



## Analysis of measuring physical quantities and multiple biochemicals of our brain's functioning, and, 'thinking' – A review

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### Abstract

'Electroencephalography (EEG)' is used for the non-invasive measurement of the electric fields of our brain. In this technique, electrodes are paced on the scalp, which record voltage potentials, generated as a result of the current flowing in and around our neurons. These electrodes detect the very little amount of electrical charges, which are generated by the brain's electrical activity. These electrical charges, either show up as a graph on a digital screen or a transcript drawn out on paper. Health Raw EEG detect these brain waves of different frequencies, such as, Gamma( $\gamma$ ) waves, which have frequency of higher than 30 Hz; Beta( $\beta$ ) waves, whose frequency ranges between 13-30 Hz; Alpha( $\alpha$ ) waves, whose frequency ranges between 8-12 Hz; Theta( $\Theta$ ) waves, whose Frequency ranges between 4-8 Hz; Delta waves, whose Frequency is below 4 Hz. Each type of brain wave has a different frequency range, amplitude and meaning. Then, 'Neurotransmitters were studied. The neurotransmitters are a few endogenous biochemicals, with whose help our neurons communicate with each other throughout the body. They are essential in shaping everyday life and functions. Studies of Neuroscience, found that, some Neurotransmitters such as, 'Dopamine', 'Serotonin', etc. have roles in controlling happiness. A few studies also found the role of 'Cortisol' in controlling happiness. Electrical activity, Brain waves and Neurotransmitters, together influence our brain's cognitive functions. These cognitive functions are deeply connected with our 'Thinking'. Thus, based on the above-mentioned concepts, Neuroscience of 'Thinking' has been analysed using Physics and mathematical approach. After this analysis, a formula to calculate 'thinking' and 'thinking energy' has been discovered. Based on this formula, hypothesis of 'thinking', 'thinking energy' and 'postulates of thinking energy' have been formulated, which may be utilized for human welfare in future.

**Keywords:** Electroencephalography, electrodes, electrical activity, brain waves, neurotransmitters

### Introduction

#### Electroencephalography (EEG)

The technique of 'Electroencephalography (EEG)' is approximately a century old. It is used for the non-invasive measurement of the electric fields of our brain. In this technique, electrodes are paced on the scalp, which record voltage potentials, generated as a result of the current flowing in and around our neurons. EEG finds a diverse spectrum of applications. It finds applications for experimental psychology and neuroimaging [1].

'Hans Berger' is credited for the discovery of human EEG in the late 1920s. He recorded some signals, which fluctuated rhythmically when the eyes were closed, and, became less rhythmic and of smaller amplitude when the eyes were open. However, originally scientific community had rejected Berger and his EEG. In 1934, British psychologists, 'Edgar Adrian' and 'Bryan Matthews' replicated the Berger's observation of EEG as the non-invasive measurement of the electric fields of our brain [1].

EEG is a direct and real-time measure of the neural activity of our brain, therefore, it can be used to

- Characterize the integrity of specific neurophysiologic pathways.
- States of consciousness or sleep.
- Precise temporal dynamics of function or dysfunction of our brain.
- Characterization of networks of our brain, connectivity between them, etc [1].

EEG looks for the irregularities in the electrical phenomenon of our Brain. Throughout the EEG

examination electrodes are placed at different points all over the head. These electrodes detect the very little amount of electrical charges, which are generated by the brain's electrical activity. These electrical charges, either show up as a graph on a digital screen or a transcript drawn out on paper Health [2, 3]. This technique can be used to diagnose various neurological disorders, such as Epilepsy, Seizure, etc. Epilepsy, Seizure activity, generates acute waveforms on EEG, whereas, brain lesions may give very slow pulses of EEG depending on the size and place of the damage. This technique may also be used for diagnosing – drug intoxication, assessing trauma or checking the brain damage in the unconscious individuals. EEG is also helpful for monitoring the flow of blood in the brain during surgery. Raw EEG detect these brain waves of different frequencies

- **Gamma( $\gamma$ ):** Frequency of higher than 30 Hz.
- **Beta( $\beta$ ):** Frequency ranges between 13-30 Hz.
- **Alpha( $\alpha$ ):** Frequency ranges between 8-12 Hz.
- **Theta( $\Theta$ ):** Frequency ranges between 4-8 Hz.
- **Delta:** Frequency below 4 Hz [2].

