From Neuroscience to Psychiatry (Draft, 15 Jan. 2014)

内容 contents

英文脳研究から精神疾病論へ　　川村坂出

参考資料１．Development of the Consciousness　意識の３レベル　英語

#1-1 Consciousness

from the low level which goes up/transfers without interruption/ continuously to the higher level. Signs of alive →alert/awareness → recursive/self-conscious. 低次から高次の意識へと連続している。すなわち弁証法的に否定の否定、質的転換を考察する。

Integration of emotional, cognitive and motive/motor activities into higher levels of functional concept can be considered as a whole "Consciousness", as will be described below briefly in a materialistic and hierarchical manner from lower to higher stages ; I-II-III. (in some details later)

Integration of emotional, cognitive and motive/motor activities into higher levels of functional concept can be considered as a whole "Consciousness", as will be described below briefly in a materialistic and hierarchical manner from lower to higher stages ; I-II-III.

I) Consciousness at the level of the brainstem (premammalian)

Alive, vital sign, awake and sleep, reticular activating system, sub-conscious, arousal.

Even the most primitive animal, the protozoa, possesses the ability of sensation. As the number of cells increases and the quality of the assembled cells differentiates into tissues, each of them obtains any special character, e.g., muscles, nerves, skin, and so forth. They are integrated in the organism and communicate each other to establish the entire body.

In the vertebrate, the lowest stage of consciousness lies in the activity of the brainstem. Animals are alive, cells and tissues of the individuals are breathing, having a close relationship with the nature, by means of metabolism; catabolism and anabolism. The biological basis of the primitive consciousness for living activities lies in this neural structure. This is the level of the unconditioned reflex (Pavlov).

In the brainstem of the vertebrate, the diffuse thalamic projection system (Magoun), or the thalamic reticular system (Jasper) particular kinds of cell groups produce amines, peptides, proteins etc. In this structure, there are neurotransmitters : dopamine, adrenalin, noradrenalin, serotonin, and acetylcholine.

The reticulo-activating system theory was proposed by Moruzzi and Magoun (1949). The monoamine hypothesis proposes that the decrease of serotonin induces the awake, while its increase induces the sleep (Jouvet 1972).

The hypothalamus is the central region dealing with “wake-and-sleep” mechanism as well as the centers for eating, sexual function, biorhythm, body temperature, energy and metabolism.

In addition to the projections from the spinal cord and the brainstem: the so-called activating system, a large number of inputs reach the thalamus from the basal ganglia and the cerebellum as well as from the cerebral cortex. Acetylcholine is also an important substance originating from the LDT （latero-dorsal tegmental nucleus）, PPN (pedunculo-pontine tegmental nucleus) and the basal fore-brain structures (Meynert basal nucl., Medial septal nucl., Diagonal band of Broca).

II) Consciousness at the level of the posterior association cortex (mammalian/lower primate)

Awareness, passive cognition, first signaling system of the conditioned

reflex.

The next stage of the consciousness, corresponding to the first (or sensory) signal system of the conditioned reflex, or the beginning stage of the second (or linguistic) signal system, may be observed in monkeys and chimpanzees. At this stage, animals are aware of circumstances using sensory activities of the subcortical and the posterior association cortical areas.

Upright walking or erect bipedalism, being able to use instruments by free forehands, through which morphological changes of speech organs (to utter voices) and use of gesture-language that led to the communication with collaborative labor and conversation to form human social society.

Consciousness of this stage can be taken as understanding the surroundings through the cognitive mechanism ranging from the sensory organ, brainstem and to the posterior association cortex (PAC). Animals perceive and recognize the events in the world (awakeness/consciousness). They adapt the surroundings and can behave properly equipped with the neural basis of conditions in everyday lives.

III) Consciousness at the level of the frontal association area or the prefrontal cortex (higher primates/homo sapiens) , corresponding to the second signaling system of the conditioned reflex (Pavlov).

Self-consciousness, social communication and behavior, abstractive way of thinking, these mechanisms are characteristics in this stage.

Consciousness levels of I, II, and III are not clearly separable each

other and are continuously changing.

The highest level of the consciousness may be regardes as self-consciousness which is thought to culminate in the human brain. According to J.H. Jackson (1931-32), “spirit/mind/consciouness” is the highest stage of hierarchical structure in the course of evolution. The prefrontal cortex (PFC) has been considered to be intimately related to the highest psychic actitivities such as ethics/morals and aesthetic sense. Recently, many studies on the disturbance of the frontal lobe, changes of character after the traumatic brain, highly memorial disturbance, working memory, atrophy of the brain have been performed scientifically in psychiatric patients and healthy control subjects. The use of instruments, erect bipedal walking, group works or communale labor, with linguistic communication have obviously been main factors for the development of the human brain, particularly the PFC in the evolutionary course/conditions of humanization from the ape (Engels, 1876)

Thus, the consciousness has highly been sophisticated in the course of evolution from lower mammals to primates (including human).

. . . .

EEG and synchronisation

If electrodes are placed on the scalp varying electrical potentials of a few tens of microvolts can be recorded between the electrodes. Recordings of potentials from electrodes on the scalp are known as electroencephalograms (EEGs).

The potentials recorded in the EEG are due to postsynaptic potentials in nerve cells. The EEG is insensitive to the activity of single cells and occurs as a result of relatively slow, **synchronised**, changes in large areas of cells. The differences in potential between two scalp electrodes are largely due to depolarisation and hyperpolarisation of the dendritic trees of cortical pyramidal cells. The folding of the cortex (gyri) is problematical for recording and interpreting EEGs because opposing layers of cortex can cancel any net potentials.

The EEG shows rhythmic activity. This is conventionally divided into the following frequency bands:

Delta waves 0-4 Hz

Theta waves 4-8 Hz

Alpha waves 8-12 Hz

Beta waves >10 Hz

Gamma waves (also called fast beta) 25-100 Hz

EEGs also contain short bursts of activity called spindles and very fast oscillations (VFOs). Spindles last for 1-2 seconds and contain rhythmic activity at 7-14 Hz. They are associated with the onset of sleep. The VFOs consist of short bursts at frequencies of over 80 Hz.

When the eyes are closed the amplitude of activity from most pairs of electrodes is increased compared with when the eyes are open. When subjects are awake the EEG consists mainly of alpha and beta activity with considerable low amplitude gamma when the eyes are open. In stage 1 sleep the EEG consists of theta waves, in stage 2 sleep of varied activity and spindles, in stage 4 sleep of delta and during REM sleep of beta and theta activity. In epileptic seizures there tends to be high amplitude activity with pronounced synchronisation between many pairs of electrodes.

The rhythmic electrical activity is due to cortical feedback loops, cortico-cortical synchronisation, thalamic pacemakers and thalamo-cortical synchronisation. VFOs have been attributed to the activity of electrical connections between cells (dendro-dendritic gap junctions) (Traub (2003)).

The gamma activity, centred on a frequency of 40 Hz appears to be related to activity in cortical interneurons that form electrical connections between their dendrites (Tamas *et al.* 2000). These oscillations can be triggered by high frequency stimulation of the posterior intralaminar nuclei of the thalamus (Barth and MacDonald 1996, Sukov and Barth 2001) and as a result of activation of the reticular system (Munk *et al.* 1996). This suggests that stimulation of cortex by thalamic sensory relays triggers gamma band activity in the cortex. A shift from gamma to beta waves can occur in human event related potentials after about 0.2 secs (Pantev 1995, Traub *et al.* 1999).

The alpha activity is related to thalamic pacemakers, perhaps as a result of intrinsic oscillatory activity in thalamic sensory relays (see Roy & Prichep 2005 for a brief review). Theta activity, which occurs during some cognitive tasks and mental arithmetic involves a loop from the cortex to the non-specific thalamic nuclei. Delta activity seems to be endogenous to cortex when input is suppressed during sleep. Beta activity is due to cortico-cortical interactions, often after a brief period of gamma activation. It should be noted that gamma and beta activity can be expressed as impulses in cortico-thalamic pathways and that when cortical and thalamic activity is correlated there is a conscious state. In other words gamma or beta waves in the cortex are not correlates of consciousness on their own - see for instance Laureys *et al.* (2002).

. . . .

ooooooooooooooooooooo

Section 2 Pavlov IP→

＃１　Conditioned Reflex

Conditioned Refles 条件反射　**Primary (1st, sensory) Signalling system**

Понятие рефлекса　**Secondary (2nd,linguistic, language) signalling system**

Unconditioned Refles 無条件反射

Разнообразие рефлексов

. . . .

Conditioned Refrex　CR:

The first (sensory) signal system

Concrete, direct stimuli, being considered as conditioned stimuli.

The second (linguistic) signal system

Cortical functional system, language being considered as conditioned stimuli.　The language is a signal of direct conditioned stimuli.

. . . .

注｝ Pavlov's famous concept is the "conditioned reflex" (or in his own words the *conditional reflex*: the translation of условный рефлекс into English is debatable).In this work he developed his idea of *"nervism"*.He was educaterd at the University of Saint Petersburg and studied the natural sciences and became a physiologist.

In 1903, Pavlov delivered a speech entitled ***The Experimental Psychology and Psychopathology of Animals*.** at the 14th International Medical Congress in Madrid, where he read a paper

He received Nobel Prize of Physiology and Medicine in 1904. He died of pneumonia at the age of 86.

. . . .

In the 1890s, Pavlov was investigating the gastric function of dogs, and later children, by externalizing a salivary gland so he could collect, measure, and analyze the saliva and what response it had to food under different conditions. He noticed that the dogs tended to salivate before food was actually delivered to their mouths, and set out to investigate this "psychic secretion", as he called it.

....

Ivan Petrovitch Pavlov was born on 26th of September 1849 in Ryazan.

Иван Петрович Павлов родился 26 сентября 1849 в городе Рязани.

He was educated at the University of Saint Petersburg and studied the natural sciences.

In 1890s, Pavlov investigated the gastric function of dogs by externalizing a salivary gland so he could collect and analyze the saliva. He noticed that the dogs salivated hearing the foot-steps of a man who gives them foods in the lab. This phenomenon was called “psychic secretion” which led Pavlov later to study the mechanism of psychic diseases. In 1897, Pavlov published a monograph: **The Work of the Digestive Glands.**

Pavlov created the definitions of the four temperament types: 1) the strong and impetuous type, 2) the strong equilibrated and quiet type, 3) the strong equilibrated and lively type, and 4) the weak type, which largely correspond, respectively, to the Greek terms 1) phlegmatic, 2) choleric, 3) sanguine, and 4) melancholic.

In 1903, Pavlov delivered a speech entitled **The Experimental Psychology and Psychopathology of Animals** at the 14th International Medical Congress in Madrid.

He received Nobel Prize of Physiology and Medicine in 1904.

"Conditioned reflex" (or in his own words the *conditional reflex*: the translation of условный рефлекс into English) is a concept or theory, termed by Pavlov.

In his late years, after 80 years of age, Pavlov worked in a psychiatric hospital, and observed, studied, discussed on the problems of psychic illness with clinical doctors.

He died of pneumonia at the age of 86, on February 25th of 1936.

....

Sechenov described in his book “Reflexes of the Brain” that all actions or behaviors in our lives, whether conscious or unconscious, can be called as reflexes in a broad sense, and that psychic processes will cease when sense organs stop to receiving stimuli. Pavlov (Fig.25) regarded the year 1863 as the starting point of his research when the book of Sechenov was published. As the fundamental principle of the conditioned reflex theory, Pavlov believed that "no actions exist without causes, motives nor stimuli”. He considered that every neural action and every psychic phenomenon has actual reality of the objective existence, it can therefore be explained materialistically through objective physiologic studies. He defined conditioned reflexes as reflexes of living bodies acquired in their individual lives, and the unconditioned reflexes as innate activities of definite reflexes, non-dependent upon the cerebral cortex, genetically/hereditary unconditionally fixed, and most importantly these are bases of a variety of behavioral reactions which are formed as conditioned reflexes.

Conditioned reflexes are classified into two parts; the first or primary and the second or secondary signaling systems. The former signals are perceived stimuli directly coming from sensory organs, whilst the latter signals have unique characteristics, bearing indirect nature of signalized signals. The first and second signaling systems are also called the sensory and language signaling systems.

The fundamental principle of the nervous processes occurring in the cerebral cortex is apparently common in ape and man, although the cerebral cortex in man is far more developed and highly organized than that in ape. The enormouse development of the human cerebral cortex, characterized by immense growth of cortico-cortical fibers connecting sensory, motor and association areas, including linguistic areas, has been caused by using tools for hunting and farming, labor for production, and communication in the society.

The relationship between the association cortex and the second signaling system (language signal system) of the conditioned reflex will be considered below. Animals receive sensory stimuli first in the epithelium of the sensory organs and perceive and recognize the information in the brain, the highest analyzer being in the cerebral cortex. Generally activities in the brain become more complex and refined as impulses travel through crossing over synapses (by means of synaptic transmission), thus shaping the brain in evolution.

In monkeys, inputs of somatosensory, visual and auditory systems have been shown to converge on a certain area in the posterior association area, i.e., the cortex surrounding the superior temporal sulcus (STS region) (Jones and Powell, 1970). The same is the case in cats, showing that the same kinds of inputs converging on the cortex surrounding the middle suprasylvian sulcus (MSS region) (Kawamura, 1973a, b, c).

The organization of association fibers that converge upon a certain region in the posterior association cortex is shown to be surrounded by these sensory areas of different modalities. This leads to the development of highly advanced areas of recognition, assuming that corresponding parts are present in man which can be conjectured as a highly developed cortical area from the phylogenetic point of view, i.e., the primitive linguistic area in the posterior association area (Wernicke area). Anatomically, the STS region in monkeys may correspond to area 39 (angular gyrus) and area 40 (supramarginal gyrus) of Brodmann (1909) in man as it takes similar or analogous location in the human brain (Kawamura, 1977). The developmental stage of this process can be considered as the transitional stage from the first signaling system to the second in Pavlovian terms, animals communicating each other by using socially defined signals.

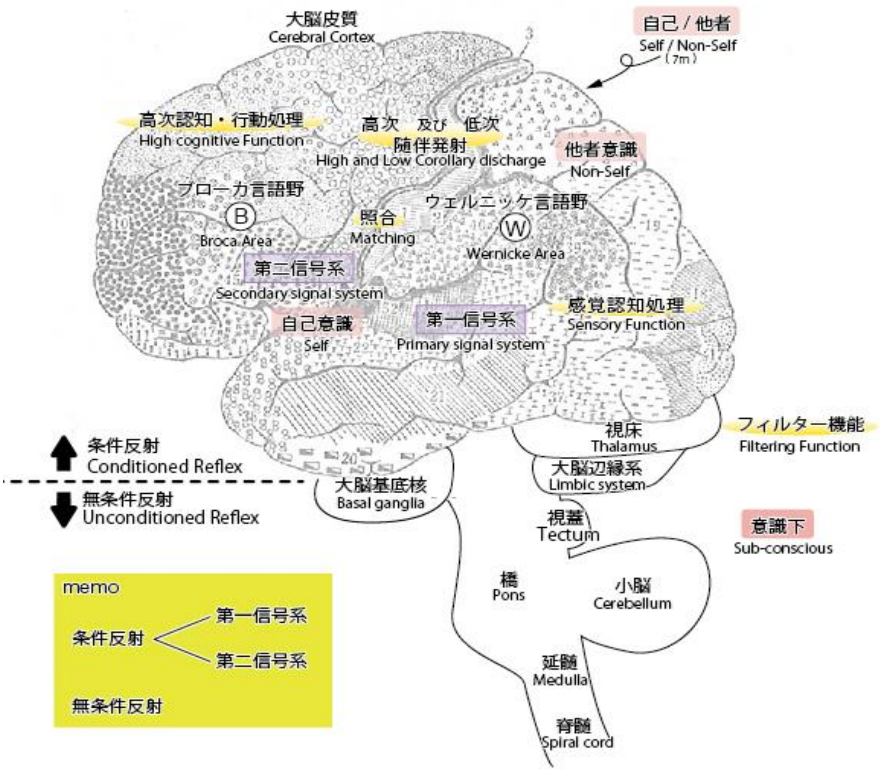
As a means of communication, we have languages by showing gestures, and by talks and letters different from the levels of simple emotional expressions, in which reactions or a kind of reflex movements are expressed unconditionally. We can hardly think it the same in essence when information is conveyed by crying sounds in emergency such as "dangerous" or "be careful". As the development of the language shows for example in higher primates, repetition of emotional expression and gestures in life generate common rules of understanding with particular signs in the society.

Namely, communication or transmission of thought and ideas always accompanied by recognition and emotion, the latter being supporting underneath. In the human brain, there are close relationships between the cerebral neocortex and limbic structures, which has been demonstrated scientifically from the standpoint of phylogenic development.

Gesture languages can be seen in the communities of monkeys and chimpanzees, and also seen at the initial stage of communication by using novel languages, or in the conversation among deaf and mute persons. Although each has its own condition, signals by gestures have common significance, transmitting ideas or concepts by means of body language. It indicates a likely possibility that general idea/representation can be transmitted among individuals by using gesture.

The brain of ape can discriminate sounds of different frequencies, but can hardly understand the meaning of spoken words lacking emotional tint. There are indeed qualitative changes in the understanding of communication between gesture and phonetic signs. This has been materialized in the process of evolution from ape to man, being able to form an idea from phonetic signs, and elevating further from the concrete idea to the abstract idea. As the history of languages shows, the letter language followed the spoken (phonetic) language. Then the language system has created a new era of a deliberate thinking. The brain thus has reached the stage in which various language centers in the posterior and anterior association cortices are in active together as a whole.

Propagation of impulses directing towards the prefrontal cortex (= the anterior association area), as mentioned repeatedly above, is absolutely necessary for the brain to develop into the stage of abstractive way of thinking. Through these processes, the active center of Broca (so-called the motor language area) has been formed, creating or adding new functions of special characteristics; abstraction and generalization. The second signaling system of conditioned reflexes (of Pavlov), qualitatively highly developed, can be accomplished through these developmental processes.



ブロードマンの脳地図　より

Conditioned reflex and the mind

It is not easy to handle the problem of mind; the whole products of the brain activities. Mental activities in man have close relations with the language function. In the central nervous system, scientists can study mechanisms of the motor, sensory or reflexes in proper ways. However, when dealing with the products of higher nervous activities; “mind or spirit”, various aspects of recognition, thinking, judgment, language, and emotion, particularly in higher primates, they often face hard situations.

Even the greatest neuroscientists such as Wilder Penfield, neurosurgeon, and John C. Eccles, neurophysiologist, who have devoted their lives to understand the higher nervous activities as neuronal functions by means of natural scientific ways, advocated the existence of mental energy or the existence of the "liaison brain" towards the mental third world in their late ages. They unfortunately reached the conclusion that the concept of the soul cannot be reconciled with our present knowledge of neurosciences as products of the higher nervous activities, and they tried to solve the problem of mind and body (=brain) in dualism. Furthermore, Roger W. Sperry who studied the functions of the left/ right hemisphere using the severed hemispheric (split) brain, and Ragnar Granit who examined the control of movement physiologically on the subcortical level, they both left the standpoint of materialism and asserted from the position of idealism, saying that psyche brings about materialistic changes or that neurons in the brain work with definite purposes. The above-mentioned authorities are pupils of Charles Sherrington (1861-1952). Sherrington is a distinguished scholar who built the foundation of the modern neurophysiology, whose reflex reflex theory is ; the brain has the action which integrates many reflexes in an organic manners and completes complicated movements.

In contrast, Russian physiologist I. M. Sechenov (1829-1905) published a book entitled "Reflexes of the Brain" (1863) from the standpoint of materialism. He studied the mechanism of the central control of the reflex movement at Claude Bernard's laboratory, and published this work after he returned home in St.Petersburg. The guiding principle on the research of Sechenov is the determinism (the term is contrary to the vitalism), in which conditions of existence of all the phenomena in the living bodies, like that of non-living bodies (inanimate objects), is absolutely determined. And he extended/adopted the principle of reflexes in the lower parts of the central nervous system to the activity of the psychological activities of animals, and opened the way to establish the theory of higher nervous activities, conditioned reflexes achieved by I.P. Pavlov.

Descartes termed the automatic reaction of living bodies as "reflexes", that occur as results of nervous induction reaching the brain, the idea being the mechanistic idealism. He advocated the principle of human's rational psyche, and tried to explain human psychology by means of the concept of reflexes. Changes of the historical concepts of the reflexes to be followed to Sechenov, Sherrington and Pavlov have been described elsewhere (Kawamura, 1999).

Sechenov described in his book "Reflexes of the Brain" that all actions or behaviors in our lives, whether conscious or unconscious, can be called as reflexes in a broad sense, and that psychic processes will cease when sense organs stop to receiving stimuli. Pavlov regarded the year 1863 as the starting point of his research when the book of Sechenov was published. As the fundamental principle of the conditioned reflex theory, Pavlov believed that "no actions exist without causes, motives nor stimuli". He considered that every neural action and every psychic phenomenon has actual reality of the objective existence, it can therefore be explained materialistically through objective physiologic studies. He defined conditioned reflexes as reflexes of living bodies acquired in their individual lives, and the unconditioned reflexes as innate activities of definite reflexes, non-dependent upon the cerebral cortex, genetically/hereditary unconditionally fixed, and most importantly these are bases of a variety of behavioral reactions which are formed as conditioned reflexes.

Conditioned reflexes are classified into two parts; the first or primary and the second or secondary signaling systems. The former signals are perceived stimuli directly coming from sensory organs, whilst the latter signals have unique characteristics, bearing indirect nature of signalized signals （信号の信号）. The first and second signaling systems are also called the sensory and language signaling systems.

The fundamental principle of the nervous processes occurring in the cerebral cortex is apparently common in ape and man, although the cerebral cortex in man is far more developed and highly organized than that in ape.

The enormouse development of the human cerebral cortex, characterized by immense growth of cortico-cortical fibers connecting sensory, motor and association areas, including linguistic areas, has been caused by using tools for hunting and farming, labor for production, and communication in the society.

The relationship between the association cortex and the second signaling system (language signal system) of the conditioned reflex will be considered below. Animals receive sensory stimuli first in the epithelium of the sensory organs and perceive and recognize the information in the brain, the highest analyzer being in the cerebral cortex. Generally activities in the brain become more complex and refined as impulses travel through crossing over synapses (by means of synaptic transmission), thus shaping the brain in evolution.

In monkeys, inputs of somatosensory, visual and auditory systems have been shown to converge on a certain area in the posterior association area, i.e., the cortex surrounding the superior temporal sulcus (STS region) (Jones and Powell, 1970). The same is the case in cats, showing that the same kinds of inputs converging on the cortex surrounding the middle suprasylvian sulcus (MSS region) (Kawamura, 1973a, b, c). The organization of association fibers that converge upon a certain region in the posterior association cortex is shown to be surrounded by these sensory areas of different modalities. This leads to the development of highly advanced areas of recognition, assuming that corresponding parts are present in man which can be conjectured as a highly developed cortical area from the phylogenetic point of view, i.e., the primitive linguistic area in the posterior association area (Wernicke area). Anatomically, the STS region in monkeys may correspond to area 39 (angular gyrus) and area 40 (supramarginal gyrus) of Brodmann (1909) in man as it takes similar or analogous location in the human brain (Kawamura, 1977). The developmental stage of this process can be considered as the transitional stage from the first signaling system to the second in Pavlovian terms, animals communicating each other by using socially defined signals. As a means of communication, we have languages by showing gestures, and by talks and letters different from the levels of simple emotional expressions, in which reactions or a kind of reflex movements are expressed unconditionally. We can hardly think it the same in essence when information is conveyed by crying sounds in emergency such as "dangerous" or "be careful". As the development of the language shows for example in higher primates, repetition of emotional expression and gestures in life generate common rules of understanding with particular signs in the society. Namely, communication or transmission of thought and ideas always accompanied by recognition and emotion, the latter being supporting underneath. In the human brain, there are close relationships between the cerebral neocortex and limbic structures, which has been demonstrated scientifically from the standpoint of phylogenic development.

Gesture languages can be seen in the communities of monkeys and chimpanzees, and also seen at the initial stage of communication by using novel languages, or in the conversation among deaf and mute persons. Although each has its own condition, signals by gestures have common significance, transmitting ideas or concepts by means of body language. It indicates a likely possibility that general idea/representation can be transmitted among individuals by using gesture.

Formation of ideas (or concepts) in the spoken language (parole, conversation, hearing speeches, etc.) is closely related to the fact that sensory images have achieved relative independence from the individual mental process into phonetic signals. Therefore, it needs to be objectified and has some sort of common rules to be followed in the society beforehand. Phonetic signs, unlike gesture signs, bear themselves own features. It is almost impossible for monkeys to use such signs that bear their own free will. The brain of ape can discriminate sounds of different frequencies, but can hardly understand the meaning of spoken words lacking emotional tint. There are indeed qualitative changes in the understanding of communication between gesture and phonetic signs. This has been materialized in the process of evolution from ape to man, being able to form an idea from phonetic signs, and elevating further from the concrete idea to the abstract idea. As the history of languages shows, the letter language followed the spoken (phonetic) language. Then the language system has created a new era of a deliberate thinking. The brain thus has reached the stage in which various language centers in the posterior and anterior association cortices are in active together as a whole.

Propagation of impulses directing towards the prefrontal cortex (= the anterior association area), as mentioned repeatedly above, is absolutely necessary for the brain to develop into the stage of abstractive way of thinking. Through these processes, the active center of Broca (so-called the motor language area) has been formed, creating or adding new functions of special characteristics; abstraction and generalization. The second signaling system of conditioned reflexes (of Pavlov), qualitatively highly developed, can be accomplished through these developmental processes.

The process of acquiring language through the evolutionary stage from ape to human probably resembles the developing process of language acquisition occurring in human children. In newborn babies, myelination in the brain is completed only in the primary motor and primary sensory cortices, but not in the association cortex. Brains of six month- old still have hardly any myelination in the prefrontal cortex. In 3 year-old brains, myelination is in its first stage in the prefrontal cortex, and it is only slightly advanced in the posterior association cortex. At the age of about 7, most of the posterior association cortex is myelinated, but in the prefrontal cortex myelination is only completed in the adolescence. Physiologically, oligodendrocytes that cover the axonal sheath facilitate the conduction velocity of impulses in the nervous system contribute to the maturation of the brain activities, mentally and bodily.

Maturation of the cerebral cortex, being accomplished by development of both the association cortex and cerebral limbic structures, has close relation with activities of recognition, emotion including linguistic functions, which can be elevated to the expression of higher levels. Desire occurring in the animal brain is fundamentally related with the limbic system together with the brainstem reticular activating system. Consequently, the higher order of volition and will develop, making it possible to fulfill intentional and planned actions. Higher levels of volition are the products of the higher nervous activities that regulate emotional feelings involving the limbic structures and modulate cognitive functions occurring in the posterior association area by the aid of the backward propagation from the prefrontal cortex. Thus the results of the present brain science are precious and useful to build up a new method of education, particularly for the juvenile and adolescence, and also to promote the wheel of our history; level up the standard of social welfare, culture, arts, music and science.

