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# Electroencephalographic pattern between high cognitive and low cognitive brains

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**Abstract:** *Background:* The brain electrical activity can vary according to the types of tasks, quality of individuals (brilliant or dull) and state (resting/exercise) of the body. *Objectives:* To compare the effect of educational course on electroencephalogram (EEG) between the high and the low cognitive medical students. *Methods:* Eighty three students were enrolled in the study. Fifty nine students scored high and 24 students scored less in the cognitive test. The EEG was recorded at the start and end of the first year course. It was recorded in an eye-closed state for 5-minutes. Data was subjected to frequency power analysis. Comparison between the groups and within the groups were done by Mann-Whitney U test ($p<0.05$). *Results:* At the course-start or at the course-end, theta and alpha1 activities were higher at many EEG sites in the low cognitive students (CS) as compared to the high CS. However, two groups showed similar change in EEG pattern on comparing between the two visits. All EEG powers (alpha1, alpha2, theta, and delta) at maximum brain areas were less at the course-end as compared to the course-start in both the groups; except prefrontal alpha1 and theta activities. Peculiarly, only in the low CS beta activity was less in the course-end as compared to the course-start. *Conclusion:* Brain neuronal activity showed similar EEG pattern change in two different cognitive groups. At the course-end, brain became more efficient (less EEG power) as compared to the course-start in both the groups. However, throughout the year, the low CS had higher EEG power (theta and alpha1) and is in stress (high beta-start of course) as compared to the high CS. Hence, efficient and trained brain has less EEG powers at rest.

**Keywords**: Electroencephalogram, Cognition, Brain, Education, Students

## Introduction

Electroencephalogram (EEG) is a record of brain electrical activity picked up from the surface electrodes placed on the scalp. It has various waves (beta, alpha, theta and delta) of various frequencies with their own physiological meaning. The theta and alpha activities of frontal brain areas increase on mental attention [1]. Brighter students might have higher delta but lower alpha and beta activities in their brain as compared to average ones [2]. In specific task (visually presented words, feature-concept pairs) theta activity of brain denotes the encoding of new information whereas alpha 2 denotes the long-term memory process in an individual [3].

This shows that the brain electrical activity can vary according to the types of tasks, quality of individuals (brilliant or dull), state (resting/exercise) of the body and other factors. Hence, how EEG gets affected on exposure of brain to a new study course was our research question. We formulated the following objectives:

1) To explore the effect of education on EEG in high and low cognitive groups of students at the start and at the end of their first year medical course and
2) To reveal the EEG powers (alpha, beta, theta, and delta) that differentiates the cognition level of the students.

## Material and Methods

Prior to the study ethical clearance was taken from the Institute Ethical Review Board (IERB) of BP Koirala Institute of Health Sciences, Dharan, Nepal. Informed written consent was taken from all the participating students. Eighty three students participated in the study. First year medical students of age 18-28 years were included in the study.

Students were screened for the substance abuse AUDIT [4] and Fragestrom [5] tests, to rule out alcohol and nicotine dependence, respectively. Students with dependence and with any mental or systemic illness were excluded from the study.

