Part- 1

SIGNIFICENCE OF SMRTI ACCORDING TO PATAÑJALI YOGA SUTRA AND ITS CORELATON WITH BRAIN WAVE COHERENCE

Part- II

EFFECT OF INTEGRATED YOGA MODULE ON BRAIN WAVE COHERENCE IN NORMAL HEALTHY VOLUNTEERS

Dissertation Submitted by

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Under the guidance of

H R NAGENDRA

TIKHE SHAM GANPAT

Towards the partial fulfillment of

Master of Science in Yoga and Education

[M.Sc. (Yoga and Education)]

To

Swami Vivekananda Yoga Anusandhana Samathana (SVYASA)

(Deemed to be University, Recognized by UGC)

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Bangalore – 560019, India

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Date:

Praśānti Kuṭiram

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V SELVI

CERTIFICATE

This is to certify that Miss V Selvi has submitted this Scriptural Research on Significence of Smrti According to Patanjali Yoga Sutra and its Corelation and With Brain Wave Coherence Effect of Integrated Yoga Module on Brain Wave Coherence in Normal Healthy Volunteers. Following integrated yogic therapy in partial fulfillment of the requirements for Master of Science (Yoga) – Jan 2010 th batch. She is doing this course at Svāmī-Vivekānanda-Yoga-Anusandhān-Saṁsthāna (SVYASA) under the Division of Life Science. This is a record of his work he did in this University.

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Declaration

I undersigned V Selvi declare that I have done the work this presents. The literary research and the experimental research is under the guidance of Dr. H R Nagendra and co-guide Tikhe Sham Ganpat**, I** further declare that this work entitled:

PART- I: Literary Research

SIGNIFICENCE OF SMRTI ACCORDING TO PATAÑJALI YOGA SUTRA AND ITS CORELATON WITH BRAIN WAVE COHERENCE

PART- II: Experimental Research titled

EFFECT OF INTEGRATED YOGA MODULE ON BRAIN WAVE COHERENCE IN NORMAL HEALTHY VOLUNTEERS

have not previously formed the basis of any degree, diploma, membership or similar titles.

Palace: Praśānti Kuṭiram

Date:

V SELVI

Standard International Transliteration Code Used to Transliterate Saṁskṛta Words.

a	=	अ	ṅa	=	ङ	pa	=	प
ā	=	आ	ca	=	च	pha	=	फ
i	=	इ	cha	=	छ	ba	=	ब
ī	=	ई	ja	=	ज	bha	=	भ
u	=	उ	jha	=	झ	ma	=	म
ū	=	ऊ	ña	=	ञ	ya	=	य
e	=	ए	ṭa	=	ट	ra	=	र
ai	=	ऐ	ṭha	=	ठ	la	=	ल
o	=	आ	ḍa	=	ड	va	=	व
au	=	औ	ḍha	=	ढ	sa	=	स
m	=	अं	ṇa	=	ण	śa	=	श
ḥ	=	अः	ta	=	त	ṣa	=	ष
ka	=	क	tha	=	थ	ha	=	ह
ka	=	क	tha	=	थ	ha	=	ह
ga	=	ग	dha	=	ध	tra	=	त्र
gha	=	घ	na	=	न	jña	=	ज्ञ

ABSTRACT

Authority or the testimony of the reliable person and scriptures forms the bases of philosophy.

The ability to remember and forget is one of the most complexes and fascinating functions of the brain. It is well known that स्मृति (SMṚTI) or memory lapses are extremely selective; we remember some things and forget others. As regards the means of memory there is great divergence among the different systems of philosophy.

Patañjali says the process by which thoughts which have been experience are retrieved is memory. स्मृति acts as an obstacle in the path of achieving peace of mind says Patañjali.

CONTENTS

PART 2

INTRODUCTION

The term philosophy literally means "Love of wisdom "or "pursuit of knowledge". [1] Indian philosophy is divided into two broad classes. The heterodox or Nastika system namely, Charvaka, Buddhism and Jainism they are called heterodox not because they are atheists, but because they reject the authority of Vedas. The orthodox or Astika system, which believe in the authority of the Vedas, namely the Nyaya of Gautama, the Vaisheshika or Kanada, the Samkhya of Kapila the yoga of Patanjali, the Purva- Mimamsa of Jaimini and the Uttara-Mimama or Vedanta of Badarayana. Every system of philosophy is based on theory of knowledge. The question of the validity and means of knowledge forms an important chapter of each system. Memory, which comes under the knowledge, plays a vital role.

We are in the era of science and technology, and the era of researches, developing ourselves predominantly at the intellectual level. Through this developing of the intellect characterized predominantly by an increased power of analysis, logic and discrimination, no doubt we have been able to unravel the mysteries of this physical universe in its greatest depth. In this regard the left brain development is wonderful and amazing, but right brain is also very important for the overall development of a human being. [2] Memory is vital to both these two lobes.

Everyone is convinced that memory plays a vital role in achieving success in life, both in the conventional sense as well as for personal growth and spiritual development. But what is memory? Memory is "the process by which people encode, store and retrieve information". The ability to remember and forget is one of the most complex and fascinating functions of the brain. How anxiety influences memory? Sigmund Freud claimed that we forget anything which causes us pain or anxiety. It is also often stated that anxiety makes us forget things. For example it is like anxiety during the examinations to students and memory loss.

By definition, memory is always the present recollection of some past cognition.

अनुभूतविषय असम्प्रमोषः स्मृतिः ॥ पातञ्जल योग सुत्र समाधिपादः १-११

Anubhūtaviṣaya asampramoṣaḥ smṛtiḥ. Samādhipādaḥ Chapter 1-11

Consequently knowledge by memory is not presentative but representative and is accordingly classified by Nyaya, as invalid knowledge. Nevertheless, memory can serve as a source of valid knowledge, if it can be shown that what is recalled or remembered was experienced in the past as a presentative cognition. According to Charaka a memory is nothing but remembrance of things directly perceived, heard (from scriptures) or experience earlier. Good memory increases the efficiency of an individual. It is divided in to 2 types) true memory, ii) false memory. [3]

Memory is the base of imaginations and thoughts. Man is thought to be intellectual due to the power of remembrance as the old experiences remain with him as impressions. Lack of memory leads to the loss of knowledge (Buddhi) and it may destroy the individual. [4]

Memory (Smrti) is one of the four and very important facets of the brain. The other three are: Manas (mind), Buddhi (intellect) and Ahankara (ego).

Manas is often called mind.