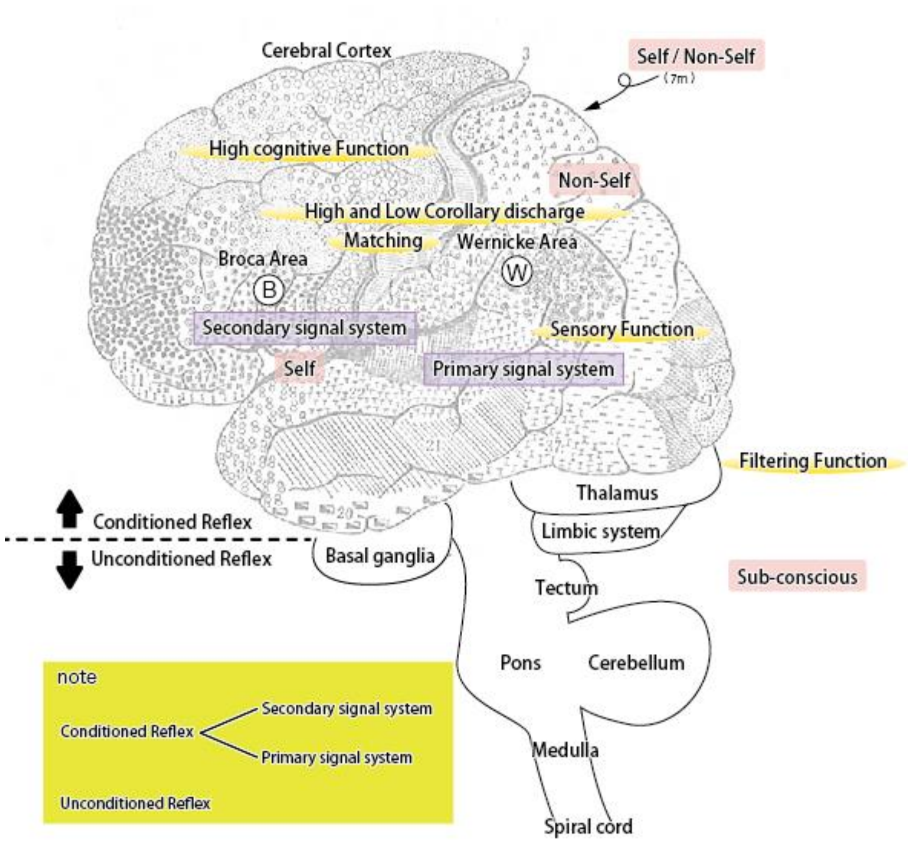
Marx and Engels further developed the evolution theory of Darwin, and pointed out that "the intentional and conscious activities of life in human beings can essentially and characteristically be distinguished from the activities of life in animals" (Economics and Philosophy, Memorandum, Marx). To avoid misunderstanding, the essential point lies not in the presence of consciousness, but it lies in the fact that they do cooperative works with alert intention in the society. As a fundamental and leading element, labor is considered as the first and foremost impelling/driving force stepping toward the way for the human from the ape, i.e., homonization or humanization. The activity of labor is indeed an advancing, driving force in the continuity of animals and man. This viewpoint has been elaborated to write an article; "Role of labors by which monkeys humanize" (Engels, 1876). His researches elucidated various aspects of related problems of evolution, labor and language. The functions and development of the cognitive association system, those of the language areas, and those of the prefrontal and motor systems and so forth are presently being elucidated and proven in the modern neurosciences.

As seen above, the higher nervous activities that underlie emotion and recognition systems are composed of three systems; cortical sensory (the first signaling) system, linguistic (the second signaling) system of conditioned reflexes, and the subcortical unconditioned reflex system. Since the concept/idea is the abstract action of the language, the second signaling system of conditioned reflexes is the basic nervous activity. The basis of emotion, on the other hand, is chiefly the action of the first signaling system, connected largely with subcortical structures (regions which constitute the limbic system including the amygdala, the septum, the bed nucleus of stria terminalis, the nucleus accumbens/the ventral striatum). Neural circuitries and processes of nervous activities that support the mechanisms of cognition and emotion are interrelated closely with each other, as discussed above by showing anatomical and physiological data. Cognition and emotion are thus indispensable aspects of two indivisible phases, which reflect actual existence in consciousness. There is no emotion without concept, and no concept is present without emotion.

Pavlov in his late years, after 80, worked in a psychiatric hospital and analytically observed patients of various types of mental diseases, for example, obsessive, delusional, hypochondrial, and depressive symptoms. We can read detailed reports on these topics written by himself (I. P. Pavlov,1903). He tried to explain these abnormal symptoms as activities of higher nervous system, using the concept of the second signaling system of conditioned reflexes. Pavlov continued his researches in psychiatric illness, particularly the experimental neurosis over 15 years, and he searched for effective methods of therapy and wanted to carry steps toward “scientifically healthy psychotherapy ".

Man can understand the high levels of abstract ways of thinking, and creates music, arts, literature and sciences which can be inherited to the next generation. Biological studies of abnormalities of the human mind and spirit are indeed to be pursued in psychiatry.

. . . .



・・・・・・・・・・・・・・・・・・・

Section 4　情動：　脳幹→視床下部→大脳辺縁系（扁桃体）

→大脳皮質

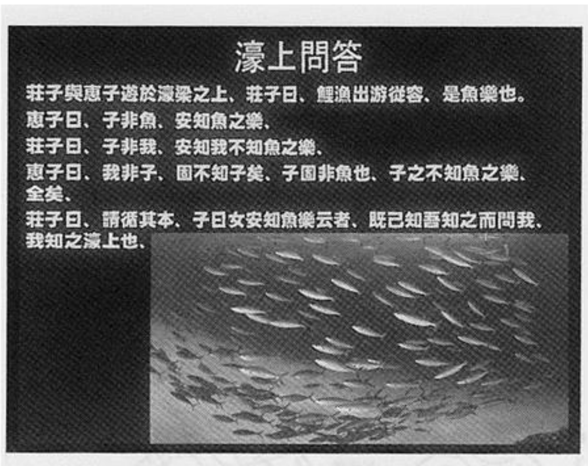
A:　情動系

魚の遊泳と扁桃体を破壊されたメダカの行動

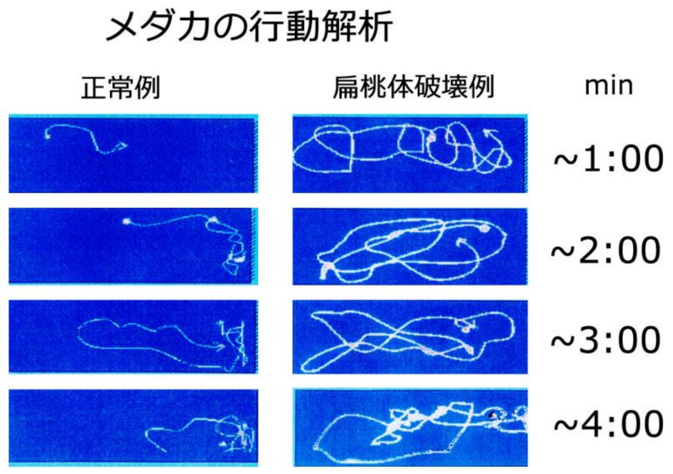
Cognition and emotion of animals in the course of evolution in BRAIN FUNCTION

Below (Fig.A) shows a dialogue of two Chinese philosophers in ancient times debating on the communication among swimming fish. They are discussing whether fish, the lowest stage of vertebrates, possesses cognitive and emotional abilities. One says “yes” insisting fish behaves merrily and seems happy. The another argues that it is impossible to answer the question, because we are human not fish, should be scientific !

荘子　と　恵子　　濠上問答



How can then our modern neuro-science can challenge to the issue ?



Mirror approaching behavior in the fish, medaka (Oryzias latipes) after lesion in the amygdala

Medaka (Oryzias latipes) and mouse for comparison.
Healthy medaka (with non-destroyed amygdala): swimming pattern is traced in the left diagram. He is approaching to the mirror where his figure is reflected.
Medaka with lesioned amygdale: swimming pattern in the right diagram. Totally indifferent to his own figure reflected in the mirror.

Numericals indicate minitutes after the fish was put in the pool.

In our experiments where Medaka (a kind of fish) are placed in the aquarium that one side of the wall is covered with mirror, a normal fish approached to the wall, while a fish with destroyed both sides of amygdala discarded own figure in the mirror and swim freely in the tab.

This behavior of the fish means the the normal fish recognized the figure of his own and approached the mirror showing the sociability, while the fish with damaged amygdala did not show any social, emotional communication. (Tsubokawa et al., 2009).

これまで、サルやヒトの認知・情動・運動関連の話をしてきましたが、トリやサカナではどうなのでしょうか？　次は、私が慶應大学にいたときに坪川先生がされた実験で（坪川, 2002; Tsubokawa ら、2009)、情動発現に関わる扁桃体の領域を、メダカで免疫組織学的(GAD,CGRP)に調べて（図８）、その対応する部位を同定しました。その扁桃体に電流を流して組織を破壊します。そして、そのときの行動変化を観察しました（図9,図10）。

メダカを泳がせておいて、一つの面に鏡を置くと、健常なメダカは鏡に映った自分の映像を見て、同類の相手と「認識」して、「社会性」を発揮してか、鏡のほうに寄ってきます。その遊泳の軌跡です。しかし、扁桃体が破壊されたメダカは鏡を置いても近寄ってきません。行動パタンに変化が現れます。群れをなし、情を交わして何らかの交流/通信（波動を因とする電磁波や超音波や声などで）をするような、コミュニケーションを示す行動（そぶり）が現れません。 A small aquarium or test tank, in which the experiments were carried out, shoaling：can be considered a simple form of affective behavior displayed in social fish species in which a single fish approaches others, When a single medaka is placed in a tank it swims freely in all directions. When a mirror is placed on one side of the tank, the same individual tends to swim close to the mirror. We defined this mirror approaching behavior as an indicator of shoaling behavior.

Transplantation of amygdala from quail to chick

Sonograph , the quail-chick chimera system

Through evolution from fish to bird, avian (bird) obtain the singing ability. Furthermore, the type of singing is different/or specific to species, e.g. between hen/chicken and quail.

Chicken ti---, for one time, while the quail song/voice is ti-ti-for two times in succsetion.

In the embryonic days 7-10 days, we did experiments to make an chimera；amygdalas of the chick were replaced by those of the quqil. As a result, when grow up the hen utteded the voice of the quail. (Tan –Takeuchi and Le Douarin, 1991). (Balaban ら, 1988).

発声器官をもたないサカナは歌うことができません。「メダカの学校は・・・」という小学唱歌がありますが、それがサカナからトリになると声を発するようになります。 トリの発声の仕組みについて、慶應で一緒だった竹内先生のお仕事を次に紹介します。トリの場合には、気管支にある鳴管（syrinx）

が発声器官で、舌下神経核支配です。ヒトの発声器官の声帯は咽頭にあり、舌咽神経と迷走神経に支配されております。竹内先生が留学された、フランスのル・ドワラン（Nicole M. Le Douarin）教授はウズラとニワトリの神経細胞の形態的差異について、顕微鏡下でクロマチン染色切片を調べるという、発生過程の研究法を考案しました(Tan -TakeuchiとLe Douarin, 1991)。

トリの胚の初期、すなわち、７日や10日という時期に（将来、中枢神経組織に分化する）ウズラの神経管の一部を切り採ってヒヨコの胚の同じ部位に置き換えるという移植をして、キメラ動物を作ります。ウズラとニワトリ（ヒヨコ）の脳のキメラを作ります（図１２）。そして、一部分ウズラの脳に置きかえて発育させます。そのときに鳴き声がどう変わるかということを調べました。最後に、脳の組織切片を作って顕微鏡観察をして部位を同定します。

これは非常に難しい実験で、高度のテクニックを要します。ヒヨコの脳にウズラ脳を部分移植してキメラ脳を作製するという実験ですが、図１３左下に表示した、②の前方の大脳だけの領域、③の大脳に加えて中脳と脳幹の先端まで含めた領域、④の大脳域を全く含めないで後方の脳幹だけの領域など、さまざまな範囲の脳組織部分のヒヨコ脳を切り取って除いた部分にウズラ脳を移植します。そしてキメラ動物の発する鳴き声を聞きます。ヒヨコの鳴き声は「チィーッ」と１回しか鳴きませんが、ウズラの雛は「チィーッ・チィーッ」と2回続けて鳴きます。図①のキメラ移植をしない場合には、鶏の鳴き声のままですが、③の移植をしますと、この二分割した「チィーッ・チィーッ」という鳴き声に変わります。そして、④になると、少し乱れてきます。なぜ乱れてくるかですが、④だと少し情動に関係する扁桃体領域が含まれています。③の移植例では（扁桃体を含んで）その領域が全部入っています（図１３）(Balaban ら, 1988)。

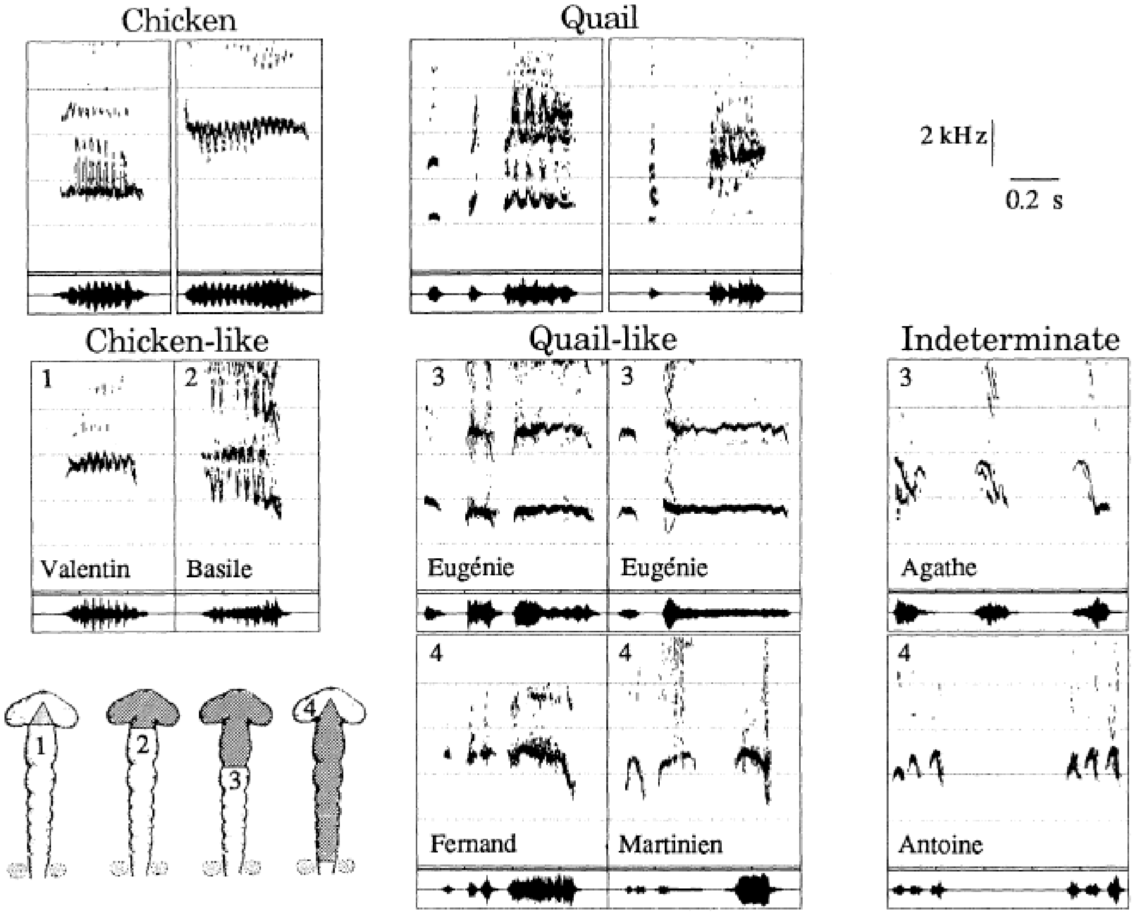


Fig. 5. Testosterone-induced juvenile crowing patterns from chickens, quails, and quail donor–chicken host brain chimeras. All crows shown were recorded between 4 and 7 days after hatching. Each box shows an amplitude-time (bottom) and frequency-time (sound spectrographic, top) representation of one crowing vocalization. Frequency and time markers are as indicated at the top right. Transplant operations are shown schematically at the lower left: 1, transplant of the dorsal neural tube primordium, giving rise to the dorsal thalamus; 2, transplant of the whole prosencephalic neural tube, giving rise to the entire telencephalon, diencephalon, and eyes; 3, transplant of the whole prosencephalic and mesencephalic neural tube, giving rise to the entire telencephalon, diencephalon, and mesencephalon including the eyes; or 4, transplant of the whole neural tube between the first somite and the caudal part of the prosencephalon, giving rise to the entire rhombencephalon, cerebellum, mesencephalon, diencephalon, and caudal portions of the telencephalon. Numbers in the upper left corner of each sonogram indicate which transplant was done. Crows from two unoperated chicks and two unoperated quail are shown on the top. Crows from chimeric animals are classified into three groups: chicken-like, two examples from two different chimeric animals that were similar in segmental structure to forms observed in normal chickens; quail-like, four examples recorded from three different chimeric animals with segmental structures that were similar to those observed in normal quail; and indeterminate, two examples of variable segmented crows from two different chimeric animals. Although these indeterminate vocalizations were segmented, their lack of quail duration and temporal patterning as well as the variability of their temporal patterning precluded their classification as quail-like; some of them are similar to rare aberrant quail crows recorded in an earlier study (*10*). Names in the sonograms denote the individual animals tested.

Zebra fish　　from Okamoto

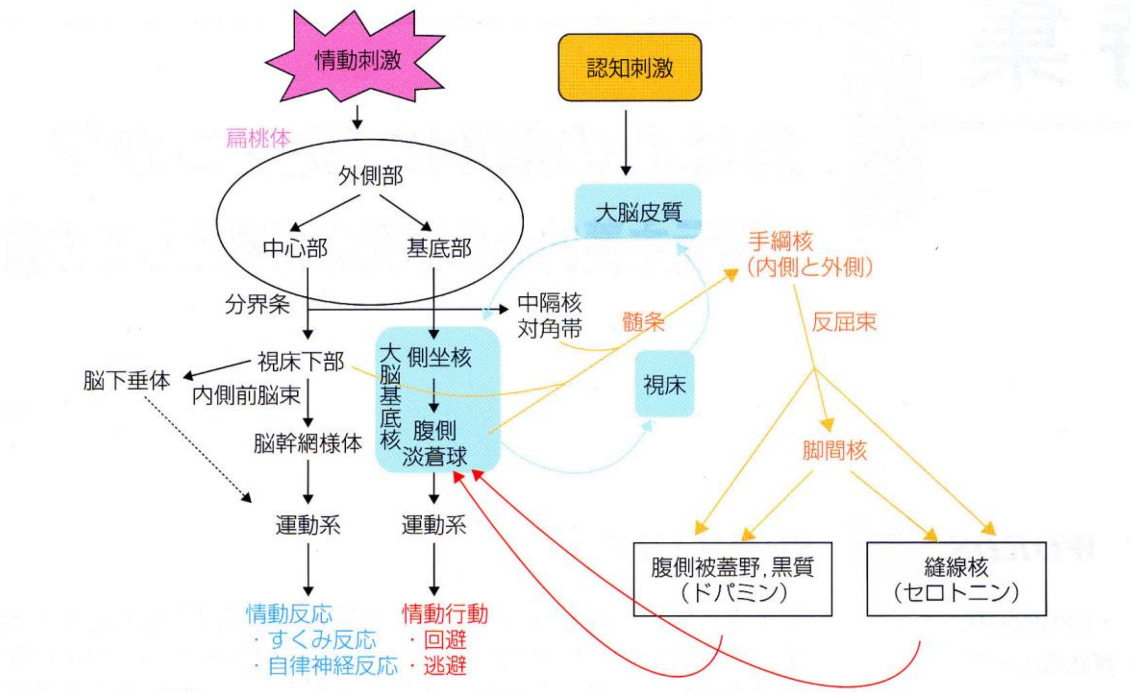


図 2. 情動刺激から行動に至るまでの神経回路

(1) 2) 4) 5) をもとに筆者作成)

小型魚類に遺伝子操作を加えることによって，“知の神経回路”である皮質・基底核ループと“情の神経回路”である辺縁系とが手綱核・脚間核・モノアミン神経細胞をつなぐ神経回路を介した相互作用によって，“価値判断をもった記憶の集合体としての自伝的自我”が形成されるプロセスを，リアルタイムで観察することができるようになるかもしれない．

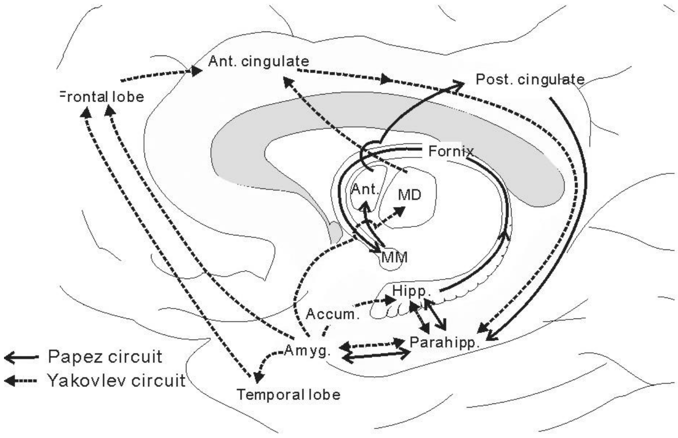
Emotional expression and the limbic system　情動の表出と大脳辺縁系—進化的な見方—

Humans understand language, art and music, because the development of the brain has reached a level to recognize symbolic signals to communicate in the society. Areas 39 and 40　(of Brodmann) in the human parietal lobe are involved in the high order　recognition, disturbance of which causes sensory aphasia, apraxia and agnosia.

Functions of the frontal lobe are the active expression of bodily and mental movements as well as planning and performing a series of actions. Cognitive information reaches the prefrontal cortex from the parietal and temporal lobes. There are no direct projections from the posterior association area to the primary motor cortex (Kawamura, 1977), having interfaces where the conversion of the sensory cognition to the active motor action occurs.

Recognition and emotion are closely related to each other in the expression of "logos" and "pathos". Sensory information reached the cerebral cortex is transmitted from the posterior association area to the anterior association cortex, or the prefrontal cortex, in which information of the stimuli can be converted and be bestowed the connotational significance reflecting the situations occurring in the external world before being sent to the higher cortical motor system.

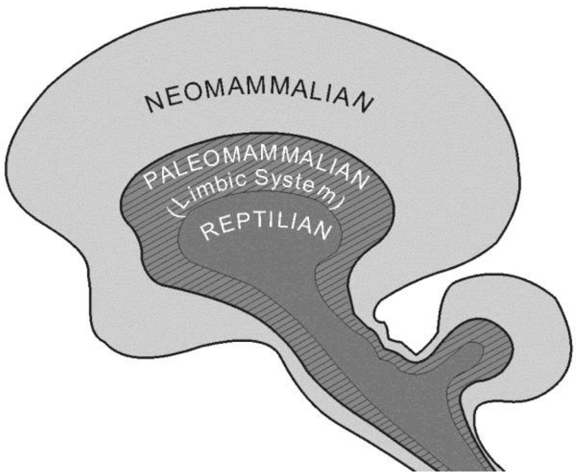
The amygdala participates in the evaluation of biological values of pleasant or unpleasant feelings in the consolidation of memory by means of emotional conditioning. Furthermore, it is well known that there are Yakovlev's and Papez's circuits, (Fig.10, see Papez, 1937) which are concerned with emotion and memory, respectively, involving the amygdala, temporal and frontal lobes, cingulate gyrus and hippocampus. In the cingulate gyrus, the amount of regional cerebral blood flow (rCBF) increases in the volitional action of monkeys in the experiment where they found a new maneuver in order to obtain rewards (Shima and Tanji, 1998) are involved in the autonomic nervous system, the highest center of which is the hypothalamus. Autonomic nervous activities comprise breathing, blood circulation, perspiration, digestion, appetite and sexual desires. These have close correlation with emotion, activated by the limbic system. Hormonal regulation system covering the hypothalamus, hypophysis and endocrine organs is under the influence of the hippocampus and amygdala. Impulses of smell and taste are known to pass into the cortical and medial nuclei (phylogenetcally old parts) of the amygdala (Norita & Kawamura, 1980), which are also associated with emotion.



10)
Yakovlev's
and

All sensory inputs, including the visceral, are involved in the autonomic nervous system, the highest center of which is the hypothalamus. As for autonomic regulation, there are neural projections from the paraventricular nucleus (PVN) to the dorsal nucleus of the vagus and solitary nucleus in the brainstem, as well as humoral influence controlled by the endocrine system. Autonomic nervous activities comprise breathing, circulation, perspiration, digestion, appetite and sexual desires. These have close correlation with emotion, activated by the limbic system. Hormonal regulation system covering the hypothalamus, hypophysis and endocrine organs is under the influence of the hippocampus and amygdala. Impulses of smell and taste are known to pass into the cortical and medial nuclei (phylogenetcally old parts) of the amygdala (Norita & Kawamura, 1980), which are also associated with emotion. Information from the amygdala can be transmitted to the hypothalamus via the stria terminalis and ventral pathways.

As a classic theory of emotional concept viewed from the phylogenetic points, "a triune brain theory" has been proposed by MacLean (1973). He considered the hierarchy of the animal brain as constructed by a three-layered system, consisting of the primitive reptilian brain, the paleo-mammalian brain and the neo-mammalian brain (Fig.11).

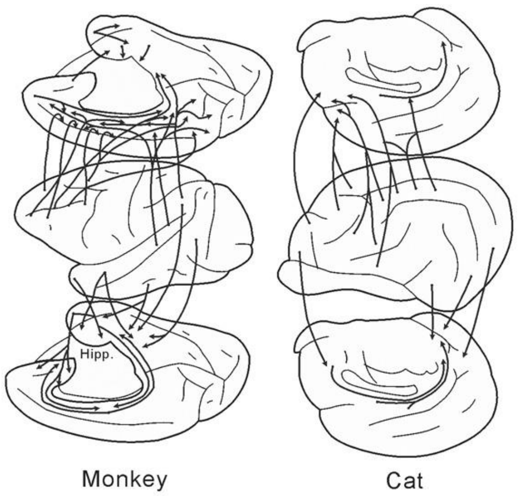


11)
MacLean
triune

The animal with the primitive reptilian brain expresses the stereotypical behavior based on primitive learning and memory. In reptiles and birds, the main structure of the motor system is the basal ganglia, and the cerebral cortex is underdeveloped. The behavioral reaction of these animals is largely determined at the level of the limbic system.

The animal with the paleo-mammalian brain, first developed in the primitive mammals, has the seat of emotion, by which the stereotypic reactive actions are regulated and controlled somewhat with flexibility.

Under these conditions, the limbic system plays important roles in the expression of behavior directly related to "emotional processes" (Bruce and Neary, 1995).



12
) neocx to

In "higher-mammals", the neocortex is involved in analyzing external environment. The cerebral cortex, cerebellum and basal ganglia develop markedly in the primates, and " cognitive process" are concerned to a large extent with the expression of behaviors. A high degree of mutual connections between the neocortex and limbic structures develops in higher animals (Fig.12), particularly in the fiber connections among the temporal association area, prefrontal area and amygdaloid nuclei. Emotional behaviors become much more refined and complex qualitatively. Abstract ways of thinking and emotional self-reflection can be achieved in the human brain. The regulation of the prefrontal area over the limbic system and the participation of the "thinking process" to the "emotional state" becomes refined and characteristic, as seen in music and art (Fig.13). Anatomically, direct and indirect connections between the prefrontal cortex and the hypothalamus and amygdala become stronger.