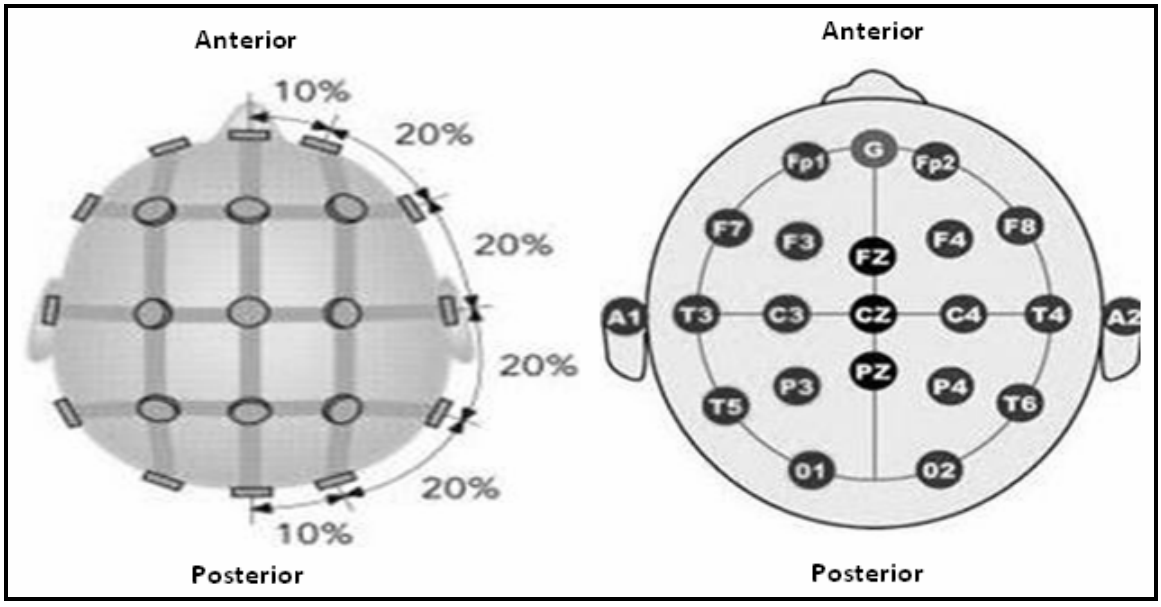
**Study variables:**

1. *Anthropometric:* Age, Height, Weight, and Body Mass Index.
2. *Cardio-respiratory:* Heart Rate, blood pressure, respiratory rate were assessed in two visits.
3. *Cognitive function Assessment (CFA):* Students cognitive function scores (CFS) were assessed at the start of the course by using a standardized questionnaire [6]. The reliability coefficient alpha of the cognitive test was 0.69, which was tested as a pilot study in a separate group of the students. The cognitive function scores of the students were coded for confidentiality. The cognitive function scores were grouped into equal halves: low CFS (0-20 CFS) and high CFS (21-40 CFS).
4. *Electroencephalogram record procedure:*

    a. *Pretesting procedure and preparation of subjects:* They were instructed to come for recording with their scalp hair washed with shampoo and without any oiling on hair. For EEG electrode placement their scalp was cleaned with skinpure (containing sand and electrolyte jelly) to reduce skin resistance. Electrodes were placed according to the international 10-20 common average reference system (figure 1) by use of EEG paste (Elefix) for fixing electrodes properly on the scalp. Electrode impedance was kept at or below 10 kΩ.

    b. *EEG Recording Setup and Electrode Placement:* EEG was recorded in eyes-closed state in a semi-inclined posture on a comfortable dental chair at room temperature 26 ± 2 degree centigrade. It was recorded from 19 conventional sites of the International Electrode (10-20) Placement System (Figure 1). Nihon Kohden-Neurofax (optikex GXMT5120) machine was used for the EEG recording in the students. Scalp sites for electrode placement were symmetric (left and right) with referenced to the ipsilateral ear (A1 or A2), figure 1. The time constant was set at 0.1 sec, the high frequency filter was at 38 Hz. The EEG band pass of 0.5 Hz-70 Hz and notch filter of 50 Hz was applied in order to avoid the power line contamination. The sampling rate, 240 Hz was used for acquisition of EEG signals.

**Fig-1:** International 10-20 common average reference system for EEG electrode placement sites



c. *EEG Data Analysis:* The EEG waveforms were analyzed by using Focus software version (1.1). For each participant, 5 minutes of EEG was recorded. The EEG records were screened for eye movements, electromyogram and electrocardiogram artifacts. The EEG record was divided into 5 segments. From each segment artifact-free-5-Sec epoch was taken and subjected to fast Fourier transformation. Altogether 5 epochs were averaged for each subject. The EEG bands were powers of delta (0.5-4 Hz), theta (4-7 Hz), alpha1 (7-10 Hz) and alpha 2 (10-13 Hz) and beta (13-32 Hz).

*Statistical analysis:* Comparison between the groups and within the groups, were done by Mann-Whitney U test, considering p value significant at <0.05. Data are expressed as median and interquartile range (quartile1-quartile3).

## Results

*Anthropometric variables:* Age and BMI were comparable among the groups, Table 1.

*Cognitive function assessment tool:* The cognitive function scores were grouped into equal halves: low CFS (0-20 CFS) and high CFS (21-40 CFS). Twenty four students secured less and 59 students secured high in the cognitive test, Table 1.

**Table-1: Anthropometric variables and cognitive score between two cognitive groups**

| Variables | Groups | |
|---|---|---|
| | Low cognitive group (Mean ± SD) | High cognitive group (Mean ± SD) |
| Age (Years) | 20.54 ±1.79 | 19.9 ± 1.62 |
| BMI (kg/m$^2$) | 20.43 ±2.13 | 21.61 ± 2.67 |
| Range of score (max.=40) | 0-20 | 21-40 |
| Range of obtained Score | 7-20 | 21-38 |

*Cardiorespiratory variables:* At the course-start, cardiorespiratory variables were comparable between the groups, table 2. However, at the course-end, heart rate was higher in the low CS as compared to the high CS, table 2. On comparison within the groups, heart rate and systolic blood pressure were decreased at the course-end in both the groups.

**Table-2: Cardiorespiratory variables between two groups and within the groups (two visits)**

| Variables | Groups | Visits | | |
|---|---|---|---|---|
| | | Start of course (1) | End of course (2) | P1 |
| | | Median (q1-q3) | Median (q1-q3) | 1vs.2 |
| Heart Rate | High cognitive | 70 (66-78.50) | 66 (59.5-72) | <0.0001* |
| | Low cognitive | 73 (68.25-78) | 69.5(65.25-74.5)** | 0.02* |
| Respiratory Rate | High cognitive | 19 (16.5-20.5) | 19 (16-21) | NS |
| | Low cognitive | 18(16.25-19.75) | 18 (16-19.75) | NS |
| Systolic Blood Pressure | High cognitive | 120 (110-122) | 110 (108-120) | <0.0001* |
| | Low cognitive | 119 (110-121.5) | 110 (110-119) | 0.03* |
| Diastolic Blood Pressure | High cognitive | 78 (70-80) | 72 (69-80) | NS |
| | Low cognitive | 78 (70-80) | 75 (70-80) | NS |

Footnote: * denotes p value (≤0.05) significantly different on comparing variables between two visits, ** denotes p value (≤0.05) significantly different on comparing variables between the high and the low cognitive groups.

