A STUDY ON THE DEPENDENCY IN THE ALPHA BRAIN WAVE RECORDED THROUGH EEG WITH ACADEMIC PERFORMANCE AND STRESS MIND STATE OF ENGINEERING STUDENTS

P. G. JANSI RANI*

Department of Mathematics,
Sethu Institute of Technology, Kariapatti-626115, Tamil Nadu, India.

ABSTRACT

This paper deals with the acquisition and analysis of Electroencephalogram (EEG) signals on engineering college students of age group 18-20 in Tamil Nadu, India, recorded through 23 electrodes of EEG using Fast Fourier transform (FFT) frequency analysis to determine the distribution of Delta, Theta, Alpha and Beta frequencies during various tasks. The development in any field is highly correlated with the development of theoretical research and its successful applications. Therefore the significance of this theoretical research lies in the insight gained into the real life applications.

Keywords: Electroencephalogram (EEG), Electrodes, Four principal brain waves, Delta, Theta, Alpha and Beta frequencies, Fast Fourier Transform (FFT), Experimental Analysis.

1. INTRODUCTION

The fast paced life style most of us have adopted has resulted in a loss of the skill to produce Theta and Alpha waves. People who have more Alpha brain waves have less anxiety and tension. Creativity is another activity for which Alpha waves are helpful. Scientists have shown that highly creative people have different brain waves from normal and non-creative people. In order to have a creative inspiration, our brain needs to be able to produce a big burst of Alpha waves, predominately on the left side, effectively shutting the left-brain down. This allows the creative right-brain to expose new idea is given in Table 1

Table-1: Left and right brain activities [1, 2]

LEFT (Analytic)	RIGHT (Global)
1. Verbal	1. Visual
2. Responds to word meaning	2. Responds to tone of voice
3. Sequential	3. Random
4. Processes information linearly	4. Processes information in varied order
5. Responds to logic	5. Responds to emotion
6. Plans ahead	6. Impulsive
7. Recalls people's names	7. Recalls people's faces
8. Speaks with a few gestures	8. Gestures when speaking
9. Punctual	9. Less punctual
10. Prefers formal study design	10.Prefers sound/music background while studying
11.Prefers bright lights while studying	11. Prefers frequent mobility while studying

We can tap our psychic abilities by understanding and altering our four principal mind state delta, theta alpha and beta since different behaviors lead specific areas to synchronize at different frequencies. For example relaxation or meditation with eyes closed leads to increased alpha waves in the rear of the head.

Corresponding Author: P. G. Jansi Rani, Department of Mathematics,*
Sethu Institute of Technology, Kariapatti-626115, Tamil Nadu, India.

The rhythmic synchrony of electrical impulses in the brain is called the Electroencephalogram (EEG). The impulses can be recorded as microvolt oscillations on the scalp. The first recording of the electric field of the human brain was made by the German psychiatrist Hans Berger in 1929 in Jena. He gave this recording the name *electroencephalogram (EEG)*. There are four basic brain waves (Fig 1) associated with different states of consciousness. Alpha wave bursts are needed for peak performance. The Alpha wave, the gate way between the outer and the inner world, was discovered by Austrian Psychiatrist, Hans Berger.

Alpha production is an innate skill of our brains and an increase in the amplitude of Alpha waves lowers the level of anxiety and inversely, reduced amplitude of Alpha waves is associated with intensifying fear.
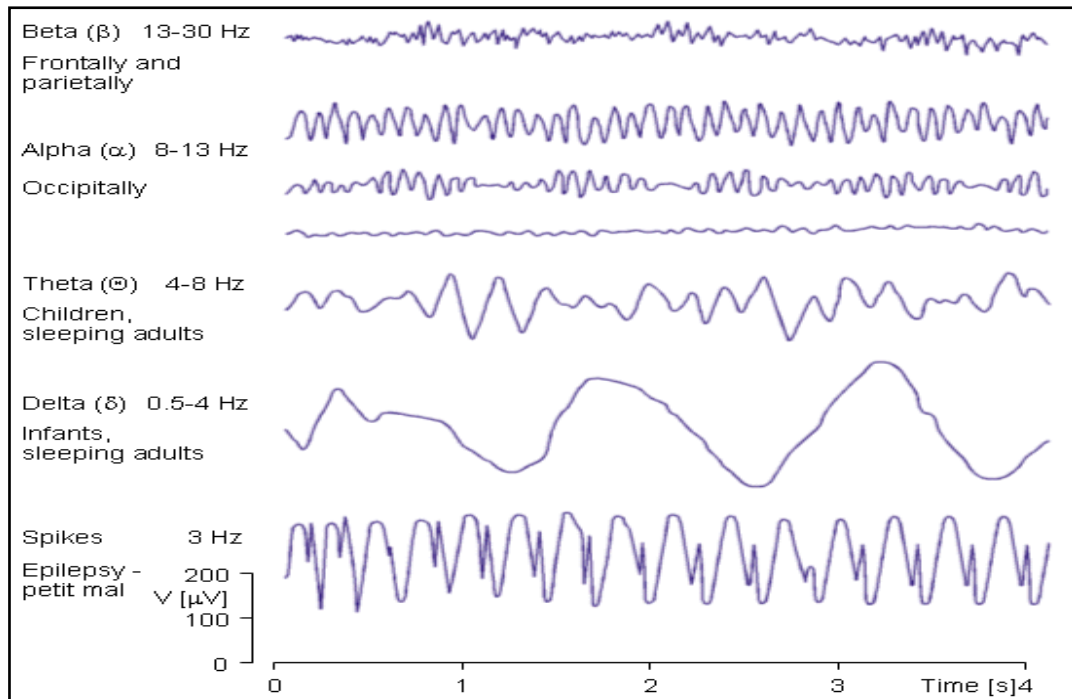

Figure-1: Four principal brain waves [1] [64]

FOUR PRINCIPAL BRAIN WAVES AND THEIR BEHAVIOURS [1]

Delta waves-1-4Hz. (1-4 cycles per second)
This brain state is related to the unconscious or super-conscious mind. Only under the most developed circumstances can a person dip into the delta state of awareness and bring back any intelligible information. Associated with deep sleep patterns.

