# Exploring Emotions and Correlations to Time, and Teenagers with Brain Computer Interfaces

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## Abstract -

For the last few hundred years emotional intensity and reaction have often been attached to hormonal teenagers going through puberty or even people with higher social sensitivity. As society progresses, variables like time of day are more common as standards of structure. Specific Correlations of emotions to hours and segmented periods of temporal change has been labeled as a psychological staple of all humans, dating back to the applications of the Ancient Greeks. These tests compare two very important aspects of life, the unpredictable and spontaneous nature of emotions, and the ordered structure of our 12 hour time schedule. These different emotions being anger, happiness, disgust, and sadness, which are induced using various Medias. A Spearman rank correlation coefficient test is used to understand statistically significant correlations between the two variables. Then, an ANOVA Test is utilized to certify that the subjects used in the experiment were not more "emotional" or more receptive to certain emotions than the other. This is important to add because of emotion's boundless nature. This project finally concludes that the specific time of day does not necessarily correlate to emotion, but rather that emotion is a much stronger virtue of the mind than previously thought.

## Keywords

Electroencephalogram, Brain Waves, Emotion, Alpha Wave, Statistics

## 1. Introduction and Research

An EEG, or Electroencephalogram Is an apparatus that uses electrodes (receptors that you can place on various parts of the head to detect waves from different parts of the brain), to record specific interactions between electrons recorded as electrical impulses. These electrodes connect to a Pre-Amplifier, which allows the very small signal from brain waves to be amplified enough to pass through a filter, making the data digestible for the interface. Next, a second Amplifier allows this new filtered EEG data to be transcribed into a computer. In this experiment, the electrodes will be placed on the bottom of the head and next to the neck to be able to detect Alpha waves, Beta Waves, Theta Waves, and Gamma Waves (all these waves correlate different activities which can be drawn to correlation of separate emotions). (Goleman *et al.* 2016)These brain patterns are the most detectable from surfaces above the from the occipital lobe, more electrodes will be placed on the top of the head, and on the sides of the head all to detect waves coming from the limbic system, or more directly the amygdala, hippocampus, thalamus, hypothalamus, basal ganglia, and cingulate gyrus all of which are mainly known for being in charge of our brains process of what we know as emotion (Harmon-Jones *et al.* 2016). A visual representation of this location placement is shown in Figure 1.

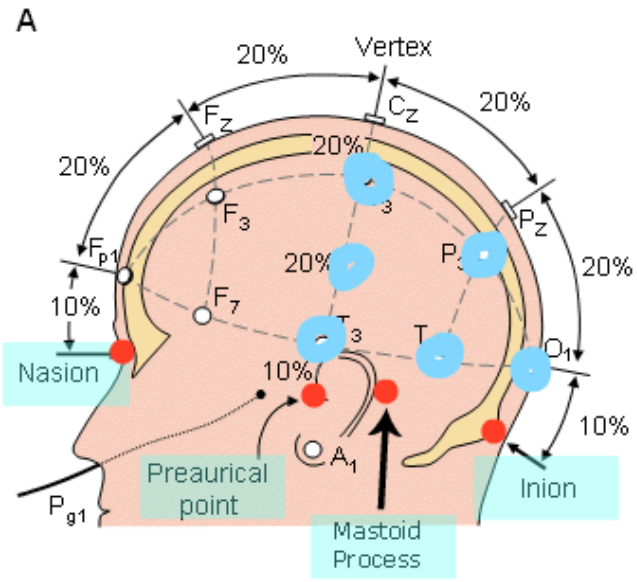


Figure 1. Electrode Placement Locations marked with Blue

The authors derived the wavelengths by making subjects watch specific clips from various films, all standardized on the Emotional Differential Scale, so that they are all in the same threshold of "funniness" or "disgustingness" for each of the subjects. (Goleman *et al.* 2016) These wavelengths are then recorded every 3 hour time period, and finally tested using the SRCC, Spearman Rank correlation coefficient test for correlation, and an ANOVA Test to certify that one subject did not have higher receptions to specific emotions. (Harmon-Jones *et al.* 2016)

### 1.1 Wavelengths and Emotion Classification

These emotions are also qualified as brain response to external stimuli, for this reason emotions can be categorized into brain waves, which is the quantifiable wavelength produced from the electrical current detected between interactions in neurons (also named as "neuron-neuron" interactions). (YJ. Liu M *et al.*1970)
These different waves depend on human activity levels, listed as the following:

