# Effects of Heart Rate Measured On An ECG

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**Abstract:**

The purpose of this project is to test the effects as well as the relationship between caffeine and anxiety on heart rate. This project measures these heart rates using an electrocardiogram or ECG, sent through a filtered circuit. The circuit was created to connect to the user, where their heart rate can be filtered and viewed on an oscilloscope and be analyzed using MatLab. The heart rate was measured in these different cases and after analysis found that the increase in resting heart rate from anxiety and caffeine. These findings aid other research and studies that suggest this increase in resting rate is due to the raising of blood pressure from these factors.

**Introduction:**

The matter of heart rate has been an interesting subject of research as the heart is the source of life to all as humans. The system cycles out oxygenated and deoxygenated blood, making certain that all parts of the body receive proper nourishment.

This important organ works with a heart beat, or a two- part pumping action which is caused by an electrical impulse (How The Heart Works 1). The cell is stimulated from its polarized state, as the heart begins to contract, a wave of depolarization spreads across the heart muscle. This depolarization is caused by the movement of positively charged ions, such as sodium and calcium (Registered Nurse RN 1). These phases can be displayed with an ECG or electrocardiogram where it shows these waveforms in a heartbeat. These graphs demonstrate the repeated activity of electrical heart rate voltage over time. An ECG is often used for diagnostic purposes as it can display odd trends or peaks in heart rate, thus is constantly used in clinics.

The average heart rate for an adult is around 60-100 BPM (beats per minute), however research has shown the connection of a higher heart rate due to anxiety as well caffeine intake. A common occurrence among individuals who experience anxiety is heart palpitations (Cleveland Clinic 1).Similarly, this increase in heart rate is known to occur from caffeine as it is a natural stimulant that affects the central nervous system, including the heart. It works by blocking the action of a neurotransmitter called adenosine, which typically slows down nerve cell activity and helps you relax and fall asleep. When adenosine is blocked by caffeine, the levels of other neurotransmitters like dopamine and norepinephrine increase. Similar to the affect of anxiety, Norepinephrine, is involved in the "fight or flight" response and causes the heart to beat faster and stronger, increasing blood pressure and preparing the body for action (How Does Caffeine Affect Your Heart 1). This project tests this theory of an increase resting heart rate from these factors. One partner is known to have slight general anxiety, thus tested both partners resting heart rates and then compared it to that with caffeine.

**Methods:**

In order to test our hypothesis data from both of partner's resting heart rates across two separate conditions was taken: our resting heart rate without caffeine and then our heart rate over a span of 30 minutes after drinking caffeine. To gather our data we generated an ECG circuit (shown in Figure 1) capable of filtering to capture heart rate and sent the output to Matlab for further analysis.

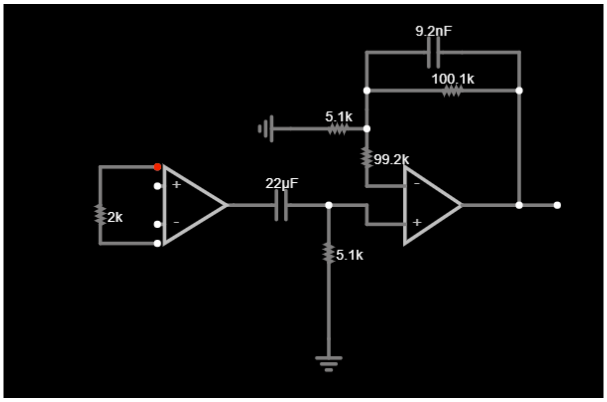


Fig 1: Block diagram of ECG circuit Low Pass and High Pass filter using an AD622 and LM741 Operational Amplifier

The resistor values used were 5.075k, 5.1k,100.1k,1.95k, and 99.2k. The capacitor values used were 22µF and 9.2nF. Using an LM741 operational amplifier and an AD6222 op amp we were able to create a low pass and high pass filter as well as achieve a gain. The filter at the LM741 was a low pass filter with cutoff frequency: $Fc_{low} = \frac{1}{2*\Pi*100.1k\Omega*9.2nF} = 159Hz$. The high pass filter was at the AD622 op amp its cutoff frequency is: $Fc_{high} = \frac{1}{2*\Pi*5.1k\Omega*22\mu F} = 1.4Hz$.

The gain at the AD 622 is determine by the resistor going from pin 1 to pin 8 our chosen Rg value was 2kΩ; and measured to be 1.92kΩ this means that the gain at the Ad622 is 30. The gain at the LM7411 is calculated by $\frac{100.1k}{5.1k} = 20$. Therefore, thegain at the LM7411 is calculated by $\frac{100.1k}{5.1k} = 20$.

