Analysing the EEG Signal Effectiveness of Chiang Rai Arabica Drip Coffee on Individual Human Brainwave

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ABSTRACT

This study focused on the impact of Arabica coffee on the concentration of Beta waves of individuals. This was done by measuring and how the Arabica coffee affects Human EEG Frequency. Local Arabica coffee from Chiang Rai, Thailand was adopted in this study as a medium to wake up the human brain wave (attention). The experimental result showed that coffee can make human brain wave (attention) increase. The study conducted on fifty participants: twenty-five males and twenty-five females aged between twenty to thirty years old. The Electroencephalography (EEG) is collected twice and compared. The effect of caffeine on human brain waves was measured using NeuroSky Mindwave mobile. The paired sample t-test was employed for comparing two groups Beta brain waves collected in the experiment. The K-means algorithm was used to perform data mining on brain waves, and the differential brain wave signal data is clustered and divided into three levels. The experimental results showed that there was a statistically significant difference between the two paired samples. Therefore, the results confirm that coffee has a direct impact on personal Beta waves.

Keywords: Electroencephalography (EEG), Statistical Analysis, Brain Wave Signal Processing, Arabica Coffee, Data Mining, Signal Classification

1. INTRODUCTION

The discovery of EEG was made in 1924 and was published in 1929 by German psychiatrist Hans Berger. Electroencephalography (EEG) was a historic breakthrough, providing a new neurological and psychiatric diagnostic tool [1] since then. The EEG tool has been used extensively in the study and research of human brain waves [2], in the past few decades, a large number of studies have found that human brain waves have different fluctuations in different times of the day and are directly related to human emotions. The use of some psychoactive drugs can also affect the activity of brain waves [3][4][5]. According to M Linden, significant improvements in mental function and attentional behavior may be due to the impact of EEG biofeedback training on increased attention [2]. In another paper, the authors used the $\alpha - \theta$ brain wave biofeedback training program to make a significant increase in the percentage of EEG recordings for fifteen - thirty-minute $\alpha - \theta$ biofeedback training data in the treatment of chronic alcoholics [3]. The authors used a biofeedback training program to train a ten-year-old boy with learning disabilities and confirmed that the Beta wave (EEG 14-Hz) is directly related to the improvement of attention [5]. The author used the Emotive EPOC headset as a non-invasive headset to provide two minutes of music relaxation before a five-minute questionnaire survey. The data showed that the beta wave (attention) of the respondents increased significantly during the questionnaire survey [19].

Human brain waves are classified into five types: Delta, Theta, Alpha, Beta, and Gamma [7]. This study focuses on the Beta wave (12.5-25 Hz) [8] [9]. In a previous study, the authors demonstrated that the Beta wave has a direct relationship with human attention [12]. According to Adam R. Clarke's study, children with attention deficits have low Beta wave activity, and children with hyperactivity disorder have high their Beta wave activity [10]. In other studies, Paulus has demonstrated that caffeine is a psychotropic substance that can stimulate Beta waves [15]. R. Paulus argued that he used caffeine to collect beta waves (13 to 30 Hz) from 60 college students, using 200 mg of caffeine or 60 ml. Subjects were tested, and the result demonstrated that coffee could improve cognitive ability, shorten reaction time, increase concentration, and increase short-term memory. [15]. In W.M. Alharbi's paper, he discovered that caffeine directly stimulates the Beta brain waves more as the concentration of caffeine in the coffee increases. In Aldhabi's research, Caffeine causes blood vessels in the human brain to contract and promote metabolism, and the brain's central nervous system and neurons work faster, and as a result people's attention is stronger [14].

Coffee is one of the most popular drinks in the world, and Arabica coffee accounts for 60% of the

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world's coffee production [18]. According to K Nieber, drinking coffee stimulates the human central nervous system and drinking up to 4 cups of coffee per day (about 400 mg of caffeine) is suitable for good health [17]. In another research paper by Dietz, Christina, in a study of coffee-to-human cognition, pointed out that 40 mg of coffee is enough to affect attention levels [16]. In his paper, D. M. Alharbi compared the effects of two types of coffee on attention levels and found that Arabica coffee is more beneficial for increasing personal attention [14], Because of this discovery. We decided to use Arabica coffee as the experimental material. In another study, the M.Glade also observed that a single dose of as little as 32 to 50 mg of caffeine could stimulate a significant improvement in alertness and concentration in just 20 minutes [23]. According to Leonard N. Bell's study, coffee has the highest caffeine content after boiling, and the caffeine content per 177 ml (6 ounces) of coffee ranges from 50 to 143 mg [11]. According to the author's experiment, one can collect brain waves 30 minutes after drinking coffee because it is absorbed rapidly within 30-40 minutes and has a half-life of 3 to 6 hours. All psychological tasks were performed on subjects between 8:00 am and 12:00 noon, as short-term memory was considered to be affected differently during the day [14].

