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# Classification of Human Brain Attention focused on Meditation, effected by L-Theanine Acid in Oolong Tea

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**Abstract**—L-theanine acid is an amino acid in tea which affects mental state directly. Along with other most popular tea types; white, green, and black tea, Oolong tea also has sufficient L-theanine to relax the human brain. It apparently can reduce the concern, blood pressure, dissolve the fat in the arteries, and especially slow aging by substances against free radicals. Therefore, this research study about the effect of L-theanine in Oolong Tea on human brain's attention focused on meditation during book reading state rely on each person by using electroencephalograph (EEG) and K-means clustering. An electrophysiological monitoring will properly measure the voltage fluctuation of Alpha rhythm for the understanding of higher attention processes of human brain precisely. K-means clustering investigates and defines that the group of converted waves data has a variable effective level rely on each classified group, which female with lower BMI has a higher effect on L-theanine than male apparently. In conclusion, the results promise the L-theanine significantly affects on meditation by increasing in Alpha waves on each person that beneficially supports production proven of Oolong tea in the future.

**Keywords**—Oolong tea; L-theanine; Human brain; Electroencephalograph; EEG; K-means; Meditation

## I. INTRODUCTION

Besides good taste and aroma of tea, it contains a lot of health benefits and medicinal properties, which are the best reason why tea is widely popular in common health market. Many previous types of research have shown that tea is the brain food which has a lot of benefits for health, especially for stress reducing and concentration increasing [1]. Naturally, the tea leaf contains Protein, Potassium, Amino Acid, Tannin, Caffeine, Vitamin C and B, Catechin Polyphenols, and a lot of other nutrients which can make the body refreshing. Also, it can reduce the concern, blood pressure, dissolve the fat in the arteries, and especially slow aging by substances against free radicals. Oolong Tea is the one of tea type founded in China that contains good medicinal properties to manage stress. Nevertheless, its locale is in a huge country, but researching and investigation of global tea consumption have shown that black tea is 78 percent, green tea is 20 percent, and Oolong tea is only 2 percent consumption [2]. That is the most research has focused on black and green tea obviously. Osaka Institute for Health Care Science in Japan has tested Oolong Tea with lab mice and results that stress levels have been improved by

18 percent [3]. They stated that the natural polyphenols are the main stress reducer.

However, studies about the effects of tea for human brain still ongoing, but not really useful for Oolong tea favoring even the agricultural product value of Oolong Tea in the research local, Chiang Rai, Thailand. Consequently, the newer research supposes to provide more information for promoting the advantage of Oolong tea.

Thereby, this research proposes the method to determine the human brain's attention focused on meditation during book reading state, rely on each person. It is implied on L-theanine effect after drinking a cup of Oolong tea by using electroencephalography (EEG) with a useful clustering algorithm, K-means clustering that meets the data mining requirement. The high reliable electrophysiological monitoring method will record the electrical activity of a central nervous system during a complete book reading in specific time. An identification of meditation steadily indicates the rhythmic activity associated with factor quantity in the experiment. Also, it would be necessary to cooperate with simple K-means clustering in next stage performance for personal effectiveness specification. Consequently, this study will provide the beneficial knowledge of meditation increasing from L-theanine acid's effect which can support local product properties proved and explicitly increase the popularity of Oolong tea as well.

## II. LITERATURE REVIEW

Since tea is one of the most popular beverages in the world, there is much research related to L-theanine acid and its effect on the human brain. In a previous study, the evidence of EEG indicates that the amino acid named L-theanine acid of tea effects on mental state directly [4]. It apparently increases the activity of the alpha frequency band that represents the relaxing effect on the central nervous system. In addition, the alpha waves activity increased linearly, which affected by the role of L-theanine acid [5]. It provides more relaxation, but alertness also affects the central nervous system directly.

Furthermore, physical relaxation from the effect of L-theanine does not induce the drowsiness status after drinking [6]. It has a most effective when consuming 50-200 mg within 30-40 min [7] and will last for 8 hours dependently on the quantity. Also, it has an anti-stress effect which induces the

cortical neuron excitation that can reduce the heart rate significantly.

Corresponding to the expectation, classification of human brain attention focused on meditation or concentration during book reading that related to Alpha waves. Alpha waves state between 8-10 Hz below than Beta waves in 11-25 Hz is the state that human brain maintains focus and process information independently [8]. That is Alpha waves range is the best choice for common learning or studying. On the other hand, Theta waves are a good way for memorization. Cooperation between Alpha and Theta can provide better concentration during full meditation with eyes closing. Alpha waves state between 8-10 Hz below than Beta waves in 11-25 Hz is the state that human brain maintains focus and process information independently [8]. That is Alpha waves range is the best choice for common learning or studying.

