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A Feasibility Study on the Emotional Quotient of Humans Towards Color using Visual Evoked Potential

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Abstract: A Brain Computer Interface (BCI) is a mode of communication based on neural activity generated by the brain. It allows subjects to send their messages or commands to a computer without any muscle movement but thinking. Direct BCIs is a developing field that has been adding a new dimension of functionality to HCI. BCI relies on Electroencephalography (EEG), an electrophysiological monitoring method, to acquire signals from the brain. One of the several components extracted is the Visual Evoked Potential. This paper focuses on P300, an event related potential (ERP) elicited by task relevant stimuli. P300 is a positive peak occurring approximately 300ms after stimulus onset. Detecting P300 in a single trial is difficult as it has very little amplitude. This peak is obtained from the occipital cortex of the brain which deals which human response to vision and colour recognition. The objective of this paper is to use an application of this P300 component. The subjects are externally stimulated with varying colours or images and their brain waves analyzed. The P300 has high signal to noise ratio and have to be extracted and amplified. The values shown in the EEG waves are classified to study the behaviour of human brain to the stimulus. This study can be used clinically to determine the onset of certain diseases, which can damage the occipital lobe of the brain, that are difficult to determine by surgery or in applications where the emotions of an individual can be determined by the emotional quotient.

Index Terms: Brain Computer Interface, EEG, Emotional Quotient, P300, Visual Evoked Potential.

1. INTRODUCTION

A brain computer interface (BCI) is a mode of direct communication pathway between a human or wired brain and a computer. BCIs are aimed at research, assistance or repair of cognitive and motor functions. A BCI is a communication and control system that has no dependency in any way on the brain‘s normal neuromuscular output channels. The user‘s intention is conveyed to the computer by brain signals, captured by an EEG machine, rather than by peripheral nerves and muscles, and these brain signals are not dependent for their generation on the brain’s neuromuscular activity. A BCI establishes a real-time interaction between the user and the outside world. [1] A typical BCI system that is commonly used is shown in Figure 1.

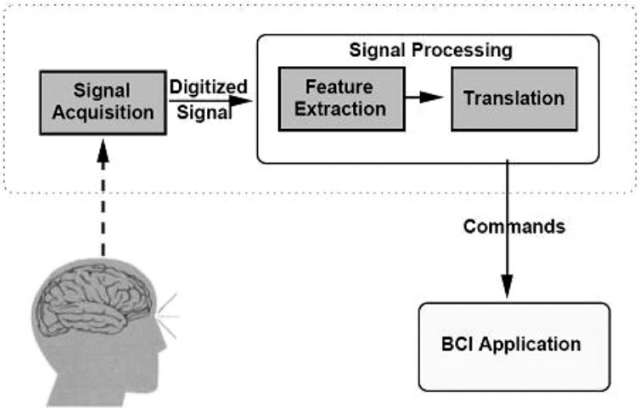

Figure 1: A typical BCI system

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Electroencephalography (EEG) is a method of measuring the electrical activity produced by the brain and is recorded from the electrodes placed on the scalp. It is typically a non-invasive procedure wherein the subject wears a cap embedded with electrodes. It measures the changes in voltage generated due to current in the neurons of the brain. The brain generates a large amount of neural activity. An action potential in an axon causes the release of neurotransmitter into the synaptic junction. The neurotransmitter diffuses across the synaptic junction and binds to receptors in a post-synaptic dendrite. The similar activity of many types of receptors and axons results in a flow of ions into or out of the dendrite. It is these extracellular currents which are responsible for the generation of EEG voltages. [2]

The 10 – 20 Electrode Placement System is an internationally well known method to describe and apply the location of scalp electrodes in an EEG test or experiment. This system is based on the relation between the placing of an electrode on the EEG cap and the cerebral cortex of the brain. Two main points used for the placing of the electrodes are the nasion, the area above the nose bridge and between the eyes, and the inion, the lowest part of the skull which is identified by a prominent bump. [2] It is shown diagrammatically in Figure 2.

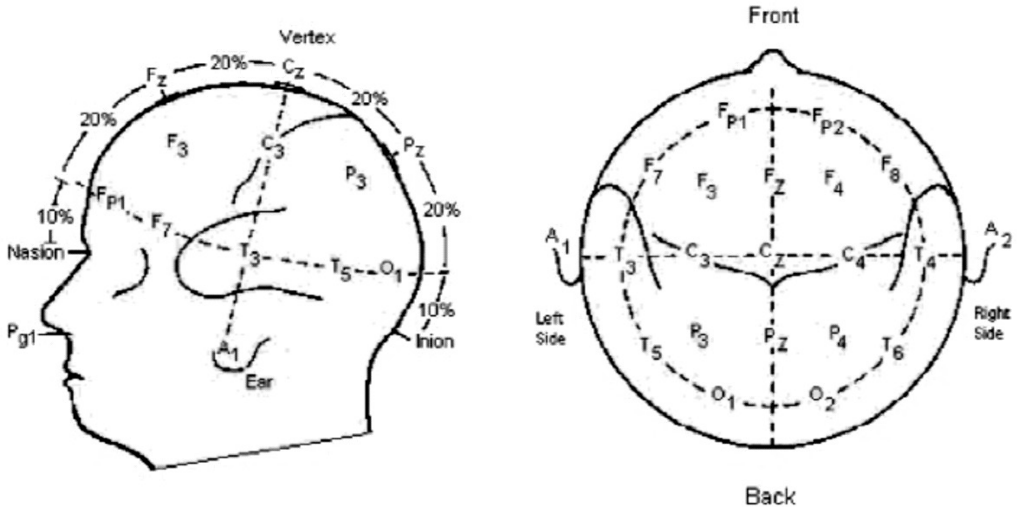

Figure 2: The 10-20 Electrode Placement System

Visual evoked potential (VEP) refers to electrical potentials initiated by brief visual stimuli, which are recorded from the scalp just above the visual cortex also known as the occipital cortex. VEP waveforms are extracted from the EEG machine by signal averaging. VEPs are used mainly to test the functional efficiency of the visual paths from the eye through the retina to the optic nerves to the occipital cortex of the brain. VEPs better test the functionality of the optic paths than scanning methods or surgeries. Any abnormality that can affect the visual paths or occipital cortex in the brain can affect the VEP. A VEP can often be found in the background EEG recorded from the occipital cortex through the scalp following a visual stimulus like a flash of light or colour. [3]

The P300 wave is an ERP component generated in the process of decision making. It is considered to be a potential generated within the brain cells or tissue, because its occurrence is not related to the characteristics of a stimulus, but how a person is affected by the stimulus. When recorded by an EEG machine, it comes out as a positive change in voltage with a delay, between stimulus given to the subject and response generated, of roughly 250 to 500 ms. The signal is usually measured most strongly from the electrodes covering the parietal lobe. The presence, measure, distribution and timing of this signal are often used as units to measure cognitive function in the decision making processes. The P300 is a positive amplitude which is calculated with a reference behind the ear with a peak at approximately 300 ms and

it varies in the delay depending upon the task performed. It is usually high over the parietal areas of the scalp.