Now let us explore about these brain waves in a little detail.

#### Brain waves

Electrodes receive the electrical signals of the brain on the surface of head. Then these electrical signals are digitized and processed. For evaluation of EEG, the most important criteria are 'Frequency'. This 'frequency' is used to detect abnormalities in clinical EEG and understanding functional behaviours in cognitive research [4, 5].

As now it is quite clear that, electrical activity of our brain generates different brain waves of different frequency ranges. Each type of brain wave has a different frequency range, amplitude and meaning. ‘Alpha waves’ are active in the state of calm or relaxation. ‘Beta waves’ are active when we’re awake. These waves are generated when we’re engaged in the tasks related to logical-analytical reasoning. These ‘Beta waves’ are active during our focus on problem-solving. ‘Delta waves’ are generated during meditation in the state of deep sleep or coma. Abnormal delta activity may be detected in those who may have learning disabilities or those for whom maintaining conscious awareness is difficult, such as, in cases of brain injuries. ‘Gamma waves’ are active during learning, memory and information processing. At last, ‘Theta waves’ are active when we are sleeping or daydreaming. Intuition or automatic tasks can be associated with these waves [4, 6].

**Biochemicals**

Neurotransmitters are a few endogenous biochemicals, with whose help our neurons communicate with each other throughout the body. They are essential in shaping everyday life and functions [7, 8]. Chemical synaptic transmission takes place mainly through the release of neurotransmitters from presynaptic neural cells to postsynaptic receptors. When the levels of specific neurotransmitters get changed in the body, different diseases may manifest, such as, Parkinson’s disease, Schizophrenia, Depression, Alzheimer’s disease, etc. These biochemicals play important roles, in early human developments also, which include, neurotransmission, differentiation, growth of neurons, and the development of neural circuitry. We may have different neurotransmitters at different points of development. For Example – Monoamines are present before the differentiation of neurons, Notochord contain high levels of Norepinephrine, ‘Serotonin’ has role in morphogenesis [7, 9, 10].

In our body different neurotransmitters are utilized for different functions. These different types of neurotransmitters include – Acetylcholine, Glutamate, GABA, Glycine, Dopamine, Norepinephrine and Seotonin. Glutamate, which is an important excitatory neurotransmitter, is the primary mediator of the plasticity of nervous system [7, 11]. Gammaaminobutyric acid (GABA) and Glycine conversely functions as the inhibitory neurotransmitters. Glycine is mainly found in the spinal cord [7, 12]. ‘Dopamine’ plays important role in multiple functions of our brain, such as – learning, motor control, reward, emotion and executive functions. Change in its level can lead to neurological and psychiatric disorders [7, 13]. ‘Serotonin’ modulates different neuropsychological processes and neural activities – thus, targeted by many neurological and psychiatric medicines [7, 14]. ‘Norepinephrine’, which is a monoamine, is produced in CNS and sympathetic nerves. When Norepinephrine is released in the brain, it effects different processes, such as, stress, sleep, attention, focus and inflammation. It also plays role in modulating the response of ‘autonomic nervous system (ANS)’. [7, 15]. Another neurotransmitter which mediates homeostatic functions in the body is ‘Histamine’. This neurotransmitter also promotes wakefulness, modulates feeding behavior and also control motivational behaviour [7, 16].

Studies of Neuroscience, found that, some Neurotransmitters such as, ‘Dopamine’, ‘Serotonin’, etc. have roles in controlling happiness. A few studies also found the role of ‘Cortisol’ in controlling happiness [17].

**Mathematical and Physics-based analysis of - Neuroscience of ‘Thinking’**

Electrical activity, Brain waves and Neurotransmitters, together influence our brain’s cognitive functions. These cognitive functions are deeply connected with our ‘Thinking’. Thus, based on the above-mentioned concepts, Neuroscience of ‘Thinking’ has been analysed using Physics and mathematical approach. Let us now take a look at this analysis.

Electrical activity of the neurons of our Brain, Brain waves and Neurotransmitters, all of them are the integral parts of the Neuroscience of our ‘Thinking’. So, what is ‘Thinking’? “Thinking is a property of our brain, which is linked to the electrical activity of neurons, brain waves and neurotransmitters.” So, let us denote this brain’s property by ‘Th’.

