ABOUT WHAT I KNOW

ZEN
IN THE
LIGHT OF SCIENCE

THÔNG TRIỆT

The Sunyata Buddhist Meditation Library

Printed & Distributed by

The Śūnyatā Meditation Association

18525 FRANTZ ROAD

PERRIS, CA 92570

Tel: (951) 789-0682

First edition: 3,000 copies

PRINTED IN USA

August 2010

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I dedicate this book to
my revered Master Thích Thanh Từ
in appreciation for his teaching.

Abbreviations

Ach	Acetylcholine
ACTH	Adrenocorticotrophic hormones
BA	Brodmann Area
BOLD	Blood-Oxygenation-Level Dependent Signal
CNS	Central Nervous System
EEG	Electroencephalographic
EN	Epinephrine
EPI	Echo Planar Imaging
FFG	Fusiform Gyrus
fMRI	functional Magnetic Resonance Imaging
GLM	General Linear Model
HBMO	Human Brain Mapping Organization
HRF	The Hemodynamic Response Function
Hz	Hertz
ICA	Independent Component Analysis
IFG	Inferior Frontal Gyrus
LTP	Long Term Pontentiation
MIP	Maximum Intensity Projection
NA	Noradrenaline
NE	Norepinephrine
PET	Positron Emission Tomography
SCN	Suprachiasmatic Nuclei
STG	Superior Temporal Gyrus

A C K N O W L E D G M E N T S

First of all, we would like to express our deepest thanks to Dr. Michael Erb, Dr. Ranganattha Sitaram and all the members of the Brain Imaging and Electroencephalography Section, Department of Radiology, University of Tübingen, Germany. During a period of five years, from 2006 through 2010, you have contributed considerable professional work and energy to help the Sunyata Buddhist Meditation Group in Germany and the Sunyata Buddhist Meditation Association in the United States to fulfill the Brain Imaging Project nurtured by the Monastic Sangha and the lay practitioners. The visualization of the 4 Awareness Faculties for the first time in the meditation history by the brain imaging technology is a great contribution to the Practical Spiritual Science of the East as well as to the Social Psychology of the West. For us, myself and the practitioner students, we consider the success of the imaging project a gift of greatly significant value we ever have from you.

We especially express our sincere thanks to Professor Dr. Wolfgang Grodd, Director, Department of Radiology, University of Tübingen Medical School and Professor Dr. Niels Birbaumer, Director, Institut für Medizinische Psychologie und Verhaltensneurobiologie, Tübingen, for approving the Brain Imaging Project of the Sunyata Meditation Center in Germany and the United States.

We thank all the assistance from our students from meditation centers in:

1. Germany (Stuttgart and Frankfurt),
2. Canada (Toronto and Ottawa),
3. Australia (Sydney),

4. Switzerland (Lausanne),
5. France (Paris and Toulouse).

In the United States, in particular, we also appreciate the contribution of a great number of students from Hawaii, Illinois (Chicago), Washington (Seattle and Vancouver), Colorado, Virginia, New York, Florida, Georgia, and all Zen students from meditation center in:

1. Oregon,
2. Sacramento,
3. Chân Không Meditation Center (San Jose),
4. South California (Santa Ana),
5. Houston (Texas).

in assisting in the following:

- Communication with the Translation Groups: Tuệ Đạt,
- Translation Groups: Paris, Sacramento, Santa Ana, and Houston.
- Orthographic check: Tuệ Minh Kiên and Huệ Hải.
- Taking care of the covers and inside pictures, for a flavour of elegance and aesthetics: Tuệ Nguyên and Tuệ Giác.
- Assuming the responsibility of the printing and publishing: Không Giới, Thuần Chánh Tín and Triệt Huệ.
- Dispatching to the United States (except for California) and Overseas Centers: Triệt Huệ.
- Free distribution to U.S. libraries in the 50 States: Tuệ Giác.

- Indexing technical and special terms alphabetical order: Tuệ Đạt, Huệ Hải and Tuệ Giác.
- English revision: Không Triệt.
- The publication of this book is financially supported by two benefactors from Southern California.

To all Buddhists and/or Meditators who have directly or indirectly promoted, assisted and contributed bibliographical, including canonical or commentarial, material, and scientific documentation, financially contributed to the printing costs.

May All the Buddhas of the Ten Directions of Space, with Compassion and Loving Kindness, bestow on you protection and bliss in abundance.

Thông Triệt,

Perris, 6 August 2010

INTRODUCING THE BOOK

The reasons

More than fifty years ago, I resolved that, circumstances permitting, I would use popular terminology to write many specialized books to expound the knowledge I have acquired in some field or other... Then, with time and the circumstances of life, I came to be convinced that Buddhist meditation was quite suitable for me. I gave up all worldly affairs and determined to follow the Way of Meditation. 1972-2010: thirty eight years have elapsed since...

Considering that all requirements have been assembled of my accumulated experience, for the generations to come, I began writing a specialized book entitled "Zen in the Light of Science" under the form "About what do I know...?"

Concerning the form:

- Format of paper: 8.5" x 11"
- Number of pages: for a book average 150 pages

  Maximum 200 pages
- Concerning the specialized terminology in the books which have/will be published in the form "About what do I know ...?", if I have not annotated a number of them, I shall extract them, synthesize them and collect up to 200 terms, have them published in booklets of 150-200 pages. Hopefully, in the near future, I can realize my aspirations to have the Encyclopedic Dictionary of Buddhism, Meditation and Science published.

Simplification of the Annotations

Buddhist meditation is, for us, **a spiritual experimental science**. This science originated in the self-realization of Buddha Sakyamuni through the mechanism of *nature of cognitive awareness.* He called that process of cognitive awareness the state of Suchness and he also called himself Tathatā (I am the Accomplished One). With such a state of mind, the Buddha looked at world phenomena. He systematically recognized their true nature. First comes Suchness (Tathatā)... This is His highest realization. With this realization, He became the historic Buddha, was called Unsurpassed Wisdom. He also called himself "Tathagatā". Thus, spirituality in Buddhist Meditation was based upon two processes: first, the results of the fourth level of samādhi. The practitioner experiences a state of Unshakable Mind, the Mind at a standstill, which is "Mind-as-such". Then with this state of mind, the practitioner looks at worldly phenomena, recognizes that the true nature of the phenomena is Tathatā.

Afterwards, in his desire to rescue all living beings, he shared his own experience of liberation from suffering and of enlightenment and deliverance, the Buddha has synthesized His personal tests on His body, mind and spiritual wisdom in order to spread them to the world through the principle of teaching according to each person's abilities. This is called "experimental".

During more than twenty years, The Buddha used conventional Truth to teach. The following twenty years, He adapted His teaching to the different levels of abilities of the followers so that all can experience awakening, liberate themselves from suffering, enlighten and reach deliverance like Him. This is a transcendent art of teaching. Until now, there has been no other Teacher as competent.

Borrowing the scientific devices

To-day, all necessary conditions being met, we have been able to have the present work published under the title **"Zen In the Light of Science."** From the standpoint of Oriental Meditation Studies, we borrow the scientific devices and means of the West to demonstrate where the Words or Doctrine of Buddha Sakyamuni have in reality acted upon the cortex, deep in the midbrain, on the Autonomic Nervous system, in the Endocrine glands. Finally, by putting into practice those teachings, the practitioner will experience for himself the effects on his own body, mind and spiritual wisdom. On the other hand, there are methods, which the Buddha taught over 2500 years ago and we need to borrow the neurosciences of the West to demonstrate their location on human brain. For instance, in Bāhiya Sutra, the Buddha taught about Four Natures: thanks to MRI, we can see where the Four Natures are located in the brain when we practice meditation.

Cooperation

To enhance the value of the book, ensure that the theory put forward accords with the scientific mind, we have invited Dr. Michael Erb and Dr. Ranganatha Sitaram to contribute to this book. They are two scientific specialists of the Department of Neuroradiology, University Hospital, Tübingen (Southern Germany). We hope the cooperation of the Tübingen University and the Sūnyatā Buddhist Meditation Institute in the United States of America will bring resounding results in the field of spiritual experimental science in the 21st century.

In the future, meditation from the East and science from the West will go hand in hand to serve humankind more positively and efficiently. The East knows how to speak, how to do, how to imagine, but is unable to show (for lack of scientific equipment compared with Western scientists). For their part, the West knows how to speak, how to show, they can see, touch, but cannot act (for lack of knowing how to exert themselves and laying strong emphasis on

exploiting the spiritual potential like the East.)

This shows there is a need for East and West to unite in this aspect.

Considering this evolution under way, we expect the veil of secrecy cast over oriental meditation will be lifted so that the "wonder" of the Nature of Awareness (the spiritual perception), a term of major importance in Buddhist psychology which, in the West, psychologists have not yet discovered.

Content

This book **Zen in the Light of Science** contains 3 chapters:

Chapter I: Causative conditions for creating this treatise.

Chapter II: Meditation is a science: a demonstration.

This chapter comprises 2 parts: in the first part, Dr. Michael Erb has brought to light the meditation techniques we applied when entering deep into the Gnostic area (or the nature of awareness area or the spiritual perception area), the location, on the cortex and in the Limbic system, of the hemodynamic response. The second part is the presentation by Dr. Ranganatha Sitaram of the results of our personal brain imaging. The images and analyses of the results presented by Dr. Erb appear to correspond greatly with our demonstrations related to the 4 awareness natures, which were referred to in Bāhiya Sutta, in Ariyariyesanasuttam or in Mahasaccakasuttam.

Chapter III : Scientific data.

This chapter comprises 4 parts in which we set forth the interaction of two mechanisms the wrong, erroneous mind and the right, straightforward mind, the difference between their respective action on the limbic system and the results for the body, the mind and the spiritual insight. Explanations are given of the successive processes of formation of spirituality in the human brain. The value of Stabilization Meditation is established thanks to the images obtained through fMRI. This is the opening part of the

presentation of Buddhist meditation as a spiritual experimental science, parallel with the theoretical part on meditation.

In conclusion, since the foundation of the Sūnyatā Meditation Institute 15 years ago, in all, 62 Elementary classes, 12 complete Prajna Intermediate classes and 3 Buddhist Psychology sessions have been conducted.

During the classes, the teaching—the theoretical explanations as well as practice guidance—has always been given from the scientific standpoint. Hopefully, with the cooperation of the Sūnyatā Meditation Monastery and the Tübingen University, Meditation will increasingly earn the attention of the West as a demand in experimental spirituality.

Perris, Riverside the 10th of August 2010

CHAPTER I

THE CAUSATIVE CONDITIONS FOR CREATING THIS TREATISE

The present background to Buddhist meditation

Throughout the past over 2500 years, innumerable changes occurred in various spheres of human life—social, environmental, political, etc... For its part, Buddhism also underwent a great deal of change and transformation: from Early Buddhism, Schools of Buddhism were established. Then 300 years after Buddha's entry into Nirvana, Councils were called to codify the Holy Scriptures. The Buddahology and Meditationology were subject to more and more diverse interpretations; resulting in methods of cultivating that were no longer in accord with the Buddha's Perfect thinking.

To-day, it's a challenge for the sincere Budda followers, who are searching for some Dhamma path to experience for themselves inward quietude, body and mind harmony and unfolding of spiritual wisdom, to find this path. That is because nowadays, a great number of Dhamma and meditation studies self-proclaim to be "Buddhistic," in spirit and principle, they are a world apart from Buddha's advocacy.

For instance, in the past, the Buddha reached realization through two outstanding means: the stabilization of the mind (Samādhi) and transcendental wisdom (Paññā). They both are based on **Suchness/Thusness,** or "the unshakeable mind." In Buddhism, we regard this as **spirituality (i.e."spiritual mind**.") Nowadays, no one pays attention to these outstanding means. During the past 2000 years, many Buddhist Schools only emphasized the use of the two ordinary vehicles, which are meditative contemplation and meditation on mental tranquillity or calm. Only the

Mahasanghīka Schools developed the quintessence of the Doctrine, which is the nature of Emptiness (Sūnyatā) and the nature of Suchness (Tathatā) and guided practitioners all the way through to the ultimate.

1. Question: - Could you give a few concrete details to help us see in spirit and principle the difference between the Buddha and present day Buddhism ?

Answer: - In the past, the Buddha emphasized stabilization meditation and ended in realizing the state of Suchness and the Three Insights, or the Threefold Knowledge. He reached the Ultimate Deliverance. Never did he pray to any Buddha to help him in his endeavour. This shows his self-reliance state of mind, which is really different from present day practices. As far as the principles are concerned, he advocated a great number of means of mental cultivation, like Contemplation (Anupassanā), Mental tranquillity (Samatha), Stabilization (Samādhi) and Transcendental Wisdom (Paññā) methods of meditation. When they practice these methods, the meditators can call on one of the six senses to stimulate one of the four natures to experience Realization.

2. Question: - So, is it because you found yourself facing the "jungle of Buddhistic Studies" and the "meditation jungle" which are proliferating everywhere that you have done the utmost to publish this Treatise?

Answer: - That is correct.

3. Question: - Then, is that the official reason of your initiative? If that is the case, could you explain the meaning of the word "Treatise" in the title of this Chapter ?

Answer: - A Treatise is a text presenting or explaining methodically or demonstrating the meditation methods that the Buddha taught or indicated directly in the canonical texts for his followers to practice in order to quickly experience Awakening or to reach different levels of Realization as the Buddha did himself. For instance, in the Bāhiya sutra, the Buddha waited until Bāhiya's mind had

reached total silence, without a single thought arising, to specifically teach him in an orderly manner the four natures of human beings. In these natures, there is absolutely no Self-Consciousness, no Self-Thinking. When the Teaching was over, Bahiyā immediately awakened, and obtained arahantship. In the sutras, this type of realization is called "instantaneous" (Pāli: khippabhiññano).

4. - Question: - Could you tell us what induced you to choose the subject "What do I know about Meditation by the light of Science ?"

Answer: - As early as the decades 1950-60s, I very much appreciated the booklets of the French collection "Que Sais-Je ?" (What do I know?) published in Paris, France and available at the Vinh Bao bookshop in Saigon. The title was borrowed from a 16th century famous French writer, Michel Eyquem de Montaigne. Not until the middle of the XXth century did the French publishing House "Presses Universitaires de France" (PUF) take the title "Que Sais-Je?" to create a collection of booklets dealing with every possible subject under every possible discipline – psychology, culture, sociology, economy... to make specialized knowledge accessible to the general public, adopting a readable and understandable style and subjects easy to implement.

I may say that in the 1950s, I was strongly influenced by a variety of books in the social field I had read in that collection and I wished I could acquire the expertise indispensable for the contribution I wished to make to the society I lived in. I came to realize that I needed a solid training in writing and in the foreign languages, and above all, specialized skills in some field of activity.

Now, in this year 2010, over half a century has elapsed. I have written seven books on meditation, and conducted 62 Elementary meditation classes and 12 Full Intermediate Prajna classes. Over a period of five years (2006 through 2010), I have undergone six functional magnetic resonance imaging sessions, knowing clearly topographic localization

in the brain. I gather the impression that I have accumulated sufficient experience and opportunity to start realizing my long-standing aspiration to write a series of books especially dedicated to meditation, after the fashion of specialists who wrote in the "Que Sais-Je ?" collection.

5. Question: - Why did you choose the "subject "Meditation in the Light of Science ?"

Answer: - I want to clarify the meaning of Buddhist meditation in the 21st century. For that, we have **borrowed** scientific equipment such as electro-encephalograms to measure the students' brain-waves during the practice classes I conducted in Stabilization Meditation. We have also **borrowed** the discoveries of neuroscientists, researchers in human brain to explain the interactions of the mind, the Dharma and the brain on the one hand and the body and mind and spiritual wisdom on the other hand.

It is a fact that meditation is a discipline which started from Buddhism, but it has universally expanded in the general public in many countries with high cultural, intellectual and industrial standards. Such countries as Great-Britain, Japan and the United States of America have considered meditation as beneficial for all walks of life and made room for it in educational institutions. Meditation no longer confines itself as a topic apart in the ivory tower of Oriental scholars. It has stepped out into people's everyday life. For instance, take a person who has *hypertension* and wants his blood pressure to decline immediately without any medicine: for that, he simply has to be seated and practice the two-step breathing, mentally and slowly counting: "1 – 2 - 3" while he inhales and "1 – 2 - 3 – 4 -5 - 6" while he exhales. After breathing that way a few times, he will feel signs of blood pressure declining. This shows that meditation obviously exerts its influence over the body. This influence needs to be dissected and demonstrated through experimental scientific methods like measuring blood pressure, glucose level in the blood, electroencephalogram, brain imaging to find out the sites of

the natures in the brain, etc. Nowadays, if one wants to enter into deep meditation, one needs to equip oneself with this scientific knowledge. Hence, when teaching the theme "**A new approach to the practice of meditation**" in various Sunyata Meditation Centers in the United States and overseas, we always call the attention of the students to the fact that "nowadays, for meditation students, it is imperative to be knowledgeable notably in neuroscience and in the meditational techniques."

6. Question: - Could you explain the scientific tools you have just referred to, like electroencephalography (EEG) and Functional magnetic resonance imaging (fRMI)…?

Answer : - As early as 1997, we opened the meditation doors to let scientific tools in: we have used EEG to measure the students' brainwaves. When practicing Stabilization, we can easily know the various states of mind, stabilized or otherwise. We can easily know where, in the stabilization process, our mind has reached, based on the brainwaves. It is then quite possible, if necessary, to modify the techniques in order to reach the target.

Using fMRI to measure the hemodynamic response in various cortices and in the midbrain, we can clearly see in those areas our meditation topic. The images indicate the value of the technique we have implemented. For instance, if we visualize any picture or utter mantras or recite Buddha's name, the prefrontal area will appear red. That is the hemodynamic response to the action of the intellect (imagination) or the mind-base or mental consciousness (concentration on an object associated with mental murmur (see Figure 1).

Figure 1: Pre-frontal area, Left Hemisphere

If the brain is scanned in an on-going meditation session, we shall recognize the brain location of the regions which were referred to in the sutras, such as the verbal chatter area (or Vitakka) and the inner silent dialogue (Vicāra) area, what occurred in the brain.

In the 21st century, fMRI will be an effective and useful means for Buddhist meditation practice to measure the stabilization processes of the meditator or the realization processes through the natures which the Buddha taught in the Nikaya sutras. We also want to demonstrate that the invaluable meditation techniques result in body and mind harmony and the expansion of spiritual insight. Actually, on which principles are they based? As a matter of fact, the Buddha aimed at helping the practitioner use his senses to stimulate one of the natures of the sensory mechanism, or the passive reflex to reach Suchness (Tathatā). Concerning these two reflexes, we have arranged as follows:

a. Through the sensory reflex, with the Knowing and insight of things as they are (Yatha-bhūta), the practitioner stimulates one of **the three natures: the nature of vision with the eyes, the nature of hearing with the ears, the nature of contact with the nose, the tongue, and the skin.**

b. Through the passive reflex, in the upright meditation posture, the practitioner uses the mind-base to apply an abstract subject, out of the sphere of reasoning, like Suchness Samādhi, Emptiness Samādhi or

Signless Samādhi.

7. - Question: - Could you tell us why, in developed countries, people regard Meditation as a *tool* capable of helping them to be healthier, more harmonious, to enjoy mental tranquility, and to enhance spiritual wisdom ?

Answer: Because Meditation does not lay emphasis on religious faith, invoke deities, as advocated by religions. On the contrary, Meditation stresses the practices which act on the brain, or on the limbic system, the autonomic nervous system or on the endocrine glands. If the meditator practices exactly according to the methods, the techniques, he will experience harmony between body and mind. Thus, people in developed countries consider Meditation more as a tool which is useful for themselves than a religious activity.

For instance, when someone suffers from chronic insomnia, he can use the meditation technique of "Looking at the darkness" to cure insomnia. Instead of saying prayers to deities for their assistance, he only has to practice regularly, observing the time prescribed or according to his free time.

8. - **Question**: Could you explain clearly what you mean by looking at the darkness, and during the meditation session, which biochemical substances are released in the brain to help cure insomnia?

Answer: - This belongs to the scientific domain. Here is the explanation: first, the darkness means obscurity. So you have to sit in a meditation room which has no light: that is the darkness. There should not be the slightest ray, otherwise it is not in conformity with the concept of obscurity. Secondly, you can be in any of the four postures– ambulatory, sitting, standing or lying, provided that the room is totally dark and your eyes are watching the darkness. While you watch, the darkness enters your eyes, crosses a group of nuclei in the hypothalamus, called "suprachiasmatic nuclei" containing a large amount of melatonin. This biochemical substance will be released to

regulate the circadian cycle. Thus, by watching the darkness, we can regulate our sleep-wake center: this technique belongs to the Meditative Contemplation method.

9. **Question**: - Could you explain why the Buddha attained Realization by spiritual means?

Answer: - In the fourth Samadhi level, the Buddha had already experienced the state of motionlessness. He succeeded through the unique way: Suchness. We have referred to this as the state of spirituality because in there, there are no fetters, no defilements or former habits, no proclivities, no afflictions... This mind helps to liberate from suffering, leads to enlightenment and deliverance. The Buddha usually described that state as malleable, perfectly pure. It is totally silent. On the image given by fMRI, we recognized that it corresponds to *the wordless cognitive awareness area*, which the brain researchers are presently still looking for.

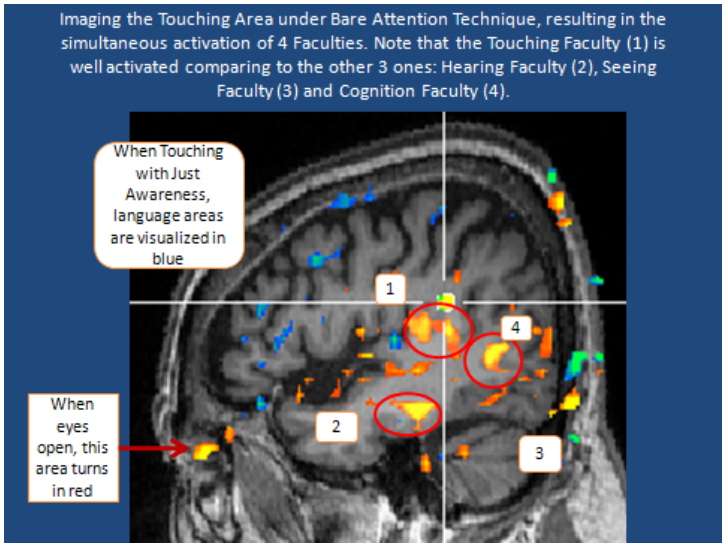

Figure 2: The four natures—Seeing, Hearing, Sensing and Cognitive awareness .

The causative conditions

1. Past causative conditions

Since the 1950s, after drifting around quite a bit for 20 years, at the beginning of 1972, I was convinced that Buddhist meditation suited me very well. I could *tread that path* to find solutions for myself in the spiritual field. At the end of the same year, I resolved to give up all the worldly ties and body of knowledge and chose the Way of Meditation.

Thanks to the recommendation of the most Venerable Thích Thiện Hoa, the Meditation Master Thích Thanh Từ accepted me for ordination, but the conditions for that were met only on the 12th of May, 1974 (which was the full Moon of the Fourth Month of the Lunar calendar). I was then ordained a monk and, under the guidance of my Teacher, the Zen Master Thích Thanh Từ, started to study meditation, joining the Second Session.

Unfortunately, more than a year later, South Viet Nam *changed hands*, and in July 1975, I had to quit my Teacher and all my classmates for a fourteen-year long "forced retreat in Re-education camps" from the South to the North... From that time to October 1977, after a little bit more than two years in the camps, one of my fellow inmates told me: "You look quite young, Venerable, have you reached 80 ?" Hearing that, I realized that I was wrong in my meditation practice. But what was wrong, I had yet to find out.

At the beginning of 1978, I was sent to the North, to pursue my "retreat" at Nam Ha Camp (Ha Nam Ninh) and in mid 1979, at Thanh Liệt Camp (Hà Tây). In February 1982, on the 4th day of the New Year, at around 3 a.m., I experienced Self-realization through a touch of my arm... (This "Realization" experience will be related in Book 2).

In the middle of 1982, we received the order to move again. When we arrived at the meeting point to continue to the

camp in Hà Tây, six persons were sitting there, waiting. The cadre accompanying us looked at them and pointed his finger at me: “Among all the persons present, you stayed longest but how comes that you look youngest and healthiest, with a better rosy complexion than the others?”

Looking at my inmates, I noticed they all looked ghastly, their faces were drawn: I knew that now, I had been exerting correctly. So from an old man of 80, I “grew young again!”

Seven years later, in 1989, after 14 years' separation from my Teacher and classmates of the Thường Chiếu Zen Meditation Institute, I returned to be with him. When I informed him that later, I would write books about meditation drawing a parallel with science, I received his agreement.

In 1991, my Teacher authorized me to explain and comment on his book “Thiền Tông Việt Nam Cuối Thế Kỷ 20” (The Vietnamese Zen Sect at the Close of the 20th century) in the form of a parallel with science.

At the end of 1992, I left for the United States of America in the framework of Humanitarian Operation (H.O.). And three years later, in 1995, I started to implement a project on the explanation and commentary of the Teaching of my teacher” in the following simple scientific form:

I depicted the regions of the wrong mind in the left and right prefrontal areas of the two hemispheres and that of the right mind at the Gnostic area, in the back of the left hemisphere (see page 150, Biofeedback article).

In particular, I described the false mind as the mental murmuring generated from the Broca area, but the parietal lobe at the posterior part of the left hemisphere also has a language area which is the Wernicke area.

During the two years 1995 and 1996, I completed the first book in two volumes to explain and comment on my Teacher's Meditation teaching under the title: “Đồ Thị Dẫn

Giải Thiền" (Explanatory Outline of Meditation). In this work, I began to demonstrate that Buddhist Meditation is a science like all the other sciences in the world. But, it is different from the others in that it is an experimental spiritual science.

Then, from 1999 to 2007, I wrote four books on meditation at a stretch, throughout their content bearing the same purpose: demonstrating meditation is an experimental spiritual science.

Since 1977, I used EEG in the classes to measure the brainwaves of the students on applying the Stabilization topics. All of my demonstrations of meditation being an experimental spiritual science is based on my 14 year personal experience during the "forced retreat in the re-education camps" I was sent to from South to North Viet Nam.

2. New Causative Conditions

This is an opportunity that I take to report about the facts which helped me to complete the book entitled "Thiền Phật Giáo Dưới Ánh Sáng Khoa Học" (Zen Buddhism In the Light of Science).

The first reason. In March 1993, I had an opportunity to go to Hawaii. I was welcomed by Dr. David Johnson and Mrs. Helene Phan-Thanh. They showed me to the Library of the Hawaii Faculty of Medicine. I came across a book entitled "Hypothalamus" by Nauta, Walle J.H., that I extremely appreciated. When I got back from the journey, I passionately took to studying the book for about four months. From there, I discovered the *principle of chain reaction* from the mind, the dharma and the brain through the techniques of practice regarding the treatment of physical and mental diseases.

I put into practice this knowledge in my book Explanatory Outline of Meditation in which I compared the hypothalamus region with the *black buffalo (false mind) and the white buffalo (true mind)* in the Ten Oxen of Chinese Ch'an.

In the middle of 1993, I had the opportunity to visit the Library of the Seattle Faculty of Medicine, Washington. I read in *Scientific American* an article about four special areas in the brain. They were the Broca area, the mental murmuring area, and two areas connected with the nature of seeing and the nature of hearing. What was more interesting was that the Seattle neuroscientists informed me that the Wernicke area was the General Interpretative Area.

The second reason. In 1994, I moved to the State of Oregon at the invitation of Dr. and Mrs. Johnson. I seized the occasion to talk about my idea of having my brain scanned. Dr. Johnson informed me that this was extremely expensive and not easy to implement. At that time, the American scientific researchers could not demonstrate the nature of Touch area and the nature of cognitive awareness yet. From then on, I nurtured the idea of having my brain scanned and waited for the opportune time.

The third reason. The time did come twelve years later, in 2006. Going to teach in Germany, my dream of my own brain imaging came true.

Thanks to the introduction by students of the Stuttgart Śūnyatā Meditation Center, two specialists of the Department of Neuroradiology, University of Tübingen, Dr. Michael Erb and Dr. Ranganatha Sitaram, conducted neuroimaging on myself, some members of the Sangha and lay students for about five years (2006-2010).

Finally, I realized my dream of demonstrating the four natures in the sensory mechanism according to the Buddha's teaching Bāhiya: hearing, touch, seeing and cognitive awareness. In particular, I could demonstrate the Vitakka (verbal thinking) and vicara (inner dialogue) sites in the pre-frontal area.

Most recently, at the beginning of 2010, Dr. Erb scanned my brain while I performed four levels of Samādhi:

- with Vitaka and without vicāra, or verbal awareness,
- without vitaka and vicāra as well, or tacit awareness,
- awakening awareness, or Full or Total awareness,
- cognitive awareness, or unshakeable Samādhi (Akuppā Samādhi).

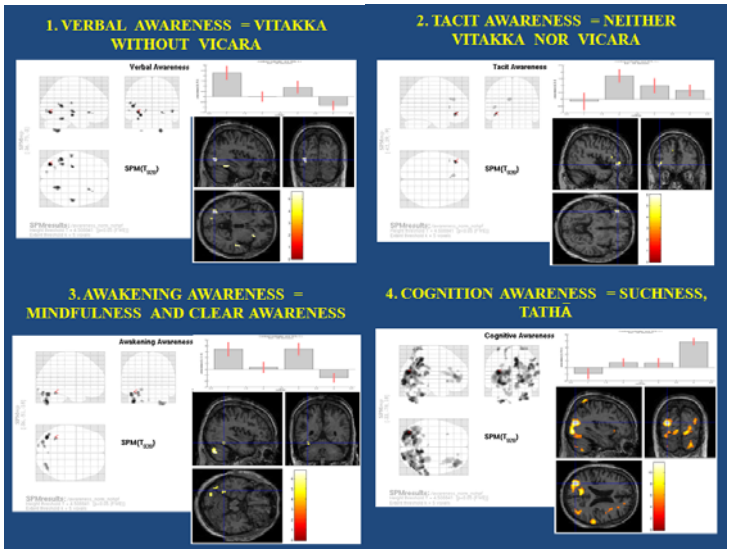

Figure 3: Results of the 4 levels of Samadhi

Dr. Erb and Dr. Sitaram presented this successful experiment in fMRI imaging at the 16th Annual Meeting of the Organization for Human Brain Mapping held at Barcelona, Spain, June 6-10, 2010.

Hopefully, "What Do I Know About Zen Buddhism In the Light of Science" will be useful to the readers who want to understand and practice Buddhist meditation in order to experience the changes of mind-nature, balance body and mind and enhance wisdom.

Thông Triệt

Perris, Riverside, 10 August 2010.

Article 1

About the authors of this article

Michael Erb (michael.erb@med.uni-tuebingen.de)

studied physics at the Universities of Karlsruhe and Tübingen, Germany, and graduated in 1985. He pursued his Ph.D. Studies on artificial neural networks at the Max Planck Institute for Biological Cybernetic in Tübingen from 1986–1990. After a research visit at the Institute for Brain Research, University of Düsseldorf, he was a research fellow at the Institute for Neurophysics, University of Marburg, Germany. Since 1995, he has been a research fellow at the Department of Neuroradiology, University of Tübingen, performing fMRI studies on a variety of research topics. He is involved in building MR compatible stimulation devices and programming MR pulse sequences and analysis software.

Sitaram Ranganatha

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obtained his bachelor and master degrees in engineering from the University of Mysore and Bharathiar University in India in 1990. Until 1992 he worked as a senior research fellow in the Bhabha Atomic Research Center, India, pursuing a project aimed at developing adaptive robotic systems. From 1992 to 2004 filled various positions such as a senior engineer and leading scientist, in the Kent Ridge Digital Labs and the Institute of Infocomm Research of Singapore. He worked in a variety of research fields including artificial intelligence and knowledge systems, intelligent transport systems, cellular communication, smart devices, synthetic creatures and brain-computer interfaces. Since 2004, he has a full-time position as a research scientist and faculty member at the Institute of Medical Psychology and Behavioral Neurobiology, Tuebingen, headed by Prof. Dr. Niels Birbaumer. He is mainly involved in developing brain-computer interfaces based on near infrared spectroscopy and real-time functional

magnetic resonance imaging as tools for communication and rehabilitation of patients with paralysis, and emotional and motor disorders. He obtained his PhD in neuroscience in 2008 for his work on metabolic brain-computer interfaces with a *summa cum laude*. He is one of the recipient's of the President of India's award for non-resident Indian scientists to collaborate with Indian universities, based on which he is now a visiting professor at the Sri Chitra Tirunal Institute of Medical Sciences and Technology in Trivandrum, India. His scientific interests lie in neural learning and plasticity, scientific study of consciousness and the development of advanced neuroimaging methods. He has authored seven international patents, and numerous engineering and scientific publications. He lives with his wife and two children in Tuebingen.