Therefore, this study is based on the previous research from Mr.Chenghu [24]. Tt focuses on the beta wave (attention). It also aimed at discovering the relationship between Beta waves and coffee. This paper proposes a method of classifying attention to classify the effectiveness of coffee by comparing the state of the brain waves participants before and after drinking coffee. Also, this research seeks to examine the changes in the beta frequency data through useful tools. In this study, the classification method used is to calculate EEG signal through Weka tools. Therefore, the results of this study provide more understanding of the effect of coffee on brain wave effects. The result of this research may help to raise the visibility of local coffee.

2. METHODOLOGY

2.1 EEG signal Recording

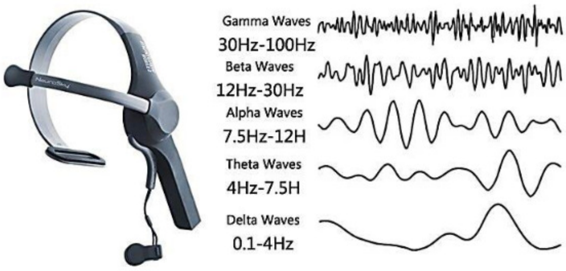

Fig.1: *The NeuroSky Mindwave mobile equipment.*

NeuroSky Mindwave mobile is a commercial EEG device that is commonly used in human brain wave experiments to measure human brainwave patterns. The sensor tip can collect the original EEG signal of the brain waves when it is placed on the left side of the forehead. It can communicate with its own Neuro Experimenter app via a Bluetooth connection. According to Ekandem's 2012 paper, Neurosky MindWave's is a useful tool to help the respondents to record EEG signals. [20]. In another paper, the authors collect brain electroencephalogram (EEG) signal by using a non-invasive NeuroSky MindWave EEG headset to record brain bioelectrical signals measured on the frontal lobe for robotic speed control [21]. This experiment fully demonstrates the stability of the signal and equipment of the NeuroSky Mindwave mobile device. In its paper, the performance of commercial brain waves (EEG) headphones was evaluated, and the results proved that EEG headphones could provide more new measurement methods and reliable data [9]. In experiments using EEG devices for brain waves acquisition, the same data set for a single EEG channel achieved an increase in accuracy [7].

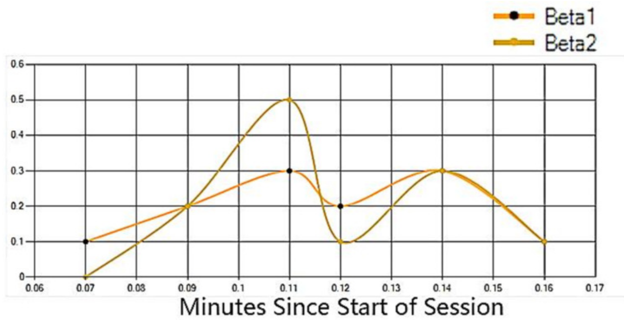

Fig.2: *A sample of EEG.*

The frequency of human brain waves is affected by drugs and also age [22]. This study focuses on the study of Beta wave (attention) to provide a more in-depth explanation about it. In order to accurately determine the increase of the Beta wave, the test subjects were relaxed for two minutes before the experiment begins. Then, the brainwave data was collected. To collect stable brainwave data, the data collection time lasts for 5 minutes. The Beta wave is in the frequency range between 12.5 and 30 (12.5 to 30 cycles per second). The sample of Beta wave frequency measurement via brainwave visualization application is shown in Fig 2.

Brain waves signal collections requires three parts: the computer side, EEG equipment, and respondents.

The steps of the experiment are divided into three phases:

Step 1: Use a Bluetooth-enabled laptop to connect with an EEG device.

Step 2: Place the EEG device with sensor on the left forehead to collect EEG signal in a non-intrusive

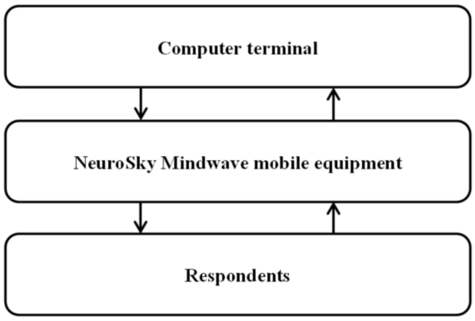

Fig.3: *Stage of EEG signal Recording.*

manner.

Step 3: Record brain waves signal with five minutes for stable EEG data.

Stages of EEG signal Recording is shown in Fig 3.

