Hypnotic Direct and Indirect Suggestions for Improving the Efficiency and Depth of Sleep: An EEG Activity Signal Processing in Various Sleep Stages

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Abstract. Brain activity can be detected through the electric signals it produces. One of the benefits of detecting electric signals in the brain is to measure a person’s sleep quality. Sleep quality can be influenced by stimuli received by the brain before going to bed. One form of stimulus that can be accepted is in the form of suggestions, both direct and indirect suggestions. In this study, the two conditions of the stimulus suggestion will be tested to describe the effect on the electrical signals of the human brain. Based on the results of the analysis it can be described that the stimulus can increase sleep efficiency. Giving influential suggestions to reduce sleep latency and increase the depth of sleep. The stronger the suggestion, the more sleep you will deepen. Suggestions can make sleep deeper and reduce sleep latency. The deeper the level of sleep and the less sleep latency show the better the efficiency of sleep. The better the efficiency of sleep shows the better the quality of sleep.

1. Introduction
Sleep is a natural need for humans. Sleep will have a positive impact if quality. Good sleep quality can help regenerate cells, restore energy, and reduce stress. Sleep quality is also determined by the variety of stimuli given before and during sleep occurs. The stimulus can affect the human brain. When we are sleeping, our brain keeps on doing activities. The condition of the body and the quality of one’s sleep through brain signals produced. The brain activity can be detected through the electrical signals it produces. The production of brain signals is referred to as an electroencephalogram (EEG). The EEG is a recording of fluctuations in brain electrical waves that have very low voltage amplitude. The voltage is in the range of 100 µV – 1mV. EEG refers to the electric activity of the brain recorded from electrodes mounted along the scalp. The electric activity of the brain is transmitted to the EEG sensor and amplified to become an EEG signal that is sufficient to be perceived by the eye.

EEG is a unique and valuable measurement of the brain’s electric functions that displays graphics of voltage differences from within two locations of brain functions recorded from time to time. EEG involves the study of these recordings of electric signals produced by the brain. [1]. The electrical
activity of the brain is produced by electric volume conductors that reflect the electrical activity of brain tissue and brain function.[2].

Brain electrical activity is strongly influenced by the stimulus received. For example, someone who does visual activity before going to bed, such as daydreaming or imagining things continuously, allows him to dream about it. This dream activity is influenced by brain waves, especially Theta waves. Unlike someone who is fast asleep, the more active wave is the Delta wave.

One stimulus that can affect brain activity is hypnosis. Hypnosis, in this case hypnotherapy, is often used to relax someone and give positive suggestions so that someone changes his behavior from negative behavior to a positive behavior. The process of hypnosis uses a variety of induction techniques in the form of suggestions, two of which are direct suggestions and indirect suggestions. The difference in these two suggestions lies in the pattern and strategy of the language used. Suggestion directly utilizes more speeches that are authoritative and imperative. Meanwhile, indirect suggestions mostly use permissive speech. Equally, the two techniques use a lot of language patterns. Thus, to find out which language pattern is the friendliest for the human brain it is necessary to test the influence of these variables.

In relation to brain signal activity during sleep, in this study EEG signal analysis was aimed at describing the effect and validation of the effectiveness of hypnosis stimulation, either through direct suggestion or indirect suggestion on sleep quality based on the two average similarity test statistical methods and two similarity test's variances at each stage of sleep, sleep latency, and sleep efficiency use analysis of time-frequency analysis. Time frequency analysis is a way to process non-stationary signals, which is the use of time and frequency that represents non-stationary signals and their analysis and processing. [2].

Sleep is divided into non-REM and REM sleep. Non-REM sleep stages and slow wave sleep (delta sleep, stage III and IV). These two conditions are influenced by differences in brain electrical signals, which are divided into: (1) Delta - referring to frequencies below 4 Hz; (2) Theta - ranges from 4 Hz to less than 8 Hz; (3) Alpha - ranges from 8 to 13 Hz, and (4) Beta - above 13 Hz [3].