Dr. Sitaram (left) and Dr. Erb

Neuroimaging Experiments on Meditation

Dr. Michael Erb, Dr. Ranganatha Sitaram

1 Neuroscience and Meditation

Since the early sixties of the last century, neuroscientific investigations of meditation have been performed with electroencephalographic (EEG) recordings. Although neuroelectric correlates of altered states of consciousness during meditation are not yet firmly established, the primary findings have implied increases in theta and alpha band power, and decreases in overall frequency (for a review see Cahn & Polich 2006). With the development of neuroimaging techniques like Positron Emission Tomography (PET) and functional Magnetic Resonance Imaging (fMRI) in the 80s and 90s, these new methods have also been applied to reveal the neurophysiologic correlates of modified self-experience in meditation practice.

For many years the 14th Dalai Lama Tendzin Gyatsho has been interested in Western science. In 1987, a series of meetings—the Mind and Life conferences—were initiated between the Dalai Lama and a number of prominent neuroscientists. This led to numerous neuroscience studies on meditation (Barinaga 2003) including neuroimaging, especially at the University of Wisconsin (Madison) surrounding the group of neuroscientist Richard Davidson.

Unlike Western science, Buddhist philosophy assumes the existence of six senses that allow the mind to interpret the world. In addition to the senses of seeing, hearing, touch (body sense), taste and smell, the sixth sense or inner sense allows us to monitor our thoughts and feelings. Buddhism is therefore viewed as a science of the mind with insights based on more than 2,500 years of studying the mind by introspection. Western neuroscience may thus gain valuable insights from this experience by adapting some of

these practices in theoretical and experimental investigations.

A fundamental question for neuroscience is the elucidation of the relationship between subjective experience and neural firing. A flash of light, for example, produces measurable evoked potentials in the visual cortex. While it is relatively straightforward to relate simple sensory stimuli to brain activity, it is, however, far less obvious how complex subjective states such as the experience of meditation are reflected in brain activity. Experimental approaches to meditation can be broadly classified into two major types with different goals concerning the states and traits of meditation (Cahn & Polich 2006). The first one investigates the differences between the mental state in normal day-to-day thinking, and the specific mental state during an ongoing meditation session. The second approach investigates the effect of meditation that persists even when not presently engaged in meditation practice. Both approaches have provided insight into the effects of meditation practice on the mind and brain of humans.

2 The Tübingen Experiment on Śūnyatā meditation

In 2006, the Śūnyatā meditation center in Stuttgart (Germany) contacted Dr. Michael Erb and asked if he would be interested in conducting neuroimaging experiments on brain activity of the Buddhist master of the school, Master Thích Thông Triệt, during meditation in the MR scanner. After discussing the challenges and scope of such an investigation and consulting with another neuroscientist, Dr. Ranganatha Sitaram, the authors consented to embark on a series of experiments to examine Śūnyatā meditation with different levels of expertise. The aim of our study was to investigate whether there are differences in brain activations between meditation and normal day-to-day thinking. And if so, we wanted to further identify brain activations pertaining to different stages and techniques of Śūnyatā meditation. The idea was

to investigate whether specific brain activity is related to different techniques of meditation.

Before discussing in more detail our hypotheses, an explanation of the central doctrine of Śūnyatā meditation is useful for a better understanding of the framework. Buddha described the methods of meditation as follows (as per Bāhiya Sutta, Anderson 2002):

"Please train yourselves thus: In the *seen*, there will be just the *seen*. In the *heard*, there will be just the *heard*. In the *sensed*, there will be just the *sensed*. In the *cognized*, there will be just the *cognized*. When for you, in the seen there is just the seen, in the heard just the heard, in the sensed just the sensed, in the cognized just the cognized, then you will not identify with the seen, and so on. And if you do not identify with them, you will not be located in them; if you are not located in them, there will be no here, no there, or in-between. And this will be the end of suffering."

The word Śūnyatā means emptiness in Sanskrit. This meditation practice has its origin in the Buddhist philosophy that signifies the impermanent nature of form, or, in other words, that objects in the world do not possess essential or enduring properties. In Buddhist spiritual teaching, cultivating insight into emptiness leads to wisdom and inner peace. Śūnyatā meditation practice is aimed at developing an ability to avoid *discursive* (wandering, long-winded) thought. Instead *insight* into the nature of reality is acquired through direct perception of the internal (bodily) and external (sensory) states. So, automatic associations of former episodes from memory, evaluation of perceptions with respect to ones' own existence and planning of future actions will be reduced, whereas self-awareness and awareness of the things in the world will increase.

2.1 Hypothesis

The aim of the present study was to investigate state changes in the brain and accompanying bodily reactions

during Śūnyatā meditation, when confronted with a variety of external stimuli. Based on the rationale behind the Śūnyatā practice, we hypothesized that the following state changes occur during Śūnyatā meditation in comparison to normal day-to-day thinking: First, brain regions that have been associated with memory retrieval, planning and executive control will be deactivated; second, brain areas related to interoception and sensory perception will be activated; and third, the respiration rate (and possibly other physiological signals) will be reduced.

As mentioned in the chapter on Biofeedback in Zen Meditation (Chapter III, Article 4), the Buddhist doctrine is embodied in a practice of meditation that guides the practitioner to "Not Naming the Object" and rather helps him to "see it as seeing" (bare or natural seeing), "hear it as hearing" (bare or natural hearing), "feel it as feeling" (bare or natural touch) and "know it as knowing" (bare or natural cognition).

We investigated the following four different meditative practices: natural seeing, natural hearing, natural touch and natural cognition. The objectives of the study were to identify brain regions associated with the different sensory states of meditation. In addition, we wanted to investigate whether there were common activations across all these practices. This was motivated by the idea that all practices are based on the Buddhist doctrine explained above. We expected to find activations in visual areas (occipital cortex) during natural seeing, in auditory areas (temporal lobe) during natural hearing and somatosensory areas (postcentral gyrus) during natural touch. We also expected brain activations common to all meditation practices in the temporo-parieto-occipital junction (e.g. Brodmann Area (BA) 39), which plays a role in multi sensory integration (Fig. 1).

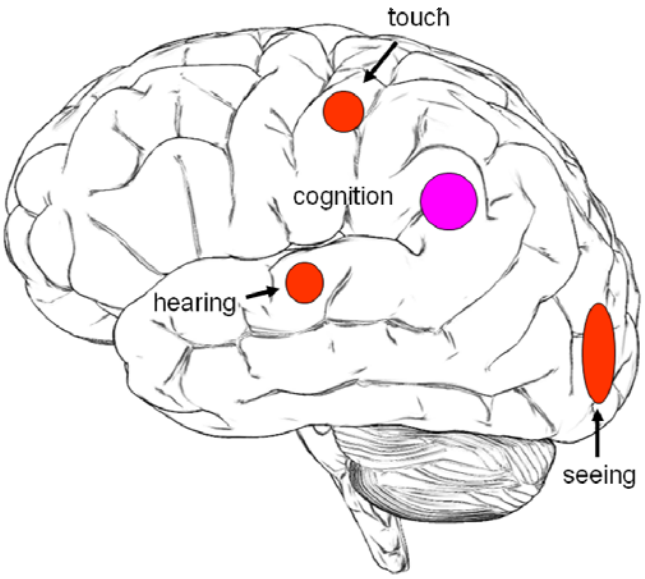

Figure 1: Hypothesis

Since 2006, we have scanned several meditators from the Śūnyatā Meditation Stuttgart e.V. (Germany) and monks and nuns from Śūnyatā Meditation Center in Riverside (CA, USA); a total of 8 participants in 18 sessions, including 6 sessions with Master Thích Thông Triệt.

In this chapter, we will present the findings from the group and a few single cases and then focus on the results of the experiments with the Master. It should be noted here that while the method allows a description of brain activations elicited during meditation, it is not suitable to investigate the effects of meditation on the autonomic nervous system and physical health.

2.2 Measurement Methods

For a better understanding and interpretation of the results of our experiments, it is necessary to provide a summary of the capabilities and limitations of the neuroimaging approach used in this study.

2.2.1 Functional magnetic resonance imaging (fMRI)

Functional magnetic resonance imaging (fMRI) is currently one of the most widely used methods for mapping human brain functions. fMRI measures the hemodynamic response to neural activity in the brain. This is possible because increased activity in nerve cells also increases their consumption of oxygen. The local response to this oxygen utilization is to increase blood flow to regions of increased neural activity, which occurs after a delay of approximately 1–5 seconds. This hemodynamic response rises to its peak of intensity around 4–5 seconds, before falling back to baseline (and typically undershooting slightly). Thus, neural activity leads to local alterations in the relative concentration of oxygenated hemoglobin and deoxygenated hemoglobin, cerebral blood volume and blood flow. As hemoglobin is diamagnetic when oxygenated and paramagnetic when deoxygenated, this difference can be measured by magnetic susceptibility sensitive MR sequences (e.g. echo planar imaging - EPI). The resulting blood-oxygenation-level dependent signal (BOLD signal, Ogawa 1990) is an indirect measure of the corresponding neural activity. In a typical fMRI experiment, the BOLD signal differences can reach up to 5% of its baseline value, implying that these small effects can only be detected by many fMRI measurement volumes and sophisticated statistical analysis methods. The standard design of fMRI experiments is the so-called block design, where blocks with stimulation or task condition are alternated with blocks of rest or control condition. As the length of the hemodynamic response function (HRF) is about 15 seconds, conditions typically alter every 20 to 30 seconds to be able to obtain multiple rises and falls of the response. With a typical spatial resolution of 3 mm, it is possible to scan the whole brain with EPI sequences in about 2-3 seconds, so that as many as 10 brain volumes can be acquired within each block. After averaging the measured volumes in all rest blocks and all task blocks respectively, one can determine the difference between these mean

values to show locations with higher values in task blocks above a selected threshold as overlays on anatomical images, typically measured with a resolution of 1x1x1 mm^3. A preliminary online analysis can be performed immediately on the scanner computer during fMRI acquisition of the experimental protocol. For refined analysis, there are several statistical methods available such as modeling the expected hemodynamic response and estimating parameters of a general linear model with the measured data. In addition some preprocessing steps like head motion correction, that is realigning the images to the first volume, and smoothing of the images can help to improve the statistical power of analysis.

Experimental protocol

We were confronted with two potential problems in the experimental setup. One concerns the scanner environment which is not optimal for meditation: the participants are placed in a narrow scanner with considerable measurement noise. To overcome this issue, it was important to have highly experienced meditators who would be able to adjust to the situation. The other problem is related to setting up suitable task and control conditions. For the present experiment, it was doubted whether meditators could achieve rapid switching between normal thinking (control condition) and meditation (task condition) within a few seconds. It was therefore decided to use longer block lengths of alternating baseline (3 times of 2 minutes each) and meditation (2 times of 3 minutes each) conditions (Fig. 2). This was a reasonable trade-off between the requirements of effective fMRI measurements and normal duration of meditation sessions.

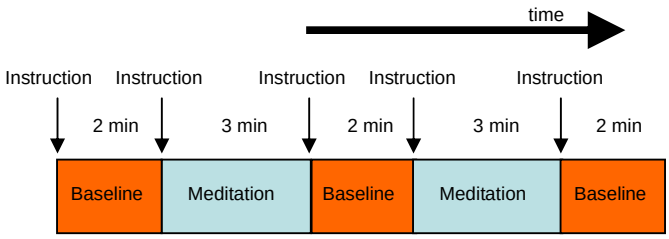

Figure 2: Experimental design

2.2.2 Physiological Signals

In addition to the BOLD signal, we recorded respiration and pulse signals to calculate time courses of respiration amplitude and frequency together with heart beat frequency. From these signals, we tried to estimate the time course of actual meditative states. There was no clear indication or previous data from Śūnyatā meditation suggesting that respiration rate changed as a consequence of the meditation state, or whether control of respiration rate was used to reach the meditation state as in other meditation practices.

After each session, participants were asked to rate the depth of the meditative state achieved in each meditation block by using a questionnaire.

2.2.3 Electroencephalography (EEG)

For some sessions, we were able to simultaneously record EEG signals from 31 electrodes with a MR compatible EEG amplifier and EEG cap (BrainAmp MR, Brain Products GmbH, Munich, Germany). EEG measures the brain's electrical activity directly, while fMRI records changes in blood flow. Combining EEG and fMRI allows for brain signals to be recorded at a high temporal as well as spatial resolution. Lutz and colleagues (Lutz et al. 2004) have shown increased gamma oscillations during meditation. We thus expected to classify different stages of

meditation with the help of EEG signals and use these time courses to find corresponding locations in the fMRI signal.

It should be noted here that there are still technical difficulties associated with combining fMRI and EEG measurement techniques, including the need to remove the MRI gradient artifacts present during MRI acquisition and the cardioballistic artifact (resulting from the pulsative motion of blood and tissue) from the EEG signals. These difficulties may interfere with data interpretation.

2.3 Additional tasks

In addition to the meditation protocol described previously, we performed an extended examination with the Master Thích Thông Triệt with paradigms targeting object recognition and language related areas, different levels of thinking, and the differences between sensory stimulation and no stimulation under normal thinking and meditation conditions. In these sessions, we used a block design with blocks of 30 seconds each for more efficient fMRI measurement. A further set of sessions tested four different levels of awareness, namely, "verbal", "tacit", "awakening" and "cognitive" awareness.

2.3.1 Visual and auditory naming of animals and tools

In the visual naming task, we projected pictures of animals and tools onto a screen inside the MR scanner that was visible to the participant via a mirror. The participant was instructed to name the object using inner speech (without actual vocalization). As we were only interested in regions engaged in object recognition and naming and not primary visual processing, we showed stimuli of scrambled images as control condition.

In the auditory naming task, we presented short sounds from animals and tools to the participant with MR compatible headphones. Each sound had a duration of 2.5 seconds and was presented randomly two times in the experimental session. To activate the primary auditory regions in a comparable way, we used the same sounds but

scrambled in the control periods. Control and task periods were signaled to the participant with a red or green rectangle, respectively. With these tasks, we wanted to identify brain areas for object recognition and language.

Visual naming should activate the higher level of the ventral visual stream including the fusiform gyrus (BA37, bilateral) engaged in visual object recognition, as well as the language areas for generating the corresponding nouns (Wernicke's area, BA22, BA39, BA40, left) and performing inner speech (Broca's area, BA44/45, premotor area, BA6, left). Auditory naming should activate the superior temporal gyrus and again the language and speech areas. Hence, with this approach, we expected to identify the brain regions where we expected changes in different meditation methods.

2.3.2 Different levels of thinking

To distinguish between different levels of thinking, we conducted a series of sessions with the Master. The protocol comprised 13 blocks with different thinking tasks (duration = 30 seconds), namely "intellect", "mind-base", and "consciousness" in alternating order. These terms were displayed as written words on the screen for the corresponding period of 30 seconds each and were used as a trigger for the participant to invoke "thinking." "Intellect" corresponded to cognitive thinking and reasoning, whereas the "mind-base" condition involved relaxed playing around with thoughts ("inner chatter") and "consciousness" referred to being aware of the self. "Counting" was used as a reference task as this can be done more or less automatically.

2.3.3 Different levels of meditative depth (awareness)

In an additional series of sessions with the Master, four different levels of meditation depth as per Buddha's description were investigated: "verbal awareness"[1], "tacit awareness"[2], "awakening awareness"[3] and "cognitive awareness"[4]. These measurements were also performed in

a block design of 2 minutes of baseline (3 times) and 3 minutes of meditation (2 times), as much faster switching between the levels could have been difficult. Master Thích Thông Triệt characterized these four states in the following way:

1. **Verbal Awareness** is equivalent to the first level of Samādhi, or *Savitakka Avicāra Samādhi*, in the original teachings.

The inner silent dialogue, or *vicāra*, refers to the mental images that arise from the memory during the sitting meditation. It hinders the practice of meditation. To prevent the inner silent dialogue from surfacing to consciousness, the Buddha taught "silent thinking", or *avicāra*, a meditation technique characterized by silently thinking the phrase, "When I breath in, I know I am breathing in; when I breath out, I know I am breathing out". This technique quiets the inner dialogue by focusing the mind on the task of breathing. The practitioner then experiences the state of "*Vitakka* without *vicāra*" Samādhi, or verbal thinking but noninner-silent-dialogue Samādhi.

2. **Tacit awareness**, *Avitakka Avicāra Samādhi*, similar to the second level of Samādhi, meaning "wordless thinking and nondiscursive dialogue".

Tacit awareness means wordless or non-verbal awareness. At this state of awareness, the practitioner masters the chattering mind during four common daily activities: walking, standing, lying, and sitting. By quieting the mind, the practitioner inactivates the networks of perception, one component of the Five Aggregates which, according to the original meditation and Zen sect, is the most important Samādhi. Through this level of Samādhi, the practitioner is able to attain all the other levels of meditation, such as *Śūnyatā* Samādhi, Formlessness Samādhi, or Wishlessness Samādhi. This is in contrast to the tradition of The Elders (*Sthaviravadin*) and *Sarvastivadah*. The Elders commended mind concentration (*Citta-ekkaggatā*)

3. **Awakening Awareness** is equivalent to the third level of Samādhi, *Sati-Sampajañña*, and is defined as the "full awareness or clearly comprehensive awareness without attachment to the objectives".

Awakening awareness is different from Wakeful Awareness which is characterized by the association of the Objective with Consciousness. Awakening Awareness is a state of the mind without the involvement of the subjective, yet the presence of the Awareness only. The Buddhist Developers assumed the term "true self" or "pure self" in which the practitioner attains Samādhi in all four daily activities.

4. **Cognition Awareness** is equivalent to the fourth level of Samādhi.

At this stage, the mind is so tranquil that the delicate breathing ceases from time to time. The Buddha calls it the "three immobile or unshakeable formations" which refers to the (1) standstill of the discursive thinking in which neither *Vitakka* nor *Vicāra* arises, (2) the standstill of thoughts in which neither feeling nor perception arises, and (3) the standstill of the body, where the breathing stops occasionally. In fact, when the practitioner reaches this stage of meditation, he can go in or out of Samādhi at ease. In Theravada Sutras, the Buddha described this status of Samādhi as "finger snapping Samādhi". The sixth Patriarch, Hui Neng, called it the "Samādhi needless to be in or out."

2.3.4 Different meditation tasks

As already mentioned at the beginning of this chapter, we utilized four different methods of meditation, namely natural seeing, natural hearing, natural touch and natural cognition. We used control conditions very similar to the meditation tasks to ensure sensitivity to the effects of specific meditation practices. For the condition "seeing" one picture was displayed on the screen in the control block

(baseline, 2 minutes), when the participant focused attention on the image and analyzed its content (normal seeing). The same picture was used in the following meditation block (3 minutes) with natural seeing. Hence, the external input (stimulation) was exactly the same in both conditions, the only difference being the mode of processing of the input. In the same way, we played identical music continuously over the MR compatible headphones in the baseline condition and in the "natural hearing" condition. The third condition "natural touch" consisted of brush strokes that were applied every second to the right palm of the hand of the meditator. Short beeps were used to pace the speed of the strokes. The fourth condition "natural cognition" was without any sensory stimulation. The start of a new block was signaled by auditory instructions and visually by the words "Baseline" and "Meditation", respectively, in each run.

In order to test the different activations caused by the sensory input, we conducted a series of measurement sessions in which the external input (seeing, hearing, touch) was switched on and off every 30 seconds. These sessions were repeated in the day-to-day thinking and meditation condition.

2.4 Data analysis

Analysis of the fMRI data incorporated several steps. After transferring the data to the local computer network and converting them to a file format usable for the analysis program package, the three dimensional volumes of each measurement time point were realigned to the first volume of the session to compensate for head movement over the whole measurement period. This is very important because the subsequent analysis is calculated for each volume element (voxel) separately. Therefore, corresponding brain locations have to be in the same position for the whole run. Unfortunately, this method can only correct replacements between volumes and not distortions caused by fast movements in the time period of the data acquisition.

Therefore, in the case of such fast movements, there are still remarkable signal variations in the data after movement correction. (This is the reason, why it is so important to fix the head with a foam cushion inside the scanner while the fMRI measurement is running.) In the case of group studies, it is necessary to transform the individual's brain images into a standard coordinate system to ensure that corresponding brain regions of the individual participants are in the same position in the new datasets. One then can localize specific positions of activations in computerized brain atlases and databases to locate the precise anatomical region, and to compare with findings from other experiments.

The standard data analysis programs used in analyzing fMRI data typically estimate a general linear model (GLM) to the measured signal time courses of small brain volume elements (voxels) in order to ascertain which parts of the brain were activated in the given task. The problem with this kind of analysis is that the time course of task performance has to be known. In our case, we could only use the time course defined by our instructions. To also obtain an objective measure for the meditative state, we used peripheral physiological signals and EEG signals. The time course of the meditative state estimated from the time courses of these different signals could then be used to search for the corresponding time courses in fMRI signals. This, however, is only possible if there is a direct and constant relationship between the signals and the meditative state, which is by itself an unresolved topic of research (e.g. Lutz et al. 2004).

In a second approach, we used a data driven method, the so-called independent component analysis (ICA, see Calhoun et al. 2009 for a review), which separates from the mixed signal time-course different spatial patterns of activations which are statistically independent of each other and hence may have originated in different sources. From these automatically generated patterns, we had to sort out

components with a time course related to the task. This method allows identification of constant activations over the whole meditation period as well as transient time courses. Other components related to movement or measurement artifacts may be used to correct the data.

2.5 Results

2.5.1 Analysis of the Physiological Signals

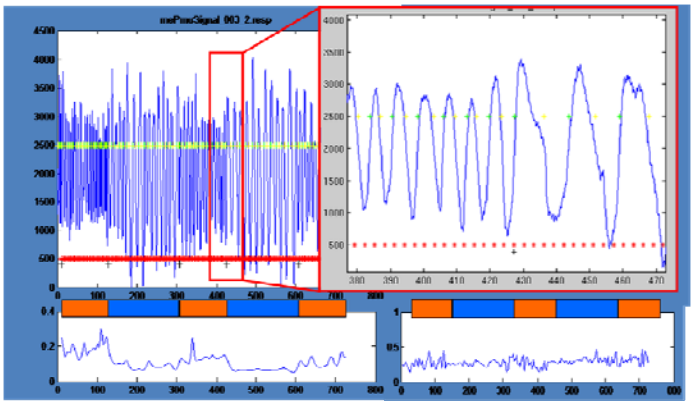

Figure 3: Physiological signals: Decrease of respiration rate

The analysis of the physiological signals revealed some interesting effects. In one participant, the time course of respiration showed a clear reduction in frequency and an increase in amplitude in the meditation periods compared to normal thinking periods (Fig. 3). Unfortunately, all other participants did not show this effect. Still another participant showed a reduction in variations in the meditation period but no changes in amplitude or mean frequency (Fig. 3 right bottom).

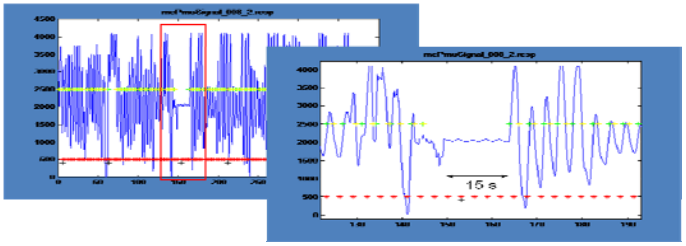

Figure 4: Physiological signals: Interruption of respiration

In a session in which the Master performed natural cognition meditation (Fig. 4), respiration was interrupted for about 15 seconds at the end of the first meditation block. This behavior has frequently been cited as reflecting deep state meditation. Analysis of pulse rates showed only small and unsystematic effects. Unfortunately, it was generally not possible to reliably infer the meditation state from the physiological signals.

2.5.2 EEG

Due to technical problems, it was not possible to completely remove the MRI gradient artifacts (Fig. 5 top). After filtering out the remaining frequency components, we could determine a small change in EEG amplitude in different frequency bands.

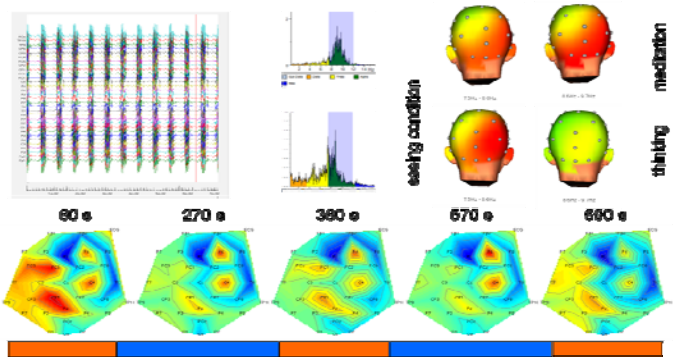

Figure 5: EEG data analysis

While we observed a decrease of beta activity in the meditation period over left parietal and central electrode sites (CZ, CP1, FC), beta activity was increased over the electrodes in right central electrode sites (C4, F4) (Fig. 5 bottom). Preliminary time-frequency analysis of the EEG signals pointed to increased power in the lower alpha bands over frontal and parietal electrode sites during meditation compared to normal thinking conditions in the stimulus switching task.

2.5.3 fMRI

2.5.3.1 Group analysis

We first calculated average group results from all investigations of the meditation condition. Although individual results were quite different, we nevertheless found some interesting activations and deactivations already in our preliminary analysis, which assumed more or less the same activations over the whole meditation periods (Fig. 6). There were higher activations in the visual cortex while performing meditation in the seeing condition, whereas highest activation in the hearing condition was found in the left Heschl's gyrus. Main activation in the touch condition was located in the left insula, and the cognition task generated additional activations in regions of the parietal lobes.

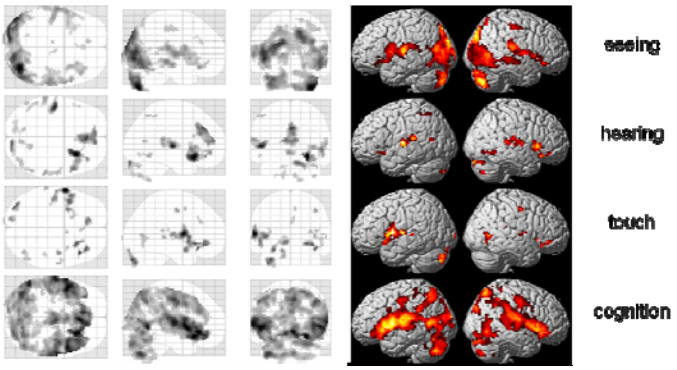

Figure 6: Group results of the four tasks

A more elaborate analysis method allowing transient time courses of the BOLD-signal (the so called independent component analysis, ICA) showed comparable results. We found the following common activations and deactivations in all 4 different meditation types when contrasting meditation with normal thinking (Fig. 7):

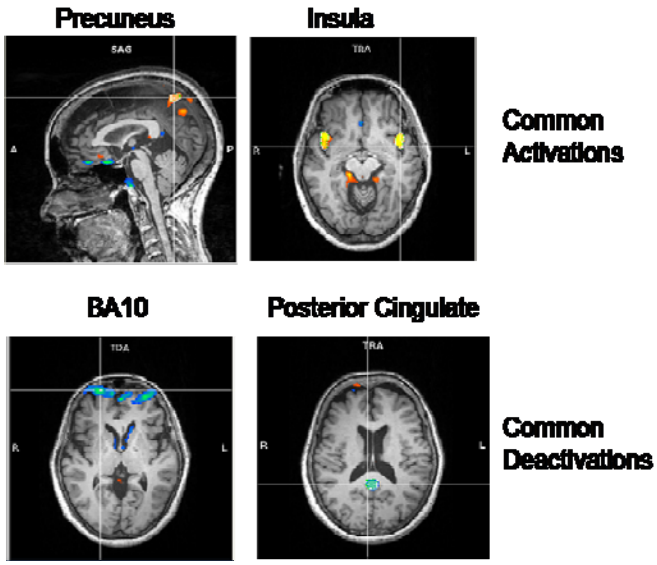

Figure 7: ICA common results

- activations in bilateral precuneus, implicated in self-processing and consciousness (Cavanna 2007),
- activations in the bilateral insula, implicated in interoception (Craig, 2009),
- deactivations in frontopolar region of the brain, namely, BA10, involved in strategic processes including memory retrieval and executive function, and
- deactivations in the posterior cingulate, implicated consistently in the default network of brain function (Raichle, 2001).

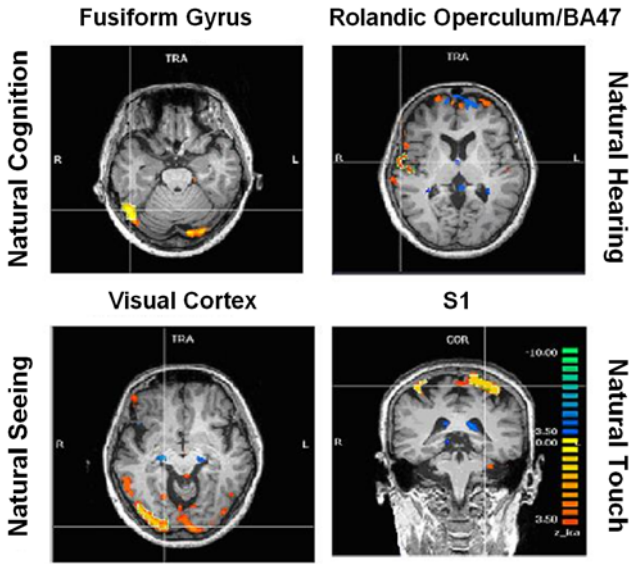

Figure 8: ICA specific results

Activations pertaining to specific meditation types (meditation versus normal thinking contrast) were as follows (Fig. 8):

1. enhanced activation of the fusiform gyrus (FFG) during natural cognition meditation condition,
2. enhanced activation of the right rolandic operculum and inferior frontal gyrus (BA 47) during the natural hearing meditation condition,
3. enhanced activation of the visual cortex during the natural seeing meditation, and
4. enhanced activation in the somatosensory cortex during the natural touch meditation condition.

2.5.3.2 Individual analysis from experiments with the Master Thích Thông Triệt

Some experiments were only performed with Master Thích Thông Triệt as he is able to reach deeper and more intense states of mind.

Visual and auditory Naming of animals and tools

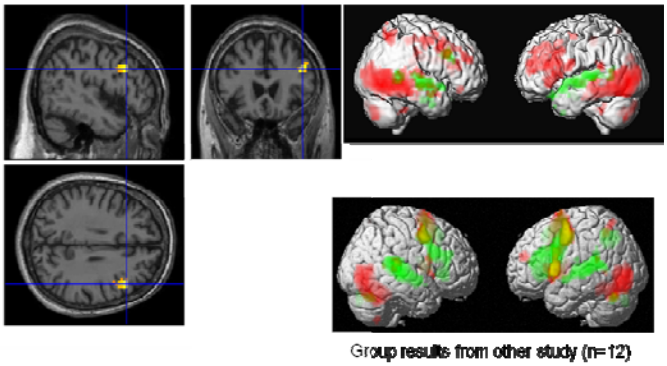

Figure 9: Visual (red) and auditory (green) naming (Master top, group bottom) left: common activation in the right IFG

With the visual and auditory naming task (Fig. 9), we could identify differentially activated regions in visual and auditory association areas and common activations in language areas (Broca's and Wernicke's areas). In particular, we found in the visual naming condition activations in the bilateral visual cortex in the ventral stream consisting of middle occipital gyri (BA 18, BA 19), fusiform gyri (BA37), inferior temporal gyri, and middle temporal gyri. These structures are associated with object recognition and form representation. Further, the cerebellum (IX, X) and inferior parietal lobes were activated prominently in the right hemisphere. In contrast to these regions, the superior temporal gyri lighted up only in the auditory naming task. Regions common to both tasks were the triangular part of the right inferior frontal gyrus (IFG) and the left superior temporal gyrus (BA22, BA42). As the Master is right-handed, a right dominance of language processing has low probability but is still possible. In more than 95% of right-handed men and more than 90% of right-handed women, language and speech is sub served by the brain's left hemisphere, but in left-handed people, the incidence of left-hemisphere language

dominance has been reported as 73% and 61% [Knecht 2000]. However, one should exercise caution in concluding that this difference compared to a group of 12 right-handed students is an effect of meditation.