Theta waves-4-7Hz. (4-7 cycles per second)
Theta state is related to our subconscious mind. We generally experience the theta level in deep meditations and in our sleep state. Here we can transcend time and space, obtain remote perceptions, and obtain information from the highest source. Associated with REM (Rapid eye movement) sleep or lucid dreaming

Alpha waves-7-13Hz (7-13 cycles per second)
Gate between the outer and the inner world. Associated with relaxed and alert state of mind. Improves our mental processes concentration, clarity of thinking, decision making, memory. Calms your body and mind while it maintains alertness. Stimulates imagination, intuition and higher awareness, increases learning ability and improves memory. This is a more internally focused, self-reflective mind-set

Beta waves-14-40 Hz. (14-40 cycles per second)
Beta is seen in highly stressful situations, and in a difficult mental concentration and focus. Associated with an conscious and excited state or our normal waking state Therefore psychic faculties are mostly muted because exterior stimuli dominate our thoughts and actions and suppress subtle realm information

Alpha waves are the prime indicators of conscious attention, and they represent the gate between the outer and the inner world and between the conscious and the unconscious. In general, the left side comprehends theory, and the right side integrates and practices it.

2. PROMPTING FOR THE RESEARCH

The pre-frontal cortex, also called the brain's executive control system, responsible for planning, organizing and sequencing behavior for self-control, moral judgment and attention are developed throughout childhood and adolescence. The nature of the stimulus may predispose some children to attention problems. The fast-paced, attention-grabbing techniques like 'rapid-zoom' pans, flashes of colors, quick movements, sudden loud noises etc, engage the brain's attention involuntarily may idle the executive control system of the brain, impoverish its development and deprive the children of the practice in using their own brain independently. But, the executive control system that goes idle may be reactivated by altering the four principal mind-states, which are responsible for different behavior. Many parents of children diagnosed with attention deficit disorder found the difficulty markedly improved after they took away television viewing privileges. Sports scientists have shown that increases of Alpha waves, primarily in the left-brain, precede optimal performance. There is a distinct difference in the brain wave pattern of an expert and a novice athlete. Just before an expert sportsmen makes his or her "move" there is a burst of Alpha in the left brain. Novice and intermediate athletes do not show this Alpha pattern. (1997 Biocybernaut Institute, *www.biocybernaut.com/ tutorial/ alpha.html*)

On the analysis based on quantitative measurements of EEG amplitudes on academically successful and unsuccessful university students during a 5 min, eyes closed, relaxed state, unsuccessful students displayed a brain wave pattern in the right hemisphere, which resemble patterns often found in depression, suggests a relative disorganization of right hemispheric activity in the unsuccessful students [3].

This prompted to do an experiment on EEG signal to analyze the alpha level during different tasks on students differing in their academic achievements, and other behaviors listed in the following experiments.

3. EXPERIMENTS

3.1. EEG ANALYSIS WITH 2 TASKS

Objective of experiment 1
To determine the alpha level among various categories of students who differ in academic achievements, stress level, behavior in the class, behavior at home, and their general attitude by examining the alpha band of their EEG, in the initial 7 minutes during initial rest with eyes closed and during task and it is given in the table 2.

Task1(7minutes)	Task2 (3minutes)
Normal relaxed state	Multiplication Task

3.2. EEG ANALYSIS WITH 5 TASKS

Objective of experiment 2
To determine the dependency on the alpha mind state among various tasks given in Table.2 with academic performance and stress mind state by examining the alpha band of their EEG, in the initial 5 minutes during rest and during different tasks and means to improve the brain power by increasing their alpha state involving physical exercise, balanced nutrition and complex mental exercises. The time taken for this experiment is given in the supplementary material of the manuscript. Also Brainwave Recorded for the student id: 635 time duration 01 – 10 seconds is given in the below fig. Brainwave Recorded for the other students is given in the supplementary material of the manuscript.

Task1 (5minutes)	Task 2 (3 minutes)	Task 3 (3 minutes)	Task 4 (1 minute)	Task 5 (1 minute)
Initial state rest and relaxed state	Listening to Rock music	Listening to Melodious instrumental Music	Multiplication Task	Thinking over Logical questions related with blood relation with eyes closed and answering after EEG recording is stopped
Fig 2			Section 3.2.1	

Figure-2: Acquisition of EEG signals during five different task

Table 3.2.1 Logical (Blood Relation) Questions (task1) and multiplication questions (task4) asked at students during acquisition of EEG signals:

1. A is my mother in law's only child's child. What is the relationship between me and A?
2. B is your father's only son in law's only daughter. What is relationship between you and B?
3. If your mother's only elder brother's only sister has only daughter, what is the relationship between you and that daughter?
4. Lavan and Kushan are father and son respectively. Mishan is Kushan's uncle. Thrisha is Lavan's sister. What is the relationship between Misha and Thrisha?
5. If A's mother in law and B's mother in law are mother and daughter, then what is the relationship A and B?
6. A's father B's father are father and son. Then what is the relationship between A and B?
7. B is A's mother's only child's son. What is the relationship of B to A?
8. B is A's mother's daughter's son. What is the relationship of B to A?
9. B is A's mother's brother's father. What is B to A?
10. B knows A's birthday falls between 20th October and 7th November. C knows that A's birthday is after 30th October. Find A is birthday?
11. When did Alber Einstein discover Newton's 3rd law of motions?

Multiplication Task

25 x 17	29x13	16x13	18x14	17x16
15x13	13x11	15x12	18x14	

3.3. PERFORMANCE ANALYSIS IN VARIOUS ENVIRONMENTS

Objective of experiment 3

To determine the variation in the performance of activities in different environments given below.

Score without Music	Score with rock Music
Without TV	With TV

4. METHODOLOGY: EEG ANALYSIS

The brain consists of about 20 billion neurons which generate electrical impulses. When these neurons work together in synchrony, tiny rhythmic, electrical potentials occur in the synapses which are specialised junctions between the neurons. The more neurons that work in synchrony, the larger the potential (amplitude) of the electrical oscillations measured in micro volts. The faster the neurons work together, the higher the frequency of the oscillations measured in Hertz. These two parameters: amplitude and frequency are the primary characteristics of brain waves.

These weak electrical signals are measured with electrodes placed on the scalp using some conductive paste. After amplification by an EEG-amplifier, the signals are fed to a computer and analysed for amplitude and frequency.From this EEG signal it is possible to differentiate between alpha (α), beta (β), delta (δ), and theta (Θ) waves. The alpha waves have the frequency spectrum of 8-13 Hz and can be measured from the occipital region [4] in an awake person when the eyes are closed. The frequency band of the beta waves is 13-30 Hz; these are detectable over the parietal and frontal lobes. The delta waves have the frequency range of 0.5-4 Hz and are detectable in infants and sleeping adults. The theta waves have the frequency range of 4-8 Hz and are obtained from children and sleeping adults.