1) Gamma: Heightened senses and perception
2) Beta: Awake, Stationary
3) Alpha: Relaxed
4) Theta: Deep "Meditation" In-active, Dreaming State
5) Delta: Deep Sleep, No Dreams

These same waves are an important tool in emotional classification, the main waves applicable in emotion distinction are Beta Waves, Alpha Waves, and Theta Waves. (YJ. Liu M *et al.*1970) Different emotions dictate specific amounts of activity, for this reason we can associate Beta Waves to emotions like happiness and anger, both of which are extremities on the emotional scale, inducing higher outputs of various neurotransmitters, the main being dopamine(YJ. Liu M *et al.*1970). Then the association of Disgust can be made to Alpha Waves, which are much more regulated rather than extreme and finally Sadness which can be associated to Theta Waves. Sadness is a repressed emotion, usually inducing and requiring less brain activity when compared to its various counterparts, for this reason Theta Waves, or the waves commonly present during deep meditation or inactivity, can be the most accurate representation. (YJ. Liu M *et al.*1970)

### 1.2 Distinction of Beta Waves in Happiness and Anger

Both Happiness and Anger, being extreme emotions, induce higher levels of brain activity which is why this is expressed in the form of Beta Waves, to make a distinction between the two is important, so that we are sure that the emotion that we expect to receive from specific media is actually received. (Harmon-Jones *et al.* 2016)
To make this distinction we can take a look at the separate trends, though they have the same wavelengths, the certain aspect to look at are the troughs and crests of the graph, happiness is very centralized around the amygdala, it

relies on the specific release of dopamine, which allows for smoother transitions between neuron interactions. For this reason we do not see a drastic change from high to low. (Goleman *et al.* 2016)
In anger we see the opposite, with a much higher transition of lower troughs to higher crests, this is because the neurotransmitter released, Acetylcholine an excitatory neurotransmitter triggering things like muscle contraction and excretion of hormones, this response requires more jagged reactions, resulting in high and low crests/troughs which is visible in the data set. (Harmon-Jones *et al.* 2016)

### 1.3 Medias and Hypothesis

Technology applied in this research is not advanced to the point of being able to differentiate each emotion with high specificity, due to this it is important to choose emotions deemed to be opposite ends of the spectrum. The human brain automatically makes these distinctions with the release of neurotransmitters like dopamine, and the reaction to this stimuli is what allows our brain to qualify emotions(Harmon-Jones *et al.* 2016). These distinctions are listed as so: happiness for the pleasantness distinction, and anger, disgust, and sadness on the unpleasantness. In this experiment the stimuli applied will be different Medias (Specifically Video) which are used to evoke different emotions. Based on these responses we put our emotion into different categories. The goal of this experiment is to identify these categories and record which of these categories has the most presence, and based off of that data use the wavelength values and frequency values to determine how intense these emotions are hypothesis makes the determination that there will indeed be a significant correlation between time and the intensity of the emotions happiness, disgust, sadness and anger. (Izard, C *et al.* 2015)
The Medias, specifically video are presented below:
Disgust: Specific clips from the movie "*The Human Centipede*" It is famous for having very gruesome, distasteful scenes
Happiness: Specific clips from comedy sketches by *Charlie Chaplin*, pieces of video that are often described as the funniest material of the century
Sadness: Specific Clips from the film "*The Notebook*" a story about romance that goes horribly wrong, very sad film
Anger: Clips from "*Anger Management*" and "*Bad Day*" Both have extremely irritating clips meant to insight anger.

These different films were graded on the "Differential Emotions Scale" (Izard, C *et al.* 2015) So that each clip was at a standard of emotional stimulant, so that there were no clips that acted funnier, or sadder than the other, but so that each clip was standardized amongst the emotions they were meant to procure. This is seen in Figure 2. (Izard, C *et al.* 2015)