2. LITERATURE SURVEY

H. Serby, et al says that the best method of using a BCI is by basing it on the P300 values obtained from an EEG reading. The only issue which is the low signal to noise ratio can be overcome by repeating the stimulus to improve user's performance. The number of trials should be adjusted to the user's average performance in order to achieve the desired accuracy. We set some thresholds which help in reaching a decision based on performance rather than a fixed number of trials. [4]

A. Mejrad says that emotional activities of the brain causes difference in EEG characteristics waves. It has been attempted to investigate the brain activity related to emotion through analyzing EEG. The important characteristics of the EEG signals are age and mental state of the subject, region of the brain, hereditary factors, influences of the brain and artifacts.[5]

Nawrocka, et al states that the most common method of recording brain waves is the use of an EEG machine. The main advantages of using this technique in BCI are the real-time evaluation of brain activity. One of the frequently used potentials is the P300 which is associated with the reaction of the person to an expected stimulus. This potential appears in the EEG about 300 ms after the stimulus and is seen in the Parietal Lobe. Visual evoked potential (VEP) arise in the central nervous system due to stimulation of the retina. The main factor determining the efficiency of a BCI is the signal to noise ratio (SNR), which directly affects the accuracy of detection. [6]

Lai, et al states that chromatic transient VEP (CTVEP) is elicited when chromatic visual stimulus is presented at low frequency, i.e., less than 4Hz, and perceived within the visual field. Fast varying luminance of conventional visual stimulus can easily fatigue and exhaust users. The safety of this VEP is due to low frequency change in the visual stimulation on one hand and no luminance variation on the other which makes it more comfortable for users than the conventional VEP. [7]

Danny Oude Bos says that psycho-physiological research shows there is a direct link between the amount of action in the left frontal lobe and the right frontal lobe and the resulting emotion. A higher activity in the left frontal region indicates a positive reaction, and high activity in the right anterior lobe depicts negative effect. The influential EEG features detected during various emotional stimuli are valence - positive, happy emotions that result in a higher frontal coherence in alpha waves, and higher right parietal beta, when compared to negative emotion, arousal - excitation presented a higher beta value and coherence in the parietal lobe, plus lower alpha power and dominance – the strength of an emotional state, which is generally expressed in the EEG as an increase in the beta/alpha activity ratio in the frontal lobe of the brain, plus an increase in beta power at the parietal lobe. [8]

3. MATERIALS AND METHODOLOGY

Emotional state of an individual can be understood from face, gesture, from text, from speech or biofeedback. An Event – Related Potential (ERP) can be generated by visual stimulus also. Since emotions could be detected by audio stimulus, we can conduct a feasibility study to determine the emotional state of an individual. As visual stimulus is based on the optic nerve, where the response might differ by gender, age, blood group, we can categorise our subjects for a better understanding. Using the Valence – Arousal model, the emotions can be classified into four groups. Using the values, the emotional quotient of the individual can be determined.

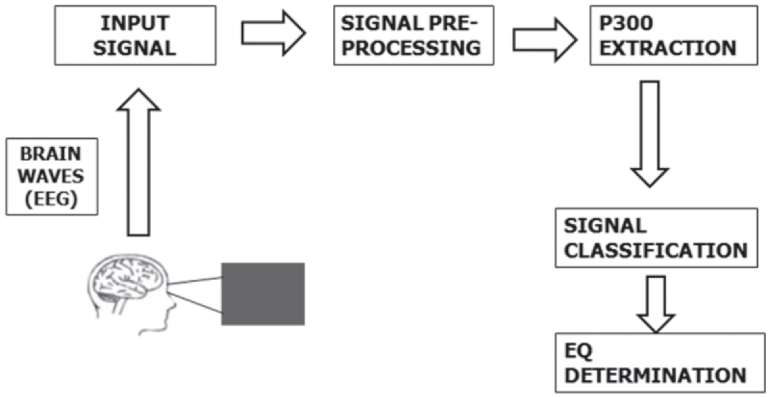

Figure 3: Block diagram of the proposed system

The device that will be used in this project is the NeuroSky MindWave Mobile Headset. This device is the culmination of EEG biosensor technology research. The headset can be linked to any device using Bluetooth technology and can be controlled from PC or android applications. The device paired to the headset is an android mobile. The sensors mounted on the headset can detect faint brainwave signals safely and passively. This device uses a non-invasive method of recording brain waves. The technology embedded in the NeuroSky headset interprets the meaning of these recorded signals. These brainwave signals can then cause effects and results in an application. Here, the android application ised in eegID which gives values for alpha, beta and gamma waves which can tell us the emotional state the subjects are in.

In this project, we aim to isolate the brain waveform from EEG and digitize the same and use it for interfacing it with the computer for determining the emotional quotient of a person. Emotion recognition from EEG can be used to determine the emotional state a person is in or find out what emotion a colour triggers in a particular individual. We aim to determine the emotional quotient of humans using EEG-based brain-computer interface system. Here we combine the property of EEG waves to detect emotions with the property of colours to trigger different emotions in humans to determine the emotional state of an individual. The current emotional state of a human is assessed using the EEG recordings and the person is asked to view different images. The consequent EEG recordings is compared with the initial recordings and his/her emotional state is determined. The person is made to view many other colours and the resulting change in colours is viewed. When the tests are done with all the colours, the experiment is completed.