Acquisition of EEG signals analysis on eight II semester students recorded through 23 electrodes of Electroencephalogram (EEG) equipment initially recorded during rest with closed eyes after that the EEG is recorded during different tasks. FFT frequency analysis gives the distribution of Delta, Theta, Alpha, Beta1, and Beta2 frequencies.

Figure-2 Acquisition of EEG signals during rest, Figure-3 Acquisition of EEG signals during Rock (fast beat) and Melodious instrumental music
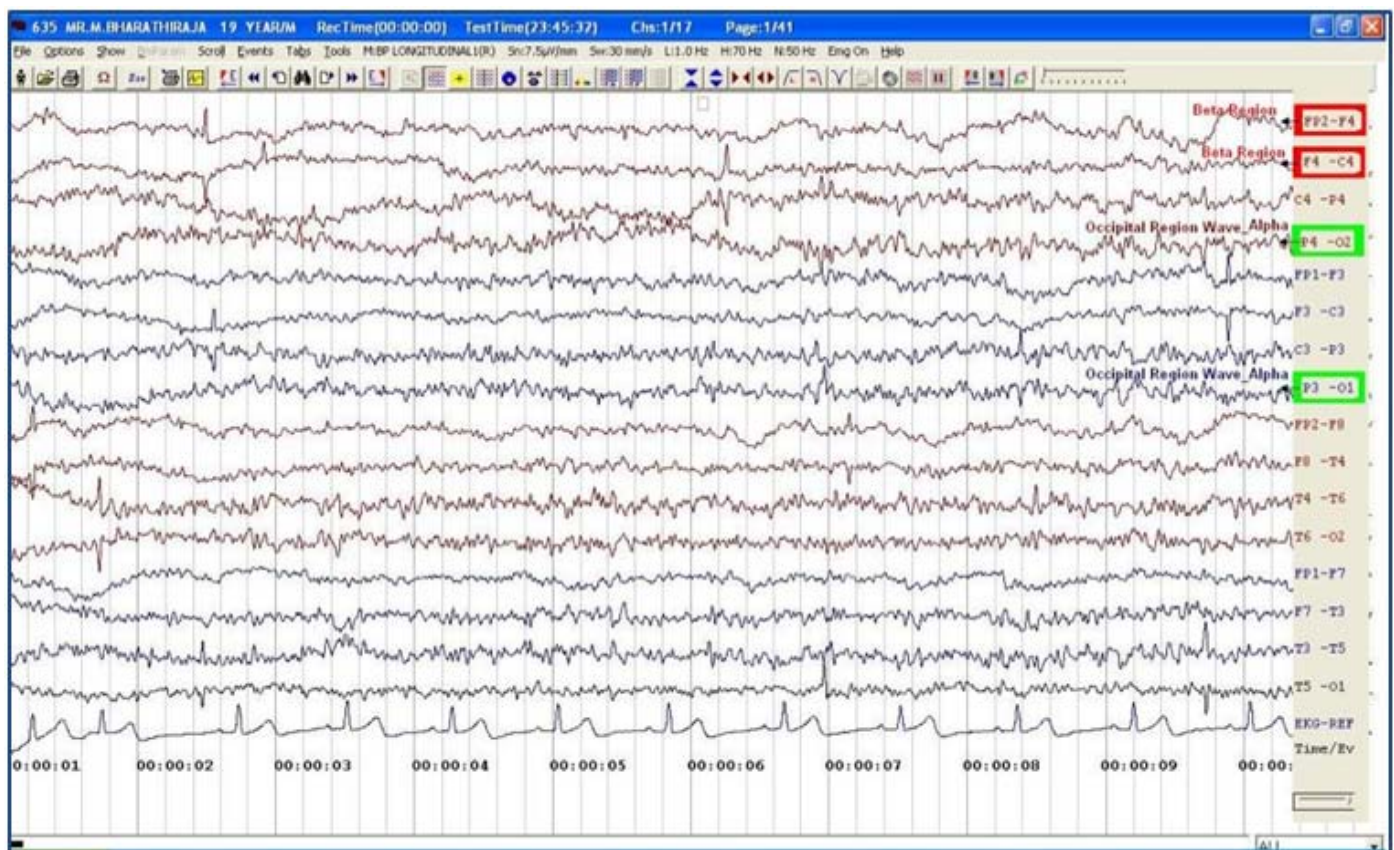