*Comparison of EEG activity between two cognitive groups at the start of the course and at the end of the course:* During the course-start, the low CS had high alpha1 and theta activities in many brain areas as compared to the high CS, Table 3. Additionally, the low CS had lesser power for delta and higher power for beta activities in few brain areas as compared to the high CS, table 3. At the end of the course, the low CS had high alpha1and theta activities in many brain areas as compared to the high CS, table 4.

**Table-3: Comparison of EEG activity between two groups at the start of the course**

| Power Band | Brain Sites | Low cognitive (n-24) | High cognitive (n-59) | p |
|---|---|---|---|---|
| | | Median (q1-q3) | Median (q1-q3) | |
| Delta | C3 | 55.75 (37.33-71.5) | 65.18 (57.16-86.34) | 0.013* |
| Theta | Fz | 34.65 (25.8-57.84) | 26.2 (19.94-36.62) | 0.024* |
| | F4 | 24.89 (14.5-39.27) | 17.84 (13.11-25.65) | 0.021* |
| | Cz | 37.45 (29.62-60.62) | 28.58 (18.81-40.68) | 0.019* |
| | C4 | 28.35 (17.48-42.35) | 18.98 (13.05-26.85) | 0.016* |
| | Pz | 32.78 (26.93-48.06) | 21.50 (16.91-36.77) | 0.005* |
| | P3 | 24.9 (16.04-31.627) | 17.92(13.88-23.14) | 0.042* |
| | P4 | 22.62 (18.03-39.20) | 16.72 (11.99-23.07) | 0.013* |
| | O1 | 20.33 (13.39-32.22) | 14.18 (9.36-22.48) | 0.023* |
| | O2 | 19.43 (14.09-34.58) | 14.16 (9.19-21.63) | 0.019* |
| Alpha1 | Fz | 90.84 (26.15-140.10) | 37(17.78-65.76) | 0.004* |
| | Fp1 | 47.98 (15.21-87.99) | 18.98(10.42-38.26) | 0.004* |
| | Fp2 | 52.98 (15.28-81.21) | 21.60 (11.54-37.49) | 0.004* |
| | F3 | 74.56(19.17-113.83) | 29.32 (13.61-52.12) | 0.004* |
| | F4 | 73.62 (21.67-115.49) | 26.12(11.74-51.63) | 0.005* |
| | F7 | 30.99 (9.1-44.77) | 12.66(5.38-23.37) | 0.003* |
| | F8 | 25.79 (8.56-43.29) | 11.56 (4.6-20.49) | 0.007* |
| | Cz | 107.2 (27.89-142.85) | 40.42 (18.55-78.05) | 0.002* |
| | C3 | 67.96 (20.30-97.86) | 31.70 (13.91-62.38) | 0.017* |
| | C4 | 86.21(20.35-119.12) | 29.9 (15-58.44) | 0.005* |
| | Pz | 126.99 (32.9-187.62) | 48.48 (19.7-97.64) | 0.002* |
| | P3 | 90.11 (26.20-224.64) | 30.3 (14.41-81.3) | 0.013* |
| | P4 | 83.28 (22.97-145.97) | 35.9(14.89-68.98) | 0.018* |
| | T3 | 29.05(10.45-43.28) | 12.52(6.357-23.5) | 0.02* |
| | T4 | 23.39(9.3-40.68) | 13.24(5.91-19.67) | 0.025* |
| | T6 | 47.05 (8.27-100.6) | 15.38(6.47-31.3) | 0.032* |
| | O1 | 78.81 (57.02-267.22) | 48.02 (21.12-90.72) | 0.035* |
| | O2 | 76.58 (48.50-229.01) | 43.68(19.940-101.22) | 0.048* |
| Beta | Pz | 31.6 (20.87-39.62) | 20.84 (16.31-31.05) | 0.05* |

Footnote: * denotes p value significant at ≤ 0.05.

