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3/18/24

Lab 5: Does muscle activity in one arm influence muscle activity in the other?

Introduction:

For this lab, we used the dynamometers to examine if muscle activity in one arm influences muscle activity in the other arm. The initial hypothesis was that muscle activity is not independent in each arm. In class, we discussed how this may be the brain being efficient by sending the same signal to both hands, but suppressing the inactive hand's signal. By observing fluctuations in simultaneous squeezing force, it will be possible to test our hypothesis and see if muscle activity in one arm influences muscle activity in the other.

Materials:

- Biopac Amplifier
- 2 dynamometers

Methods:

For each condition, we collected data for 15 seconds, and did 3 trials. During the first trial, we were required to maintain a slight squeeze on the dynamometer with the left hand at a constant force, while simultaneously rhythmically squeezing the second dynamometer with the right hand at maximum intensity, once every two seconds. In the second condition, similar to the first condition, we maintained a slight squeeze on the dynamometer with the left hand at a constant force. However, in this condition, we were instructed to rhythmically squeeze the second dynamometer with the right hand with moderate force, once every two seconds. The third condition involved squeezing the dynamometer with the left hand only slightly, applying a constant force, while keeping the right hand relaxed. For the fourth condition, we maintained a slight squeeze on the dynamometer with the right hand at a constant force, while simultaneously rhythmically squeezing the second dynamometer with the left hand at maximum intensity, once every two seconds. In the fifth condition, we maintained a slight squeeze on the dynamometer with the right hand at a constant force. However, in this condition, we were instructed to rhythmically squeeze the second dynamometer with the left hand at a moderate force, once every two seconds. The sixth condition involved squeezing the dynamometer with the right hand only slightly, applying a constant force, while keeping the left hand relaxed.

Results:

Figures:

Condition 1:

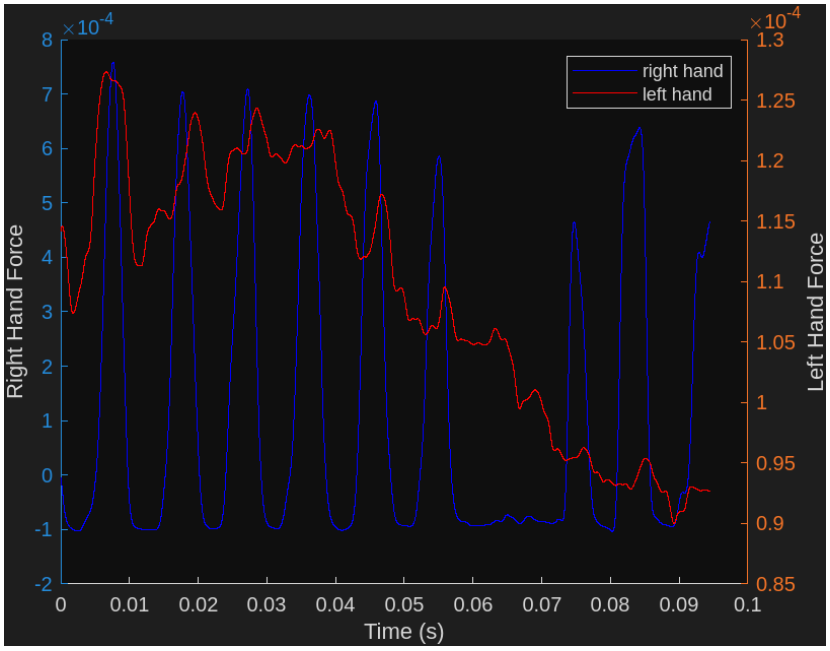

Figure 1. The force data for our squeezing after filtering.

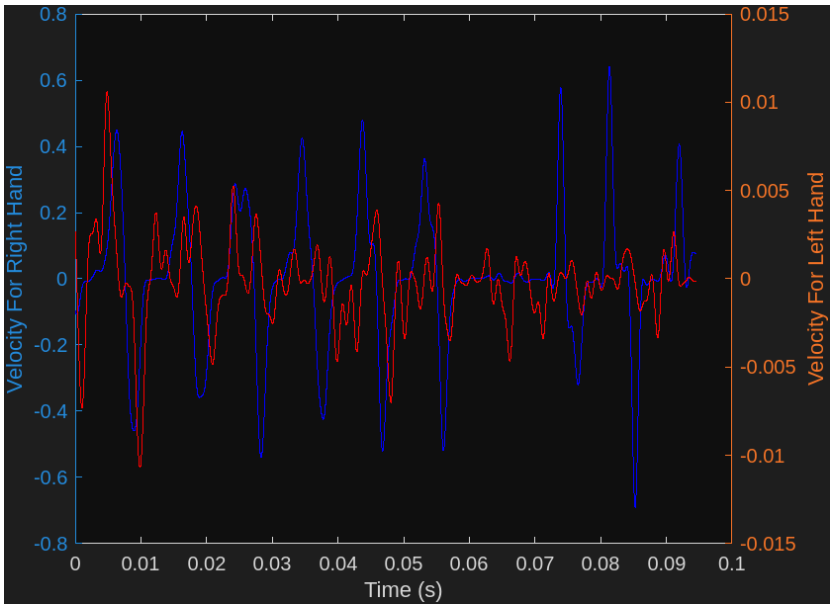

Figure 2. The derivative of the force graphed (filtered).