The various emotions were classified using Valence and Arousal value as in Wei Wang(2011) and Danny Oude Bos(2010). The Valence and Arousal value was calculated using the Bayes‘ classifier and based on those values, the various emotions are classified. The Valence-Arousal dimension model is used to classify emotions.

- HAPPY/PLEASANT emotion – Valence positive and arousal positive
- FEAR/TENSION emotion –Valence negative and arousal positive
- DEPRESSED/SAD emotion – Valence negative and arousal negative
- NORMAL/SATISFIED emotion – Valence positive and arousal negative

A. Data Acquisition

The data acquisition is a phase where the actual EEG recording of the subject is taken as per our desired activity. It forms the most important part of any BCI process because it is based on the acquired readings that the further steps are carried out. The first step in a data acquisition process is to alert the subject that the process is about to begin and ask him/her to relax and cooperate accordingly. A set of images where the chosen colours are dominant is played to the subject. This acts as the required stimuli.

As external stimuli, several images where the chosen colours are dominant are selected. The chosen colours are blue, red, yellow and green. These colours are selected specifically for certain purposes. Green is the colour of nature. It symbolizes growth, harmony andfreshness. Green has strong emotional relation with safety. Blue is taken as the color of the sky and sea. It is often associated with depth and stability. It is a symbol of trust, loyalty, confidence, intelligence, faith, truth, and heaven. Red is the color of fire and blood, so it is often thought of with energy, war, danger, strength, power, determination as well as passion, desire, and love. Yellow is the color of the sun. It is usually associated with joy, happiness, intellect, and energy.

The following questionnaire will be filled by each of the subjects before they sit for the tests:

1. What is your age?
2. Gender: M ☐ F ☐
3. What is your blood group?
4. What is your post of employment?
5. Do you suffer from any of the following?
   - Blood Pressure ☐
   - Diabetes ☐
   - Tuberculosis ☐
   - Any other ☐
6. Are you under any medication?
7. Have you been treated for any serious illness previously?
8. What colours do you prefer?
9. What memories does the preferred colour evoke?
10. Is there any specific colour you do not like?

B. Extraction of P300 values

The raw EEG is obtained from the data acquisition phase. The EEG data of each subject is stored as a separate file. There are possibility of distractions and unwanted junk values caused due to line noise, external disturbances and irrelevant activities. Hence, we go for P300 extraction which is a process of extracting the useful data alone from the entire raw EEG data recorded. After extracting the required data from the raw data, several excel sheets were obtained for each activity separately. Technically, the raw EEG data was translated to five frequency bands: Delta (1-4HZ), Theta (4-8HZ), Alpha (8-13HZ), Beta (13-30HZ) and Gamma (36- 40HZ) bands.

C. Signal Classification

In the Bayesian (or epistemological) interpretation, probability measures the degree of belief. Bayes' theorem then relates the degree of belief in a proposition before and after accounting for evidence. For example, somebody proposes that a biased coin is twice as likely to land heads than tails. Degree of belief in this might be 50%. The coin is then flipped a number of times to collect evidence. Belief may increase to 70% if the evidence supports the proposition.

For proposition A and evidence B,

P(A), the prior, is the initial degree of belief in A.

P(A | B), the posterior probability, is the degree of belief having accounted for B.

P(B | A)/P(B) represents the support B provides for A.

The Standard Deviation formula for calculation of valence and arousal is:

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$$

The influential EEG features detected during various emotional stimuli are: Valence - positive, happy emotions result in a higher frontal activity shown in alpha, and higher value for right parietal beta power, compared to negative emotion and Arousal - excitation presented a higher beta power and coherence in the parietal lobe, plus lower alpha activity.

Bayes' theorem says P(A/B) = P(A1/B) ^ P(A2/B) … ^ P(An/B)/P(B).

P(A/B) – VALENCE value with respect to AROUSAL

P(A1/B) – Frontal-Coherent-Alpha

P(A2/B) – Right-Parietal-Beta

P(A3/B) – Coherent-Alpha

P(A4/B) – Coherent-Parietal-Beta

Bayes' Theorem is defined as a theorem describing how the conditional probability of each of a set of possible causes for a given observed outcome can be computed from knowledge of the probability of each cause and the conditional probability of the outcome of each cause. It is stated mathematically as the following equation.

$$P(A/B) = \frac{P(B/A)P(A)}{P(B)}$$

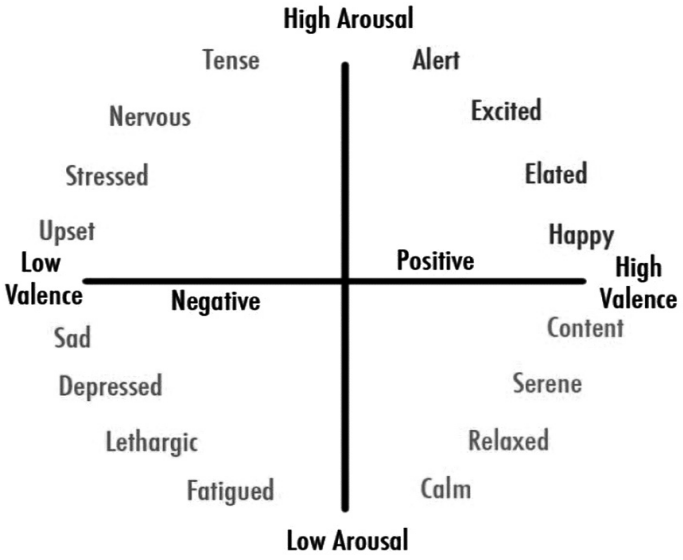

Figure 4: Valence Arousal Model

D. EQ Determination

Emotional Quotient (EQ) also known as emotional intelligence is the ability of an individual to recognize their own and other people's emotions, to know the difference between different emotions and identify them

appropriately and to use emotional information to guide thinking and behavior. This module involves the process of determining the Emotional Quotient of an individual after the experiment. The values received after classification is then put into a scale and compared with the initial emotional state of the individual to determine how relaxed or how depressed the subject is.