2.2 EEG signal processing

The analysis of the characteristics of EEG signals is a significant research interest. The main methods include current (ARM) autoregressive methods, (WT) wavelet transform, (EM) eigenvector method, (FFT) fast Fourier transform, and (TFD) time-frequency distribution. This experiment uses NeuroSky officially recommended calculation formula due to the use of NeuroSky Mindwave mobile equipment.

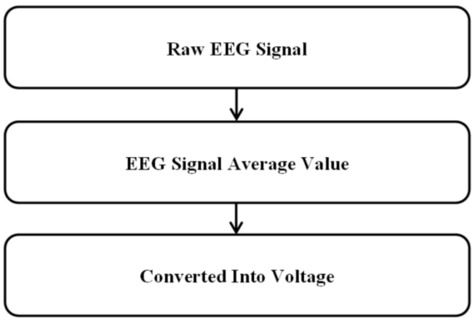

Fig.4: *Stages of EEG signal processing.*

The TGAT hardware standard equation (1) for an analysis:

$$V_v + \frac{(R_v * \frac{1.8}{4096})}{2000} \tag{1}$$

1.8 = the constant biased voltage
4096 = the Value range upper limit
R_v = the average of raw value
V_v = the voltage value [24].

2.3 Experiment Preparations

The experiment conducted brain wave testing on fifty participants, aged between twenty and thirty, half men and women, in groups of twenty-five. According to WDM Aldhabi, caffeine is absorbed rapidly within 30-40 minutes and has a half-life of 3 to 6 hours. The experiment tasks were performed on subjects between 8:00 am and 12:00 noon [14].

A drip coffee maker and coffee spoon are needed for this experiment because brewing takes about 5-10 minutes. As a general rule, it recommends about 15 grams of ground coffee per 8-ounce cup of coffee. One cup of brewed coffee (8 oz.) contains about 70140 mg of caffeine, or about 95 mg on average. Besides, the coffee spoon is used to measure the amount of coffee each time to ensure that each cup has the same amount of coffee. The coffee machine and coffee spoons used are shown in Fig 5.

Fig.5: *The coffee maker and coffee spoon.*

The average dry matter of Arabica coffee is 1.25%. Therefore Every 240 ml of brewed, drip coffee has caffeine content of 65 - 120 mg. A drip brewer needs approximately 90 degrees of hot water to make the coffee. The length of brewing time is around four minutes. The experiment needed 240(ml) of Arabica drip coffee for the respondents. About forty minutes after taking the coffee, the caffeine reaches the maximum concentration in the human body. Consequently, before performing the brain waves detection via EEG equipment, the respondents were given approximately forty minutes in order to get the effect of the coffee. A quiet classroom is needed for the participants to record the EEG, The coffee and experimental site are shown in Fig.6.

Fig.6: *The coffee and Experimental site.*

2.4 Data Analysis Processing

Machine learning is divided into supervised learning and unsupervised learning. Supervised learning means that the training set's labels need to be specified manually. Unsupervised learning means determining the labels of the training set can be done automatically [6].K-Means algorithm belongs to unsupervised learning [13]. For a given sample set, the sample set was divided into K clusters according to the distance between samples. This is done by arranging the points in the clusters as close as possible to each other and making the distance between the clusters as large as possible. The algorithm defines similarity by measuring the distance between Euclidean data points. This process is shown in Fig.7.

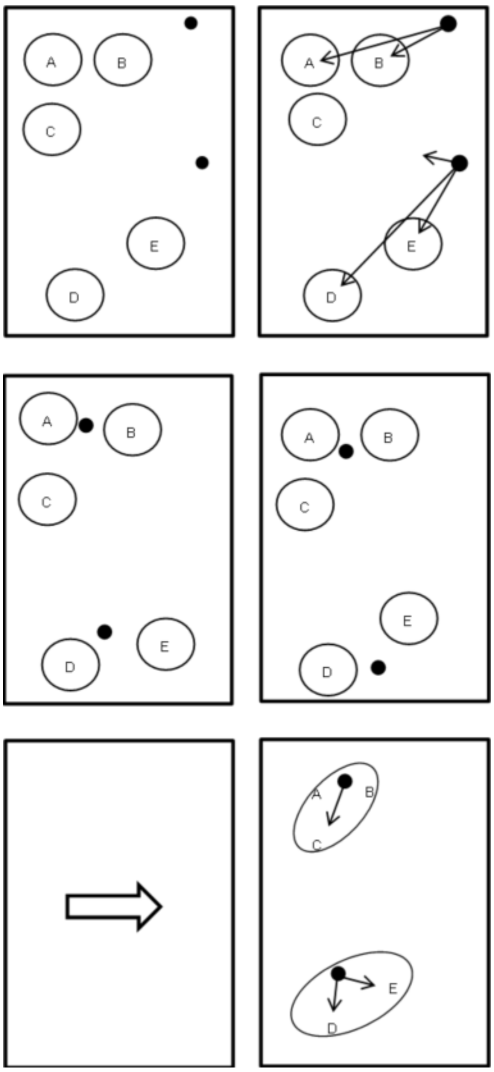

Fig.7: *The Sample of K-means algorithm principle.*

Fig 7 shows that there are five points in the data and two seed points, so the K value is two. Then, the algorithm of K-means can be described as follows:

Step 1:
Randomly take two seed points.