Thus, a questionnaire has been used in mindfulness meditation testing [9]. They apply EEG to perform brain activities recording during relaxing and questionnaire performing state. As a result, Alpha waves and Theta waves during meditation are completely higher than relaxation.

Furthermore, Yoga has been proven as a brainwave activation significantly [10]. There is three type of the main branches, including asana-based, meditation based, and breathing based Yoga in this study. An association between breathing and meditation practice during Yoga activity is claimed that can increase Alpha waves activity. They describe that Yoga is a form of meditation that involves the mind relaxation introduced to concentration.

Previously, the relaxation therapy has been tested with Hyperactivity Disorder-Hyperactive (ADHD) in children patients case [11]. To approach the brain wave of control samples, EEG also used in this study as a brainwave recorder. As the expectation to increase Alpha and Theta waves, the experiment shows that the sample has a better attention. Theta and Alpha waves are significantly increasing in the experimental results.

It clearly shows that increases in Alpha waves activity cause a higher concentration. This is related to L-theanine acid in Oolong tea, which affects the human brain's attention as well.

### III. METHODOLOGY

#### A. Brain Wave

The human brain has a unique brain wave frequencies. There are five types of brain wave; Gamma, Beta (low, midrange, and high beta as its sub-sections), Alpha, Theta, and Delta waves ordered by the depth of brain waves. Brainwave frequencies represent in cycles per second (Hz), depending on its own unique state. The conscious state describes the status of learning mind characteristics. Subconscious mind refers to the imagery or fantasy thinking. Where unconscious is deep sleep, and dreamless.

Gamma waves have a range between 30-100 Hz. The highest and fastest frequency, which refers to the high processing in brain system like a motor function. Also,

Gamma waves are important for learning and information processing, but too much stress and anxiety during activity.

Beta waves have a range between 12.5-30 Hz. Mostly known as a high frequency with low amplitude waves during waking state. This is the very fast brain waves related to common five physical sense process. It also can be split into three sections; Low Beta Waves (12.5–16 Hz), Midrange Beta Waves (16.5–20 Hz), and High Beta Waves (20.5–28 Hz,). Obviously increased by critical thinking and high-performance activity.

Alpha waves have a range between 7.5-12 Hz. These waves demonstrate the slow brain activity in the normal waking state with relaxation state and light meditation. During conscious, the human brain has a creative thinking, also optimal learning. It has a gap between conscious and subconscious state. An essential phenomenon called Alpha blocking can occur during activity to prevent the brain from stress [12]. Furthermore, Alpha waves range is the best optimal state for learning [13].

Theta waves have a range between 4-7.5 Hz. It involved in daydreaming and sleep and represents the deep meditation during drowsy. This state benefits from creative and intuition activity because of the natural mind. Moreover, many research also shows that this is the best state for memorization and creatively.

Delta waves have a range between 0.5-4 Hz. It normally represents the deep sleep with dreamless during unconscious state. The restoration and healing process occur along with the lowest frequency. However, abnormal delta activity also can occur in this state and affect to longterm experience learning, such as brain injuries.

The EEG graph and simple description of each brain waves shown in Fig. 1.

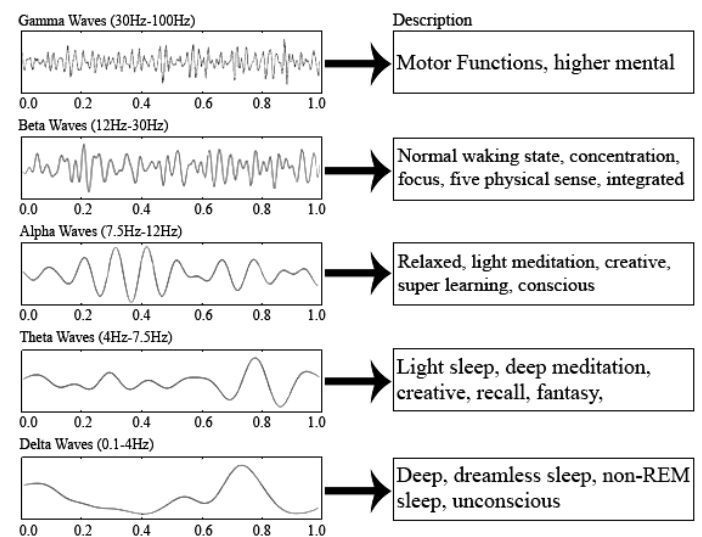


Fig. 1. Brain waves charts description.