For determining the Emotions of an individual, we use the Valence Arousal model depicted in Figure 4. This is also known as the circumplex model of emotion and was developed by James Russell. This model shows that emotions are distributed in a two-dimensional space, containing arousal and valence dimensions. Arousal is depicted on the vertical axis and Valence is represented on the horizontal axis. The centre of this circle is depicted as a neutral valence and a medium arousal levels. This model shows that any human emotion can be depicted as a certain level of valence and arousal or at a neutral level.

4. EXPERIMENTATION

The experiment for the project is conducted in very careful and planned environments as the brain being a very sensitive organ, responds to every single stimulus. So in order to get a clear set of values, we ask the person to sit in a quiet and dark room. A light or a sound can trigger a stimulus thus resulting in noise in the experiment. The person is then explained about the project and the experimental steps. Asking the person to relax throughout the procedure is utmost necessary or that too, adds to noise in the values. Making sure the patient is very comfortable and relaxed in every step of the experiment is very essential.

The subject is asked to close their eyes and relax. The device is carefully fixed on the head and the ear-clip in position. The application is checked to see if it the device is in place and it is running well. The subject is informed to meditate on each of the colours that will be shown to them. The timer was set. Then, colours were shown to the subject. The person was asked to open their eyes, look at the colour for 5 seconds and then close their eyes. During this time period, the readings were recorded in a tablular format. The person was then given a 1 minute break to relax again and the above step was repeated. A set of 4 colours were shown and the procedure was repeated 10 times and readings taken to ensure the subject was trained and inorder to avoid signal to noise ratio.

Figure 5: The NeuroSky Brainwave Headset

Rather than the technical developments and gadgets, the human being was considered as an important factor in a successful BCI. BCI system involves as much cooperation from the subject as from the BCI computing device. The subjects were chosen in accordance with the requirements of the work to be carried

out. Since the session is based on analyzing the human emotion, a person with good mental health is chosen. A series of discussion is carried out with the subjects, analyzing the psychological state of the subjects. At first, a quantitative EEG was taken for the subject and it was analyzed and explained to the subject and later the subject was put through training sessions. The factors like external disturbances and line noise or earth ground potential can affect the recordings. These factors were well considered during many trials before starting the actual sessions.

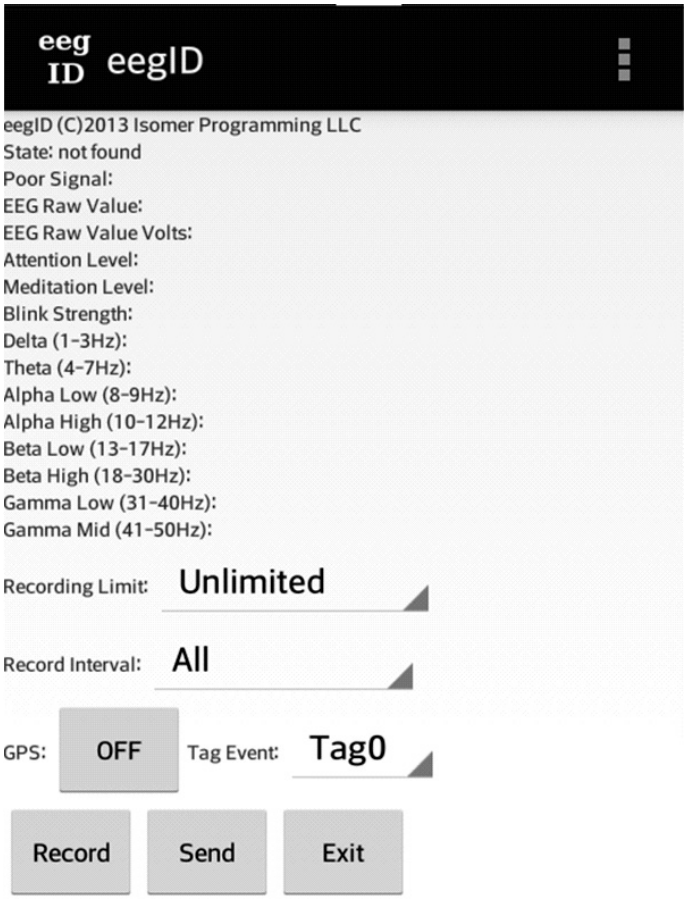

Figure 6: The android application eegID

The above shown Figures 5 and 6 are the device and application, respectively, used in the experiment. The MindWave Mobile Headset has four sensors at the temporal and central lobes, namely, T3, C3, C4, T4. It has a reference electrode at the frontal-polar position, Fp1 and a ground electrode in the form of an ear-clip. The headset is connected to the application via Bluetooth technology. This application helps us to tabulate the readings after every experiment as it sends the values received via email. This application is very helpful even during an experiment to determine whether the device has been placed properly or not.

5. RESULTS

The experiment was conducted for 60 subjects, both male and female, the ages varying from 19 to 29 years. The blood groups of the subjects belonged to the following groups: A +ve, A –ve, B +ve, B –ve, AB +ve and O +ve. The raw data was collected using the experiment and tabulated. For each subject, values were received for the following attributes, Alpha Low, Alpha High, Beta Low, Beta High, Gamma Low and Gamma Mid. The values were then normalised to bring them into a feasible range for calculation. This was done using the formula

$$\text{Normval} = \frac{x - \min}{\max - \min}$$

where, x is the value w.r.t each subject max and min are the maximum and minimum values of a particular attribute.