Figure-3(a): EEG 1: brainwave Recorded for the student id: 635 time duration 01-10 seconds.
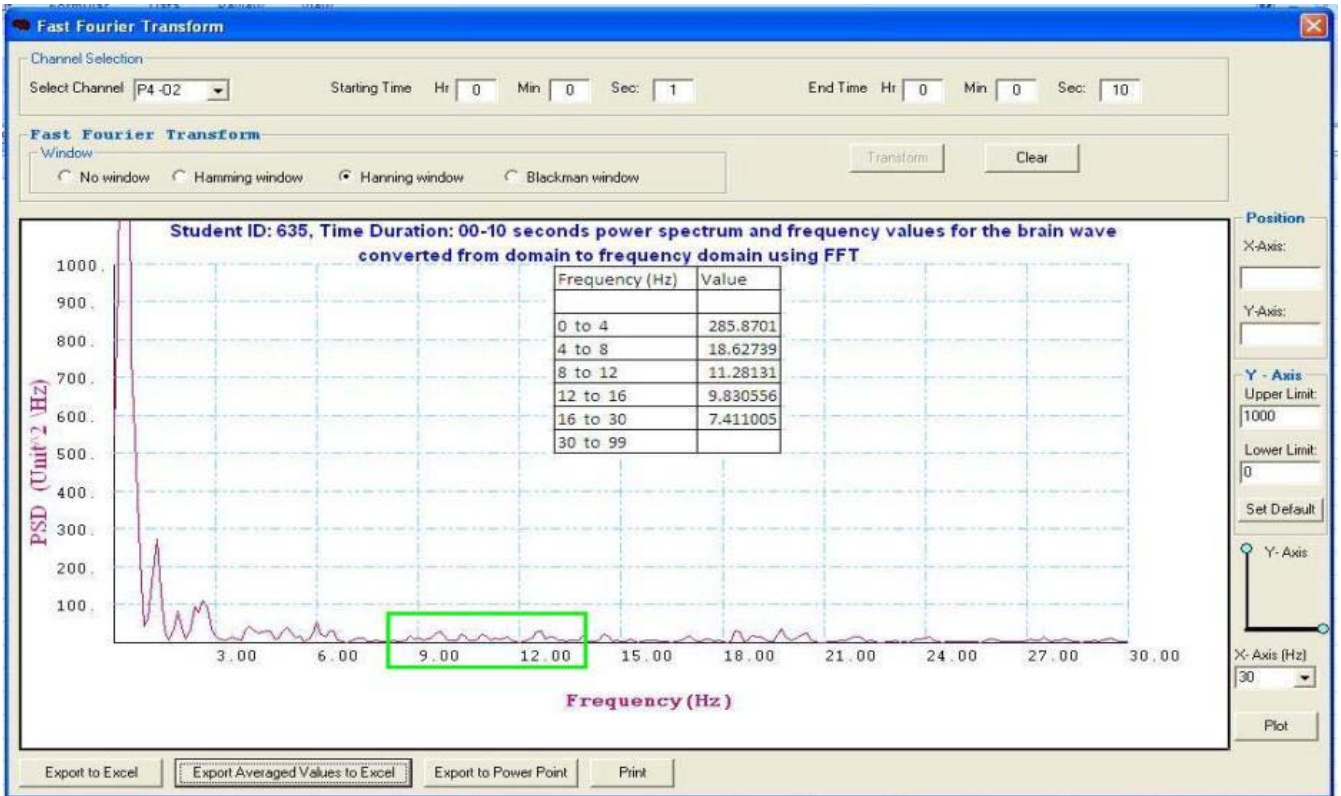
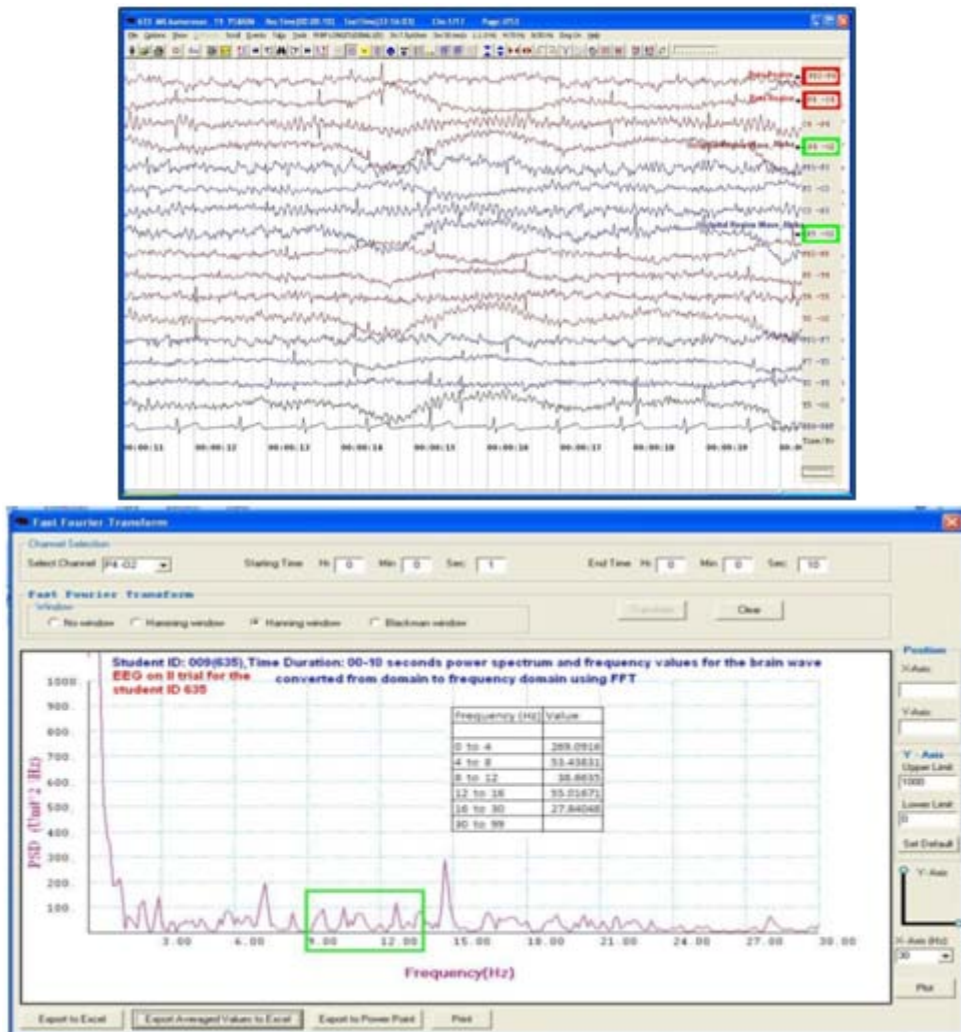**Figure-3(b):** Power spectrum and frequency values for the brain wave using FFT.
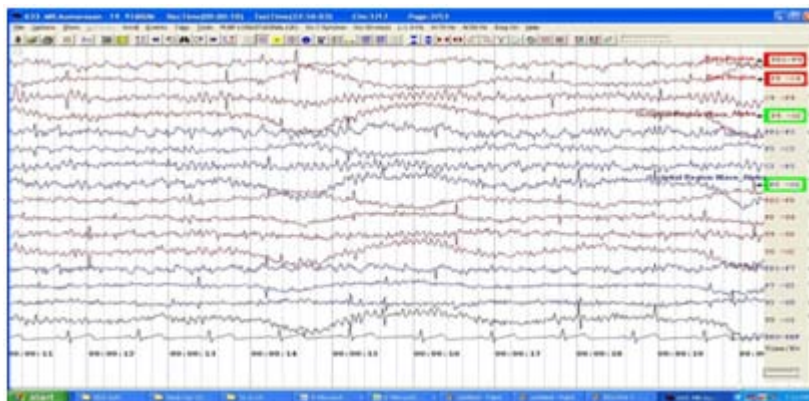