संकल्प विकल्पात्मकः मन ।

Saṅkalpa vikalpātmakaḥ manaḥ।

(A changing mind oscillating from one state to another)

This is the most gross state of mind when this randomness gets channelised the energies start getting useful. Buddhi, the intellect sorts out the information in the form of thoughts, analyses them and puts them into different bins. This power of Buddhi the intellect called discrimination is the one that is special about all human beings. [5]

आहार निद्रा भय मैथुनञ्च सामन्यमेतत् पशुभिर्नराणां ।

बुध्दिर्हितेषाम् अधिको विशेषः बुध्दिर्विहिनः पशुभिः समानः ॥

Āhāra nidrā bhaya maithunañca sāmanyametat paśubhirnarāṇāṁ।

Budhdirhiteṣām adhiko viśeṣaḥ budhdirvihinaḥ paśubhiḥ samānaḥ।।

“Hunger, sleep, fear, procreative instinct are common to man and animals. It is Buddhi (discriminating faculty) that is special for man. A person who does not have this Buddhi is equal to an animal” [6]

From Buddhi emerges memory. The third facet of mind is Smrti or memory. The storehouse of information is sorted but by the intellect –the Buddhi-and whatever is decided to be stored is passed on to memory. Not all information needs to be stored –only those important thoughts, which the Buddhi decides, will find entry into memory. They will be ready to be unearthed anytime we need to retrieval of information list of memory. The memory is defined as:

अनुभूतविषय असम्प्रमोषः स्मृतिः ॥ पातञ्जल योग सुत्र समाधिपादः १-११

अनुबहह्मतावश्धिाया ासामपरामखश्धाह् समभ्नतह्हि ॥ सामब्रदहपिब्रदाह् च्हापतेर १-११

“When the thoughts which have been experienced are retrieved is called memory”. [5]

At the background of all these states of mind is the Aham. The ‘I’ often called Ego. Whatever activates we do there is the ‘I’ thought. ‘I’ am seeing, ‘I’ am doing and so on. This is the subtlest accepts to mind.

All these facets of mind come under the broad heading of Antaùkaraëa.

The classification of mind by Patanjali is as follows:

1. Pramā□a -State of right knowledge. (Like seeing actual water in a lake)

2. Viparyaya-State of wrong knowledge. (Like a mirage or hallucination)

3. Vikalpa- Random State

4. Nidrā- Deep sleep

5. Smṛti-Memory

CHAPTER-2

AIM AND OBJECTIVES

AIM

To compile and understand the concept of Smṛti (memory) according to Patañjali

OBJECTIVES

To identify the factors which can influence the process of memory?

To explore the Yoga methods for developing the memory

CHAPTER 3

CONCEPT OF MEMORY

Everyone is convinced that memory plays a vital role achieving success in life, both in the conventional sense as well as for personal growth and spiritual development.

The concept of memory is also essentially limited to brain and its functions. Even with this limited perspective, we have seen the fascinating dimensions of memory of Antahkaranas (Inner tools of perception) and memory as part of this inner word of amazing subtlety. [7]

Memory is the base of imaginations and thoughts Man is thought to be intellectual due to be the power of remembrance as the old experience remain with him as impressions. Lack of memory leads to the loss of knowledge (Buddhi) which may destroy the individual [4]

Memory (Smrti), is one of the four and very important facets of the brain. The other three are Manas (mind), Buddhi (intellect) and Ahaìkära (ego).

Manas is often called mind.

संकल्प विकल्पात्मकः मनः।

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This is the most gross state of mind when this randomness gets channelised the energies start getting useful. Buddhi, the intellect sorts out the information in the form of thoughts, analyses them and puts them into different bins. This power of Buddhi the intellect called discrimination is the one that is special about all human beings.

3.1 Source material

Different commentaries on Pataïjali yoga sutras

3.2 Etymology of the word memory

“The manas, the intellect, the ego and the Citta (memory) constitute internal instrument (mind). Doubt, certitude, egoism and memory these are their objects.

In Sanskrita,

स्मृति Smṛti means स्मरण Smaraṇa and

mexa Medhā constitute memory.

Medhä is Buddhi.

Smaraṇa is process of remembering.

The Saàskåta which arises because of the special conjunction between Ätma (soul) and the manas mind is termed as Smrti. [8] ,[9]

3.3 Concept of Småti (memory) Småti according to Pataïjali Yoga Sutras

According to Pataïjali yoga sutras, memory (Småti) is one of the four and very important facets of the brain. The other three are: Manas (mind), Buddhi (Intellect) and Ahankara (ego).

Manas is often called mind.

पातञ्जल योग सुत्र समाधिपादः १-६

प्रामā□ा वपिारयाया वकिालपा नदिरā सम□ताया□ ॥

सामब्रदहपिब्रदाह् च्हापतेर १-११

1. Pramā□a-State of right knowledge. (Like seeing actual water in a Lake)Memory is defined as the retention of the past experience in the mind. But it is to be noted that these experiences are retained in the mind. As mere impressions it is not considered as a citta- vått̊i. It is only when the potential experiences are converted into their active state in the form of mental images that they can properly be considered as citta vått̊i. Hence, Småti comprises all those

images which are modifications of the mind, which are produced without any kind of direct contact with the outer world.

2. Viparyaya-State of right knowledge.

   (Like a mirage or hallucination), which is false and not based upon the true nature of its objects

3. Vikalpa –Random state –Verbal delusion arises when words do not correspond to reality.

4. Nidrā -Deep-Sleep is a wave of thought about nothingness.

5. Småti -Memory-Memory is when perceived objects are not forgotten. But come back to consciousness.

अनुभूतविषय असम्प्रमोषः स्मृतिः ॥

पातञ्जल योग सुत्र समाधिपादः १-११

Anubhūtaviṣaya asampramoṣaḥ smṛtiḥ.

Samādhipādaḥ Chapter 1-11

When the thoughts which have been experienced are retrieved is known as memory. [5]

At the background of all these states of mind is the Aham. The 'I' often called Ego. Whatever activates we do there is the 'I' thought. 'I' am seeing, 'I' am doing and so on. This is the subtlest accepts to mind.

"The process by which thoughts which have been experienced are retrieved is called memory".

Anubhūta - memory is the absence of the experienced objects .The mental process in recalling a past experience is a peculiar one. That is the reason why memory has been classified as a type of citta- vått̊i. At the background of all these states of mind is the Aham. The 'I' often called Ego. Whatever activates we do there is the 'I' thought.' I' seeing, 'I' am doing

and so on. This is the subtlest accepts to mind. All these facets of mind come under the broad heading

अन्तःकरण अनताह्कारान्ना ॥

संकल्प विकल्पात्मकः मनः।

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This is the most gross state of mind when this randomness gets channelised the energies start getting useful. Buddhi, the intellect sorts out the information in the form of thoughts, analyses them and puts them into different bins. This power of Buddhi the intellect called discrimination is the one that is special about all human beings.

The third facet of mind is Småti or memory which arises from Buddhi. The storehouse of information is sorted but by the intellect, the Buddhi and whatever is decided to be stored is passed on to memory. Not all information needs to be stored –only those important thoughts, which the Buddhi decides, will find entry into memory. They will be ready to be unearthed anytime we need. Retrieval of information is list of memory.

The classification of mind (the five kinds of thought waves) by patanjali is as follows:

3.4 Concept of Smṛti (memory) Smṛti according to modern medical science

1. RETENTION-impression of past expression is retained in the mind. The retention capacity in different persons; may differ in individuals and depends upon recovery, frequency, interest and association.

2. RECALL-the impressions of the mind are recalled or recollected by the recognitions of particular person and the memory is established.

Memory (Smṛti), is one of the four and very important facets of the brain. The other three being manas (mind), Buddhi (Intellect), Ahankara (ego) Manas is often called mind. Manas is often called mind.