BLUE								
AGE	GENDER	BLOOD GROUP	ALPHA LOW	ALPHA HIGH	BETA LOW	BETA HIGH	GAMMA LOW	GAMMA MID
25	Female	B-	16772373	9369	6776	18210	4197	3876
23	Female	O+	1926	22001	9876	14989	5556	1888
26	Male	A+	16750027	28824	17917	11252	6402	3730
23	Male	B+	11775	7069	2232	1786	1023	1099
24	Female	B+	75866	16760152	44090	65598	16756630	24411
23	Female	A-	2320	3404	4220	862	508	517
22	Male	O+	28182	32053	15711	16086	5419	695
21	Female	A+	4395	20138	11523	5809	6572	2870
23	Female	B+	6577	4104	6216	13380	5822	1462
25	Male	B-	2773	5284	9642	3869	1369	1389
25	Male	O+	16133	20054	5191	5409	1817	923
26	Male	O+	1700	16749705	4126	9976	3039	4584
24	Female	B-	21105	5484	5320	20350	1727	2110
26	Female	A-	17438	30993	16750034	11044	9280	2907
27	Male	O+	16765260	32262	27791	19688	3354	1032
25	Male	O+	14957	25552	13272	13030	7145	2802
26	Female	O+	16747530	17960	6447	12473	2142	2116

GREEN								
AGE	GENDER	BLOOD GROUP	ALPHA LOW	ALPHA HIGH	BETA LOW	BETA HIGH	GAMMA LOW	GAMMA MID
25	Female	B-	24974	12380	3108	7527	3238	3029
23	Female	O+	24974	12380	3108	7527	3238	3029
26	Male	A+	3782	5487	15141	2819	4104	2345
23	Male	B+	16762434	22993	11142	19237	8457	7489
24	Female	B+	16756953	15766	20932	65586	28706	4736
23	Female	A-	2259	12111	5383	3669	1782	1288
22	Male	O+	11245	9876	4889	24278	23056	4558
21	Female	A+	10405	17733	7352	4926	3683	2460
23	Female	B+	17329	10069	5181	4377	4834	1529
25	Male	B-	2695	7111	6553	2728	1699	1225
25	Male	O+	9183	16762117	19209	18468	7146	7057
26	Male	O+	605	464	741	1262	992	179
24	Female	B-	16248	16769389	16690	17114	8976	4423
26	Female	A-	9511	25983	23790	11940	16754448	7378
27	Male	O+	303	28888	6866	22573	10076	7289
25	Male	O+	5678	3893	10278	4734	1916	1103
26	Female	O+	5639	31020	11470	11249	6000	4068

After normalization, the difference was found between Alpha Low and High, Beta Low and High and Gamma Low and Mid to see the variation in these attributes to determine an estimate of a subject's reaction to the colours. These values are shown in Figure 7.

YELLOW

AGE	GENDER	BLOOD GROUP	ALPHA LOW	ALPHA HIGH	BETA LOW	BETA HIGH	GAMMA LOW	GAMMA MID
25	Female	B-	71910	86935	53874	46812	16762587	3828
23	Female	O+	51457	31640	18544	14141	3938	2060
26	Male	A+	7383	6436	25462	4673	8645	1883
23	Male	B+	48353	252203	419147	343609	135012	16752566
24	Female	B+	145734	55568	16768489	46343	49958	21495
23	Female	A-	18670	13770	3038	4043	2792	1848
22	Male	O+	3766	21025	3516	7532	3181	1169
21	Female	A+	9796	12476	22500	9132	5604	1904
23	Female	B+	87080	16744927	14955	19786	24284	5156
25	Male	B-	16760288	22142	19662	16247	4804	2857
25	Male	O+	896205	254643	527546	261926	57481	16766450
26	Male	O+	16758557	23116	15022	16745580	8998	4886
24	Female	B-	6301	4515	17782	4149	2761	1233
26	Female	A-	189487	139927	138407	271253	91717	74942
27	Male	O+	23255	9088	6836	11273	3688	453
25	Male	O+	9258	6185	11920	7546	1157	499
26	Female	O+	1029	13716	13315	6619	6169	1403

RED

AGE	GENDER	BLOOD GROUP	ALPHA LOW	ALPHA HIGH	BETA LOW	BETA HIGH	GAMMA LOW	GAMMA MID
25	Female	B-	14295	16769887	4521	4978	5211	4161
23	Female	O+	1521	2945	2797	1140	567	345
26	Male	A+	16770501	8499	17697	7433	4887	3916
23	Male	B+	12527	16759552	27575	24198	27065	2020
24	Female	B+	16771079	17316	32124	16758867	19288	7953
23	Female	A-	16755689	131940	28389	7816	6128	5879
22	Male	O+	16759229	10969	12515	16410	4659	5328
21	Female	A+	16024	49907	7869	14077	12322	4567
23	Female	B+	31221	16755121	90462	42248	7416	15076
25	Male	B-	7951	11302	8359	4420	5829	3607
25	Male	O+	2599	1447	2081	3565	1606	1040
26	Male	O+	4115	26026	13176	15139	5077	1127
24	Female	B-	8886	16744790	7459	17833	7639	7645
26	Female	A-	20104	9524	10186	4631	2683	1710
27	Male	O+	15571	17655	8184	4076	1599	931
25	Male	O+	16005	16744361	28529	11512	3303	1451
26	Female	O+	4095	14266	14261	9517	6060	2050