| Table-4: Comparison of EEG activity between two groups at the end of the course | | | | |
|---|---|---|---|---|
| **Power Band** | **Brain sites** | **Low cognitive (n-24)** | **High cognitive (n-59)** | **p** |
| | | **Median (q1-q3)** | **Median (q1-q3)** | |
| Theta | F3 | 25.45 (18.08-41.71) | 16.76(13.15-23.37) | 0.02* |
| | F7 | 12 (6.61-15.03) | 7.84 (5.04-12.54) | 0.04* |
| | Cz | 41.64 (22.94-58.41) | 26.4 (18.79-36.43) | 0.04* |
| | C3 | 28.6 (11.07-38.86) | 14.18 (10.78-21.76) | 0.04* |
| | T4 | 6.27 (5.2-11.16) | 3.86 (3.09-5.4) | 0.0001* |
| | T5 | 4.06 (2.6-5.19) | 2.5(1.51-3.75) | 0.03* |
| | Pz | 32.72 (16.75-47.38) | 20.68 (13.73-29.64) | 0.01* |
| | P3 | 20.39 (11.06-27.72) | 12.8 (9.43-19.27) | 0.03* |
| | P4 | 19.45 (15.66-31.97) | 13.64 (10.25-20.6) | 0.03* |
| | O1 | 17.81 (12.7-28.56) | 13.62(8.26 -23.14) | 0.02* |
| | O2 | 19.53 (13.23-29.11) | 11.86 (8.21-20.67) | 0.02* |
| Alpha1 | Fz | 80.12 (29.43-132.65) | 38.38 (17.04-79.5) | 0.01* |
| | Fp1 | 49.24 (23.6-96.87) | 27.16 (13.67-55.32) | 0.02* |
| | Fp2 | 55.24 (21.61-96.69) | 23.92 (12.24-53.3) | 0.01* |
| | F4 | 53.22 (22.04-103.12) | 32.88 (12.6-60.14) | 0.02* |
| | Cz | 83.48 (35.93-182.8) | 68.72 (19.02-89.47) | 0.04* |
| | T3 | 18.78 (6.26-22.75) | 9.92 (3.59-19) | 0.03* |
| | T4 | 19.26 (7.16-28.79) | 9.16 (3.31-16.28) | 0.01* |
| | T6 | 12.38 (6.44-23.99) | 6.88 (2.62-11.56) | 0.03* |
| | Pz | 76.48 (44.94-230.15) | 48.78 (18.16-126.4) | 0.03* |
| | P4 | 88.86 (20.27-135.84) | 32.62 (15.81-84.98) | 0.04* |
| Footnote: * denotes p value significant at ≤ 0.05. | | | | |

*Comparison of EEG activity within the low cognitive group between two visits:* In the low CS, theta activity was significantly less in left prefrontal (Fp1) area but its activity was high in temporal (T3, T4, T5, T6) brain areas at the course-start as compared to the course-end. Delta activity was seen significantly high in the temporal brain areas only. Similarly, beta, alpha1, and alpha2 activities were higher at the course-start as compared to the course-end in many brain areas, table 5.

*Comparison of EEG activity within the high cognitive group between two visits:* In the high CS, alpha1 activity was less in the prefrontal (Fp1 and Fp2) brain areas, but its activity was high in the temporal brain areas at the course-start as compared to the course-end (Table 6). Additionally, at the course-start, alpha2, theta, delta and beta activities were high in some brain areas as compared to the course-end (Table 6).

| Table-5: EEG activity between the start and the end of the course in low cognitive group, n-24 | | | | |
|---|---|---|---|---|
| **Power Band** | **Brain sites** | **Start of course Median (q1-q3)** | **End of course Median (q1-q3)** | **p** |
| Delta | T5 | 33.91(25.035-47.62) | 12.47 (10.305-17.55) | <0.0001* |
| | T6 | 33.16 (20.265-44.13) | 17.85 (13.76-25.56) | 0.004* |
| Theta | Fp1 | 16.71(12.87-28.74) | 20.24(14.30-33.69)↑ | 0.034* |
| | T3 | 9.21 (7.56-12.5) | 6.4(4.345-9.69) | 0.024* |
| | T4 | 7.83 (5.98-14.34) | 6.27 (5.2-11.16) | 0.032* |
| | T5 | 12.78(6.20-15.97) | 4.06 (2.6-5.19) | <0.0001* |
| | T6 | 10.5 (4.52-16.46) | 3.21 (2.24-4.025) | <0.0001* |
| Alpha1 | T3 | 29.05 (10.45-43.28) | 18.78 (6.26-22.75) | 0.008* |
| | T5 | 53.55 (16.945-154.8) | 11.77(3.24-23.82) | <0.0001* |
| | T6 | 47.046 (8.275-100.6) | 12.38 (6.435-23.98) | <0.0001* |
| Alpha2 | T3 | 11.57(5.29-18.73) | 7.33 (4.18-13.67) | 0.033* |
| | T4 | 10.4 (4.745-23.14) | 8.65 (5.28-14.44) | 0.045* |
| | T5 | 24.37 (9.38-53.53) | 3.99 (1.905-7.58) | <0.0001* |
| | T6 | 18.78 (5.13-58.73) | 5.8 (1.94-10.20) | <0.0001* |
| | C4 | 33.74 (19.31-73.565) | 31.68 (16.80-46.16) | 0.037* |
| Beta | FZ | 24.88 (20.89-30.93) | 19.67 (12.6-25.70) | 0.002* |
| | F3 | 21.99 (17.365-25.91) | 15.19 (13.29-21.07) | 0.045* |
| | F4 | 20.48 (15.28-24.12) | 17.08 (11.03-21.66) | 0.015* |
| | F8 | 10.06 (5.13-13.88) | 6.38 (4.44-8.64) | 0.003* |
| | T4 | 11.31 (6.03-16.38) | 9 (6.63-13.16) | 0.037* |
| | T5 | 13.33 (10.45-21.35) | 6.31 (4.99-8.33) | 0.001* |
| | T6 | 11.1(8.24-17.74) | 7.77 (5.09-12.13) | 0.049* |
| | Cz | 25.76 (21.92-36.86) | 24.33 (14.435-28.83) | 0.016* |
| | C3 | 25.06 (13.68-26.69) | 18.86 (11.13-23.56) | 0.028* |
| | C4 | 23.48 (15.16-26.57) | 18.31 (11.59-22.98) | 0.006* |
| | O2 | 25.08 (19.53-43.94) | 23.06 (18.03-35.5) | 0.021* |
| Footnote: * denotes p value significant at ≤ 0.05. | | | | |