संकल्प विकल्पात्मकः मनः।

Saṅkalpa vikalpātmakaḥ manaḥ|

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CHAPTER 4

INFLUENCE OF KLEṢA ON MEMORY (SMṚTI)

Patañjali has classified Småti as one of the Citta Vṛttis binding factors which causes trauma of the mind. They are also the causative factors for the generation of Kleṣas (afflictions)". The lack of awareness of reality (Avidyā), the sense of "I" (Asmitā) attractions (Rāga), Repulsions (Dveṣa) and strong desire for life (Abhiniveṣa) are the great afflictions or causes of all miseries in life. [7]

CHAPTER 5

DIFFERENT DIMENSIONS OF MEMORY

Logical Memory

Measures of forgetting (i.e., Savings scores) based upon the Logical Memory and Visual Reproduction tests of the Wechsler Memory Scale. [10] Logical Memory and Visual Reproduction subtests of the Wechsler Memory Scale are verbal and nonverbal memory tasks. [11]

Associative Memory

Associative Memory is a working memory. When associative memory capacity is exceeded, long-term memory compensates. [12] Age-related declines in associative memory are proposed to result from deficits in older adults' ability to recollect the past. [13]

Verbal Memory

A number of the neuro-anatomical components of a distributed system for signal processing and storage relevant to auditory—verbal memory function. [14] Verbal memory is mediated mainly by the left temporal lobe. [15] Improvement in verbal memory is associated with memory processing in accordance with possible neuro-anatomical modifications in the left temporal lobe. [16]

Visual Memory

Visual memory is mediated mainly by the right temporal lobe. [15]

CHAPTER 6

MEMORY AND SPIRITUAL EVOLUTION

Patañjali Yoga Sutra

योगश्चित्तवृत्तिनिरोधः। पातञ्जल योग सुत्र १-२

Yogaścittavṛttinirodhaḥ। Pātañjala Yoga Sutra 1-2

"Yoga is the control of thought-waves in the mind."

श्रध्दावीर्यस्मृतिसमाधिप्रज्ञापूर्वक इतरेषाम्।पातञ्जल योग सुत्र १-२०

Śradhdāvīryasmṛtisamādhiprajñāpūrvaka itareṣāmpātañjala yoga sutra 1-20

"The concentration of the true spiritual aspirant is attained through faith, energy, recollectedness, absorption and illumination".

समाधिभावनार्थः क्लेशतनुकरणार्थश्च। पातञ्जल योग सुत्र २- २

Samādhibhāvanārthaḥ kleśatanukaraṇārthaśca। Pātañjala Yoga Sutra 2- 2

"We may cultivate the power of concentration and remove the obstacles to enlightenment which cause all our sufferings"

CHAPTER 7

TECHNIQUES TO IMPROVE MEMORY

Taking into consideration the 5 layers of our existence (Pañcakoṣa)

Annamaya Koṣa-Techniques of yoga

Relaxation techniques-Yoga Nidra, Dharana, etc., enhance memory

Meditation- Om Meditation, Transcendental Meditation, Cyclic meditation

Prāṇayāma Koṣa–Kapalabhati, Suryanuloma viloma, Nadi suddhi pranayama

Manomaya Koṣa (Emotional level)-repetition of thoughts, memorization, Emotions can influence strong memories – Bhakti yoga- kama-preme- tyaga-bhakti.

Vijñānamaya Koṣa –analysis, discrimination and understanding, sravana Manana,

Nidhidhyāsana निधिध्यासन - Jñāna yoga ज्ञान योग

Ānandamaya Koṣa – deepest of the memories –total memory of the entire creation. Retain that wisdom; maintain a continuous stream of awareness at all points of time and to be tune with creation.Memory of Atma is most elevating. [8]

To live in tune with this knowledge base, to have the recall of this state is the real memory development.

ऋतम्भरा तत्र प्रज्ञा

Ṛtambharā tatra prajñā

"In that Samādhi, knowledge is said to be "filled with truth."

The awareness blossoms and a total awareness emerge at that stage

Patañjali says while explaining the layers of Samādhi, seeds and attachment may still remain within the mind, even though perfect concentration has been achieved.

And these seeds of desire are dangerous, as we saw in considering the fate of those, who concentrate without non-attachment.

When Pātañjali talks about Saṁyama (Concentration धारणा Dhāraṇā+ Meditation ध्यान Dhyāna+ Absorption समाधि Samādhi), one can unravel the knowledge hidden deep within the subtler layers of the memory.

Summary Table of Scientific Literature on Memory

Sr. No.	Author, Year of work	Topic	Findings
1	Bharat Kumar Patra, 2004	A Comparative study of Three Different Yoga Modules on Logical Memory in School Children	All the yoga modules i.e. Intelligence Quotient group (IQG), Creativity group (CVG) and Physical stamina group (PSG) showed ↑ Logical Memory (IQG=32.69%, CVG=30.17%, PSG=14.60%) No gender effect (no significant difference on memory between males and females)
2	Biswaji Majumder, 2004	A Comparative Study of Three Different yoga Modules on Associative memory of School Children.	All the yoga modules i.e. Intelligence Quotient group (IQG), Creativity group (CVG) and Physical stamina group (PSG) showed ↑ Associative Memory (CVG – 12.2%, IQG-11.4%, PSG- 11.3%) No gender effect (no significant difference on memory between males and females)
3	Karuna Muthy, 2004	Efficacy of Three Different Yoga Modules on Verbal Memory in	↑ Verbal Memory No gender effect (no significant difference on

		School Children (9-12 years).	memory between males and females)
4	Shatrughan Singh Naruka, 2004	Efficacy of Three Different Yoga Modules in Visual Memory on School Children.	↑ Visual Memory All 3 groups showed significant increase in visual memory ($p<0.001$, paired sample test) but physical stamina showed a higher increase (33.7% change) than other two groups. The balancing effects of yoga modules could have been responsible for increase the visual memory in all the three groups increase)
5	Pushpavathi, 2004	Efficacy of Three Different Yoga Modules in Verbal Memory on School Children	↑ Verbal Memory↑PS showed a higher increase CV(8.84% PS(17.59%).(IQM=9.05%, physical stamina group showed better performance compared to other two groups.
6	Shruddha S Kamat, 2004	Effect of Yoga on the Visual Memory in School Children	↑ Visual Memory IQ IQ showed a higher increase (27.73% increase) than other two groups: creativity and Physical stamina The total males between groups showed significant difference. (p=0.000) The

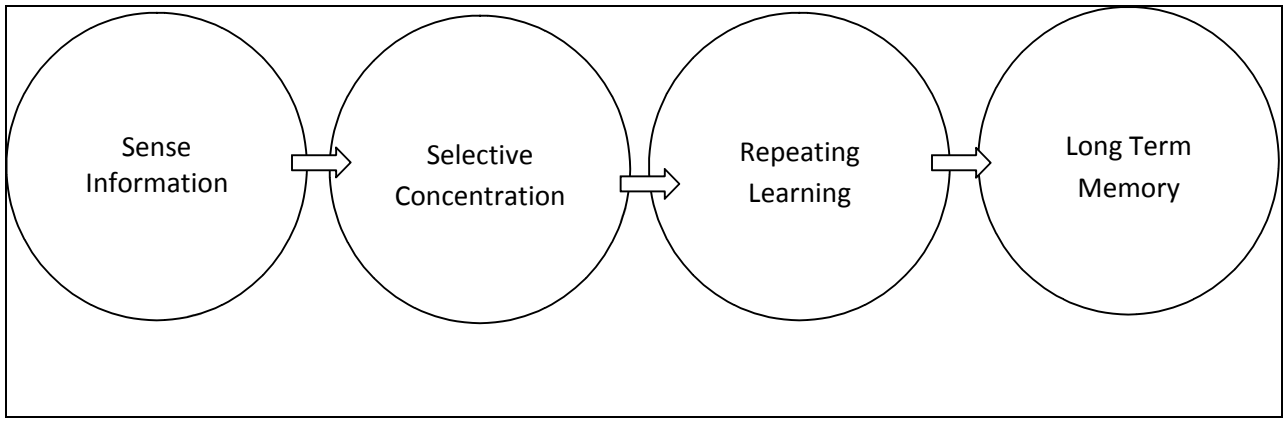
			total females did not show significant difference between groups. (p=0.067).
7	Sripad h Ghaligi, 2005	Effect of Vedic Chanting on Memory and Sustained Attention	↑ Sustained attention (assessed through letter and character cancellation task), ↑ Memory ↑ Calming down the mind Chanting group showed significant increased scorings in both the memory tests (VMS, p=0.001; SMS, p=0.002).
8	Ketki Gokhale Abhay, 2006	Effect of Yogic Relaxation Techniques on Memory and Sustained Attention in CABG Patients.	↑ Memory (assessed though verbal and spatial memory test) Yoga group Yoga group showed highly significant recovery of 75% in verbal memory from 8th to 45th day compared to control group.↑ Sustained Attention (assessed through six-letter cancellation test)
9	Sangeeta, 2006	Immediate effect of Kapalabhati on HRV and Memory in Normal Subjects	Kapālabhāti→ ↑ verbal and spatial memory significant change between both the sessions (p > 0.05). Verbal Memory (VM) score and Spatail Memory (SM) scores increased significantly