With our own heart rate as the input, the leads of the electrodes were connected to the input of our operational amplifier. Before analyzing the heart rate bpm with matlab the ECG circuit was connected to the oscilloscope to ensure it was working correctly (Fig.2)

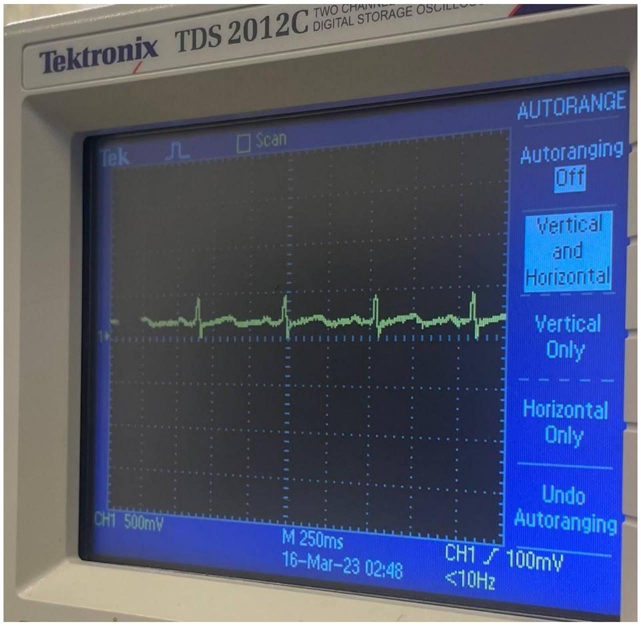


Figure 2: Heart rate acquired from ECG circuit shown on oscilloscope.

The output, was then sent to Matlab where we used a live data acquisition script to receive data and acquire the heart rate as shown below:

```
%live data acquisition script

s=daq.createSession('ni')
%p=daq.createSession('ni')% %ni’ is for National Instruments
s.Rate=500; %sample rate for our signals were sampled

addAnalogInputChannel(s,'Dev1',0,'Voltage')
s.DurationInSeconds=30;%acquires data for 30 seconds
duration = s.DurationInSeconds


[ECGsignal,time] =s.startForeground();

plot(time,ECGsignal) %plots our graph of the signal voltage vs time


[pks,locs]=findpeaks(ECGsignal, 'MinPeakHeight', 0.23) %finds where the max points from our data if it is over a voltage of 0.23
HeartRate=size(locs)*2 %counts size of matrix of where the max points are and multiplies it by 2 to get a full heart rate across a minute
```

This code specifies a sample signal at a rate of 500 Hz over a span of 30 seconds. The code acquires a sample every 0.02 seconds giving 1500 total samples for each measurement. This then returns a graph of the respective ECG signal or the voltage vs time, and finds the peaks in the data. However, in an ECG wave there is an R peak as well as a T peak in one heartbeat. To prevent Matlab from including the T wave, analysis of the graphs proved that all R waves at least hit a voltage of 0.23, thus we included a parameter of 'MinPeakHeight' of 0.23 where it only accounts for peak voltages over 0.23 V.

A lead was connected to ground (above the leg) and two across the chest to pick up heart rate. This data acquisition was performed 12 times on each partner to get data on their resting heart rate and another 12 times to get data on heart rate without caffeine for further analysis. The data acquisition with caffeine was taken over the span of 30 minutes, running the matlab about every 2 minutes in order to see the results of the caffeine.

**Results**

Each time the matlab function was run the resulting heart rate voltage output was plotted on a graph (Fig.3) displaying the voltage spikes (heart beats) for the thirty seconds it acquired data..

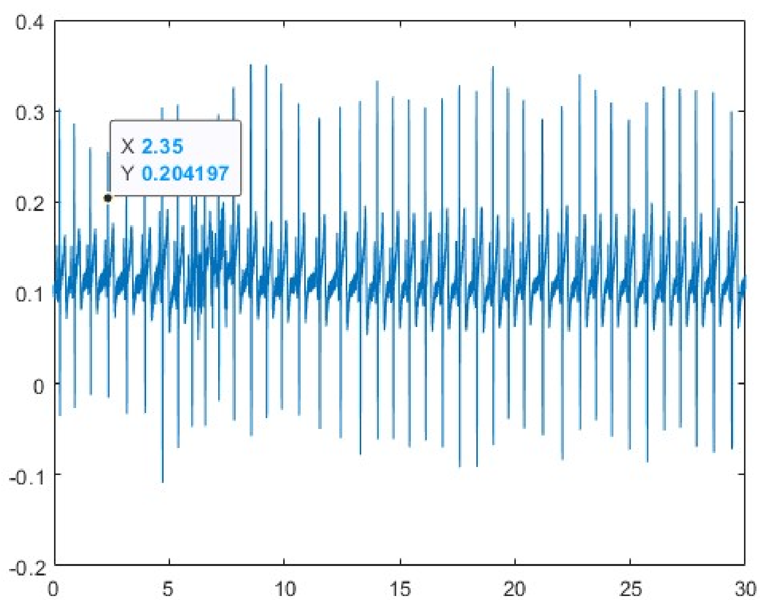


Figure 3: Matlab plot of heart rate over thirty seconds

The results showing Megan's and Savannah's resting heart rate over 12 trials is shown in Table 1.