Step 2:
Seek the distance of two seed points for all the five sample points (As can be seen from Fig 7, A and B belong to one seed point whereas C, D, E belong to another one seed point in the middle part).

Step 3:
Next, the seed point has to move to the center of "point key" that belongs to itself.

Step 4:
Then Fig 7 step 2 and 3 are repeated until the literation finishes (it shows in the fourth step of the graph that aggregated A, B, C in one group, and D, E stay in another one).

Step 5:
Finally the best clustering results are found.

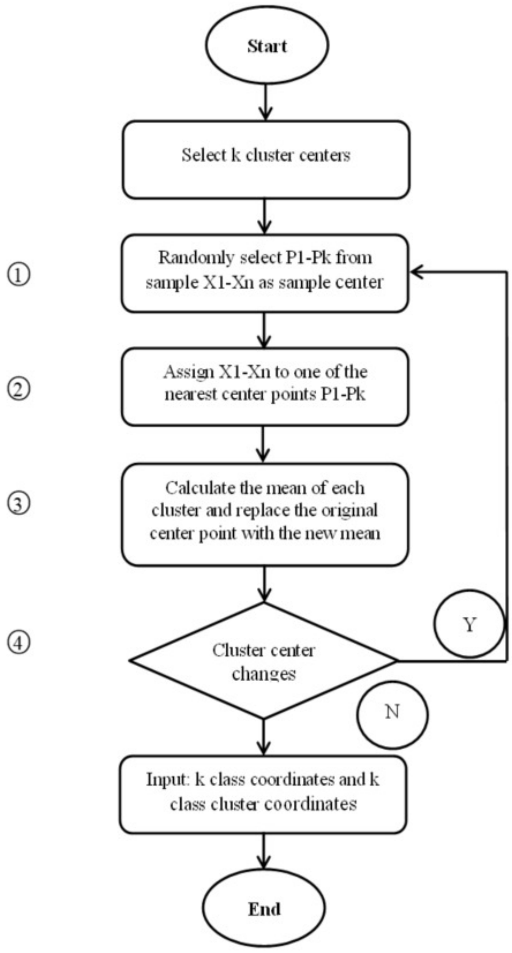

Fig.8: *The Sample of K-means algorithm flowchart.*

Fig 8 shows that the entire calculation process is as follows:

Process 1:
Determine the sample set, and then randomly select k center points according to the number of categories k to be divided.

Process 2:
Group assigning sample points X1-Xn to the nearest central point and calculating the distance sum of each

center point to the sample point.

Process 3:

Re-select the center point, using the newest center point of the new cluster.

Process 4:

Recalculate the distance from all samples to the k point, and calculate the distance and contrast calculated in Fig 8 process 2 to determine whether the center point changes, whether the algorithm converges.

End Process.

The K-means clustering algorithm is a prototype-based partitioning technique that attempts to discover clusters of user-specified numbers (K). It attempts to create an isomorphic cluster or similar subgroups in the data. Therefore if two data points are similar, they will be treated as the members of the same clusters. In Fig 7, iteration of and loop occurs until the best cluster is found. The K-means algorithm flow chart is shown in Fig 8.

In this experiment, the K-means classification algorithm will classify the brain waves data after drinking coffee and cluster the vertical beta bands to the highest and lowest beta frequencies. Eventually three clusters centered on three k points are formed, thereby obtaining a memory frequency affected by coffee.

All data shows as three ordered clusters using the WEKA tool. It can effectively classify brain wave data after drinking coffee.

