normal4, size(Normal1)) % rostral ipsilateral wing

plotter(Normal1, Normal5, size(Normal1)) % caudal ipsilateral wing

%% Pitched Flight EMG

plotter(Pitch1, Pitch2, size(Pitch1)) % rostral contralateral wing

plotter(Pitch1, Pitch3, size(Pitch1)) % caudal contralateral wing

plotter(Pitch1, Pitch4, size(Pitch1)) % rostral ipsilateral wing

plotter(Pitch1, Pitch5, size(Pitch1)) % caudal ipsilateral wing

%% Rolled Flight EMG

plotter (Roll1, Roll2, size(Roll1)) % rostral contralateral wing

plotter (Roll1, Roll3, size(Roll1)) % caudal contralateral wing

plotter (Roll1, Roll4, size(Roll1)) % rostral ipsilateral wing

plotter (Roll1, Roll5, size(Roll1)) % caudal ipsilateral wing

**Statistical Methods:**

With the collected EMG data, using a *pearson correlation* seemed reasonable as it would test the association between the activity of the wing beat frequencies. In other words, when a cockroach uses one wing, is that a factor in determining another wing will be used? For the three orientations, we tested the relationship between the wings of the rostral contra-ipsilateral axis, caudal contra-ipsilateral axis, and the ipsilateral right axis. The Pearson values found can be found in the slides I emailed to professor Rieke. Rather, here I will show you the Matlab scripts I used for Pearson.

1) written function to calculate the Pearson:

% the pearson function takes in data from two

% sets of data, calculates the covariance between

% the sets, and finally spits out the calculated

% pearson correlation value

function [ p ] = pearson\_f( x, y )

C = cov(x, y);

p = C(2)/(std(x)\*std(y));

end

2) I then used the command window to calculate the Pearson values between the EMG data:

% generate the Pearson coefficients for cockroach CPG flight

% data. Here we compare the anterior wings, posterior wings, and

% ipsilateral anterior and posterior wings.

format Compact

% Normal flight patterns

pearson(Normal2,Normal4) % rostral Contra-ipsilateral axis

pearson(Normal3,Normal5) % caudal Contra-ipsilateral axis

pearson(Normal4,Normal5) % ipsilateral right axis

% Pitched flight patterns

pearson(Pitch2,Pitch4) % rostral Contra-ipsilateral axis

pearson(Pitch3,Pitch5) % caudal Contra-ipsilateral axis

pearson(Pitch4,Pitch5) % ipsilateral right axis

% Rolled flight patterns

pearson(Roll2,Roll4) % rostral Contra-ipsilateral axis

pearson(Roll3,Roll5) % caudal Contra-ipsilateral axis

pearson(Roll4,Roll5) % ipsilateral right axis

Following this we utilized the simplicity of transforming the data from the time domain to the frequency domain via Building a simple function in Matlab that takes in a column of data containing the EMG signals and spits out the plot of power(DB) vs. frequency (Hz). Here is the code for that.

1) Construct a plotfreq function that can carry out a fft:

% The plotfreq function takes in the column of data

% that contained the voltage values in the time domain.

% this will then be used to contruct the frequency domain.

function [ output\_args ] = plotfreq(x)

[s, f, t, p] = spectrogram(double(x), 39800, 0, 0:1:100, 4000, 'yaxis')

plot(f, p)

xlabel('freq (hz)')

ylabel('power (dB)')

end

2) create the fourier transform by calling the plotfreq(data) function and passing the data:

% These are the command window lines that I called to

% generate the Fourier transforms of my data

%% Normal Flight

plotfreq(Normal2) % rostral contralateral wing

plotfreq(Normal3) % caudal contralateral wing

plotfreq(Normal4) % rostral ipsilateral wing

plotfreq(Normal5) % caudal ipsilateral wing

%% pitched flight

plotfreq(Pitch2) % rostral contralateral wing

plotfreq(Pitch3) % caudal contralateral wing

plotfreq(Pitch4) % rostral ipsilateral wing

plotfreq(Pitch5) % caudal ipsilateral wing

%% Rolled Flight

plotfreq(Roll2) % rostral contralateral wing

plotfreq(Roll3) % caudal contralateral wing

plotfreq(Roll4) % rostral ipsilateral wing

plotfreq(Roll5) % caudal ipsilateral wing

**Streamlined Conclusion**

The Fourier Transform of the data from the time to frequency domain provided valuable insight into seeing how the wing beat frequencies changed in the cockroach flight CPG in order to accommodate for the different orientations of suspended flight. As for future uses of the statistical procedures used, I believe that FFT has vast application across numerous neuro-specific topics, such as recording fish EODs, or even looking at human/primate EMG, stimulus-induced activity.