| Table-6: EEG activity between the start and the end of the course in high cognitive group, n-59 | | | | |
|---|---|---|---|---|
| **Power Band** | **Brain sites** | **Start of course Median (q1-q3)** | **End of course Median (q1-q3)** | **p** |
| Delta | Cz | 91.5 (68.16-113.68) | 75.8(63.85-95.22) | 0.049* |
| | C3 | 65.18 (57.16-86.34) | 54.7(38.8-70.37) | <0.0001* |
| | P3 | 61.32 (52.51-87.16) | 50.5 (41.01-71.27) | <0.0001* |
| | T3 | 28.94 (21.16-39.23) | 20.34 (14.84-31.67) | 0.002* |
| | T4 | 29.32 (22-42.2) | 21.08 (15.01-26.22) | <0.0001* |
| | T5 | 36.58 (23.77-54.88) | 12.42 (7.5-20.74) | <0.0001* |
| | T6 | 33.38 (17.02-46.75) | 15.02 (9.51-20.27) | <0.0001* |
| Theta | Fz | 26.2(19.94-36.62) | 24.88 (18.47-29.63) | 0.019* |
| | T3 | 7.9 (5.75-11.56) | 5.28 (3.1-7.31) | <0.0001* |
| | T4 | 7.74 (4.82-10.25) | 3.86 (3.09-5.4) | <0.0001* |
| | T5 | 9.66 (5.55-15.45) | 2.5(1.51-3.75) | <0.0001* |
| | T6 | 7.64 (4.13-10.05) | 2.44 (1.54-4.14) | <0.0001* |
| | C3 | 18.9 (14.37-25.46) | 14.18 (10.78-21.76) | 0.007* |
| | P3 | 17.92 (13.88-23.14) | 12.8 (9.43-19.27) | <0.0001* |
| Alpha1 | Fp1 | 18.98(10.42-38.26) | 27.16 (13.67-55.32)↑ | 0.003* |
| | Fp2 | 21.6 (11.54-37.49) | 23.92 (12.24-53.3)↑ | 0.024* |
| | T3 | 12.52(6.357-23.5) | 9.92 (3.59-19) | 0.02* |
| | T4 | 13.24 (5.91-19.66) | 9.16 (3.31-16.28) | 0.004* |
| | T5 | 31.16 (7.81-61.64) | 6.18 (2.4-12.48) | <0.0001* |
| | T6 | 15.38 (6.47-31.3) | 6.88 (2.62-11.56) | <0.0001* |
| Alpha2 | Fz | 27.46 (12.49-54.33) | 23.12 (12.1-46.68) | 0.0318 |
| | F3 | 20.96 (9.72-50.61) | 17.76 (9.88-34.4) | 0.05* |
| | F4 | 21.62 (11.07-41.52) | 17.9 (8.03-37.99) | 0.024* |
| | F7 | 9.38 (5.58-20.4) | 7.88 (4.62-15.8) | 0.046* |
| | F8 | 9.7 (4.63-14.48) | 6.26 (3.27-12.9) | 0.005* |
| | T4 | 11.07 (5.99-18.88) | 8.02 (4.36-12.48) | 0.001* |
| | T5 | 24.38 (10.34-53.5) | 4.74 (2.39-9.59) | <0.0001* |
| | T6 | 15.98 (5.84-38.41) | 4.24 (2.54-8.64) | <0.0001* |
| Beta | C3 | 18.06 (13.38-24.43) | 16.28 (12.01-23.77) | 0.022* |
| | T5 | 15.68 (8.65-21.98) | 5.86 (3.67-12.28) | <0.0001* |
| | T6 | 10.92 (7.26-16.89) | 5.12 (3.25-10.08) | 0.02* |
| Footnote: * denotes p value significant at ≤ 0.05. | | | | |

*Summary of results:* Either during the course-start or at the course-end, maximum brain EEG powers (with few exceptions) were high in the low CS as compared to the high CS (Figure 2 and 3). Additionally, maximum brain areas EEG powers were decreased at the course-end (with few exceptions at prefrontal brain waves) as compared to the course-start in both the cognitive groups (figure 4 and 5).