			($p < 0.05$
10	Naorem Arjun Singh, 2009	Influence of Bhastrikä Präëäyäma practice among young adults on their immediate memory	Bhastrikä → ↑ Immediate Memory Bhastrikä pränäyäma group shows more significant difference than the non Bhastrikä practice group.

CHAPTER 8

BRAIN WAVE COHERENCE AND MEMORY

Brain waves and memory process



Source: http://www.mind-shop.de/downloads/MC2/Brainwaves_and_memoryprocess.pdf

What are brain waves?

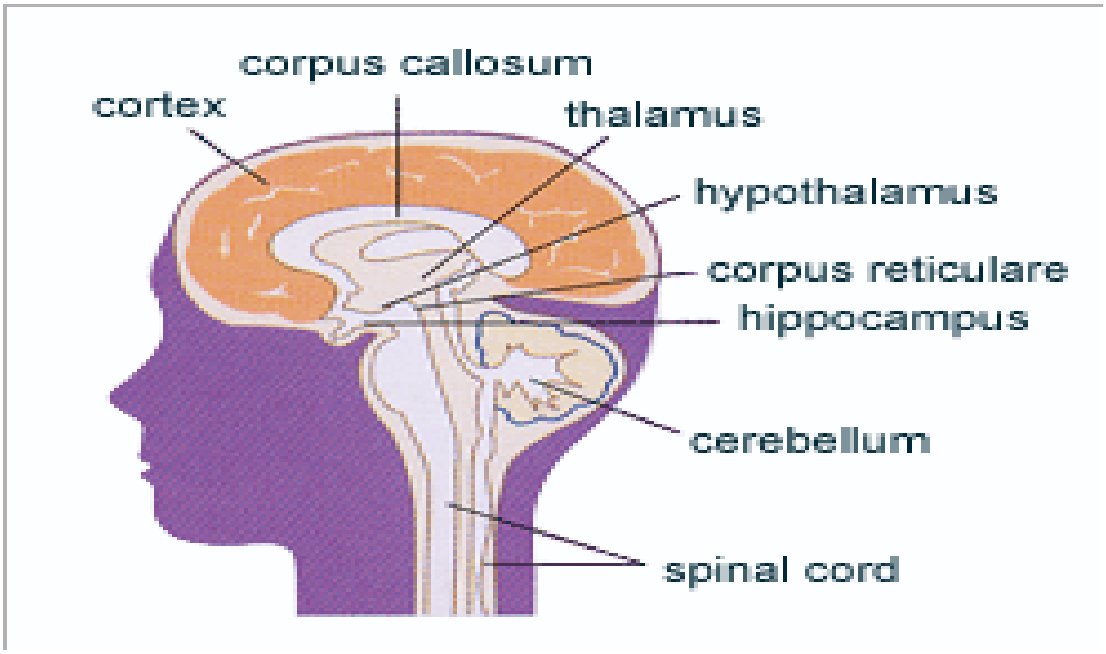
The brain waves are signals that occur on the brain surface. These waves occur as a result of an ion penetrating through the cell membrane of an excited neuron. To observe the brain waves, the volatge of EEG (electroencephalo-graphy) has to be amplified to its millionth power with an electrode placed on the brain surface. In this case, the brain states can be understood indirectly by measuring the variations in the brain waves.

Brain waves	Frequency	Brain activity conditions
Beta	13~30 Hz	All conscious states including the states of acting and speaking
Alpha	8~12 Hz	Relaxed, meditative, and closed-eyed states
Theta	4~7 Hz	Creative, studious, and relaxed states.

Delta	1~3 Hz	Deep sleep state

Source: http://www.mind-shop.de/downloads/MC2/Brainwaves_and_memoryprocess.pdf

Brain Waves and Memory Process



Source: http://www.mind-shop.de/downloads/MC2/Brainwaves_and_memoryprocess.pdf

As brain is processing semantic memory operation, memorizing and grasping simple meaning of a word, the effect of alpha occurs and episodic memory referring to one's own experience processes and alpha decreases and theta of hippocampus increases. When hippocampus translates new information and combines this with prior information, genuine theta is released. Also through activation of nerve joint hippocampus induces long term memory process or strengthens it. If hippocampus is removed, past information can be remembered but not the story a person just talked about. [21][22]

CHAPTER 9

SUMMARY AND CONCLUSION

When ones memory is in good condition, it means activities are well organized its usefulness is confirmed, this is how the whole mechanism of one's success takes place.

We are in the era of science and technology, and the era of researches, developing ourselves predominantly at the intellectual level. Through this development of the intellect characterized predominantly by an increased power of analysis, logic and discrimination, no doubt we have been able to unravel the mysteries of this physical universe in its greatest depth. In this regard the left brain development is wonderful and amazing. Like how right brain is also very important for the overall development of human being utilizing our left brain is absolutely necessary.

Everyone is convinced that memory plays a vital role achieving success in life, both in the conventional sense as well as for personal growth and spiritual development.

As regards the subject Memory there is great divergence among the different systems of philosophy. According to Caraka a memory is nothing but remembrance of things directly perceived, head (from scriptures) or experienced earlier.

The third facet of mind is Smrti or memory. The storehouse of information is sorted but by the intellect- the Buddhi –and whatever is decided to be stored is passed on to memory. Not all information needs to be stored- only those important thoughts, which the Buddhi decides, will find entry into memory. They will be ready to be unearthed anytime we need. Retrieval of information is list of memory. The memory is defined as: The process by which thoughts which have been experienced are retrieved is called memory".

One can improve memory power in different levels by following Pātañjala Aṣṭāṅga Yoga.

In the spiritual evolution of an individual memory plays a vital role. Pātañjali says Yoga is the control of thought –waves in the mind. Hatha Yoga Pradipikā says one whose mind is neither asleep nor awake, (whose mind), is devoid of memory and forgetfulness, neither oblivious nor active, and is indeed liberated.

Memory thus becomes closely linked up with epistemology, the study of knowledge, both are necessary to each other. Two are inseparable to the path of perfection.