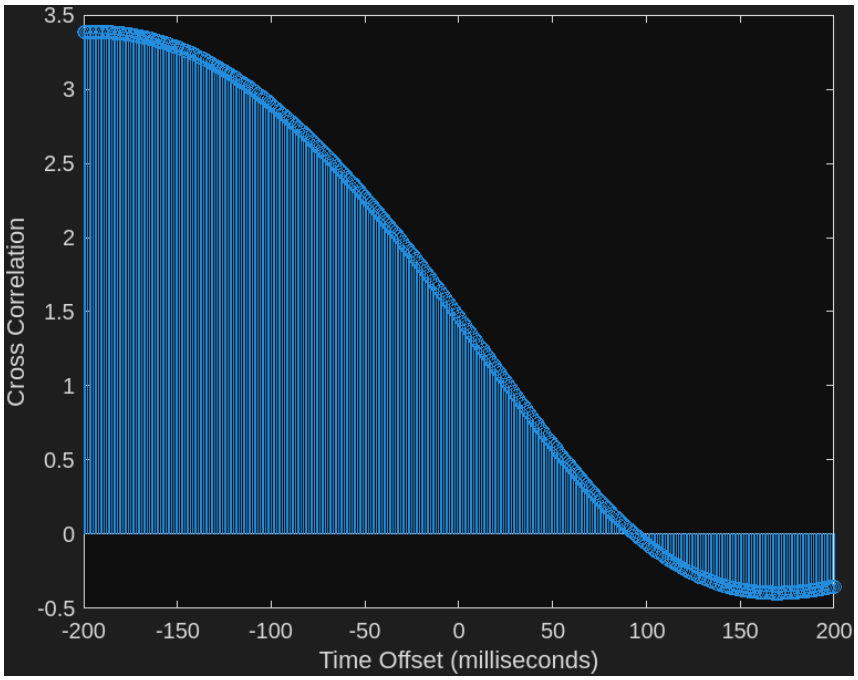

Figure 3. The stem plot of the correlation between the left and right hand data. Notice the peak at approximately -150, suggesting a 150 millisecond lag between the left and right.

Condition 2:

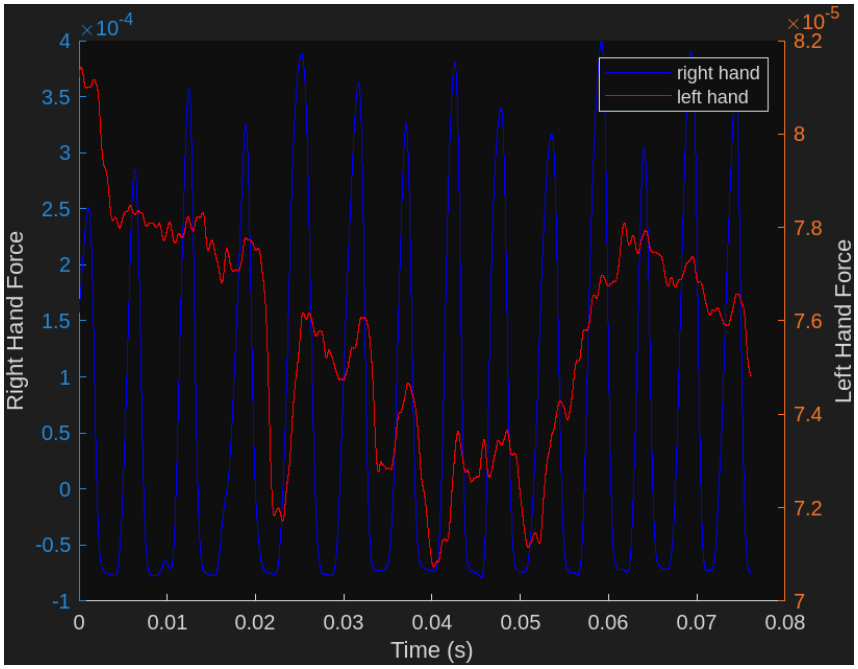

Figure 4. The force data for our squeezing after filtering.