**Fig-2:** Map of EEG sites and power *at the course-start* in the low cognitive group as compared to the high cognitive group. *Note:* Theta is mainly high in central and right hemisphere of the brain whereas alpha1 is high in almost all the brain areas. Beta power is high and delta power is less in the PZ and C3 brain areas, respectively.

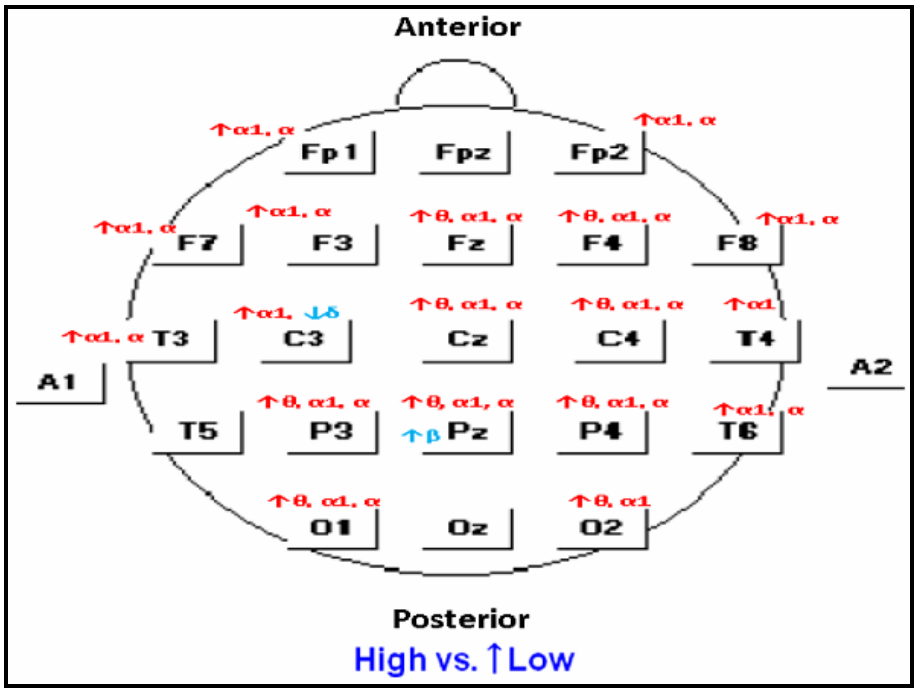



**Fig-3:** Map of EEG sites and power *at the course-end* in low cognitive group as compared to high cognitive group

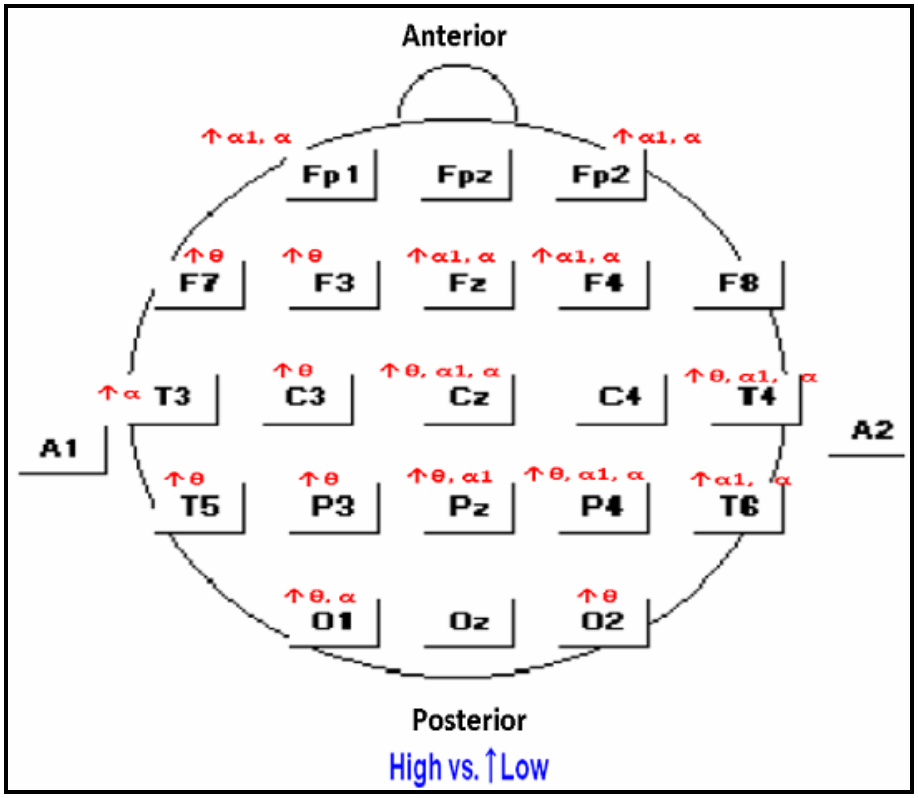


**Fig-4:** EEG sites and power in *high cognitive group* at the end of the course as compared to the start of the course

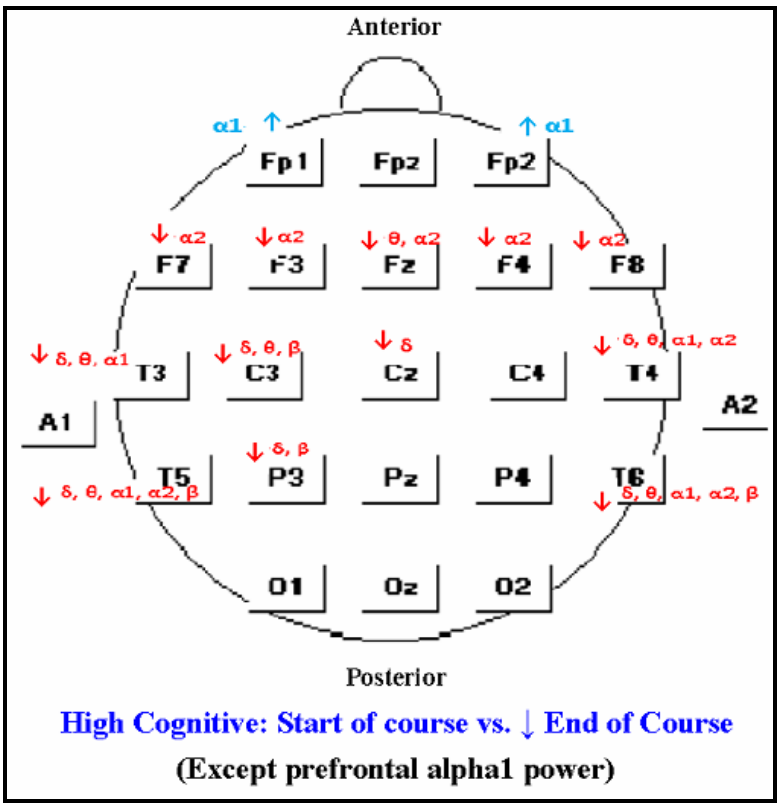
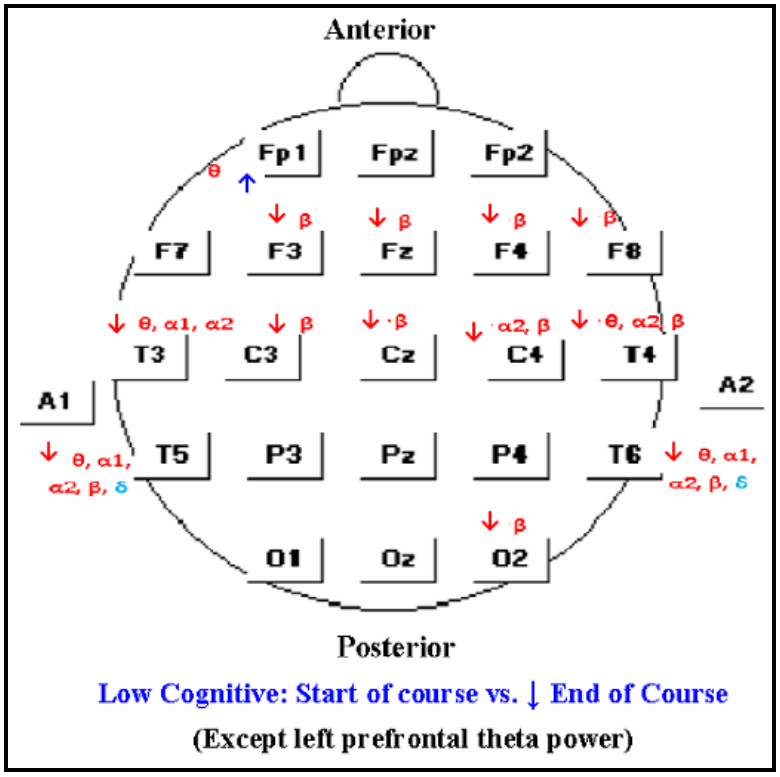



**Fig-5:** EEG sites and power in *low cognitive group* at the end of the course as compared to the start of the course



## Discussion

We explored the effect of medical education training on the electroencephalographic power in the high and the low cognitive group of students in their first year of study. We found the cardiorespiratory variables [heart rate, respiratory rate and blood pressure] at the course-start were comparable between the two cognitive groups. However, at the course-end, heart rate was higher in the low CS as compared to the high CS. This implies the low cognitive students are slightly stressed at the end of the course than their high cognitive peers. The stress might be due to the annual exam preparation.