Research related to efforts to improve the quality of sleep is very rarely done [4], especially related to stimulus in the form of language or suggestion. Even though suggestions or words can influence a person's behavior. In fact, suggestions or words can influence a person's behavior [5][6]. However, until now, studies that have discussed suggestions, especially in relation to sleep activities have not been specifically carried out, especially studies related to stimulus in the form of direct suggestions and indirect suggestions. The results of this study can be used to improve sleep quality and reduce sleep problems, such as insomnia.

2. Methodology
This study uses quantitative methods with experimental approaches. The experimental approach is characterized by the existence of far greater control over the research environment and several manipulated variables to observe its influence on other variables[7]. In this study, data was collected on 18 subjects with short-haired male age range 20–25 years. Experiments carried out in a room that has been conditioned so that the subject can fall asleep comfortably. In this experiment, two stimuli were given to obtain sample data with three conditions, namely normal or no stimulus conditions, with direct hypnosis stimulus suggestions and indirect hypnosis suggestions. Each experiment was conducted during the day with a time span of 50–90 minutes. The mechanism used in this study is the Brain Computer Interface (BCI) mechanism using EEG Ganglion sensors from OpenBCI. This BCI mechanism is a safe system because it is noninvasive, sensors are not inserted into human brain tissue, but are placed on the surface of the scalp. Thus, this sensor does not hurt the research subject[8].

The Ganglion OpenBCI Board is an EEG sensor that uses a personal computer (PC) as a controller that can be connected, both with bluetooth and wifi networks. The Ganglion Board sensor has four
channels, which are connected by a cable and at the end there is a dry electrode which is attached to the binding belt. These electrodes are then affixed to the surface of the scalp. In addition, there are two-channel reference electrodes that are attached to the earlobe. This device can acquire brain electrical signals and store them on the HDD and SD-card[8]. The acquired data is displayed on the screen to be observed and analyzed using OpenBCI GUI[9], EEGBrowser[10], and EEGLab software[11][12]. OpenBCI GUI software is specifically designed to process signals from OpenBCI devices. There are a number of settings made when recording with the OpenBCI GUI, namely, a horizontal scale of 30 mm/s, a vertical scale of 100µV or 200µV, a low cut of 1 Hz, high cut 50Hz, a notch filter 50Hz and a sampling frequency of 200 Hz. Furthermore, note that the impedance does not exceed 15Ω. Meanwhile, EEGBrowser and EEGLab are used to display and analyze RAW EEG data.Data retrieval is done using the international system principle 10-20. The 10-20 system is a standard electrode placement used to record EEG data and is a widely used standard[13][14][15]. EEG recording is done by comparing the voltage between the active electrode on the scalp and the reference electrode from the sensor at the farthest point of the heart or the area that has the lowest impedance of the body. The installation of the reference electrode is intended to avoid interference from the body's current flow. Because the effect of noise on an EEG signal that has a low voltage is very strong, the sensor used must be very sensitive. This study used dry electrodes placed on six channels, namely: Frontal Polar 1 (Fp1), Frontal Polar 2 (Fp2), Occipital 1 (O1), Occipital 2 (O2), and two reference channels on the auricle (A1) and (A2). After the data is obtained, we analyze statistically by using SPSS to do the two average similarity tests (T-Test) and the two-variance similarity test (F-Test). The use of SPSS follows the steps that have been integrated to carry out the test [16][17][18].

3. Result and Discussion
In this study, 54 data collection sessions were conducted on 18 male subjects aged 20-25 years. Data retrieval is not homogenized and is done when the subject closes his eyes to sleep. This experiment provided two stimuli to get three conditions, namely a condition without the stimulus, and a stimulus with hypnosis, direct suggestion and indirect suggestion. This experiment examines how much influence direct and indirect suggestions have on relaxation conditions based on certain parameters. The parameters are sleep latency, nonrapid eye movement (NREM 1, NREM 2, NREM 3), wake after the sleep onset (WASO), and sleep efficiency. These parameters are displayed in table form as follows.