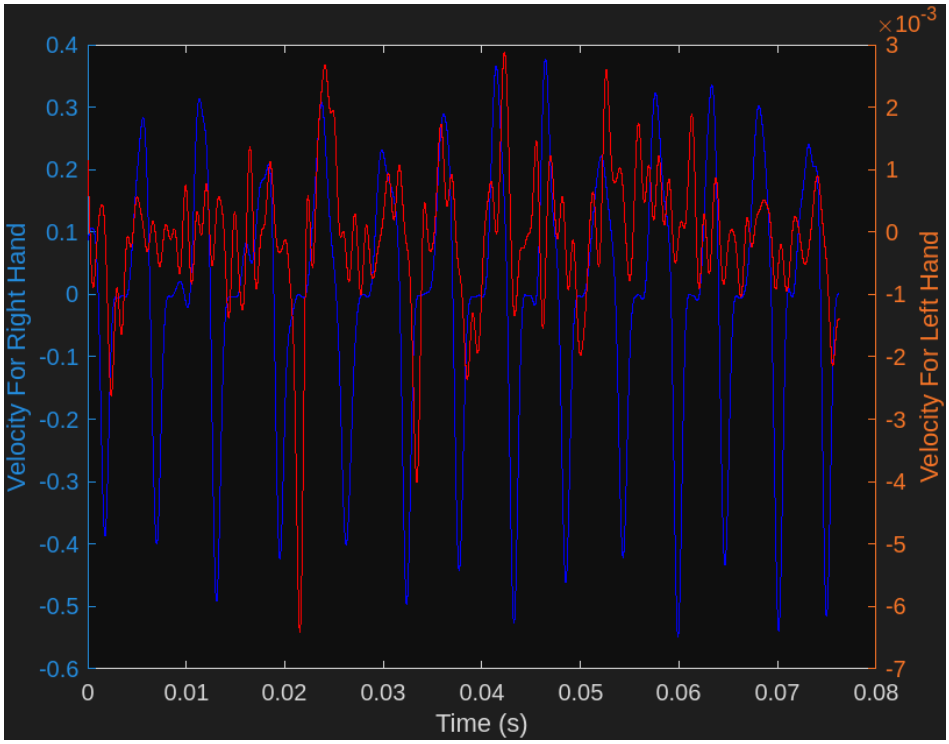

Figure 5. The derivative of the force graphed (filtered).

Condition 3:

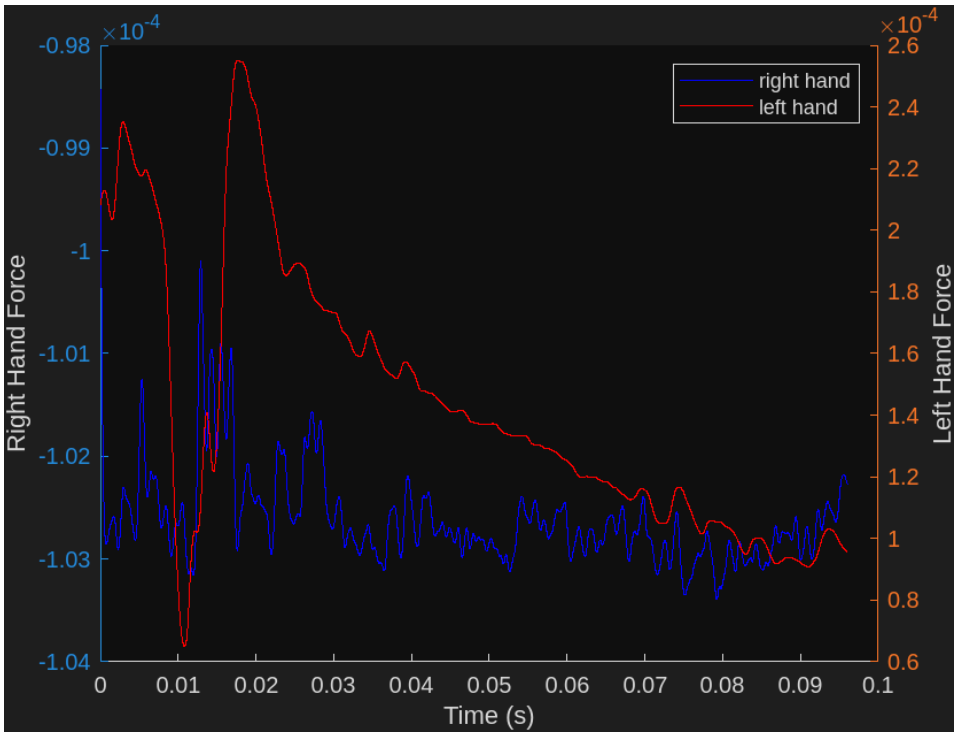

Figure 6. The force data for our squeezing after filtering.