3) env

The structure of the human neocortex is further advanced than in the monkey in terms of its areal expansion, cortical width and fiber connections. Microscopically, differentiation of pyramidal neurons, development of neuronal circuitry are noteworthy. Use of tools in labors, co-working in the society, communication with language, all these have enabled the human brain to reach the highest levels of cortical development.

Comparisons of the corticocortical connections between cats and the monkeys have been illustrated and discussed elsewhere (Figs. 14, 15, Kawamura, 1977). A greater degree of differences certainly exists between humans and monkeys than between cats and monkeys (Fig. 16). Regionalization and lamination in the human cerebral cortex are also important factors for the basis of analytical mechanism of the higher order brain functions.

情動の神経回路—扁桃体、前頭前野、側頭葉—についての概説

扁桃体は、広範な大脳皮質領域から脳幹・脊髄までの中枢神経系（CNS）全体にわたり、神経回路網によって複雑に結びついている。これに加えるに、内分泌・自律神経系やペプチド・モノアミンなど液性伝達系をも含めると、CNS 全体を対象としなければならない。断片的に概説するのではなく、動物一般の扁桃体の生理機能を総括的に論じることは重要ではある。
が、ここでは、高等動物とくに人間の扁桃体について考えてみたいので、ヒトで著しい発展を遂げた大脳皮質レベルに話題を絞りたい。改めて扁桃体は、前頭前野の眼窩面(orbitofrontal)、内側面(medial prefrontal area、とくに帯状運動皮質 cingulate motor cortex)、側頭葉の前方域(temporal pole)、内側(hippocampal formation)、下面(とくに紡錘状回近傍 fusiform gyrus)、と強く結合している。そして、これらの皮質域間の関連性も考慮しながら、異現同根で不可分の関係にある情動機能と認知機能の周辺に関心は払われる。
　トピックスとして以下の 3 点、すなわち、①「原始的感覚」としての嗅覚と情動と生命を支える自律機能、② 側頭葉の紡錘状回が関わる表情の認知、③ 前頭前野（内側面および外側面）が関わる能動性・「社会脳」機能、でまとめてみる。

１）「原始的感覚」としての嗅覚（・味覚）と情動と生命を支える自律機能

動物は餌を捕り、敵から守るために、最初に嗅覚と味覚を発達させた。これらの感覚刺激は扁桃体に、そこからさらに視床下部へと伝達される。大脳皮質を持つ動物になると、扁桃体から皮質に終わる神経路、さらに皮質・視床下部路が形成されてくる。これらの線維の終始域は前頭葉内で、嗅覚皮質は眼窩面に、味覚皮質は弁蓋部（43 野、一般動物では島皮質）にあり、視床経由のいわゆる上行性感覚伝導路もここに終わる。この事実から、これらの皮質領域が呼吸・循環を含む自律機能および「原始的感覚」の情動と認知・分析のはたらきに関与していることが言える（生理学的研究もこれを裏付けている）。

。。。。。。。。。。。。。。。。。。。。。。。。。。。。

大脳辺縁系（扁桃体と海馬、特に情動系に重要な扁桃体に注目して）

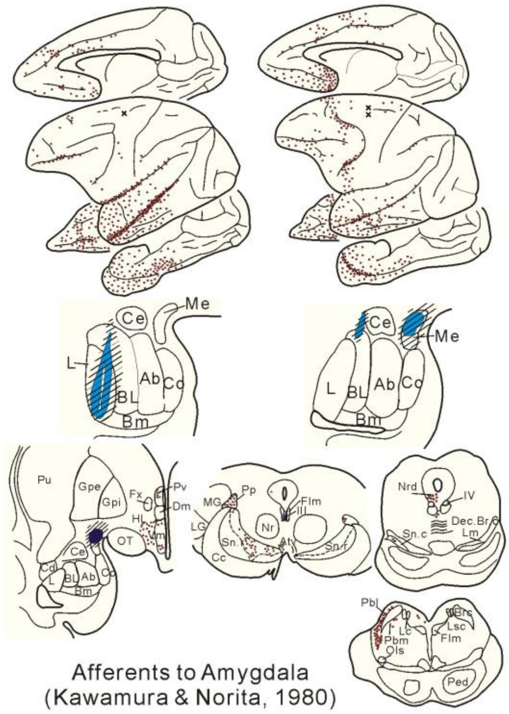
参考資料　23　Limbic system 大脳辺縁系:

Amygdala　　Emotion　情動

Hippocampus　　Memory 記憶

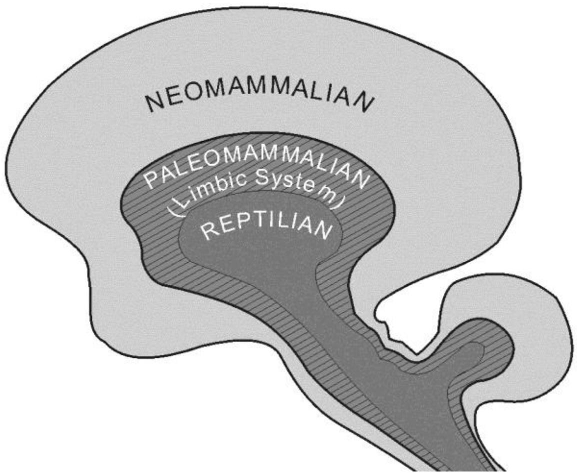
The amygdala participates in the evaluation of biological values of pleasant or unpleasant feelings in the consolidation of memory by means of emotional conditioning. Furthermore, it is well known that there are Yakovlev's and Papez's circuits [put references] which are concerned with emotion and memory, respectively, involving the amygdala, temporal and frontal lobes, cingulate gyrus and hippocampus. In the cingulate gyrus, the amount of regional cerebral blood flow (rCBF) increases in the volitional action of monkeys in the experiment where they found a new maneuver in order to obtain rewards (Shima and Tanji, 1998) are involved in the autonomic nervous system, the highest center of which is the hypothalamus. Autonomic nervous activities comprise breathing, blood circulation, perspiration, digestion, appetite and sexual desires. These have close correlation with emotion, activated by the limbic system. Hormonal regulation system covering the hypothalamus, hypophysis and endocrine organs is under the influence of the hippocampus and amygdala. Impulses of smell and taste are known to pass into the cortical and medial nuclei (phylogenetcally old parts) of the amygdala (Norita & Kawamura, 1980), which are also associated with emotion.

All sensory inputs, including the visceral, are involved in the autonomic nervous system, the highest center of which is the hypothalamus. As for autonomic regulation, there are neural projections from the paraventricular nucleus (PVN) to the dorsal nucleus of the vagus and solitary nucleus in the brainstem, as well as humoral influence controlled by the endocrine system. Autonomic nervous activities comprise breathing, circulation, perspiration, digestion, appetite and sexual desires. These have close correlation with emotion, activated by the limbic system. Hormonal regulation system covering the hypothalamus, hypophysis and endocrine organs is under the influence of the hippocampus and amygdala. Impulses of smell and taste are known to pass into the cortical and medial nuclei (phylogenetcally old parts) of the amygdala (Norita & Kawamura, 1980), which are also associated with emotion. Information from the amygdala can be transmitted to the hypothalamus via the stria terminalis and ventral pathways.



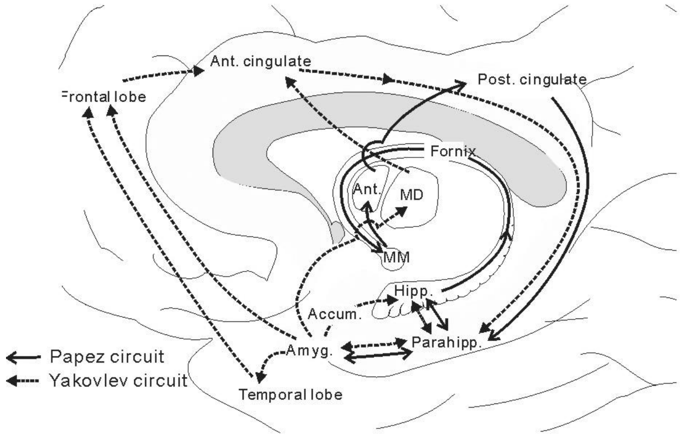
Afferents to Amygdala
(Kawamura & Norita, 1980)

As a classic theory of emotional concept viewed from the phylogenetic points, "a triune brain theory" has been proposed by MacLean (1973). He considered the hierarchy of the animal brain as constructed by a three-layered system, consisting of the primitive reptilian brain, the paleo-mammalian brain and the neo-mammalian brain.



The animal with the primitive reptilian brain expresses the stereotypical behavior based on primitive learning and memory. In reptiles and birds, the main structure of the motor system is the basal ganglia, and the cerebral cortex is underdeveloped. The behavioral reaction of these animals is largely determined at the level of the limbic system.

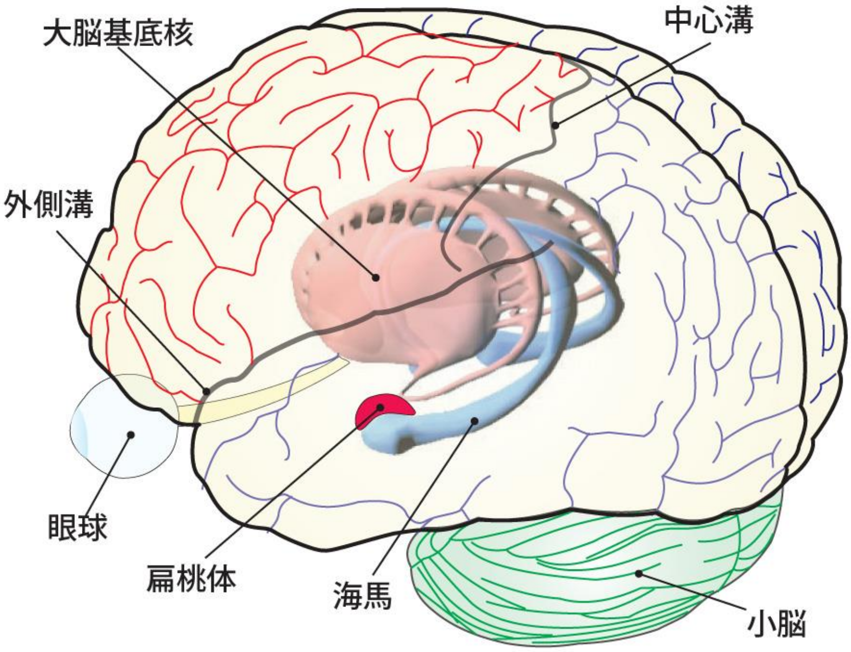
The animal with the paleo-mammalian brain, first developed in the primitive mammals, has the seat of emotion, by which the stereotypic reactive actions are regulated and controlled somewhat with flexibility. Under these conditions, the limbic system plays important roles in the expression of behavior directly related to the "emotional process" (Bruce and Neary, 1995).



Functions of the frontal lobe are the active expression of bodily and mental movements as well as planning and performing a series of actions. Cognitive information reaches the prefrontal cortex from the parietal and temporal lobes. There are no direct projections from the posterior association area to the primary motor cortex.[Extend discussion !] having interfaces where the conversion of the sensory cognition to the active motor action occurs.

Recognition and emotion are closely related to each other in the expression of “logos” and “pathos”. Sensory information reached the cerebral cortex is transmitted from the posterior association area to the anterior association cortex, or the prefrontal cortex, in which information of the stimuli can be converted and be bestowed the connotational significance reflecting the situations occurring in the external world before being sent to the higher cortical motor system.

The amygdala participates in the evaluation of biological values of pleasant or unpleasant feelings in the consolidation of memory by means of emotional conditioning. Furthermore, it is well known that there are Yakovlev's and Papez's circuits, which are concerned with emotion and memory, respectively, involving the amygdala, temporal and frontal lobes, cingulate gyrus and hippocampus. In the cingulate gyrus, the amount of regional cerebral blood flow (rCBF) increases in the volitional action of monkeys in the experiment where they found a new maneuver in order to obtain rewards (Shima and Tanji, 1998) are involved in the autonomic nervous system, the highest center of which is the hypothalamus. Autonomic nervous activities comprise breathing, blood circulation, perspiration, digestion, appetite and sexual desires. These have close correlation with emotion, activated by the limbic system. Hormonal regulation system covering the hypothalamus, hypophysis and endocrine organs is under the influence of the hippocampus and amygdala. Impulses of smell and taste are known to pass into the cortical and medial nuclei (phylogenetcally old parts) of the amygdala (Norita & Kawamura, 1980), which are also associated with emotion.



メモ（日本文、重複あり）

扁桃体からの出力　：

大別して３つを挙げ得る。すなわち、①扁桃体の中心核（および一部、内側皮質核）から起こり中隔核、視床下部（前核、腹内側核、弓状核）、内側視索前核などへ終止する分界条という繊維束、および②主として基底外側核を出て内側に走り、側坐核や外側視床下部から内側部にかけて分散状に分布する腹側投射系と呼ばれる繊維群、さらに③広範囲の大脳領域、とくに側頭葉、梨状葉皮質、前帯状回、眼窩面皮質へ終わる投射がある。

また、眼窩面皮質および嗅内野を含む側頭葉皮質と扁桃体との間には直接の相互結合がみられる(Kawamura と Norita, 1980)。種々の感覚性刺激の海馬への入力は嗅内野など海馬周辺皮質を介してみられるが、扁桃体への入力は間脳、中脳のいくつかの神経核（視床諸亜核、視床下部の腹内側核、黒質、縫線核など）や脳幹内の結合腕傍核、青斑核などからの直接の投射が存在する。海馬と扁桃体は発生学的にも機能的にも異なる構造物であるが、この両構造物間の繊維連絡は、少なくともサルの段階で明らかに存

在する（Aggleton, 1986）。大略、扁桃体の外側核・副基底核からは嗅内野へ、基底核・副基底核からはCA1/CA3へ投射がみられ、逆に海馬台・CA１からは扁桃体の基底核・皮質核に、嗅内野からは扁桃体の基底核・外側核への投射が存在する（Amaral ら, 1992）。現在、連合野を含む大脳皮質や海馬・扁桃体の特定領域および視床下部諸亜核との間の連絡を究明すべく多くの研究がなされている（LeDoux,1998；Aggleton, 2000；松本と小野、2002）。

以上英文

。。。。。。。。。。。。。。。。。。。。。。。。。

Section 5　認知：　感覚受容体→脳幹→視床→大脳皮質連合野→前頭葉

b) Filtering function in the thalamus 視床の役割

Sensory stimuli from the periphery ascend to reach the thalamus and therein; thalamic filtering-mechanism works, appropriate quantity (amount) of sensory stimuli reach the cerebral cortex; perceive and regulate the level of the arousal situation. In SCZ patients, the thalamic filtering function is disturbed, resulting in the hyper-arousal state in the cortex due to the excess amount of sensory stimuli from the surrounding world. Carlsson and Carlsson (1988) proposed that the circuitry of the cortico-striato-thalamo-cortex may regulate the filtering function of the thalamus as an example of feedback loops.

Filter 機能　（大熊輝雄 text p.329）

DA 系（過剰伝達）**とグルタミン酸系**機能（G 性機能の低下）**の障害と視床フィルター障害仮説**を結びつけたものに、Carlsson A (1988)の統合失調症ドーパミン仮説がある。

視床フィルター障害仮説は、統合失調症の過覚醒 hyperarousal 状態や認知障害を視床のフィルター機能障害から説明するものである。正常な状態では、sensoric stimuli fron the periphery ascend to reach the thalamus and relayed therein; thalamic filtering-circuitry works, appropriate quantity and quantity (amount) of sensory stimuli only reach the cerebral cortexand perceive, regulate the levelof the arousal situation 知覚されるとともに、大脳皮質の覚醒水準を調節する。In schizophrenia patients, the thalamic filter function is disturbed, resulting in the hyperarousal state 過覚醒状態 in the cortex owing to the excess amount of the stimuli; occurring information-treating disturbance and cognition disturbance 過度の刺激が大脳皮質に到達するために皮質が過覚醒状態になり、情報処理障害・認知障害がおこると考えられている。

Carlsson は視床のフィルター機能を調節する feedback loops として大脳皮質・線条体・視床・大脳皮質回路を想定した。 正常者では視床のフィルターが開かれて入力が過剰になると、この feedback loops が視床のフィルター回路を抑制し、感覚入力を制御する。feedback loops の一部である線条体

は、cortex からグルタミン系によって促進的な影響を、中脳から DA 系によって抑制的な影響を受けている。SCZ でグルタミン系の機能低下、ドーパミン系の機能亢進が起こると、それらはともに線条体の視床に対する抑制機能を脱抑制し、視床のフィルターが開いて大脳皮質の過覚醒を起こす。

関連事項：ミスマッチ陰性電位 MMN：

事象関連電位の一つで、標準刺激（聴覚刺激）から偏きした刺激に対して現れ、自動的・前認知的な感覚過程（注意機能）を反映する。SCZ で MMN の振幅が低下している。とくに音素刺激で振幅低下が顕著であり、SCZ の言語処理異常が高次の意味処理だけでなく、より基本的な知覚の段階から生じていることが示唆されている。

関連事項：プレパルス抑制 prepulse inhibition(PPI)

急に大きな音響刺激を与えると生体に驚愕反応 acoustic startle response (びっくり反応)が起こるが、大きな音刺激の直前に驚愕反応を起こさない程度の小さい事前刺激（prepulse、予告刺激）を与えておくと、通常生じる筈の驚愕反応が抑制される現象。SCZ では prepulse による驚愕反応抑制の程度が減弱している。これは意志が関与しない純粋に生理学的レベルの所見であることは重要である。

・・・・・・・・・・・・・・・・・・・

第４章

上記から、数学の新しい定理として、下記の 4 個の定理（川村—坂出 - 高橋）を得る。

Theorem 1 *Let X be a nonempty set and let* $\{f_1, f_2, \dots, f_n\}$ *be a real valued function on X. Let* $I = \{1,2,\dots,n\}$ *and define a real valued function F on X × I by*

$$F(x,i) = f_i(x) \quad for\ all\ (x,i) \in X \times I.$$

Let $c \in R$ *and suppose that F is* $\mathcal{W}-$ *convexlike in its first variables and for any n nonnegative numbers* $\alpha_1, \alpha_2, \dots, \alpha_n$ *with* $\sum_{i=1}^{n} \alpha_i = 1$, *there exists* $x_0 \in X$ *such that*

$$\sum_{i=1}^{n} \alpha_i f_i(x_0) \le c.$$

Then the following holds:

$$\underbrace{\inf}_{x \in X} \max_i f_i(x) \le c.$$

Proof. *From above (12) that holds F is* $\mathcal{W}-$ *convexlike implies that F is convexlike. So we have the Theorem 6.3.4 by Takahashi, W. : pp182-183 of "Nonlinear Functional Analysis, Fixed Point Theory and its Applications" : Yokohama Publishers, 2000.*

Theorem 2 *Let X be a nonempty set and let* $\left\{f_i(x_1), f_i(x_2), \dots, f_i(x_n)\right\}$ *be a real valued function on X. Let* $I = \{1,2,\dots,k\}$ *and define a real valued function F on X × I by*

$$F(x_n, i) = f_i(x_n)\ for\ all\ (x, i) \in X \times I.$$

Let $c \in R$ *and suppose that* F *is* $\mathcal{W}-$*pure convexlike such that satisfied by*

① $\exists f_i(x_1), f_i(x_2) \in X$

② $f_i(x_{n+2}) - (\alpha + \beta) f_i(x_{n+1}) + \alpha\beta f_i(x_n) = 0$ *and* $f_i(x_n) > 0$

③ $-1 < \beta < 0 < \alpha < 1,\ 0 < (\alpha + \beta) - \alpha\beta < 1$ *and* $(\alpha + \beta) > 0$

and for any k *nonnegative numbers* $\gamma_1, \gamma_2, \dots, \gamma_k$ *with* $\sum_{i=1}^{k} \gamma_i = 1$*, there exists* $x_0 \in X$ *such that*

$$\sum_{i=1}^{k} \gamma_i f_i(x_0) \leq c.$$

Then the following holds:

$$\underbrace{\inf}_{x \in X} \max_i f_i(x_n) \leq c \quad and \quad \lim_{n \to \infty} f_i(x_n) = 0.$$

Proof. The reference was made of the case $k = 4$ above our discussions in this paper. So we shall have a generalized case of k nonnegative numbers.

Theorem 3 *Let X be a nonempty set and let* $\{f_i(x_1), f_i(x_2), \dots, f_i(x_n)\}$ *be a real valued function on X. Let* $I = \{1, 2, \dots, k\}$ *and define a real valued function F on X* $\times$ *I by*

$$F(x_n, i) = f_i(x_n)\ for\ all\ (x, i) \in X \times I.$$

Let $c \in R$ *and suppose that* F *is* $\mathcal{W}-$*linear or linear such that satisfied by*

① $\exists\, F_1 = \mathrm{f}_i(x_1),\ F_2 = \mathrm{f}_i(x_2) \in X$

② $\mathrm{f}_i(x_{n+2}) - (1+\beta)\,\mathrm{f}_i(x_{n+1}) + \beta\,\mathrm{f}_i(x_n) = 0$ *and* $\mathrm{f}_i(x_n) > 0$

③ $-1 < \beta < 0$

and for any k *nonnegative numbers* $\gamma_1, \gamma_2, \dots, \gamma_k$ *with* $\sum_{i=1}^{k} \gamma_i = 1$, *there exists* $x_0 \in X$ *such that*

$$\sum_{i=1}^{k} \gamma_i\, \mathrm{f}_i(x_0) \le c.$$

Then the following holds:

$$\underbrace{\inf}_{x \in X} \max_i \mathrm{f}_i(x_n) \le c \text{ and}$$

$$\text{if } F_2 = \beta\, F_1 \text{ then } \lim_{n\to\infty} \mathrm{f}_i(x_n) = 0 \ \text{ otherwise } \lim_{n\to\infty} \mathrm{f}_i(x_n) = \frac{F_2 - \beta\, F_1}{1-\beta} > 0.$$

Proof. The reference was made of the case $k = 4$ above our discussions in this paper. So we shall have a generalized case of k nonnegative numbers.

Theorem 4 *Let X be a nonempty set and let* $\{\mathrm{f}_i(x_1), \mathrm{f}_i(x_2), \dots, \mathrm{f}_i(x_n)\}$ *be a real valued function on X. Let* $I = \{1, 2, \dots, k\}$ *and define a real valued function F on* $X \times I$ *by*

$$F(x_n, i) = \mathrm{f}_i(x_n) \text{ for all } (x, i) \in X \times I.$$

Let $c \in R$ *and suppose that* F *is* $\mathcal{W}-$*linear or linear such that* *satisfied by*

① $\exists\ F_1 = \mathfrak{f}_i(x_1),\ F_2 = \mathfrak{f}_i(x_2) \in X$

② $\mathfrak{f}_i(x_{n+2}) - (1-\alpha)\,\mathfrak{f}_i(x_{n+1}) - \alpha\,\mathfrak{f}_i(x_n) = 0$ *and* $F_n = \mathfrak{f}_i(x_n) > 0$

③ $0 < \alpha < 1$

and for any k *nonnegative numbers* $\gamma_1, \gamma_2, \ldots, \gamma_k$ *with* $\sum_{i=1}^{k} \gamma_i = 1$, *there exists* $x_0 \in X$ *such that*

$$\sum_{i=1}^{k} \gamma_i\,\mathfrak{f}_i(x_0) \le c.$$

Then the following holds:

$$\underbrace{\inf}_{x \in X} \max_i \mathfrak{f}_i(x_n) \le c \text{ and}$$

$$\text{if } F_2 = -\alpha F_1 \text{ then } \lim_{n\to\infty} \mathfrak{f}_i(x_n) = 0 \ \text{ otherwise } \lim_{n\to\infty} \mathfrak{f}_i(x_n) = \frac{F_2 + \alpha F_1}{1+\alpha} > 0.$$

Proof. *Let* $\beta = (-\alpha)$ *in above theorem 3 and we have this theorem 4.*

. . . .

参考資料　22　Pavlov mechanics for playing music appreciated in brain　和文は参考資料 4 を見よ

Pavlov mechanics for playing music appreciated in brain

June 12, 2013

56

Koki KAWAMURA

Hitoshi SAKAIDE

ABSTRUCT

KAWAMURA schema (Ref.1) on playing music appreciated in brain will be solved using Pavlov mechanics model that comes to a conclusion such as identical thesis on being insisted by Sechenov and his scholarly disciple Pavlov that no less response on living individuals, conditioned reflex or inheriting higher nervous activities including cognition than stimulating from the senses inputs or the inner environment is needed.

Brain's inner nervous system being in-completed, it needs for its completeness on putting information from the outer system in order to let the brain learn.

(Ref.1) KAWAMURA schema, Koki KAWAMURA "Playing brain in art" special issue 2012 pp.43 in Japanese

Section1.

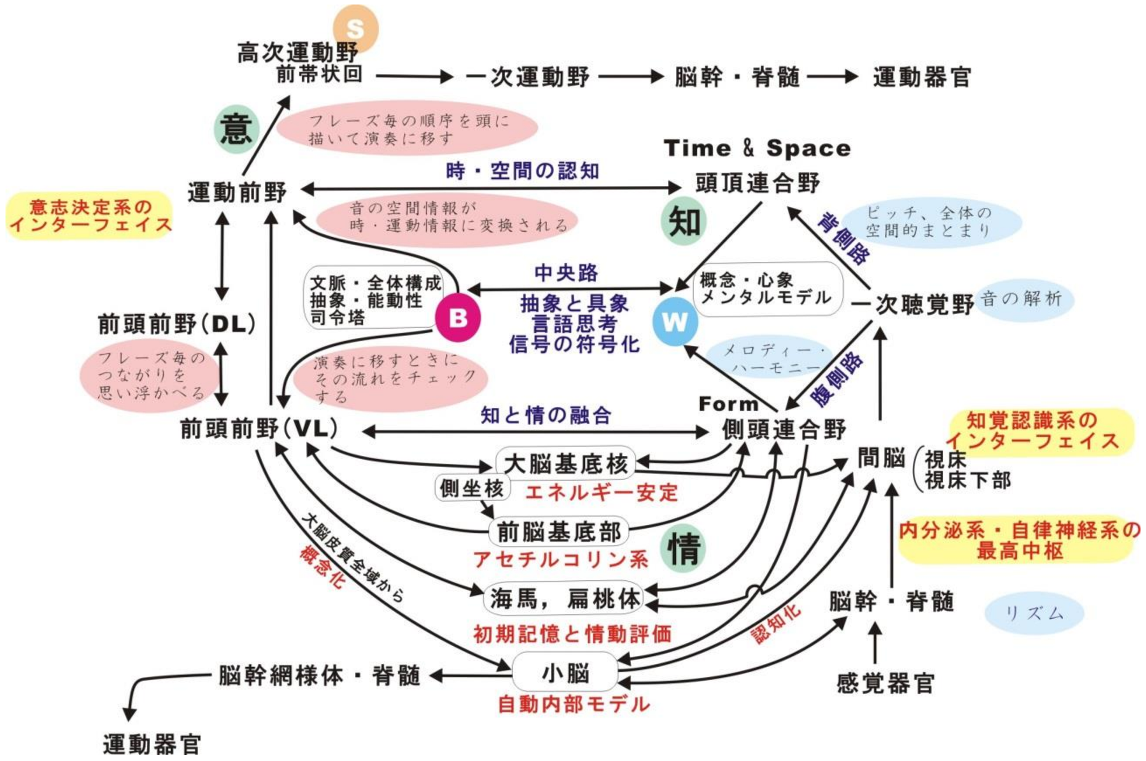


Fig.1 KAWAMURA schema on playing music in appreciated brain 1

We describe the denotation of organ names by symbols with the fallowing Fig2.