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3.1. Statistical Analysis with $T$-Test

T-Test or analysis of two similarity test averages is used to see whether there is an influence of music stimulus on non-stimulus at each stage of sleep. “This is a conservative approach and is based on studies that have shown that tests for equality of variances are often unreliable” [16][17]. The two mean similarity test results can be seen in Table 3 and Table 4. The hypothesis used in this test, namely:

$H_0$ = There is no influence between the music stimulus to the condition without stimulus

$H_a$ = There is an influence between the music stimulus to the condition without the stimulus.

| Abbreviation: | P = Phase | VAR = Variable | SUB = Subject | NREM = Non-Rapid Eye Movement |
|---------------|-----------|----------------|--------------|-----------------------------|
| $P$           | NS = No stimulus | DS = Direct Suggestion | IS = Indirect Suggestion |
| $VAR$         | NS = No stimulus | DS = Direct Suggestion | IS = Indirect Suggestion |
| $SUB$         | NS = No stimulus | DS = Direct Suggestion | IS = Indirect Suggestion |
| $NREM$        | NS = No stimulus | DS = Direct Suggestion | IS = Indirect Suggestion |

### Table 1. EEG Measurement of Sleep Latency, NREM Phase 1–3, Wake After Sleep Onset

| Time (S) | P | VAR | SUB | NREM 1 | NREM 2 | NREM 3 |
|----------|---|-----|-----|--------|--------|--------|
|          | 1 | 41  | 30  | 2252   | 2062   | 2372   |
|          | 2 | 180 | 64  | 2032   | 2739   | 2176   |
|          | 3 | 67  | 31  | 1379   | 2523   | 3332   |
|          | 4 | 0   | 54  | 2465   | 1941   | 2351   |
|          | 5 | 206 | 127 | 897    | 1786   | 2662   |
|          | 6 | 145 | 49  | 988    | 1609   | 2483   |
|          | 7 | 90  | 55  | 94     | 3153   | 2332   |
|          | 8 | 142 | 96  | 56     | 3511   | 3046   |
|          | 9 | 89  | 0   | 0      | 2572   | 2555   |
|          | 10| 95  | 0   | 0      | 1974   | 1985   |
|          | 11| 151 | 77  | 35     | 1754   | 2662   |
|          | 12| 136 | 82  | 91     | 1948   | 2195   |
|          | 13| 199 | 63  | 81     | 2187   | 1864   |
|          | 14| 304 | 209 | 236    | 619    | 929    |
|          | 15| 52  | 0   | 28     | 867    | 1154   |
|          | 16| 133 | 118 | 118    | 2875   | 2255   |
|          | 17| 274 | 222 | 258    | 3233   | 2969   |
|          | 18| 0   | 0   | 37     | 2572   | 2476   |
| AVE      | 128| 71  | 77  | 2071   | 2171   | 2420   |

### Table 2. The similarity test results are two averages with direct suggestions

| SLEEP LATENCY | NREM 1 | NREM 2 | NREM 3 |
|---------------|--------|--------|--------|
| Non-Stimulus  | 128    | 2071   | 1811,83 |
| Direct        | 70,94  | 2171,11| 1811,83 |
| Suggestion    |        |        | 244,5  |
| Non-Stimulus  |        |        | 625,61 |
| Direct        |        |        |        |
| Suggestion    |        |        |        |
| Non-Stimulus  |        |        |        |
| Direct        |        |        |        |
| Suggestion    |        |        |        |
| Non-Stimulus  |        |        |        |
| Direct        |        |        |        |
| Suggestion    |        |        |        |