2.5 Statistical Analysis

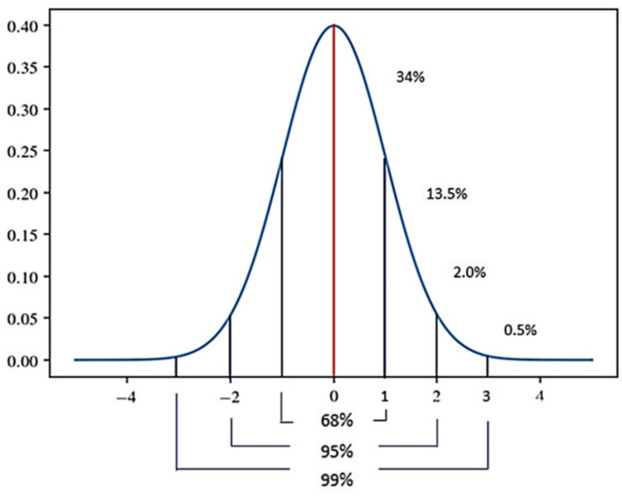

Fig.9: *the t-test distribution.*

A paired sample t-test is performed to test the possibility of a significant difference in the mean of the two paired populations. The pairing here means that there is a one-to-one correspondence between the two sample values, and the sample capacities are similar [25]. In a previous brain waves analysis experiment, the t-test was used to detect the effectiveness of caffeine on brain waves, and the post-test t-test analyzed at 95% confidence level. The results showed significant differences [15]. In another study, Clarke used an independent sample t-test to compare the activity of total power and power for each band in each region, and the θ/β ratio between the subgroup and the control group [10].

Therefore, in this study, we investigate to determine whether there is a difference between the frequency of brain waves before and after drinking coffee. The hypothesis was set at 0 values, assuming that coffee does not affect human brain waves. A paired sample t-test was selected to test whether there are differences between the two samples.

Since it is impossible to determine whether there is a difference, the two-tailed test was selected. When the null hypothesis is established, the probability P value of the average of the two brain wave samples before and after the coffee was obtained. When the p-value is less than or equal to 0.05, it indicates that the frequency of the brain waves before and after drinking coffee is different. It indicates that human brain waves frequency is affected by coffee. Therefore, based on the p-value, it can be concluded that when the p-value is >0.05, the null hypothesis is accepted, and it shows that coffee does not affect human brain waves. However, when the p-value is ≤ 0.05, it proves that coffee has a significant effect on human attention level.

3. RESULTS AND DISCUSSION

The results were analyzed using the K-means algorithm and compared with the previous analysis. The results confirmed that caffeine absorb from drinking coffee affected the EEG signal. In other words, drinking coffee affects the Beta wave or human attention.

The coffee tree is native to Ethiopia in Africa. The coffee trees grow at high altitudes, near volcanos or in limestone or granite soil. The temperature difference between day and night must be large, the dry and wet seasons must be distinct, and the soil must be fertile. Lower temperatures, and their larger daily amplitudes, induce slower growth and more uniform ripening of the berries. Rainfall requirements for Arabica coffee production are at least 1200 mm per year with a maximum of 2500 mm. Coffee plants grow and yield better if exposed to alternate cycles of wet and dry seasons[18].

Thailand's Chiang Rai and other nearby provinces are located in the northern mountainous areas. Upper Northern Thailand is a mountainous area of 85,920 km2 which borders Myanmar to the north and west and Laos to the north and east. Coffee is grown at altitudes between 700 and 1400 meters with the average annual temperature between 18 28°C, and with an annual rainfall of 1,200 - 1,500 mm/year. The elevation and rainfall in the northern part of the country are suitable for growing Arabica coffee beans.

Since 1849, Arabica coffee bean has been planted in Thailand, Arabica coffee is a significant cash crop for the northern highland part of Thailand. Chiang Rai province is one of the main planting areas in the north [26, 28] in 1982, they have been inspired to increase local Arabica coffee cultivation. Growers emphasize for rust resistance, higher yield, and better quality.

In a previous study, the researchers performed a differential difference test on samples from three countries of the same variety of Arabica coffee. The results of the experiment proved that the process and produce conditions can cause the difference quality in Arabica coffee bean [27].

In order to support the above experimental results, future research may require a questionnaire survey of respondents, and it is necessary to know whether respondents are coffee dependent, drink coffee regularly, or drink a small amount of coffee, or if they drink no coffee at all. These would provide more detailed information about coffee and brain waves.

Also, Beta brain wave classification studies for Prefrontal cortex of left cerebral hemisphere could fill the gap in BCI for speed control. This will be the future study direction of this research.

Respondents in the experiment are showed in Fig 10 and the sample of EEG raw signal is shown in Fig 11.

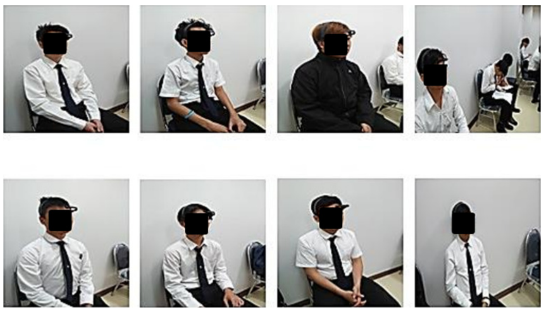

Fig.10: *The respondents.*

Delta	Theta	Alpha1	Alpha2	Beta1	Beta2	Gamma	Gamma
303216	48495	10726	18836	5987	11431	10690	6510
147313	45466	3528	3315	4397	5481	3596	1460
131794	154428	29218	6416	19562	6494	6282	5286
13143	4743	13351	3890	6667	6482	4444	2989
455132	67977	26796	8036	6135	8919	3499	886
1298	4654	2037	1213	3781	7020	3038	1043
9384	3317	2751	2207	2475	4672	2313	3245
9596	4585	3425	2576	5840	6537	1750	987
3023	5061	1043	2296	4338	3244	3513	1286
					7010.57		