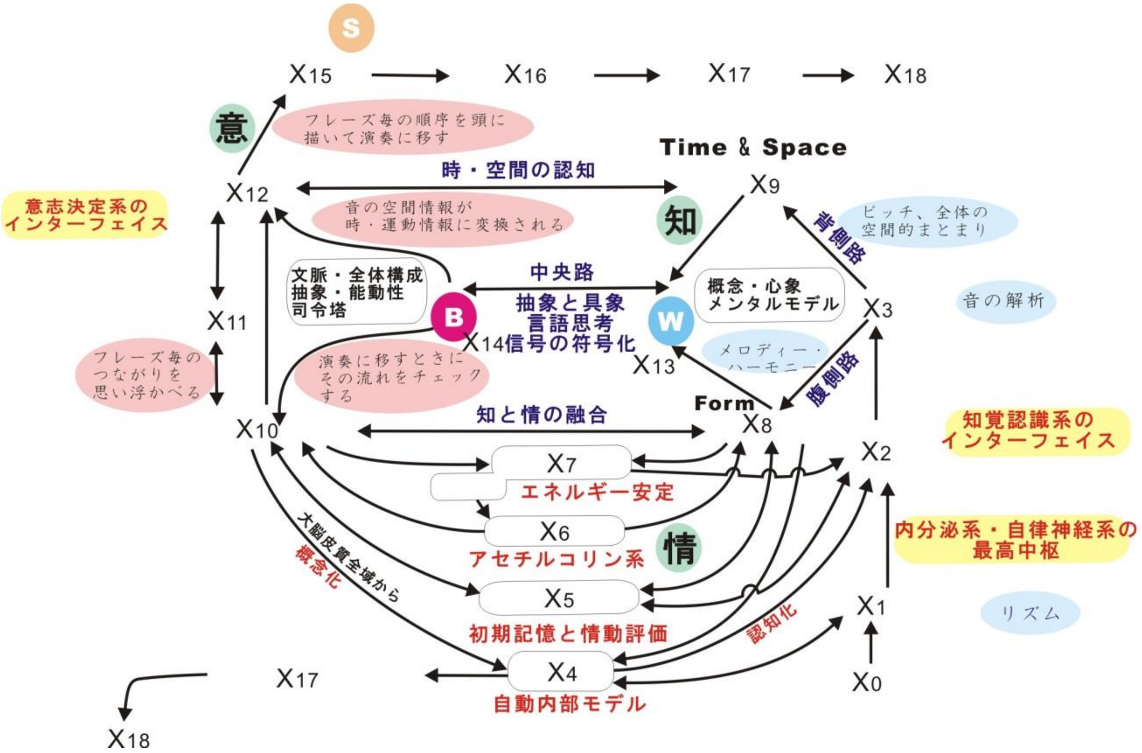


Fig2. KAWAMURA schema on playing music in appreciated brain 2

Sounds, air oscillation received with the sense organ X_0 shall transform into electronic signals in its nervous system.

We perceive the rhythms and the either high or low tone of sounds at the brainstem X_1.

Higher recognition shall be controlled with the level of cerebral cortex.

At the posterior association area, the flow forks off into two directions.

One direction is for sound occupied the Time ＆ Space flow X_9.

The other for sound constructed the Melody ＆ Harmony flow X_8 that contains sound Form through emotional and cognitive systems.

They are two of dorsal and ventral pathways that are focused onto the prefrontal area of both X_{10} and X_{12}.

Thus Geschtalt is made that a forming oneness is recognized with each other as a whole.

Allow the processes go further into the primary motor cortex X_{16} through complicated ones at the higher motor cortex X_{15} that we can say a musical performance in general.

The symbol of → denotes mapping in our figures (Fig.1 and Fig.2) that we consider as primary function. The system of our figures shall be a model of a system of equations.

Two fallowing figures are of Pavlov concepts, following the first Pavlov concept figure.

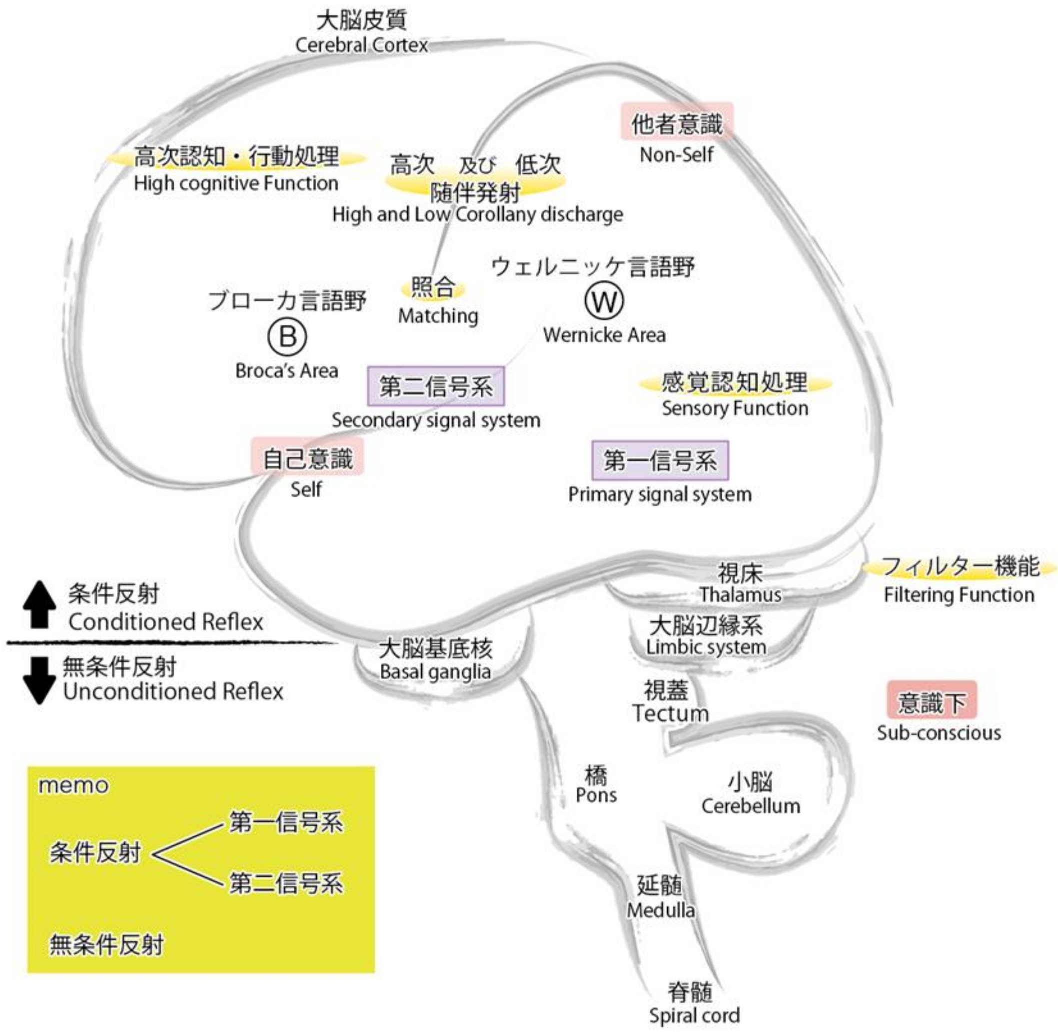
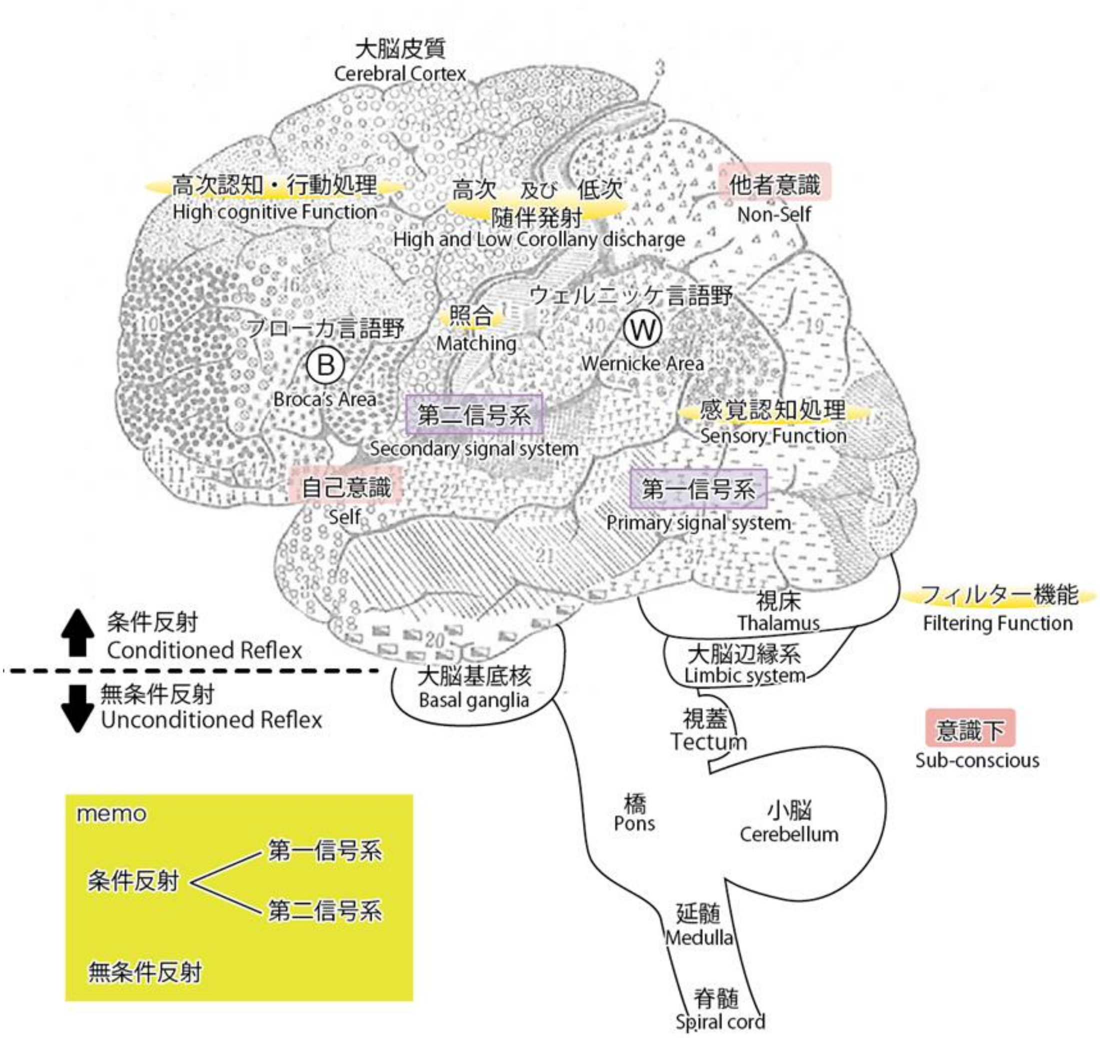


Fig.3 Pavlov concept

The fallowing is illustrated into Brodmann's brain map.



ブロードマンの脳地図　より

Fig.4 Pavlov concept into Brodmann's brain map

Section2.

2-1. Definitions of terms in the Pavlov theory

(1) Conditions shall denote external forces that are added on a (signalling) system.

(2) Conditioned stimuli shall denote the external forces that let sense organs in living creatures stimulate.

(3) Un-conditions shall denote no relations between the living creatures and the environmentally external forces.

(4) Reflexes shall denote nervous activities that are stimulated on living creatures (animals) as individuals.

(5) Conditioned reflexes shall denote such that organic nervous systems on living creatures (animals) as individuals shall response to stimuli of external forces in their environment. The conditioned reflex activities in dogs and other higher animals are held only in their cerebral cortexes. Nervous systems that respond to stimuli of external forces shall be defined as the first signalling system, and hold equilibrium between their inner forces and the external forces. These responses are called the first conditional reflexes.

Linguistic nervous systems acted by these reflexes are called as the second conditioned reflexes. A linguistic base signal generated by this effect re-acts the first conditioned signals. The second conditioned reflexes are called linguistic conditioned reflexes.

(6)Unconditioned reflexes shall denote nervous activities automatically generated in order to sustain life support for living creatures as individuals without the environmentally external forces.

These are defined as the zeroth signalling system or the zeroth nervous activities that shall not be responded to the environmental external forces.

(7)Pavlov theory contains three systems, the zeroth, the first and the second signalling system that are represented unconditioned, the first conditioned, the second conditioned reflexes, respectively.

(8)Since Pavlov theory contains the above three, higher nervous activities than the zeroth in relationships among the three ordinal numbers, 0, 1, 2 implies that the higher nervous activities shall be the first and the second nervous activities in all.

(9)An advanced principle of higher nervous activities shall be a principle that shows such that the signals of the nervous activities are transformed from the first to the second in their signalling systems.

(10)The second signals are called a language generated with the linguistic nervous systems, in that are, Wernicke's area and Broca's area.

(11)We shall classify (animal's) circadian rhythm and homeostasis in a day into four categories during such arousal, hypnosis, shallow sleep and deep sleep for human, specially.

As for awareness, three appropriate categories shall be classified in all, in these are arousal, hypnosis and shallow sleep, and deep sleep in all wherein hypnosis and shallow sleep, deep sleep are presented by NON-REM (non-rapid eye movement) sleep, REM (rapid eye movement) sleep, respectively.

2-2.A mechanics model in a Pavlov theory

(1) The theory has external forces and inner forces.

(2) It has the interaction law of action and reaction.

(3) It has a linguistic conditioned reflex equation equivalent to Newton's equation.

(4) It has an advanced principle on higher nervous activities.

2-3. Mathematical model of the Pavlov mechanics

1. Axiom of choice

We can take one or one by one element from all of sets.

2. General choice function

General choice function is denoted a function that takes elements in the axiom of choice.

3. Specific choice function "＊"

Specific choice function "＊" shall be a function that takes only one element from elements in a set.

For instance, a set consists of seven elements like {0, ƒ, ～, ∨, Π,

(,)} implies such that we can take like “0”…1, “f”…3, “$\sim$”…5, “$\vee$”…7, “Π”…9, “(”…11, “)”…13.

(ref.2) Gödel “On formally undecidable propositions of *Principia mathematica* and related systems Ⅰ” 1931 pp156-157 COLLECTED WORKS Volume Ⅰ OXFORD UNIVERSITY PRESS 1986

4. Ordinal numbers

(1) The object symbol 0 shall be an ordinal number.

(2) The function symbol $*'$ shall represent as successor from $*$.

(3) The choice function “ $*$ ” shall be a function such that we take only one element from all the elements composed of (1) and (2).

(4) We can take “0”=1, “$0'$”=2, “$0''$”=3, “$0'''$”=4,…, “$0'''^{\cdots'}$”=18, wherein the last term shall contains 17 components of $'$.

(5) The object symbol 0 by (1) and 1, 2, 3, …,18 by (4) that makes 19 symbols shall be defined as ordinal numbers herein.

(6) Above these alone shall be ordinal numbers.

5. Index numbers

Symbol n shall represent an index number.

Index number n shall be a variable that represent each index number such that the index numbers are like 0, 1, 2, 3,..., 18.

Above alone shall be index numbers.

6. External forces and internal forces

External forces shall represent the symbol such that $-F$.

Internal forces shall represent the symbol such that $+F$.

A balance between the external forces and the internal forces shall represent such that $F + (-F) = 0$.

(ref.3) Pavlov "20 years objective study in animal's higher nervous activities"

"As a part of nature, one of the living creatures of animals is a complicated system such that there is a balance to be held, at an every certain moment, between his inner forces and the environmental external forces only if he exists as one of living creatures."

7. Elements of sets (on the first signals and the second signals)

The elements $X_0, X_1, X_2, \ldots, X_{18}$ of a set shall represent the first signalling system.

The representation of F as all the elements of a set on the first signalling system implies that F shall be what we call a set-value, namely whole element of the set.

The elements w, b of a set shall represent the second signalling system.

The elements of a set shall be denoted by those that they are not sets.

Above alone shall be elements of a set.

8. The corresponding relationships between the elements of a set and organs of brain

Each element of the set on the first signalling system shall be a variable corresponded by its name of the organs of brain. We show the following table.

The first signalling system in brain			
variable	name of organ		
X_0	sense organ		
X_1	brainstem・spinal cord(upward path, perception system)		
X_2	diencephalon	thalamus	hypothalamus
X_3	primary auditory cortex		
X_4	cerebellum		
X_5	hippocampus	amygdala	
X_6	basal forebrain		
X_7	basal ganglia	nucleus accumbens	
X_8	temporal association area		
X_9	pariental association area		
X_{10}	prefrontal area (VL)		
X_{11}	prefrontal area (DL)		
X_{12}	premotor area		
X_{13}	Wernicke's area		
X_{14}	Broca's area		
X_{15}	higher motor area	anterior cingulate gyrus	
X_{16}	primary motor cortex		
X_{17}	brainstem・spinal cord(downward path、motor system)		
X_{18}	locomotorium(muscle)		

The elements w, b of the second signalling system shall be each variable in Wernicke's area, Broca's area, respectably. We show these in the following table.

The second signalling system			
valiable	function		
w	concept・mental image	mental model	
b	contex・total structure	abstruct・activation	commander

9. Sets (the first signalling system, the second signalling system, Wernicke's area, Broca's area)

The sets of the first signalling system and the second signalling system shall not be empty.

The universal set X= $\{F\} = \{X_0, X_1, X_2, \ldots, X_{18}\}$ shall be a set of the first signalling system.

The singleton set W={$\mathcal{w}$} shall be a set of the second signalling system in Wernicke's area.

The singleton set B={$\mathcal{b}$} shall be a set of the second signalling system in Broca's area.

The singleton set b={X_{14}} shall be a set of the first signalling system in Broca's area.

The universal set L={$\mathcal{w}, \mathcal{b}$} $= \{\mathcal{w}\} \cup \{\mathcal{b}\} = \mathrm{W} \cup \mathrm{B}$ shall be a set of the second signalling system.

Above all of the sets alone shall be X, L, W, B and b={X_{14}}that mean a set of the first signalling system, a set of the second signalling system, a singleton at Wernicke's area by the second conditioned reflexes, a singleton at Broca's area by the second conditioned reflexes and a singleton at Broca's area by the first conditioned reflexes, respectively.

10. A model of a linear system of equations on the inner network for the first conditioned reflexes (the first signalling system)

Model of selfcontained structure for the first signalling system in brain		
	Input system of response signals for the first sygnalling system in brain	
	(Given an inititial value such as unknown = known)	
	0	$X_0=\omega_0$
	Respnse signal transmition system for the first signalling system in brain	
	(Incomplete system such as solve with 18 unknowns and 17 equations)	
	1	$X_1+\alpha_1X_0+\beta_1X_4=\omega_1$
	2	$X_2+\alpha_2X_1+\beta_2X_4+\gamma_2X_5+\delta_2X_7=\omega_2$
	3	$X_3+\alpha_3X_2=\omega_3$
	4	$X_4+\alpha_4X_1+\beta_4X_8+\gamma_4X_{10}=\omega_4$
	5	$X_5+\alpha_5X_2+\beta_5X_8+\gamma_5X_{10}=\omega_5$
	6	$X_6+\alpha_6X_7=\omega_6$
	7	$X_7+\alpha_7X_8+\beta_7X_{10}=\omega_7$
	8	$X_8+\alpha_8X_3+\beta_8X_5+\gamma_8X_6+\delta_8X_{10}=\omega_8$
	9	$X_9+\alpha_9X_3+\beta_9X_{12}=\omega_9$
	10	$X_{10}+\alpha_{10}X_5+\beta_{10}X_6+\gamma_{10}X_8+\delta_{10}X_{11}+\varepsilon_{10}X_{14}=\omega_{10}$
	11	$X_{11}+\alpha_{11}X_{10}+\beta_{11}X_{12}=\omega_{11}$
	12	$X_{12}+\alpha_{12}X_9+\beta_{12}X_{10}+\gamma_{12}X_{11}+\delta_{12}X_{14}=\omega_{12}$
	13	$X_{13}+\alpha_{13}X_8+\beta_{13}X_9+\gamma_{13}X_{14}=\omega_{13}$
	14	$X_{14}+\alpha_{14}X_{13}=\omega_{14}$
	15	$X_{15}+\alpha_{15}X_{12}=\omega_{15}$
	16	$X_{16}+\alpha_{16}X_{15}=\omega_{16}$
	17	$X_{17}+\alpha_{17}X_{16}=\omega_{17}$
	18	$X_{18}+\alpha_{18}X_{17}=\omega_{18}$

We show the fallowing matrix representation as a model of a self-contained structure for the above first signalling equations system in brain.

			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
0	X_0		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		ω_0
1	X_1		α_1	1	0	0	β_1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		ω_1
2	X_2		0	α_2	1	0	β_2	γ_2	0	δ_2	0	0	0	0	0	0	0	0	0	0	0		ω_2
3	X_3		0	0	α_3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		ω_3
4	X_4		0	α_4	0	0	1	0	0	0	β_4	0	γ_4	0	0	0	0	0	0	0	0		ω_4
5	X_5		0	0	α_5	0	0	1	0	0	β_5	0	γ_5	0	0	0	0	0	0	0	0		ω_5
6	X_6		0	0	0	0	0	0	1	α_6	0	0	0	0	0	0	0	0	0	0	0		ω_6
7	X_7		0	0	0	0	0	0	0	1	α_7	0	β_7	0	0	0	0	0	0	0	0		ω_7
8	X_8		0	0	0	α_8	0	β_8	γ_8	0	1	0	δ_8	0	0	0	0	0	0	0	0		ω_8
9	X_9	×	0	0	0	α_9	0	0	0	0	0	1	0	0	β_9	0	0	0	0	0	0	=	ω_9
10	X_{10}		0	0	0	0	0	α_{10}	β_{10}	0	γ_{10}	0	1	δ_{10}	0	0	ε_{10}	0	0	0	0		ω_{10}
11	X_{11}		0	0	0	0	0	0	0	0	0	0	α_{11}	1	β_{11}	0	0	0	0	0	0		ω_{11}
12	X_{12}		0	0	0	0	0	0	0	0	0	α_{12}	β_{12}	γ_{12}	1	0	δ_{12}	0	0	0	0		ω_{12}
13	X_{13}		0	0	0	0	0	0	0	0	α_{13}	β_{13}	0	0	0	1	γ_{13}	0	0	0	0		ω_{13}
14	X_{14}		0	0	0	0	0	0	0	0	0	0	0	0	0	α_{14}	1	0	0	0	0		ω_{14}
15	X_{15}		0	0	0	0	0	0	0	0	0	0	0	0	α_{15}	0	0	1	0	0	0		ω_{15}
16	X_{16}		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	α_{16}	1	0	0		ω_{16}
17	X_{17}		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	α_{17}	1	0		ω_{17}
18	X_{18}		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	α_{18}	1		ω_{18}

Herein, the α, β, γ, δ, ε with index numbers shall be allowed to be proportional constants without 0 and the ω with index numbers shall be allowed proportional constant with 0.

The system of equations are made that the → of Fig.2 shall be assumed as mapping (primary function).

(Examples)

The equation number 3 : $X_3 + \alpha_3 X_2 = \omega_3$ is represented for $X_2 \rightarrow X_3$.

The equation number 1 : $X_1 + \alpha_1 X_0 + \beta_1 X_4 = \omega_1$ is represented for

$$\left.\begin{matrix} X_0 \\ X_4 \end{matrix}\right\} \rightarrow X_1.$$

The remark is that two arrows of the one → from X_0 to X_1 and of the other → from X_4 to X_1 on the Fig. 2 are illustrated.

We will check the structure of this system of equations.

This system of equations consists of two subsystems:

(1) The input system at the number 0, and,

(2) The transmission system from the number 1 to the number 18.

In the case without the environmentally exterior forces, we have not the inner forces because of the interaction law between action and re-action of mechanics that is why the (1) above is not true.

Consequently, we will check a solution of (2) alone.

The system of (2) holds 18 equations and 19 unknown terms such that the equations are short from one equation for gaining the solution.

Thai is, the solution is not gained so that the system of (2) may be called incomplete system.

On the other hand, in the case with environmentally external forces, we have the inner forces because of the interaction law between action and re-action of mechanics that is why there is a balance between them such that the first signalling system works. That is called the first conditioned reflexes.

(ref.4) Pavlov "20 years objective study in animal's higher nervous activities"

"The principal physiology phenomena of the normal effect by cerebral hemisphere are what we call conditioned reflexes. These are temporal connections between the environmentally innumerable factors that act animal receptors and certain effects on the animals"

Herein, that the (1) is true implies that the (2) is true.

Adding a missing equation (1) to the (2) implies that we are able to gain a solution such that we hold the same 19 each equations and unknowns.

Then, the system composed by (1) + (2) is called complete system.

That results that we call a model of the "completeness" gained a self-contained structure model.

Therefore, the first conditioned reflexes make the first signalling system a self-contained structure model.

(Remark) Term of completeness or incompleteness by Gödel means such that a mathematical system is complete or incomplete is equivalent to that the system is decidable or undecidable, respectively.

And more, we will show the fallowing solution by matrix representation.

Herein, let a matrix with 19 rows and 19 columns be M and let a_{ij} component be a_{ij}.

Then we have $M=(a_{ij})$. Moreover, let a component of matrix M be a column vector P_j.

Then we have $P_1=(a_{i1})$.

Next, $\mathrm{Subst}\,A\begin{pmatrix} b \\ a \end{pmatrix}$ shall be defined as function that is substituted b for a in the A.

Let the determinant $|M|=|a_{ij}|$ and let P_j be j-column components of a_{ij}.

Then, $\mathrm{Subst}\,|M|\begin{pmatrix} \omega \\ P_j \end{pmatrix}$ shall be a determinant such that let P_j be ω meaning ω_i in $|M|=|a_{ij}|$.

Hence, the solution of the system of equations results in the notation of

$$X_i=\frac{\mathrm{Subst}\,|M|\begin{pmatrix} \omega \\ P_j \end{pmatrix}}{|M|}.$$

That is a proof figure in the process to gain the solution in case with the initial condition $X_0=\omega_0$.

11. Functions and inverse-functions (meaning act and re-act)

$\mathcal{G}$, $\mathcal{B}$ shall be function symbols such that represent as act from the first signalling system onto the second signalling system.

$*$ shall be function symbol while $*^{-1}$ represents its inverse function.

The $\mathcal{G}^{-1}$, $\mathcal{B}^{-1}$ shall represent as re-act from the second signalling system to the first signalling system.

In addition, the $\mathcal{G}$ shall de defined as Gestalt function while the $\mathcal{G}^{-1}$ shall be a set-valued function.

Above denotations alone are the functions that represent as act and re-act.

12. Mapping (meaning act from the first signalling system to the second signalling system)

The $\mathcal{B}$ conducts in a mapping from a singleton set b={X_{14}} to a singleton set B= $\{\mathscr{b}\}$.

The $\mathscr{b} = \mathcal{B}(X_{14})$ can be written.

The $\mathcal{G}$ conducts in a mapping from a universe set X= $\{F\}$ to a singleton set W= $\{\mathscr{w}\}$.

The $\mathscr{w} = \mathcal{G}(F)$ can be written.