### Table 3. The similarity test results are two averages with indirect suggestions

| SLEEP LATENCY | NREM 1 | NREM 2 | NREM 3 |
|---------------|--------|--------|--------|
| Non-Stimulus  | 128    | 2071   | 1811,83 |
| Indirect      | 76,5   | 2419,56| 2063,89 |
| Suggestion    |        |        | 244,5  |
| Non-Stimulus  |        |        | 621,28 |
| Indirect      |        |        |        |
| Suggestion    |        |        |        |
| Non-Stimulus  |        |        |        |
| Indirect      |        |        |        |
| Suggestion    |        |        |        |
| Non-Stimulus  |        |        |        |
| Indirect      |        |        |        |
| Suggestion    |        |        |        |

4
Based on the two similarity tests, it can be described that in sleep latency and NREM 3, both in direct suggestion and indirect suggestion, there is a significant effect because it is outside the reception area H0, i.e. -2.306 < 0 < 2.306. However, NREM 1 and NREM 2 did not show any significant influence, either on direct suggestion or indirect suggestion. Fewer sleep latencies indicate that sleep efficiency is higher and shows good sleep quality. Meanwhile, NREM 3 represents the duration of deep sleep. The higher the deep sleep shows the better the quality of sleep.

3.2. Statistical Analysis with F-Test

F-Test analysis is performed to compare the distribution of two sets of variances. The results of the F-Test are shown in Table 5 and Table 6. Meanwhile, the hypothesis used is as follows.

H0 = There is no difference between the music stimulus to the condition without stimulus
Ha = There is a difference between the stimulus of the music to the condition without the stimulus.

| Table4. F-Test results with direct suggestion stimulus |
|-----------------------------------------------|
| SLEEP LATENCY | NREM 1 | NREM 2 | NREM 3 |
|----------------|-------|-------|-------|
| Non-Stimulus | 7124,235 | 4268,173 | 120998,6 |
| Direct Suggestion | 4,318 | 2,517 | 1,838 |
| F TABLE | 3,44 |
| INFO | H0 is rejected | H0 is accepted | H0 is accepted |

| Table5. F-Test results with indirect suggestion stimulus |
|-----------------------------------------------|
| SLEEP LATENCY | NREM 1 | NREM 2 | NREM 3 |
|----------------|-------|-------|-------|
| Non-Stimulus | 7124,235 | 4268,173 | 120998,6 |
| Indirect Suggestion | 4,132 | 1,148 | 0,346 |
| F TABLE | 3,44 |
| INFO | H0 is rejected | H0 is accepted | H0 is accepted |

Based on the data, as a whole after the F-Test, it can be seen that there are significant differences in conditions without stimulus and conditions with stimulus in the sleep latency phase. Fewer sleep latencies, shows good sleep quality. However, at the stage of sleep, both NREM 1, NREM 2 and NREM 3, both the stimulus with direct suggestion and stimulus with indirect suggestions, did not show a significant difference. Thus, it can be described that giving suggestions; either directly or indirectly can reduce the duration of sleep latency.

4. Conclusion

From the results of the trials conducted on 18 male students aged 20–25 years with three treatments (without the stimulus, with direct suggestion and indirect suggestion stimulus) for 50–90 minutes, a number of things can be concluded:

1. Sleep latency in conditions without the stimulus is longer than stimulus, both direct and indirect suggestions. This shows that giving suggestions can reduce sleep latency and improve sleep efficiency.

2. If viewed from the stages of sleep, NREM 1 and NREM 2 do not show a significant effect on sleep quality and efficiency. In contrast to the two stages, NREM 3 which shows higher quality and efficiency of sleep better with conditions when stimulated compared to non-stimulus conditions because NREM 3 is closely related to deep sleep. So, it can show that the stimulus is very influential on the level of depth of sleep. The stronger the suggestion is given, the deeper the sleep will be.

3. There is no significant difference in the stages of sleep (NREM 1, 2, 3) indicating that the provision of suggestions, both directly and indirectly, did not differ significantly in this stage of
sleep. However, giving suggestions, both directly and indirectly, at the sleep latency stage has a significant difference in the condition without the stimulus. This can be described that giving suggestions can reduce sleep latency so that sleep efficiency will be much better.

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