Different levels of thinking

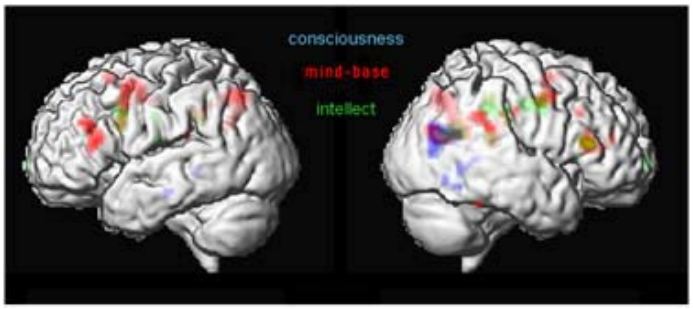

Figure 10: Different levels of thinking

The first analyses of these sessions (Fig. 10) demonstrated common activations in the posterior end of the right middle temporal lobe and the angular gyrus (BA39). This area is implicated in the integration of multimoldal data and interpretation of written words (Damasio 1994). Persinger and colleagues (2001) have shown, that out-of-body experiences and mystic experiences could be triggered, if the region of the temporal lobe is stimulated with transcerebral weak complex magnetic fields. The experimental condition "intellect" showed activations in the dorsolateral superior frontal gyrus. Commonly activated regions with "intellect" and "mind-base" condition activate the right triangular part of the inferior frontal gyrus (Broca's area, BA 44/45) and the brain regions to the left and right precentral gyrus (premotor cortex, BA6). Brain areas involved in "conscious" thinking were mainly constrained to the temporal and parietal lobe. It is important to note, that the area within BA 44/45 common to "intellect" and "mind-base" thinking is in the same region, but not at the same position as the area in the right frontal lobe that was found to be commonly activated by the visual and auditory naming task.

Different levels of meditation depth (levels of Awareness)

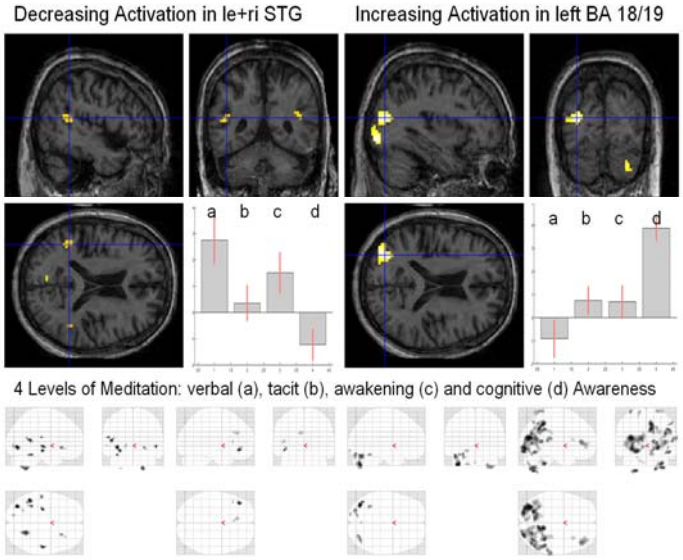

Figure 11: Four levels of Awareness

Analysis of these different meditation levels (Fig. 11) showed a decrease of activation in the left and right superior temporal gyrus (STG) and an increase of activation in the left higher visual areas (BA 18/19), the right inferior frontal gyrus (IFG), the right insula and right cerebellum (Crus1). Inspecting the four different "glass" brains (maximum intensity projection, MIP) (Fig. 10, bottom) one notices a widespread global increase in the occipital lobe for cognitive awareness.

Different Meditation tasks with and without stimulation

In our first experimental protocol (section 2.2.1), external stimulation was held constant to elicit only the differences between normal thinking and meditation. In the currently reported experiment, the design was changed so that the brain state was kept constant (either baseline or meditation), while the external stimulation was switched on and off. For this experiment, we used a design with 11 blocks of 30 seconds resulting in a session length of 5

minutes 30 seconds. Each of the three tasks "seeing", "hearing" and "touch" were performed two times, first with normal thinking and in the next run with meditation. Comparing the activations induced in these two sessions, we identified differences in processing external stimuli in the different brain states.

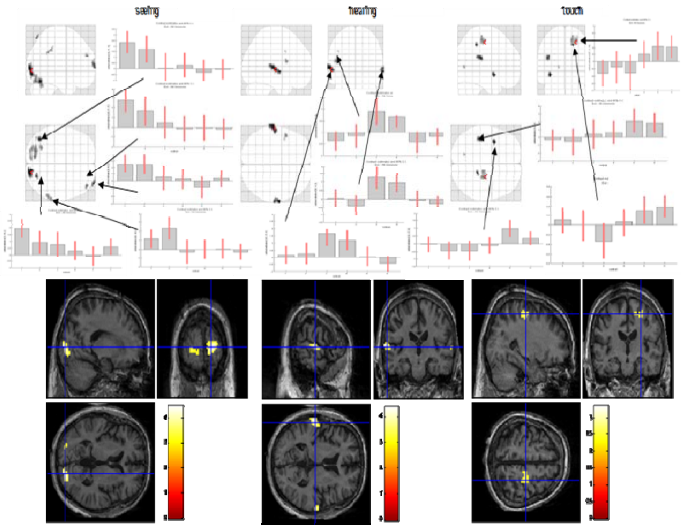

Figure 12: Switching stimulation (seeing, hearing, touch; normal thinking and meditation)

In the "seeing" session (Fig. 12, left), we found activated regions in the primary visual cortex on both sides, the left cerebellum and left fusiform gyrus, the right supramarginal gyrus and inferior parietal lobe (BA40) and the middle and superior frontal gyrus (BA10). In the "hearing" condition (Fig. 12, middle), we identified the main activations in left and right superior temporal gyri (BA22/42) and in the left frontal operculum (BA44/45). In the "touch" condition (Fig. 12, right), we found activations in left insula and rolandic operculum and in right postcentral gyrus, the primary somatosensory area. We generally observed a smaller amplitude in the meditation condition compared to normal thinking in all three primary sensory areas. This

can be interpreted as reduced sensitivity to changes of external stimulation in the meditative state. Two explanations are possible, that is either the gain of the external input is decreased or the level of activation is maintained by "filling up" with internal generated activity.

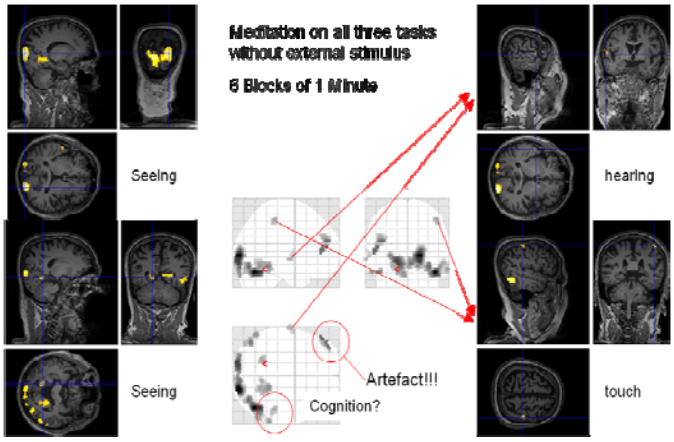

Figure 13: Cognition with block length of one minute

It was not possible to find a comparable design for the "cognition" condition as there was no external input. Therefore, we decided to use a design with 1 minute blocks of normal thinking and meditation without external input and simultaneous concentrating on "seeing", "hearing", "touch" and "cognition". This fast switching between the two states was only possible with a very experienced meditator as Master Thích Thông Triệt. When the blocks were only 30 seconds long, he experienced problems leaving the meditative state. We thus settled for 60 second blocks. In this session, the online evaluation already provided some findings. However, more sophisticated analysis including the consideration of movement parameters resulted in less (false positive) activated regions. Nevertheless, we could identify regions in the visual (occipital lobe, BA17, BA19), auditory (Heschl's gyrus, BA41) and somatosensory (BA3) areas showing

enhanced activation in the meditation state compared to the control state.

3. Conclusions

Our results show that Śūnyatā meditation enhances perception of external stimuli and interoception of internal bodily states, as shown by heightened activations in sensory areas and the insula when compared to the normal, day-to-day thinking state in sessions with long meditation periods (3 minutes) and constant external input. In the sessions with fast changes of external stimuli (30 seconds), the pattern was reversed: brain activation was reduced in the primary sensory areas in the meditation state compared to intellectual thinking. This can be explained by an additional activation in the time periods without external stimulation in the meditation state as was found in the cognitive condition. If this supplementary activation is not purely additive, that is the enhancement of activation with external stimuli is smaller than the inserted activation without external stimuli, it will result in a reduced difference (Fig. 14).

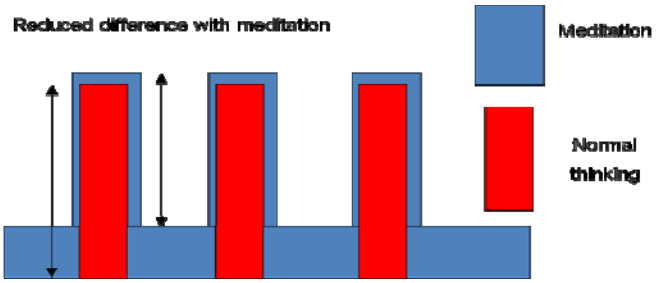

Figure 14: Reduced difference in meditation state

Our findings suggest that Śūnyatā meditation reduces discursive thought as shown by a consistent deactivation of the BA10, a brain region involved in memory retrieval, planning and executive function. It enhances the self-conscious state reflected in the increased activation of precuneus. Being in a meditative state seems to replicate

the default state of brain function as shown by the deactivation of the posterior cingulate. The analysis of meditation depth shows decreasing activations in semantic language area (STG) and increasing activations in higher visual areas. Our work supports the view that experienced meditation practitioners are able to produce repeatable and reliable states and verbal reports of meditation, even in the uncomfortable environment of the MR scanner.

Experiments of the kind described here are difficult to perform and still hampered by problems. The findings thus need to be interpreted with caution. Nevertheless, the first results are promising and more evidence needs to be gathered. We plan to expand the study to different levels of experience and other meditation methods to arrive at a framework that allows describing the brain activity in different mental states. The type of investigation performed here requires participants with a strong self control of mind obtained by many years of training. Observation of mental processes in these participants can help to isolate sub functions of mind and search for the underlying neural substrates.

Acknowledgements

We thank all the participants and supporters of this study from the Śūnyatā Meditation Stuttgart e.V[1]. (Germany) and monks and nuns from Śūnyatā Meditation Center in Riverside (CA, USA).

In addition, we thank Maike Borutta and Vinod Kumar for assistance with the fMRI measurement; Adrian Furdea and Ander Ramos for conducting EEG measurement; Prof. Dr. Brigitte Stemmer for helpful comments on this manuscript; and last but not least Prof. Dr. Wolfgang Grodd and Prof. Dr. Niels Birbaumer for providing the opportunity to use our time and the equipment to perform this study.

1. e. V = eingetragener Verein = Association

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Article 2

Neuroelectric and Hemodynamic Correlates of Śūnyatā Meditation – Combined fMRI-EEG Study

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INTRODUCTION

The word meditation describes practices that self-regulate the body and mind. *Śūnyatā* (Sanskrit - emptiness) meditation stems from the Buddhist philosophy that signifies the impermanent nature of form; meaning that objects in the world do not possess essential or enduring properties. In Buddhist spiritual teaching, cultivating insight into emptiness leads to wisdom and inner peace. Śūnyatā meditation practice is aimed to develop an ability to avoid discursive (wandering, long-winded) thought, and instead acquire insight into the nature of reality through direct perception of the internal (bodily) and external (sensory) states.

AIM and HYPOTHESES

The aim of the present study was to investigate state changes in the brain and physiology during Śūnyatā meditation when participants are confronted with a variety of external stimuli: visual, auditory and tactile. Based on the rationale behind the Śūnyatā practice, we hypothesized that the following state changes occur during meditation in comparison to normal day-to-day thinking:

1. Memory retrieval, planning and executive control areas of the brain will be deactivated;
2. Brain areas related to interoception and sensory perception will be activated.

MATERIALS and METHODS

Participants: Experienced Meditators

Participants included the Śūnyatā meditation master Thich Thong Triet (age: 80 years, years of meditation experience > 30, meditates 7 hours per day), 1 other expert monk and 2 expert nuns (mean age: 70 years, years of meditation experience > 15, meditate 4 hours per day), and 2 more intermediate practitioners (mean age: 50 years, years of meditation experience > 5, meditate 1 hours per day).

Experimental Protocol

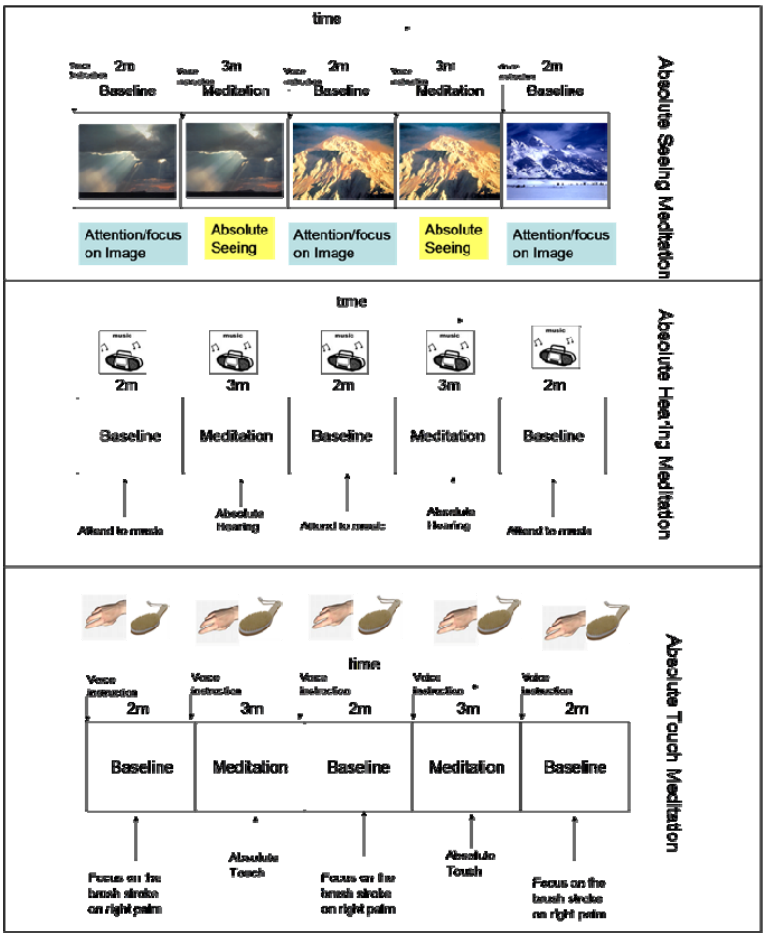
The experimental protocol comprised of 3 blocks of baseline, normal day-to-day discursive thinking (duration=2min) and 2 blocks of meditation (duration=3min) alternating with one another. Four methods of meditation, namely, absolute seeing, absolute hearing, absolute touch and absolute cognition were

measured in separate sessions, with the above protocol, in accompaniment with visual, auditory, touch stimuli and no stimuli, respectively. Identical stimuli were presented in the baseline and meditation blocks to tease-out the influence of meditation practice on brain activations.

In addition, four different levels of meditation depths as described in Buddhism were investigated, namely:

1. Verbal awareness
2. Tacit awareness,
3. Awakening awareness
4. Cognitive awareness.

These measurements were performed in the same block design as above.


time
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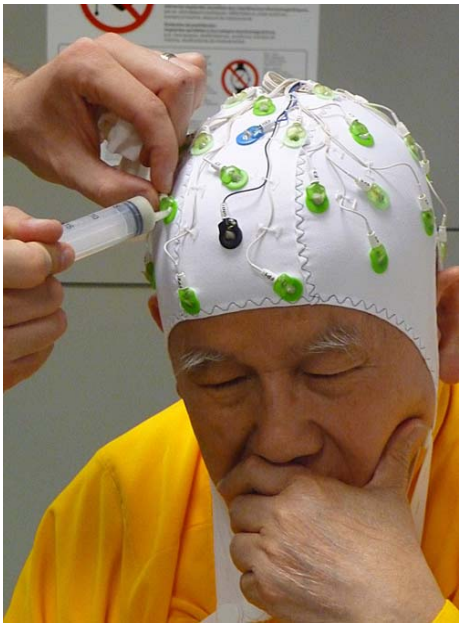
fMRI, EEG and Physiological Measurements (electroencephalogram)



RESULTS

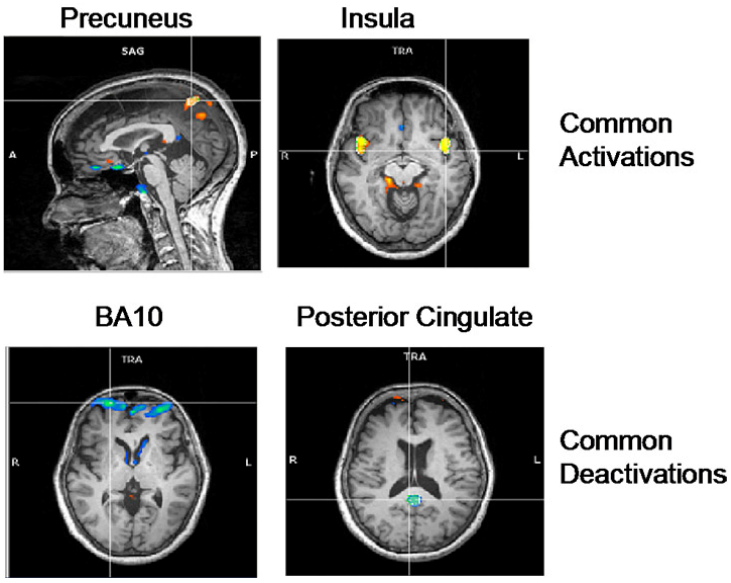
A standard echo-planar imaging (EPI) sequence on a 3T whole body scanner (Siemens, Erlangen, Germany) with the following parameters was used: TR=3000ms, TE=40ms, number of slices=36. For superposition of functional maps upon brain anatomy a high-resolution T1-weighted structural scan of the whole brain was collected from each subject. The above protocols were repeated on different days (5) in a series of measurements spanning 3 years, with the last session utilized for simultaneous measurement of EEG (with BrainAmps MR compatible amplifier and EEG cap) and fMRI. In addition, pulse and respiration were measured and at the end of each run, meditators were requested to make subjective ratings of depth of meditation they achieved in each block of meditation.

fMRI Results

Group Independent Component Analysis Results

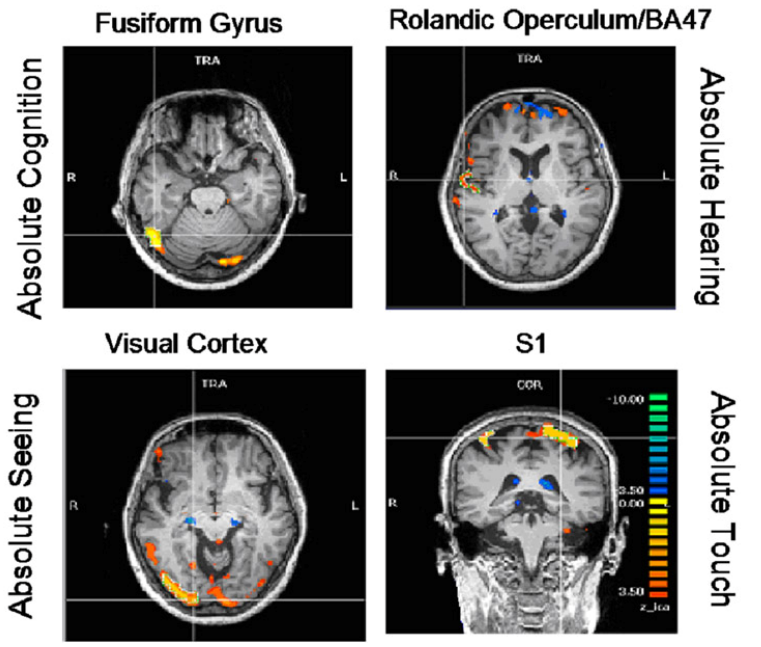
Common activations and deactivations across meditation types:

1. Activation in bilateral Precuneus, implicated in self-processing and consciousness (Cavanna 2007).
2. Activation in the bilateral insula, implicated in interoception (Craig, 2008).
3. Deactivation in frontopolar region of the brain, namely, BA-10, involved in strategic processes including memory retrieval and executive function.
4. Deactivation in the Posterior Cingulate, implicated consistently in the default network of brain function (Raichle, 2000).

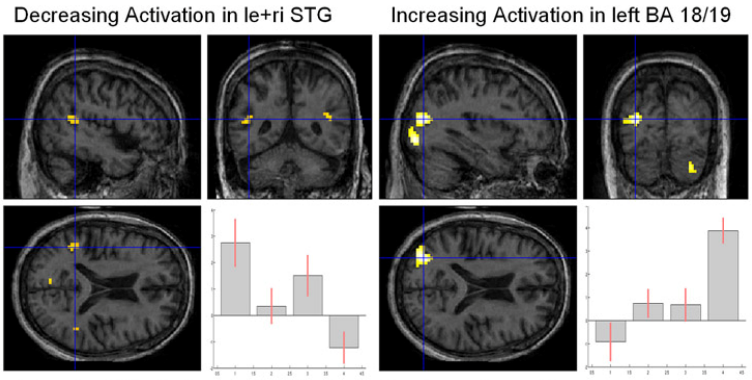


Meditation type specific activations:

1. Enhanced activation of the fusiform gyrus (FFG) during absolute cognition meditation,
2. Enhanced activation of the right rolandic operculum and inferior frontal gyrus (BA 47) during the absolute hearing meditation,
3. Enhanced activation of the visual cortex during the absolute seeing meditation, and
4. Enhanced somato sensation during the absolute touch meditation.



Analysis of different meditation levels shows a decrease of activations in the left and right superior temporal gyrus (STG) and an increase of activation in the left higher visual areas (BA 18/19), the right inferior frontal gyrus (IFG) and the right insula.

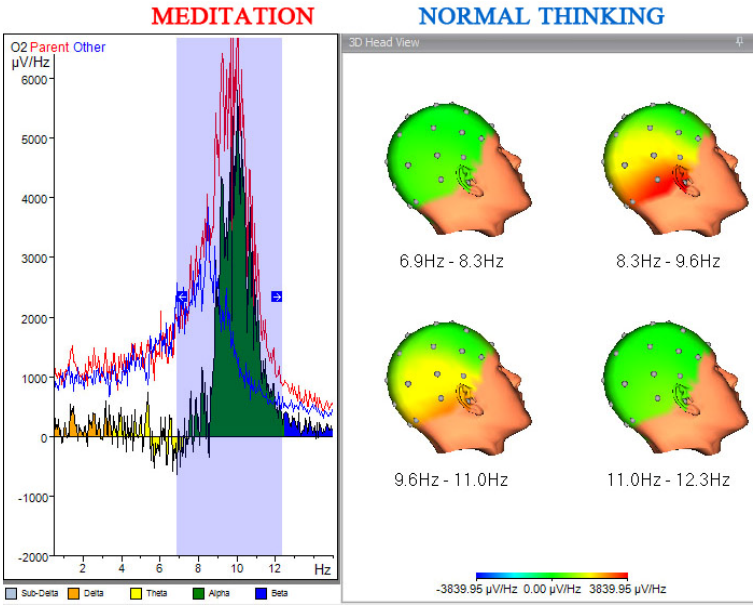


4 Levels of Meditation: verbal, tacit, awakening and cognitive Awareness

EEG Results

Absolute Seeing Meditation

Meditation of the different senses, namely, absolute seeing, hearing and touch showed increased alpha power in duration meditation compared to normal thinking in the occipital, temporal and sensorimotor regions, respectively, in congruence to the fMRI results.



CONCLUSIONS

Our results show that Śūnyatā meditation enhances perception of external stimuli and interoception (of internal bodily states) as shown by heightened activations in sensory areas and insula when compared to the normal, day-to-day thinking state. This type of meditation reduces discursive thought as shown by a consistent deactivation of the BA-10 involved in memory retrieval, planning and executive function.

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Article 1

THE LIMBIC SYSTEM

INTRODUCTION

The role of Buddhist Meditation

Nowadays, when we learn and practice various meditation subjects, we need to provide ourselves with new knowledge. This includes the following:

- neurons**;**
- biochemical substances in the nervous system and the endocrine glands;
- the functions of the brain;
- and most importantly, how the Mind functions while we implement meditation subject-matter in the four postures: walking, standing, lying and sitting. Correct or inaccurate practices are both based on this fundamental principle.

We usually include these subjects in the lesson entitled "Scientific knowledge". In the elementary and Prajna intermediate classes, we place strong emphasis on the theoretical aspects of Scientific learning and the techniques of implementation. These two categories of learning combined with Dharma and Meditation Studies lay the foundation for learning Buddhist meditation, in an endeavour to improve the quality of life in the twenty-first century.

The value of interaction

The value of meditation for human life lies in the interaction of the mind, the teaching, the brain, the nervous system, the endocrine glands and the biochemical substances in the limbic system. That is why, in each particular epoch, meditation becomes a successful and efficient method for the body and mind to obtain spiritual insight.

Nowadays, developed nations equipped with advanced technologies and high intellectual standards regard meditation as a *tool c*apable of adjusting psychological states, curing psychosomatic diseases, especially stress, and circadian rhythm disturbances (or turning upside-down sleep-wake cycles) causing female breast cancers and insufficient melatonin, which helps human beings lead a more harmonious life, increase work productivity, and creativity, and cultivate generosity, tolerance and altruism in their hearts.

Some nations—including Great-Britain, Japan and the United States—have already welcomed meditation in their educational systems. We hope that, in the future, the Departments of Education in various countries will include Meditation as a school discipline to guide elementary and secondary pupils in the development of their spiritual insight.

The role of the Limbic system

The present essay is a contribution to the foundation of this spiritual science. It is also a means to promote the important role of the limbic sytem in meditation practice. Indeed, from the moment we put into practice whichever subject-matter, *we* use our mind to apply the technique to apply the teachings of Buddha or of the Patriarchs.

In this process, the mind sends out continual nerve impulses to the site of the cerebral cortex connected with the *intention* of the mind. The cortex is responsible for interpreting the order by continually emitting informative neuro signals in the form of waves, called "brain waves", and transmit them to the limbic system and other related sites. Then, an axis or transmission chain of nerve impulses is opened. These nerve impulses operate in the form of brain waves or as neurotransmitters. They continually operate in the limbic system following the instructions given by the mind.

The limbic system consists of a great number of centers. These interact to bring beneficial or harmful results to the body, the mind or the spiritual insight through the release of biochemical substances according to the instructions given by the mind in the form of nerve impulses.

The role of the mind

Generally speaking, correct or inaccurate practices, good or bad results, all lies on the response process of the limbic system. The core point that we have to pay attention to is from which mechanism the informative neural signals originate via the "instructions" of the mind.

- If good results are obtained, it is due to the fact that the meditator's mind knows how to correctly implement the techniques. In Zen terms, it is an awakened mind, which does not infer, root through the past, discriminate: it simply applies the technique in the *hic et nunc* (here and now) mode. In this process, that mind has unintentionally penetrated the sensory world. If eyes are used to see an object in the *hic et nunc* mode, then the seeing process will stimulate the nature of seeing mechanism at the back of the left hemisphere. The nerve impulses will simultaneously go straight to

the nature of awareness mechanism. At that very moment, one can recognize clearly how the object is before one's eyes while in the mind, not a single hint of flurry, anxiety, harshness, irritation arises whatsoever. The network of nerve fibres related to the nature of seeing or of the awareness mechanism is immediately activated for direct connection with the limbic system mechanism located in the middle of the brain. At that moment, through brain fMRI imaging, we can see the color (in the computer image) in the internal part of the limbic system is red, which indicates that the area inside is activated. At the same time, another transmission chain axis is open, starting with the hypothalamus then the pituitary gland and finally the autonomic nervous system.

The curing of diseases rests upon the basic activation along this axis. We can then note the importance both of correctly applying the techniques of the awakening of the mind. The mind emits impulses, that directly reach the awareness area and the other constituents of the limbic system. Following that is the action of a chain axis. Chemical substances beneficial to the body will be released resulting in a healthy body, a peaceful mind and wisdom.

- Conversely, unsatisfactory results are due to the use of two of the three frontal mechanisms: the thinking mind, consciousness and distorting intellect.

Correct meditation does not only involve decisiveness and commitment to regular practice; rather, the key point is to know which techniques are appropriate to the activation of a given area of the cortex.

Only through such a clear process can we recognize the important role of the limbic system. It helps us gain

experience in the good or bad results reaped by the body, mind and spiritual insight through a meditation session of ten to sixty minutes. But here, the mind plays the decisive role: it chooses the subject-matter, it implements, it activates the brain. In the end, it reaps good or bad results through the release of biochemical substances by the nervous system and the endocrine glands. These substances are the agents of the balance or the imbalance of the internal organs and limbs. And what lies behind the mind? It is self, in harmony or in disharmony, blissful or discontented, healthy or ill.

Being awake: a necessary condition

For that reason, we have to be awake, in order not to mistake correct and inaccurate meditation practices. Being awake allows us:

- to choose the mental object suitable to meet the demands and adapt to the capacities;
- to choose the technique corresponding to the mental object;
- to know how to combine the mental object and the technique to act on one of the three or four awareness mechanisms.

Being awake concerns the intellect, for in reality, we are nothing but a thought. In sum, being awake is a necessary condition. It is a determinant for the success of meditation, this enables the harmony of body and mind and the development of enterprising quality.

Hopefully, this complementary essay will help the reader increase the body of scientific knowledge connected with the meditational practices of Contemplation (Quán), Pacification of the active mind or mental tranquillity (Chỉ), Absorption (Định) and Spiritual Insight (Huệ). It will also

show clearly the reasons for practicing regularly in the four postures—walking, standing, lying and sitting—that is:

- to educate the neurons in adopting new habits: working their way to the path of silence;
- to store data in the long-term memory reserve;
- to build up a cognitive map.

In meditation, cognitive maps play a decisive role concerning *the penetration principle of* abstract subject-matters.

One must build up a cognitive map in order to gain a solid experience in meditative absorption, eliminate habits of thought and defilements, remove fetters and proclivities and reach spiritual wisdom.

Part 1

The Origin of the Limbic System

History - An outline

Paul BROCA, a French neuroanatomist (1824-1880) was the first person to coin the word "**limbic**" in 1878. He was researching in the area surrounding the brain stem, under the cerebral cortex—the cingulate, the center of perceptions—above the corpus callosum and the hippocampus, the center of long-term memory, in the middle of the two temporal lobes. He noticed this area had a round-edged shape, lying at the way-in and way-out of the cerebral hemispheres, like a threshold. Hence he gave it the name "limbic" (Latin, limbus = rim, ring). Later on, he used the phrase "the greater limbic lobe" ("le grand lobe limbique") to describe the lower faculties area as opposed to the "higher faculties" on the cortex.

In the mid-twentieth century, a great number of neuroscientists called the limbic system "the visceral brain" to indicate its key role in the autonomic nervous system (responsible for the regulation of the visceral functions), and in the emotional and olfactive aspects. In 1952, Dr. Paul McLean (b.1913), an American brain researcher at Yale Medical University, formally called it "the Limbic System".

Nowadays, neuroanatomists and neuroscientists all use this phrase to refer to the structural organization of the system comprising a bundle of intricate nerve fibres that constitute a circuit system and the gray matter areas encircling the thalamus in the midbrain of each hemisphere and in the diencephalon. The structure is ring-shaped and constitutes a neural circuit surrounding the upper part comprising the olfactory regions, the cingulate gyrus, the hypothalamus, the long-term memory, the short-term memory and the gray matter.

Recently, the neuroscientists discovered that the thalamus contains a great number of areas, which receive visual and olfactive inputs then send out those signals to the hypothalamus and the amygdala, which in turn arouses emotional nuances in response to the information received.