However, within the groups, at the course-end, we found the heart rate and systolic blood pressure were decreased in both the groups. This implies that initially (course-start) they were in stress but at the course-end they became familiar with the learning environment that might have decreased their blood pressure and heart rate [7] in the same manner within the groups. Nevertheless, the low CS was in the high state of stress at the course-end as compared to the high CS might be due to their low mental ability and exam stress.

We found the low CS had high alpha1 and theta activities in many brain areas as compared to the high CS (figure 2 and 3) both at the start and end of the course. The theta and alpha activities of frontal brain areas increase on mental attention [1]. We found these two waves (alpha1 and theta) are higher in frontal as well as in many brain areas of the low CS as compared to the high CS. This shows that the low cognitive brains are utilizing their maximum brain energy/resources for the attention purpose. This attention could be for the learning or for the other environmental adjustments that they have encountered during the medical college stay.

Both the groups of students were in the same study process but the low CS seems utilizing their excess brain resources (EEG powers) for attention purpose even at the course end. Whereas, the high CS is storing their attention energy by decreasing the firing level of the theta and alpha neurons at the course end. This stored energy can be utilized whenever it is required to capture the relevant things during the learning process. In specific task, theta activity of brain denotes the encoding of new information whereas alpha2 denotes the long-term memory process in an individual [3].

In our study, we did not found significant difference in alpha2 activity between the groups, but theta and alpha1 powers were less in the high CS. Hence, brilliant students (high cognitive) use fewer mental resources either during rest or during any cognitive task by activating less brain resources (less alpha1 and theta powers). The neural efficiency seems to be more effective in the high cognitive students as supported by other studies [8].

However**,** the high IQ individuals showed a high EEG alpha power while resting with eyes open and when they solve problems [9], opposite to our findings. The contradiction is possibly due to the methodological difference that we have recorded the EEG at rest (eyes close) without any external stimuli. Some other studies found that the alpha band (7-13 Hz) decreases when the IQ increases [10]. Hence, an individual having less alpha1 and theta power has been accounted for high mental activity in our study.

In our study, other EEG powers at the course-start, beta (mid-parietal) activity was high and delta activity (left central) was less in the low CS as compared to the high ones. However, at the course-end, beta and delta activities were comparable between the groups. Brighter students might have higher delta but lower alpha and beta activities in their brain as compared to the average ones [2], which we found at the start of the course. Later, at the course-end, there were no significant differences in beta and delta activities between the groups. The similarity for delta and beta powers between the groups at the course end could be a brain adaptation due to exposure to the similar training/learning environment.

In our results within the groups, EEG powers in many brain areas (alpha1, alpha2, beta, and theta) either in low or high CS were lesser at the course-end as compared to the course-start (figure 4 and 5). This might be due to the

similar medical education training given to two cognitive groups. Initially, they had higher EEG powers because they were not familiar with the medical study. Later, as a part of the training to conserve and save energy resources of brain their EEG powers decreased at the completion of the study. In the other sense, neural efficiency has increased at the course-end in both the groups. Reports mention that the long-term experience (familiarization - neural efficiency) can compensate for lower intellectual ability, even at the level of the cortical activation in the taxi drivers [11], supporting our finding. Moreover, it might be that the low cognitive brain can change into an efficient brain when they undergo the learning process for some time period that their brain may match with the high CS brain.

However, we found prefrontal alpha1 activity in high CS and left prefrontal theta activity in low CS were higher at the course-end as compared to the course-start. This implies that firing of the prefrontal neurons (alpha1 or theta) increases when students' capture or encode the new information [3] while exam preparation. Hence, by increasing the firing of neurons that generate alpha1 and theta activities in the prefrontal brain area students are attentive to grasp knowledge (self learning) for the upcoming annual examination at the course-end.

We found the beta activities in many brain areas were less at the course-end as compared to the course-start in the low CS. Such, beta effect was not seen in the high CS. The beta activity is considered to be high in the stressful conditions [12-13]. The low cognitive student seems to be in more stress and anxiety [12-14] in the start of the course. The probable cause of stress in the low cognitive students might be the inability to adjust in the unfamiliar environment i.e. medical study. Later, when they finished their one year course the beta activity was decreased, possibly because of familiarization to the study towards the course-end. This stress can increase their stress hormone "cortisol" [15] which may hamper their brain learning or retrieving capacity [16]. The assessment of cortisol levels and its effect on EEG pattern in low and high CS needs a further study.

In conclusion, the brain neuronal activity became more efficient (less EEG power) towards the course-end then at the course-start in two cognitive groups. The similar changes in EEG waveforms in two groups could be an adaptation occurring in the students' brain due to the familiarization to the similar study and training environment. Nevertheless, the low cognitive students are in stress with high beta activity at the course-start as compared to the course-end. Additionally, throughout the year, the low cognitive students had higher EEG power as compared to the high cognitive students.

Hence, whether at the start or at the course end the efficient brain has less EEG power as compared to their counterparts. Thus, an individual having less alpha1 and theta power has been accounted for high mental activity. Those having high alpha1 and theta powers throughout the brain were considered to have low mental activity. These individuals try to encode the new information by being attentive and utilizing high mental resources.

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