#### B. K-means Clustering

K-means clustering is a popular machine learning method for cluster analysis in data mining, which matches with the requirement to simply determine the different effect on each

person in this study. It can specify the given data set through fixed clusters, and provide a result as a group of data. That is a clustering  $n$  observation into  $k$  clusters, which is the nearest mean. Generally, the procedure conducts as following [14].

The first step is a procedure of cluster analysis. The nearest mean is the least squared Euclidean distance. The algorithm usually represents the nearest cluster by distance.

Second step: Reassign the new means ask centroids of data into the new clusters.

Consequently, this research performs K-means clustering via Weka clustering tool function for simply partition the observations.

#### IV. EXPERIMENTAL RESULTS

Oolong tea products for this experiment will be taken from research local market, Chiang Rai, Thailand. Also, the required participants in this study will specify on the 10 students (5 students per gender) with 20 - 21 ages who unusually drink any tea in the local university. The experimental results of this study provide the yield as these following steps respectively.

##### A. Oolong Tea Preparation

In the experiment and analysis of L-theanine in Oolong tea brewed in 100 ml 80°C water for 3 min from 1 g sample was 6.09 mg/g [15]. Additionally, L-theanine extraction was founded at 2.5 min during reservation time but still remain retention 20 min for total extraction before drinking. However, due to an increase in relaxation state related to Alpha waves is usually occur within 30 min to an hour [16], the participants have a rest for 30 min before performing brain wave measurement in the next step.

##### B. Brain Frequency Measurement via EEG

This research performs NeuroSky mindwave mobile device as a simple EEG equipment, shown in Fig. 2.



Fig. 2. NeuroSky mindwave mobile device.

The brain wave data will be collected during EEG operation, focused on the alpha frequency band during book reading state, continuously for 5 min. Alpha-rhythm in frequencies in 7.5–12.5 Hz ranges can be detected [17]. Each collected data demonstrate the different level of Alpha waves for no drink and drink state, which converted into a voltage.

Then, corresponding to the converted data from experimental monitoring represents Table 1.

To encounter significance testing, t-Test: Paired Two Sample for Means statistics have been performed frequently, among the data collected from 10 students ( $n = 10$ ), shown in Table 2.

TABLE 1. DETECTED ALPHA WAVES IN A VOLTAGE

Student No.	Age	Gender	Body Mass Index (BMI)	Alpha Waves ( $\mu V$ )	
				No drink	Drink
1	21	Male	20.1	0.003292389	0.004228271
2	21	Male	21.8	0.002984484	0.003137011
3	20	Male	22.6	0.003202895	0.003243174
4	20	Male	22.8	0.003313916	0.003422301
5	20	Male	21	0.003594527	0.004281386
6	20	Female	18.9	0.002708574	0.003316136
7	21	Female	20	0.002643683	0.002960008
8	20	Female	19	0.004109907	0.006017725
9	20	Female	19.9	0.003622419	0.005989996
10	20	Female	21.1	0.003926499	0.004528779

TABLE 2. T-TEST: PAIRED TWO SAMPLE FOR MEANS STATISTICS

State	n	mean	S.D.	t	df	P	Confidence Level (95.0%)
No drink	10	0.0033	2.3477	-3.1274	9	0.0061	0.0003
Drink		0.0041	1.2796				0.0008

There was a statistically significant difference between no drink and drink state, and  $P < 0.05$ . Therefore, the null hypothesis is rejected that there is a significant difference between two states. After drank Oolong tea, the participants definitely have a higher rhythmic activity that indicates more meditation on each person.

##### C. Data Clustering

It begins with performing of K-means clustering via Weka clustering tool functions to observe  $k$  clusters.

During operation, as the mean value of EEG results is defined, the final cluster centroid will represent precisely.

Data partition is evaluated on 10 instances (training data), 5 attributes (Age, Gender, BMI, No drink, and Drink). The visualization of K-means clustering in Weka shown in Fig. 3 and Fig. 4, plotted on No drink and Drink state respectively.