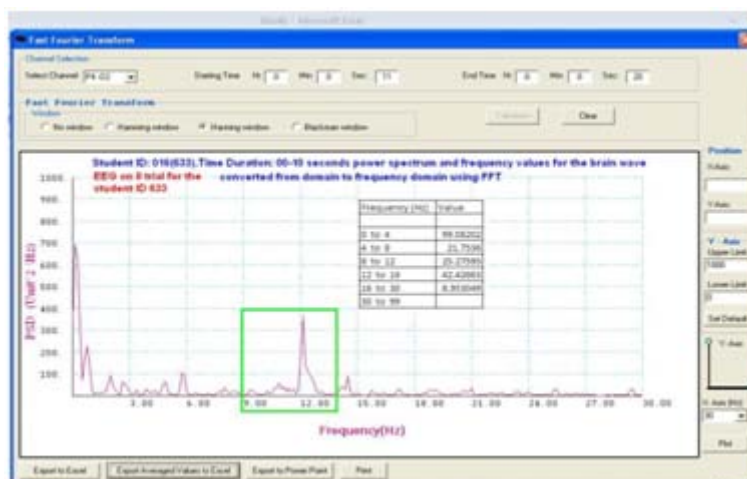**Figure-4(a), (b):** EEG 1a, FFT 1a

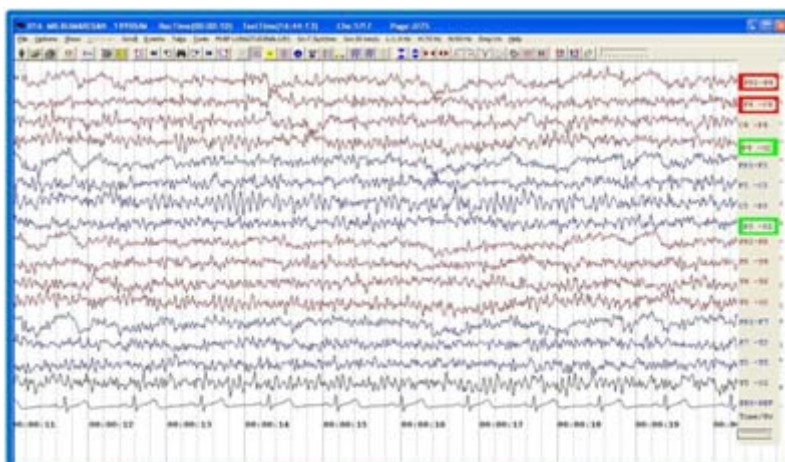**Figure-5(a), (b):** EEG 2, FFT 2

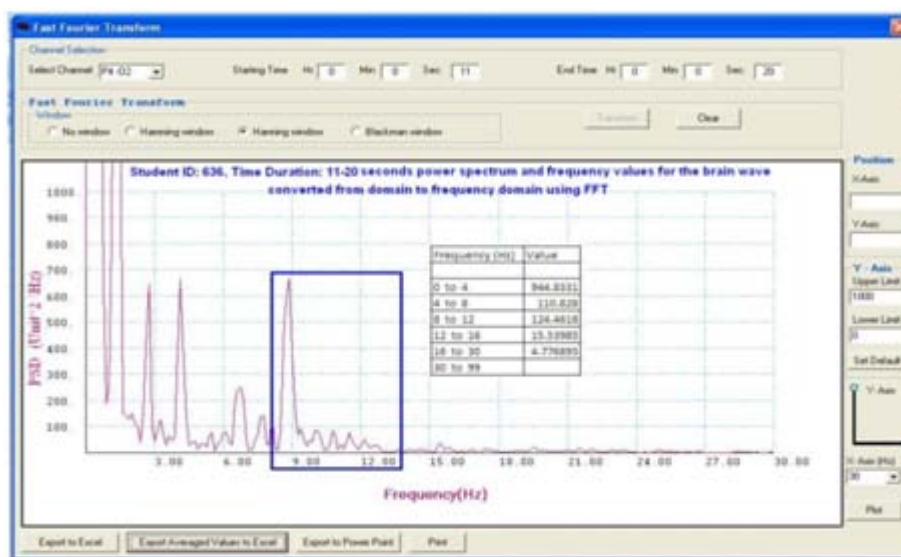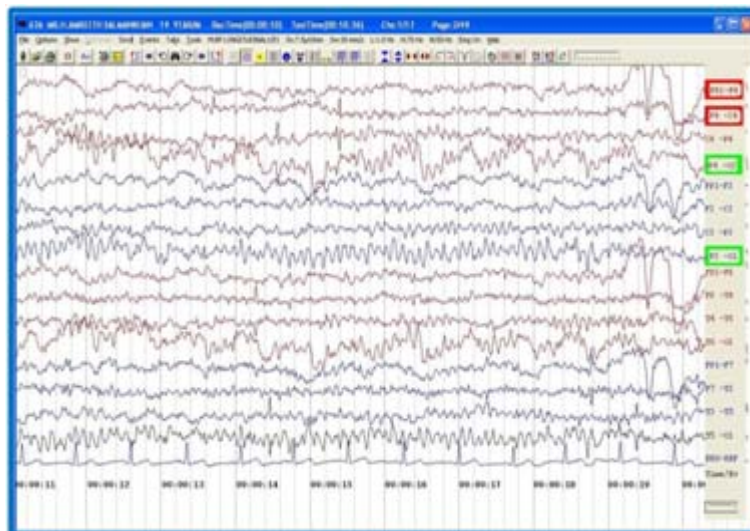
Figure-6(a), (b): EEG 2a, FFT 2a

Figure-7(a), (b): EEG 3, FFT 3

5. EXPERIMENT 1: EEG ANALYSIS WITH 2 TASKS

Sample of 8 students who were selected for sample study of EEG analysis differing in various categories like academic performance and stress level, from the class where I taught and know the students behavior and attribute well is given in table 2.

Table-2: EEG 1a: Brainwave Recorded for the second time for the student id: 635 time duration 01 – 10 seconds.

S. No	Name of the student (Abbreviated)	EEG ID	Students attitude and Behaviour observed by the staff	10 th mark	HSC	I Semester	Academic	Behaviour in the class feed back from class teacher	P4-02 8 to 12	P3-O1 8 to 12	Total Alpha in 2 Electrodes Task 1	Total Alpha in 2 Electrodes Task 4	Average Alpha of Task 1	Average Alpha of Task 4	Between Initial rest and During
1	ATH	636	Very dynamic calm responsible School first in HSC. won't get tensed	A	S	A	E	VCD	156	205	361	691	180	346	16

2	APN	638	Very much relaxed won't get tensed easily will take everything easily	A	A	A	G	VCD	145	207	352	594	176	297	17
3	DK	639	Very curious does not get tensed but is anxious but don't show much outside have the capacity to control emotions. Very good in studies especially in mathematics	A	A	B	E	T	85	54	139	124	69	62	23
4	AK	640	Wants to be free. Does not like parents' strict activities	B	B	D	M	T	71	58	129	182	65	91	19
5	KAN	634	Easily gets tensed even and takessmall matter(small comparison) seriously	B	C	B	M	T	53	41	94	124	47	62	20
6	BR	635	Is always thinking of something (Family problem)	D	B	A	G	ATS	36	27	63	125	32	63	18
7	KMN	633	Is always thinking of something(Intensive Family problem)	B	B	B	M	ATS	34	21	55	79	28	40	21
8	LAW	637	Won't talk much with staff and not so jovial with friends	A	S	A	E	T	23	28	51	48	26	24	22

It is observed that students having relaxed behaviour and dynamic in activities (Sl.No 1, 2) have much higher alpha measure and students having intensive family problem Always Thinking about Something (ATS with stress) have very less alpha measure (SL. NO. 6,7). For the students in Sl.No 6 and 7 second time after 10 days, again EEG was taken to see if there is any change. The reading is given in table 3 this pilot study motivated the researcher do further study in this research.