Considering the different nuances manifested by the various components of the limbic system, we can see the latter is the basic support of emotions or feelings in the human brain:

- the two pre-frontal areas (consciousness and thinking mind) send in emotional data to the hypothalamus;
- the latter immediately creates the nuances associated with each emotional content included in the mental factors, such as:

- greed-hatred-ignorance, self-conceit, doubt, evil views, grief, joy, grudge, love, aversion, anxiety, fear, panic, sorrow, dishonesty and covetousness, envy, etc... in response to the signals sent by the two prefrontal areas.
- the whole erroneous mind or mental formations take shape and are sent out from this structure (hypothalamus). The emotions are straightaway dispatched in two directions:
    1. first, to the viscera—heart, liver, pancreas, lungs, kidneys—producing either favourable or unfavourable effects upon them. Adverse effects result in visceral diseases, like gastric ulcers, hypertension, arrythmia, diabetes mellitus... while a beneficial outcome keeps the internal organs in good condition, in equilibrium;
    2. the second path conveys the emotions to the nervous center (the somato-sensory area, lying crosswise, on top of the head) causing them to display in the complexion, glittering eyes, lips, limbs, voice and heart rate... expressions of distress, suffering, joy, enthusiasm, delight, merriment...

For instance, when a person hears some piece of music strongly connected with his adolescent years, the melody as well as the words excite his pre-frontal cortex, making him remember images of the past associated with sweet or sad memories; these memories activate the hippocampus and the hypothalamus then flow to the peripheral nervous system. He immediately recollects bitter-sweet memories of the past that he shared with his beloved ones. If he is unable to repress his emotions, it will bring tears to his eyes...

However, his emotional state continues: emotional signals will be sent to his viscera, bearing upon his heart, liver, stomach, bowel... If it keeps tormenting him, sadness, melancholy, bitterness, sorrow will continue to be deducted or imagined by his thinking mind and consciousness and his intellect will conceive superfluous complicate matters. His viscera will be negatively affected by toxins discharged by the endocrine glands. From his internal organs, his trouble will ascend to the cortex.

Eventually, he will receive the painful information and will make the decision to find a cure: he either goes to a doctor for treatment or adopts methods of treatment by meditation. These are called "biofeedback". A mind that is not tranquil, that is worried and suffering sends impulses to the brain. The brain responds by conveying them to the limbic system where the connected areas react by releasing chemicals in keeping with the emotional levels, which will cause disease in the body (internal organs). Conversely, a diseased body causes concern to the mind. In the end, the mind reaps the fruit of the emotions and feelings it has generated.

Part 2

Functions and Composition

Functions

The functions of the limbic system are as follows:

1. It is the catchment area of all information flowing in from:
   a. the mind, thinking mind, consciousness in the two pre-frontal areas of the left and right hemispheres,
   b. the primordial awareness mechanism (the triangle-shaped region, posterior part of the left hemisphere),

   c. the internal organs (their unconscious autonomic functions),
   d. the brain stem, and
   e. the external environment (weather conditions, climate).

2. In response, it externalizes the emotions or absence of emotions in three different levels through the bodily, verbal and mental formations of the average person, the awake or enlightened person and the saintly person.

3. In the autonomic nervous system, it plays an important role in the regulation of such bodily functions as:
   a. the maintenance of the body temperature, blood pressure and glucose level in blood;
   b. the control of the visceral activities through various emotional expressions.

4. It is connected with instinctive emotions:
   a. defense instinct,
   b. vital instinct,
   c. sexual instinct.

These instincts interact with other areas of the cerebral cortex like the left and right prefrontal lobes, the hypothalamus, the working, short-term (emotional) and long-term memory areas.

5. It is closely connected with impressions (through feelings) on the one hand and thought (through cognition) on the other hand.

6. In a given living environment, conscious awareness is full of all types of emotions: sadness/joy, grief/misery, sorrow/equanimity, contentment/discontentment, which all occur through the interaction of the limbic system and the prefrontal lobes. If *discontentment* arises often, it generates dissatisfaction, grudge, rage, sorrow...

This transfer of information between the cerebral cortex and the limbic system explains why emotions sometimes put logic aside (feeling prevails over reason) or, on the contrary, why reason manages to block the expression of our emotions when circumstances are not favourable (reason prevails over feeling). Knowing that, we then will understand why at odd times, we happen to be unconscious, mistaking irrational facts for logical (feeling prevails over reason) while at other times we are indeed level-headed, lucidly recognizing groundless facts and reject them (reason prevails over feeling).

Seen from the angle of the Karma concept in Buddhism, the limbic system shows the important role it plays in *creating, shedding or transforming Karma*.

As regards the twelve causation links, the limbic system enables us to see two of them connected with Ignorance (instinctive emotions) and Formations (expressing the nuances of the wrong mind through body, speech and thought).

From the spiritual angle, the limbic system shows us the links of Wrong Thought and Meditative absorption to mental and physical diseases or mental transformation and physical regulation of psychosomatic diseases.

Composition

Theoretically, the limbic system is composed of four structures: the hypothalamus, the thalamus, the long-term memory area, the Amygdalla (short-term memory). But to that, we add the gray matter and two endocrine glands, the pineal gland and the pituitary gland (or hypophisis), which also lie within the limbic system area. The pineal gland is located next to the thalamus and the pituitary gland is under the control of the hypothalamus.

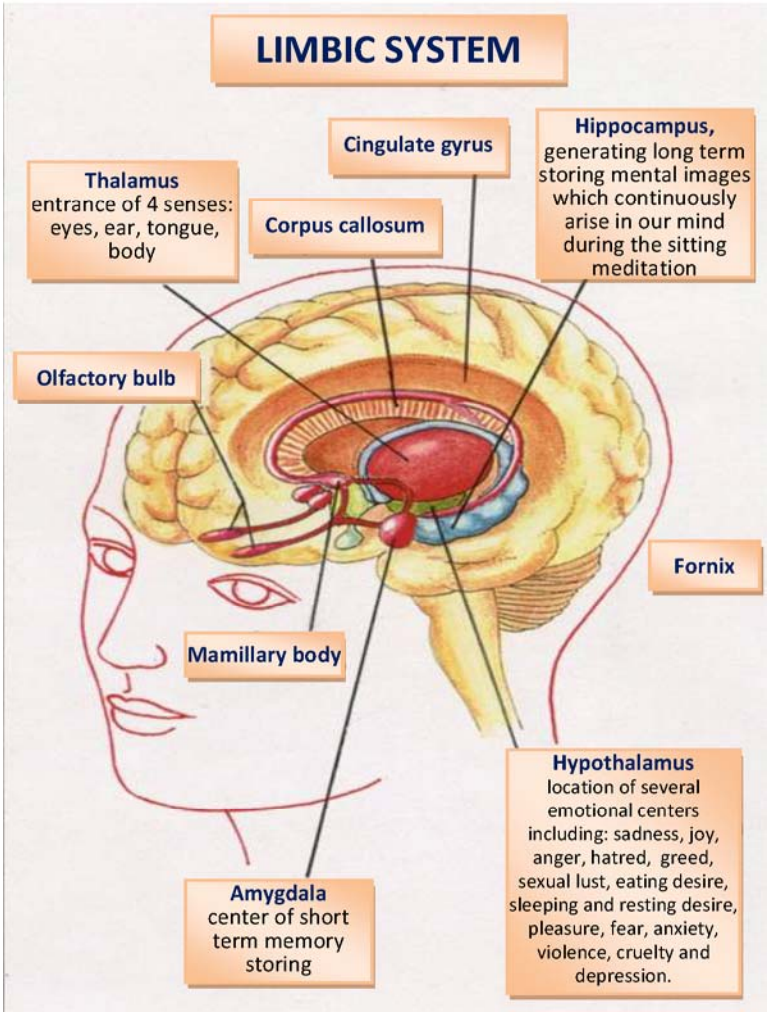

Figure 1 : Limbic system

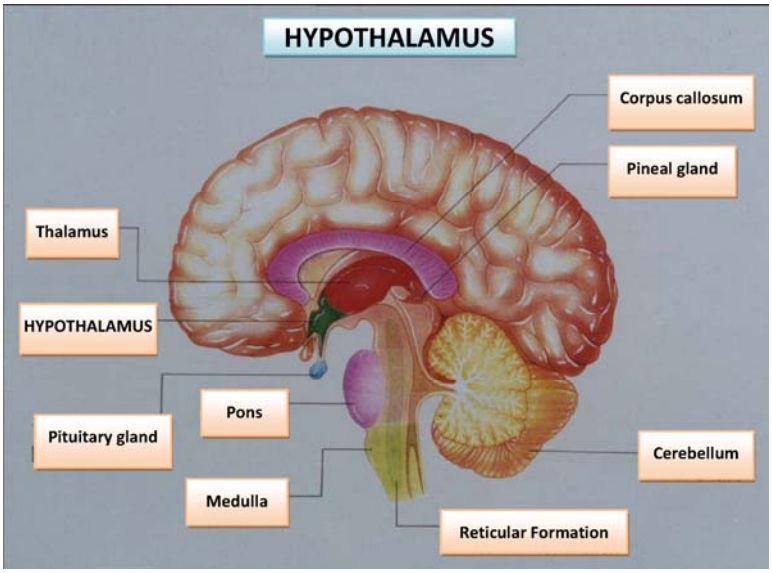

Figure 2 : Hypothalamus

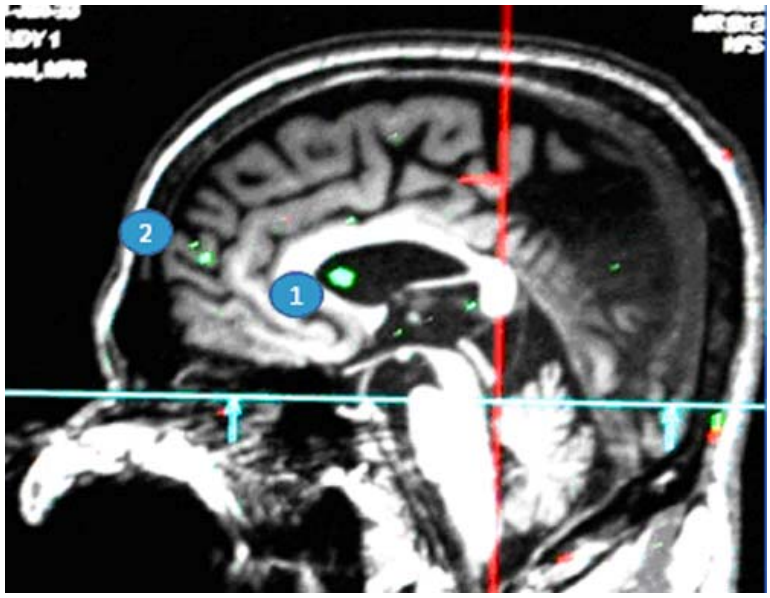

Figure 3: When the nature of aware cognition is present, the hypothalamus appears in the green colour (1), and so does the Broca area which is at rest (2). This is the state of meditative absorption

The Four Mechanisms in the Limbic System

I. The Hypothalamus

A fascinating structure—a tiny area of the limbic system located inside the brain, behind the eyes, below (hypo) the thalamus and above the pituitary gland, hence its name—hypothalamus. The hypothalamus is a key part of the mid-brain, lying on either side of the third ventricle. It is the regulating center of the functions of the internal organs, blood, heart rate, and the center of expression of the three nuances of the wrong mind, the right mind and Buddha mind through the four limbs, the head, face, glittering of the eyes, lips, mouth and body.

Weight

The hypothalamus weighs about 4 grams, i.e. 1/300 of the whole brain. In volume, it represents some 1/100 of the total surface. It plays a part in practically every behavioural aspect, including food intake, sexual activity, sleep, temperature regulation, emotions, endocrine functions, and motion.

Functions

Despite its small size, the hypothalamus is functionally most important for our daily life. It regulates all our bodily and mental activities. It can adjust the functions, mental consciousness, behaviours and internal organs. It helps our body to be in good health, have a rosy complexion, but all the same, it can cause psychosomatic diseases, or make us look sloven, haggard because it connects directly with the endocrine system and the autonomic nervous system. Hence, it is regarded as a higher autonomic center or as the Master of all the endocrine glands.

Since the neural axis of the groups of nuclei in the hypothalamus extends to the sympathetic and

parasympathetic centers at the brain stem, the impulses from the hypothalamus can continually stimulate or inhibit the lower autonomic centers. In other terms, the hypothalamus plays the role of regulating, coordinating and supervising the autonomic activities inside the body. It coordinates the mind, the brain and the body, and it coordinates the nervous system and the limbic system as well. It also has pleasure centers connected with food intake and sexual activities.

Its function is comparable to a principal relay center between the cortex and the lower autonomic centers. The impulse pathways from other centers of the limbic system reach the hypothalamus. And through a great number of pathways of synapse space in the hypothalamus, these impulses are conveyed downstream to the autonomic centers in the brain stem and to the rhachial (truncal) ones of the spinal column. So, the functions of the hypothalamus are similar to links between the cortex and the lower centers, that is between the mind and the body. The emotions it conveys causes changes in the functions of the body. It is a critical relay center, which allows the mind to influence the whole body—sometimes unfortunately generating psychosomatic diseases.

The roles of the centers

An outline

The hypothalamus has seven centers, each of them is composed of a great number of nuclei. Neuroscientists have discovered some twenty-two groups of small nuclei, the most important one being:

1. The center of emotional response and of expression of the bodily, verbal and mental behaviours.

   For all the sources of emotion such as sadness, joy,

grudge, shouting, lament, prayer, rebuke, ignominy, shivering, disgust, flushing with anger, turning pale with fear, heart failure, fainting, roughness, brutality, concupiscence, gluttony, fight-or-flight response, robbing or plundering, assault or invasion, repentance or regret, gentleness or quietness, resourcefulness or sluggishness, etc... the hypothalamus is *the driving force*. Conversely, if we manage to attain meditative stabilization (samādhi), the true mind manifests itself, our deep mind turns peaceful, dispassionate, natural, quiet, silent, pure. The hypothalamus also resorts to corporeal and verbal means to express those nuances.

2. It is the center of supervision and the check station of all the corporeal and mental activities as far as it controls the autonomic nervous system to influence blood pressure, heart rate, deep or shallow respiration rhythm, and the movements in the digestive tract and the visceral organs.

   It is considered as a multifunctional mechanism of nerve centers. Without it, our nerve center (or mind) cannot express the nuances of emotions and feelings as they really are. For instance, when you shout at someone without any expression of anger, your shouting has no influence upon your viscera. You simulate anger outside while there is no such feeling inside. On the other hand, if you fly into fury, the impulses will lead their way to the hypothalamus, which will immediately show the nuances connected with your anger via the sympathetic nervous system, the viscera and the whole range of corporeal gestures—limbs, head, face, glittering eyes, lips and mouth, voice.

   In principle, the hypothalamus is under the control of the nerve center, which comprises the mental faculty, or mind base (left hemisphere) including the distorted and

awakened intellect, the discriminating mental consciousness (right hemisphere) and the triangle-shaped area in the posterior left hemisphere, belonging to the sensory mechanism. If none of these four sites sends it nerve impulses containing messages like good-evil, right-wrong, inference, serenity, quietude... it will keep silent.

In reality, besides the central nervous system, the hypothalamus also receives information directly from other regions: the smells entering through the nose make their way to it first, and the short-term and long-term memory centers of the limbic system refer information directly to it, skipping the mental faculty to create body physiological states .

That is why neuroscientists call it the "neural clearinghouse", *implying that it collects incoming information from the five sense organs, from the environmental weather, from outside temperature, from the viscera and the nerve centers then sends signals out to the autonomic nervous system* and *the endocrine system, inducing the response to the information it has conveyed*.

Through *the portal venous system,* the hypothalamus stimulates the anterior lobe of the pituitary gland for it to secrete six types of hormones. As for the posterior lobe, it is checked through neural projections. It also has the role of supervision and regulation of the autonomic nervous system, both sympathetic and parasympathetic. For instance, when we suddenly receive a warning signal or for some reason we get excited, signals are immediately relayed by the nerve center to the hypothalamus, which acts upon the sympathetic nervous system. The latter sends impulses to the heart, lungs and eyes, making the heart beat

faster, respiration accelerate, the pupils dilate and the flow of blood in the muscles increase. In the medical jargon, it is called *the fight-or-flight response*.

3. The hypothalamus has many groups of neurons involved in the control and regulation of body temperature, such as the sensation of heat or cold (inducing perspiration or shivering). Hence, it is regarded as the body temperature regulation center. The anterior part responds to heat, the posterior to cold and shivering.
4. It controls the water balance in the body.
5. It regulates alimentary behaviour.
6. It regulates the circadian cycle. The suprachiasmatic nuclei (SCN) is the site for action aiming at the regulation of circadian rhythms, including the secretion of **melatonin,** the sleep-wake cycles and the body temperature rhythm. To help treat chronic insomnia or prevent or treat breast tumors or cancers, or tumors of the prostatic gland, we can use the technique of looking at the darkness to stimulate the release of melatonin by the suprachiasmatic nuclei.
7. Most importantly, it coordinates the functions of the endocrine system through the pituitary gland, contributing to keeping the body in good condition.

Precisely because of its important and effective characteristics, to treat psychosomatic disorders, contemporary Western psychologists and psychanalysts have resorted to the practice of yogic or Buddhist meditation to act upon the hypothalamic mechanism

Summary and Conclusion

In the context of the whole brain, the hypothalamus is a mass of gray substance, which, in spite of its tiny volume, representing 1/300 of the total, is regarded as the center of expression of the mental, emotional and physiological aspects of the body through the action of various regions:

1. The pre-frontal areas of the two hemispheres and the thalamus,
2. The limbic system, the olfactory bulbs and the brain stem including the reticular formation and the visceral impulses ascending to the medulla oblongata (Brain stem).

When erroneous thoughts do not arise, the hypothalamus produces a state of blood activation, which projects on the endocrine system and helps treat psychosomatic diseases: diabetes, blood pressure, neurasthenia, depression, stomach ulcers...; it results in excellent health, eagerness, joy (rapture and enthusiasm). If *the nature of awareness is present*, spiritual change and transformation as Zen originates there because it generates states of bio-action, helping to eliminate former habits and defilements and to recover from psychosomatic diseases. In this context, it is the *White Buffalo,* which symbolizes the right mind in the history of Chinese Zen.

In terms of KARMA, the hypothalamus is a structure connected with the group of mental formations. It expresses all the nuances of the wrong mind through the body (limbs, trunk, head, face, eyes, skin and internal organs) and Speech (including the sound intensity of cries, shouts, gentleness, moaning, resentment, discontentment, etc...). In this case, it is the *Black Buffalo* in The Ten Ox-Herding Pictures.

Digestion, weight gain, appetite, sexuality, wakefulness (arousal), all are related to the hypothalamus. Blood pressure, heart rate, body temperature are also influenced by it. It controls the pituitary gland and influences the whole endocrine system. It contains a great number of tiny clusters of nerve cells called nuclei. These nuclei influence many processses of formation, in human beings and animals, of various psychological and physiological categories such as hunger, thirst, body temperature, sexuality, sleep, joy and sadness, blissfulness, pleasure, happiness, as well as instincts... It is regarded as the center of expression of the mundane/erroneous mind through emotional responses, or manifestations of acute, unrelenting, preying emotions, or emotional stress, or latent proclivities. Critical, sudden emotions such as supreme joy, hitting the jack-pot, extreme fear, can cause heart attack resulting in sudden death.

All that being said, the whole range of functions of the hypothalamus is directly dependent on *our* level of awakening or ignorance. If we are *unenlightened and led astray*, we usually are attached to the mundane root-cause, the mundane knowledge, our mind will be like a stubborn buffalo. We shall never be able to implement the basic methods of meditation. In the end, we shall reap the resulting physical illnesses as well as the mental defilements. If we *awake* and keep trying hard to make thoughts arise through becoming silent, *reaching non-verbal awareness*, the right mind will arise, insight wisdom will become luminous. Then, the hypothalamus plays the role of regulating the organism, resulting in physical wellness, a fresh rosy complexion, a blissful mind, with all psychosomatic diseases cured.

II. The Thalamus

The thalamus and the hippocampus constitute the diencephalon or mesencephalon, both being located between the two hemispheres and the mid-brain. Thalamus comes from the Greek "thalamos" chamber, room. The two hemispheres indeed lie safely on it. It lies inside the brain,

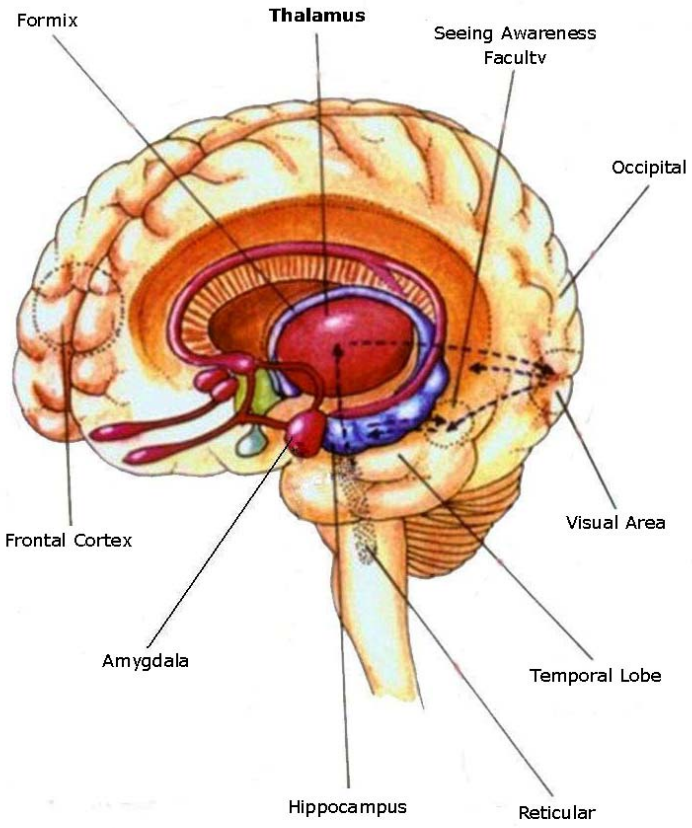

Figure 3: Thalamus

and all the incoming sensory information pass through it first, except for the odours, which directly reach the hypothalamus prior to the thalamus. It is the second relay structure, the most notable. It contains many groups of nuclei with special functions. Depending on the destination sites of the information conveyed, they have been given special names by neuroscientists. They are responsible for the gross interpretation or recognition of the incoming sensory information signals to relay or distribute them to the associated areas.

Sources of information

The following entities convey information to the thalamus:

1. The reticular formation sends visual, auditory, gustatory and tactile information;
2. The hypothalamus transfers smells, psychological feelings and sensations from the internal organs;
3. The cerebellum transfers the body balance and the orientation of sounds;
4. The motion volition transfers the activities to the internal organs, limbs and trunk.

Functions

1. Receives and transfers the informative sensory signals to the frontal, parietal, occipital and temporal lobes.
2. Mediates the sensations, the activities concerning the movements of the body, to awake the cerebral cortex and the memory.
3. The reticular formation is the first relay station and the thalamus is the second. It plays an important role in transferring the sensation information to all directions of the cortex from the eyes, the ears, the tongue and thought. It regulates the level of awareness, vigilance,

mindfulness, the emotional areas of sensory experience.

III. The Hippocampus - Long-term memory

Anything we "know that comes within the sphere of experience" is encoded in the long-term memory store. The hippocampus plays a major role in the memory of the nuances of knowing:

- *reporting knowing*, belonging to the mental consciousness sphere,
- *referential knowing*, belonging to the cogitation realm (mental faculty),
- *inferential knowing* belonging to the intellect realm, and
- *silent knowing,* which stands within the sphere of the nature of awareness.

For instance, because we have learned how to drive, we know clearly the meaning of the road signs, hence, while driving, all along the way, we can conform with the highway codes each and everytime we come across them without **mentally murmuring a single word about them**: this is *tacit awareness* of the objects. We are not confused, we do not doubt. The reactions of our limbs, head, face are in accord with each one of the sense objects. It is the visual awareness of the general interpretative mechanism, located in the site of the nature of seeing which provides the material. In Zen terminology, that area is the visual awareness area of the "nature of seeing". This tacit visual awareness relies on the memory in the hippocampus for data supply.

At the same time, although mental consciousness accumulates experience from the driving lessons, every time we see the road signs, we always let the mental murmuring of the names of the signals (objects) slip out

before disclosing our awareness of their contents: that is the memory of mental consciousness associated with the nature of seeing. It happens that we also *mentally murmur the contents of the objects our eyes see*: that is the memory of mental consciousness.

It also occurs that we can see a signal without remembering its meaning and function. We try and think hard about that signal we learned. Meanwhile, we keep *mentally muttering* about it. Finally, we recognize it (or we do not): the thinking memory, or the memory of the mental faculty, has operated.

Now, if we can see the signal without clearly recognizing it, but after presuming and reasoning, we draw a conclusion, then, the memory in the intellect has been at work. For example, we see a thread and shout "A snake!" Although it impinges on the senses, this memory is laden with presumption and reasoning: the thread is not a snake! It is not the sense object.

Thus, the role of the pair of hippocampus is associated with the long-term memory of the four aspects of **knowing**. It is part and parcel of the limbic system, lying each one on either hemisphere under the temporal lobe. It is a mass of gray substance, its curved shape evoking a sea-horse, which induced the early anatomists to give it the name of "Sea-horse" (Hippocampus).

Functions

The hippocampus has the following functions:

1. Remembering names, images, sounds, events and all perceptions: seeing, hearing, smelling, tasting and tactile contact. This is called **fact memory**, usually acquired by learning, but short-lived. However, quite a few facts can be encoded in **long-term potentiation**

(LTP) such as those which have strongly excited the senses, producing impressions not easily obliterated.

2. Within the context of learning through *practice and profuse repetition*, this memory is consolidated into long-term memory, helping to accumulate experiences in cognition about individual objects, and is called **skill memory**. For example, if we regularly practice certain subject-matters related to meditative development of stabilization (Định), one day will come when we have experience in Định just like flicking the fingers. With skill memory, all events or objects have become compressive cognition in the general interpretative area.

   All the memories are stored in specific distinct centers. In particular, the hippocampus is the storage place for other memories because its roots are connected with other memory centers including perceptions and cognition. For that reason, it is called t*he store room of long-term memories*. From three-year old children to adults, everyone has the capacity to memorize all the experiences lived in accordance with actual experience. That is because everyone has a pair of hippocampus, not because our conscious minds are blank and anything can be easily encoded there as many people used to believe.

   The hippocampus stores long-term memory in order to supply individual areas of the cortex later on.

3. The middle links either excite and respond with conditions, either allude or evoke hints or cues and attitudes consistent with each situation. All these links have been retained in the long-term memory store and become *procedural memorie*s. For example, as we have had cycling experience since childhood, now, when we need to go cycling, we are still able to do it

without mental murmuring.

Procedural memory is very necessary in meditative development of stabilization (Định). After zealously practising for a few months the subject-matter "No speech", when a meditator really has a firm experience of the technique called "*Non-verbal awareness*", the long-term memory store has saved *the procedural memory of that process*. When he sits to meditate the subject-matter "*Not naming the object"*, he simply has to *evoke* the content "*not naming the object"*. Immediately, the related data, which, through regular training, has been self-saved in the long-term store, starts implementing according to the procedure "*not naming the object*". Then, in the twinkling of an eye, all the neurons of the somato-sensory area in unison respond exactly to the signal "*not naming the object*" while the chattering mind still has not expressed itself.

If, unexpectedly, some wrong thought creeps in, no sooner has he hinted at the leitmotiv "No speech" or "tacit awareness" than the wrong mind comes to a stop. Eventually, that person will enter meditative stabilization and may reach deeply into it without spending too much time in conflict between wrong thought and right mind. That is the meaning of the links between conditioned stimulation and conditioned response and between the *hint at "no speech"* and the appropriate attitude of the somato-sensory area toward verbal formation at rest.

4. The other parts of long-term memory are constituted by the general knowledge we have taken in. For instance, we know that two and two make four, or that Buddha Sakyamuni is the founder of Buddhism. We understand the meaning of many words, such as Meditation, Meditative stabilization, the nature of awareness,

Bodhi, Nibbana, delusive thoughts, etc... as well as abbreviations like Skt, TV, St; Dr. This falls within *semantic memory* (the meaning of terms or expressions). Hence, if we do not learn and accumulate the necessary stock of knowledge of a discipline we are practising, we shall know nothing about that discipline. For instance, learning meditation practice without any knowledge concerning meditation, we shall understand nothing about it when we hear such terms pertaining to Buddhistic jargon as pondering, discursive thinking, verbal formation at rest, mindfulness and clear awareness, the nature of awareness, the nature of Buddha.

5. If we are used to watching videos or movies, when sitting in meditation, the images and pieces of story—moving, strange, frightful or attractive—will in succession loom up. Furthermore, in ourselves, we keep poetic, sweet memories of our childhood, our prime or our powerful and influential times, ruling the roost or fluttering about, generous and of pleasant company... and, unexpectedly, some event looms up, connected with some chapter of our life when we were rolling in riches, draped in gorgeous silk and velvet, or, on the contrary, swirling up and down, wretched, bitter, frightful, sorrowful, arousing certain past *episodes* so very clearly that they seem to have occurred only the day before. That is called *episodic memory*, in the development of which, *mental dialogue,* or internal speech takes place. In Zen terminology, it is called "to adhere to falsehood" or "to be carried away by delusion".

   Nota bene - Both *semantic memory* and *episodic memory* usually arise simultaneously. For instance, in his book "The sources of Meditation", translated and

expounded in Vietnamese by Zen Master Thích Thanh Từ, Zen Master Guifeng Zongmi says "Who knows *cultivating the Way to attain Realization* is precisely the foundation of Meditation?". It immediately makes us remember that "cultivate the Way and attain Realization" means the experience perceived when we really achieve *no thinking* or *the nature of awareness clearly manifests,* which we know through learning. And if later on, we again come across the phrase "cultivate the Way and attain Realization", we shall worry about neither the meaning nor the details any longer. We know its meaning, we know it is the result of the unremitting exertions we have expended in diligently, tenaciously practising meditation, and the resulting effect on the body, mind and spiritual insight that we have experienced. Or that it is the result of the practise of a given meditation method that we personally know. Outsiders cannot for certain have any perception of it.

6. Theoretically, the role of the hippocampus is to provide "**a Cognitive Map**" to all those who want to start off—on whichever way—toward their target objective. Most certainly, this map is different from road maps. These draw the paths we can rely on to start, but we do not start yet. We do not know whether bridges, roads, bends, forks, woodlands that existed decades ago still conform to the standards of the ultra-modern techniques of road construction of the present Public works Department.

   For the meditator, sutras (the sayings of Buddha) symbolize road maps. If we want to penetrate the sutras, we need a Cognitive map.

   So, at this point, in order to see clearly the *nature of awareness*, we have to rely on sutras. Sutras symbolize

the finger, and we rely on the guidance of sutras to practice. If we faithfully practice in conformity with the guidance of the sutras, we shall succeed in seeing the moon of our own nature of awareness. The sutras themselves are not the nature of awareness that we have experimented in our body and mind. Sutras just render Buddha's words, it does not mean that those words have manifested fully in our mind. In order to know clearly how the nature of awareness is, it is necessary that we put into practice the teachings in the sutras. This putting into practice is precisely the way of drawing *cognitive maps*.

Consequently, *a cognitive map* is one that we have effectively treaded, be it only once, and so, we really have some experience of the path. We know how much adversity and hardship it involves; we know what the instructions in the sutras and the sastras mean concretely. Then, we can proceed without being afraid of going astray or departing from the doctrine or not being in conformity with the holy sayings. Like relying on the finger to see the moon, in order to go home without fear of getting lost, we need a cognitive map. If we are unable to draw for our personal use such a map, never shall we complete the path to mastering our thinking, for the nature of awareness to clearly manifest.

Practicing a method again and again until we reach a high level of subtlety and cleverness is implementing the principle of saving data in the long-term memory store. When we master the method, then we have achieved the saving of the cognitive map in the long-term memory store. Once the cognitive map is completed, we are in the position of using the procedural memory, which is also called *non-*

declarative memory or *unthinking memory*. We carry out current activities silently without thinking or saying a single word. We follow the *procedural cognition.* The left hemisphere has organized in the right order all the steps related to the course of operations included in the activity we are going to perform or are performing. On resorting to this basic principle, we know for sure we shall master our thinking, opening up the way for the nature of awareness to clearly manifest without fear of being lead out of one's track.

For that precise reason, we consider the hippocampus to be the storage place of Samadhi material. If we want to have different Samadhi processes and contents, we need to draw up a cognitive map inside the hippocampus, that is to say the long-term memory store.