PART 2

EFFECT OF INTEGRATED YOGA MODULES ON BRAIN WAVE COHERENCE IN NORMAL HEALTHY VOLUNTEERS

ABSTRACT

Background

With growing scientific evidence, yoga is emerging as an important health behavior-modifying practice to achieve states of health, both at physical and mental levels.

Objective

To assess mental performance through Brain Wave Coherence (BWC) analysis in students undergoing Yoga Instructor's Course (YIC).

Materials and Methods

30 YIC students with 25.77±4.85 years of mean age participated in this single group pre-post study. The BWC data was collected before (pre) and after (post) the YIC training program using BrainMaster (Model: 2E Part # 390-001), Michigan, USA.

Statistical Analysis

Means, standard deviations, Kolmogorov-Smirnov test, and Wilcoxon signed rank test were used for analyzing the data with the help of SPSS 16.

Results

A complete statistical and spectral analysis showed 43.24% increase ($P<0.001$) in Delta, 9.13% increase ($P=0.289$) in Theta, 57.85% increase ($P<0.001$) in Alpha, 17.65% decrease ($P=0.136$) in Beta and 9.19% increase ($P=0.586$) in Gamma BWC between pre and post intervention measurements.

Conclusion

BWC study showed significant increase in both Delta and Alpha wave coherence suggesting that YIC training program can result in improvement of coherent and integrated brain functioning among students, thus paving way for their better mental performance and overall heal.

Key words

Brain Wave Coherence, mental performance, yoga

CHAPTER-10

INTRODUCTION

Stress certainly seems to be an inescapable element of the modern life of a student. Stress management is required for students to decrease depression and anxiety, and to improve sensitivity toward themselves, peers, and parents. EEG coherence is a measure of correlation or synchrony of the EEG waves recorded at two points on the scalp. Mathematically, it is the absolute value of the cross-correlation function in the frequency domain of two electrical signals. [17] Coherence reflects the number and strength of connections between two brain areas. [18] Higher coherence indicates that these two parts of the brain are working more closely together. Similarly, higher coherence is associated with more integrated and effective thinking and behavior, including greater intelligence, creativity, learning ability, emotional stability, ethical and moral reasoning, self-confidence, and reduced anxiety. [19]

With growing scientific evidence, yoga is emerging as an important health behavior-modifying practice to achieve states of health, both at physical and mental levels. [20] Previous study of yoga on Brain Wave Coherence (BWC) in managers reported significant increase in Delta BWC showing efficacy of yoga for managerial effectiveness. [21] A study by Aftanas LI and Golocheikine SA [22] on Sahaja Yoga Mediation reported that subjective scores of emotionally positive "blissful" experience significantly correlated with theta, whereas scores of internalized attention with both theta and alpha lower synchronization. Previous study of EEG coherence on Zen Mediation showed an increase in slow alpha EEG coherence in the frontal region induces meditation with a predominance of internalized attention.[23] High degree of cardio respiratory synchronization during yoga was demonstrated by Cysarz and Bussing suggesting a state of restful alertness. [24]

INTERPRETATIONS OF BRAIN WAVE COHERENCE

Sr. No.	Brain Wave	Frequency Range (Hz)	Coherence Value
1	**Delta** (δ)	1-3	1) Coherence between 0.0 and 0.4 is not significant, because random signals
2	**Theta** (θ)	4-7	

3	**Alpha** (α)	8-12	can have a small amount of coherence. Coherence values above 0.5 and especially exceeding 0.6 are significant for Brain Wave Coherence training. 2) Coherence value is like a correlation coefficient that shows the degree of correlation between the signals. If they are very similar in frequency content, they will have a coherence value near 1.0, and if they are different, they will have a low coherence near 0.0. 3) For each signal, the range of coherence is 0.0 to 1.0 and for significant coherence value, the signals should be very similar in frequency content.
4	**Beta** (β)	13-39	
5	**Gamma** (γ)	40-45	

The EEG alpha activity occurred predominantly in the anterior half, and occurred silently in the posterior half of the brain during Qi Gong meditation.[25] Moreover, a study by Travis [26] revealed that Transcendental Meditation practice was marked by significantly lower breath rate, higher respiratory sinus arrhythmia amplitudes, higher EEG alpha amplitude and higher alpha coherence.

However, the neurophysiological changes that characterize the efficacy of Integrated Approach of Yoga Therapy (IAYT) for students have not been adequately studied. Hence, we have designed present study to assess the efficacy of twenty one days Yoga Instructor's Course (YIC) Program based on IAYT in university students using BWC recordings

CHAPTER 11

LITERATURE REVIEW

Significant increase in delta BWC in the present study may be associated with the higher states of consciousness. [49] Moderate increase in alpha BWC in the present study may be related with wakefulness and vigilance [50],[51],[52]and is the essential requirement for managerial effectiveness. [53],[54] This outcome may also be related to the findings from earlier studies in which percentage of alpha waves were higher in persons performing meditation with good coherence suggesting good homogeneity, uniformity, and increased orderliness of brain functioning.[55] Similarly, it was reported that Transcendental Meditation (TM) increases frontal alpha coherence, which reflects an enhancement of frontal lobe integration, as increased cognitive flexibility, intelligence, and emotional stability.[56] However, implications for increase in theta and decrease in beta BWC in the present study were uncertain but may be correlated with thought-free respiratory suspension. [57] Furthermore, it was demonstrated that increased occipital gamma power was related with enhanced sensory awareness. [58]

Ganpat and Nagendra (2011) have reported significant increase in Delta Wave Coherence and moderate increase in Alpha and Gamma Wave Coherence suggest good homogeneity, uniformity, and increased orderliness of brain functioning which reflects in enhancement of frontal lobe integration, increased cognitive flexibility, intelligence, and emotional stability. Thus, SMET intervention contributed to better emotional stability of the managers. [59]

CHAPTER -12

AIM AND OBJECTIVE

Aim

To assess Brain Wave Coherence (BWC) in students undergoing IYM

Objective

To analyze, discuss and report Delta, Theta, Alpha, Beta and Gamma BWC changes subsequent to IYM.

Hypothesis

The effect of *yoga practice* may improve better performance on BWC.

Null Hypothesis

The effect of *yoga practice* may not improve better performance on BWC.

Rationale

Earlier investigations have shown the usefulness of yoga program in reducing stress, providing deeper rest than good sleep, improved sleep structure, cognitive responses as well as brain functioning. This study is to further understand the effect of IYM as a 21days residential program for university students in developing academic excellence in university students assessed through the pre and post measurements of BWC.

The rationale for the study is that an Integrated Approach of Yoga Therapy, the basis for IYM works at all levels of human system- physical, mental, emotional, intellectual and spiritual to build a total personality development for academic excellence.

CHAPTER-13

METHODS

13.1 Subjects

Thirty YIC students with 25.77±4.85 years of mean age participated in this single group pre-post study. The BWC data was collected before (pre) and after (post) the YIC training program using BrainMaster (Model: 2E Part # 390-001), Michigan, USA.