Table-3: Two students brain wave measure on second trail

S. No	Name of the student (Abbreviated)	EEG ID	Students attitude and Behaviour observed by the staff	10 th mark	HSC	I Sem	Academic	Behaviour in the classs feed back from class teacher	P4-02 8 to 12	P3-O1 8 to 12	Total Alpha in 2 Electrodes Task 1	Total Alpha in 2 Electrodes Task 4	Average Alpha of Task 1	Average Alpha of Task4	Bewteen Initial rest and During Multiplication
6	BR	9	Always thinking of something (Family problem)	D	B	A	G	ATS	32	23	55	184	28	92	-64
7	KMN	16	Always thinking of something(Intensive Family problem)	B	B	B	M	ATS	53	32	86	166	43	83	-40

It is observed that in figure EEG 1, FFT 1, EEG 1a, FFT 1a, EEG 2, FFT 2, EEG 2a, FFT 2a, EEG 3, FFT 3, table3, with details of the second EEG analysis, their Alpha measure was less compared to EEG of others who participated in the first EEG analysis experiment. It is also observed that these two students show an increase in alpha level while doing multiplication task both during test-1 and test-2.This pilot study is the basis for further study in students' brain wave analysis.

Figure-8: Average alpha measure in 5 different tasks
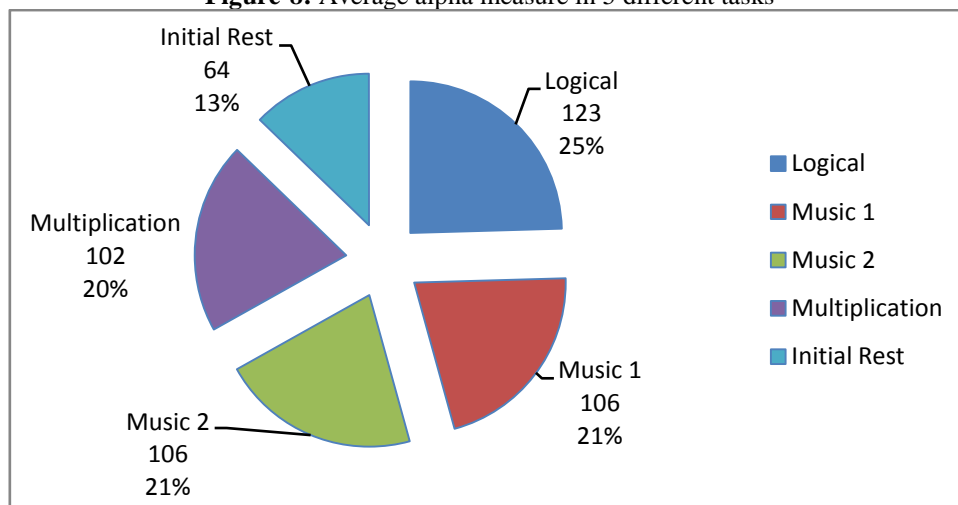
Pie Chart 8 Measuring average alpha measure during five different tasks

S. No	EEG ID	Average Alpha				
		Rest	Loud Music	Melody	Multiplication	Logical
		Average Alpha of Task 1	Average Alpha of Task 2	Average Alpha of Task 3	Average Alpha of Task 4	Average of Alpha Task 5
1	004	151	188	264	197	319
2	680	144	232	241	209	324
3	017	86	120	94	78	183
4	014	128	178	105	149	242
5	681	86	252	207	174	230
6	002	33	83	81	85	141
7	016	43	87	97	83	105
8	003	65	144	170	136	157

9	670	62	181	191	134	154
10	013	58	122	93	69	88
11	010	60	84	79	48	63
12	672	60	69	78	58	66
13	682	62	128	148	136	140
14	009	28	37	100	92	69
15	637	26	0	0	24	0
16	005	103	223	169	219	188
17	633	28	0	0	40	0
18	634	47	0	0	62	0
19	639	69	0	0	62	0
20	635	32	0	0	63	0
21	640	65	0	0	91	0
22	638	176	0	0	297	0
23	636	180	0	0	346	0
	Total	1790	2129	2117	2850	2468
	Average	64	106	106	102	123
	Position	**4**	**2**	**2**	**3**	**1**

Table-4: Average Alpha Measure

Measuring increase in alpha measure between two different tasks
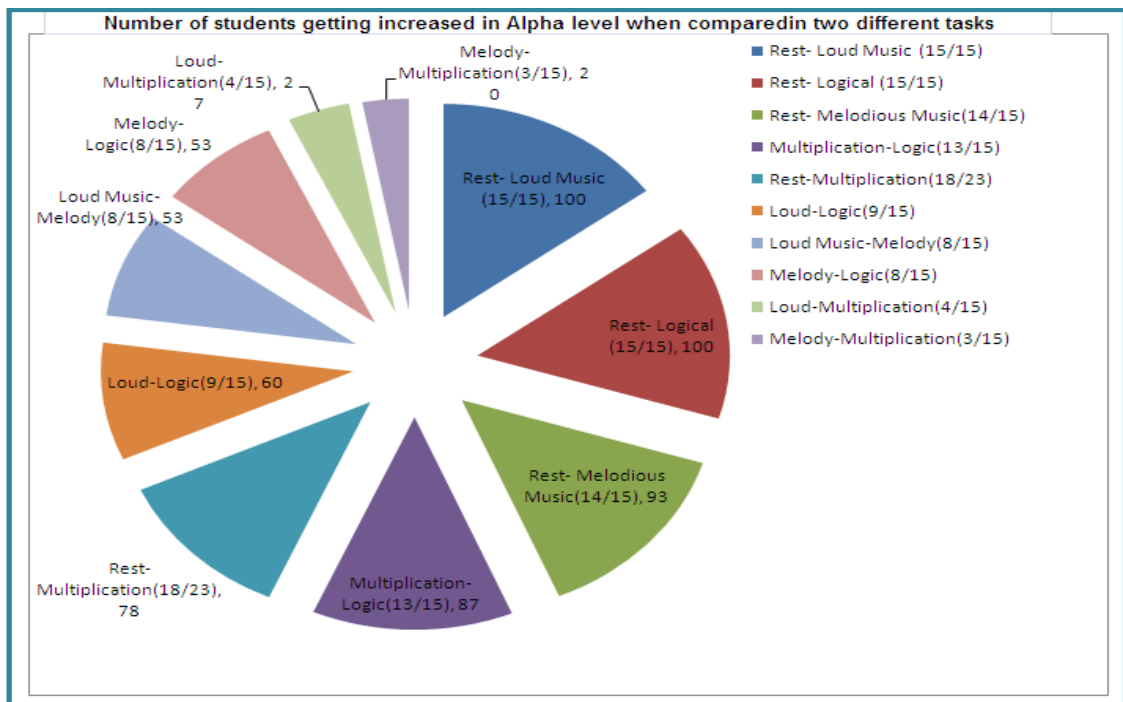