These mappings shall represent as act from the first signalling system to the second signalling system.

13. Inverse mapping (meaning re-act from the second signalling system to the first signalling system)

The $\mathcal{B}^{-1}$ conducts in a mapping from a singleton set B= $\{\mathscr{b}\}$ to a singleton set b={X14}.

The $X_{14} = \mathcal{B}^{-1}(b)$ can be written.

The $\mathcal{G}^{-1}$ conducts in a set- valued mapping from a singleton set W= $\{w\}$ to a universe set X= $\{F\}$.

The $F = \mathcal{G}^{-1}(w)$ can be written.

These inverse mappings shall represent as re-act from the second signalling system onto the first signalling system.

14. The specific choice functions "n" and "F"

The "n" shall be a specific choice function such that we can take only one number from all the $n(n = 0,1,2,\dots,18)$.

Thus, the choice of 14 from $n(n = 0,1,2,\dots,18)$ implies that "n" = 14 can be written.

The "F" shall be a specific choice function such that we can take only one element from all of the inner forces.

We will inform n such that a specific ordinal number should be distinct from a representative of all the ordinal numbers is important.

The former shall be defined as arbitrary specification such that $\exists n(n = 0,1,2,\dots,18)\exists Xn : X$ "n" = "F" .

The latter shall be defined as arbitrary universalization such that $\forall n(n = 0,1,2,\dots,18)\forall Xn : Xn = F$.

Let us assume that $\forall n(n = 0,1,2,\dots,18)\forall Xn$: X "$n$" $= F$ and that we can take X "n" for a certain one of 18 in all n, then F is a universal element, namely, F is equivalent to all the 18 elements.

Hence, we have 1=18. That is contradiction.

Hereinafter, we need a careful distinction.

15. Digestion function $\mathrm{Dig}(a,b)$

We shall define Digestion function $\mathrm{Dig}(a,b)$ as follows.

$$\begin{cases} a=b & \text{implies } \mathrm{Dig}(a,b)=0. \\ a\neq b & \text{implies there does not exist } \mathrm{Dig}(a,b) \end{cases}$$

Above definition alone is a definition of Digestion function $\mathrm{Dig}(a,b)$.

16. KAWAMURA function $\mathrm{K}(14)$ and its variations $\mathrm{K}(14)a$ and $\mathrm{K}(14)b$

We are following Pavlov in searching for modeling of how brain works in mathematics. In the first place, we tried illustrating the Fig. 2 on symbolization of variables by codes of brain organ names. In the second place, we tried giving the three following character types of human in order to adapt with the Fig. 2.

We willingly try to present this conceptive function as follows.

The definition of KAWAMURA function $\mathrm{K}(14)$ is like:

$$\begin{cases} \{\mathrm{K}(14)\}=\{2,3,5,8,9,14\} & \text{a set}-\text{valued function of artist type} \\ \{\mathrm{K}(14)\}=\{13,14\} & \text{a set}-\text{valued function of thiker type} \\ \{\mathrm{K}(14)\}=\{10,11,12,14,15,16\} & \text{a set}-\text{valued function of activist type} \end{cases}$$

$\mathrm{K}(14)a$, $\mathrm{K}(14)b$ shall be the variations of KAWAMURA function.

The index a shall be defined as duration between arousal and sleeping, namely semi-arousal.

The index b shall be defined as duration of NON-REM sleeping, being capable of dreaming.

The definition of KAWAMURA function $\mathrm{K}(14)a$ is like:

$$\begin{cases}\{K(14)a\} = \{2,3,5,8,9,14\}a & \text{a set} - \text{valued function of semi} - \text{arousal artist type}\\ \{K(14)a\} = \{13,14\}a & \text{a set} - \text{valued function ofsemi} - \text{arousal thinker type}\\ \{K(14)a\} = \{10,11,12,14,15,16\}a & \text{a set} - \text{valued function of semi} - \text{arousalactivist type}\end{cases}$$

The definition of KAWAMURA function $K(14)b$ is like:

$$\begin{cases}\{K(14)b\} = \{2,3,5,8,9,14\}b & \text{a set} - \text{valued function of artist type dreaming}\\ \{K(14)b\} = \{13,14\}b & \text{a set} - \text{valued funvtion of thinker type dreaming}\\ \{K(14)b\} = \{10,11,12,14,15,16\}b & \text{a set} - \text{valued function of activist type dreaming}\end{cases}$$

Above defined alone are KAWAMURA function and its variations.

(Remark) Pavlov showed that there are the very three types in general to be classified that are distinct from each of the human nervous systems. One people develop the first signalling system better than the second signalling system (artist type). The others develop the second signalling system better than the first signalling system (thinker type). And more, most of the people play the role of coordinator by themselves and develop the well-balanced inter-relationships between the two systems.

17. Pavlov function $\text{Пав}(14) \stackrel{\text{def}}{=} \text{Пав}\left(\text{“}n\text{”} = 14\right)$

The definitions of Pavlov function $\text{Пав}(14)$ are as follows:

(1) $\text{Пав}(14) = \square(14) = 14$ *during arousal state*

(2) $\text{Пав}(14) = \diamondsuit(14) \fallingdotseq K(14)a$ *during hypnotic state*

(3) $\text{Пав}(14) = \blacklozenge(14) \fallingdotseq K(14)b$ *during shallow sleeping state*

(4) $\text{Пав}(14) = \blacksquare(14) \neq \text{“}n\text{”}$ *during deep sleeping state*

Herein, symbols □,◇,◆, ■ shall be represent arousal, hypnotic, shallow (REM) sleeping, deep (NON-REM) sleeping, respectively. (A dream is dreamed during REM sleeping.)

In addition, one thing that the symbols □, ■ are made of the modal logical symbols in necessity, negative necessity, respectively is there.

Another thing that symbols ◇,◆ are made of the modal logical symbols in possibility, negative possibility, respectively is there.

Above defined alone are cases of the Pavlov function.

(Remark) Shallow sleeping is equivalent to REM sleeping, and deep sleeping NON-REM sleeping.

(Remark) The symbols □,◇,◆, ■ shall be ones of the modal logics that has 4-valued logics.

(1) □(14) shall be 14 in nessecity resulting that it is 14.

(2) ◇(14) shall be 14 in possibility resulting that it is ambiguous 14.

(3) ◆(14) shall be not 14 in possibility resulting that it is ambiguous not 14.

(4) ■(14) shall be not ("n" = 14) in nessecity resulting that it is not 14.

(Remark) The Пав(14) = ◇(14) during hypnotic state has diversity so that it is very important to analyze object survey for schizophrenia or some other a certain type neurosis and psychosis.

All of the symptoms in schizophrenia—indifference, obtundation, immobilization, drollness, and likewise—are found in which of the cases with hypnotic state. From the point of view, Pavlov draws a conclusion. "When studying the symptoms of the schizophrenia above said, we come to a conclusion that these symptoms represent chronic sleeping states." However, we need evidences over experiences agreed with general symptoms.

Use of mathematics in this field will be an advanced study task.

Exampl1. A sixty year old lady said that the very thing I am really a child of thirteen because I have milk teeth.

(Matching impediment between the past and the present)

$$\Pi_{\text{aв}}(14) = \diamondsuit(14) \fallingdotseq K(14)c$$

Herein, $\{K(14)c\} = \{5,14\}$ may be available.

18. Matching function $\text{Mat}(X_{14}) \stackrel{\text{def}}{=} X_{14} + \text{Dig}\left(\Pi_{\text{aв}}(14), \text{“}n\text{”}\right)$

The Matching function $\text{Mat}(X_{14}) \stackrel{\text{def}}{=} X_{14} + \text{Dig}\left(\Pi_{\text{aв}}(14), \text{“}n\text{”}\right)$ conducts that

① $\Pi_{\text{aв}}(14) =$ “n” implies $\text{Dig}\left(\Pi_{\text{aв}}(14), \text{“}n\text{”}\right) = 0$ resulting $M(X_{14}) = X_{14}$, and

② $\Pi_{\text{aв}}(14) \neq$ “n” implies $\text{Dig}\left(\Pi_{\text{aв}}(14), \text{“}n\text{”}\right)$ of false resulting not matching.

Consequently,

The Matching function $\text{Mat}(X_{14}) \stackrel{\text{def}}{=} X_{14} + \text{Dig}\left(\Pi_{\text{aв}}(14), \text{“}n\text{”}\right)$ shall be defined such that we have

$$\begin{cases} \text{Mat}(X_{14}) = X_{14} & \text{implies } X_{\Pi_{\text{aв}}(14)} = X_{\text{“}n\text{”}} = \text{“}F\text{”}, \text{and} \\ \text{Mat}(X_{14}) \neq X_{14} & \text{implies not matching.} \end{cases}$$

Above defined alone are of the Matching function.

Next, we will be able to overview the four stages by substitution of the (11. and 12.) to the above definition.

(1) Arousal $\Pi_{\text{aв}}(14) = \square(14) = 14$

We will gain $\text{Mat}(X_{14}) \stackrel{\text{def}}{=} X_{14} + \text{Dig}\left(\square\,(14), \text{“}n\text{”}\right) = X_{14}$ such that we have $X_{14} = X_{\text{“}n\text{”}} =$ “F” where the matching with the internal force F results in extracting just $14 =$ “n” from the matching data base.

(2) Hypnotic and shallow sleeping $\Pi_{\text{aв}}(14) \fallingdotseq K(14)$

We will gain $\text{Mat}(X_{14}) \stackrel{\text{def}}{=} X_{14} + \text{Dig}\left(K(14), \text{“}n\text{”}\right) = X_{14}$ such that we have $X_{K(14)} = X_{“n”} = “F”$ where there is $K(14)$ of a set-valued including 14 implies that

(a) when it comes to forming $\{ “n” \} = \{2,3,5,8,9,14\}$ we will gain the ambiguous artists matching.

(b) when it comes to forming $\{ “n” \} = \{13,14\}$ we will gain the ambiguous thinkers matching.

(c) when it comes to forming $\{ “n” \} = \{10,11,12,14,15,16\}$ we will gain the ambiguous activists matching.

(3) Deep sleeping $\Pi_{aB}(14) = \blacksquare(14) \neq “n”$

We will gain $\mathrm{Mat}(X_{14}) \overset{\text{def}}{=} X_{14} + \mathrm{Dig}(\blacksquare(14), “n”) \neq X_{14}$ such that we have $X_{\Pi_{aB}(14)} = X_{\blacksquare(14)} \neq X_{“n”} = “F”$ where there is not a matching to exist in this case.

19. Fixed point theorem on the matching function

Let function $f(x)$ be $f(x) = x$ then x is called a fixed point of the function.

(1) Arousal case

Let the matching function be $\mathrm{Mat}(X_{14}) = X_{14} + \mathrm{Dig}(\square(14), “n”)$ such that we gain $\mathrm{Mat}(X_{14}) = X_{14} + \mathrm{Dig}(14, “n”)$ then $14 = “n”$ implies $\mathrm{Mat}(X_{14}) = X_{14}$.

Consequently, $14 = “n”$ implies that we show X_{14} is a fixed point. Therefore, there exists a fixed point theorem for $\mathrm{Mat}(X_{14}) = X_{14}$ to be seen.

(2) Hypnotic case

Let the matching function be $\mathrm{Mat}(X_{14}) = X_{14} + \mathrm{Dig}(\diamondsuit(14), “n”)$ such that we gain the possibility to represent

$\mathrm{Mat}(X_{14}) = X_{14} + \mathrm{Dig}(14, \text{“}n\text{”})$ then the possibility of $14 =$ “n” implies we show the possibility that X_{14} is a fixed point.

Therefore, there is possible of a fix point theorem for the matching function.

(3) Shallow sleeping case

Let the matching function be $\mathrm{Mat}(X_{14}) = X_{14} + \mathrm{Dig}(\blacklozenge(14), \text{“}n\text{”})$ such that we gain the possibility not to represent $\mathrm{Mat}(X_{14}) = X_{14} + \mathrm{Dig}(14, \text{“}n\text{”})$ then the case is the same of the ambiguity with the (2) of the possibility to represent such that we gain the possibility of $14 =$ “n” as the possibility to be $\mathrm{Mat}(X_{14}) = X_{14}$.

Consequently, X_{14} is possible of a fixed point.

Therefore, there is possible of a fix point theorem for the matching function.

(4) Deep sleeping case

Let the matching function be $\mathrm{Mat}(X_{14}) = X_{14} + \mathrm{Dig}(\blacksquare(14), \text{“}n\text{”})$ such that we gain $\blacksquare(14) \neq$ “n” then $\mathrm{Mat}(X_{14}) \neq X_{14}$.

Consequently, this matching function does not hold any fixed point.

Therefore, we do not have any fixed point theory in this case.

20. Self- consciousness

Let the state of absent consciousness be defined as the case of not working matching effects at all then it is equivalent to $\Pi_{\text{ав}}(14) \neq$ “n” instead, namely the same pattern with the deep sleeping case of the 14. (3).

Consequently, we have $\Pi_{AB}(14) \neq$ "n" $\Leftrightarrow$ ■$(14) \neq$ "n" .

In due course have we examined that there is not any fixed point in the state of absent consciousness because of $Mat(X_{14}) \neq X_{14}$ in the above the 19.

However, where there is consciousness even in vegetative state of a human there is some fixed points.

Considering from the viewpoint of the relationships between consciousness and fixed point, $Mat(X_{14}) = X_{14}$ implies the meaning of both being its fixed points and working its matching effects.

Let the matching effects be defined as consciousness effects then $Mat(X_{14}) = X_{14}$ implies the X_{14} in itself will be aware of itself as a matter of course.

The X_{14} places in Broca's area and its recursive relationships shall be defined as self-consciousness.

The fallowing results are made that

(1) Distinct self-consciousness implies arousal case.

(2) Vague and ambiguous self-consciousness implies hypnotic and shallow sleeping case.

(3) Lack of consciousness implies deep sleeping.

(Remark) Herein, we can analyze self- consciousness because that we can find it for its fixed points. However, the consciousness itself will not be able to be analyzed by this nervism alone.

21. Are there fixed points in brain?

That self-consciousness is equivalent to the fixed points for the matching function results in that self-consciousness does exist, vaguely exist, does not exist by the states of circadian rhythm and homeostasis.

Consequently, there are four fallowing aspects:

(1) Arousal case has the existent necessity of fixed points in brain.

(2) Hypnotic case has the existent possibility of fixed points in brain.

(3) Shallow sleeping case has the non-existent possibility of fixed points in brain.

(4) Deep sleeping case has the non-existent necessity of fixed points in brain.

22. Matching equation

Let $F = \mathrm{Mat}(X_{14})$ be matching equation.

The solution of the matching equation shall be "F" $= X_{14}$.

In this solution, there exists fixed point theorem of the 19.

Then, that is with arousal and both hypnotic and shallow sleeping where there is the necessity, possibility, respectively to hold a solution of the matching equation.

That is with deep sleeping where there is not a solution of the equation.

23. A system of linearly primary equations of the second signal system by the second conditioned reflexes

At Wernicke' area Ⓦ and Broca's area Ⓑ situated in the center of the Fig.2 and the Fig.3 we can find as follows:

Ⓑ ⟷ Ⓦ

We shall consider an arrow that has both right and left directions to be seen above as the composition of the → and ← .

Responses of the linguistic nervous system of Wernicke' area Ⓦ and Broca's area Ⓑ acted by the first conditioned reflexes implies that the second conditioned reflexes occur in the w, b second signalling system where we have the two following mappings derived from 12.

$$\begin{cases} b = \mathcal{B}(\mathrm{X}14) \\ w = \mathcal{G}(F) \end{cases}$$

Herein, there are acts from the first signaling system onto the second signaling system in the higher nervous activities.

Then, $b \to w$ implies $w + \eta_1 b = C_1$.

In addition, $w \to b$ implies $b + \eta_2 w = C_2$.

Herein, η_1, η_2, C_1, C_2 are constant.

Let these be the following set of equations.

$$\begin{cases} w + \eta_1 b = C_1 \\ \eta_2 w + b = C_2 \end{cases}$$

The solution is

$w = \frac{C_1 - C_2 \eta_1}{1 - \eta_1 \eta_2}$ and $b = \frac{C_2 - C_1 \eta_2}{1 - \eta_1 \eta_2}$.

Consequently, we gain

$$\frac{w}{b} = \frac{C_1 - C_2 \eta_1}{C_2 - C_1 \eta_2} = \frac{1}{m}.$$

That is transformed to

$$w = \frac{1}{m} b.$$

Therefore, we have the fallowing.

$$\mathcal{G}(F) = \frac{1}{m}\mathscr{b} = \frac{1}{m}\mathcal{B}(X_{14})$$

The two mappings of $\mathcal{G}$ and $\mathcal{B}$ represent as act from the first signaling system onto the second signaling system.

As focus on this equation $\mathcal{G}(F) = \frac{1}{m}\mathscr{b}$, we will take an inverse-function.

That the expression $y = \frac{m}{n}x$ conducts that of $x = \frac{n}{m}y$ will make the inverse-function $y^{-1} = \frac{n}{m}x^{-1}$ such that we have $F = m\mathcal{G}^{-1}(\mathscr{b})$.

This equation $F = m\mathcal{G}^{-1}(\mathscr{b})$ makes F represent a universe of $X_0, X_1, X_2, \dots, X_{18}$ as a whole and the very same equation $F = m\mathcal{G}^{-1}(\mathscr{b})$ shall represent as linguistic conditioned reflex equation. Herein, we call the $\mathcal{G}^{-1}(\mathscr{b})$ in the right side of the equation "linguistic-base signal".

Thus, the equation implies that the linguistic-base signal re-acts the first signaling system.

24. An advanced principle on the higher nervous activities

We will show you a process by which a second signal output equation shall be conducted from the linguistic conditioned reflex equation.

(1) There exists the linguistic conditioned reflex equation $F = m\mathcal{G}^{-1}(\mathscr{b})$ for all external forces.

(2) Then, we gain $F = Xn = m(n)\mathcal{G}^{-1}(\mathscr{b})$ for all external forces.

(3) Let a matching expression $F = \mathrm{Mat}(X_{14})$ substitute to the above equation.

(4) Then, $\mathrm{Mat}(X_{14}) = m(n)\mathcal{G}^{-1}(\mathscr{b})$ is reduced from the matching equation.

(5) The matching equation shall be solved where there is $X14 = \mathrm{Mat}(X14)$ for the fixed point theorem.

(6) Consequently, $X14 = \mathrm{Mat}(X14) = m(14)\mathcal{G}^{-1}(b)$ is resulted.

(7) Thus, we call $X14 = m(14)\mathcal{G}^{-1}(b)$ the second signal output equation that we gain.

(8) And let $X14 = m(14)\mathcal{G}^{-1}(b)$ substitute to it, then $X14 = m(14)\mathcal{G}^{-1}(\mathcal{B}(X14))$ is resulted in the fixed point of selves-consciousness, namely being confirmed $X14 = f(X14)$ in the Broca's area.

(9) An equation of the advanced principle on the higher nervous activities is stated to be reduced to $X14 = \mathrm{Mat}(X14) = m(n)\mathcal{G}^{-1}(b) = F$ or

$\mathcal{B}^{-1}(b) = X14 = \mathrm{Mat}(X14) = m(n)\mathcal{G}^{-1}(b) = F = \mathcal{G}^{-1}(w)$.

By $n = 14$ the equation of n is solved. That is why the second signal output equation is reduced. This equation expresses re-actions by the second conditioned reflexes.

(10) The expression shall hold the necessity to exist during arousal, the possibility to exist during hypnosis, not to exist during shallow sleep and not to exist during deep sleep.

(11) The above all alone are the advanced principle of the higher nervous activities.

(Ref.5) Pavlov abbreviation of the statements at the soviet science academy, 1932

"Herein, an advanced principle on the higher nervous activities (abstraction of a lot of signals in the first signaling system — and at the same time generalization) is held, on the other hand analysis and synthesis on the advanced generalized signals are held…"

25. Set-valued linear algebra

The discussion (on the above 22.) will make us take up the following set-valued linear algebra.

A differential equation $\frac{\mathrm{dy}}{\mathrm{dx}} = -\eta$ is solved to an indefinite integral $y + \eta x = \mathcal{C}$ where there is $\mathcal{C}$ un-decidable.

Let $n = 0,1,2,\dots,18$ and let F be universe of $X_0, X_1, X_2, \dots, X_{18}$ as a whole.

A set of equations $(X_0, X_1, X_2, \dots, X_{18})$ is like

$$\begin{cases} \frac{\mathrm{d}\mathcal{G}(F)}{\mathrm{d}b} = -\eta_1 & \text{resulting in} \quad \mathcal{G}(F) + \eta_1 b = \mathcal{C}_1 \\ \frac{\mathrm{d}b}{\mathrm{d}\mathcal{G}(F)} = -\eta_2 & \text{resulting in} \quad b + \eta_2 \mathcal{G}(F) = \mathcal{C}_2 \end{cases}$$

That implies a set-valued linear algebra.

The above set of equations will be represented as the following linear algebra.

$$\begin{pmatrix} 1 & \eta_1 \\ \eta_2 & 1 \end{pmatrix} \begin{pmatrix} \mathcal{G}(F) \\ b \end{pmatrix} = \begin{pmatrix} \mathcal{C}_1 \\ \mathcal{C}_2 \end{pmatrix}$$

Hereby, let V1= $\begin{pmatrix} 1 \\ \eta_2 \end{pmatrix}$, V2= $\begin{pmatrix} \eta_1 \\ 1 \end{pmatrix}$, K= $\begin{pmatrix} \mathcal{C}_1 \\ \mathcal{C}_2 \end{pmatrix}$ and let A= $\begin{pmatrix} 1 & \eta_1 \\ \eta_2 & 1 \end{pmatrix}$ =(V1 V2).

Then, we gain A= $\begin{pmatrix} 1 & \eta_1 \\ \eta_2 & 1 \end{pmatrix}$ =(V1 V2).

Next, we define $\mathrm{Subst}\,A\begin{pmatrix} b \\ a \end{pmatrix}$ as a substitution function of a to b in A.

This is also a function stated in the following (Ref.6).

(Ref.6) Gödel "On formally undecidable propositions of *Principia mathematica* and related systems I" 1931 pp152-153 COLLECTED WORKS Volume I OXFORD UNIVERSITY PRESS 1986

Thus, we gain the two followings.

Subst $|A| \binom{K}{V1} = \begin{vmatrix} \mathcal{C}_1 & \eta_1 \\ \mathcal{C}_2 & 1 \end{vmatrix} = \mathcal{C}_1 - \mathcal{C}_2\,\eta_1$,

Subst $|A| \binom{K}{V2} = \begin{vmatrix} 1 & \mathcal{C}_1 \\ \eta_2 & \mathcal{C}_2 \end{vmatrix} = \mathcal{C}_2 - \mathcal{C}_1\,\eta_2$.

Consequently, we gain the two followings.

$$\mathcal{G}(F) = \frac{\text{Subst } |A| \binom{K}{V1}}{|A|} = \frac{\begin{vmatrix} \mathcal{C}_1 & \eta_1 \\ \mathcal{C}_2 & 1 \end{vmatrix}}{\begin{vmatrix} 1 & \eta_1 \\ \eta_2 & 1 \end{vmatrix}} = \frac{\mathcal{C}_1 - \mathcal{C}_2\,\eta_1}{1 - \eta_1\eta_2},\quad \mathscr{b} = \frac{\text{Subst } |A| \binom{K}{V2}}{|A|} = \frac{\begin{vmatrix} 1 & \mathcal{C}_1 \\ \eta_2 & \mathcal{C}_2 \end{vmatrix}}{\begin{vmatrix} 1 & \eta_1 \\ \eta_2 & 1 \end{vmatrix}} = \frac{\mathcal{C}_2 - \mathcal{C}_1\,\eta_2}{1 - \eta_1\eta_2}$$

From these we gain

$$\frac{\text{Subst } |A| \binom{K}{V1}}{\mathcal{G}(F)} = |A| = \frac{\text{Subst } |A| \binom{K}{V2}}{\mathscr{b}}$$

Resulting in

$$\mathcal{G}(F) = \frac{\text{Subst } |A| \binom{K}{V1}}{\text{Subst } |A| \binom{K}{V2}}\,\mathscr{b}$$

Hence, we gain the following.

$$\mathcal{G}(F) = \frac{\mathcal{C}_1 - \mathcal{C}_2\,\eta_1}{\mathcal{C}_2 - \mathcal{C}_1\,\eta_2}\,\mathscr{b}$$

From $y = \frac{m}{n}x$ resulting $x = \frac{n}{m}y$ implies $y^{-1} = \frac{n}{m}x^{-1}$ such that we have in general to be stated as

$$F = \left(\frac{\mathcal{C}_2 - \mathcal{C}_1\,\eta_2}{\mathcal{C}_1 - \mathcal{C}_2\,\eta_1}\right)\mathcal{G}^{-1}(\mathscr{b})$$

Herein, let $\left(\frac{c_2-c_1\eta_2}{c_1-c_2\eta_1}\right)$ be written as m, then we gain $F=m\mathcal{G}^{-1}(b)$.

The F in the equation $F=m\mathcal{G}^{-1}(b)$ shall represent as universe of $X_0, X_1, X_2, \ldots, X_{18}$ as a whole. The equation $F=m\mathcal{G}^{-1}(b)$ shall be linguistic conditioned reflex equation.

The $\mathcal{G}^{-1}(b)$ on the right side of the equation is named linguistic-base signal by 22.

Section3.

Why $\mathcal{G}^{-1}(b)$ is named linguistic-base signal?

How is the linguistic-base signal $\mathcal{G}^{-1}(b)$ in the second signaling system produced in social community life?

We wonder if our language generates for social life such that we communicate with each other using primitive one of gesture, sign, signal voice for necessity of reproductive behavior, hunting or farming, namely corporative labour and elaborate one of abstract higher signal form.

We will show you the following example in order to study.

Let the second signal b be a specific linguistic formula “taking a good wife” Y, then the social linguistic-base signal $\mathcal{G}^{-1}(\mathrm{Y})$ is discussed.

“Snow Country” by YASUNARI KAWABATA, Japanese novel prize awarder (Ref.3) includes that a good piece of Chijimi linen comes to forming a “taking a good wife”, where there is OJIYA Chijimi in the book “Snow Country Tales” by Suzuki Bokushi.

For each piece of Chijimi weaving in the market there is a paper tag written by weaver's name and address. The piece of Chijimi is appraised.

"With prizes awarded for the best pieces of weaving, it came also to be sort of competition for husbands." (Ref.7) YASUNARI KAWABATA "Snow Country"

Let Xn to be the appraisal quality of the n-th piece of Chijimi with paper tag in weaver's name and address.

(The appraisal quality shall represent as real number order.)

Let Y to be preference for taking a wife or competition for husbands.

(The preference shall represent as real number order.)

Let $\mathcal{G}(\mathrm{X}n)$ to be represented by Geschtalt function in the Snow Country community.

A cognition model of the community shall be made by substitution of $\mathscr{b}$ in the second signaling system in brain to Y in the community.

$$\begin{cases} \mathcal{G}(\mathrm{X}n) + \eta_1 \mathrm{Y} = \kappa_{1n} \cdots \text{①} \\ \mathrm{Y} + \eta_2 \mathcal{G}(\mathrm{X}n) = \kappa_{2n} \cdots \text{②} \end{cases}$$

The equation ① that represents Y→$\mathcal{G}(\mathrm{X}n)$ at the standing point of woman shows a desire to be better competition for husbands in spite of worse quality of Chijimi product.