| Megan Control | Savannah control | Megan with Caffeine | Savannah with Caffeine |
|---|---|---|---|
| 72 | 84 | 72 | 122 |
| 58 | 90 | 58 | 122 |
| 66 | 80 | 66 | 96 |

| Megan Control | Savannah control | Megan with Caffeine | Savannah with Caffeine |
|---|---|---|---|
| 68 | 82 | 68 | 88 |
| 80 | 88 | 80 | 82 |
| 72 | 92 | 72 | 88 |
| 64 | 86 | 64 | 86 |
| 56 | 88 | 56 | 80 |
| 62 | 76 | 62 | 88 |
| 64 | 78 | 64 | 86 |
| 64 | 82 | 64 | 128 |
| 66 | 86 | 66 | 100 |

Table 1: Heart rate measurements in beats per minute of Savannah and Megan with and without caffeine

The average values and standard deviations were found. Megan's average control heart rate is 66 beats per minute with a standard deviation of 6.5. Megan's average heart rate after drinking caffeine was found to be 71.5 beats per minute with a standard deviation of 9.2. Savannah's average control heart rate was found to be 84 beats per minute with a standard deviation of 4.9. Savannah's average heart rate after drinking caffeine was measured to be 97 beats per minute with a standard deviation of 17.

A graph of comparing the control heart rates for Megan and Savannah were compared in a scatter plot (Fig 4).

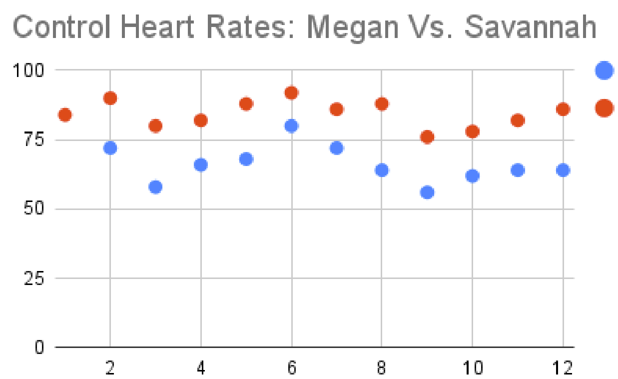


Figure 4:Plot of Savannah and Megan's measured heart rates without caffeine. Savannah's heart rate is with red dots and Megan's is with blue dots (trial number is along x axis and heart rate is along y axis)

**Discussion**

The results achieved were what were expected from past scientific studies. Savannah's average resting heart rate, 84 beats per minute, was higher than Megan's average resting heart rate, 66 beats per minute which makes sense because Savannah self reported a high anxiety and stress level. On the other hand, Megan reported feeling relaxed and calm. Studies have shown that anxiety's activation of the autonomic nervous system causes increased heart rate (Heart Palpitations & Anxiety). Thus, it makes sense that Savannah's heart rate was higher. Furthermore, both of the sets of average heart rates were lower without caffeine than they were with caffeine; Savannah's jumped from 84 bpm to 97 bpm and Megan's jumped from 66 to 71.5. By releasing plasma catecholamines caffeine activates the autonomic nervous system, pumping epinephrine through the body and increasing the heart rate (Gonzaga). The results in this lab correlate to this information by displaying that by drinking caffeine one's heart rate increases. Despite the results matching up to what was expected, the experiment had areas for future improvement. If more time was available the experiment could run more than twelve trials per data set. By getting more data, the results would be more reliable. Additionally, running these heart rate tests on more people would further validate the results. By testing for instance, 50 people with anxiety and 50 people without anxiety; one could observe if the average heart rate for those with anxiety was higher than those without. This would help to show that anxiety raises heart rate and was the likely factor in why Savannah's heart rate was higher than Megan's

**Conclusion:**

By using an ECG circuit with data sent to matlab the experiment was able to gather reliable data for the heart rate of Megan and Savannah with and without caffeine. The results were meaningful because they validated previous scientific studies and literature that say anxiety and caffeine are factors which increase heart rate. Furthermore this lab shows how one can effectively find heart rate by plotting the output of ECG circuit voltage and finding the number of peaks. This is so valuable because of the importance of heart rate monitoring. The heart works to pump blood throughout the body and is vital for living (Schmerling). By monitoring one's heart rate clinicians can better assess one's health and risk of future heart attacks or cardiovascular disease.

Works Cited


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