Figure 7: The raw data values of each colour

			BLUE			GREEN			YELLOW			RED		
AGE	GENDER	BLOOD GROUP	ALPHA HIGH - ALPHA LOW	BETA HIGH - BETA LOW	GAMMA MID - GAMMA LOW	ALPHA HIGH - ALPHA LOW	BETA HIGH - BETA LOW	GAMMA MID - GAMMA LOW	ALPHA HIGH - ALPHA LOW	BETA HIGH - BETA LOW	GAMMA MID - GAMMA LOW	ALPHA HIGH - ALPHA LOW	BETA HIGH - BETA LOW	GAMMA MID - GAMMA LOW
25	Female	B-	-0.999307	0.000630	0.035934	-0.000760	-0.002372	0.009664	0.000893	-0.000421	-0.999082	0.999238	0.000045	0.052968
23	Female	O+	0.001078	0.000386	0.015282	0.000620	-0.011090	0.004244	-0.001183	-0.000263	-0.000099	0.000098	-0.000081	0.003200
26	Male	A+	-0.996814	-0.000317	0.034291	0.000092	-0.016611	0.007261	-0.000058	-0.001240	-0.000390	-0.999284	-0.000595	0.049774
23	Male	B+	-0.000400	0.000055	0.007388	-0.997948	-0.010992	0.024686	0.012149	-0.004500	0.991160	0.998728	-0.000184	0.023587
24	Female	B+	0.995510	0.001362	-0.751099	-0.998052	-0.019583	0.014012	-0.005379	-0.997336	-0.001683	-0.998793	0.997689	0.101858
23	Female	A-	-0.000055	-0.000119	0.001397	0.000578	-0.005241	0.003766	-0.000294	0.000059	-0.000043	-0.991040	-0.001209	0.075444
22	Male	O+	0.000113	0.000103	0.002946	-0.000091	-0.003438	0.013738	0.001028	0.000239	-0.000107	-0.998465	0.000250	0.068305
21	Female	A+	0.000819	-0.000260	0.025382	0.000428	-0.007450	0.007681	0.000158	-0.000798	-0.000208	0.002034	0.000388	0.057868
23	Female	B+	-0.000267	0.000509	0.010858	-0.000442	-0.004965	0.004412	0.992971	0.000288	-0.001127	0.997349	-0.002858	0.195980
25	Male	B-	0.000030	-0.000263	0.010368	0.000254	-0.006654	0.003554	-0.998068	-0.000204	-0.000103	0.000213	-0.000217	0.045665
25	Male	O+	0.000115	0.000095	0.005520	0.999037	-0.020396	0.023279	-0.038261	-0.015838	0.996610	-0.000056	0.000106	0.012252
26	Male	O+	0.999308	0.000430	0.043329	-0.000018	0.000000	0.000000	-0.997907	0.998140	-0.000232	0.001319	0.000135	0.013187
24	Female	B-	-0.001051	0.000978	0.017808	0.999049	-0.017555	0.014114	-0.000108	-0.000814	-0.000078	0.998064	0.000636	0.098514
26	Female	A-	0.000690	-0.998890	0.025604	0.000973	-0.026100	-0.975250	-0.002959	0.007927	-0.000985	-0.000618	-0.000314	0.020975
27	Male	O+	-0.997517	-0.000403	0.006556	0.001695	-0.005833	0.023902	-0.000846	0.000264	-0.000180	0.000137	-0.000228	0.010823
25	Male	O+	0.000513	0.000067	0.024645	-0.000116	-0.010856	0.003122	-0.000185	-0.000261	-0.000026	0.997614	-0.000997	0.017541
26	Female	O+	-0.997314	0.000441	0.017845	0.001504	-0.011850	0.013071	0.000755	-0.000400	-0.000271	0.000619	-0.000265	0.025233
26	Female	A+	0.000001	0.000440	0.013874	0.000740	-0.006079	0.008705	0.012487	0.009666	-0.001097	0.993411	0.000306	0.064880
25	Male	O+	0.001977	-0.001556	0.120878	0.991295	0.986138	0.028867	-0.000945	0.000365	-0.000204	0.000737	-0.000062	0.004819
27	Female	B+	0.000707	0.000330	0.018198	-0.000684	-0.007702	0.014957	0.996985	0.998789	-0.000163	0.000199	0.000655	0.086970
24	Female	AB+	-0.000588	0.004082	0.094357	-0.000503	-0.005244	0.000838	-0.000332	0.000089	-0.000187	0.000426	-0.000837	0.032876
26	Male	A-	-0.005015	0.000192	0.012092	0.000138	-0.000948	0.004704	-0.001939	-0.993600	-0.001162	-0.000093	0.000182	0.063696
24	Male	O+	-0.001214	0.000215	0.020777	0.999216	-0.032426	0.018837	0.000634	-0.000480	0.000048	0.994648	-0.000782	0.065534
27	Female	A+	-0.000317	0.000041	-0.000032	-0.000077	-0.012468	0.024380	0.000041	0.000711	0.000000	0.000531	0.000323	0.032947
26	Male	O+	-0.002892	0.996098	0.998820	0.000428	-0.006162	0.005194	0.000367	-0.000934	-0.000427	-0.997081	0.998143	0.090237
27	Female	A-	0.995048	-0.001375	0.083537	-0.000771	-0.024056	0.006758	0.003066	-0.000327	-0.000281	0.000077	0.001320	0.050235
28	Male	O+	0.001078	0.994499	0.070657	0.998369	0.983770	0.006458	0.000138	-0.000101	-0.000622	0.000370	0.000058	0.043756
28	Female	O+	-0.000399	-0.000318	0.011151	-0.994937	-0.014017	0.010356	0.000831	-0.000912	-0.000237	0.997332	-0.994212	-0.807070
23	Female	A+	0.000110	-0.000009	0.003777	-0.000809	-0.010231	0.006050	0.004816	0.002607	-0.000774	-0.000052	-0.000073	-1.000000