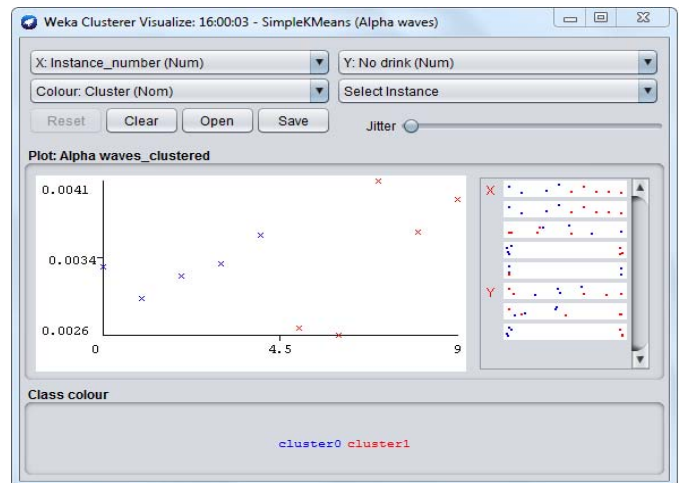


Fig. 3. Weka clustering result plotted on No drink data.

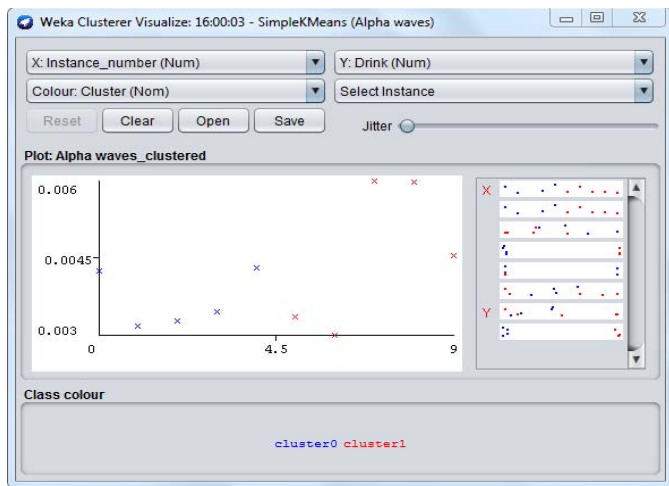


Fig. 4. Weka clustering result plotted on Drink data.

Validation of data with 5 iterations is performed completely, shown in Table 3.

TABLE 3. CLUSTERED INSTANCES

Cluster No.	Age	Gender	Body Mass Index (BMI)	Alpha Waves ( $\mu V$ )	
				No drink	drink
0	21	Male	21.8	0.002984484	0.003137011
0	20	Male	22.6	0.003202895	0.003243174
0	21	Male	20.1	0.003292389	0.004228271
0	20	Male	22.8	0.003313916	0.003422301
0	20	Male	21	0.003594527	0.004281386
1	21	Female	20	0.002643683	0.002960008
1	20	Female	18.9	0.002708574	0.003316136
1	20	Female	19.9	0.003622419	0.005989996
1	20	Female	21.1	0.003926499	0.004528779
1	20	Female	19	0.004109907	0.006017725

Obviously, clustered data are grouped based on their similar characteristics. Simply specify by gender; male and female as two groups of data.

#### D. Results

According to Table 4, means of clustered results are defined for each group of instances conditionally.

TABLE 4. CLASSIFIED INSTANCES

Gender	Alpha Waves ( $\mu V$ )	
	No drink	Drink
Male	0.003277642	0.003662429
Female	0.003402216	0.004562529

There are 0.003470215 and 0.003982265 for means of each gender, male and female respectively. Thus, the difference is  $0.003470215 - 0.003982265 = -0.00051205$ . That is L-theanine has more effect on a female with lower BMI in this experiment. Therefore, the effect of L-theanine in Oolong tea on drinkers varies by a person individually.

#### V. CONCLUSION

As a result, it is obvious that the participants who drank Oolong tea by a defined amount have higher levels of Alpha waves when compared with No drink state ( $0.0033 < 0.0041$ ),

which represent the level of meditation or concentration is definitely increasing.

Moreover, the classification method states that how much L-theanine from Oolong tea affected on Alpha waves within the specific time in the experiment. Any range of Alpha waves also describes the effect of Oolong tea depending on each person independently. Apparently, the results indicate that female with lower BMI has more effect on L-theanine than male;  $0.003470215 < 0.003982265$  for No drink and Drink in male and female respectively. Actually, that is the effect of L-theanine varies on any person in this experiment.

Consequently, since the tea products are chosen from the research local, the results of this research definitely implement to prove the medicinal properties and relatively increase the value of the local Oolong tea product.

Furthermore, for the more concrete result to support the above hypothesis, the future work will regard responding level with larger scale sample testing that will describe how Oolong Tea affects to the participant. The various factors, including age in a different period (from younger to elderly), BMI, gender, and mixing of different experience in tea drinking will be tested all together.

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