Characteristics

In the mechanism of mental objects (objects of the wrong mind, comprising mental consciousness and mental faculty), the hippocampus plays a major role in retrieving the images of the six faculties of senses that at the same time are deep-rooted, have the meaning of keepsakes and the character of memories of facts (belonging to experience) beyond the control of volition. (In other words, the data from long-term storage springs up then heads for the mental faculty. From then on, the mental faculty responds by a continuing mental dialogue or imagining, depending on the content sent from the long-term memory storage).

From the eyes, the images go via the reticulate formation to the thalamus and from there to the occipital lobe. From here, the route is twofold: one goes toward the nature of seeing (the general interpretative area), the other for the hippocampus for storage. So, its principal function is to

store data sent from the occipital lobe.

Structure

The hippocampus is directly associated with many sensory fibres of the five groups: *vision, sound, smell, taste, touch,* and many other brain areas, called **dharma** (mental objects), such as the intellect area, the discriminating mental consciousness area and the general interpretative area. It is directly attached to the two temporal lobes lengthwise and underneath.

The hippocampus totals some forty million pyramidal neurons. According to researchers' estimates, approximately from the age of forty on, about five per cent of them lose their shape during each decade.

When the hippocampus is damaged

If his/her hippocampus area is damaged, a meditator cannot perform to the ultimate end. That is because meditative stabilization (samadhi), including both the teaching and the practice, is based on the long-term memory area. If we learn the Dharma and do not memorize the Dharma, the teachings of the Master (spiritual counsellor), the classical examples, if we do not grasp the meaning of various zen expressions; if we do not remember the principles and the techniques that govern the practice, how then can we have the capacities to exert?

Any of all the above-mentioned subject-matters requires that long-term memories are in store. But how can a damaged hippocampus save material? That is a hinderance. Yet, in this case, we can resort to breathing, seeing, hearing and contact techniques

Causes for hippocampal damage and how to form new memory

There are two causes for damage :

1. Epilepsy, causing trouble in memory.
2. Oxygen starvation, usually limited in time.

Moreover, blood stasis in some part of the hippocampal structure results in the loss of recent memories (anterograde amnesia) because *new* information cannot be encoded and saved, but does not affect old memories.

Generally speaking, hippocampus damage results in memory loss.

One can restore memory by stimulating the brain to create new synapses connecting neurons in the brain.

In adults, neurons cannot regenerate, but they can establish a great number of new synapses for storing material and for interconnection. This explains why old persons (age 60-70) can continue to acquire new knowledge and encode new memories although the neurons in their long-term memory center have started to die out at around forty. Consequently, if the hippocampus is stimulated, new synapses will grow, existing ones will be consolidated, resulting in the invigorating of memories. That process of reactivation of long-term memory potentiality is called long-term potentiation (LTP).

IV. Emotional memory (Short-term memory) - Amygdala

Two groups of almond-shaped nuclei of gray substance, the amygdalae are groups of nerves in the limbic system. They are one of the links of the brain structure influencing such types of psycho-emotional behaviour as aggression, fear, distress, anger, fight and defense.

Lying deep within the mid-brain, beneath the temporal lobe, amygdala is an important structure of the limbic system. While the hippocampus plays a major role in remembrance, the amygdala puts in order the images in memories to arouse imagination. Both are dependent on the complex net of sensory connections (eyes, ears, nose, tongue, skin/body). All our sensations—sight, sound,

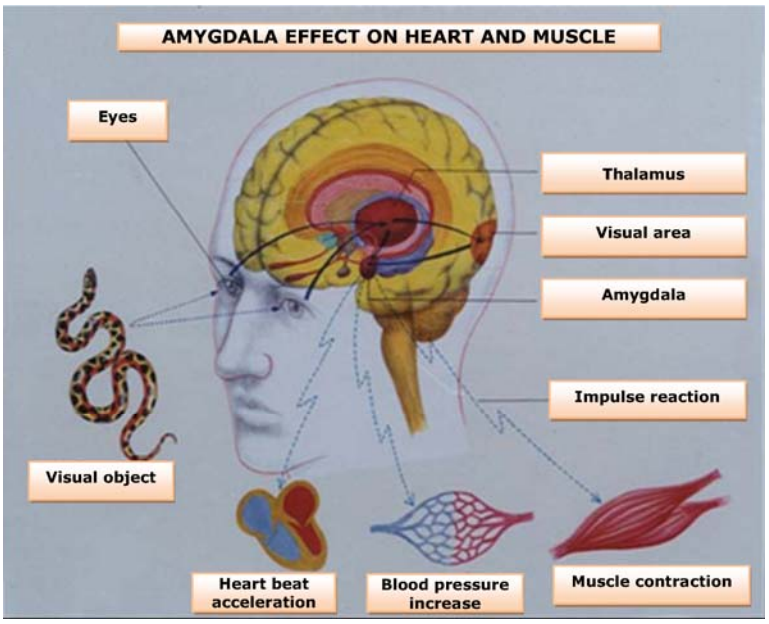

Figure 5: Amygdala Effect on Heart and Muscle

smell, taste and touch—can arouse remembrance, but not with equal ease. Smell and taste have a special faculty of stimulation. In the case of smell, the olfactory fibers

directly connect with the hippocampus and the amygdala, and it is to be emphasized that there is the participation of visual receptors, the entry points of visual objects. When the eyes see a smell object, they immediately convey the *image seen* to the cortex; the latter sends impulses to the limbic system causing the *emotional memory* to arise. For instance, lay people might remember the smells they are familiar with such as barbecue meat, sea algae, fish simmered in fish sauce, the fragrance of the opposite sex partner. For their part, monks might remember the salted soya bean preserve, incense fragrance, and so on...

When one piece of perceptive information includes a content that arouses emotions like fear when the eyes see a cobra lying on the road side barring the way, it is conveyed to the thalamus via reticula formation. From the thalamus, it splits into two directions: one descends straight to the amygdala and the other to the visual area in the occipital lobe (at the nape of the neck). In minute details does the amygdala receive direct information from the thalamus, so it has immediate emotional reactions. Through these reactions, it transfers the emotional data to the heart, which causes acceleration of the heart beat and elevation of the blood pressure (due to fear), then conveys it to the muscles, which results in their contraction, saying nothing yet of the amygdala continuing to convey impulses to the hypothalamus, which will express in a concrete way the nuances of the *mundane mind*. We shall let out our behaviour towards the snake: either go and fetch a stick to beat it or avoid it or shiver with fear and worry.

However, because the visual area from the occipital lobe sends visual information at the same time to the emotional

memory and long-term memory centers and to the nature of seeing located in the general interpretative area, so the latter establishes that the object seen (visual object) is not a

snake. The information reaching the amygdala will quell the fear response. Or, the awareness area of the nature of seeing keeps silent, arousing no discriminating thought: *when seeing, just see*, the fear response will not arise either, as if the response were brought to a stop while in reality, it does not hold any "no-fear" repressing thought. (This shows that right mindfulness lies within the sensory mechanism).

Precisely for that reason, the emotional memory is always dependent upon the role of the amygdala. Hence, the amygdala is considered as the Center of Action. It sends forth emotional memory impulses directly to the hypothalamus and indirectly to the septal area, activating the septal nuclei, which send forth sensory impulses to the hypothalamus a second time. Hence, the septal area is defined as the second Action Center.

When the amygdala is overexcited, it produces aversive feelings capable of bringing about such tragic/disastrous consequences as the committing of homicidal crimes as in the case of the slaughter in Nepal at the beginning of 2002, in which the Prince Dipendra himself shot his parents, the reigning King and Queen, as well as members of the royal family in the royal palace and finally committed suicide...

In meditation, to practice the opening of the various parts of the sensory mechanism, we can isolate the amygdala, so that we can avoid unwholesome deeds, or acts of outrageous states of frenzy. In that way, we maintain uprightness befitting meditation practitioners.

Damaged amygdala modifies an individual's personality as follows:

- docile behaviour,
- restlessness,

- fighting mood,
- overindulgence in alimentary intake,
- overindulgence in sensuous lust.

CONCLUSION

Considering this watershed in the study and practice of meditation, we need to unite closely with modern science so that we can firmly grasp the true worth of the Buddha Dharma. Moreover, we need to reconsider our standard of knowledge of Buddha's Law. Here is set out, at the threshold of the twenty-first century, the condition for us to move forward steadily on the Path, to better understand the Dharma and to fulfill our altruistic ideal of rescueing all beings. No longer shall we regard Zen studies in the East as an odd, mysterious discipline as we previously did while we were faced with the " jungle of the Zen jargon".

ANNOTATIONS

1. **Mental factors:** factors of the mind (Pāli: cetasika). Refers to the manifested nuances of the mind or the mental concomitants or properties generated by the reactions of the Formations, or volition factors, and the consciousnesses. Generally speaking, mental factors are the actions of consciousness (called "King of the mind"). Without consciousness, the various mental factors cannot come into existence. For example, the reason why greed-hatred-ignorance arises is because consciousness is discriminating. Thus, greed-hatred-ignorance are mental factors.
2. **Mental formations:** The factors creating thought include sensations and perceptions
3. **The peripheral nervous system** is a part of the nervous system that lies outside the central nervous system and includes the spinal nerves and the cranial nerves. It is responsible for the communication between each and every part of the body and the central nervous system.

   The hypothalamus is the anterior and terminal of the diencephalon, and is located beneath the thalamus.

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Article 2

THE AUTONOMIC NERVOUS SYSTEM

INTRODUCTION

The world has been changed in many fields: (1) expansion of communication, (2) reform in Psychology (3) scientific inventions in the domain of space, cerebrology, medicine, pharmacology, immunology, biology, chemistry, physics, sociology, etc… In the early twenty-first century, meditation, in my opinion, needs to accommodate to the new era. My intention is to demonstrate the connection of meditation to the body, mind, and spiritual wisdom of the human being. Meditation is a perfect way to serve humanity regardless of race, religion, social class, or level of knowledge avoiding conflict, killing and hatred. By practicing meditation one can regulate the function of certain areas of the cerebral cortex, limbic system, brain stem, and endocrine system, one can achieve internal balance and a change of view of world phenomena. Meditation directly or indirectly facilitates the functioning of internal organs, balancing body and mind, and enlightening spiritual wisdom.

Speaking generally, meditation can be thought of as a Science. With an appropriate subject and method of practicing, that is suitable to the needs and the ability of the practitioner, one is able to experience:

1. Improved personality, morals, and cognition. Improved social relations; no longer praising self and blaming others. Living with adequate physical needs and manifesting generosity and tolerance to others.

2. Improved health status.
3. Improved efficiency at work.
4. Improved creativity.

These four Effects of Meditation are essential and serve as a foundation for social order, security, and cohesiveness in all human activities.

This article, about the Autonomic Nervous System (**ANS**), is written for those who practice meditation in a systematic (scientific) way and wish to help others with their own experiences. The practice of meditation should be practical without unrealistic expectations. It should be built upon basic knowledge by understanding the effect of meditation on the ANS. It helps us to understand the positive effects of meditation on the body, mind, and cognition. Improved techniques of meditation can not only result in physical improvement but also in spiritual unfoldment. Inappropriate practice may lead to increasing health problems. By adjusting or improving one's meditation technique one can realize better control of one's blood pressure and blood sugar, and help to prevent and relieve illnesses especially those caused by the imbalance of the ANS, such as migraine headaches, and some gastrointestinal and cardiovascular disorders.

Finally, one can use meditation techniques to experience good health, a tranquil mind and insight; however if these goals are not experienced, one should review his practice and adjust it in order to save time.

Happiness and calmness depends on a transformed point of view and the balance of his body and mind; otherwise, all one obtains is suffering and affliction due to lack of harmony with family, friends, and coworkers.

Practicing correct meditation produces real and durable happiness for individuals, and security for society. It must be the ideal goal that a beginner should experience.

The following discussion will help you to understand the functions of the ANS and the relation of different techniques of meditation to its functions to avoid troubles for body and mind due to incorrect practicing.

Outline

The ANS is a part of the peripheral nervous system. It is a means to express emotional states, and self awareness. It is divided into the **Sympathetic** and the **Parasympathetic** systems. When the sympathetic system activates to respond to environmental changes, it secretes biochemical substances to cause the body to adapt to the situation caused by a psycho-emotional reaction.

The parasympathetic system is continuously active and regulates the function of many internal organs for their physiological harmony in digestion, circulation, and elimination.

Both systems function to keep internal balance which is essential for our wellness. Stress, anger, fear, and emotions destroy internal balance with biochemical's released related to tension and causing diseases of the inner organs.

Practicing meditation with an appropriate technique helps us adjust functional disorders of organs in order to achieve physical wellness, harmony of body and mind, as well as harmony of the individual in the environment.

Meaning

The word "autonomic" originated from the Greek word "autonomia" meaning "independence." Autonomic means self controlling or self regulating.

The ANS also known as "involuntary," means that it works without participation of consciousness. We normally can't give orders to our visceral organs because their functions are involuntarily controlled by the ANS.

Affect

Nowadays, thanks to neurological discoveries, it is known that despite self controlling and self functioning, the ANS is partly influenced by mechanisms of thinking, consciousness, intelligence, and awareness nature mediated by the hypothalamus. In these instances, the ANS is no longer "self governing." Conversely, it is mainly controlled by the hypothalamus, which is known as the master gland.

The hypothalamus acts on the cerebral cortex, the ANS, as well as the endocrine system starting with the pituitary gland. The hypothalamus has many nucleus groups where each group is related to a particular set of nerves. It regulates the secretions of the endocrine glands, controls the ANS and receives information from the following mechanisms:

1. Thinking (thought calculation, discussion, judgment, and reasoning).
2. Intelligence (guessing, invention, imagination).
3. Consciousness (discrimination, comparison, and duality) creating emotional states such as anger, anxiety, doubt, fear, speculation, creativity, and imagination, of which the subject is "the ceaseless self attachment".
4. Thoughts from the transformed intelligence or mechanism of the Awareness Nature, of which the subject is "the Boss" or "the True Self" creating

serenity, tranquility, mindfulness, tacit awareness, awakening awareness, and wordless cognition.

Generally speaking, the hypothalamus expresses a state of the true mind or disturbed one due to the Self playing a mundane or spiritual role. A great part of our wellness, especially proper functioning of our visceral organs, depends on it.

BIOFEEDBACK IN MEDITATION

Biofeedback in meditation is based on the activation of the ANS. One can practice any method of meditation such as contemplation, just knowing, concentration, insight cultivation, by using one of the five senses to work on a suitable subject. That sense immediately activates the sympathetic or parasympathetic part of the ANS.

Actually, our wellness depends on the balance of the five systems inside the body:

1. The body structure (bone, muscle, skin, nerve, vessels…) and their functions
2. The biochemical processes of chemical substances to get into the body through respiration and digestion
3. Effects of environmental pollution and contagious diseases
4. Functional disorders of the nervous system due to consuming toxic food or tension due to using inappropriate techniques of meditation such as imagination or intense focus on a subject
5. Emotional processes of a mundane mind and spiritual tendencies.

The emotional state of a disturbed mind caused by fighting, competition, disputation, anger, hatred, fear, or sorrow

weakens the balance of the ANS leading to illnesses. On the contrary, spiritual cultivation facilitates internal as well as social and familial harmony. It is also essential for the activation of the self healing mechanism.

Proper methods of meditation practice not only can fix health problems, but also restore our biological energy.

PHYSIOLOGIC ANATOMY of the ANS

The ANS is divided into the Sympathetic and Parasympathetic systems:

1. The Sympathetic system is made up of paired ganglionated trunks from both sides of the spinal cord, extending to the different internal organs.

   Sympathetic nerves from the thoracic spinal cord extend to the eyes, salivary glands, lungs, heart, liver, stomach, gallbladder, intestines, pancreas, and adrenal medulla.

   Because of the special connection of the adrenal medulla to the sympathetic nerve endings, it is considered a part of the sympathetic system.

   Sympathetic nerves from the lumbar spinal cord extend to the colon and bladder.

2. The parasympathetic system consists of certain fibers of the third, fifth, seventh, ninth, and tenth cranial nerves from the brain stem and the sacral part of the spinal cord.

The oculomotor nerve relates to the pupils, ciliary muscles, and muscles of the eye.

The trigeminal nerve relates to the ophthalmic nerve, and the muscles of mastication of the upper and lower jaws.

The facial nerve relates to the salivary glands and lacrimal glands.

The glossopharyngeal nerve relates to the pharynx, and tongue.

The vagus nerve relates to the heart (decreased rate), lung (slowed rate), larynx (dilated), bronchi (constricted), blood vessels in intestine and anus (dilated), gallbladder (increased secretion), stomach (increased digestion), pancreas (increased secretion of insulin), intestine and colon (increased motility and relaxed sphincter, and bladder (constricted).

FUNCTION of the ANS

The ANS involuntarily controls functions of the body. This system helps control the heart rate, arterial pressure, gastrointestinal mobility and secretion, urinary bladder emptying, lung function, sweating, body temperature, and many other activities.

One of the most striking characteristics of the ANS is the rapidity and intensity with which it can change visceral functions. For instance, it can increase the heart rate to double within 3 to 5 seconds; the blood pressure can be doubled in 10 to 15 seconds or decreased low enough to cause fainting in 5 seconds.

The ANS works continuously, although one part may do more work than another at a given time and one may have an opposing function to another.

1. Basic characteristics of Sympathetic function

The sympathetic system generally functions in emergencies such as “fight-or-flight,” stress, fright, strong emotion and also in sexual activities. It is able to respond to the needs of the body in these activities. It receives information from

the hypothalamus and works concordantly with the brain and the adrenal medulla. It controls the distribution of blood to different parts of the body by vasoconstriction or vasodilatation, produces erection of the hairs, gooseflesh, dilatation of the pupils, regulation of body temperature, copious sweating and sends more blood to the extremities during exercise.

Most of sympathetic nerve endings secrete *norepinephrine* (NE) also called *noradrenaline* (NA). This substance stimulates the adrenal medulla to secrete *epinephrine* (EN) and more NE. These substances increase the blood pressure, heart rate, blood sugar, blood lipids, strength of muscles, decrease motility of the intestines, cause cold and moist skin, shaking of hands, a scattered mind, and absence of fear of death.

The sympathetic system is classified in the alert system.

2. Basic characteristics of parasympathetic function

The Parasympathetic system functions in situations that are not tense. It is also called the "digestive and rest system" because its main work is digestion and elimination of urine and feces. For example, it is active when a person takes a rest and reads the newspaper after a meal. The parasympathetic nerve endings secrete acetylcholine that counteracts norepinephrine of the sympathetic nervous system and epinephrine of the adrenal medulla. It has an important role in the regulation of the cardiovascular system, decreasing blood pressure, decreasing blood lipids, activating the secretion of saliva , increasing blood to the stomach and intestines to help digestion, increasing blood to the brain, creating an energetic body with warm skin, a sharp mind, and helping the recovery from memory loss.

Effect of meditation

Nowadays, one can adjust his heart rate with psychosomatic medical practice. Through meditation, one is able to achieve harmony and balance of the sympathetic and parasympathetic systems. This balance is vital for good health, a calm mind, and wisdom.

According to Buddhist psychology, the psychological behavior of an individual affects the activity of the ANS.

The sympathetic system is activated by the emotional mind, called mundane mind, while the parasympathetic system is connected to the sacred (spiritual) mind, or Buddha mind. The sympathetic system also has a role in manifesting latent, insidious emotions, pain, fear and tension as well as extreme joy or alertness. It is important to know that anger and resentment cause the secretion of norepinephrine and fear and worry cause the secretion of epinephrine. Disputation, even for religious purposes, intense focus on the subject of meditation, and body negligence by overdoing meditation also activates the secretion of these two substances. If these situations persist, the body will become imbalanced because the sympathetic system is over- stimulated. The result may be heath problems, due to the effect of the sympathetic chemicals, such as insomnia, migraine headaches, depression, memory loss, chronic fatigue, stress, an irregular heart beat, high blood pressure, diabetes… Besides, persistent worries and fear can also cause the thymus gland to shrink leading to a reduction of immunity.

The parasympathetic system is responsible for a quiet and relaxed mind. It is classified as the quiet system and manifests when the “three tense mind” (three tenses include past, present, future) is replaced by the “here and now” one.

Meditation language says this quiet mind is influenced by transformed intelligence, wordless awareness, tacit awareness, awakened awareness, awareness nature, true mind or "the Boss" and plays an essential role in spiritual experience. For example, by practicing Samādhi Meditation or Insight Meditation, one can experience tranquility of the mind with an absence of thinking called Samatha or the state of solid concentration called Samādhi. It is also activated by religious practice such as recitation of Buddha's teaching, beating a gong, repetition of a divine saying, praying, naming one's beads, and repetition of Buddha's name done individually or in a group. Although there is thought in this case, but without sense of bias, stimulation, confrontation, or discrimination accompanied with a regular rhythm, it is effective in relaxing the mind and activating the parasympathetic instead of sympathetic system. Another word, parasympathetic functioning is related to religious experience at a normal level and to spiritual experience at a higher level.

SUMMARY and CONCLUSION

1. Autonomic means self governed or independent. The ANS controls functions of internal organs, regulates activities of cardiovascular, digestive, urogenital systems. It works continuously and involuntary.
2. It is named "self governed" because its function is not controlled by consciousness. We can control skeletal muscles, but cannot do the same with the stomach and heart muscles because they are activated by the ANS.
3. The ANS is not fully self governed because it is activated by the hypothalamus that is influenced by one of the three states of awareness: (1) Consciousness awareness, (2) Thinking awareness (3) and Insight awareness. This is an important point. By practicing

meditation, one can control activities of the ANS, to make the parasympathetic system work better and realize the value of meditation to human life.

4. The ANS includes all nerve cells carrying information between the central nervous system and internal organs. It is divided into two parts: sympathetic and parasympathetic, which have opposite functions in order to regulate the smooth muscles, heart muscle, and endocrine glands. It has an important role in assuring respiration, circulation as well as to expressing different experiences to emotional states.

   Most of the sympathetic nerve endings secrete NE and parasympathetic nerve endings secrete Ach. These chemicals have an opposite effect on visceral organs and glands.

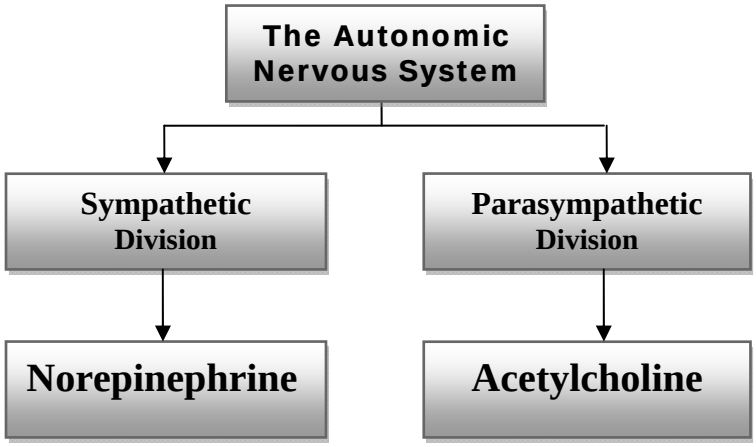


Chart 1: Automatic Nervous System

5. The Sympathetic system participates in almost all activities of organs, so its dysfunction is partly responsible for causing illnesses such as gastric ulcers, high blood pressure, cancer… or it can help in the cure

of these problems in the short term or long term if one knows how to use the method of respiration for healing of Chi Kung, for example.

Some activities such as dancing, running, swimming long distances, lifting weights, physical or intellectual overwork, and intense focusing on the subject in meditation stimulates the sympathetic system that may cause psychosomatic illnesses.

Those who have an overactive sympathetic system usually get a dry mouth, moist palms, and increased heart rate even at rest.

6. The Parasympathetic has an opposite effect to the sympathetic system in order to make an organ rest and restore energy, decrease blood pressure, blood sugar and lipids, with a normal heart rate and digestion and a slow rhythm of breathing.

General Actions of Parasympathetic and Sympathetic Nervous system on Internal Organs

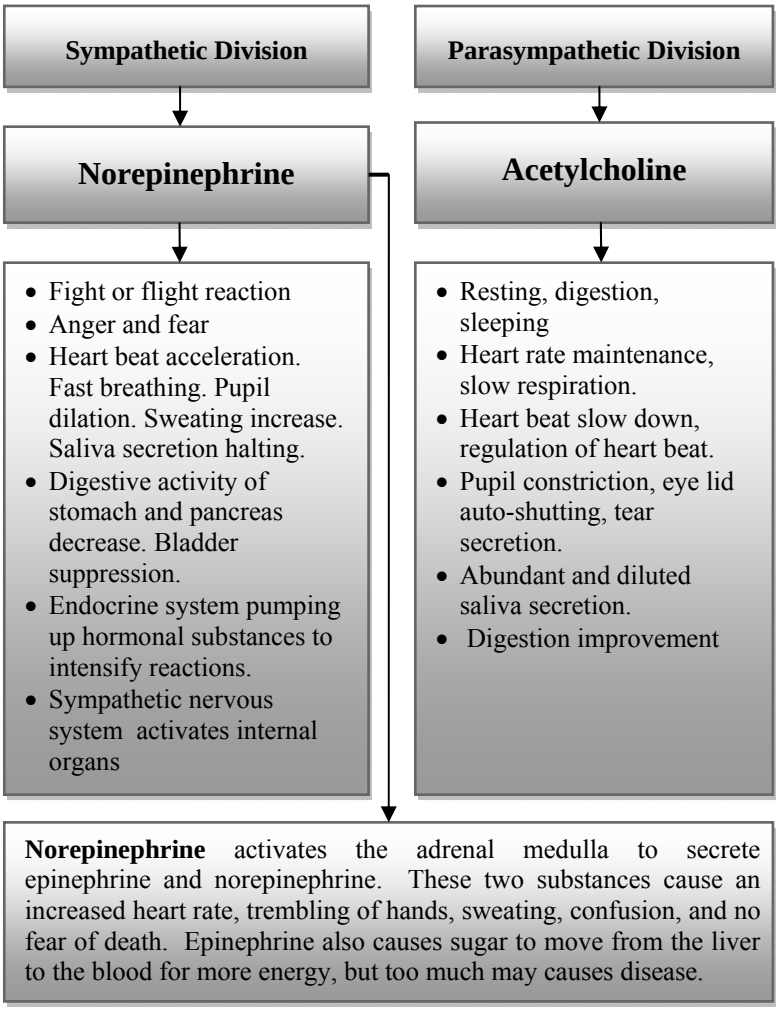


Chart 2: General Actions of Parasympathetic and Sympathetic Nervous system on Internal Organs

ANNOTATION

1. **Neurotransmitters**: A group of chemicals of nerve cells that transmit information from one nerve cell to another in the brain. It activates most of the neurons. Feeling, sensation, thinking, movement, action, and reaction, all depend on the balance or imbalance of these neurotransmitters. They are named Norepinephrine, Epinephrine, Acetylcholine, Dopamine, Serotonin, and Histamine according to their chemical constructions. Most organs receive Acetylcholine and Norepinephrine to express a state of true mind or false mind, under the presence of a "Tranquil Self" or "Agitated Self".

2. **Norepinephrine**: Substance found in sympathetic nerve endings and the anterior lobe of the pituitary gland. It activates the pituitary gland to secrete ACTH (Adrenocortico trophic hormones). One of the roles of this hormone is to lengthen the response to stress. It also causes the secretion of norepinephrine and epinephrine in the adrenal medulla. It is also found in the locus coeruleus of the brain stem.

   Anger, discomfort, concentration, cause secretion of norepinephrine.

   Effects of norepinephrine:

   - Increased blood lipids
   - Mental disorders especially depression, manic-depressive psychosis with
   - An excessive amount, but with the proper amount it helps memory, and ability to study.
   - Increased blood pressure, heart rate, and constricted veins.

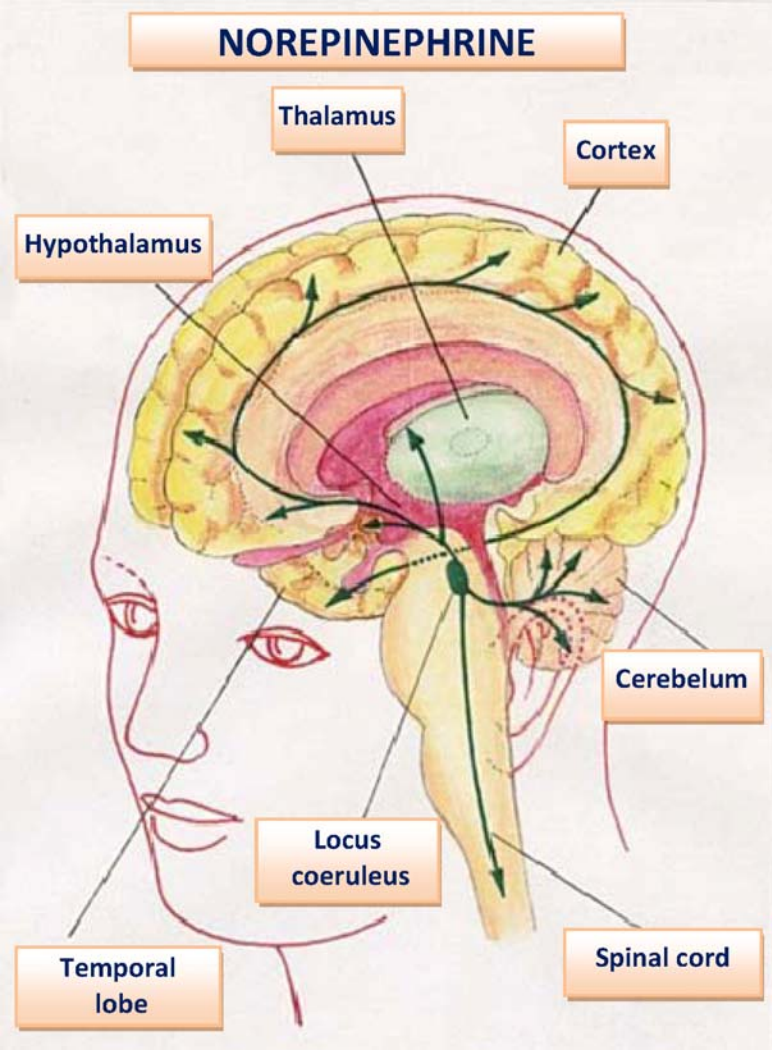


Figure 1: Norepinephrine system

3. **Epinephrine**: secreted by the adrenal medulla when it is activated by the sympathetic nervous system.

   Adrenal medulla secretes 75-80% epinephrine and the rest is norepinephrine.

Epinephrine is activated by:

- Stress
- Excessive physical training
- Fear, worry
- Response to emergency when sympathetic system is activated.

Effects of Epinephrine:

- Affects the cardiac muscle, increased heart rate, palpitation. Excessive epinephrine may cause cardiogenic shock if the volume of blood returned to the heart is decreased suddenly. When having fear, epinephrine secretes and causes a rapid heart rate, pale skin, cold extremities.
- Both epinephrine and norepinephrine are secreted when experiencing fear. These substances create blood lipids.
- Epinephrine from the adrenal medulla increases metabolism to cause an increased body temperature, shortness of breath, and low blood sugar. It explains why fear, worry, or a psychological state of escape from something wears out one's energy.
- Fear and worry cause nervousness as well, but if the person gets help, or solves the problem, he is able to restore the balance in his blood pressure, sugar, and lipids will return to normal levels. The technique of two phase breathing is effective in creating this balance immediately.

4. **Acetylcholine** (Ach) is synthesized from *choline* and *acetylcoenzyme A*. It is secreted in many places such as parasympathetic nerve endings, motor area of the

cortex, medial septal nucleus of the thalamus, basal nucleus of the hypothalamus, pontomesencephalo-tegmental complex of the brain stem. Acetylcholine is especially secreted by sympathetic nerves to activate sweat glands.