The equation ② that represents $\mathcal{G}(\mathrm{X}n)$→Y at the standing point of man shows a desire to be better appraisal quality for taking a more beautiful and good wife.

This set of equations is solved such that we gain $\mathrm{X}n = m(n)\mathcal{G}^{-1}(\mathrm{Y})$ for all n as is concerned at the (23. and 25.) of section 2.

From this solution, the left side of expression, namely quality of Chijimi, is a product that real number m multiplied by the social linguistic-base signal $\mathcal{G}^{-1}(\mathrm{Y})$ on the right side of expression, namely preference order on real number line.

Hence, the quality of Chijimi is a form of representation by the linguistic-base signal for taking a good wife.

(Remark) In addition,

Section4.

. . . .

Section 6 運動： 随意運動、自動運動、能動性、大脳、大脳基底核、小脳

5-4.大脳皮質→大脳基底核→視床→大脳皮質の再帰的サーキット

我々は、この再帰的サーキット問題の解決において随伴発射を考察するであろう。

この大事な問題は、別稿で考察するであろう。

・・・・・・

以下に

参考資料 6a Cortex—Basal ganglia—Thalamus

として

Ⅰ．Motor system loop (pink, yellow)、Ⅱ．Association system Loop (blue)、Ⅲ．Limbic system loop (green) についての概略を記述しておくこととする。（Figures の重複あり）

A diagram showing basic relation between the cerebral cortex, thalamus and cerebrum --

Ⅰ. Motor system loop

1） Sensory-motor loop

sensorimotor area→putamen→external(e) and inner(i) segments of globus pallidus(GP)→ VLo →motor cortex

2） SMA-proper loop

supplementary motor area (proper) →putamen→ medial part of GPe/GPi → medial part of VLo → SMA-proper

3） pre-SMA loop

pre- Supplementary motor area →latera; part of caudate nucleus→ middle part of GPe/Gpi→ lateral part of VApc→ pre-SMA

4） PM loop

premotor →lateral part of CN→ dorsomedial part of GPe/GPi→ medial part of VApc→ PM

5） Eye movement loop

Frontaleye field／supplementary frontal eye field→central part of CN→pars reticularis of s, nigra→ VAmc,MDpl →frontal eye field

Ⅱ. Association system loop

Frontal and parietal association cortical areas→large parts of CN and anterior part of putamen→ substantia nigra and GPe/GPi → MDpc and part of VAmc →association areas

Ⅲ. Limbic system loop

Limbic cortex/amygdala・hippocampus→ventral striatum→ventral pallidum→ medial part of MDmc→limbic cortex

基底核と大脳皮質との間の並列的神経回路。大別して、①運動系、②連合系、③辺縁系のループがある。(川村、2007a 改変; Alexander ら, 1986、参照)

Circuit loop ： Cortex → Striatum → thalamus → Cortex

大脳皮質－基底核－視床－大脳皮質のループ

Ⅰ. 運動系ループ

1）運動感覚系ループ

知覚運動野→被殻→淡蒼球外節／内節→ VLo →運動野

2）固有補足運動野(SMA-proper) 系ループ

SMA-proper →被殻→ GPe/GPi の中間部→ VLo 内側部→ SMA-proper

3）前補足運動野(pre-SMA) 系ループ

pre-SMA →尾状核(CN) の外側部→ GPe/Gpi の中間部→ VApc の外側部→ pre-SMA

4）運動前野(PM) 系ループ

PM → CN の外側部→ GPe/GPi の背内側部→ VApc の内側部→ PM

5）眼球運動系ループ

前頭眼野／補足前野眼野→ CN の中央部→黒質網様部→ VAmc,MDpl →前頭眼野／補足前野眼

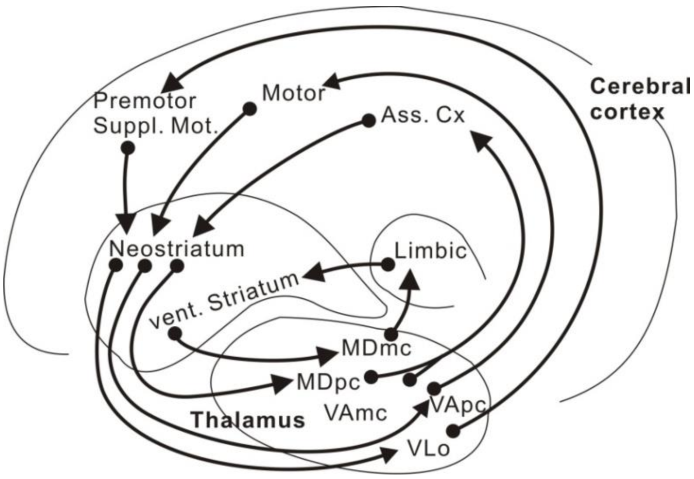
野

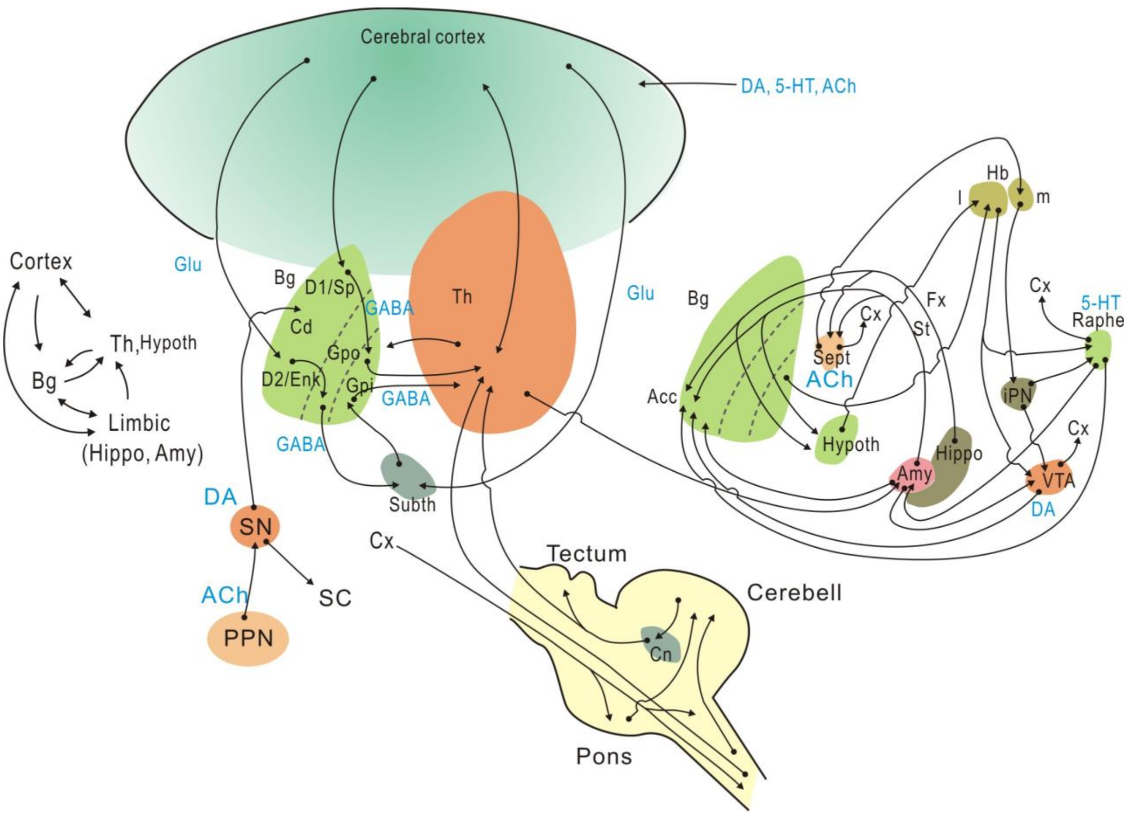
Ⅱ．連合系ループ

前頭連合野／頭頂連合野→ CN の大部分と被殻の前部→ SNr および GPe/GPi → MDpc と一部 VAmc →連合野

Ⅲ．辺縁系ループ

辺縁皮質・扁桃体・海馬→腹側線条体→腹側淡蒼球→ MDmc 内側部→辺縁皮質





主な略号：

DA：Dopamine、5-HT：Serotonin、Ach：Acetylcholine、 Glu：グルタミン酸、

GABA：ギャバ、 Acc:側坐核、Amy： 扁桃体、Bg：大脳基底核、Cx：大脳皮質、

Hippo：海馬、Hypoth：視床下部、PPN：脚橋被蓋核， Raphe：縫線核，SC：上丘、 Sept：中隔核、SN：黒質、Subth：視床下核、Th：視床、VTA：腹側被蓋野

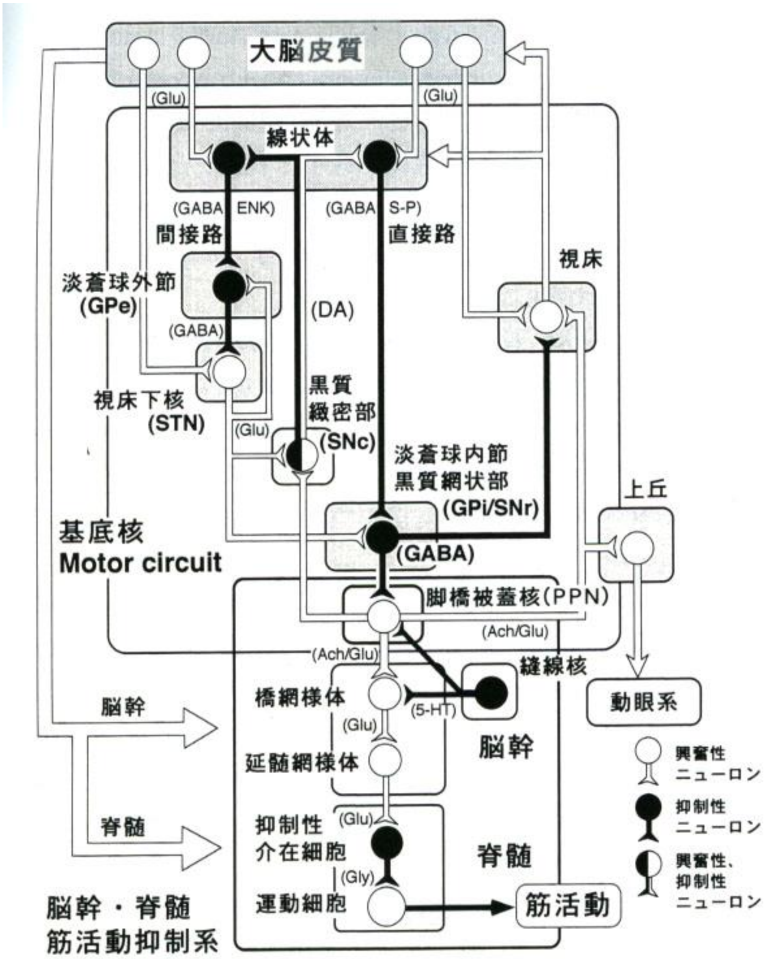
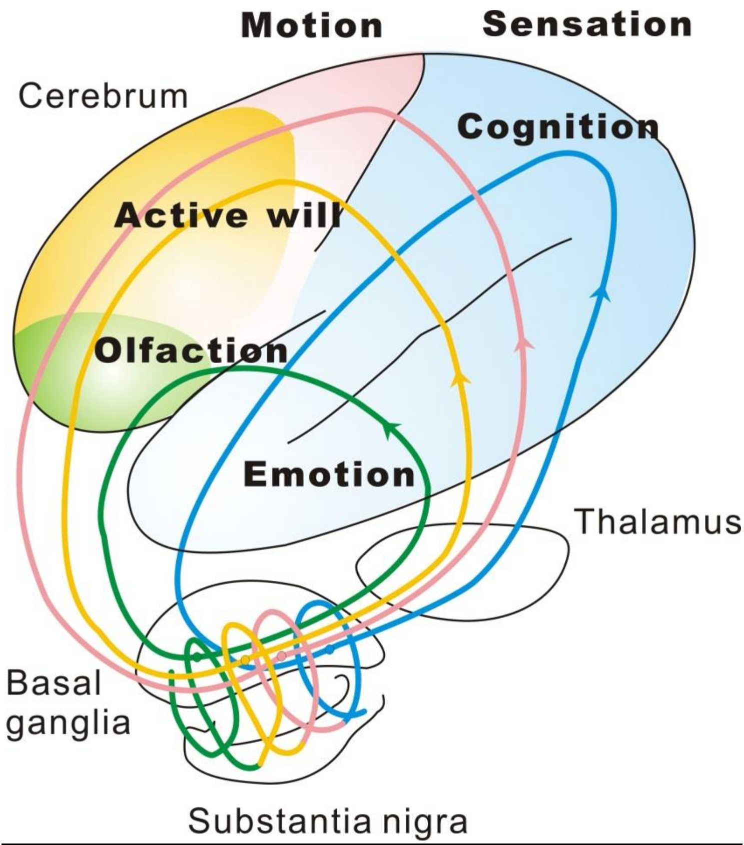


図 6　基底核の Motor circuit と筋活動の制御に関する仮説モデル

詳細は本文参照。Glu；グルタミン酸，GABA；ガンマアミノ酪酸，ENK；エンケファリン，S-P；サブスタンス-P, DA；ドーパミン, 5-HT；セロトニン，Gly；グリシン。



Ⅰ． Motor system loop (pink, yellow)

Ⅱ． Association system Loop (blue)

Ⅲ． Limbic system loop (green)

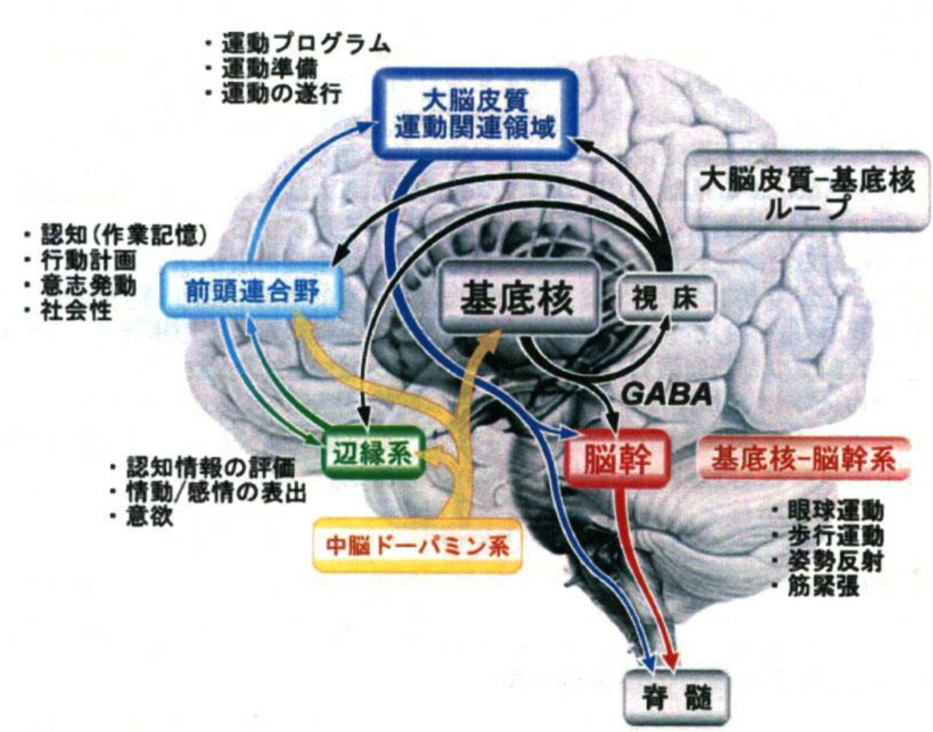


図 10. 基底核機能のまとめ．詳細は本文参照．

1） Alexander, G.E., DeLong, M.R., and Strick, P.L.
Parallel organization of functionally segregated circuits linking basal ganglia and cortex, Annu. Rev. Neurosci. 9(1986) 357-381.

12） Hikosaka, O., Nakahara, H., Rand M.K., Sakai, K., Lu, X., Nakamura, K., Miyachi, S., and Doya, K.

Parallel neural networks for learning sequential procedures, Trends Neurosci. 10 (1999) 464-471.

23） Miyachi,S., Hikosaka, O., Miyashita, K., Karadi, Z., and Rand, M.K.
Differential roles of monkey striatum in learning of sequential hand movement, Exp. Brain Res. 115 (1997) 1-5.

24） 中村加枝
大脳皮質－基底核関連と情報統合－手続き記憶と閉回路システムによる‘Executive function’、 Brain Medical 13 (2001) 343-352.

・・・・・・・・・・・・・・・・・・・・・・

上と図版の重複があるが、数学的モデルを下に挿入する

参考資料 15　Model of the functional brain・・・川村サーキット Circuit　(坂出記)

We are going to arrange the followings. 100719

A round trip model

cerebral cortex(G_1), basal ganglia(G_2), thalamus(G_3) を回る neural curcuit の図、

091211 付け

We define F(x)=x as fixed point.

Let Ｆ be（Ｆ4Ｆ3Ｆ2Ｆ1）,and then we can think of the following equation F4(F3(F2(F1(x))))=x as F(x)=x .

Suppose the 4 dimensions in Hilbert space, and we will be able to illustrate a 2 axis in order to draw x and y axis that makes y＝ｆ（ｘ）or, ｍ〈ｙ｜＝n ｜ｘ〉 that may make a sense of 〈ｙ｜ｘ〉＝ 0 used by Bra and Ket Vectors in Dirak's Quantum mechanics.

A remark will be made that we do not know if F shall constitute an inner product, but an assumption such that the mappings satisfy

Baillon's nonlinear ergodic theorem by which we shall try to apply later on is one thing and the assumption such that the mappings attribute with inner products is another.

There are 4 vectors; **a**,**b**,**c** and **d** such that responded 4 mappings :

a→**b**→**c**→**d**→**a** come to composing a round trip

A three circuit model

We denote three circuits G1, G2 and G3 by cerebral cortex, basal ganglia and thalamic nuclei, respectively, and x, y, z and w by emotion/olfaction, cognition, motion, active will, respectively as well such that

G1 = (x1, y1, z1, w1) ….. cerebral cortex,

G2 = (x2, y2, z2, w2) ….. basal ganglia

G3 = (x3, y3, z3, w3) …… thalamic nuclei.

Thus, we can show the fallowing image such that

Ｇ1—Ｆ1—Ｇ2

Ｇ2—Ｆ2—Ｇ3

Ｇ3—Ｆ3—Ｇ1.

Presentation of Bra and Ket vector by Dirak’s quantum mechanics

We can show the following equations concerning the three circuit model using the bra and ket vector such that

$F1 = F3\ (F2\ (F1)) = \langle G1, G2\rangle = x1x2+y1y2+z1z2+w1w2$

$F2 = F1\ (F3\ (F2)) = \langle G2, G3\rangle = x2x3+y2y3+z2z3+w2w3$

$F3 = F2\ (F1\ (F3)) = \langle G3, G1\rangle = x3x1+y3y1+z3z1+w3w1$

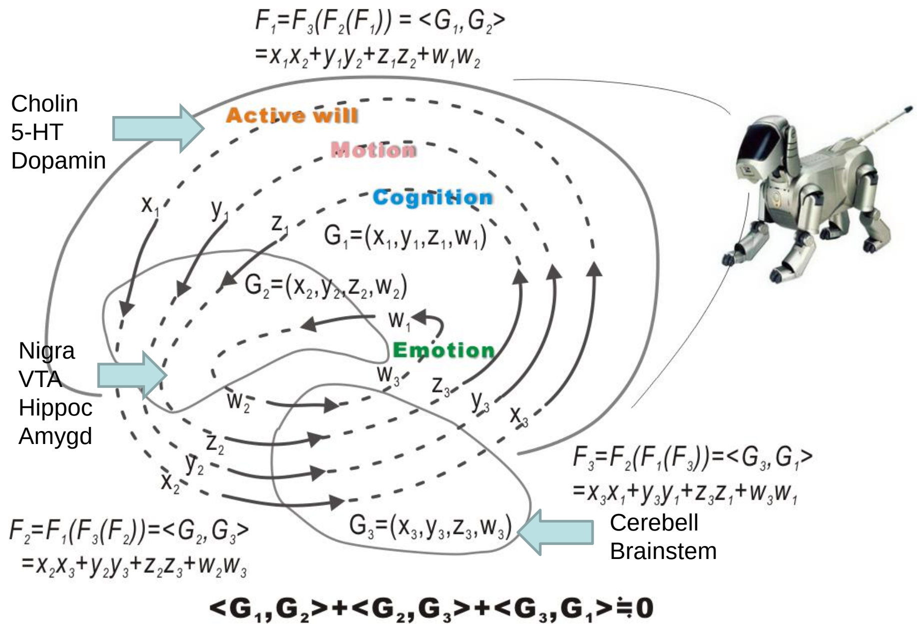
$\langle G1, G2 \rangle + \langle G2, G3 \rangle + \langle G3, G1 \rangle = 0.$

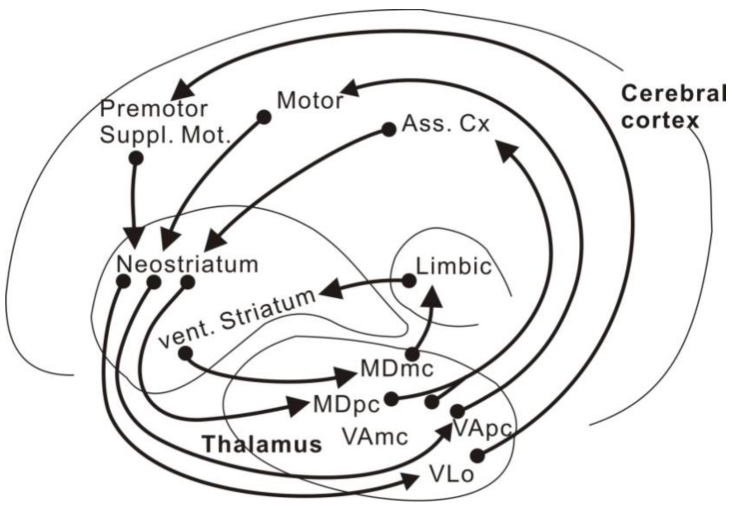
If you take Bra Vector for $\langle f| = e^{-ix} = \cos x - i \sin x$ and Ket vector for $|f\rangle = e^{ix} = \cos x + i \sin x$, you can easily get the inner product such that $\langle f|f\rangle \equiv \langle f, f\rangle = \cos^2 x - i^2 \sin^2 x = \cos^2 x + \sin^2 x = 1$ that is a real number.

A remark is made that $\langle \alpha | \beta \rangle$ is different from $|\beta\rangle\langle \alpha|$ by applying greater than 1 dimension (reference is made to **REF1** in the next page).

We can say the case with the inner product being 0 as orthogonal that is why we take up Hilbert space.

The illustrations are shown like these.





REF1

$< \quad \alpha \mid = \ (a,b)$,

$|$ $\begin{bmatrix} & \\ & \end{bmatrix}$ c

d $\quad \beta >=$

○ $\langle \alpha \mid \beta \rangle = ac + bd$

○ $\mid \beta \rangle\langle \alpha \mid = \begin{pmatrix} c \\ d \end{pmatrix} (a,b) = \begin{pmatrix} ca & cb \\ da & db \end{pmatrix}$

The later two illustrations that are made by Dr. Kawamura shall be applied with mathematical models.

An analogy of the circular formula of reproduction in Marx's "Das Capital" for the three circuit model will conduct to Baillon's Non-linear Ergodic theorem.

The Marx's formula G — W — G would be of interest. Substitute W for F and we have in a round trip way such that

G1—F1—G2

G2—F2—G3

G3—F3—G1.

That is like Dr. Kawamura's illustrations. That is amazing.

F1+F2+F3=0 ・・・①

implies Marx's turn over G—G with ⊿G=0 (no profit).

F1+F2+F3≠0 ・・・②

implies Marx's turn over G—G with ⊿G≠0 (some profit).

In case with ① F1+F2+F3=0, let the average (mean)of G1, G2 and G3, then the index number shall be recursive with each three-time numbers. Thus, we have

M3=1/3 (G1+G2+G3) =1/3 (G1+F1G1+F2F1G1)

M6=1/6 (G1+G2+G3+G4+G5+G6)

=1/6 (G1+G2+G3+G1+G2+G3)

=1/3 (G1+G2+G3) =M3.

Therefore, we have M3n =M3 where there is a fixed point concerning 3n, however Gn does not converge to G when n is infinity owing to a round trip concerning Gn .

In case with ② F1+F2+F3≠0, suppose F be F1=F2=F3=T, then we have F2F1=T^2 that make the above case applied by Baillon's Non-linear Ergodic theorem with taking x for G according to G1=G、G2=TG、G3=T^2G、G4=T^3G (that is a turn-over of G1) .That is why we have

$MnG = 1/n\ (G + TG + T^2 G + \cdots)$.

That is seems to us as $MnX = 1/n(x + Tx + T^2x + \cdots T^{n-1}x) \in C$ that has weak convergence deducted by the theorem and that has fixed point set of mapping T (namely F). The mapping shall be a non-expansive one of a non-empty closed convex subset C into itself of Hilbert space.

The theorem is apparently shown in Wataru Takahashi's textbook, where we substitute M for S, such as

$MnX = 1/n(x + Tx + T^2x + \cdots T^{n-1}x) \in C$

$n \to \infty$、$MnX = 1/n \Sigma k=0 \sim n-1\ T^k x$ weakly convergent, ・・・・・

when

$T \to F$、

$MnG = 1/n\ (G_1 + G_2 + G_3 + \cdots + Gn)$ +++=x

$= 1/n\ (G_1 + F_1G_1 + F_2G_2 + F_3G_3 + \cdots + F_{n-1}G_{n-1})$,

$\because\ F_2G_2 = F_2 F_1G_1 = F_1^2 G_1,\ F_3G_3 = F_3 F_2 F_1 G_1 = F_1^3 G_1,$ ・・・・・

$= G_1 /n\ (1 + F_1 + F_1^2 + F_1^3 + \cdots + F_1^{n-1}) \in C.$

$MnG = 1/n \Sigma GF^k x, (k=0 \sim n-1)$ or

$= G/n \Sigma F^k x, (k=0 \sim n-1)$

covergent weekly and have a fixed point.

conclusion

That may be to say that we have an equilibrium point in our brain.