Fig.11: *A sample of EEG raw signal.*

3.1 Electroencephalographic signal conversion

The methodology showed that the collected raw beta brain wave data needs to convert into the voltage. The raw and converted data can see in tables 1 2.

Table 1: *Female EEG Raw Data.*

No	Sex	Age	Raw Beta Waves Before drink	Raw Beta Waves After drink	Voltage Beta Waves Before drink	Voltage Beta Waves After drink	Voltage Beta Waves Effect range
1	F	21	24361.50	33915.65	0.005353	0.007452	0.002000
2	F	21	9688.852	17877.08	0.002129	0.003928	0.001790
3	F	20	15589.48	23513.62	0.003425	0.005167	0.001740
4	F	20	18059.88	25449.55	0.003968	0.005592	0.001620
5	F	20	9492.693	15718.83	0.002086	0.003454	0.001360
6	F	21	14337.15	20356.82	0.003150	0.004473	0.001320
7	F	21	13927.81	19887.52	0.003060	0.004370	0.001300
8	F	21	8091.507	13189.94	0.001778	0.002898	0.001120
9	F	22	24493.87	29590.50	0.005382	0.006502	0.001119
10	F	20	9521.150	14499.03	0.002092	0.003186	0.001093
11	F	21	12113.95	17090.06	0.002662	0.003755	0.001093
12	F	20	6103.551	10934.45	0.001341	0.002403	0.001061
13	F	20	11249.53	15675.82	0.002472	0.003444	0.000972
14	F	22	10152.46	13907.35	0.002231	0.003056	0.000825
15	F	20	15838.75	19303.30	0.003480	0.004241	0.000761
16	F	21	10217.83	13645.35	0.002245	0.002998	0.000753
17	F	20	11599.39	14937.37	0.002549	0.003282	0.000733
18	F	20	26242.77	29211.64	0.005766	0.006419	0.000652
19	F	20	11868.01	14697.62	0.002608	0.003229	0.000621
20	F	20	14681.26	16194.41	0.003226	0.003558	0.000332
21	F	20	11402.69	12635.84	0.002505	0.002776	0.000270
22	F	21	9975.706	10749.42	0.002192	0.002362	0.000170
23	F	21	12105.52	12639.91	0.002660	0.002777	0.000117
24	F	20	15701.27	16147.59	0.003450	0.003548	0.000098
25	F	21	16201.64	16457.67	0.003560	0.003616	0.000056

Table 2: *Male EEG Raw Data.*

No	Sex	Age	Raw Beta Waves Before drink	Raw Beta Waves After drink	Voltage Beta Waves Before drink	Voltage Beta Waves After drink	Voltage Beta Waves Effect range
1	M	20	8476.718	15719.45	0.001863	0.003454	0.001591
2	M	20	11777.12	18668.46	0.002588	0.004102	0.001514
3	M	20	18671.83	24204.73	0.004103	0.005318	0.001216
4	M	21	6272.515	11326.33	0.001378	0.002489	0.001110
5	M	20	8723.735	13616.07	0.001917	0.002992	0.001075
6	M	21	13964.99	18276.40	0.003068	0.004016	0.000947
7	M	20	11917.22	16218.32	0.002619	0.003564	0.000945
8	M	20	10934.35	14894.30	0.002403	0.003273	0.000870
9	M	20	7399.007	10894.36	0.001626	0.002394	0.000768
10	M	20	9326.403	12578.72	0.002049	0.002764	0.000715
11	M	20	8188.377	11425.76	0.001799	0.002511	0.000711
12	M	20	12828.51	15945.04	0.002819	0.003504	0.000685
13	M	20	17921.10	20925.74	0.003938	0.004598	0.000660
14	M	19	6023.347	8576.801	0.001323	0.001885	0.000561
15	M	19	14712.02	17142.67	0.003233	0.003767	0.000534
16	M	21	9780.357	11925.74	0.002149	0.002620	0.000471
17	M	20	5804.076	7586.153	0.001275	0.001667	0.000392
18	M	20	7527.101	9197.776	0.001654	0.002021	0.000367
19	M	20	11575.81	13062.20	0.002544	0.002870	0.000327
20	M	20	7081.071	8428.620	0.001556	0.001852	0.000296
21	M	20	10326.40	11578.72	0.002269	0.002544	0.000275
22	M	20	11605.67	12702.68	0.002550	0.002791	0.000241
23	M	19	11609.57	12547.09	0.002551	0.002757	0.000206
24	M	19	6655.272	7343.968	0.001462	0.001614	0.000151
25	M	20	15920.42	16568.23	0.003498	0.003640	0.000142

3.2 T-TEST Statistical Performance

A paired sample t-test is performed on brain waves before and after drinking to get the statistical performance result. The analytical results are shown in Table 3.