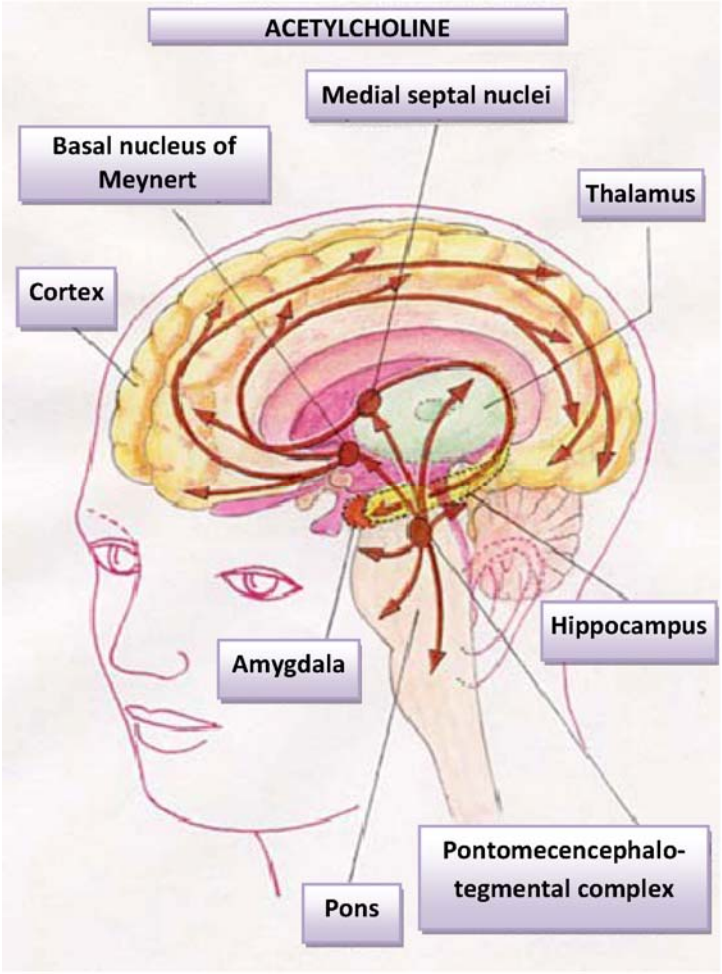


Figure 2: Acetylcholine system

Effects of Acetylcholine:

- Restore or strengthen memory and ability to learn.
- Alzheimer has gradual impairment of memory and cognitive function caused by lack of acetylcholine in the cortex. Contrarily, excessive cortisol also causes memory loss
- Quick mind
- Energetic body, strong muscles and bones
- Strengthen urologic function
- Use in treatment of glaucoma, hypertension, breathing disorders caused by bronchoconstriction

Side Note

Generality of function of the nervous system

The nervous system is very complex but generally includes two divisions: The central nervous system and peripheral nervous system.

The central nervous system (CNS) includes the brain and spinal cord with their nerves and end organs that control voluntary and involuntary acts. It has function in governing consciousness and mental activities in which the brain has an essential role.

The brain is considered the place where the mind, consciousness, and nature of awareness are located, so they can't function if the brain is injured. The brain is the center to control the real mind as well as the wrong one, word and wordless cognition. It manifests the mind, consciousness, and nature of awareness through states of affliction, suffering, calmness, instant realization, and full realization. Without it, the latent ability of enlightenment is unable to

develop. That is why the human body is valuable for spiritual cultivation, as per Buddha Gautama.

The peripheral nervous system (PNS) is the portion of the nervous system outside the CNS connecting CNS to end organs. It is composed of the somatic nervous system and autonomic nervous system (ANS). The somatic nervous system includes sensory nerves transmitting sensory information from receptors of the entire surface of the body and some deep structures to CNS and motor nerves transmitting information from the CNS to control skeletal muscles. Acetylcholine is found to be one of the rapid acting transmitters of the somatic nerves.

EFFECT of SYMPATHETIC and PARASYMPATHETIC NERVES

ORGAN	PARASYMPATHETIC	SYMPATHETIC
Lacrimal gland	Stimulated	None
Eyelid	Closed	None
Pupil	Constricted	Dilated
Salivary gland	Increased, thin saliva	Decreased, dry mouth
Bronchi & trachea	Constricted, Slow breathing with temporary cessation of breathing	Dilated, normal breathing
Heart muscle	Slowed rate	Increased rate
Coronaries	Dilated	Constricted / Dilated

Skin arterioles	None	Constricted
Blood vessels	None	Constricted; increased blood pressure
Liver	Slight glucose synthesis	Glucose released
Intestine	Increased peristalsis, Relaxed sphincter	Decreased peristalsis, Increased sphincter tone
Gall bladder	Contracted	Relaxed
Kidney	None	Decreased output
Adrenal medulla	None	Increased secretion of EP and NE
Pancreas	Increased insulin & enzymes	Increased glucagon
Bladder	Contracted	Relaxed
Sweat glands	None	Sweating on palm of hand & Copious sweating sole of foot (cholinergic)
Stomach	Increased motility & enzymes	Decreased motility & enzyme
Mental state	Tranquil, calm, comfortable	Sad, latent emotions; alert, worry, fearful, angry

Article 3

ELECTROENCEPHALOGRAPHY (EEG)

INTRODUCTION

Using scientific technology to observe the mind

Usually, with the normal eyes, we cannot see the appearance and the features of the mind. These days, with the aid of electron microscopes, PET and fMRI technology that can image the brain and record the brainwaves, we are able to observe—and monitor the status of the brain undergoing various levels of mental activity. This is the result of research by scientists starting from the beginning in the 19th century until today.

Nowadays, neurology scientists can visualize the status of the brain during the course of thinking, feeling, and perception on the computer monitor. Most of the functional activities of the brain such as thinking, cognition, and perception generate different brainwaves that can be recorded and quantified. These brainwaves give off nerve impulses or electric potentials, that transmit to the limbic system across the cerebral cortex through a nerve fiber network, also called axon system.

The cerebral cortex is a part of the brain that is divided into different areas or regions. These areas have different functional activities related to psychology, physiology, intellectual activity, perception, cognition, thinking, motion, feeling, language, creativity, art, short-term memory, intelligence, and spirituality.

In order to easily recognize the function of the different areas of the brain, neurologists divide the brain into four lobes, each with different functions:

1. The function of the right prefrontal lobe is associated with consciousness; the left hemisphere of the brain is associated with the mind-base and the intellect. These three areas, combining with the faculty of language, which comprises wordy thinking (*Vitakka*) and discursive dialogue (*Vicāra*) to establish the status of verbal awareness, are under the control of the self. In Buddhist meditation, these three areas are a hindrance for the meditator who practices Samādhi that, according to the Theravada tradition, is the mind status of wordless awareness belonging to the Awareness Faculty. It is not the mind status of concentration upon an object as in the case of the Yoga meditation. When the meditator practices and experiences steady and stable Samādhi, chattering mind, mental murmuring, and inner silent dialogue have no chance to arise.
2. The function of the occipital lobe is related to vision or the seeing faculty.
3. The function of the temporal lobe is related to hearing or the hearing faculty.
4. The parietal lobe plays two important functions:

- Associated with the touching of the three senses: smelling, tasting/feeling, and touching.
- Associated with cognitive awareness in order to interpret the meaning of the surroundings in contact with the senses through communication to the Wernicke area and the Broca area. These two areas have the function of encoding and decoding the meaning of the nerve signals transmitted from contact

with the outside world or inside the body. If these two areas appropriately function and the practitioner knows how to meditate in a proper way, he will realize the spiritual value of Buddhist meditation.

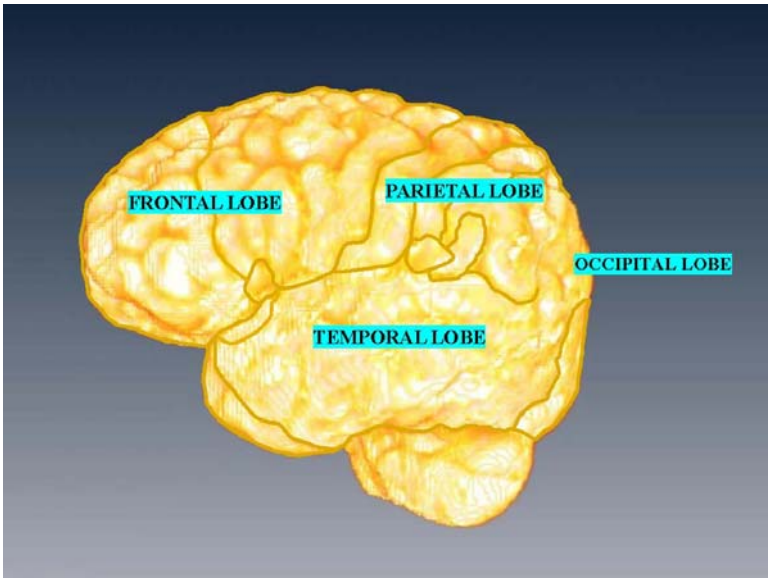


Figure 1: Location of four Brain Lobes

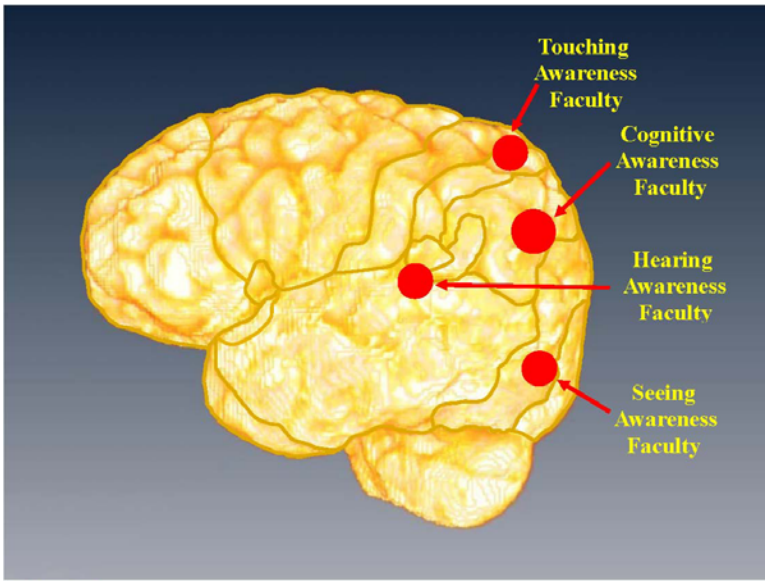


Figure 2: Location of four Awareness Faculties

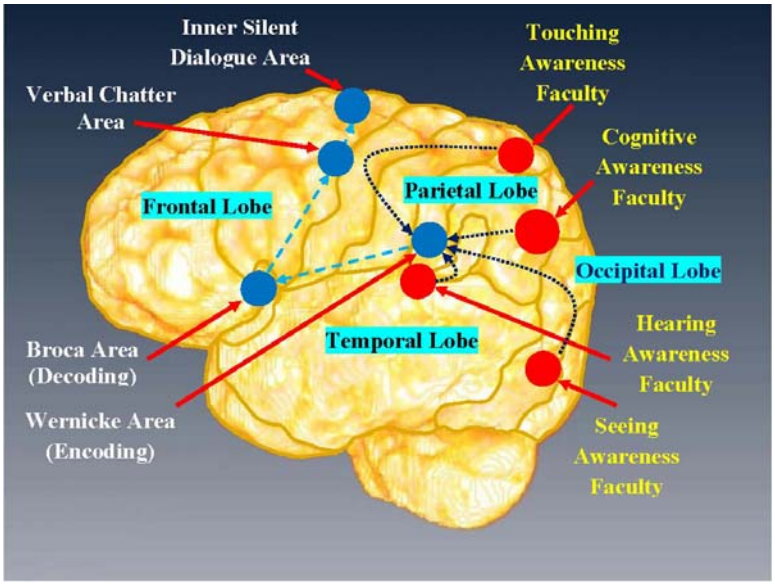


Figure 3: Language pathway

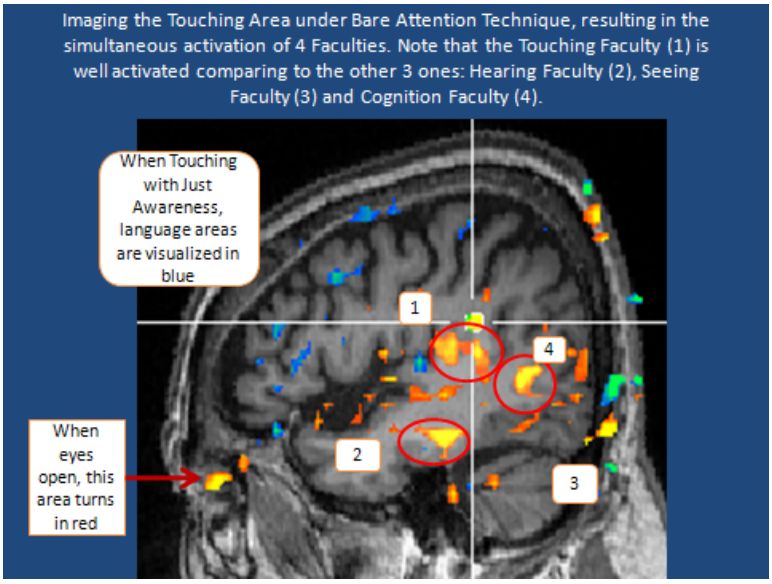


Figure 4: Resulting in the simultaneous activation of 4 Faculties

In Buddhist meditation, all 3 lobes are related to the 4 awareness faculties that comprise 2 features of noble minds: the mind of the Sage and the mind of the Buddha. These 2 noble minds play a role of utmost importance to the meditator who wants to advance in developing his spiritual potential for the sake of ending suffering and attaining enlightenment.

Back to the past

René Descartes (1596-1650)

In previous centuries, before electronic technology had been developed, Descartes (1596-1650), a French mathematician and philosopher, was considered reasonable to postulate that the mind was non-matter. At that time, there was no understanding about the mind and its form, the

interaction between the mind and the brain, the effect of the mind upon the autonomic nervous system, memory-storing system, endo-secretory gland system and internal organs.

Some people assume that the mind has no origination-base in the brain due to its non-material nature. It is not true. Without the origination-base, how do emotions such as sadness, displeasure, joyfulness, sorrow, anger… express on our face? Take an analog example. Neither the real speaker exists inside the telephone, nor the announcer inside the TV set. Although the speaker or the reporter is not found inside the radio or the TV set, it does not imply that there is no person who creates the voice or the pictures.

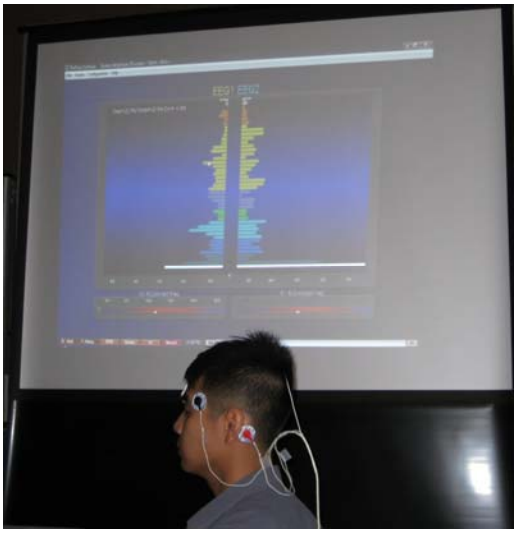


Figure 5: Practitioner under being monitoring brainwaves by means of EEG

Similarly, based on the fact that the mind is non-material and unable to be observed, we can not deny its existence within our brain or its role as the root of our psychosomatic diseases. Scientific researches have demonstrated that most of the psychosomatic patients have common mental problems such as anxiety, mental disorder, stress or fear. Recent psychologists have found the medical efficacy of

Meditation in treating psychosomatic diseases, up to some extent.

Meditation works on regulating the mind through a variety of practical techniques of awareness-as-such based on vision, hearing and touch/feeling. If regularly practicing these techniques in daily life, we will experience cessation of the habit of discursive thinking of the mind-base, the imagination of the intellect and dualistic discrimination of the consciousness. Immediately, as a result, we will experience awareness of the-here-and-the- now.

Thus, although formless, the mind must have an origination. It generates from our brain under different aspects: mental images, wordless dialogue, or non-stop discursive thinking all day and all night long. The Buddha described this mind in Rohitassa Sutra as "… feeling, perception, mental formation, consciousness are not outside of this body"

Since 1997, we have used electroencephalography technology as a tool to monitor mental activities of the brain. As a result, we found that brainwave patterns are well correlated with the progress level of meditation functioning. The meditation practitioner was able to observe and self-evaluate the progress of his practice through the brainwave recording.

DEFINITION

What is Electroencephalography?

Electroencephalography (EEG) is a technique of recording electrical activity generated by the neural network of the brain. Multiple electrodes are placed in contact with the scalp of the practitioner and they transmit the electrical charges over a short period of time to the computer which in turn transforms the charges into a form of oscillated

waves. The brainwave reflects the activity of the neurons, corresponding to the mental status of the brain such as:

- Activity through the process of thinking, reasoning, discriminating, memory
- Recollecting by means of wordless dialogue or discursive th
- inking;
- Imagination or autosuggestion;
- Practice of halting silent dialogue, awareness, just awareness.

Equipment assistance

Nowadays, Buddhist meditation or Yoga meditation centers in the USA, Japan, and India have been using EEG to monitor the progress of the practitioner's mental consciousness (*Manoviññāṇa* or *Mano* consciousness) during the period of meditating on certain meditation topics. Based on the result of the EEG records, the progress in taming or halting verbal thoughts of the practitioner is evaluated. Usually, the duration of the EEG recording lasts from 5 to 10 minutes.

Evaluation of the EEG technique

In our new direction of meditation practice attempts to demonstrate, objectify and clarify the teachings of the Buddha and the Patriarchs, such as:

- Controlling the verbal and talkative thoughts (*Vitakka* and *Vicāra)*,
- Wordless thoughts and cessation of thinking;
- Controlling perceptional formations, not to follow false thoughts in order to manifest the Buddha Nature.

Since 1997, we have employed EEG to monitor the "process of the mind" of the practitioners, including 2

parts: false mind and true mind. Thanks to the EEG, we could evaluate our method of meditation practice to control the mental dialogue to halt the false thinking, and to dwell in the "Suchness (Tathā)" at the highest level.

In subsequent years, after the end of every retreat times lasting from 1 week, 10 days, 3 months, 6 months, 1 year or 3 years, we have monitored the brainwaves of practitioners to guide them on how to control their mental dialogue in order to reach the stage of Samādhi. Once the practitioner controls his mental dialogue, he can easily attain the state of Samādhi. Dwelling in the state of Samādhi, the false mind is transformed at ease and spiritual wisdom also has a favorable condition to develop. In addition, at that stage of mind, the ability of memory recovery and synapse regeneration becomes real.

During the last 2 years (2009-2010), in Perris (California), Böblingen (Germany) and Paris (France), during a 10-day long meditation retreat, we guided the practitioners to meditate through 3 steps of Samādhi: (1) verbal but non-discursive dialogue Samādhi, (3) wordless and non-discursive Samādhi, and (3) Mindful Awareness Samādhi *(Sati Sampajanna Samādhi)*. The practitioners have experienced "Silent Wordless Awareness" and "Wordless Awakening Awareness", which manifested under the brainwave of theta and delta pattern, respectively.

What is the false mind process?

The false mind process is the uncontrollable manifestation of various levels of psychological sentiments of various categories during the meditation session without the control of wandering thoughts. Besides, during sitting meditation, when practitioners use the following techniques:

1. Imagination about or concentration on an object in front of their eyes,

2. Effort in observation or investigating an object on or outside of the body,
3. Chanting mantras, reciting Sutras, or rhythmically reading Buddha names, the brainwaves of the practitioner manifested Beta or Alpha patterns, indicating the activity of the false mind...

What is the true mind process?

In contrast, the true mind process was attained during sitting meditation via the following mental status:

1. Wordless Awareness
2. Tacit Awareness
3. Awakening Awareness
4. Wordless Cognitive Awareness
5. Mindfulness Awareness
6. As-Such Wisdom
7. Dwelling in As-Such Mindful Awareness

The brainwave of the practitioners expresses the Theta or Delta patterns depending on the progression of Samādhi from low to high level.

EFFECT

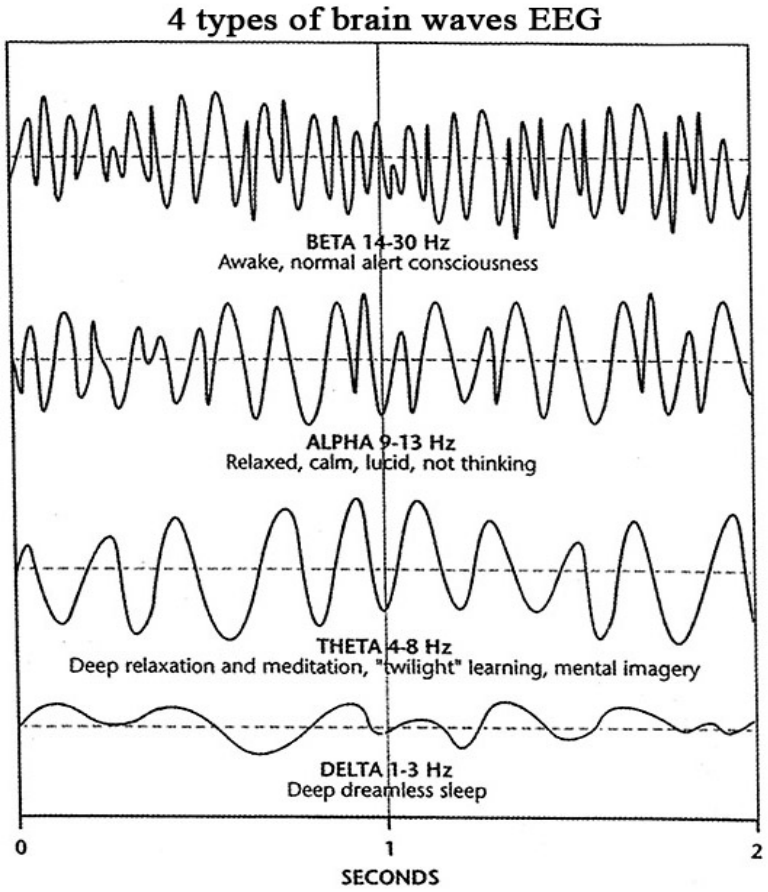
The EEG graph is an important tool to evaluate the tranquility level of spirituality or the effectiveness of the cessation of false thoughts of the practitioner after a period of practice from 7 days, 10 days, 1 month, 3 months, 1 year or 3 years. After each period of meditating mentioned above, if the practitioner had not experienced controlling false thoughts, even in a short few seconds, although the

verbal thinking was still going on, he had to reconsider his technique/method of practice:

1. Has he practiced regularly?
2. Has the practice method/technique led toward the control of thinking in order to manifest the Awareness Nature?
3. Has he practiced the go-around method? Had he played the cat-and-mouse game with the false thoughts? Has he always had the discursive dialogue all day long instead of experience in "wordless awareness"? Has he ever put in use the technique/method of Wordless Awareness, Just-Awareness, and Tacit Awareness…?

MEANING OF BRAINWAVES

With the aid of EEG, neurologists record the electric charge fired from the neurons and transmitted along the axon. This electric charge manifests under the form of a wave, thus called brainwave. There are 4 different brainwave patterns: **Beta, Alpha, Theta,** and **Delta**.



Four brainwave patterns of EEG

I. BETA BRAINWAVE

Meaning

C. Maxwell Cade, a Briton, the first scientist who established the biofeedback model defining Beta brainwave as "*the normal waking rhythm of the brain associated with active thinking or active attention, focusing on the outside world or solving concrete problems. The strength of the signal is increased by anxiety and reduced by muscular activity."*

From the view point of meditation, the Beta wave is always associated with Silent Speaking (*Vitakka* and *Vicāra)* and Perceptional Formations (Touch/Feeling and Perception).

Characteristics

Beta wave pattern has 14-30 Hz per second. "Hz" indicates the frequency of the oscillating wave cycle in a second. "Hz" stands for "Hertz", the name of the German physicist: Heirich Hertz (1857-1894). In 19th century, Hertz was the person who first discovered the light wave emitted from a radio station. His name was used as unit of oscillating brainwave frequency in 1 second.

The brainwave of the Beta pattern represents the activity of false thoughts, false mind, discursive thinking (*Vitakka* and *Vicāra)* and perceptional formations (Feeling and Perception). It is also the result of intellectual reasoning, complex thinking, and dualistic discrimination of the consciousness through non-stop mental discursive thinking, imagining over an objective of experience, or practice on a meditation topic.

Condition of occurrence

The Beta pattern brainwave generally appears in the following cases:

- For the beginner, surrounding noise during meditation.
- Right after a meal.
- High blood pressure and metabolism rate increase.
- Under anxiety the heart beat increases, as does the respiration rate, the practitioner can not think straight, the mind might be out of control and the Beta brainwave immediately irregularly oscillates.

During sitting meditation practice, the Beta wave appears under these following circumstances:

- When awaking with the consciousness as well as with intentional concentration of thought on a subject, mental attentiveness is in full force through thinking, reasoning, discursive dialogue along with psychological sentiment expression.
- Discursive dialogue upon problems related to the life.
- Imagination about something.
- Mental images and memory recall, especially long-term memory, leading to discursive dialogue about those mental images.
- When feeling arousal in response to contact with the outside world, the practitioner uses the consciousness, mind-base or intellect to study and to solve the problem of the objective through the functions of analysis, combination, comparison, reasoning….
- Under intentionally and constantly alert status, similar to the situation of "the cat laying in wait for the mouse". The analogue of this is that the practitioner thinks that he is the "cat" and the thought is the "mouse"; when the mouse appears, the cat jumps over to catch it. This is a

tense effort to hold down thoughts from arising without success.

- Especially, the practitioner strenuously endures the pain or the numbness in the legs, the Beta brainwave pattern is generated. In full or half lotus sitting position, if the practitioner struggles in maintaining the body upright for the predetermined 60 or 120 minutes long and battles to oppress false thinking or plays cat-and-mouse game with false thoughts, the Beta brainwave also occurs. The more effort the practitioner puts in struggling with the false thoughts, the more nerve-racking it is, resulting in distancing himself from the meditation objective.

Comparative to the Dharma teachings

The Beta pattern brainwave occurs when 4 out of 5 aggregates, namely feeling, perception, mental formations, and consciousness, representing false thinking, arise. However, if a feeling had arisen and the practitioner not attached to it, the Theta pattern of brainwave would have occurred.

Method to control Beta wave and generate Alpha wave

In order to control the Beta brainwave and to have the Alpha brainwave instead, the practitioner may use the method "*verbal thought*" to cut off the wandering thinking habit by one of these following techniques:

1. Counting the breath.
2. When breathing in, silently count 1. When breathing out, silently count 2… thus continuing until 10. Then repeat the cycle of breathing and counting. Counting the breath for 30 seconds, the Beta brainwave will gradually lower its frequency and change into an Alpha brainwave.

3. Reciting Buddha's name.
4. The practitioner can also use the method of reciting the Buddha's name with an even rhythm. The recitation can be voiceless or vocal, adequately audible to the ears. The Beta wave frequency also reduces and the Alpha wave appears instead.
5. Chanting a mantra.
6. Similar to the above method of reciting Buddha's name, a mantra is used instead of the Buddha's name.
7. Silent counting.
8. The practitioner also silently and slowly counts from 1 to 10 for 10 seconds, the Alpha wave also occurs.
9. Mind concentration.
10. The practitioner also concentrates his mind on certain places in his body such as the nose tip, pubic area below the navel. He also sits with the upper body straight and focuses his mind in contemplating the sensation of each internal organ of the body such as abdomen, hand, head, face… the Beta wave also is replaced by an Alpha wave.
11. These above methods, in meditation terms, are called "using verbal thoughts to halt wandering thoughts"

Method to control the Beta wave and generate the Theta wave

To control the Beta brainwave in order to have Theta, the practitioner may apply these following techniques:

1. When sitting with a straight upper body and looking at any object in front of the eyes to "just see" it, the

brainwave will change the Beta to Theta pattern right away.

2. When hearing the surrounding sound to "just hearing" also slows down the Beta wave to change it to a Theta wave.

3. Practicing "just aware" in any daily activity such as walking, standing, sitting (except meditation sitting) including tooth brushing, bathing, driving, eating, drinking… for a short period continuous from 7 to 10 days, the Theta wave will replace the Beta wave. The practitioner is always "just aware" of the just happening feeling at the event of 5 senses in contact with the surroundings. This is termed "Samādhi within motion", which simultaneously stimulates the mechanism of the Awareness Nature.

II. ALPHA BRAINWAVE

Meaning

Associated with an object, the Alpha brainwave represents the "temporary halting mind", which reflects the Verbal but Awakened Awareness of consciousness resulting from the activity of the right and left prefrontal brain areas, the Broca area, together with the silent discursive thinking area.

The Beta wave indicates the increase of activity of the mind-base, consciousness, and intellect in relation to verbal and perceptional formations, whereas the Alpha wave means the increase of autosuggestion with regard to "*Vitakka* without *Vicāra*" (verbal thinking but without discursive dialogue).

Autosuggestion is a meditation practice in which the practitioner proposes to himself a verbal affirmation or a

mental image to create a joyful reflection or psychological impression. It is often associated with imagination rather than reality.

Characteristics

The Alpha wave represents a calm and relaxed mind, yet not really as tranquil as the Theta wave does. The frequency of the Alpha wave is lower than that of Beta, ranging from 9 to 13 Hz on average. The Alpha brainwave is characterized by the presence of "silent verbal thoughts" but without the "discursive dialogue". In other words, it is a mind status with *Vitakka* but without *Vicāra.* It is equivalent to the status of Awakening Consciousness. Although being awakened, the mind with the Alpha wave is still in dualistic discrimination involving the self and its object. Particularly in this process, there is no thinking activity of the mind base but only the focusing/concentrating on an object of consciousness or imagining toward an object of the intellect.

Condition of occurrence

The Alpha wave is generated when the practitioner utilizes consciousness to focus or concentrate on an object. During that time, the wandering mind is tamed but thinking is not completely halted due to the presence of concentrating thought. This process is the status of one-pointedness mind (*citta-ekaggatā)*.

In general, the conditions that generate the Alpha brainwave are as follows:

The interaction of the self + the mind (Consciousness, Mind-base, and Intellect) + Autosuggestion + Objective

(main topic or Dharma) leads to the rise of the Alpha brainwave.

1. To limit the fluctuation of the mind, the practitioner makes an effort to concentrate on an object in front of the eyes or on the body such as the pubic area, the top of the nose, or the middle of the forehead. During this mental process of concentration on an object, the Alpha wave is generated. Wandering thoughts do not arise, and non-verbal thinking does not exist and the mind maintains the concentration on an object under one sharp and clear thought.
2. To prevent the mind from wandering, when practicing meditation in daily activities such as walking, standing or sitting, the practitioner purposely concentrates his mind on one single object such as reciting the Buddha's name or the beads. Thus, although the mind is still active on subtle scale, it is settled down, not as much fluctuation as that in the status of the Beta wave.
3. Counting breaths from 1 to 10 and following the process of breathing in and out.
4. Falling sleep while meditating creating Alpha waves as well.
5. The appearance of a sudden thought in one's mind without any intentional thinking initially.
6. Daydreaming, fantasizing, remembering, and visualizing things in the mind.
7. Wishful thinking and dreaming of things one wants to achieve in the future.
8. Recalling, or longingly and regretfully remembering things, which have happened in the past, then envisioning ways to correct past mistakes.

9. Utilizing auto suggestive thinking to continuously imagine things that one has never known or seen previously; or envisions in an after-life location.

Comparison

In contrast with the Beta wave, the Alpha wave reflects the constant presence of Perception, one component of the five aggregates activity.

In comparison with the Beta Wave, which represents bad, malicious thoughts that induce stress, the Alpha brain wave represents good intentions, tranquility of thought or clearly knowing an object. It equates to a one-pointed(ness) mind.

In this thought process, volition still exists. It is the "I-consciousness" somehow concentrating or focusing on an "I-object".

Although a practitioner with an Alpha wave brain who ultimately concentrates on an object does stay in a relaxed and calm state, he/she still experiences arising thoughts, such as following some bodily activities, or imagining things in the mind. It is intentional.

For example, initially trying to practice a Breathing technique and later imagining how to inhale/exhale breaths, that is called "self-indulgence/self-suggestion." In this process, one uses his thinking mind to practice:

- Trying to memorize from 1 to 10; recounting when missing the count, or counting backward: 10, 9, 8 ...1; or forward: 1, 2, …10.
- Imagining in the mind how breathing should be done.

Although wandering thoughts do not appear in this

condition, they are still considered to be imagination. Mind has not completely been tranquil; it still attaches to the surrounding objects.

At another time, one imagines or envisions that every inhaled or exhaled breath will bring a fresh mind and healthy body. On the surface, it seems like his mind is relaxed and calm; however, continuous thoughts and after thoughts do arise in this state.

When ones' mind works at this subtle level, the Alpha waves regularly appear. This low frequency wave is slow, and has an average frequency from 9 to 13 Hz per second.

Therefore, when one practices Counting Breaths, Monitoring Breaths, or Contemplating/Observing an Object on the body or Self-Suggestion for an image, an after-life realm, the Alpha wave appears at once. This shows that there is a connection between the mind and consciousness.