DETAILS OF SUBJECTS

	n	Age Range	Mean± Standard Deviation
Males	16	18- 37	25.69±4.74
Females	14	19- 35	25.86±5.14
Total	30	18- 37	25.77±4.85

13.2 Inclusion criteria

- Age range 18 and 37 years and
- Both male and females

13.3 Exclusion criteria

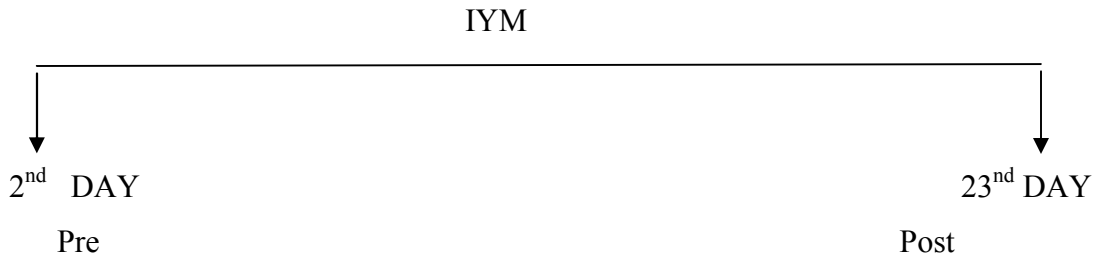
- Students with serious medical conditions
- Students taking medication
- Using any other wellness strategy
- Students using psychiatric drugs, alcohol, or tobacco in any form.
- Females during menstrual disorder

Informed Consent

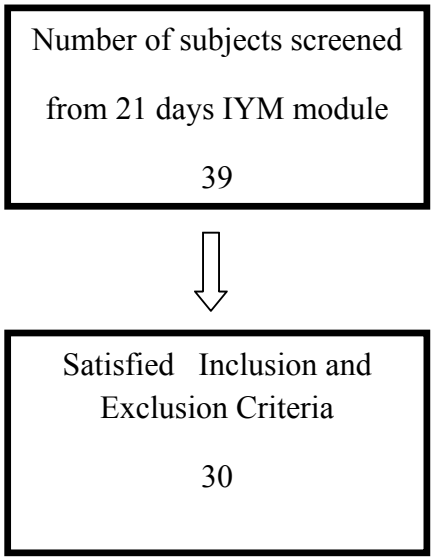
An informed consent was obtained from all the participants.

13.4 Design

A single group pre-post study



TRIAL PROFILE



13.5 Assessments

The brain wave is a bioelectric potential that is recorded from the surface of the skull, using appropriate electrodes and instrumentation. Coherence is the condition of synchrony between the waves generated in between the 2 hemispheres of the brain. For example: if the left and right occipital lobes are generating Alpha waves of similar frequencies, there is some coherence between them. Brain wave coherence is the recording of electrical activity along the scalp produced by the firing of neurons within the brain. In this study we have used Brain Master 2 Channel EEG version 2.0 from Bio-Medical Instruments, Inc., Warren, Michigan for BWC recording[11],[12] which records the brain waves and through an inbuilt software gives the coherence values of Delta (δ), Theta (θ), Alpha (α), Beta (β) and Gamma (γ) waves.

Recording conditions

EEG data were collected using a 2-channel ECI electrode cap from the following locations: C3 and C4. These scalp locations were referenced to linked earlobes, with the ground at the forehead. All recordings were done in similar conditions using Brain Master 2 Channel EEG version 2.0 for clinical from Bio- Medical Instruments, Inc., Warren, Michigan.
Sampling Frequency Rate fixed at 256 Hz.
Protocol of Settings file: EEG Pro 2 Channel Alpha Synchrony
Run of Length: 10.0 Minutes.
The electrode impedances were kept below 10 kΩ to ensure noise- free, accurate and good EEG recordings.

Procedure

The participants were instructed to sit in any comfortable meditative posture with eyes-closed either on the chair or on the ground.
Coherence Calculation and Training using the BrainMaster
In general, a sinusoidal signal can be written as:
$y(t) = Aycos(wt) + Bysin(wt)$
Where "w" is the angular frequency in radians per second. This represents a constant sinewave with any amplitude or phase. The amplitude and phase of the signal are determined by the values of A and B. If A and B are constant, then the signal will have a constant amplitude and phase, being a continual, endless sinewave.
If the signal is time-varying, it can be written as:
$y(t) = Ay(t)cos(wt) + By(t)sin(wt)$
The modulation produces "passbands" that give the signal its time-varying properties. If A(t) and B(t) are sufficiently quickly changing, this equation can represent an arbitrary band-limited signal, not just a sinewave. The time variation of the A(t) and B(t) components can provide a considerable amount of variability, and the ability to accurately reflect a signal such as the complex alpha wave in the EEG, as a rapidly changing function of time. This is the method used in the BrainMaster quadrature filters.

The values of A(t) and B(t) are computed within a quadrature filter, according to the Fourier principle.
Once we have values for A and B for any signal, we can calculate many useful values for it. This is in addition to having the ability to compute and display the waveform itself.
The amount of power (in microvolts2) in an EEG signal is given by:

$$Ey2 = Ay2 + By2$$

The same way we can calculate the spectral power in a signal (for any frequency component), we can calculate the "cross spectral power" for a pair of signals.
The amount of power shared by two EEG signals can be given by the "cross-power":

$$Eyz2 = Ayz2 + Byz2$$

Where Ayz2 = ayaz and Byz2 = bybz

Using this notation, one form of the equation for the coherence between two signals is:

$$Cyz = \frac{2\ Eyz2}{Ey2 + Ez2}$$

This can be said to be "The cross-spectrum divided by the sum of the autospectra".
It is easy to compute this coherence using the coefficients from the quadrature filter.
In terms of the filter outputs, this becomes:

$$C(y,z) = \frac{2\ (ayaz + bybz)}{(ay2 + by2) + (az2 + bz2)}$$

Thus, we simply compute the "cross coefficients" of the filters, and then divide it by the sum of the power out of the two filters. This calculation can be made on every sample of EEG,

providing a real-time, running value for coherence between the two channels. Note again that the coherence is a function of time, the same way that the values of A(t) and B(t) are functions of time, that can change rapidly, depending on the quadrature filter bandwidth and rolloff characteristics.

This coherence is like a correlation coefficient that shows the degree of correlation between the signals. If they are very similar in frequency content, they will have a coherence value near 1.0, and if they are different, they will have a low coherence near 0.0.

From the equation, it is clear that the coherence of two identical signals will always be 1.0. It is also seen that two signals that are otherwise identical, will have lower coherence if one of them adds any "out of band" signals that are not coherent with the signals. For example, a pair of 10 Hz, 10 uV sine waves will have a coherence of 1.0. But if one of them adds, say, 10 uV of a 20 Hz sine wave, then the coherence will go down proportionately (to 0.67, in this case, because the signals are 2/3 identical)

In the BrainMaster coherence is calculated and displayed for all 8 components (delta, theta, alpha, lobeta, beta, hibeta, gamma, and user). In addition a threshold can be set between 0.01 and 0.99 for training. The operator can select any or all of the 8 components for sound feedback, hence coherence training. In addition, the coherence can be shown on the summary screen, and read from the Excel spreadsheet that contains the minute-by-minute statistics.

In EEG, a coherence of between 0.0 and 0.4 is not considered significant, because random signals can have a small amount of coherence. However, coherence values above 0.5 and especially exceeding 0.6 are significant for EEG training. In exceptional cases, coherence of 0.8 and above may be seen, but this is unusual for EEG. In practical up training, the user should be working to achieve coherence values in excess of 0.6. The BrainMaster provides coherence thresholding for this purpose, and sound feedback to assist the trainee. When any of the 8 EEG components that is "enabled" (selected for display or sound feedback) exceeds its threshold, a MIDI sound is provided, allowing the trainee to learn to produce this coherence in the selected channels and component band.