Figure-9: Pie Chart 6.2 Measuring increase in alpha measure between two different tasks
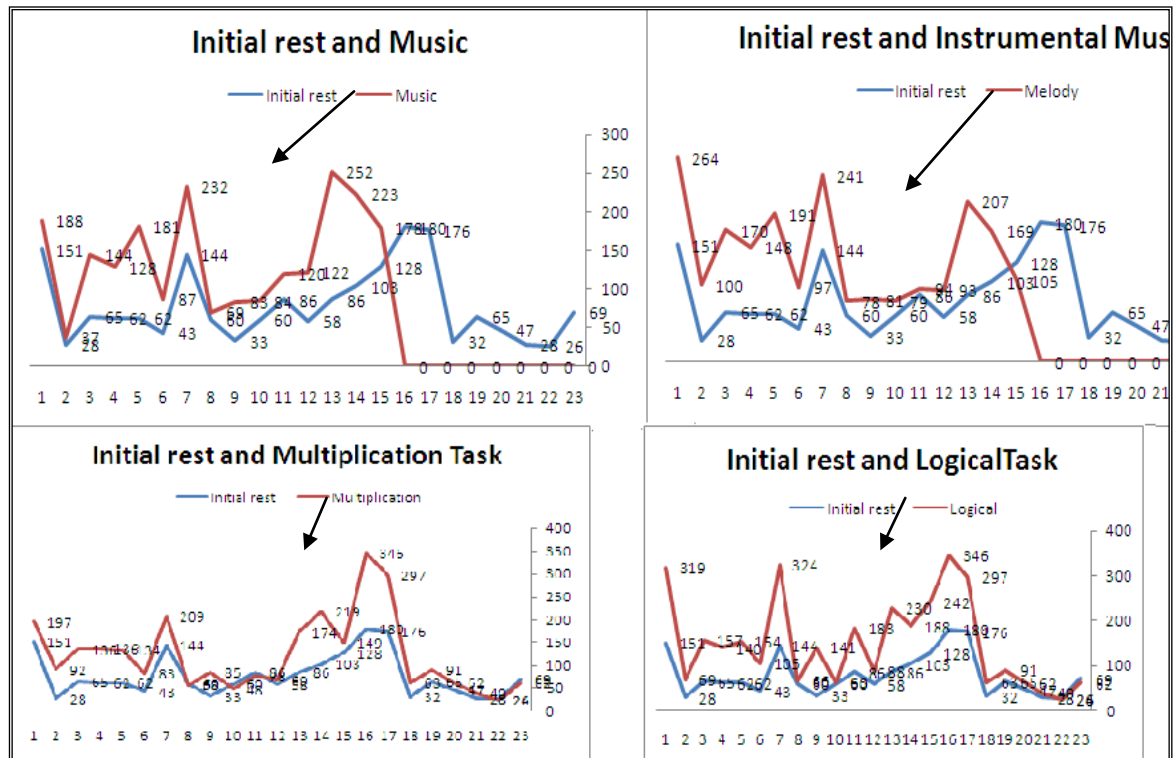
Figure-10: gives the comparative alpha measure during two different tasks:

6. RESULT

From the EEG analysis of the students, it is inferred that music and logical (in blood relation) questions play a significant role in increasing alpha frequency in students' minds state.

7. EXTRACTION OF DECISION RULES USING ROUGH SET THEORY

Extraction of decision rules using rough set theory through the data mining software ROSETTA data mining software.

Instances	Conditional Attribute 10th(SSLC Mark)	Conditional Attribute 12 th (HSC Mark)	Conditional Attribute I year Mark in college	Conditional Attribute Class Teacher's opinion about students academic level	Conditional Attribute Behaviour in the class(Given by the class Teachers)	Decision Variable Alpha Level based on students EEG recording
1	D	D	D	VP	ATS	33
2	S	A	A	E	LT	65
3	S	S	S	E	LT	151
4	B	B	B	G	T	103
5	D	B	A	G	ATS	28
6	C	C	F	M	VT	60
7	A	A	B	E	NT	160
8	D	D	F	P	T	58
9	C	C	F	VP	VT	128
10	C	C	F	M	VT	64
11	B	B	B	M	ATS	43
12	B	B	A	G	T	86
13	B	B	B	M	ATS	28
14	B	C	B	M	T	47
15	D	B	A	G	ATS	32

16	A	S	A	E	VCD	180
17	A	S	A	E	T	26
18	A	A	A	G	VCD	176
19	A	A	B	E	T	69
20	B	B	D	M	T	65
21	A	A	E	E	VCD	62
22	A	B	B	G	T	60
23	A	A	E	E	T	144
24	A	A	B	E	T	86
25	A	A	B	VG	T	62

Table-5: Information Table

Rules extracted from Johnson's and SAV Genetic Reducer algorithm using Rosetta data mining software are given in table 6.11 and rules extracted from Manual Reducer Algorithm are given in table 6.12