Applying the Meditation of Contemplation helps one's mind cease wandering thoughts; unwanted thinking does not arise but mental activity still exists because one's mind is trying to focus on a selected meditation subject. This is a condition that makes Alpha waves appear.

Relationships between Alpha Waves and Five Senses

From the biophysical viewpoint, Alpha waves are associated with one's eyes, and the awareness of discriminative consciousness and intellect.

Practicing the technique Looking at the Sunlight or Watching Clouds in the sky will quickly induce Alpha waves. They also appear when Cloud Watching is simultaneously taking place with other mental activities of

silent voices and inner dialogues.

Additionally, one can create more Alpha waves when meditating with the eyes rolled upwards.

Techniques to induce Alpha waves to lead to Theta waves

- Alpha waves will be replaced by Theta waves if the following techniques are used:
- Breathing with the Nonverbal/Wordless Awareness technique;
- Looking at an object upfront with *tacit awareness* or *Just Awareness.*
- Sitting meditation in a relaxed state. For example: using the Tongue Relaxation, or Facial Relaxation will activate the Alpha waves at first, then followed by the Theta waves.
- Having a detached awareness or wordless awareness mind.

III. THE THETA BRAINWAVE

Meaning

The Theta wave represents tranquility of the mind: the existence of Wordless Awareness. The rhythm of tacit and Awakening Awareness coordinates with activities of the Gnostic Area located in the back of the left brain hemisphere. Theta Waves appear when there is definitely no volition or attentiveness inside or outside of one's body.

The practitioner's mind is in an empty state, being aware yet detached of everything. In the Five Aggregates, the non-attached feeling constantly exists, but Perception, Mental Formations and Consciousness are absent.

Characteristics

Theta Waves have the frequency of 4 to 8 Hz per second. This is a deep state of meditation or relaxation. Thoughts do not automatically arise in the practitioner's mind. Speech and perceptional formations are quiet. The short term, long term, and working memory are not working.

Therefore, the Theta Waves are considered the foundation of all types of Samādhi. In this stage, both verbal thinking (*Vitakka*) and inner dialogue (*Vicāra*) are absent. Perceptional formations are also not present.

Conditions of occurrence

The Theta waves immediately arise when a practitioner applies the following techniques:

- Tacit awareness
- Awakening awareness
- Suchness awareness [7]
- Thusness awareness[8]
- Controlling the silent voices

Additionally, when meditating with relaxation techniques like Tongue Relaxation, or Facial Relaxation, the Alpha Waves initially appear then followed by Theta Waves.

Comparison

Theta waves equal the state of non-verbal thinking or non-inner dialogue. On the other hand, the Alpha waves equal the state of *Annupassana*, autosuggestion or focusing on a topical object. When the practitioner ceases the silent talks and the inner dialogues, the Delta waves immediately appear. Maintaining this nonverbal state from 10 to 30 minutes, the waves can be seen on a computer screen.

IV. THE DELTA BRAIN WAVE

Meaning

The Delta wave represents a solid concentrated mind. The wordless awareness appears and usually combines with nonverbal cognitive awareness in the Buddhita's area. The practitioner's mind is completely subjective.

Characteristics

The Delta wave has high amplitude with frequency from 3 to 4 Hz or a lower frequency of 1 to 3 Hz per second. Looking at a computer screen, its image resembles closely a long, straight line.

Condition of occurrence

With techniques as follows:

- Wordless Cognitive Awareness
- Suchness Awareness
- Seeing things as such,

the Delta wave arises. Measuring them merely at that moment is not accurate because the wandering mind will come back. To continuously maintain the Delta state, the meditator must solidly reinforce the exercise elimination of silent chattering in the four daily activities.

Comparison

Equipped with Nonverbal Cognitive awareness, one can go into the Delta state, while Tacit and Awakening awareness lead to the Theta state. The Delta Wave state is compared to the state of a person who is in deep meditation of the second level of Samādhi with a unified mind, and the third level of Samādhi with awakening mindfulness. Compared to the meditation sect, it is the non verbal or wordless state of mind, from which the Eight Winds (Life Influences) cannot sway the practitioner

Others circumstances

In meditation, the Delta waves represent the state of "Mind as Such" or the "Wordless Cognitive Awareness" which last from 5 to 10 minutes, or a whole meditation session. For those who do reach the Samādhi state yet not knowing what is happening in the surroundings or not achieving the nonverbal awareness, the Delta wave does appear but the spiritual wisdom has not been present spontaneously.

The Delta wave also arises when the practitioner sleeps deeply and the reticular formation does not receive any signal from outside, for example in the case of being under anesthesia.

A person who is in deep sleep or is comatose can manifest

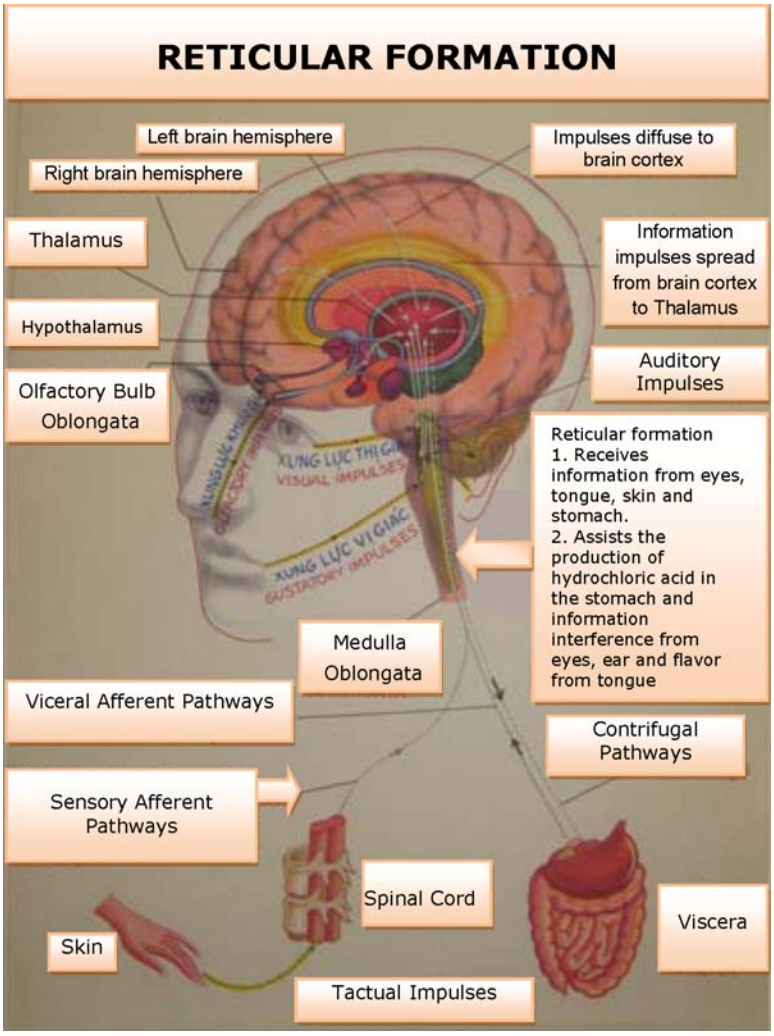


Figure 6: Reticullar formation

the Delta waves but the Wordless Cognitive Awareness is not present.

Effect

The Delta wave's effect mainly comes from intuition and empathy. One who owns these waves is a very

understanding person. The Four Immeasurable Minds: loving kindness, compassion, infinite joy, and non-attachment will be seen outwardly in his body, speech and mind.

Spiritual wisdom and creativity are developed from the Delta waves. At the Delta state, one achieves inexplicable spiritual insights as follows:

- Understanding empathy (an ability to understand or to be sensitive to others' feelings and emotions)
- Sensing in advance a premonition, a presentiment = a cognitive consciousness appearing without the interference of the 5 senses.
- A foreboding = a prophetic indication of a coming event.

Delta waves can be thought of as kind of human radar. A longtime practitioner who has continuously and firmly achieved these waves for many years has the capacity of sensing people's thinking waves.

At a higher level will be the development of creativity[10]. This includes the Four Unlimited/Unobstructed Eloquences[11], and the innovation[12].

NOTE: In this reading, we are pleased to present the Program of Neuroimaging in which our brain images were taken by Dr. Erb and Dr. Ranga.

In mid June of 2006, two of our meditation practitioners, Ms. Minh Van and Mr. Quang Nguyen of the *Sūnyatā* Meditation Stuttgart Center in Germany came to the Tubingen University to have the pictures of their brains taken during meditation and without meditation using the Telsa machine and the fMRI. This study was done by two professors: Dr. Michael Erb and Dr. Ranganatha Sitaram. The following years, from 2007 to 2010, they continuously

took the brain images of the Sūnyatā Sangha and two meditators Minh Huệ and Quang Chiếu to determine precisely certain brain areas and their functions during meditation.

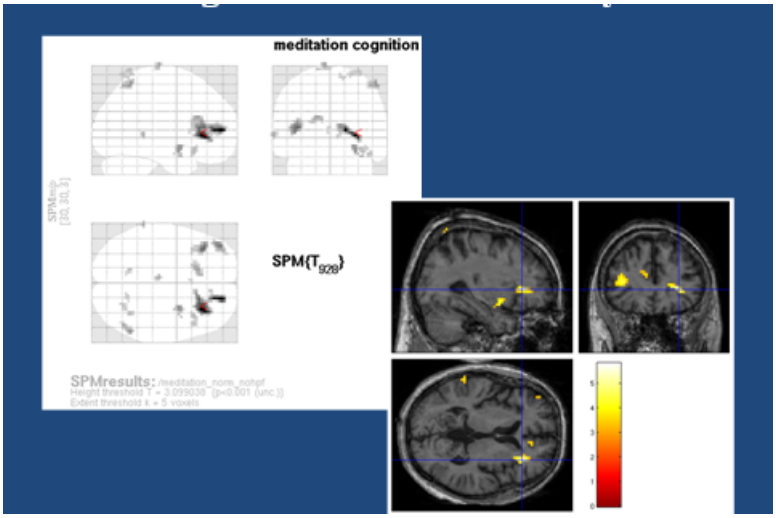


Figure 7: Cognitive Awareness Faculty

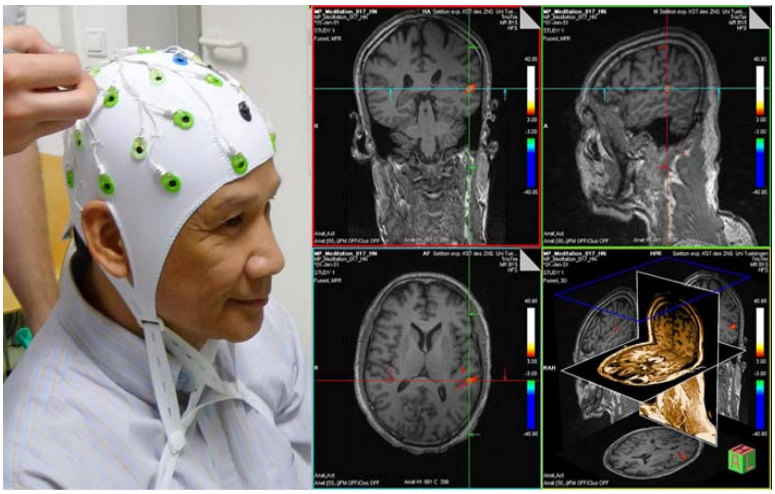


Figure 8: A brain image of meditator Quang Chiếu in deep meditation when the Cognitive Awareness at work

In the year of 2009 and 2010, Dr. Erb especially utilized simultaneous measurement of EEG and fMRI to measure our Sangha's and Quang Chiếu's brain waves while exercising the Four Awareness Faculties.

1. Wernicke, the first speech area.
2. The second speech area.
3. Hypothalamus.
4. The right and left frontal lobe.
5. The working memory.
6. The emotional memory which was named the Short-term memory by neuroscientists in the past.
7. The long-term memory, located in an opposite area with the cognitive sensory area in the left rear lobe, functions based on the parietal lobe

Two years later (2010), we had a chance to image our brain combining with EEG.

TECHNICAL TERMS

1. **PET** is the abbreviation of Positron Emission Tomography. This is a nuclear medicine medical imaging technique technology in which brain functions can be recorded on a computer monitor while a patient lies flat on a bed/table that moves incrementally through a pipe-like scanner. The technicians use positron which is the antimatter that counterpart of an electron. It has the same mass as an electron but the antiparticles from positron have the opposite charges, the positive charge. It produces the emission of the radioactive atoms. Neuroscientists use it to study the blood flow concentrated at the specific locations in the brain to determine which area of the human brain

feeling and thinking can be established.

Since 1988, Steven E. Petersen, Michael I. Posner, Peter T. Fox, Mark Mintun, and Marcus E. Raichle, the neuroscience researchers from a medical school in Seattle, Washington have begun utilizing the PET technology to study the functions of human brains. They found that the speech area is located in the left frontal lobe and the hearing area can be found in both left and right temporal lobes.

2. **fMRI** stands for "functional Magnetic Resonance Imaging". This is a neuro-imaging technology, which takes clear and detailed pictures of the central nervous system and the spinal cord. It assists the neuroscientists to accurately identify the functional regions of the brain and how they operate.

During this process, a human's mind can be observed on a computer monitor in another room.

3. **Brainwaves:** The brain constantly produces electrical activity and brain waves are the rhythmic fluctuation of electric potential between parts of the brain. They can be measured with frequency and amplitude.

4. **Tầm** means *Vitakka* in Pali: pondering, reflection, common meaning: silent talk or chattering. **Tứ:** V*icāra*: means discursive thinking, investigation, examination. Popular meaning: the inner dialogues.

5. **One-pointedness of the mind:** *citta/cittassa-ekaggatā*. The technical term of *Ekaggatā* is one pointedness. It is one of the seven realms of the mental consciousness. *"Eka"* means one. Combining with the word *"citta"* or *"cittassa"*, it means one point in mind. In many Buddhist

scriptures, it means concentration, contemplation or tranquility.

Initially, it's just an object of the consciousness. One's mind becomes aware of an object, then it can be distracted by other objects.

Thus, the basic definition of "*ekaggatā*" only means a selected concentration. It has the same meaning with *samādhi*. However, there is a complete difference between *ekaggatā* and *samādhi.* The technical meaning of *Ekaggatā* is the concentrated/focused consciousness. It can help the practitioner develop to a higher level of meditation, yet silent voices and inner dialogues still exist. In the *Dhammasaṅgini Abhidharma* created by Mahamaudgalyayana during the Third Council, *Samādhi* and one-pointedness mind have the same definition. Nikāya Sutra does not agree with this explanation.

Technically, "*ekaggatā*" is the first method in practicing *Samādhi* by focusing all thoughts into one point. When mind is less distracted one can proceed to the next step.

5. **Amplitude:** This scientific terminology shows the objective measurement of the degree of change underneath the brainwave graph. It is the electrical power measured by the microvoltage.

6. **Frequency**: It is the speed of undulations in the waves measured in Hz/second. Frequency used to identify the brain waves are: Alpha, Beta, Theta and Delta. The relationship from these waves determines or emphasizes whether one is using his mind base, mental consciousness and his Buddhita area at any time during the meditation.

7. **The Thusness Awareness: knowledge of the true reality = the knowing of a thing or object as it is or as in reality; knowing in accordance with reality; the knowledge of the true reality (of phenomena):** In Pali: *Yathabhutanana*; in Sanskrit: *Yathabhutajnana*. This terminology comes from the Theravada of *Nikāya* or *Agama* Sutra. It means that if a condition, a thing or an object exists, just know it as it is; in case it does not exist then just know that it does not; when seeing things, only knowing them as they are, without adding or taking anything away from it. That is the knowledge of the true reality. Sanskrit sutra says: "the thing that appears now, then knows it appears now; things that do not appear now then just know they don't appear *(santam va atthi nasssati asantam va natthi'ti nassati*)." In reality, attaining the Thusness awareness or the knowledge of the true nature, it means that insight wisdom has appeared. Insight wisdom means knowing of true reality, non-dualistic knowing.

8. **Knowing as it is**: the emptiness awareness. This is the cognitive awareness, non-verbal awareness on a subject and it is the fourth function from the Buddhita area. In Pali: *Tathāñāṇa, Tathāpajānanā.*

9. **Unified mind (or) Unification of the mind**: Pali: *cetaso-ekodibhava*, also known as *ekothibhava or ekotibhava***.** The technical term of "unification" (*ekodibhava*) usually describes the transformation from the beginning level of Samādhi to the second level; "*eko*" means unique or single. Unified mind describes a unique one that is non-dualistic and non-chattering.

It is a state of non-verbal thinking; a mere flowing of non-stop thoughts. The mind is not entrapped to a vision or an object. Reflection and discursive thinking do not appear

and it equals the second level of Samādhi, a condition of non-reflection, non-discursive awareness. This state, however, is different than the one-pointedness of the mind (*cittassa-ekaggata*), which is maintaining an objective consciousness. One-pointedness mind is not *Samādhi*; it's just a practice of ceasing wandering thoughts and Alpha waves appear.

In the one-pointedness mind state, the Alpha waves arise. On the other hand, the Theta waves come with the unified mind, and lastly, the Delta waves appear when one's mind is in the awakening awareness and the non verbal awareness state.

10. **Creativity**: the ability to discover many new ideas, concepts, principles, techniques and to discern unique connections, relationships and insights.

11. **The Four Unlimited/Unhindered Eloquences:** the four spontaneous, unlimited capacity of interpretation of the Buddhita or the Spiritual Gnostic area.

a) Unlimited eloquence in Dharma = the Buddhita area spontaneously develops an ability to understand all aspects of the Dharma. This knowledge helps people with different abilities and level of achievements understand dharma completely.

b) Unlimited eloquence in Meaning: the ability to deeply understand Buddha's Dharma and to utilize various ways to explain it to the followers so that they can understand and practice the Dharma.

c) Unlimited Eloquence in language: the ability to use varieties of terms, phrases, or samples of regional or local dialect when teaching Dharma.

d) Unlimited eloquence in speech: the ability to debate, or to eloquently discuss, and argue the Buddha's teaching in suitable levels to the audience without any difficulties.

12. **The Innovation**: the knowledge spontaneously developed from one of the four Buddhita mechanisms of sensory.

Article 4

BIOFEEDBACK IN MEDITATION

I. INTRODUCTION

1. New Concept on Meditation

In present living conditions, we face a web of much more complex problems than the people of the previous centuries. Every individual of the present time is influenced by their living environment. We have made great progress in every field of science: universe, space, physics, biology, medicine, neuroscience… Nowadays meditation is not restricted to self-suggestion. The way of practicing meditation has to be suitable to our current living conditions in order to fit into the fast advancement of modern civilization. The new concept of studying and practicing meditation anticipates human progress in the 21st century.

2. New viewpoint

Oriental meditation should not be restricted to living conditions of humans in only one geographic area. Meditation is no longer considered a mysterious practice or difficult to understand. Meditation is a science. Yet it differs from other sciences because it is a spiritual science. Meditation is a science of developing human awareness in order to facilitate the lives of humans, who live in various environmental conditions, not only developing their consciousness and intellects. Nowadays, humans are living under the consequences of science and technology. Thus,

the practice of meditation must have a foundation of spirituality and practical sciences.

3. Relationship between the mindfulness of concept and the experience of reality.

Realizing the concept of reality without experiencing it is not equivalent to touching the true reality. Without direct contact with reality, we never have the experience of what we have realized through conceptualization. Without experience of reality, our meditating practice does not produce any beneficial results except a falsified experience which may lead to an inflated self concept and lack of respect for others, as well as to mistakenly inflate our knowledge about the practice of meditation. That mental attitude is similar to the story of a person who has a treasure buried in his garden but he does not want to put any effort to retrieve it. He always makes stories about the undisclosed treasure and never really benefits from it. He never experiences the treasure and the luxury of the wealth that the treasure might bring up to him.

In contrast, experiencing the reality is to actually hold the treasure in his hands and enjoy all the power and wealth of it. Experiencing the reality is to have direct contact, not through an intermediate means of conceptuality or wordy description or fictitious imagination. In meditation, realization is a necessary condition whereas experience is an ultimate one. Experiencing reality is to achieve the goal of the teachings of the Buddha. The relationship between these concepts mentioned above, the Buddha's teaching or Dharma, the realizing and the experiencing of the reality is tightly intertwined.

4. Effect of biofeedback in meditation.

Once in touch with reality, we experience the process of bio-reaction in our body, our mind and our spirituality. These bio-reactions induce a chain of biological activities in our body such as blood flowing toward the extremities of the limbs, lower blood pressure, reduced blood sugar level, and increased body temperature, resulting in significant improvement or even healing of our somatic diseases. During meditation, our mind becomes serene and peaceful without attachment to underlying prejudices and biases toward others and the outside world. We become tranquil and stable. Our intellect becomes brilliant, transformed. We no longer need to gratify our ego through the meditation process by misinterpreting the meditation result or fabricating false stories of the practice.

5. The difference of the two living backgrounds: the present and the past

In the past, albeit the knowledge of the neuroscience was not well known, practicing meditation resulted in beneficial effects on the body, mind and spirituality. The living environment of the distant past was different from that of our present age in which modern civilization and dominance of science and technology affects much of our daily life. Humans in the distant past lived in harmony with nature; they did not live in an environment surrounded by all kinds of defilements as we do in the present time. They did not burden themselves with as much responsibility toward the family, and society as we do now. People did not live under as much man-made pressure, interfering with others through politics, economics, war, excessive rules and religions. They did not worry about home mortgages, household expenses nor unemployment, wars and military duties. People in the past, in general,

were not conditioned by so many man-made living environments. Thus, past conditions for people to practice meditation were much more favorable than those of people in modern society.

Nowadays, so called civilized living is always under the pressure of employment, economic activities, politics, religions, and warring conflicts, and the living environment. Our life is constantly stressful because we continuously anticipate the complex matrix of modern daily life. It is very difficult for our mind to stay calm and harmonious with the surrounding living environment. As a result, nowadays meditation practice is much more difficult than that in the past. For these reasons, the practice of meditation in the present time requires knowledge of the dharma teaching, the meditation concept, neurological science and a meditation technique in order to succeed in the development of body, mind and spirituality and to avoid all of the detrimental effects caused by wrong practice. This essay is written to elucidate these viewpoints.

II. DEFINITION

What is feedback?

Feedback is the response to an inducing motive. Biofeedback in meditation is a process of biological activities in our body during the practice of meditation with the technique taught by the Buddha or Zen Patriarchs. The term “bio” refers to the biological activities inside the body caused by the secretion of chemical substances in neural cells, the nervous system and the endocrinal glands during the practice of meditation. When teaching theoretical and practical meditation, it is very important for us to know the progress of practitioners. We require the practitioners to go through a test in order to evaluate the progress of their

practice. The biological effect through this test is the feedback. Under the practice, the brain is induced to secrete the chemical substances. These biological chemicals have dual effects on the body, beneficial or harmful, depending on their intensity. The right practice with the right technique and the right dharma teaching yields beneficial effects. On the other hand, the wrong practice and the wrong technique results in harm to the body. The wrong practice may end up with several abnormalities for the body, mind and spirituality such as mental disorders, cardiovascular diseases, diabetes, stress, migraine, Alzheimer and Parkinson diseases as well as a biased or cloudy intellect. Right practice regulates high blood pressure, diabetes, gastric ulcers, neural disorders and stress, resulting in the improvement of facial complexion, smooth and ruddy skin, mental stability, memory restoration, and a brilliant intellect.

III. THE PRINCIPLE OF BIOFEEDBACK IN MEDITATION

1. Principle of activation-effect

The mind plays a key role in meditation. It has the powerful ability to bring physical health or illness and a brilliant or cloudy intellect to the practitioners. When practicing meditation, the mind must work upon the basis of dharma teaching and practical techniques. Based on this, the mind directly activates the brain which in turn decodes (interprets) the neural signals then relays the decoded signals now in the form of thought to another appropriate cortex and inner brain. In other words, when the mind is activated, it creates a neural surge that is transmitted to the part of the body relevant to the thought initiated by the mind. The cortex has three main areas:

a) The prefrontal area of the left brain hemisphere that plays the function of thinking, reckoning and reasoning.

b) The prefrontal area of the right brain hemisphere that plays the role of distinction. These two prefrontal areas are considered false mind or sundry mind.

c) The area of the occipital lobe in the back of the left brain hemisphere which is named the spiritual Gnostic area or Buddhist area or awareness area.

The inner brain covers the limbic system, the brain stem and the endocrines. The limbic system is composed of the thalamus, hypothalamus, long term memory and short term memory areas, and the autonomic nervous system. The internal structure of these areas contains the biochemical substances that have dual effects, both beneficial and detrimental to the body, mind, and the intellect. Depending on the intensity of the informative neural signals of the mind, appropriate chemical substances are secreted accordingly.

2. Brain area

Buddhita Area or Spiritual Gnostic Area

Practicing meditation in a right way with a right technique results in the harmony of the body and mind, as well as the development of intellectuality and spirituality. This is a self-developed intellectuality, a transcendental wisdom. It does not derive from the common knowledge originating from the mind base or intelligence; it takes root from the mechanism of the Buddhita area or the spiritual Gnostic area. Meditating with specific meditation topics to directly stimulate the Buddhita area induces wonderful effects upon our body, our mind, and our spirituality.

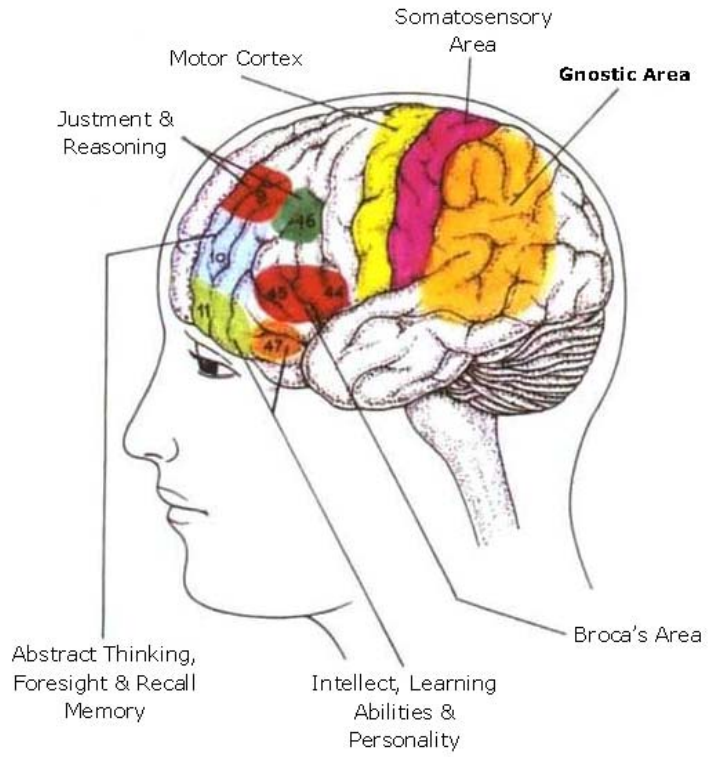


Figure 1: The Awareness Faculty area locates in the back of the left brain hemisphere.

The Buddhita is a Zen term. In Theravada or Hinayana tradition, it was considered a non-born wisdom or self-generating wisdom; in Mahayana tradition in which the Mind-Only System belongs, the master of canon, Paramartha, named it as Pure Consciousness or the 9th consciousness, for its non-competitive, non-dualistic awareness. In neuroscience, it is termed the spiritual

Gnostic area or general interpretative area. We have named it Wordless Awareness from which, without attachment of thought or word, Pure Awareness originates.

Pre-thought awareness is the very first consciousness as a whole and simultaneous recognition of the initial contact of the five senses with the outer world. That very moment of recognition, prior to the intervention of mind consciousness under the form of thought, concept, or verbal thinking, is a just pure and simple non-thought awareness. At that moment our mind is completely pure and tranquil. However, we are not able to prolong that mind state due to our inability to control the non-thought awareness of our mind and right afterward. So, wordy thought arises.

The brain area responsible for the non-thought awareness is located in the back of the left brain hemisphere. The function of this brain area is to be aware of the outer objects of the five sense organs without the intervention of the "Self" or the "I". From the beginning of the awareness process, it quietly and thoughtlessly recognizes the objects. In the presence of wordless awareness, anger, affliction, anxiety, fear, conflict, competition, and hatred are totally absent; the mind of the practitioner becomes perfectly calm, tranquil and relaxed; the intellect is completely non-biased; and emotional feelings are absent. Thus, all the inner biological energies of the body are synchronously developed. Bioaction in meditation is based on the functional presence of the Buddhita. Through a series of interactions between the mechanism of the Buddhita, the brain, and other endocrinal glands, the physical condition improves and the mind becomes peaceful and blissful.

Based on this bio-interaction, the role of the Buddhita is very important in the regulation or treatment of psychosomatic disorders. When the Buddhita functions,

the nervous system is not under stressful conditions, anxiety does not exist, attachment to the outer world is disengaged, and hatred is vanished—only pure and wordless awareness is existent. That is clear recognition without the attachment of dualism: love/hate, right/wrong, good/bad… under the presence of the Buddhita, the parasympathetic nervous system is activated leading to the secretion of acetylcholine which in turn decreases the blood pressure, lowers cholesterol, eases the body, and intensifies memories. The parasympathetic system under this kind of stimulation also activates the pancreas to secrete insulin that regulates the blood sugar of diabetics.

The Hypothalamus

The limbic system is composed of many areas of the inner brain. Each area has a function and plays a particular role. Among these, the hypothalamus is a most important nervous center. Its function is to control the autonomic nervous system and to transmit the "mind signals" from the cortex to the other centers of the brain. It expresses the superficial as well as the deep features of the false mind and the real mind. When we are under the pressure of emotions such as sadness, anxiety, fear, and anger, these signals of the false mind are transmitted to the hypothalamus which in turn relays these emotional signals to four other areas: i) the thalamus, ii) the sympathetic nervous system, iii) the pituitary, and iv) the internal organs, particularly the heart. Therefore, extreme joy may lead to heart arrest; being overly angry may also result in vomiting blood.

The function of the thalamus is to disperse the emotional signals to the short term and long term memory and to the overall cortex. When the signals reach the somatic sensory area located in the parietal lobe which relays the signals to

the sympathetic nervous system, sadness immediately expresses its features on the face and in the eyes. If sadness is too deep, the eyes may shed tears, lips turn down, and cheeks droop. The sympathetic nervous system secretes epinephrine and norepinephrine. Both these neurotransmitters are detrimental to the cardiovascular system, blood, and other internal organs such as the stomach, liver, and kidney. The overproduction of these two substances is the cause of the diseases of the internal organs. Underlying the overproduction of these two neurotransmitters are emotional feelings such as distress, anxiety, and fear of the mind attached to the outer world or non-mindful intellect.

Thus it is the mind that induces the diseases of the body through the process of the production of neurotransmitters from the sympathetic nervous system and the endocrines. That mind is a false mind which is under the control of the "Self". The concept of "I" and "Mine" creates the false mind. In contrast, the real mind is free of emotions; the concept of "I" and "Mine" is absolutely absent, only a flow of wordless awareness exists. The Zen sect temporarily gives it a misnomer of "the Master" or the "True Self". When the flow of non-thought awareness is present, the hypothalamus reverses its activity, resulting in the autonomic nervous system activating the parasympathetic system to secrete the beneficial neurotransmitter acetylcholine.

In summary, the practitioner is able to activate his brain to produce beneficial acetylcholine by combining the appropriate meditation topic, the proper meditating technique, and mindful intellect to interact to his advantage. Through this interaction process serotonin and melatonin secrete from the Pineal; insulin from Pancreas; acetylcholine, serotonin, dopamine… from the brain stem.

3. Close linkage between the mind, the dharma, the technique and the brain

When we teach meditation we elucidate the close linkage between the mind, the Dharma, the meditating technique, and the brain. Biofeedback is the result of the interaction of the four factors.

This is the basic knowledge that the practitioner should clearly understand throughout the practice. The beginner has to comprehend why the right practice and the right technique yields improvement of health, tranquility of the mind, and healing of psychosomatic disorders. On the other hand, practice with the wrong Dharma and wrong technique leads to diseases of the body and mind such as high blood pressure, diabetes, stomach ulcer, stress, memory loss, and Schizophrenia disorder.

The teaching of the Buddha and the Patriarchs is always trustworthy. If the practitioner does not learn the essence of the dharma and utilize the right meditating technique, he will end up with all kinds of psychosomatic disorders. The key point of meditation is how to do it in a proper way. The practitioner must keep in mind this important point in order to avoid any possible mistakes during the course of meditating.