| Factor | Item | Item–factor correction |
|---|---|---|
| I. Interest (.76) | attentive | .88 |
| | concentrating | .79 |
| | alert | .87 |
| II. Enjoyment (.87) | delighted | .81 |
| | happy | .87 |
| | joyful | .86 |
| III. Surprise (.75) | surprise | .83 |
| | amazed | .85 |
| | astonished | .87 |
| IV. Sadness (.85) | downhearted | .86 |
| | sad | .79 |
| | discouraged | .82 |
| V. Anger (.68) | enraged | .74 |
| | angry | .84 |
| | mad | .86 |
| VI. Disgust (.73) | feeling of distaste | .86 |
| | disgusted | .85 |
| | feeling revulsion | .78 |
| VII. Contempt (.78) | contemptuous | .89 |
| | scornful | .90 |
| | disdainful | .84 |
| VIII. Fear (.68) | scared | .88 |
| | fearful | .90 |
| | afraid | .89 |
| IX. Shame/shyness (.83) | sheepish | .73 |
| | bashful | .87 |
| | shy | .88 |
| X. Guilt (.77) | repentant | .78 |
| | guilty | .83 |
| | blameworthy | .80 |

Figure 2. Emotional Differential Scale

## 2. Methods

It is initially expected that there will indeed be a significant correlation between time and the intensity of the emotions happiness, disgust, fear and sadness. The determination that can also be suspected underlines that every test subject will have the general same reaction to media, with account of different specific thresholds of different people and their reactions to different stimuli. To run the tests samples of 1 adult Male, 1 adult female, and 1 teenager will be examined over 3 hour intervals throughout a 12 hour period. The examinations will use the EEG, its creation will be described later. These readings will be taken while someone watches the aforementioned Medias, during the labeled time periods, to test whether the time of day affects any emotions, and to see if a Teenagers emotional reception will be more variable compared to an adult. This is explained in more detail in "Data and Statistical Analysis". Once the EEG is created and testing is ready, an EEG headband is used to hold the electrodes to the head, which is also applied with electrode gel to offer smooth and continuous connection to important located points. Experimentation took a period of 12 hours, with the creation of EEG taking much longer than that. Using more advanced materials would be beneficial as well as a larger team to carry out the procedure.

### 2.1 Materials

When building an EEG the greatest obstacle to overcome regards cost, in this experiment a EEG with a cost of less than 30 US Dollars was able to be constructed for applicable use in the following experiments, the materials and acquisition of such is listed below(Griffiths *et al.* 2003):

1) PCB (Printed Circuit Board) to house all of my components
2) Amplifier Board
3) 16 Resistors
4) Various Capacitors
5) Serial Cable
6) 9-pin d-sub interface
7) Low Pass Filter(With extra inputs for various channel inputs from Electrodes)

These multitudes of parts coalesce to form the aforementioned EEG that can be described in 3 main parts, which first includes the Pre-Amplifier, this component retrieves the detections of neuron-neuron interactions (previously mentioned electrical currents in the brain) and amplifies them to a level in which exterior interfaces can make specific detections (Griffiths *et al.* 2003). This data then flows through the input channels, and through a low-pass filter so that the wavelengths of various brain waves can be separated and easily comprehensible. These values then pass through a final adapter, offering as the final component that sizes initially extremely small signals so that interfaces such as computers are able to read the data. (Griffiths *et al.* 2003) (Izard, C *et al.* 2009) This is modeled in Figure 3.