Table 3: *Paired sample t-test of Beta wave.*

Status	Mean	df	N	P-value	Confidences -95.0%
(F)Before drink	0.003015	24	25	2.12E-08	0.05
(F)After drank	0.003939				
(M)Before drink	0.002329	24	25	2.06E-08	0.05
(M)After drank	0.003000				

According to Table 3, the Beta wave is strengthened after drinking coffee. When the beta wave was tested, it resulted in a p-value ≤ 0.05. This result indicates that there is a statistically significant difference in the effectiveness of beta wave frequency. The subjects of this research were between 19-24 years old, with twenty-five males and twenty-five females. After the subjects drank the coffee, their Beta brain waves showed higher frequency. This means that the subject's level of attention has increased after drinking coffee.

3.3 Clusters and Confusion Attribute

According to the method of Partitioned clustering, the best clustering result is shown in Table 4.

It can be divided into three sufficient levels (k=3): low, medium, and high levels. The division of the levels is shown in table 4.

Table 4: *Input Classes to Clusters: Female.*

Classes to Clusters	*No. of Clusters (%)*
(1)LOW	13(52%)
(0)MEDIUM	4(16%)
(2) HIGH	8(32%)

From Table 4, low clusters, medium clusters, and high clusters of the effectiveness of human Beta brain waves are represented by clusters number 0, 1 and 2, separately. Low clusters, medium clusters, and large clusters accounted for 52%, 16% and 32% of the total cluster, respectively.

Table 5: *Input Classes to Clusters: Male.*

Classes to Clusters	*No. of Clusters (%)*
(1)LOW	8(32%)
(0)MEDIUM	5(20%)
(2) HIGH	12(48%)

From Table 5, low clusters, medium clusters, and high clusters of the effectiveness of human Beta brain waves were represented by clusters number eight, five, and twelve, separately. Low clusters, medium clusters, and high clusters accounted for 32%, 20%, and 12% of the total cluster, respectively.

For unlabelled raw data samples, the K-means algorithm can discover some internal structures and rules between the data, but humans need to manually determine the cluster of categories (k) when two data points are similar, the distance between the data point and the centre of each group to classify each point, and then the entry points are classified in the group with the closest centre of the group. The mean of all vectors in group is used to recalculate the centre of the group. And repeat these steps for a certain number of iterations. Select the run that appears to provide the best results. They are treated as a cluster.

The clustering result of the Beta wave of female and male subjects is shown in Tables 6 and 7, respectively.

The female recipient's sample was divided into three levels: eleven participants in the lower cluster, four participants in medium clusters, seven participants in the high clusters.

Table 6: *Confusion Attribute Level: Female.*

Classes to Clusters	*0*	*1*	*2*
(1)LOW	11	0	2
(0)MEDIUM	0	4	0
(2) HIGH	0	1	7

Table 7: *Confusion Attribute Level: Male.*

Classes to Clusters	*0*	*1*	*2*
(1)LOW	7	0	1
(0)MEDIUM	0	5	0
(2) HIGH	0	1	11

The sample of male subjects was divided into three levels: twelve participants at a high level, five participants at the medium level, and eight participants at the low level. In summary, there are three clusters: low, medium, and high.

Table 6 shows that there are two incorrect clusters in the low cluster and one incorrect cluster in large clusters. From Table 7, there is one incorrect cluster in low clusters and one incorrect cluster in the large cluster.

Experimental data shows that the accuracy rate is 88% for females and 92% for males, which is acceptable. It means that the results of unsupervised learning algorithms can be successfully implemented in this study. The visualized result is shown in Fig 12.

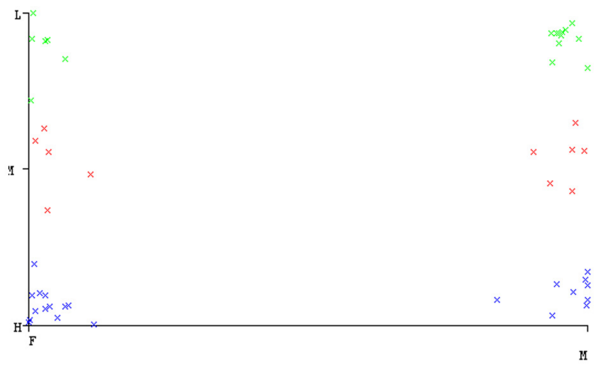

Fig.12: *The beta wave clustering visualization.*

According to the gender, female subject beta wave data before and after drinking is shown in Fig 12 and male subject beta wave data before and after drinking is shown in Fig 13.