21	Female	A+	-0.000096	-0.002169	-0.945583	-0.000070	-0.011986	0.022318	-0.000129	0.001722	-0.000358	-0.000234	0.000069	0.042909
24	Female	B+	-0.998255	-0.000155	0.010720	-0.998871	-0.010254	0.004715	-0.000078	0.997446	-0.997962	-0.006412	-0.002015	-0.900412
25	Male	B+	-0.999587	0.000569	0.017211	-0.994568	0.967205	0.011743	0.996796	-0.000168	-0.998144	0.009750	0.024141	0.249301
26	Male	O+	-0.000188	-0.000599	0.039559	-0.002412	-0.011227	0.012191	0.998034	0.000402	-0.000516	0.999326	0.994507	0.029306
27	Female	A+	-0.001482	0.000063	0.002719	0.998342	-0.010188	0.006133	-0.002480	-0.010877	-0.997975	0.000015	0.000870	0.034250
26	Male	O+	-0.000154	0.001102	0.009965	0.000219	-0.009457	0.003015	0.993244	0.997336	0.000026	0.000452	0.000187	0.012758
25	Female	A-	0.000086	-0.000052	0.024119	0.999633	-0.002910	0.002939	0.009554	0.000143	-0.000125	-0.996988	-0.998155	0.233581
25	Female	AB+	0.000141	-0.000593	0.012090	0.000286	-0.028605	0.026054	-0.014822	0.025517	0.010988	-0.995702	0.000769	0.614908
25	Male	B-	-0.006645	-0.000982	0.005794	0.000383	-0.013547	0.003976	-0.006065	-0.001995	-0.997761	-0.000090	-0.000657	0.004385
27	Male	O+	-0.000486	0.000255	0.002322	0.001522	-0.002240	0.014066	0.000382	-0.000202	0.000064	0.000491	-0.000289	0.004134
25	Female	A+	-0.999929	-0.000117	0.011008	0.001047	-0.004970	0.027206	-0.992572	0.002625	0.000755	-0.993284	0.003726	0.060222
24	Male	B-	0.000797	0.000308	0.018900	-0.000110	-0.006075	0.013529	0.998773	-0.000123	-0.000346	-0.001679	0.000043	0.162250
26	Male	B	0.993655	-0.000595	-0.746117	-0.997800	-0.009890	0.006800	-0.003339	0.002041	-0.001335	0.000884	0.994589	0.242582
20	Male	B+	-0.000283	0.000292	-0.945957	-0.001186	-0.006910	0.003974	0.001001	-0.000063	-0.000240	0.000370	0.000466	0.049850
24	Male	O+	0.000751	0.000347	0.007884	-0.997447	-0.028343	0.009193	0.998622	0.000222	-0.000154	-0.000074	-0.000345	0.037788
29	Male	O+	0.018294	-0.020442	0.821611	-0.997493	-0.053183	0.116424	0.004730	0.004257	-0.002025	0.004132	-0.993045	0.000664
23	Male	O+	0.001082	0.000119	0.054651	-0.997450	0.984302	0.047462	-0.998473	0.000882	-0.000042	0.000275	0.000453	0.043698
26	Male	A-	-0.998315	0.000287	-0.799549	0.000144	0.995664	0.018411	-0.001194	0.000140	0.000038	-0.000637	0.000048	0.012657
19	Male	A+	0.019297	-0.052463	0.895007	-0.993912	-0.021335	0.002419	-0.000337	-0.000078	0.000000	-0.997952	-0.998492	0.039096
26	Female	O+	0.000499	-0.001038	0.062696	0.000071	-0.010016	0.024691	0.011627	-0.009437	0.017305	-0.000218	-0.000081	0.011363
24	Female	O+	-0.029705	0.003697	0.952589	-0.956892	-0.972583	0.982316	0.014180	0.018031	-0.028927	0.995642	0.004771	0.529640
26	Male	O+	-0.000220	-0.000026	0.016404	-0.998341	-0.008666	0.013518	0.000798	0.000717	-0.000434	0.000659	-0.000678	0.076813
24	Female	B+	0.007420	-0.001565	0.147981	0.000965	-0.008064	0.024173	0.000207	-0.001956	0.001280	-0.000310	-0.000071	0.012337
24	Female	B+	0.997671	0.000396	0.094590	-0.000036	-0.002432	0.026624	-0.000079	0.000000	-0.000045	0.001438	0.000309	0.105566
26	Male	B+	-0.004177	0.990886	0.177483	0.001176	-0.012794	0.014028	-0.989568	0.004295	-0.997511	-0.000791	0.000400	0.034928
26	Female	A+	0.998860	0.997830	0.017306	0.000189	-0.005453	0.006360	-0.003301	-0.006887	-0.994894	-0.000002	-0.000264	0.072407
29	Male	O+	0.000166	0.999766	-0.876671	-0.000081	-0.011931	0.018941	0.000075	0.002078	-0.023151	0.998340	-0.000481	0.103550
26	Female	B+	-0.997282	-0.001300	0.028328	-0.000934	-0.011507	0.010413	-0.006894	0.987786	0.994961	-0.993425	0.991153	0.158804
24	Male	A+	0.000418	0.000277	0.003532	-0.997647	-0.009195	0.011528	-0.000280	-0.000314	0.000002	-0.000236	0.000072	0.050127
28	Male	B+	0.000231	-0.000319	0.009086	0.000823	-0.016136	0.016851	-0.005836	-0.000036	0.994651	0.000069	0.000297	0.012095
22	Male	A+	0.999461	0.000634	0.087066	-0.000621	-0.019702	0.011699	0.000694	0.000062	-0.000435	-0.994499	0.003510	0.185231