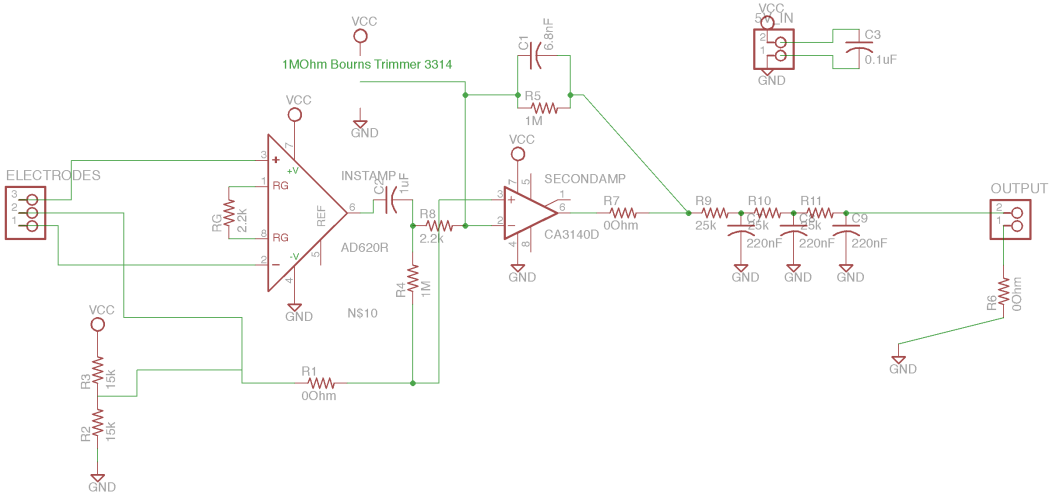


Figure 3 . EEG Circuit Diagram

This assembly attaches to 16 electrodes placed into an electrode cap on surfaces of electrode gel which allows for smooth application and less chances of connection loss. (Griffiths *et al.* 2003) To test these contraptions the sample

of one adult female, one adult male, and one teenager was used in order to derive not only correlation between the standardized 3 hour interval of time and emotion, but also the effect that age applies. (Griffiths *et al.* 2003) To read the data derived using the EEG, the application Bio ERA was utilized which acts as a visual design user interface that allows the user to quantify the data received. (Griffiths *et al.* 2003)

## 3. Data and Statistical Analysis

Data was collected using the applied EEG, created with the budget of 30 dollars on the sample of 1 adult male, 1 adult female, and 1 adult teenager. These readings are applied in the form of recorded brain waves, which are quantified and read as specific wavelengths. This specific data as previously mentioned is recorded as 2 main variables.

The first variable is time of day which we are testing for correlation to the different emotions, this will be recorded in 3 hour intervals at the timings 9am, 12pm, 3pm, 6pm, and finally 9pm.

The next variable is emotion, to be able to test this variable it is important to render it into a numerical quantity. In this experiment the built EEG described is used to record the Wavelength, seen as a reaction to various stimuli. There are three main Brain Waves that are often described as the main response of emotion these are Theta Waves, Alpha Waves, and Beta Waves each at specific wavelength thresholds listed as: Theta Waves: 4-8Hz, Alpha Waves: 8-13Hz, and finally Beta Waves:13-32Hz. The higher the wavelength received in the described threshold, the higher the emotion intensity. (Izard, C *et al.* 2009)

It is vital to note that every person has different reaction levels of different emotions, one may experience higher levels of happiness than another in reaction to the same media, to make sure this does not change the reliability of the data set a ANOVA Test was applied, which tested the null hypothesis questioning whether the different samples proved to have a higher emotional reaction to the same medias.

The two tests which were applied are the Spearman Rank Correlation Coefficient test, and the ANOVA Test, the SRCC Test shows us correlation and relationship between our variables, and the ANOVA test outlines that our different subjects are not more emotional than the other, but rather reliable subjects to gain data from without excessive variance. These tests were important because the SRCC allows us to compare ordinal data, acting as a non-parametric test. The three main variables being tested were time of day and emotion, emotion being quantified in the form of brain waves, all of which was derived using the EEG.

### 3.1 Data Presentation

First the tables will outline the general results of Wavelength for each emotion in each specific sample, then the values will be outlined in an SRCC Correlation Test ultimately testing our null hypothesis for the understanding that Time of Day is correlated to intensity of specific emotions.

| HAPPINESS | Adult Female | Adult Male | Teenager |
|---|---|---|---|
| 9:00 AM | 13 Hz | 13.6 Hz | 13.8 Hz |
| 12:00 PM | 13.4 Hz | 13.6 Hz | 13.7 Hz |
| 3:00 PM | 14 Hz | 14.2 Hz | 14.4 Hz |
| 6:00 PM | 13.3 Hz | 13.6 Hz | 13.6 Hz |
| 9:00 PM | 14.4 Hz | 14.3 Hz | 13.5 Hz |
| BETA WAVES | | | |

Figure 4. Happiness Wavelength vs Time Data Set

Figure 4 is a representation of the readings from the emotion response Happiness. Each wavelength is listed at each time interval of 3 hours and under each sample, with the listed Wave type in the bottom left corner.

| DISGUST | Adult Female | Adult Male | Teenager |
|---|---|---|---|
| 9:00 AM | 8.2 Hz | 8 Hz | 8.3 Hz |
| 12:00 PM | 8.4 Hz | 8.6 Hz | 8.8 Hz |
| 3:00 PM | 10.3 Hz | 9.2 Hz | 9.2 Hz |
| 6:00 PM | 8.3 Hz | 8.6 Hz | 8.6 Hz |
| 9:00 PM | 8 Hz | 8.5 Hz | 8.2 Hz |
| ALPHA WAVES | | | |