Figures 12 13 show the frequency range of high beta (attention level) concentrations in female and male participants in this study.

3.4 Compare two genders

A two-sample t-test was performed on brain waves of females and males, and then a significant test was performed. The statistical results of the Beta wave are shown in Table 8.

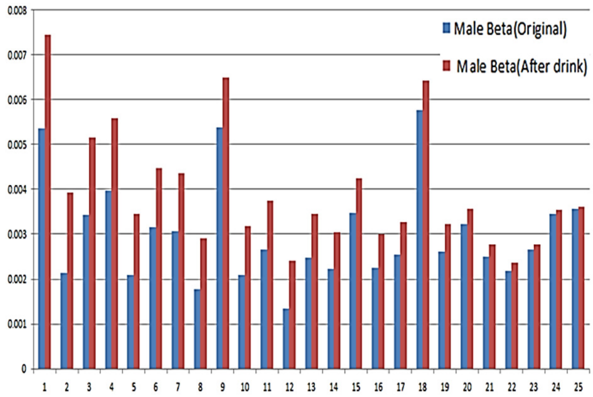

Fig.13: *Female Beta wave.*

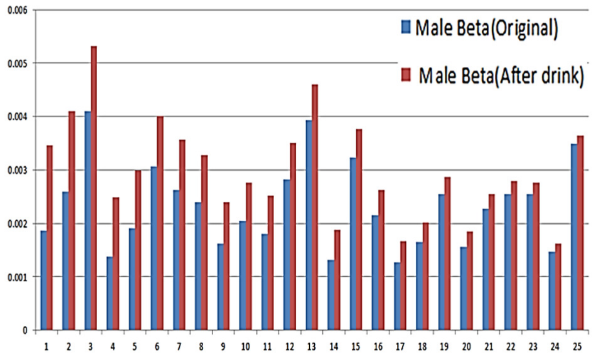

Fig.14: *Male Beta waves.*

Table 8: *Comparison of genders.*

Status	***N***	***Mean***	***df***	***P-value***	***Confidences -95.0%***
Female	25	0.0009	48	0.07	0.05
Male	25	0.0006			

Based on Tables 1 2, the Beta wave Effect range for females and males is shown in Fig 14.

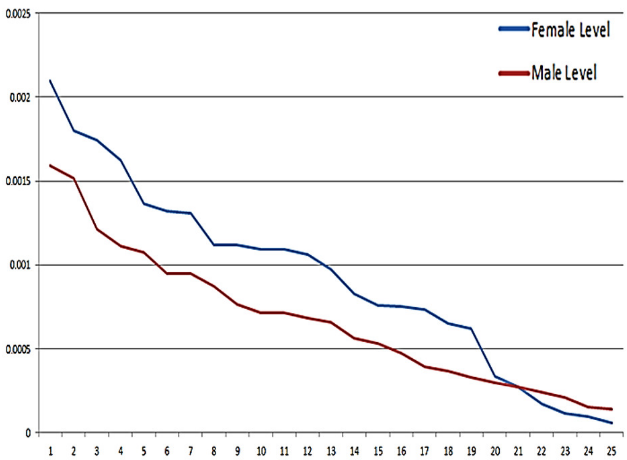

Fig.15: *Difference between Female and Male.*

According to Table 8 and Fig 15, there is no significant effect in the human beta wave between female and male subjects after drinking coffee.

4. CONCLUSION

We designed an EEG experiment to determine whether drinking Arabica coffee can increase the human brain waves (Beta wave), because the Beta wave has a special connection with human attention. We wanted to prove coffees content also increases human attention. The experiment collected fifty brain wave samples, twenty-five of which were from males and twenty-five from females. The EEG signal collection time lasted five minutes for recording stable and reliable brain waves.

This experiment used two methods to analyse brain wave data statistically. A T-test uses the t-distribution theory to infer the probability of occurrence of differences, and thus compares the difference between the two averages The K-means algorithms compared with the t-test can interpret more information about the effect of Arabica coffee on attention.

Based on the statistical data result, the data difference between drinking and not drinking (both cases) indicates that all participants had a higher Beta wave (attention level) after drinking Arabica coffee. The results of this experiment are related to previous studies, suggesting that caffeine in coffee can increase Beta waves.

The results of the experiment prove the value of Chiang Rai local Arabica coffee in Thailand for people who wait to boost their attention level. Despite this, the effects of coffee vary depending on individual participants.

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