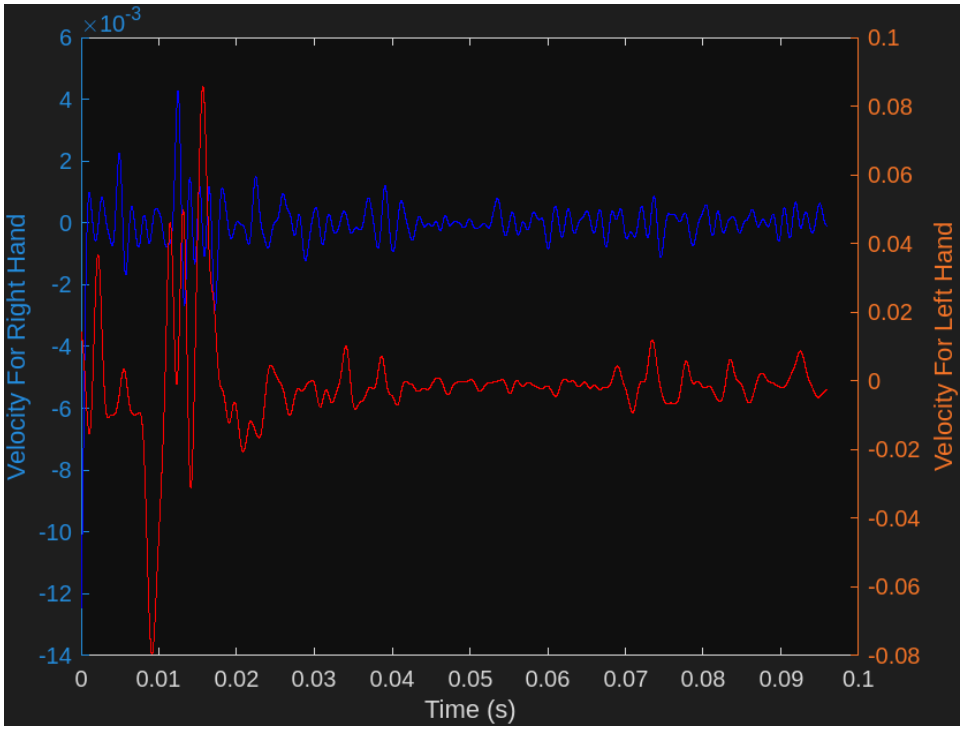

Figure 7. The derivative of the force graphed (filtered).

Condition 4:

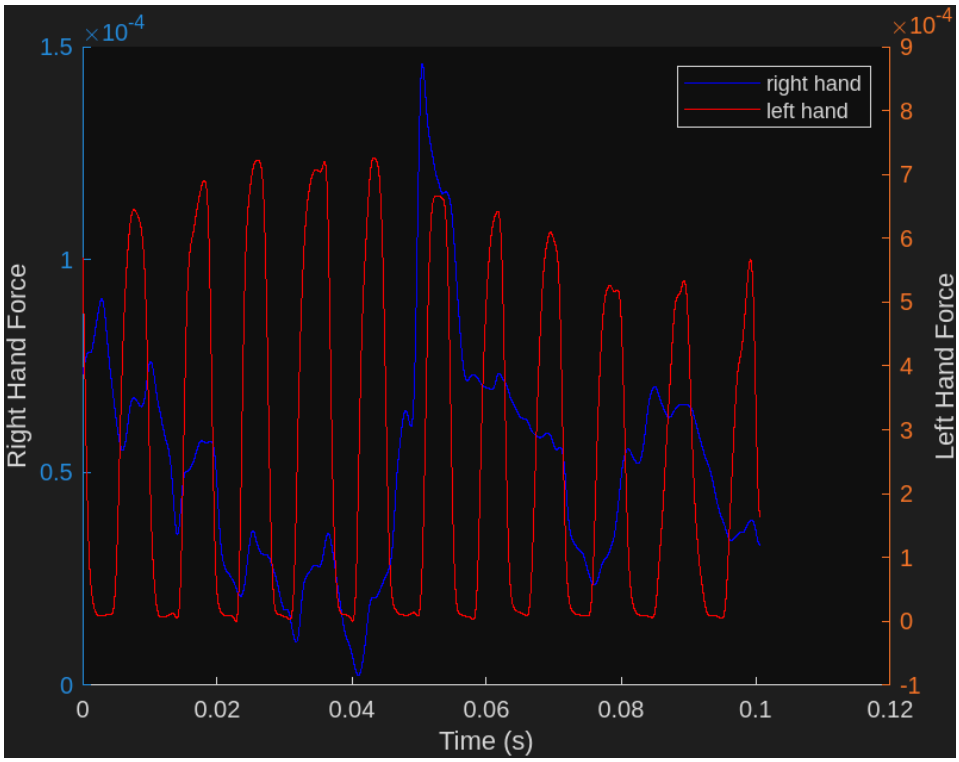

Figure 8. The force data for our squeezing after filtering.