このとき４次元空間（ヒルベルト空間の４次元）で考えれば、４個の次元から２個の次元を取り出して、

ｘ軸とｙ軸とすれば、ｙ＝ｆ（ｘ）とかけます。

（これを　ｍ〈ｙ｜＝ｎ　｜ｘ〉とディラック量子力学のブラベクトルとケットベクトルで書いた方程式にしただけです。）

4 個がａｂｃｄなら、図で一回りするので、a→b→c→d→a と写像が４個あります。

・・・・・・・・・・・・・・・・・・・・・・・・・・・・

1）　は、具体的にＦが内積かどうか不明であるが、エルゴード定理が成り立つような写像（mapping）を仮定するのと、Ｆが内積(inner product)であるかどうかを仮定することとの因果関係は、特にない。

Ｇ1―Ｆ1―Ｇ2　;Ｇ2―Ｆ2―Ｇ3　；Ｇ3―Ｆ3―Ｇ1

x：emotion/olfaction

y：cognition

z：motion

w：active will

・・・・・・・・・・・・・・・・・・・・

波動関数(wave function ?) ; 無限次元空間(infinite space dimension)を考える。量子力学(quantum mechanics)、超関数(distribution and hyperfunction)、Heaviside 関数(Heaviside function)

Bra Vector　＜f｜＝ e^{-ix} = cos x － i sin x

Ket Vector　 ｜f＞＝ e^{ix} = cos x + i sin x

内積をとると＜f｜f＞≡＜f, f＞= $\cos^2 x - i^2 \sin^2 x = \cos^2 x + \sin^2 x = 1$(実数 R となる)

In case　＝０　だと、直交系(orthogonal)となる。Hilbert space として内積が使える。直交で表せる。Banach sp.では内積がない。

………………………………………………………………

大脳基底核のはたらき—古くて新しい視点

以上の考察からも明らかなように、大脳基底核は、大脳新皮質、大脳辺縁系、中脳ドーパミン系との密接な結びつきから考えて、認知、運動（能動的活動）、意欲、情動などの「精神機能」を統合する上で重要な位置を占めるにもかかわらず、なお未開拓の研究分野である。大脳基底核の背側部は黒質線条体（A9）系の主な標的部位として感覚運動機能に関係し、他方、腹側部は中脳辺縁ドーパミン（A10）系の主な標的部位として海馬や扁桃体、さらに視床下部と共に辺縁系の中核を成していると以前からみなされてきた。

なお、線条体入力軸索終末には少なくとも大脳皮質由来のグルタミン酸作動性（その受容体はNMDAタイプで、樹状突起棘/スパインの頭部にある）のものと黒質由来のドーパミン作動性（その受容体はD1, D2 グループで、樹状突起棘/スパインの頚部にある）のものがある。

これらの入力を受けてGABA 作動性の抑制性投射ニューロンが視床ニューロンおよび大脳基底核あるいは前脳内側基底部の細胞群(マイネルト基底核 nucleus basalis of Meynert、ブローカの対角帯 diagonal band of Broca、無名質 substantia innominataなど)内のコリン作動性ニューロンに神経終末を与えている。そして、これらの視床ニューロンおよび大脳基底核ニューロンは、ともに広く大脳皮質に興奮性の出力を与えており、フィードバック的に大脳皮質の働きを制御している。

さらに一言すると、抗精神病薬(クロルプロマジンやハロペリドール)の作用点(伝達物質の受容体)や疾患モデル動物を用いた薬物作用機序の研究の結果も考慮されて、統合失調症における情動処理障害仮説—視床フィルター機能不全仮説(thalamic filter hypothesis)—が カールソンらによって提唱されて久しい[Carlsson and Carlsson , 1988] 。この仮説には、現在の神経科学の進歩の上に立って再検討されるべき点も多いが、大脳皮質－大脳基底核－視床－大脳皮質という「再帰性」神経回路(網)のなかで情報統合処理が障害されるとして、16年も前に統合失調症障害を見据えた点は注目に値する。

現在われわれは、大脳基底核をめぐる回路網をベースにした機能形態学や認知パタン形成についての優れた総説 [たとえば、Parent and Hazrati, 1995a,b ; Graybiel, 1997; Mink, 1999; Hikosaka et al., 1999, 2000] に接することができる。これに関連する注目すべき最近の知見としては、大脳(新)皮質から直接投射をうける尾状核と被殻(同質の構造体で両者はまとめて新線条体と呼ばれる)から入力をうける淡蒼球(外節と内節とに区分される)からは、視床の運動核(VA/VL)へ投射がある他に髄板内核群や視床網様核(両者とも新線条体にフィードバック様に投射して閉回路を作っている)にも投射がなされている点であろう。とくにこの視床網様核は上行性網様体賦活系(ascending reticular activating system, Moruzzi and Magoun, 1949)の間脳における中継核に相当し、視床から大脳皮質に広汎な覚醒刺激が送られる際に抑制過程として関与すると言われている [Masson et al., 2002] 。

大脳基底核の機能をより簡明に解釈すれば、以下のようになろう。すなわち、運動系に

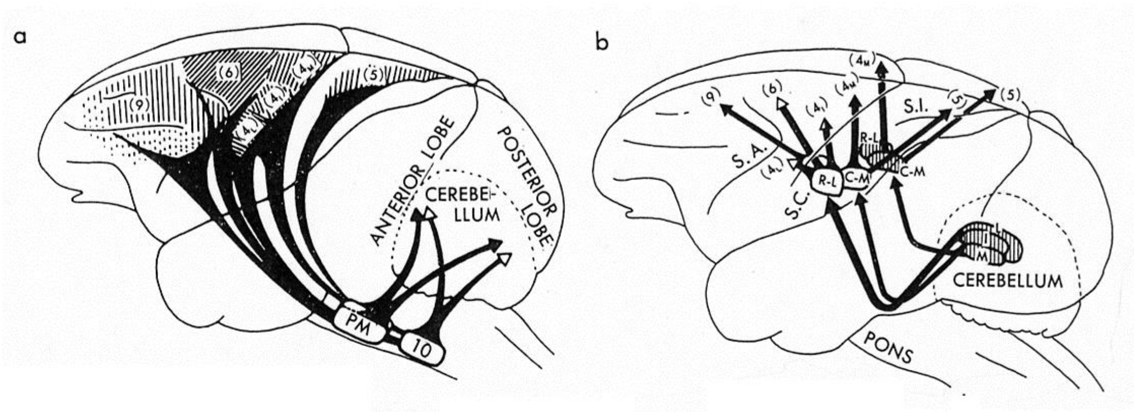
おいても、知覚系においても、さらには認識・情動系においても、体外および体内からの刺激による過剰で不適切な入力を阻止し、コントロールして適正な覚醒状態を保ち、新皮質とくに能動性機能の場である前頭葉を活性化させることによって、霊長類とくにヒトが日々の行動、生活において注意を集中することに大きく関与するものと思われる。この情報入力に対する抑制機能ないしフィルター機能が傷害されると、雑多な情報を適切に選択することができなくなり、過剰な感覚刺激を処理できず、その結果として能動機能が低下し、思路は乱れて、奇妙な思考形態をとることにもなる。今後、統合失調症の病態の解析を目指す、新たな視点を据えた研究が望まれる。

。。。。。。。。。。。。。。。。。。。。。。。。。。。

小脳

参考資料　24　小脳関連事象

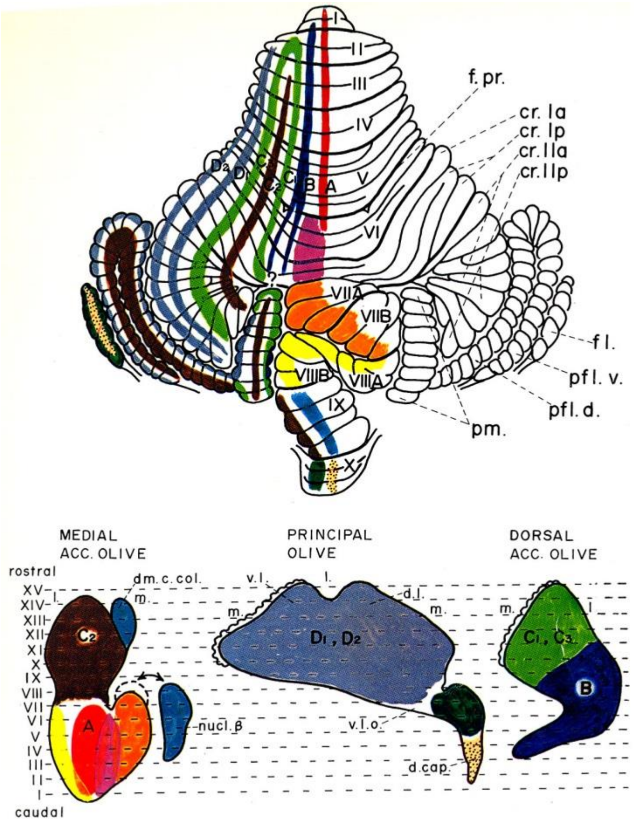
大脳・小脳　ループ　　自動性　　運動と思考



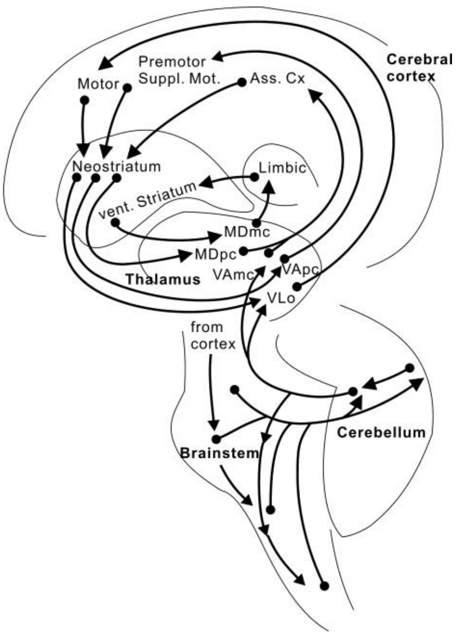
Organization of the cortical association areas and mutual correlations between the cerebrum and the cerebellum

The cortical association areas develop as the animal becomes higher, expanding in areas and relative proportional areas within the cortex increase. From the entire cerebral cortex, including the sensory, motor and association areas there are large projections , via the pontine nuclei and the inferior olive among others, to the almost entire parts of the cerebellar cortex.

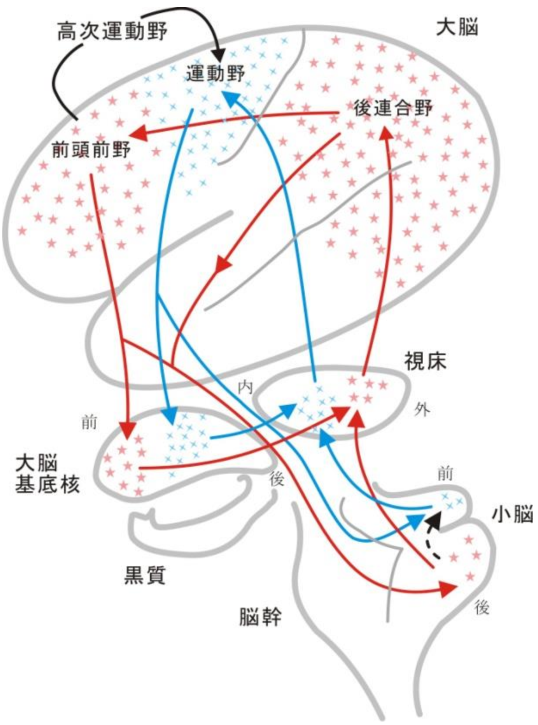
by means of projections of mossy and climbing fibers. Topographic correlations of the mossy (4, 5, 17) as well as the climbing (3, 9, 10, 16) fibers have been studied in fair details(Figs. 4&5). There are also topographic relationships in the projection from the cerebellar cortex, via the thalamic nuclei, to the cerebral cortex. As concerns the reciprocal (mutual correlations) connections between the large and small brains, as they are commonly called, it is elucidated by Sasaki (28) and his collaborators that 1) the lateral region of the cerebellum is related to the prefrontal, the premotor and the lateral part of the motor area, while 2) the intermediate region is related to the entire parts (particularly in the intermediate area) of the cerebral cortex (sasaki, ref. 28).



I
II
III
IV
V
VI
VIIA
VIIB
VIIIB
VIIIA
IX
X
D2
D1
C3
C1
C2
B
A
f. pr.
cr. Ia
cr. Ip
cr. IIa
cr. IIp
fl.
pfl. v.
pfl. d.
pm.
MEDIAL ACC. OLIVE
PRINCIPAL OLIVE
DORSAL ACC. OLIVE
rostral
caudal
dm.c.col.
nucl. β
v.l.
l.
d.l.
m.
D1, D2
v.l.o.
d.cap.
C1, C3



Premotor
Suppl. Mot.
Motor
Ass. Cx
Cerebral cortex
Neostriatum
Limbic
vent. Striatum
MDmc
MDpc
VAmc
VApc
VLo
Thalamus
from cortex
Brainstem
Cerebellum



In Cerebellum new info and old info. Changes the route
Conversion of neural circuit from the cognitive to motor co-ordinate axis (stream of impulses).
Routes of new/novel stimuli (shown in red) travel from the posterior lobe of the cerebellum→thalamic lateral nucleus →posterior association area→prefrontal cortex→ anterior part of the striatum →thalamus

Routes of repetitive/used/accustomed stimuli (shown in blue) travel from the anterior lobe of the cerebellum →thalamic medial nuclei→ supplementary motor area →middle part of the striatum →thalamus. (Kawamura, 2009)

The cerebellum as organs of movement and throught

連合野の構成および大脳・小脳間の相互作用および関連事項

大脳皮質連合野は、動物が高等化に伴って発達する。領域的にも拡大し、皮質全体に占める割合も増大する。大脳皮質の感覚野、高次運動野、連合野を含む広範囲の領域から、橋核および下オリーブ核を経由して、各々苔状線維および登上線維が小脳皮質の広い領域に投射が行なわれている。その苔状線維投射 4, 5, 17）および登上線維投射 3, 9, 10, 16）の局在関係（図４、図５）も調べられている。視床核を介する小脳皮質から大脳皮質への投射にも局在性が認められる。この小脳・大脳関連ループに関しては、小脳半球外側部は大脳皮質の運動野外側部、運動前野および前頭前野との間に、他方、小脳中間部は大脳皮質の全運動野（とくにその中間部）との間に相互連絡が存在することが Sasaki 28）によって明らかにされた。

The cerebellum has recently been paid much attention as functioning recognition, language function including the thinking (or thought), in addition to (long been throught) the regulation or modification of the motor system. In a broad sense, the cerebellum is concerned with the inhibitory function of the mental activities.

Although the various spheres of cerebellar control are to some extent the tasks of different parts of the cerebellum, the machinery they employ appears to be essentially identical. In recent years the idea of the cerebellum as a "learning machine" has been in focus. If so, it might be imagined to be of importance for all kinds of learning.

In the Behavioral Sciences in 1986, Leiner, Leiner and Dow from Oregon have published an article entitled “Does the Cerebellum Contribute to Mental Skills?” (Behavioral Neuro-Sciences, vol.100, 443-454, 1986) and discuss this problem. Neurosurgeons have noted that stereotactic lesions of the most lateral parts of the cerebellar hemisphere in man do not give rise to detectable motor disturbances, as one might have expected. The authors point to the fact that in man the cerebellar hemispheres and particularly the lateral part of the dentate nucleus are more developed than even in anthropoid apes. This lateral part is histologically, embryologically and histochemically different from the medial part. Several anatomical and physiological studies in monkeys and apes indicate that fibers from the dentate nucleus supply divisions of the thalamus that project to the frontal association cortex. Scanty evidence from human studies seems to be in agreement. The authors studied a patient who had a lesion of the lateral part of the dentate and found that there was a defect in his capacity to respond to anticipatory clues, in addition to the defects in performing motor acts correctly. As they phrase it: “the ideational manipulations that precede planned behaviour were suffering.” The findings made concern only effects on the planning of motor functions. To discover whether the cerebellum is of importance for the learning and performance of purely mental skills, will be a difficult task, particularly since the studies will have to be made on human beings. It is not inconceivable, however, that by using appropriate psychological tests and tomographic procedures、[(MRI, PET, rBF)] demonstrating areal differences in blood flow and metabolism some information could be obtained.(22)

小脳は運動の調節・制御に関与するのみならず、認知・思考を含む言語機能、ひいては広く「精神」

機能の制御活動にも関わっていることが注目されている。『小脳は mental skill に貢献しているか？』と題する論文を20年前に発表したLeiner ら**21)** は、ヒト歯状核外側部の障害症例において、行動を計画し、それを観念として実行するような予測能力が著しく低下していることを観察した。最近は、MRI, PET, rBF（局所脳血流）などを使用して言語やイメージを含む認知機構に、小脳半球、とくに後葉の外側部や歯状核が関与していることが証明されている。

The cerebellum revisited

Cerebro-cerebellar communication loop

Control-system modeling

Feedback control

Forward model

モデル予測制御　Model Predictive Control　(MPC)

前向き制御　feed-forward reduction of motor variability (運動分散)

Feed-forward space-code associative learning of the cerebellum (Fujita)

………………………………………………………………………………….

[See Eccles chap Ito in part]　bellow　下記は参照文献

4.4. Modeling cerebellar circuitry

Network modeling, as initially undertaken by Marr (1969) and Albus (1971), is essential for conceiving operational principles of complex neuronal networks in the cerebellar cortex. On the other hand, control system modeling is essential for conceiving the operational principles of neural systems involving the cerebellum and extracerebellar systems (for review, see Barlow, 2002). The control system modeling of the cerebellum that was inspired originally by experimental findings has now far exceeded our present experimental approaches. The hypothesis that the cerebellum provides forward and/or inverse models of controlled objects has successfully been applied to produce a robot that acquires a motor skill by learning. Even though engineering realization by itself is a kind of verification, we are still far from confirming the internal model hypothesis in a real cerebellum. Thus, cerebellar researchers look forward to determining how internal models, forward and inverse, are computed within a real cerebellum! Bottom-up, realistic (experimentally based) modeling also has merit. It reproduces in a computer the behavior of a single neuron or a small neuronal circuit on the basis of knowledge of the cable properties of dendrites, activities of ion channels and synaptic receptors, and inter- and intracellular signal transduction (De Schutter et al., 1999). Indeed, all the updated knowledge presented in this article concerning cerebellar circuitry at the molecular and cellular levels can be incorporated into realistic computer models. These three types of modeling approach mentioned above are complementary to each other and conjointly they should lead in time to more complete understanding of the operational principles of the cerebellar neuronal machine.

4.5. Cognitive functions of the cerebellum

Leiner et al. (1986) proposed involvement of the cerebellum in cognitive functions on the basis of the evolutionary development of the cerebellar hemisphere associated with the expansion of the cerebral association cortex. This view has been receiving more and more support from recent anatomical, brain imaging, clinical, and modeling studies (see Schmahmann, 1997). Recent virus mapping in monkeys has revealed the topology of function in the dentate nucleus (Dum and Strick, 2003). Projections to the motor and premotor cortex originate from the dorsal portions of the dentate nucleus, while projections to the prefrontal and posterior parietal areas of the cortex originate from the ventral portions of the dentate nucleus. The anterior intraparietal area of the posterior parietal cortex also receives projections from a broad area of the dentate nucleus (Clower et al., 2005). Purkinje cells located primarily in Crus II of the ansiform lobule receive inputs from the prefrontal area 46 and project to the same area 46 (Kelly and Strick, 2003). This implies that a closed cerebrocerebellar communication loop is also found in the prefrontal cortex, thereby supporting the hypothesis that the cerebellum provides a forward model for mental functions of the cerebral cortex. This is analogous to the interactions of the cerebellum with the motor cortex for the elaboration of voluntary movement (recall Fig. 7). The internal model hypothesis has been expanded conceptually to apply to cognitive functions such as thought (Ito, 1993b, 2005). This capacity can be considered to be a manipulation of mental models that are small-scale models of reality. These may be used by the mind to anticipate events requiring reason and an explanation (Craik, 1943). One may suppose that in thought, a mental model of an image, idea, or concept is formed in the temporoparietal association cortex. In a later stage of thought, mental models already formed are manipulated as the controlled object by the prefrontal cortex as the controller. The prefrontal cortex manipulates the mental models, just as the motor cortex moves body parts during voluntary movements. In an even later stage of thought, the cerebellum copies a mental model to form an internal model. Thus, thought proceeds with the internal models of the mental models as the controlled object. Because the processes occurring in the cerebellum do not reach the level of awareness, the internal model hypothesis explains how we become able to conduct movements and thoughts unconsciously (automatically yet skillfully) after repeated exercises. For example, an idea pops out even without an obvious conscious effort to think it out! This hypothesis also explains diverse psychological and pathological mental experiences such as delusion, hallucination in schizophrenia, and lack of sympathy to other persons as being caused by an impairment of a cerebellar internal model

(Frith et al., 2000; Blakemore and Sirigu, 2003; Ito, 2005). The cerebellum may thus govern a large unconscious part of our mind. An interesting recent report on premature infants showed that unilateral cerebral injury is associated with a significantly decreased volume of the contralateral cerebellar himeisphere. Conversely, a unilateral primary cerebellar injury was shown to be associated with a contralateral decreasae in cerebral volume (Limperopoulos et al., 2005). This explains how an early-life cerebellar injury contributes to the high degree of cognitive and behavioral, as well as motor, deficits in premature infants. It will be a great challenge for future cerebellar research to decipher information of a cognitive nature encoded and processed in the neuronal circuitry of the cerebellum.

5. Concluding comments

Four decades have passed since Sir John Eccles pioneered a modern neuroscientific approach to the cerebellum. The neuronal machine concept of the cerebellum was developed into a self-consistent form, and its further refinement is still underway. Currently, knowledge in neuroscience is advancing rapidly at the molecular/cellular level on one hand and the behavioral/cognitive level on the other. To understand mechanisms underlying the generation of brain functions, however, it is essential to bridge these two levels with more detailed knowledge about neuronal circuitry. Without such information, the eventual goal of neuroscience, which is to understand the brain from the molecular to the behavioral level of analysis, will never be reached. Cerebellar research should continue to play a key role in this synthesis on the basis of an integration of experimental and computational approaches. Its goal is to fully understand the mechanisms and roles of the cerebellum as a universal learning machine involved broadly in the neural control of bodily and mental functions.

[See Eccles chap Ito in part] above

…………………………………………………………………………………….

Ito (13,14,15) have made it clear that the cerebellum also has the "predictive control" , as the cerebrum having the feed-back control which convert to the feed-forward reduction of motor variability. (using technology terms). And paid attention upon the similarities between the motor and the throught.

In the case of the former (motor), people intend to move the body by using or activating the brain regions in areas of premotor cortex, supplementary motor and primary motor areas, whileas in the through processing,

working activities in the linguistic association areas of the cerebral cortex and activate and move ideas and concepts and Ito assumed that

ability of thinking process automatically drive forward

Thinking model (use psychological terms)

Thinking or throught is to let the modeled concept move

"throught is the movement (let it activate), it = modeled concept in the brain "

Try to apply (correspond) the motor control system proposed in the cerebellum for the thinking (model) control system in the cerebrum

Ito13,14,15）は、大脳のフィードバック制御の働き、すなわち、「前向き制御」に転換する「予測制御」（工学用語を借用して）の働きを、小脳はもっていることを明らかにし、思考と運動の類似性に注目した。運動の場合には運動前野、補足運動野そして一次運動野を働かせて身体を動かすが、対して思考の場合には言語連合野を働かせて観念や概念を作り、思考過程を前向きに自動化する働きがあると推定した。伊藤は「思考は脳内にあるモデル化された概念を動かすことである」という意味の心理学用語を用いて「思考モデル」と呼び、小脳において提示された運動制御系を大脳のモデル思考制御系に適用（対応）させて提案した。

In other words, to explain in other way,

Internal models. A characteristic feature of voluntary motor control is that after repeating a task, one is able to perform the task precisely and without the feedback that was required before the task. For example, one can quickly learn to take a cup to the mouth with the eyes closed. A normally functioning cerebellum is required to accurately perform a quick movement in the absence of visual feedback…………………………..

In the effort to mimic this learning capability, I conceived the concept of internal feedback from an internal model of the controlled object formed in the cerebellum via the cerebrocerebellar communication loop (Ito, 1970, 1984). A similar idea was formulated computationaly as the ‘‘forward model’’ by Kawato et al. (1987).

(from Eccles chap. Ito)

As the results of repeating influential work(ing) of the anterior association cortex that contains Broca linguistic area upon the thinking model in the posterior association area that contains Wernicke area that is one element of memory reservoir supporting the cognitive thinking, one can use the reciprocal connections of cerebrocerebellar pathways , and finally becomes possible to the proceed the thought (or thinking pattern) automatically (in various ways) without avtivities of the cerebrum , once the internally simmulated model is formed in the cerebellum.

Thus the thinking model will proceed in such following ways shown below.

1) The PFC influences (works) upon the thinking model in the posterior association cortex.
2) Thinking model that simulates the dynamic characteristics is formed in the cerebellum.
3) The PFC work upon or approaches to the thinking model in the cerebellum.

After repeating (or repetition) of the above procedures, and once the thinking model is formed in the cerebellum, thought goes on semi-automatic and develop the thinking process unconsciously (Fig.6).

すなわち、大脳皮質内でブローカ野を含む前連合野が、認知思考の要素の貯蔵庫であるウェルニッケ野を含む後連合野内に存在する思考モデルに繰り返し働きかけた結果として、ヒトが大脳皮質内活動として思考、すなわちさまざまに考えることをくり返すうちに、小脳と大脳皮質との間を両方向性に密接に結ぶ結合 2,28) を使って小脳内にそのシミュレートされた思考モデルが形成されてしまえば、何度か、既に経験された思考に関して、改めて大脳皮質内活動をすることなく自動的に思考が進むことになるとした。「思考モデル」は以下の順序で進行する。すなわち、①前頭前野が後連合野内の思考モデルに働きかける。②この思考モデルの動特性をシミュレートするモデルを小脳内に作る。③前頭前野はこの小脳内思考モデ

ルに働く。この過程を繰り返し続けることにより、半ば自動的に思考することが可能になり、思考モデルの逆モデルが小脳内にできれば、無意識に思考過程が進行するようになる（図６）。

Starting from the cerebellum, flow of novel (or new) and accustomed (repeated) impulses and afterward, how the flow changes its stream and transform its types,

Now、hear at the first time, the posterior cerebellar hemisphere, transfer (move from the hemisphere, noecortex to the old vermal part)

Old, accustomed tune, anterior lobe in this fig. 32 (2006), that I made based upon the data from Sakai et al., (1999), from red to blue lines in fig.32, when repeat again and again,

Not only the functional dynamic loop of the cortico-striate-thalamic , cerebellar inputs come to join this circuit . to the cerebellum, all kinds of sensory and motor inputs enter the cerebellum. Constantly changing situation, smooth, automatic, integrative mechanism of treating the processing of all these signals,

Basis of music performance, when the activities or info/function of the dynamics of the cerebellum. Not only motor system, but also the cognitive and language, thinking, second signao processing system of I.P. Pavlov. Fig. 33 total picture !