Table-6: Rules extracted from Johnson's and SAV Genetic Reducer algorithm

Decision rules from SAV, Johnson, RSES Exhaustive algorithm, RSES Johnson reducer, RSES Genetic reducer
10(A) AND ISem(A) AND Academic(E) AND BC(T) => Alpha(26)
10(D) AND ISem(A) AND Academic(G) AND BC(ATS) => Alpha(28) OR Alpha(32)
10(D) AND ISem(D) AND Academic(VP) AND BC(ATS) => Alpha(33)
10(B) AND ISem(B) AND Academic(M) AND BC(ATS) => Alpha(43) OR Alpha(28)
10(B) AND ISem(B) AND Academic(M) AND BC(T) => Alpha(47)
10(D) AND ISem(F) AND Academic(P) AND BC(T) => Alpha(58)
10(A) AND ISem(B) AND Academic(G) AND BC(T) => Alpha(60)
10(C) AND ISem(F) AND Academic(M) AND BC(VT) => Alpha(60) OR Alpha(64)
10(A) AND ISem(B) AND Academic(VG) AND BC(T) => Alpha(62)
10(A) AND ISem(E) AND Academic(E) AND BC(VCD) => Alpha(62)
10(B) AND ISem(D) AND Academic(M) AND BC(T) => Alpha(65)
10(S) AND ISem(A) AND Academic(E) AND BC(LT) => Alpha(65)
10(A) AND ISem(B) AND Academic(E) AND BC(T) => Alpha(69) OR Alpha(86)
10(B) AND ISem(A) AND Academic(G) AND BC(T) => Alpha(86)
10(B) AND ISem(B) AND Academic(G) AND BC(T) => Alpha(103)
10(C) AND ISem(F) AND Academic(VP) AND BC(VT) => Alpha(128)
10(A) AND ISem(E) AND Academic(E) AND BC(T) => Alpha(144)
10(S) AND ISem(S) AND Academic(E) AND BC(LT) => Alpha(151)
10(A) AND ISem(B) AND Academic(E) AND BC(NT) => Alpha(160)
10(A) AND ISem(A) AND Academic(G) AND BC(VCD) => Alpha(176)
10(A) AND ISem(A) AND Academic(E) AND BC(VCD) => Alpha(180)
Manual Reducer Algorithm
10(A) AND HSC(S) AND ISem(A) AND Academic(E) AND BC(T) AND Alpha(26) => Alpha(26)
10(B) AND HSC(B) AND ISem(B) AND Academic(M) AND BC(ATS) AND Alpha(28) => Alpha(28)
10(D) AND HSC(B) AND ISem(A) AND Academic(G) AND BC(ATS) AND Alpha(28) => Alpha(28)
10(D) AND HSC(B) AND ISem(A) AND Academic(G) AND BC(ATS) AND Alpha(32) => Alpha(32)
10(D) AND HSC(D) AND ISem(D) AND Academic(VP) AND BC(ATS) AND Alpha(33) => Alpha(33)
10(B) AND HSC(B) AND ISem(B) AND Academic(M) AND BC(ATS) AND Alpha(43) => Alpha(43)
10(B) AND HSC(C) AND ISem(B) AND Academic(M) AND BC(T) AND Alpha(47) => Alpha(47)

10(D) AND HSC(D) AND ISem(F) AND Academic(P) AND BC(T) AND Alpha(58) => Alpha(58)
10(C) AND HSC(C) AND ISem(F) AND Academic(M) AND BC(VT) AND Alpha(60) => Alpha(60)
10(A) AND HSC(B) AND ISem(B) AND Academic(G) AND BC(T) AND Alpha(60) => Alpha(60)
10(A) AND HSC(A) AND ISem(B) AND Academic(VG) AND BC(T) AND Alpha(62) => Alpha(62)
10(A) AND HSC(A) AND ISem(E) AND Academic(E) AND BC(VCD) AND Alpha(62) => Alpha(62)
10(C) AND HSC(C) AND ISem(F) AND Academic(M) AND BC(VT) AND Alpha(64) => Alpha(64)
10(B) AND HSC(B) AND ISem(D) AND Academic(M) AND BC(T) AND Alpha(65) => Alpha(65)
10(S) AND HSC(A) AND ISem(A) AND Academic(E) AND BC(LT) AND Alpha(65) => Alpha(65)
10(A) AND HSC(A) AND ISem(B) AND Academic(E) AND BC(T) AND Alpha(69) => Alpha(69)
10(B) AND HSC(B) AND ISem(A) AND Academic(G) AND BC(T) AND Alpha(86) => Alpha(86)
10(A) AND HSC(A) AND ISem(B) AND Academic(E) AND BC(T) AND Alpha(86) => Alpha(86)
10(B) AND HSC(B) AND ISem(B) AND Academic(G) AND BC(T) AND Alpha(103) => Alpha(103)
10(C) AND HSC(C) AND ISem(F) AND Academic(VP) AND BC(VT) AND Alpha(128) => Alpha(128)
10(A) AND HSC(A) AND ISem(E) AND Academic(E) AND BC(T) AND Alpha(144) => Alpha(144)
10(S) AND HSC(S) AND ISem(S) AND Academic(E) AND BC(LT) AND Alpha(151) => Alpha(151)
10(A) AND HSC(A) AND ISem(B) AND Academic(E) AND BC(NT) AND Alpha(160) => Alpha(160)
10(A) AND HSC(A) AND ISem(A) AND Academic(G) AND BC(VCD) AND Alpha(176) => Alpha(176)
10(A) AND HSC(S) AND ISem(A) AND Academic(E) AND BC(VCD) AND Alpha(180) => Alpha(180)

Table-6: Manual Reducer Algorithm

8. RESULT

From the decision rules extracted from the above algorithms it is inferred that if we particularly notice the rules, the conditional variable ATS (the students always thinking about something in the class) is assigned with the decision variable with minimum alpha value 13 rules out of 14 rules.

9. SUMMARY

Since the intelligence of brain cells is dependent upon mental exercise, students are suggested to enhance their relaxed, focused and receptive alpha mind state by defocusing one's attention through external and/or internal sources. Such students will be able to absorb new information easily and become more successful persons. Also it is observed from this study that performance of any task with the accompaniment of loud music and television reduces the score. Today, television and music plays an increasingly prominent role in student's lives. Most of the students have the practice of studying with background music or television. Youngsters who have this practice can to increase their working efficiency by avoiding these distractions.

ACKNOWLEDGMENT

REFERENCES

1. http://members.arstechnica.com/x/albino_eatpod/specific-eeg-states.gif.s
2. http://ezinearticles.com/?Right-Brain,-Left-Brain&id=43531
3. You-Shyang Chen, Ching-Hsue Cheng. "Evaluating industry performance using extracted RGR rules based on feature selection and rough sets classifier", Journal of Expert systems with
4. http://www.bem.fi/book/13/13.htm

Source of support: Nil, Conflict of interest: None Declared.