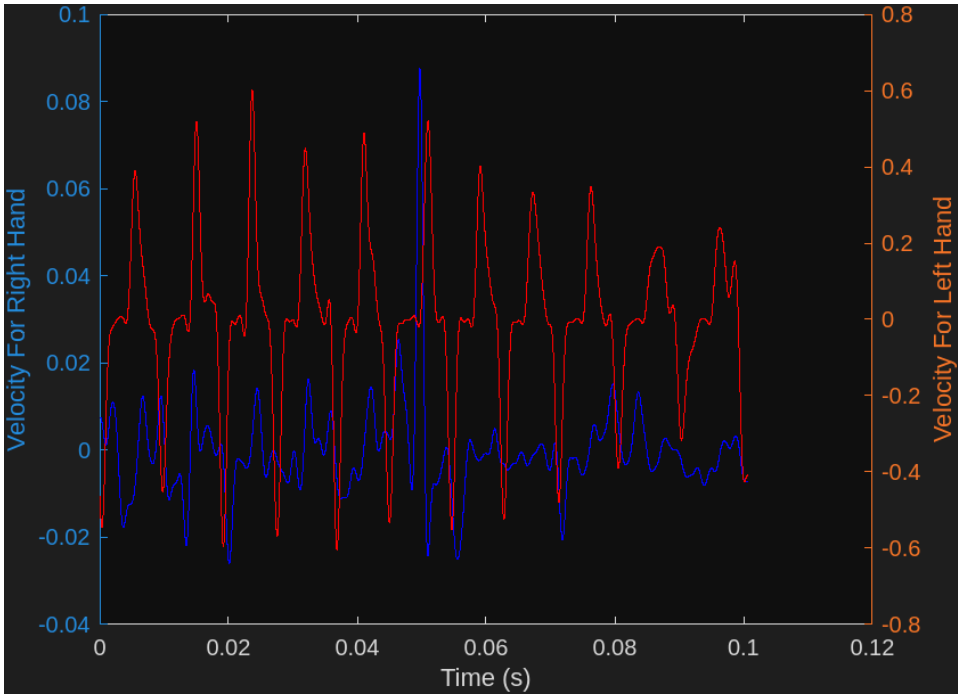

Figure 9. The derivative of the force graphed (filtered).

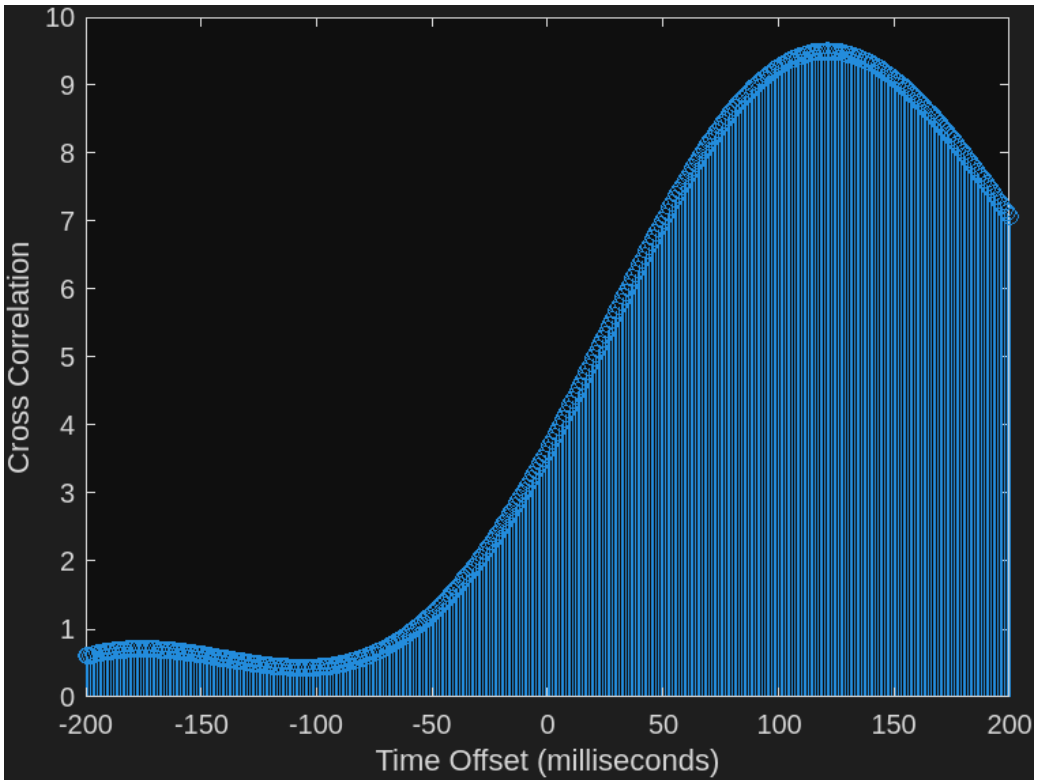

Figure 10. The stem plot of the correlation between the left and right hand data. Notice the peak at approximately 120, suggesting a 120 millisecond lag between the left and right.