It is also possible to downtrain coherence in the BrainMaster, by selecting this option. In this case, the sounds will come when a component is below its threshold, thus leading the trainee to keep the coherence low in the pair of channels.

Intervention

All the subjects participated in the Yoga Instructor's Course (YIC) which is based on Integrated Approach of Yoga Therapy. Details are given in Appendix 1

Data Collection

We collected brain wave coherence data using 2-channel electrode locations C3 and C4. We referenced these scalp locations to linked earlobes, with the ground at the forehead. We did all recordings in similar conditions using Brain Master 2 Channel brain wave version 2.0 for clinical from Bio-Medical Instruments, Inc., Warren, Michigan. We chose sampling frequency rate of 256 Hz. Protocol of setting file was brain wave Pro 2 Channel Alpha Synchrony. Run of length was 10.0 minutes. We kept the electrode impedances below 10 KΩ to ensure noise-free, accurate, and good brain wave recordings. [27], [28]. We studied BWC for the same subject at the same time of the day for pre and post data. During BWC recording, each subject was resting on the chair with the eyes closed for 10 minutes in Bio-Field Energy Laboratory of S-VYASA University.

Data Scoring

BrainMaster calculates and displays coherence for different components as delta, theta, alpha, beta, and gamma. In addition, we can set a threshold between 0.01 and 0.99 for training. The operator can select any or all of the components for sound feedback; hence coherence training was easy. In addition, we can show the coherence on the summary screen, and read it from the Excel spreadsheet containing the minute-by-minute statistics. Coherence between 0.0 and 0.4 in brain wave is not significant, because random signals can have a small amount of coherence. However, coherent values above 0.5 and especially exceeding 0.6 are significant for brain wave training. [29]

Data Analysis

All statistical analysis was carried out using the version 16.0 of the Statistical Package for Social Sciences (SPSS) software. The Kolmogorov-Smirnov test showed that the data was not normally distributed. We used Wilcoxon signed rank test to compare means of the data.

CHAPTER 14

RESULTS

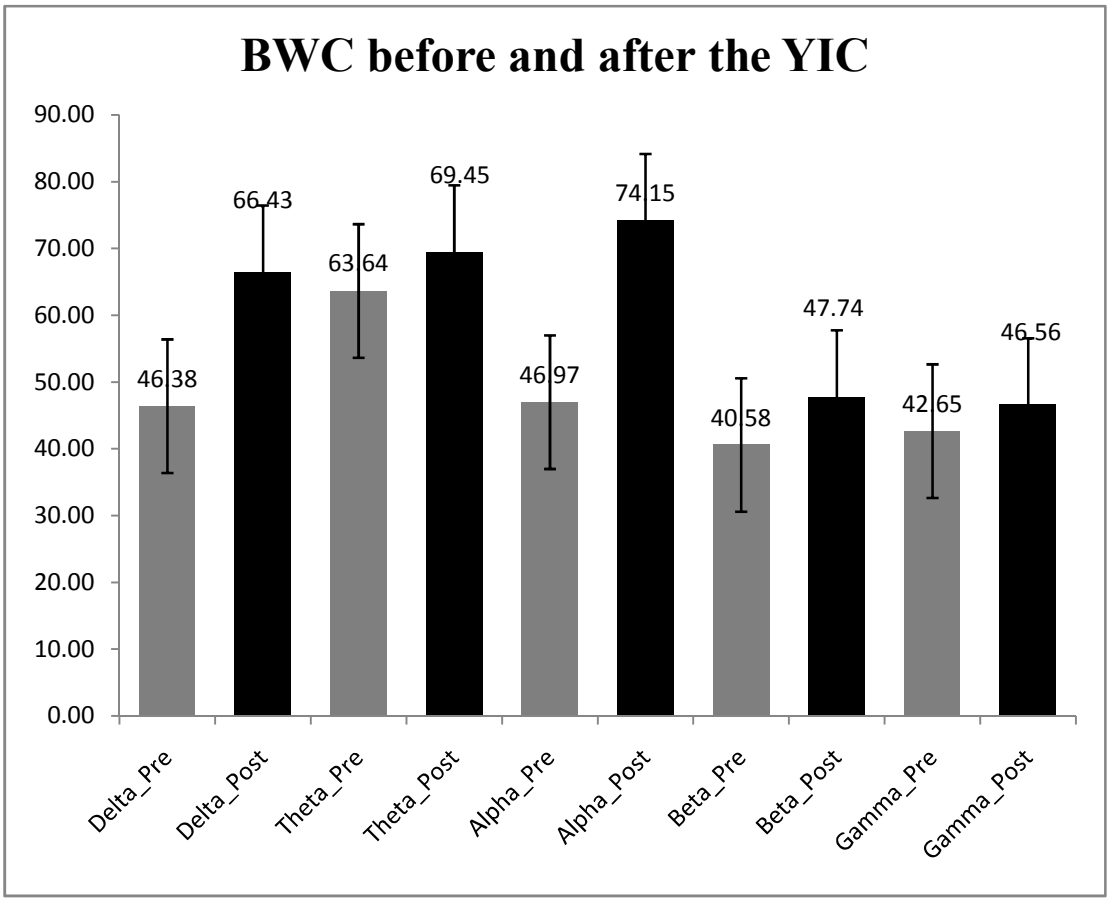
A complete statistical and spectral analysis showed 43.24% increase (P<0.001) in Delta, 9.13% increase (P=0.289) in Theta, 57.85% increase (P<0.001) in Alpha, 17.65% decrease (P=0.136) in Beta and 9.19% increase (P=0.586) in Gamma BWC between pre and post intervention measurements.