Figure 5. Disgust Wavelength vs Time Data Set

This table is a representation of the data collected in response to media describing disgust, with the same wavelengths listed in Figure 5 at each time, these are recorded Alpha Waves listed in the bottom left corner.

| SADNESS | Adult Female | Adult Male | Teenager |
|---|---|---|---|
| 9:00 AM | 4 Hz | 4 Hz | 4 Hz |
| 12:00 PM | 4.7 Hz | 5 Hz | 4.8 Hz |
| 3:00 PM | 6.4 Hz | 7.2 Hz | 6 Hz |
| 6:00 PM | 4.3 Hz | 4.8 Hz | 5.4 Hz |
| 9:00 PM | 3.3 Hz | 3 Hz | 4.6 Hz |
| THETA WAVES | | | |

Figure 6. Sadness Wavelength vs Time Data Set

Figure 6 outlines the various wavelength values surrounding the insighted emotion of sadness, here we see the application of theta waves.

| ANGER | Adult Female | Adult Male | Teenager |
|---|---|---|---|
| 9:00 AM | 13 Hz | 14 Hz | 14 Hz |
| 12:00 PM | 16 Hz | 16 Hz | 15.5 Hz |
| 3:00 PM | 18 Hz | 14 Hz | 16 Hz |
| 6:00 PM | 17.3 Hz | 13.5 Hz | 13 Hz |
| 9:00 PM | 20 Hz | 18 Hz | 14 Hz |
| BETA WAVES | | | |

Figure 7. Anger Wavelength vs Time Data Set

Figure 7 represents the recording of response to the anger stimulant, or media inciting anger, with the same beta waves of higher awareness/brain activity.

### 3.2 Spearman Rank Correlation Coefficient

There are two main tests applied in this experimentation to derive the required results so that an adequate conclusion can be made. With this correlation test the calculation for R-value and $r^2$-value for each adult and teen emotional intensity values and time of day on the 3 hour interval were compared, it is important to note that there were no unusual trends in the data.
The x-axis labels hours ranging from 1-12 recorded in 3 hour intervals, the y axis outlines brainwave wavelength in hertz(Hz).

### 3.3 Anger

Running the test we see the Adult female procured the R-value of 0.93, and an $r^2$ Value of 0.87. This shows strong positive correlation, the model explains a strong upward correlation illustrated by the R- Value. This implies a highly statistically significant correlation between time and emotion.

Adult Male experience the r value of 0.46, and an $r^2$ value of 0.21, this shows us weak positive correlation, and this model is weak and does not explain the data adequately, with the various values being very unpredictable. However, an overall upward trend is apparent, but is better modeled as a non-linear model (quadratic).

Teenagers also experience a lower r value at 0.32, and a $r^2$ value of 0.10, this shows a weak negative correlation with an weak linear model, because the $r^2$ is low. The points follow no real pattern making the distribution of points quite random.

Due to the fact that 2 out of the 3 people in this part of the study had a weak correlation with a weak $r^2$ value we can deduce that the model does not explain the majority of data presented, with this presentation we can conclude that there is not a strong linear correlation between time of day and intensity of anger. However, since $r^2$ is low, there is a possibility that the data will better fit the quadratic model, rather than the presented linear model.

### 3.4 Sadness

Adult Mother Experiences an R-Value of -0.25 and an $r^2$ value of -0.06, this implies a Weak Negative Correlation, this model is not useful due to the extremely low $r^2$ value but from plotting the consequential points on a graph it seems more likely that a quadratic model would more likely fit the data set better

Adult Male has an R-Value of -0.22, and an $r^2$ value of 0.05, this again has a very weak negative correlation, rendering a model that is not very useful with the same quadratic model tendencies.

Teenager again is not much better, with an r value of 0.37, and an $r^2$ value of 0.14, this is a weak positive correlation with the model only explaining around 14 percent of the data, Once again, this data set looks increasingly like a quadratic model with a vertex at 3 PM.