Now,

$$Th \propto I_{Th} \text{----- Eq. (1)}$$

Where,  $I_{Th}$  = Total amount of electric current produced in different parts of our brain while thinking.

$$Th \propto V_{Th} \text{-----Eq. (2)}$$

Where,  $V_{Th}$  = Total amount of potential difference (voltage) produced in different parts of our brain while thinking.

Now,

$$I \propto 1/R \text{ or } I_{Th} \propto 1/R_{Th}$$

Where,  $R_{Th}$  = Total resistance offered by the myelin sheaths of electrically active neurons.

and,

$$I = V/R \text{ or } V = I.R$$

Therefore, we can say that,

$$V_{Th} = I_{Th} \cdot R_{Th} \text{----- Eq. (3)}$$

Now,

$$Th \propto S \text{----- Eq. (4)}$$

Where, S = Level of ‘Serotonin’ neurotransmitter.

$$Th \propto D \text{----- Eq. (5)}$$

Where, D = Level of ‘Dopamine’ neurotransmitter.

$$Th \propto C \text{----- Eq. (6)}$$

Where, C = Level of ‘Cortisol’.

**High level of ‘Serotonin’ indicates positive ‘Th’ and high level of ‘Cortisol’ indicates stressful ‘Th’.**

$$Th \propto f_{Th} \text{----- Eq. (7)}$$

Where,  $f_{Th}$  = Frequency of brain waves.

$$Th \propto \lambda_{Th} \text{----- Eq. (8)}$$

Where,  $\lambda_{Th}$  = Approximate wavelength of brain waves.

Now, from Eq. (1) – Eq. (8), we can conclude that,

$$Th \propto I_{Th} \cdot V_{Th} \cdot S \cdot D \cdot C \cdot f_{Th} / \lambda_{Th} \text{----- Eq. (9)}$$

Putting Eq. (3) in Eq. (9), we have,  

$$Th \propto (I_{Th})^2 \cdot V_{Th} \cdot S \cdot D \cdot C \cdot f_{Th} / \lambda_{Th} \text{ ----- Eq. (10)}$$

On removing the proportionality sign, we have,  

$$Th = K_{Th} \cdot I_{Th} \cdot V_{Th} \cdot S \cdot D \cdot C \cdot f_{Th} / \lambda_{Th} \text{ ----- Eq. (11)}$$
– From Eq. (9).

OR,  

$$Th = K_{Th} \cdot (I_{Th})^2 \cdot R_{Th} \cdot S \cdot D \cdot C \cdot f_{Th} / \lambda_{Th} \text{ ----- Eq. (12)}$$
– From Eq. (10).

Where,  $K_{Th}$  = Coefficient of ‘Thinking energy’.  
 If, ‘Serotonin’ is high, then,  $K_{Th}$  = Coefficient of positive ‘Thinking energy’.  
 If, ‘Cortisol’ is high, then,  $K_{Th}$  = Coefficient of stressful ‘Thinking energy’.  
 Eq. (11) and Eq. (12), are the formulas to calculate ‘Thinking’.  
 However, in future, this formula may change also, depending upon the discoveries on neuroscience of ‘thinking’.

### Conclusion

- Different physical quantities and levels of Neurotransmitters, not only have effect on various cognitive functions, but, also ‘thinking’ linked with these cognitive functions.
- From Equations (11) and (12), we can conclude –

**Hypothesis of ‘Thinking’ and its fuelling energy:** It states that, “Thinking is one of the complex properties of our brain, which functions as a result of the products of, ‘coefficient of thinking energy’, and, the physical quantities associated with electrical activity, levels of chemicals, and, waves of our brain. It is also inversely proportional to the wavelength of brain waves.”

### Future Prospects

The concept of ‘Thinking’ and ‘Thinking energy’ can be utilized for human welfare, based on the hypothetical postulates of ‘ $K_{Th}$  (Thinking energy)’, mentioned below –

#### Hypothetical postulates of ‘thinking energy ( $K_{Th}$ )

- Every individual is born with this energy. This energy resides naturally in every surviving and conscious individual.
- This energy provides capacity for all the cognitive functions of our brain – learning, memory, reasoning, problem-solving, feeling emotions, creativity, logical ability, etc.
- The magnitude of this energy remains almost constant for every individual. However, it may vary from mentally healthy to mentally ill patients, from victims of intellectual disability to a genius, and, may also vary from organism to organism.
- This energy maybe distributed and shared between, mother and foetus also, as the brain of foetus develops and grows.

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