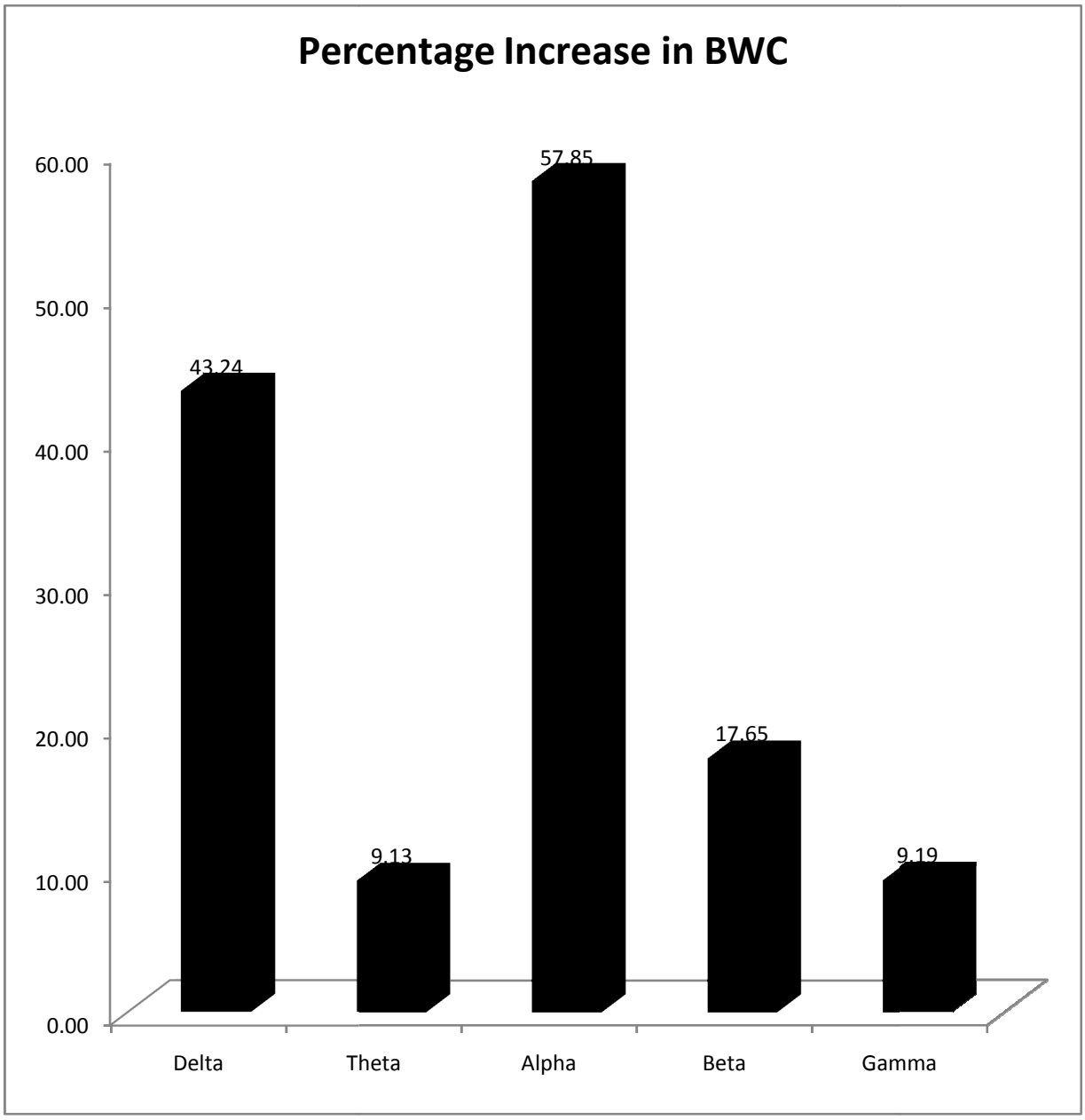
Table 1: Data Analysis

Brain Waves Coherence	**Mean ± Standard deviation**		**Percentage increase (↑)**	***P***
	Before YIC (pre)	**After YIC (post)**		
Delta (δ) 1-3 Hz	46.38±20.51	66.43±20..13	↑ 43.24	<0.001*
Theta (θ) 4-7 Hz	63.64±23.79	69.45±28.55	↑ 9.13	0.289
Alpha (α) 8-12 Hz	46.97±21.47	74.15±21.68	↑ 57.85	<0.001*
Beta (β) 13-39 Hz	40.58±18.41	47.74±22.30	↑ 17.65	0.136
Gamma (γ) 40-45 Hz	42.65±18.46	46.56±26.54	↑ 9.19	0.586

***Significant at 0.001 level**

Figure BWC before and after the IYM





Delta (δ) and Alpha ((α)) increased significantly at *P*<0.001 level

CHAPTER-15

DISCUSSION

A complete statistical and spectral analysis of the data showed 43.24% increase (P<0.001) in Delta, 9.13% increase (P=0.289) in Theta, 57.85% increase (P<0.001) in Alpha, 17.65% decrease (P=0.136) in Beta and 9.19% increase (P=0.586) in Gamma BWC between pre and post intervention measurements. [Table 1]

Everything good about the brain depends on its coherent, orderly functioning. Recent studies in neuroscience have found that world-class athletes have higher EEG coherence than controls, and higher-performing CEO's display greater coherence than other executives. [30] During ordinary waking consciousness, EEG patterns are generally scattered, disorderly, and rapidly changing. [31] By contrast, as the mind settles by the practice of yoga, brainwaves tend to become rhythmic and orderly. [32]

Normally applied to scalp EEG sensors that detect cortical neuron activity in the area below the sensor, the electrical waves are computer analyzed in a very precise manner to determine how similar the two waves are to each other over time. Specifically, the brainwave pattern from two points of the scalp are analyzed first for a given frequency band, say, alpha—between 8 and 12 cycles per second. These two converted signals are then examined over about a 1-2 second period to get an average value of the similarity in the upward and downward movement of each of the two waves. Thus, the researcher obtains an accurate measure of the constancy of the phase relationship of the two wave patterns over a given time period. This constancy is closely correlated with fundamental modes of brain information transfer. [33],[34]

In the present study it was observed that twenty one day of IYM program significantly increase Delta and Alpha BWC and a high level of coherence between two EEG signals indicates a co-activation of neuronal populations and provides information on functional coupling between these areas. [35] Significant increase in Delta EEG coherence may be associated with heightened efficiency of brain functioning and may improve mental performance and overall health.[36] Similarly, significant increase in Alpha EEG coherence is associated with wakefulness and vigilance and is the essential requirement for 'student efficiency.'[37],[38],[40],[41],[42] Findings from

earlier studies suggest that percentage of alpha waves were higher in persons performing meditation with good coherence which suggests good homogeneity, uniformity, and increased orderliness of brain functioning.[43] Arambula et al have reported that subjects who practiced Kundalini Yoga Meditation could achieve balance in lateralization of cerebral functions with an increase in alpha EEG activity.[44] Similarly, Cahn et al have shown that TM increases frontal alpha coherence, which reflects an enhancement of frontal lobe integration, as increased cognitive flexibility, intelligence, and emotional stability.[45] Furthermore, activation in alpha wave coherence can produce a state of well-poised readiness, and deep relaxation. It may be associated with improved creativity, sense of well-being, and ability to perform effectively.[27] [28]

The mechanism by which IYM program may improve mental performance and overall health in students, while increasing Delta and Alpha EEG coherence, may be related to the notion that during IYM, the ordinary thinking process settles down. This settling down is due to integration and synchronization of the left hemisphere (logical capacity) and the right hemisphere (intuitive capacity) of the brain. In addition, students gain a distinctive psychophysiological state of 'restful alertness'. The following factors indicate the 'restful alertness' and may be the mechanisms of improved mental performance and overall health: [17] [45] [46] [47] [48]

1. Decreased respiration
2. Decreased skin conductance
3. Decreased plasma lactate and cortisol
4. Increased cerebral blood flow
5. Faster H-reflex recovery
6. Shorter latency of auditory-evoked potentials
7. Decrease in autonomic arousal (sympathetic activation)
8. Psychological factors
9. Mind and body integration

Thus, this study has shown that IYM is activating and increases the experience of alertful rest.

CHAPTER-16

SUMMARY AND CONCLUSION

The present study investigates the effect of BWC on university students undergoing IYM. This is a single group pre-post design with 21 days intervention of IYM in a residential set-up. 30 IYM students with 25.77±4.85 years of mean age participated in this single group pre-post study. The BWC data was collected before (pre) and after (post) the IYM training program using BrainMaster (Model: 2E Part # 390-001), Michigan, USA. A complete statistical and spectral analysis showed 43.24% increase ($P<0.001$) in Delta, 9.13% increase ($P=0.289$) in Theta, 57.85% increase ($P<0.001$) in Alpha, 17.65% decrease ($P=0.136$) in Beta and 9.19% increase ($P=0.586$) in Gamma BWC between pre and post intervention measurements.

BWC study showed significant increase in both Delta and Alpha wave coherence suggesting that IYM training program can result in improvement of coherent and integrated brain functioning among students, thus paving the way for their better mental performance and overall health.

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