### 3.5 Disgust

Adult Female with values sourced from the Disgust Tests, we have an r value of -0.08, and an $r^2$ of 0.01, the linear model suggests very little correlation, and it is not explanatory for any of the data. Plotting the data on a graph reveals that the data is non-linear but not quadratic either. This data set is strange, the brain waves seem to be almost random.

Adult Male has a similar trend, with an r value of 0.37 and an $r^2$ is equal to 0.14. This shows weak positive correlation. However the model is not explanatory, as it only accounts for again, 14 percent of the data. This data shows a very linear correlation.

Teenager again, has a similar trend with an r value of -0.15, with a $r^2$ value at 0.02, This is a very weak negative correlation, and an extremely low $r^2$ value meaning the model is not effective. The data appears to be highly variable with no real trends.

### 3.6 Happiness

Adult Female has an r value of 0.75, with the $r^2$ value of 0.56. There is a strong linear correlation with a relatively accurate model. This data expresses a strong upward trend.

Adult Male has an r value of 0.62, and an $r^2$ value of 0.38. A semi accurate model is present here which explains 38 percent of the data with relatively strong positive linear correlation. Just like the previous model, this data also expresses an upward trend.

Teenager has an r value of -0.31 and an $r^2$ value of -0.10. This is a weak model with a slight negative correlation. This data expresses no real trends in either direction with the frequency staying constant throughout the day.

Overall, the majority of the cases that were tested produced the conclusion that the data was better represented with different, non-linear models. In other instances the data appeared completely random, without any adherence to any

trends. In conclusion, it does not seem that there is a strong linear correlation between emotional intensity and the time of day.

## 4. ANOVA Test

In the application of this test, the author used mean emotional intensity for each emotion of each subject and compared the numerical values against each other. The null hypothesis explains that the means are equal and all three subjects are just as "emotional" as the other, while the alternate hypothesis explains that one member is more emotional than the other

### 4.1 Anger (ANOVA Test)

*Data Summary*

| | Samples | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | Total |
| N | 5 | 5 | 5 | | | 15 |
| $\Sigma X$ | 84.3 | 75.5 | 72.5 | | | 232.3 |
| Mean | 16.86 | 15.1 | 14.5 | | | 15.4867 |
| $\Sigma X^2$ | 1448.29 | 1154.25 | 1057.25 | | | 3659.79 |
| Variance | 6.748 | 3.55 | 1.5 | | | 4.4455 |
| Std.Dev. | 2.5977 | 1.8841 | 1.2247 | | | 2.1084 |
| Std.Err. | 1.1617 | 0.8426 | 0.5477 | | | 0.5444 |

standard weighted-means analysis

*ANOVA Summary* Independent Samples k=3

| Source | SS | df | MS | F | P |
|---|---|---|---|---|---|
| Treatment [between groups] | 15.0453 | 2 | 7.5227 | 1.91 | 0.190480 |
| Error | 47.192 | 12 | 3.9327 | | |
| Ss/Bl | | | | | |
| Total | 62.2373 | 14 | | | |

Graph Maker

Figure 8. Anger ANOVA Test

Since the p value is equal to 0.19, and we are given that the a value is 0.05, p is greater than a so we accept the null hypothesis and conclude that neither subject is angrier than the other, or has a higher reception to anger.

### 4.2 Sadness (ANOVA Test)

*Data Summary*

| | Samples | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | Total |
| N | 5 | 5 | 5 | | | 15 |
| ΣX | 22.7 | 24 | 24.8 | | | 71.5 |
| Mean | 4.54 | 4.8 | 4.96 | | | 4.7667 |
| $\Sigma X^2$ | 108.43 | 124.88 | 125.36 | | | 358.67 |
| Variance | 1.343 | 2.42 | 0.588 | | | 1.2752 |
| Std.Dev. | 1.1589 | 1.5556 | 0.7668 | | | 1.1293 |
| Std.Err. | 0.5183 | 0.6957 | 0.3429 | | | 0.2916 |

standard weighted-means analysis

*ANOVA Summary* Independent Samples k=3

| Source | SS | df | MS | F | P |
|---|---|---|---|---|---|
| Treatment [between groups] | 0.4493 | 2 | 0.2247 | 0.15 | 0.862297 |
| Error | 17.404 | 12 | 1.4503 | | |

Figure 9. Anger ANOVA Test

Since the p value is 0.86 and the given a value is 0.05, p value is greater than a. Therefore, we accept the null hypothesis again concluding that neither one family member is more sad than the other, or does not have a higher receptiveness to sad emotions.