Condition 5:

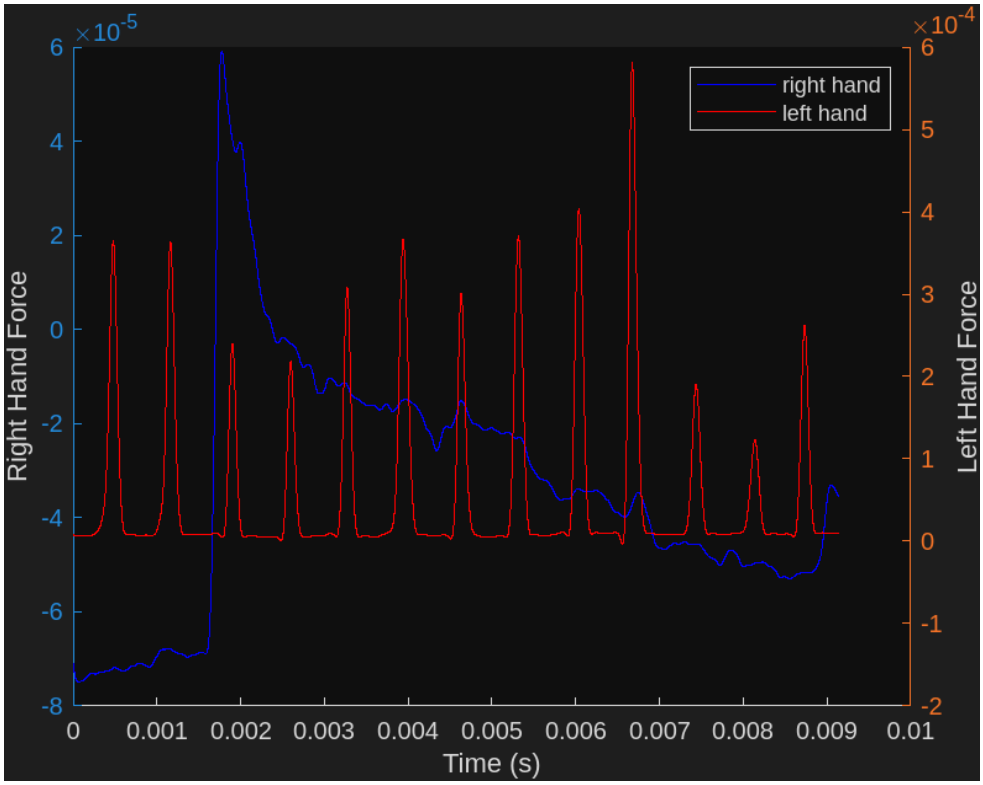

Figure 11. The force data for our squeezing after filtering.

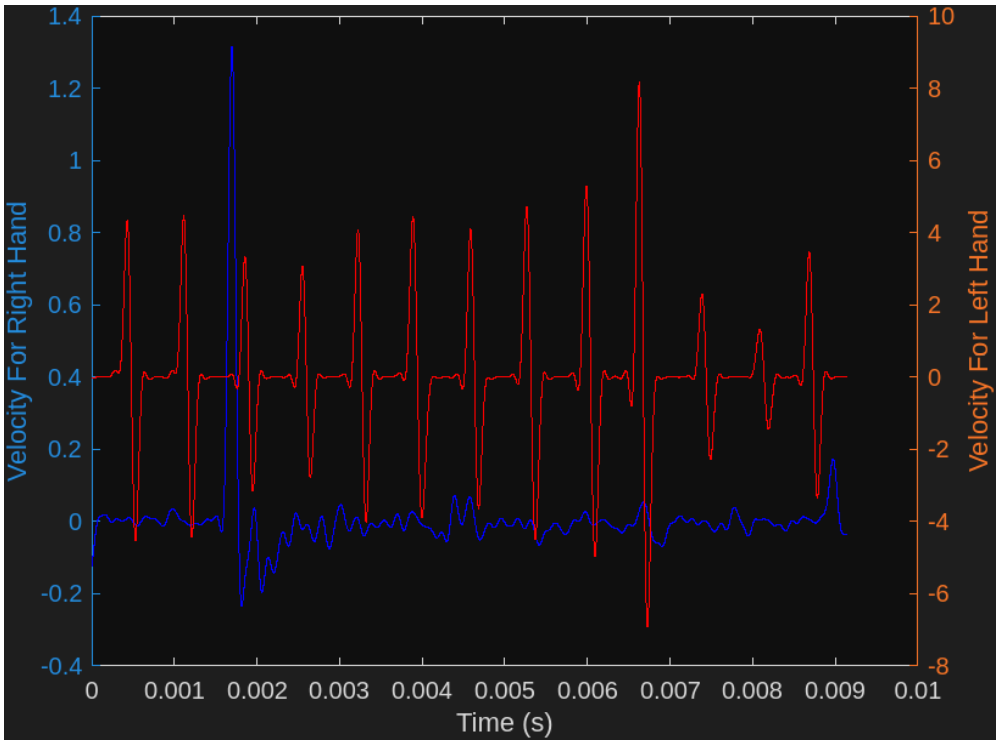

Figure 12.