Figure 8: The normalised dataset

The graphs obtained from these data values are shown below:

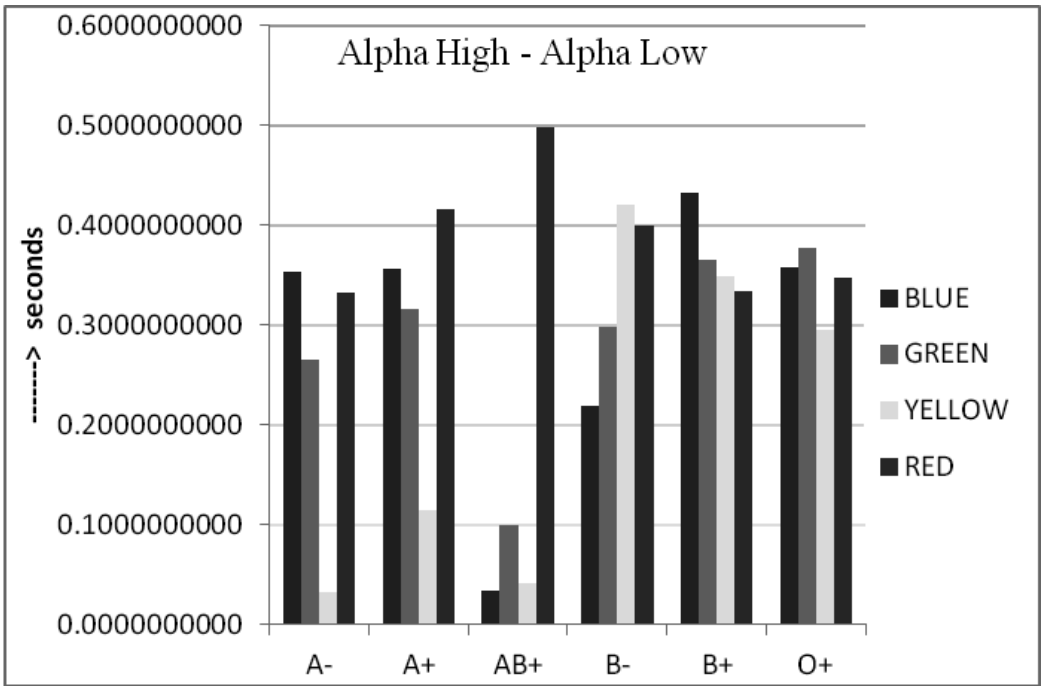

Figure 9: Alpha Values graph

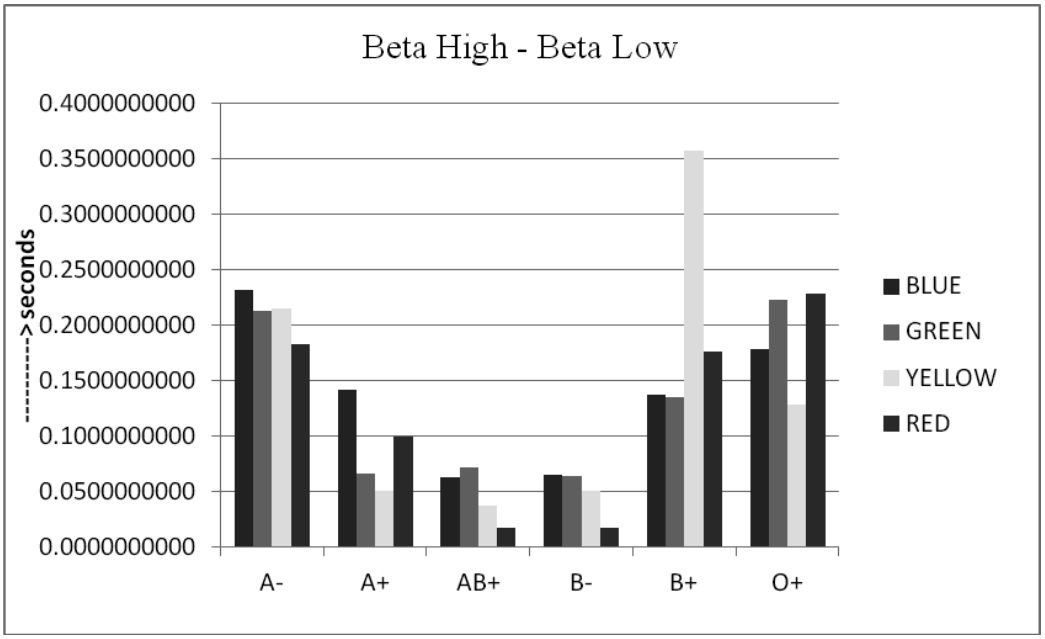

Figure 10: Beta Values graph

From Figure 9, we can say that the high alpha values for Blue colour for the blood groups, A^+, A^-, B^+, O^+ shows that these groups are very relaxed on seeing a Blue colour. Similarly, B^+ and O^+ groups are very relaxed towards Green colour. B^- group is very relaxed towards yellow colour. A^+ and AB^+ are very relaxed towards Red colour. The high alpha values represents the subject is in a very relaxed state of mind. The colour triggers a happy emotion or a very relaxed memory.

From Figure 10, the high values of Beta shows the brain is active, that is, in the thinking mode. The high values towards a particular colour shows high brain activity. The subject could be recollecting a memory with regard to the colour.

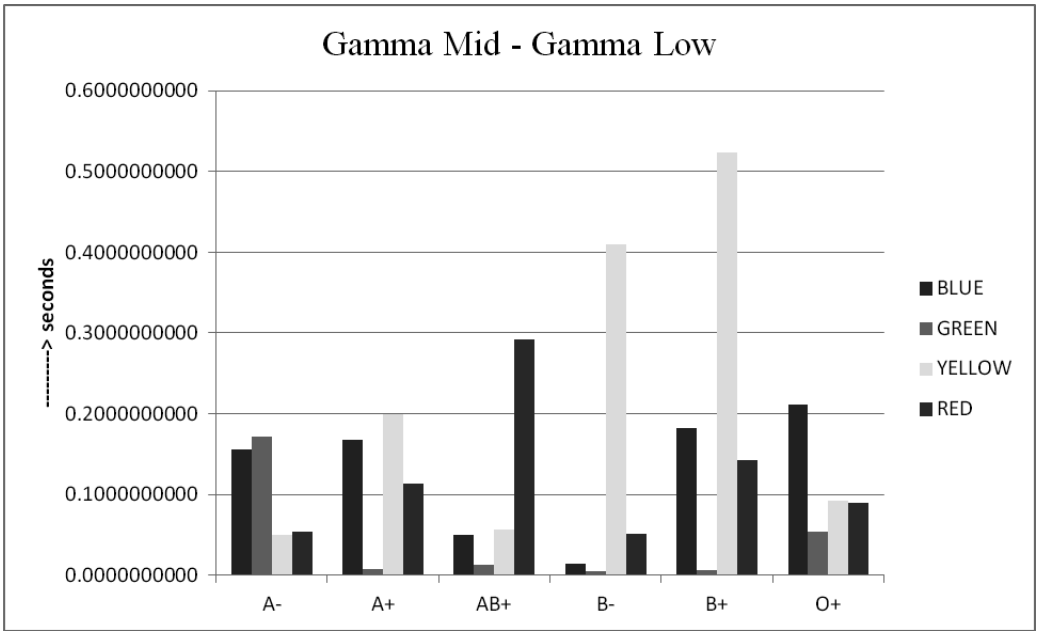

Figure 11: Gamma Values graph

From Figure 11, the high gamma values shows high levels of excitement which means the person's aversion to that particular colour. It could also be developed due to the intensity of the colour which might provoke this emotion in a subject. Bright colours tend to provoke a reactive stimulus rather than a responsive stimulus in an individual.

6. CONCLUSION

This project is a feasibility study of humans emotions towards colours and the dataset contains 60 values. The results show the relation between a subject's blood group and colours. However, to get a more precise conclusion, further experiments have to be conducted with age and a more varied subject pool. Colours are associated with memories. Hence, variations can occur with respect to the cultural background of an individual, the social status of an individual. A more detailed resul could be obtained with more advanced devices where more number of electrodes can be placed for a more accurate reading in a subject.

The subject's concentration can be improved by increasing the number of trials. And a more prolonged session inorder to let the subject be more comfortable. This study can again be related to the age category, the gender category and much more to obtain various relationships between the attributes of an individual and their reactions to colours. More colours can be added to see a more varied reaction.

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