### 4.3 Disgust (ANOVA Test)

*Data Summary*

| | Samples | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | Total |
| N | 5 | 5 | 5 | | | 15 |
| ΣX | 43.2 | 42.9 | 43.1 | | | 129.2 |
| Mean | 8.64 | 8.58 | 8.62 | | | 8.6133 |
| $\Sigma X^2$ | 376.78 | 368.81 | 372.17 | | | 1117.76 |
| Variance | 0.883 | 0.182 | 0.162 | | | 0.3512 |
| Std.Dev. | 0.9397 | 0.4266 | 0.4025 | | | 0.5927 |
| Std.Err. | 0.4202 | 0.1908 | 0.18 | | | 0.153 |

standard weighted-means analysis

*ANOVA Summary* Independent Samples k=3

| Source | SS | df | MS | F | P |
|---|---|---|---|---|---|
| Treatment [between groups] | 0.0093 | 2 | 0.0047 | 0.01 | 0.990058 |
| Error | 4.908 | 12 | 0.409 | | |

Figure 9. Anger ANOVA Test

Since the p value is 0.99 and we know the given value is 0.05, p is greater than a so in this case we accept the null hypothesis again, showing us that no one subject had a higher reception to emotions surrounding disgust.

### 4.3 Happiness (ANOVA Test)

*Data Summary*

| | Samples | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | Total |
| N | 5 | 5 | 5 | | | 15 |
| $\Sigma X$ | 68.1 | 69.3 | 69 | | | 206.4 |
| Mean | 13.62 | 13.86 | 13.8 | | | 13.76 |
| $\Sigma X^2$ | 928.81 | 961.01 | 952.7 | | | 2842.52 |
| Variance | 0.322 | 0.128 | 0.125 | | | 0.1754 |
| Std.Dev. | 0.5675 | 0.3578 | 0.3536 | | | 0.4188 |
| Std.Err. | 0.2538 | 0.16 | 0.1581 | | | 0.1081 |

standard weighted-means analysis

*ANOVA Summary* Independent Samples k=3

| Source | SS | df | MS | F | P |
|---|---|---|---|---|---|
| Treatment [between groups] | 0.156 | 2 | 0.078 | 0.41 | 0.672604 |
| Error | 2.3 | 12 | 0.1917 | | |

Figure 10. Anger ANOVA Test

Finally the p value is 0.67, and the given a value is 0.05, because the p value is greater than the a value we accept the null hypothesis once more

For all four tests for each emotion, the null was accepted. We, therefore, conclude that no subject had higher reception to specific emotions than the other.

## 5. Conclusion

This research comes to the conclusion that there is in fact no statistically significant correlation between emotion intensity, and the time of day, we also know that various people do not have too different of emotion intensity/reception variables (People are not much naturally angrier than another). We would expect humans to be more variable, with emotions flipping like a coin, but we see here that reaction and emotions are much more inset, and are much stronger than previously expected. We also see that though it is expected for Teens to be more emotionally variable than their adult counterparts, this is proven wrong with relatively similar results, hormonal changes change more immediate reactions rather than overall emotion.

## 6. Future Opportunities

This field of emotional informatics, and classifications is revolutionary, especially with this smaller scale application of EEG, this concept allows for higher groups of people to create, and apply higher level of tests. Usually, EEG's are often upwards of thousands of dollars, with the design that is applied, and used in the aforementioned research, we are able to derive reasonable data sets. Some ways to clean up this experiment could be to use higher level machinery, such as MRI, and even internal EEG sensors, offering the highest level of recording. Though this has some limitations, direct applications of specific neurotransmitters to insight specific emotions could be helpful for a standard emotional response for easy recording, such as dopamine for happiness, and acetylcholine for anger. There are many fields to develop on, the brain is the last frontier of the human body and this experiment offers a new lense to worlds of psychoanalysis and consciousness, with lots of untapped potential.

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## 8. Biography

**Arhan Surapaneni** is a sophomore at Stanford University’s Online High School. He is leader of various clubs leading from Neuroscience, to International Medicine Olympiad, he has also edited and created the curriculum for various programming camps, as well as a teaching assistant for various courses, working with projects on public health with University of Washington. He hopes to study Neuroscience and go on towards medical school later in college.