Condition 6:

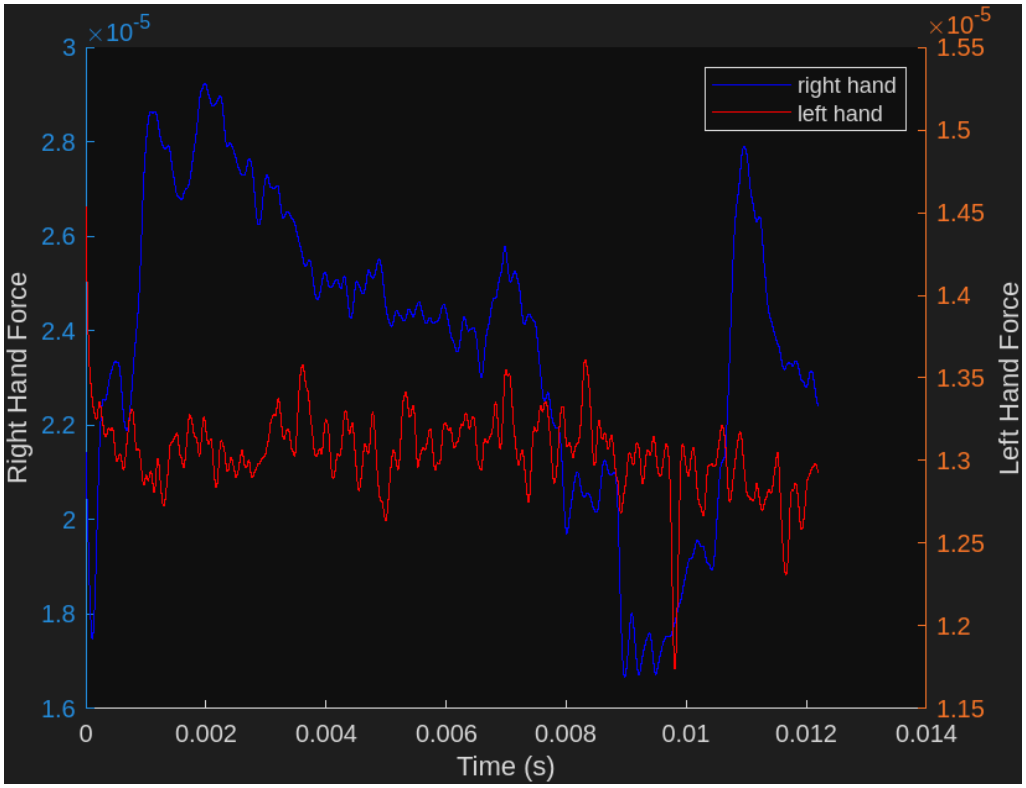

Figure 13. The force data for our squeezing after filtering.

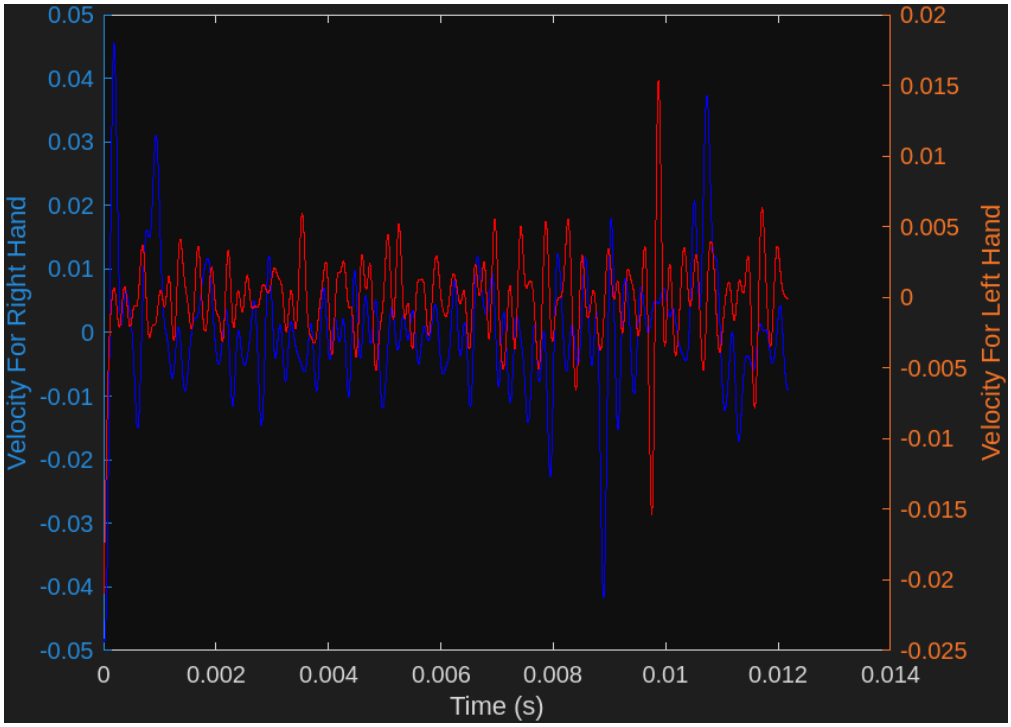

Figure 14. The derivative of the force graphed (filtered).