Following are the common mistakes of the beginners:

- Using wordy interpretations and complicated conceptualization to interpret the Dharma teaching instead of the common and simple meaning.

- Using a biased instead of mindful intellect in practice.

- Activating the sympathetic system instead of parasympathetic nervous system.

- Exercising concentration, imagination and silent verbal dialogue in the mind instead of relaxation and wordless awareness.

- Focusing on mind-consciousness terms such as “should know”, “must know” instead of simply “just awareness”, “non-thought awareness.”

- Favoring wordy mind-consciousness in daily life instead of wordless awareness.

The mistaken practice of meditating leads to psychosomatic disorders as a result of wrong activation of biological activity of the brain. Depending on the usage of the wordy or wordless technique the outcome of meditation is different. Wordless technique activates parasympathetic nervous system; wordy technique lacking awareness activates the sympathetic system.

4. Chain Axis

The brain, the nervous system and the endocrines of human beings have the ability to produce several chemical substances which are able to regulate both beneficial and unfavorable effects on the body and the mind. Meditating with the appropriate dharma method and right meditation technique stimulates a series of bio-reactions in the axis including the Buddhita nature, the limbic system, the hypothalamus, the parasympathetic system, the endocrines, the brain stem, and the cortex in order to balance the physical condition of the body. Meditating appropriately also stimulates the body to create other bio-energies such as good health, enlightened mind, blissful life, and harmony with the surrounding living conditions. It also intensifies the intellect as a result of memory improvement and enhancement of perception. Biased ideation no longer

exits. Ill deeds are not expressed due to inactivation of the amygdala.

Biofeedback is the interaction of the chain axis mentioned above after the principle of causation: from the existence of this, that becomes; from the happening of this, that happens; from the non-existence of this, that does not become; from the non-happening of this, that does not happen. The mindful intellect plays the principal role in beneficial biofeedback whereas the endocrinal system is only involved in the process of production of the chemical substances in response to the chain bio-reaction between the mind and the Buddhita nature, between the Buddhita nature and the limbic system….

In summary, the proper practice of meditation results in beneficial effects whereas improper practice leads to the disorders or even diseases of the body and the mind. This outcome is very important for practitioners to keep in mind in order to avoid harmful consequences during the practice of meditation.

IV. FOUR FACTORS INVOLVING BIOFEEDBACK

To elucidate biofeedback in Meditation, it is necessary to emphasize four factors involved in the meditation process.

1. Role of the mind

The mind in this case is not the enlightened mind, but it is one in the state of mindfulness and intelligence. The mindful mind is able to recognize the genuineness of the teachings of the Buddha (Dharma) or the patriarchs. Intelligence helps us to distinguish which Dharma leads us to direct contact with and experience of the awareness nature or the Buddhita, that one exerts on the mind base and the mind consciousness. Mindfulness plays a very

important role in choosing the right meditation practice method among the so called "Zen forest". It is the mindful mind that gives up the old conventional path of thinking and makes the decisive turn of mind to change the course of cultivation of the Dharma teachings. It helps us to evaluate and value the real Dharma that we believe in; to overcome all the obstacles undermining our mind that prevent us from initiating the meditation practice; to cease all the excuses for being reluctant in Dharma cultivation and meditation practice. The mindful mind also prevents us from being tempted to practice voodoo, amulet and superstition, worship of spirits and or god-based icons, as well as blindly abiding ritual formality, which does not have any ability to lead us to attain awareness, transformation of view and regulation of psychosomatic disorders. Instead, we choose a practical method which is able to activate the Buddhita, the center of the meditation process.

In short, in meditation practice, we need to follow the instructions and wisdom of the Buddha instead of ordinary lay people. To realize the right direction and choose the appropriate Dharma subjects to practice are the concrete stepping stones for the cultivation and practice of meditation. And the awakened mind plays a decisive and important role.

2. The role of the Dharma subjects

The Dharma subjects are short topics focusing on practical methods extracted from the teachings of Buddha (Dharma) or from treatises of the patriarchs. They are short and precise procedures that serve as practical guidelines for meditating. We must thoroughly understand the concept of the subject then continuously and consistently put them to practice during the course of daily activities including

walking, standing, lying and sitting. With continuous and consistent practice of the Dharma subject, we might experience the reality of the subject. Only on the ground of experiencing the reality, we are able to experience it as a result of the assimilation of the concept and reality. This joined experience is the final goal of meditating practice.

Experience is not a product of the imagination of the mind but the tangible result of practice. Experience is the real outcome of the Buddhita mechanism in response to the end result of the concept-reality assimilation process. We can actually recognize its real effects on our body, our mind, and our spirituality through body experience, mind experience, and spirituality experience, respectively. To attain this experience is our ultimate goal. At that time the false mind disappears and the real mind is manifest. The "master" is really present in the six senses. There is a transformation in our demeanor. Our complexion becomes brighter; our look is no longer dull. In meditation practice, the mere understanding of the meaning or the concept of the Dharma without concept-reality assimilation is considered an unaccomplished practice.

It is important to not confuse a realization with an actual experience. Through the patriarch's teachings, we recognize that we all do have the Buddhita, the Awareness Nature, which is considered as an absolute truth in the Basic Level of our Sunyata Meditation Association. That recognition is a mere concept about the reality but not a real experience of it. Conceptual realization alone never leads to wisdom, creation, tolerance, generosity, and harmony.
Yet, that realization is important because it changes the course of our spiritual cultivation journey from thought-based consciousness to non-thought-based awareness of the

Buddhita. With it, we no longer depend on word or thought in our high level of meditation practice. Therefore, after the conceptual realization of reality, we must continue to practice under the guideline of that concept until we are able to experience the reality behind it when the concept and the reality perfectly assimilate. At that moment, the false mind disappears and the real one is expressed. The "master" is really present in the six senses. There is a transformation in our demeanor. Our complexion becomes brighter; our look is no longer dull.

The meditation practitioner needs to realize the essence of the Buddha teachings or the treatise prior to actually practicing. Realizing the concept of the teachings is a necessary step for beginners, experiencing reality through the body, mind, and spiritually is the final goal of meditation practice. The teachings of the Buddha and the treatises of the patriarchs are the means or guidelines to attain non-conceptual underlying reality. We need to follow these guidelines and faithfully practice them on a regular basis. Without continuation of practice, the results never become reality. Our ultimate goal is to attain the experience of reality, not to merely realize the concept of the teachings. Conceptual realization (alone) never leads to wisdom, creation, tolerance, generosity, and harmony.

The very important principle of concept realization and reality experience must be accomplished. Conceptualization-only never leads us to the end of the journey. We study the Buddha teachings not for the sake of becoming the Dharma teacher; we learn the treatises not to become philosophers. We have to realize, through the meaning of words and language, the essence of the teachings and the treatises for the purpose of experiencing reality. The ultimate application of the teachings of the

Buddha or the patriarchs is to master our mind in order to induce the bio-reaction for the benefit of the body, mind, and spirituality.

In addition, we have to be a role model for our children. We have to demonstrate that Buddhism is to develop the spirituality of humans, to transform the secular mind into the awakened one, developing compassion among sentient beings.

3. The role of the practical technique

During practice we have to know the technique. Once we have knowledge of the technique, we may cut short the practice journey. Instead of spending 10 years of practicing in the dark without a proper technique to experience the non-thought awareness, we may experience it in a short couple of months. The key technique is that we work directly on the mechanism of the intrinsic Buddhita nature. We do not use thought, silent dissertation or discursive conversation in our mind for the explanation of the false or real mind. In short, we do not practice meditation by playing merry-go-round. Though each method and technique is different from each other, all of them lead to the activation of the neural cells belonging to one of four brain areas of the Buddhita mechanism. As a result of this activation, we have the experience of the "marvelous" benefits from biofeedback in meditation.

When the Buddhita mechanism is activated, the whole brain axis composed of cortex, limbic system, endocrines… is also activated leading to the secretion of beneficial chemical substances of the parasympathetic nervous system and healing diseases of the body and mind disorders, as well as improving the agility of the intellect. This is the

result of biofeedback. Without this amazing effect, meditation never becomes a useful tool in the daily life of humans.

4. The role of the brain

Nowadays, in learning and practicing meditation we need to understand the role of the brain which is the basis of the mind, the mind and consciousness as well as the Buddhita or Awareness nature. Thanks to the brain, humans are ranked higher than other sentient beings on the evolution scale. Humans are considered superior to other living things due to a sophisticated brain which is composed of hundreds of billions of neurons. With ability to generate hundreds of billions of electro-signals and the transmission of emotions and thoughts, the brain expresses human personality including good/bad, dull/bright, moral/amoral through action, behavior, attitude, and word. Without the brain, the mind cannot function to outwardly express the nuances of false or real mind through action and word. When the mind orders the six sense organs to contact with objects, the brain interprets all the details relating to the object. Psychosomatic diseases, stress, mental disorders, memory loss, depression, and Parkinson disease, as well as stupidity, self-respect, pride, and demeaning others take root from the brain. The brain also plays a role in well being, a bright complexion, and sharp intellect. If a portion of the brain is injured, behavior, attitude, action, and language also change although the sense organ is still intact. In this case, the mind cannot control the brain function.

In general, when the mind is under a constant stressful situation such as worry, fear, and doubt, the brain will secrete chemical substances which cause harmful effects on

the internal organs such as heart, liver, kidney, blood, and neural cells of the body. Psychosomatic diseases are the result of constant manufacture of norepinephrine by the sympathetic nervous system or the brain stem. Norepinephrine enters the blood stream and induces the adrenal medulla to secrete epinephrine and cortisol which is toxic to neurons causing the neurodegenerative diseases such as Parkinson and Alzheimer diseases. In some cases, it may play a large role in cancer. On the other hand, if the mind is in a constant relaxation state, the brain will secrete chemical substances such as acetylcholine, dopamine, serotonin, and melatonin beneficial to internal organs. The mind-body interaction is a closed circle. The stressful mind causes diseases of the body which in turn creates diseases of the mind. We often say, "The mind is the conductor of the orchestra, who conducts the six senses musicians, eye, ear, nose, tongue, skin, and mind base to perform music and he is also the listener to listen to and enjoy the performance of the orchestra." This is the result of biofeedback.

V. NOTES ON BIOFEEDBACK IN MEDITATION

In meditation, relaxation of the mind or thought plays an important role in biofeedback in the treatment of psychosomatic disease and neural disorders. It is a detoxified medicine to heal stress, emotional and neural disorders. When the mind is relaxed, the limbic system is activated followed by the hypothalamus, then the parasympathetic nervous system and other internal organs such as pineal gland, brain cortex and the beneficial acetylcholine and dopamine are released, resulting in quick restoration of normal functions of the neurons and internal organs. Dopamine can heal Parkinson and Schizophrenia diseases. A schizophrenic patient has the illusion of

hearing and vision due to the lack of dopamine combined with the overproduction of glutamate in the brain areas responsible for hearing and seeing. By relaxing the mind or thought, the facial nerves and the tongue may induce dopamine production to ease Schizophrenic and Alzheimer symptoms. Alzheimer disease originates from deficiency of acetylcholine in the cortex. Acetylcholine also regulates the movement of the body, plays an important role in the reduction of blood pressure, improvement of learning ability, memory restoration and developing awareness. Acetylcholine has the function of maintaining mindfulness, intensifying memories, and developing awareness. Many areas in the inner brain and reticular formation also produce acetylcholine.

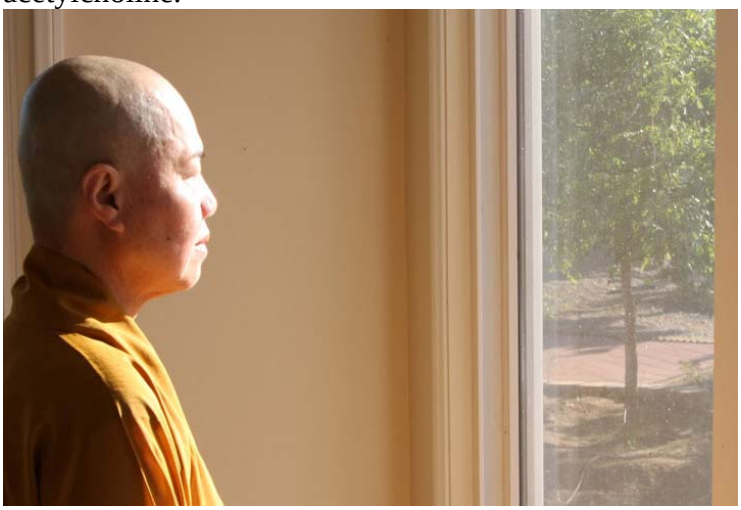


Figure 2: Practice looking at the reflection of sunshine

To treat chronic insomnia and migraine, one may use the technique of contemplation of sunlight for 10-20 minutes per session on six consecutive days. When contemplating

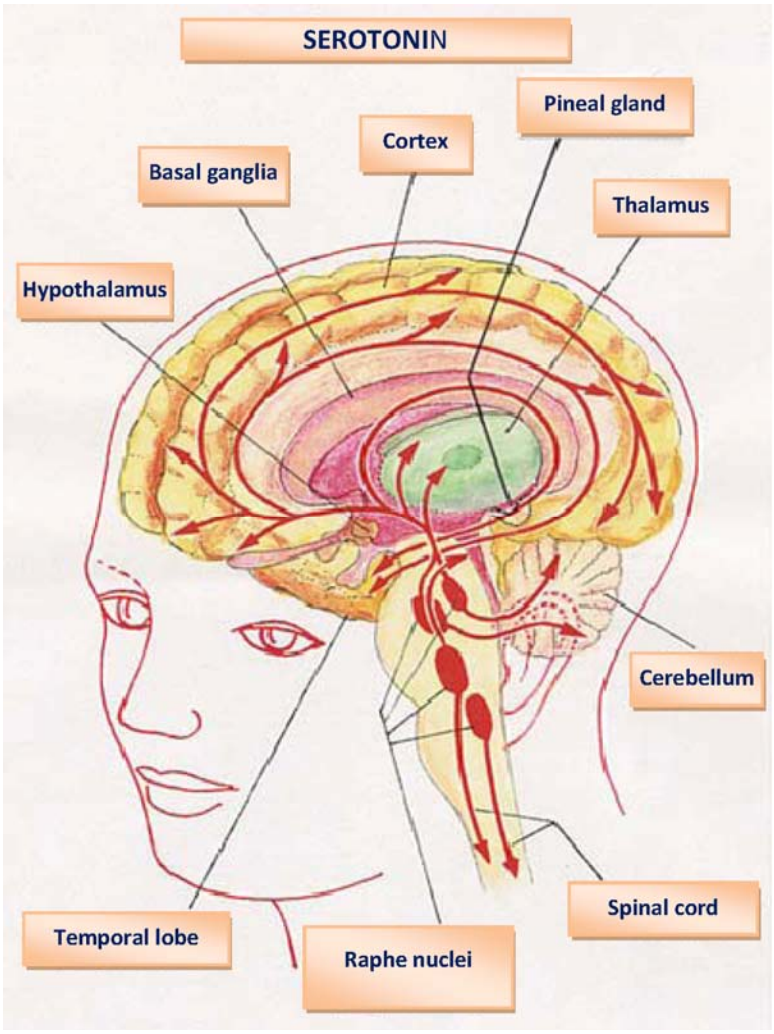


Figure 3: Serotonin system

the sunlight, one may sit in a comfortable chair, and leave the mind free of attachment of any kind, even not thinking about sunlight. One should contemplate the sunlight as the sunlight is. That is it. This technique is to look by the seeing nature, a component of the Buddhita nature, which

activates the pineal gland to secrete serotonin and melatonin and simultaneously regulates the dopamine at the occipital lobe of brain to regulate the illusion of hearing and vision. Serotonin is an important neurotransmitter and is secreted by the pineal gland. It helps to improve health, tolerate extended work days, regulate day-night cycle, and treat depression. Serotonin also helps to treat stomach bloating, lack of appetite, and regulates neural disorders and anxiety. Serotonin is also very effective in healing migraine. By contrast, a deficiency of serotonin results in depression, sleep loss, anxiety, discouragement, impatience, and a lack of enthusiasm.

Melatonin is able to regulate the sleep/wake cycle, treat chronic insomnia, and cancer. It also helps to reduce hypertension, prevent heart attacks, strokes, and cataract advancement. Melatonin is produced by the pineal gland and hypothalamus. It is capable of stimulating the immune system, restoring memory loss and treating Alzheimer disease.

VI. QUESTIONS & ANSWERS

Q1. How do we know if our practice is incorrect?
A1. When practicing on any object, constant concentration on this object will lead to repeated stress. Even though wandering thoughts cannot interfere during this time, it results, however, in recurring stress, and one will never truly experience the mindfulness of the Nature of Awareness.

In the responses to stress, norepinephrine and epinephrine will be secreted. The release of these substances leads to the physiological effects demonstrated in physical responses such as fatigue, dry mouth, rapid heart rates, and

elevation of the blood pressure. It is a result of incorrect meditation practice.

Q2. What type of result should one get when using the "cat preying mouse" technique to cease wandering thoughts?
A2. The Sympathetic system will be frequently stimulated, resulting in the release of norepinephrine which causes high blood pressure.

Q3. Why?
A3. In the process of "preying" the wandering/false thoughts, one not only tries to catch but also stays aroused to cease any false thoughts arising at that moment. Exercising this technique persistently for many days will lead to stress, and the final result of this practice is the elevation of blood pressure and sugar levels. At the same time, one will never experience "Wordless Awareness" in the Gnostic area.

Q4. Why cannot one experience that state?
A4. Because the Gnostic state or the Nature of Awareness can only happen when one does not use consciousness to concentrate on any object.

Q5. Without using the "cat preying mouse" technique, how can one stop the arising of wrongful thoughts?
A5. Let's use the "Not Labeling the Object" technique. Whatever the object is, one *just knows it as knowing, sees it as seeing, hears it as hearing, or touches, or even just perceives it as it is*. In this process, the false and misleading mind, as well as wandering/wrongful thoughts cannot interfere. One does not experience stress. After many days practicing, observation of the analytical intellect, discriminatory awareness of mind consciousness, and the evaluation of perception thinking will gradually

decrease. In exchange, the awakening ability will slowly become a stable and efficient factor in daily activities.

Q6. Why does mind play an important role in creating a biological effect in meditation practice?
A6. Because when one's mind is awakened, it has faith, joyfulness, and considerations in studying the meaning of Dharma, listening to the Dharma talks, making friends with good practitioners for cultivation assistance, selecting appropriate Dharma for application, and especially it will be faithfully studied to reach the ultimate assimilation between the subject and object. This creates the biological effect in body and mind. When one of the three functions in the Gnostic area is stimulated, an axis of the chain of reactions will be activated in the brain. That is the time when beneficial chemical substances inside the body are produced. The beneficial effect on body, mind, intellect, and spirituality is called body experience, mind experience, intellect experience, and spiritual experience, respectively.

Q7. But how does the axis work?
A7. Let's use the "Not Naming the Object" technique as an example. In this technique, we use the eyes to stimulate the visual sense in the Gnostic area. One sees the object but not giving it a name. That is the time when we are clearly aware of the object but our mind does not attach to it. The visual sense appears as it is. The left and right frontal lobes are both inactive; therefore, emotion does not appear. When s*eeing a thing just as it is*, the limbic system is immediately activated, followed by a chain of reactions which travels through an axis of hypothalamus, endocrine glands, parasympathetic nervous system, and brain stem.

Q8. What kind of chemical substance will be secreted when the sympathetic nervous system is activated?

A8. Norepinephrine.

Q9. When the parasympathetic nervous system is activated, what chemical substance is secreted?
A9. Acetylcholine.

VII. SUMMARY

For meditation practitioners who have attended the Introduction to Basic Meditation classes, Biofeedback in Meditation is not an unusual topic. It is, on the contrary, only something unheard of to those who have never known about or/and never practiced meditation, or even to those who did practice in the past but had never experienced changes or improvements through biofeedback.

1. Having a thorough grasp of the Biofeedback system

To use proper techniques in practicing meditation, one can have the capacity to develop the biological resources inside the body for attaining a better, meaningful lifestyle. That is the ability to readjust malfunctioning in the brain and the endocrine glands. Understanding thoroughly how and why the biofeedback system works will help us to stay away from incorrect practices which usually affect the body and unintentionally cause stress, physical weakness, and anxiety.

Adjusting these exercises can also assist in preventing hypertension, irregular heart rates, or any decrease in health. For those who have a mental illness or chronic stress, and have been aware that neither Western nor Eastern medication is an effective treatment for them, guiding them to proper meditation can help them to self-regulate this malfunctioning condition.

Meditation has a practical and valuable effect on mind-body and spiritual wisdom. This effect is called Biofeedback. When studying and practicing meditation, one must clearly grasp the interaction between Mind, Dharma, Techniques, Brain, the Limbic System, Endocrine Glands, the Neurological System and the body.
Meditation does not promise a long lasting happiness and tranquility in any mysterious, fictitious, far away world which can be obtained after death. On the contrary, meditation assists us experiencing the "here and now", the balance within body and mind, the true happiness and harmony with your surroundings and people around you, the immense generosity and compassion with all beings, and the expansion of spiritual wisdom. In daily life, it helps to decrease suffering caused by long-term illness, to alleviate stress from an unsatisfactory life, and to reduce sadness and anxiety affected by daily troubles and difficulties. The mind will lighten, in harmony with everyone, even when one has to spend tremendous energy working either in a manual labor job or at an intellectual profession. One needs to be aware of things as they are and to be mindful in walking, standing, lying, and sitting in daily activities to produce the bio-energies within the body. These bio-energies are the result of the effect of the biochemical substances released by billions of neurons, muscles, internal organs, endocrine system, neurological system, and the human drive to succeed.

Inside the human body, there are many chemical substances which can be produced to both benefit and harm it. Practicing correct meditation techniques will trigger the chain effect on the Buddhita axis, hypothalamus, parasympathetic nervous system, pituitary gland, endocrinal glands, and the brain stem in order to create

balance in the internal organs and to induce more bio-energies in the brain. To have a healthy and balanced body, one will feel peaceful and happy, then memories and awareness will increase.

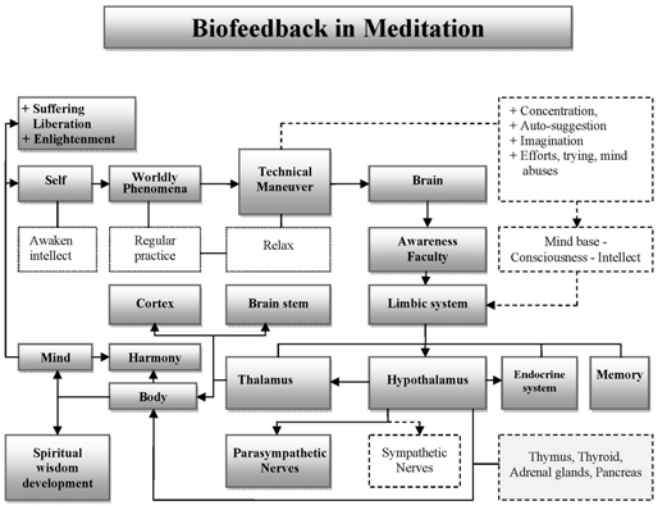


Figure 4: Biofeedback in Meditation

Fundamentally, when combining the practicing techniques with maneuvering the Dharma subjects, the effect will be a relaxed mind. It is a detached mind, or a non-object attached mind. It is a mind's comprehension of the actual state of a thing as it is.

From the technique of "Not Naming the Object," "Not Labeling the Object," to the ones of "Bare-Attention," or "Two-Stages Breathing", one merely aims to transform the mind preoccupied with the discursive thinking, discriminatory thoughts, and the reasoning /judgment into the one of tranquility, calmness. Going through that process, the forever, wordlessness and quietness of the Buddhita Nature will truly appear, spiritual wisdom will

arise, and the heart of compassion will obtain fully conditioned for expansion. Consequently, the "compassion field" logically radiates.

In response to the relaxed mind, the Brain and its inner part which is the hypothalamus area, is immediately affected. As a chain effect, it secretes chemical substances. One's body, at last, will feel energetic and healthy and the mind will simultaneously feel like it is brightened up, happy and in harmony with surrounding areas. Wisdom arises because memories have been increased; defiled habits will lessen and finally proper thinking/view will be recognized.

It is the biofeedback principle. This principle is based on the application of proper Dharma, the utilization in correct meditation techniques, and the interaction with Buddhita mechanism to attain the good results of mediation nature to attain a good result. Applying incorrect Dharma, excluding the involvement of the Buddhita nature, and improper meditation will bring harmful results to one's body and mind. Those negative results are hypertension, diabetic, stomach ulcer, insomnia, heart conditions and stroke, memory loss, declining thought and judgmental ability.

2. Human body is Valuable

It is a mistake for one to not want to protect his body but to abuse it instead. Meditation practitioners should follow the Buddha's exemplar appreciation of the body. Six years living in austerity and forcing his body to suffer, Buddha had come to the realization of how valuable his physical being was. He stopped abusing his body and acknowledged it as an essential way to help him attain the utmost enlightenment.
One's body should be seen as a boat to help him crossing

over the life and death sea. A fit body can assist in practicing regular cultivation. It ceases suffering from physical disharmonies such as constipation, hypertension, memory loss, anxiety disorder or Parkinson disorder. Physical health is a way to attain a more meaningful life in the aspect of serving people, especially serving our own family members. An unhealthy body will prevent long-term meditation practices, and it will be difficult for cultivation. When one's body is sick, his mind will suffer as well.

3. Meditation as a tool to create harmony in human beings

The important factor in meditation is to develop the efficiency of the Awareness nature. In reality, the Awareness nature is naturally innate in all of us, but we do not know how to make it become a permanent function so as to efficiently influence the brain neurological system, the Limbic system and the endocrine glands. Knowing how to apply proper techniques in meditation, one will use the awakened intellect to directly activate one of the four elements of Awareness nature, and will experience the true value of the Awareness nature without the necessity of shoving away or removing or contemplating the wandering thoughts. Whenever one of the four elements of the Awareness nature is merely stimulated, the intellect, the mind consciousness and the base mind simply become non-existent.

Nowadays, both Western Medicine and Psychology view meditation as a potential tool to treat mental illness, depression, and schizophrenic disease. By using the meditation subjects combined with functioning techniques to trigger the true senses of the Awareness nature, one will

be able to self regulate the malfunctioning of the limbic system, the autonomic nervous system, and the Endocrine glands. Among a variety of scientific studies in the world, Buddhist meditation is categorized as an Applied Science of Spirituality. It is considered a tool with its capacity to heal physical illness and chronic depression. This is the harmonious relationship between an individual's mind and body, between individuals and others, and between an individual's physical being and his surrounding nature. Harmony will appear once there is a balance between body and mind. Happiness and peace actually underlie this practical principle.

For example: living in the family, a meditation practitioner creates a harmonious relationship between husband and wife, children and parents or relatives, resulting in the disappearance of conflict, competition, or arguments within the family. When participating along with a Singh body or practitioner group, one will easily communicate with others. There should be no jealousy between the practitioners.

Living in a Singh, a meditating monk does not generate any hatred or jealousy, or should not be discontented with other's status, and authority. A contented, joyful and relaxed environment frequently shows in one's action and words.

If there is an imbalance between body and mind, disagreements will happen, it results in physical illness and a discontented mind. Individual conflicts take place between each other. One cannot avoid the sorrow of the imbalance of the mind and body.

VIII. CONCLUSION

Unlike the ancient days, to study and practice meditation nowadays, we need to equip ourselves with basic scientific understandings of the brain, the limbic system, the autonomic nervous system, the endocrinal glands and the meditation techniques. This will help us to quickly recognize the value of meditation on our daily activities based on several factors. This new foundation will be extremely practical and essential for our long spiritual journey. When practicing it, we are alone in it. We walk, and practice by ourselves. There will be no friends around, nor having Dharma in mind. We will either get on the ring to fight off the ghostly wrongful thoughts or compete within ourselves to nullify the ordinary defiled characters and to exhibit the true self clearly and steadily.

We do not hold on to the impractical concepts which do not benefit beginners; on the contrary, we need this new knowledge for the sake of the safety of our spiritual journey. Follow it and we will neither worry about turning to the wrong path nor do we want to get the harmful effects from practicing it. The central effects of meditation are to assist practitioners to achieve the following:

1. Mind transformation
2. Self regulating physical illness
3. Balancing/harmonizing body and mind.
4. Living in harmony with one's surroundings and
5. Developing spirituality.

All of these experiences are based on the principle of Biofeedback in meditation. To understand it deeply and to effectively practice it, we really need to have knowledge in Biofeedback.

IX. NOTES

1. **Parkinson disease** is a degenerative disease of the brain or disorder of the central nervous system normally caused by the lack of dopamine. It is characterized by muscle rigidity, difficulty and slowness of movements, body tremor with trembling of hands, arms, legs, jaws and face, poor balance and coordination; and at worse, trouble in talking. It is also called *Paralysis agitans* or shaking palsy. Parkinson usually begins between the age of 50 and 70, the average age of onset is 58. In a healthy physical condition, dopamine is secreted from the hypothalamus area and the *Pars compacta* region of the *Substantia nigra* (literally "black substance"), which is located in the brain stem.

2. Depression is characterized when one feels extremely sad, constantly anxious and/or pessimistic, hopeless, or loss of interests and energy in performing daily activities. It can lead to suicidal thoughts. The biological symptoms in depression include:

- thyroid malfunction
- cortisol increase from adrenal glands
- insomnia or oversleeping
- loss of appetite
- loss of weight
- constipation
- decrease in sexual desire
- feeling of hopelessness, pessimism
- loss of interest or pleasure in hobbies and activities that were once enjoyed
- difficulty concentrating, remembering or making decisions
- staying away from social activities
- lethargy

- ruminating about the past
- loss of self confidence

Treatment with Meditation includes:

- contemplating in the sunlight to induce the secretion of serotonin or staring into the darkness for induction of melatonin
- two-stage breathing
- practicing internal breathing

3. **Migraine headache.** Migraines are due to a combination of the expansion of blood vessels and the release of certain chemicals, which cause inflammation and pain.

One of the symptoms is seeing an aura. It is one of the common visual disturbances and serves as a premonition (warning) that lasts for few minutes and precedes the headache phase. For example, the patient can see blurring or bright spots within the visual field. Other symptoms include: anxiousness, fatigue, nausea, tingling on one side of the body, problems in concentration.

Causes: there are various causes triggering migraines: (1) Low level of serotonin, (2) low level of magnesium, (3) excessive alcohol, chocolate and cheese consumption, (4) neural disorders, (5) chronic stress, which contracts the facial, neck and head skin, (6) blood clots caused by platelets blocking the inside of blood vessels, (7) improper sitting or standing positions unsuitable to the nerves and muscles.

Treatments:

- facial/muscular relaxation to activate the secretion of acetylcholine and dopamine.

- taking vitamin B6, magnesium pills, and medications prescribed by specialists.

4. Alzheimer is a brain disorder which progresses from mild forgetfulness and gradually to cognitive changes and complete memory loss. It is generally diagnosed in middle aged people.

Treatment:

- practicing Relaxation and Listening to the Sound method to produce acetylcholine.
- following the primary physicians' advice and taking prescribed medications.

5. Schizophrenia. This illness is caused by various factors; the majority of causes are that one's mind is shaken by a strong emotional shock. This triggers the malfunction in the limbic system.

Neurological researchers also discover that malfunctioning of the limbic system is the result of the imbalance in chemical reactions of the brain involving the neurotransmitters glutamate and dopamine; too much glutamate compared to not enough of dopamine substance. High level of glutamate neurotransmitter gives one delusional thoughts such as others are spying upon and trying to control his activities, makes him hear voices and ordering him to do things.

Additionally, an excessive glutamate substance and less dopamine in the frontal lobe, in the listening areas, and in the occipital and temporal lobe, makes patients have disorganized thinking, garbled speech, and mood swings and sometimes becoming violence.

Cognitive impairments often interfere with the patient's ability to lead a normal life and earn a living. They can cause great emotional distress.

Treatment: Meditation only has the ability to regulate the limbic system for the stabilization of the mind. Different methodologies will affect the secretion of the chemical substances from pineal gland, parasympathetic system, and brain stem to produce serotonin (by contemplating sunlight), acetylcholine (by tongue relaxation), acetylcholine and dopamine (by 2-stage breathing).

In addition, practicing Qi Gong also induces the secretion of norepinephrine through the sympathetic system and coenzyme 10 inside the muscle cells.