Discussion and Conclusion:

Our results showed that muscle activity is not independent, and is affected by muscles in the other arm. This is seen in the xcorr plots from conditions 1 and 4, where the stem plots illustrate the correlation between the left and right hand's forces. Figure 3 shows the highest correlation at around 150 milliseconds, suggesting that there was a lag of around 135 milliseconds between the left and right hand's signals, and Figure 10 shows its peak correlation at around 120 milliseconds, suggesting a delay of around 120 milliseconds between the signals. Despite this delay, there is a clear correlation between the signals when they are lined up. This agrees with the hypothesis that the left and right hands are not controlled independently. In Figure 8, it is particularly clear how squeezing with the right hand corresponded with slight increases in the force on the left hand's supposedly constant squeezing. We did have issues recording the data initially, because there seemed to be a delay when recording the data. This was a result of the BPE matlab script recording data starting from the moment it was run, rather than only after the time and channel data were set. We fixed this by beginning the trial the second the script was run, rather than waiting for the prompts. Despite these difficulties, we were able to clearly observe the correlation between the left and right hands in gripping the dynamometers. It is notable that during class, we discussed the possibility that signals sent to one hand are also sent to the other hand, and the awareness of the phenomenon might have influenced our results. The increased awareness about the expected results may have made the subject more conscious about the force in the "inactive" hand. In addition, while collecting the data, the subject was able to see the matlab plot of the data as it was being recorded by the dynamometer, which may have allowed the subject to reduce their force when they were meant to be squeezing constantly. This could have led to a false correlation, and could have been avoided by either blindfolding the subject or otherwise stopping them from seeing the live force data.

Matlab code:

Driver code:

```
clc;
clear vars;
close all;
funky("part1/trial1/ch1data.mat","part1/trial1/ch2data.mat", "right hand", "left hand", "blue", "red", 1)
funky("part2/trial1/ch1data.mat","part2/trial1/ch2data.mat", "right hand", "left hand", "blue", "red", 2)
funky("part3/trial1/ch1data.mat","part3/trial1/ch2data.mat", "right hand", "left hand", "blue", "red", 3)
funky("part4/trial1/ch1data.mat","part4/trial1/ch2data.mat", "right hand", "left hand", "blue", "red", 4)
funky("part5/trial1/ch1data.mat","part5/trial1/ch2data.mat", "right hand", "left hand", "blue", "red", 5)
```

funky("part6/trial1/ch1data.mat","part6/trial1/ch2data.mat", "right hand", "left hand", "blue", "red", 6)

Funky code:

```
function [] = funky(file1, file2, label1, label2, color1, color2, dataset)
figure
SF = 1000;
data1 = open(file1);% input data1 as string
data2 = open(file2);% input data2 as string
% loading up the data
data1 = data1.ch1data;
data2 = data2.ch2data;
% setting up the time array to match each data array
Time = linspace(0,data1(end)*SF,size(data1,2));
hold on
% filtering
[A, B] = butter(2,5/500, "low");
data1filtered = filtfilt(A,B,data1);
data2filtered = filtfilt(A,B,data2);
% plotting
yyaxis left
plot(Time,data2filtered, "Color", color1)
xlabel('Time (s)')
ylabel('Right Hand Force')
yyaxis right
plot(Time,data1filtered, "Color", color2)
ylabel('Left Hand Force')
legend(label1, label2)
hold off
% find the derivative
vel2 = diff(data2filtered)./diff(Time);
vel2 = [vel2,vel2(end)];
vel1 = diff(data1filtered)./diff(Time);
vel1 = [vel1,vel1(end)];
% filtering derivative
[A, B] = butter(4,5/500, "low");
vel2filtered = filtfilt(A, B, vel2);
vel1filtered = filtfilt(A, B, vel1);
figure
yyaxis left
```

```
plot(Time,vel2filtered, "Color", color1)
hold on
ylabel('Velocity For Right Hand')
yyaxis right
plot(Time,vel1filtered, "Color", color2)
ylabel('Velocity For Left Hand')
xlabel('Time (s)')
hold off
% **ONLY FOR CONDITIONS 1 AND 4** using xcorr to find the delay
if (dataset == 1 || dataset == 4)
  [correlation, lag] = xcorr(vel2,vel1, 200);
  figure
  stem(lag, correlation)
  xlabel("Time Offset (milliseconds)")
  ylabel("Cross Correlation")
end
```