次に小脳をスタート・ポイントとして見たときの新旧の興奮伝達の流れと変化・移動について話

題を移します。彦坂先生のグループ(Sakaiら、1999)の実験結果を基にして私が作った図３２を示します(川村、2006)。初めに耳慣れない音のリズムを聞かせると、小脳半球の後葉が活動しますが、そのリズムに慣れてくると、あるいは「聞き慣れたリズムだな」と感じるようになると活動の中心が前葉に移り、何回も繰り返すと、この赤線で描いた流れのルートから青線のルートに移行します。このように、大脳皮質や大脳基底核の変化だけではなくて、不随意運動系に属する小脳の活動変化も入れて、それに脳幹、脊髄内の興奮伝達をも含めて認知機能/情動の処理/運動の自動的円滑統御などの統合に関係する（音楽の演奏の基盤を考えることにもなる）神経回路のスケッチ像を描いて脳内の情報伝達の全体像を図３３に試作してみました。

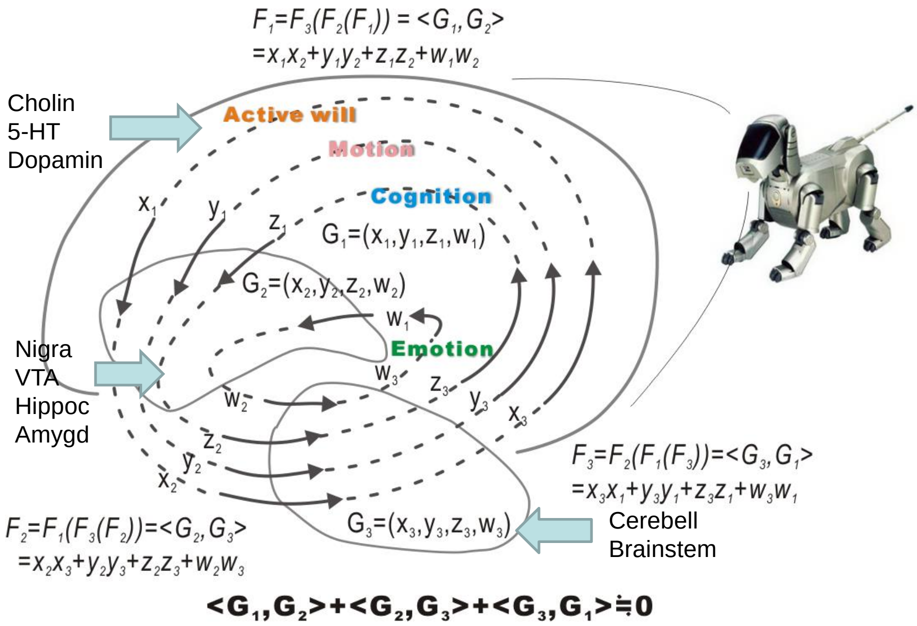
oooooooooooooooooooooooooooooooooooo

わかる数学脳モデル英文化（坂出準作成）11/5/2010

Model of the functional brain

We are going to arrange the followings. ~~(100719)~~

1) **A round trip model**



cerebral cortex(G_1), basal ganglia(G_2), thalamus(G_3) を回る neural curcuit の図、

091211 付け

We define F(x)=x as fixed point.

Let F be（F４F３F２F１）,and then we can think of the following equation F4(F3(F2(F1(x))))=x as F(x)=x .

Suppose the 4 dimensions in Hilbert space, and we will be able to illustrate a 2 axis in order to draw x and y axis that makes ｙ＝ｆ（ｘ）or, ｍ〈ｙ｜＝ｎ ｜ｘ〉 that may make a sense of 〈ｙ｜

x 〉 = 0 used by Bra and Ket Vectors in Dirak's Quantum mechanics.

A remark will be made that we do not know if F shall constitute an inner product, but an assumption such that the mappings satisfy Baillon's nonlinear ergodic theorem by which we shall try to apply later on is one thing and the assumption such that the mappings attribute with inner products is another.

There are 4 vectors; **a**,**b**,**c** and **d** such that responded 4 mappings :

a→**b**→**c**→**d**→**a** come to composing a round trip

2) A three circuit model

We denote three circuits G1, G2 and G3 by cerebral cortex, basal ganglia and thalamic nuclei, respectively, and x, y, z and w by emotion/olfaction, cognition, motion, active will, respectively as well such that

$G1 = (x_1, y_1, z_1, w_1)$ ..... cerebral cortex,

$G2 = (x_2, y_2, z_2, w_2)$ ..... basal ganglia

$G3 = (x_3, y_3, z_3, w_3)$ ...... thalamic nuclei.

Thus, we can show the fallowing image such that

G1—F1—G2

G2—F2—G3

G3—F3—G1.

3) Presentation of Bra and Ket vector by Dirak's quantum mechanics

We can show the following equations concerning the three circuit model using the bra and ket vector such that

F1 = F3 (F2 (F1)) = <G1, G2> =x1x2+y1y2+z1z2+w1w2

F2 = F1 (F3 (F2)) = <G2, G3> =x2x3+y2y3+z2z3+w2w3

F3 = F2 (F1 (F3)) = <G3, G1> =x3x1+y3y1+z3z1+w3w1

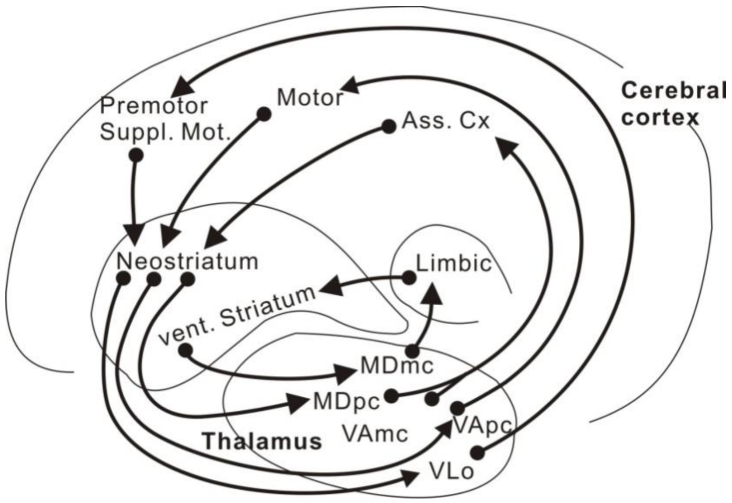
< G1, G2 > + < G2, G3 > + < G3, G1 > = 0.

If you take Bra Vector for $\langle f | = e^{-ix} = \cos x - i \sin x$ and Ket vector for $| f\rangle = e^{ix} = \cos x + i \sin x$, you can easily get the inner product such that $\langle f | f\rangle \equiv \langle f, f\rangle = \cos^2 x - i^2 \sin^2 x = \cos^2 x + \sin^2 x = 1$ that is a real number.

A remark is made that $\langle \alpha | \beta \rangle$ is different from $| \beta \rangle \langle \alpha |$ by applying greater than 1 dimension (reference is made to **REF1** in the next page).

We can say the case with the inner product being 0 as orthogonal that is why we take up Hilbert space.

The illustrations are shown like these.

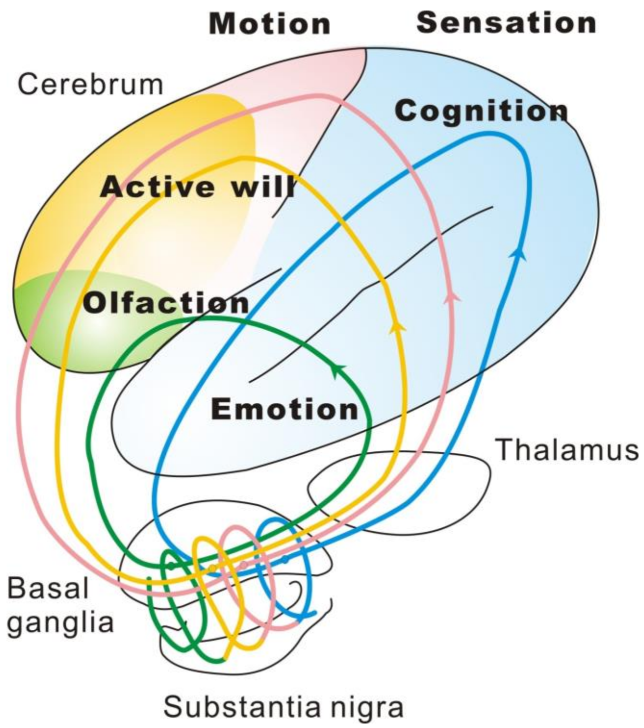


REF1

$< \alpha | = (a,b)$,　$| \beta > = \begin{pmatrix} c \\ d \end{pmatrix}$

○ $< \alpha | \beta > = ac + bd$

○ $| \beta > < \alpha | = \begin{pmatrix} c \\ d \end{pmatrix} (a,b) = \begin{pmatrix} ca & cb \\ da & db \end{pmatrix}$



The later two illustrations that are made by Dr. Kawamura shall be applied with mathematical models.

4) **An analogy of the circular formula of reproduction in Marx's "Das Capital" for the three circuit model will conduct to Baillon's Non-linear Ergodic theorem.**

The Marx's formula G — W — G would be of interest. Substitute W for F and we have in a round trip way such that

G 1—F 1—G 2

G 2—F 2—G 3

G 3—F 3—G 1.

That is like Dr. Kawamura's illustrations. That is amazing.

F 1+F 2+F 3=0 ・・・①

implies Marx's turn over G—G with ⊿G＝0 （ no profit ）.

$F1+F2+F3 \neq 0$ ・・・②

implies Marx's turn over G—G with $\triangle G \neq 0$ (some profit) .

In case with ① $F1+F2+F3=0$, let the average (mean)of G1, G2 and G3, then the index number shall be recursive with each three-time numbers. Thus, we have

$M3=1/3\ (G1+G2+G3)\ =1/3\ (G1+F1G1+F2F1G1)$

$M6=1/6\ (G1+G2+G3+G4+G5+G6)$

$=1/6\ (G1+G2+G3+G1+G2+G3)$

$=1/3\ (G1+G2+G3)\ =M3.$

Therefore, we have $M3n=M3$ where there is a fixed point concerning 3n, however Gn does not converge to G when n is infinity owing to a round trip concerning Gn .

In case with ② $F1+F2+F3 \neq 0$, suppose F be $F1=F2=F3=T$, then we have $F2F1=T^2$ that make the above case applied by Baillon's Non-linear Ergodic theorem with taking x for G according to $G1=G$、$G2=TG$、$G3=T^2G$、$G4=T^3G$ (that is a turn-over of $G1$) .That is why we have

$MnG=1/n\ (G+TG+T^2G+\cdots)$.

That is seems to us as $MnX=1/n(x+Tx+T^2x+\cdots T^{n-1}x) \in C$ that has weak convergence deducted by the theorem and that has fixed point set of mapping T (namely F). The mapping shall be a non-expansive one of a non-empty closed convex subset C into itself of

Hilbert space.

The theorem is apparently shown in Wataru Takahashi's textbook, where we substitute M for S, such as

$MnX=1/n(x+Tx+T^2x+\cdot\cdot\cdot\cdot T^{n-1}x) \in C$

$n\to\infty$、$MnX=1/n\Sigma k=0\sim n-1\ T^kx$ weakly convergent,・・・・・

when

$T\to F$、

$MnG=1/n\ (G_1+G_2+G_3+\cdot\cdot\cdot\cdot\cdot+Gn)$ +++=x

$=1/n\ (G_1+F_1G_1+F_2G_2+F_3G_3+\cdot\cdot\cdot+F_{n-1}G_{n-1})$,

$\because\ F_2G_2=F_2F_1G_1=F_1^2G_1,\ F_3G_3=F_3F_2F_1G_1=F_1^3G_1,$ ・・・・・・

$=G_1/n\ (1+F_1+F_1^2+F_1^3+\cdot\cdot\cdot\cdot\cdot\cdot+F_1^{n-1}) \in C.$

$MnG=1/n\Sigma GF^k x$, $(k=0\sim n-1)$ or

$=G/n\Sigma F^k x$, $(k=0\sim n-1)$

covergent weekly and have a fixed point.

5) conclusion

That may be to say that we have an equilibrium point in our brain.

このとき４次元空間（ヒルベルト空間の４次元）で考えれば、４個の次元から２個の次元を取り出して、

ｘ軸とｙ軸とすれば、ｙ＝ｆ（ｘ）とかけます。

（これを　m〈y｜＝n　｜x〉とディラック量子力学のブラベクトルと

ケットベクトルで書いた方程式にしただけです。）

4 個がａｂｃｄなら、図で一回りするので、a→b→c→d→a と写像が４個あります。

・・・・・・・・・・・・・・・・・・・・・・・・・・・・

2）　は、具体的にＦが内積かどうか不明であるが、エルゴード定理が成り立つような写像（mapping）を仮定するのと、Ｆが内積(inner product)であるかどうかを仮定することとの因果関係は、特にない。

Ｇ1―Ｆ1―Ｇ2　;Ｇ2―Ｆ2―Ｇ3　；Ｇ3―Ｆ3―Ｇ1

x：emotion/olfaction

y：cognition

z：motion

w：active will

・・・・・・・・・・・・・・・・・・・

波動関数(wave function ?)；無限次元空間(infinite space dimension)を考える。量子力学(quantum mechanics)、超関数(distribution and hyperfunction)、Heaviside 関数(Heaviside function)

Bra Vector　＜f｜＝ e^{-ix} = cos x － i sin x

Ket Vector　｜f＞＝ e^{ix} = cos x + i sin x

内積をとると＜f｜f＞≡＜f, f＞= $\cos^2 x - i^2 \sin^2 x = \cos^2 x + \sin^2 x = 1$(実数Ｒとなる)

In case　＝０　だと、直交系(orthogonal)となる。Hilbert space として内積が使える。直交で表せる。Banach sp.では内積がない。

・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・

この部位に Neuroscience vs Psychiatry を考察する　邦文まだ出来てない

Section 3　神経科学→精神医学

#3 Brain Science/Neuroscience

Emotion, Cognition, Motion, Active movements, Intention

情動、認知・認識、運動、能動性、意思・意志

○○○○○○○○○○○○○○

#9-1　脳科学から見た精神医学的一側面

We summarize briefly the functional organization of the brain. Major higher nervous functions on the cortical levels; one is cognitive/emotional and the other is motor/volitional functions as passive and active systems, respectively. These higher levels of nervous functions, the total products being called as mind/spirits, are represented and regulated by activities of the posterior and anterior halves of the cerebral cortex which are supported by underlying subcortical structures. They are the limbic and autonomic regulatory systems, including the rhythms of 1) awake / sleep, 2) walking, and 3) day-and-night. Behavior in everyday-life is supported on the ground of healthy rhythms, deviation of which causes physical and mental abnormalities.

Disturbances of the day-and-night rhythm lead to mood disorders or depressive states involving predominantly the hypothalamus and amygdala. Disturbances of the sleep and awake rhythm are accompanied by the fatigue of the body, mental instability and frustration due to the exhaustion of functional regulation in the brain stem covering from the medulla oblongata to the thalamus.

In addition, there is the neurotransmitter system organized throughout the brain, such as the serotonin system (5-HT) of the raphe nucleus origin, noradrenalin or the norepinephrine system (NA or NE) of the locus ceruleus origin, the dopaminergic system of the ventral tegmental area (VTA)/ substantia nigra (SN) origin. Besides, there are excitatory amino acids and inhibitory GABA systems well as an acetylcholine (ACh) system which has been related to intelligent activity.

While in the posterior association cortex, perceiving and recognizing stimuli from the external world, their values (good or bad, profitable or harmful, plus or minus, etc.) are judged in the amygdaloid complex with emotional feelings. All of these inputs perceived and recognized first in the posterior part of the cerebrum are then treated intentionally in the frontal lobe, predominantly in the prefrontal cortex, results of which give outputs through the motor and emotion-expressing systems. The former is the motor cortex-striatal system, and the latter is the hypothalamus-pituitary system. A variety of other humoral factors, e.g., amines, peptides and hormones participate in the brain development. Adolescence is the developmentally crucial period when the "self" is established through struggle of life, upon which a spot-light will be given below in connection with psychological development in humans.

In human, there are many psychotic problems that occur in puberty or adolescence (11- 15-18-22 years old, ages vary according to the wider or narrower sense) including schizophrenia. Adolescence corresponds to a certain period of human life when changes of bodily and mental growth are tremendous. Physically, the secondary sexual characteristics (penis, larynx cartilage, change of voices, pubic hairs etc. in male and mamma, pubic hairs, menstration, fat-deposit etc. in female) appear prominent. Bodily changes that happen at about 11-15 years old produce big influences consciously or unconsciously upon mental aspects of self. In one word, the problem is how the "mind", mental activities, can cope with the increase of physical energy accompanied by the inner mental tension. As materialistic bases are concerned, organic changes are subjectively involved in the activities of the emotional, autonomic and humoral systems covering peptide, hormones and neurotransmitters. There is a sudden increase of the differential coefficient of mental activities towards external stimuli, resulting in increased sensitivity (abnormal irritability) to the inner and outer stimuli. As a consequence, emotion becomes unstable. People living in mutual relationship with others become aware of their immature selves for the first time in adolescence, and try to be independent from their parents and teachers. With excessive sensitivity of self-consciousness in mind, they respond to the surroundings and want to make sure of their own existence. What is occurring in the brain at that time? Cortical neurons in the primary sensory and sensory association areas respond, and transmit information to the frontal cortex. The mechanism in which the cerebral association area adjusts and controls the activities of limbic structures and diencechalic regions should "properly" be activated in adolescence. Namely, the control system of the neocortex over the limbic and humoral systems, especially the frontal association area should properly be formed at the time of the brain development, when the maturation (including myelination) of the prefrontal area accomplishes, which is the leading role of governing the whole function of the brain. If developmental disturbances occur at this period, characteristic features of mental derangement would occur; aggressive attack, resistance and self-conceit, characteristics in the youth. Their standard of judgment is still on the way of admittance from the grown-up society, which is not defined with firm consciousness.

Ambivalence can be observed in both cognitive and emotional aspects, appearing more frequently in the latter. The evaluation of positive and negative values, contradictory to each other, exists simultaneously in the same individual. For example, feelings of superiority vs inferiority, confidence vs dependence, respect vs contempt, obedience vs resistance, and love vs hatred.

Ambivalence is one of the most prominent symptoms in patients with schizophrenia. In adolescence, man feels it hard to respond to sudden, unstable changes from emotional aspects, the self being not established, social identity (the term borrowed from psychoanalysis) not being formed and remained immature. In the society, he or she becomes to be treated as an adult, unfortunately.

Thus, adolescence is an important period in life, for the formation of self-identity, self-consciousness and mind/spirits/morals. On the other hand, views of life or philosophy that have been taught in the family and at school are forced to confront with contradiction/inconsistency with those in real/actual life, and through the contact with society man should compromise and accept the necessary evils. "A good child" who has been obedient and subordinate to parents and teachers, confronted with difficulties, is requested for the first time to stand on his own feet. Since he will be asked in his speech and behavior to have his own responsibility, he will be confused and be amazed in the social, when its environment is not normal. For the character formation, proper development of the prefrontal cortex in adolescence becomes a key, since its function includes ethics and morals.

Addiction to stimulant drugs and hypnotic poisoning (often provokes psychosis) has recently become a serious social problem. These can be regarded biologically as disturbances of humoral, autonomic and immunological systems; involving mainly neurotransmitters and receptors in the brainstem level as well as in the forebrain. The problem of the drug dependence causes the disorders of personality and character. Disturbances or abnormality of appetite (anorexia and bulimia nervosa) or a sexual desire is also deeply related with the dysfunctions of rhythms chiefly of the hypothalamic centers, occurring very often in the adolescence. As stated above, expression of libido in both mind and body in puberty is a characteristic and troublesome matter which represents difficulties in becoming assimilated into the development of self. It is controlled and regulated in the modern society where the direct expression of libido is legally taboo. What is regulating as a whole is the cerebral neocortex, especially the prefrontal cortex, sending fibers to the limbic structures.

As mentioned above, functional processes of the prefrontal cortex that regulate and control subcortical structures corresponds to the formation of self-identity in developmental psychology. Adolescence is the period of “Sturm und Drang”. The general concept of values on the relationships between parents and children and between teachers and pupils loses its basic background, and may break down, which ultimately requires the organization of mind and body. Man recognizes himself as being the social existence in the course of life from boyhood to adolescence, and has to obtain "us" in "me" in the company. That is, through exchanges with people, and the social rule and responsibility grow in the mind. Biologically, this corresponds to the stages of neural development from the posterior association cortex to the prefrontal cortex.

In their childhood and adolescence, the young people worry about their inharmonious way of relationship between themselves and others. They have a tendency not to openly divulge their feelings. While they bully and disregard others, they pretend to be good children. In adolescence, their behaviors are often inconsistent and contradictory, being unable to express desire and dissatisfaction. Mentally, they are insecure, impatient and stressed, and likely to fall into insomnia, nausea, and autonomic nerve breakdown.

Recently, serious distortion of social environments has produced juvenile delinquencies; hijacks, killing innocent people etc. The whole society is responsible for these criminals and must pay every effort to improve the environmental situations. Physical disturbances of hormonal regulation in the central nervous system, and disturbances in the regulation of the cerebral neocortex upon the limbic system and the hypothalamus need to be investigated further.

. . . .

#9-2 Brain science and psychiatry

The whole product of brain activities can be taken as "mind" of animals. Animals communicate in their own societies, using gestures and voices, and human beings are able to transfer the products of "mind" to the next generation in the forms of creating arts, music and literature. Accumulation of the inheritance is embodied as culture and civilization in the human society, where people of normal as well as abnormal characters are struggling to live. It is important, therefore, for psychiatrists to study the abnormal aspects of mind, particularly on the basis of biological sciences. It is one of our aims to combine the recent results of the brain science with those of the human science.

Recognition and emotion are closely related to each other in the expression of “logos” and “pathos”. Sensory information reaching the cerebral cortex is transmitted from the posterior association area to the anterior association cortex, or the prefrontal cortex, in which information of the stimuli can be converted and be bestowed the connotational significance reflecting the situations occurring in the external world before being sent to the higher cortical motor system.

Maturation in man, both bodily and mentally, is established in the course of development, in particular during adolescence, and formation of human features is closely related to the cerebral maturity which includes the formation of “thought”, “emotion“ and “volition” and self-consciousness, being the total results of brain activities. In the working society, through communication with others, humans use words as sophisticated signals, connecting verbs with nouns, uses verbal tenses, and distinguishes active and passive voices. Man also expresses and controls feelings of love, angry, sorrow and joy in the community.

Schizophrenia usually starts in adolescence. Communication with other people becomes inflexible and autistic. Although intentional activities decline gradually, there are no signs of intellectual deficits. However, the disturbance of cognition and the loosening of thinking ways are very often recognizable from others, and sometimes hallucination occurs. Schizophrenia literally means the “split mind” (shizos=separate; phrenia=spirit or mind) or in German “intrapsychische Spaltung” as it has been called. It differs from “split brain” or histological damage in the brain used in neurology where pathologic signs or symptoms are constantly obvious .

Thus the "split brain" can be defined as organic and its symptoms are usually permanent, whereas the “split-mind" may be functionally disconnected concept. Symptoms of the split brain include aphasia (speech disturbance), apraxia (behavior disorder), and agnosia (cognitive disorder), which have been studied extensively since the last century. In 1960s, Sperry and Gazzaniga studied symptoms in patients who had undergone operations cutting cerebral commissural fibers (the corpus callosum and the anterior commissure) as a therapy for epilepsy. Admitting that it is fairly logical and even formal to describe, three types of "splitting" can be discussed below; ① the rostro-caudal split between the forebrain (telencephalon and diencephalon) and the midbrain, ②the split between the right and left cerebral hemispheres, and ③the split between the anterior and posterior association areas in the cerebral cortex.

Considerations will be given below in the order of ①, ②, and ③

.

In the ① split :

Stimuli in the outer world excite sensory cells in the sensory organs, but the information does not reach the forebrain, with the exception of the olfaction and visual whose pathways are not interrupted in the border of the forebrain and the midbrain. Other sensations, such as the somatosensory (except for the face region), auditory, gustatory and so forth, may remain unconscious. Motor functions are based on spontaneous reflexes. Activities of the brain may correspond to the level of the reptile brain (cf. MacLean's triune brain hypothesis of three-layered hierarchy). Emotional expression generated in the subcortical limbic system as well as in the endocrine and autonomic systems cannot be controlled by higher activities of the cerebral cortex. As a consequence, animals may feel unstable states of mind, and difficult to adapt to the environmental changes.

In the ② split :

Commissural fibers connecting the thalamic nuclei of both sides, the adhesio interthalamica, are absent in about 15% of the human brains. Other commissural pathways are: in the optic tectum that connects the both sides of the dorsal part of the midbrain, and the posterior commissure which connects both sides of the preoptic area, Darkschewich nucleus and Cajal's interstitial nucleus, the habenular commissure, the hippocampal commissure and the anterior commissure.

Phylogenetically the newest commissural pathway is the corpus callosum, the biggest in man. The operation of cutting the corpus callosum was conducted for the purpose of medical treatment for neoplasm or epilepsy by Gazzaniga, Sperry and others (1965, 1967, 1991). Examinations have been performed in cases in which the corpus callosum (also the anterior commissure in part) was cut. In the split-brain patients, disturbance of naming objects in the left visual field, dyslexia in the left visual field, agraphia in the left hand, and the constructive apraxia in the right hand were observed. The important result of this study is the discovery that the functional specialization is evident between the right and left hemispheres in the human cerebrum.

Structural asymmetry has been reported on the habenular nucleus in the mole and Drosophila and on the Mauthner cell in the fish spinal cord, although the physiological significance is elusive. The functional difference between the right and left cerebral hemispheres has been known in the human brain. In higher subhuman primates, however, the difference has not been successfully studied so far.

The remarkable development of the cerebral cortex in man as compared with that in apes can be summarized as follows: a) linguistic areas highly developed in both the posterior and anterior association areas, b) very large frontal lobe, especially the frontal association area (= prefrontal cortex), and

c) a large number of cortico-cortical fibers, connecting bi-directionally between the anterior and posterior association areas.

It is said in human that the left cerebral hemisphere is predominant over the right hemisphere in the comprehension and expression of the language, whereas the right hemisphere is predominant over the left hemisphere in the comprehensive recognition of compound forms and fragmentized figures to build up the conscious-integration of Gestalt (Sperry), or in the function of transforming special information into groups in images by manipulation or using hands (Gazzaniga).

However, the information in both hemispheres is constantly communicated through commissural fibers; so that the functional predominance of the hemisphere is not absolute. With this concept in mind, it is said in general that the right hemisphere is concerned with images of signs transmitted by means of emotional experience, thus suited for solving problems using imagination, while the left hemisphere is related with understanding languages, searching for rules to connect different kinds of signs. Understanding in the right hemisphere loses its individual colors after transmission through the corpus callosum to the left hemisphere, thus bearing its common concept.

In the ③ split :

The discrepancy between the anterior (or frontal) and the posterior (parietal, temporal and occipital) association areas will be considered below. The study of regional cerebral blood flow (rCBF) in the brain of chronic schizophrenic patients was developed recently by Ingvar and others (1974). They showed that decreased amounts of rCBF were noted in the frontal association cortex of the patients than in the healthy controls, and also that increased amounts in the parieto-temporal than the frontal areas in the patient brains. The increase and decrease of the amount of regional blood flows are considered as reflecting the level of the metabolism, correlated with the functional activities of its brain region. Therefore, it can be considered that in schizophrenic patients the function of the frontal association area is decreased, while that of the posterior association is conversely increased.

Based upon the above consideration, the split-mind symptoms of the mental disease, especially schizophrenia (so to say temporally function disorders), are now ready to be considered, although highly hypothetical.

Firstly, regulatory disturbances of the cortical functions in the cerebrum upon subcortical structures may cause impulsive, disordered, and reflective patterns or manners of emotional expression.

Secondly, the disturbance of bilateral hemispheric communication may cause deterioration or even loss of normal thinking-flows, thus resulting in the mal-formation of cognitive conceptualization which may lead to the abnormal cognition ; hallucination and delusion. Disturbances of establishment of self consciousness occur, as a result of self-disorientation in the surrounding world together with bitter experience suffering from other people in the community.

Thirdly, the antero-posterior separation of the association cortices is likely to cause declining of activities, volitions and feelings, manifesting sometimes symptoms of autism or depersonalization. It should be stressed here that the deficits are in many cases functional and temporal, and that the symptoms are not irreversible to be involved in the incurable organic deficits. The disease can indeed be curable by means of medical drugs and psychiatric therapies.

Generating an animal model which represents schizophrenia-like symptoms has been carried out, by injecting amphetamine or methamphetamine into rats (Utena, 19##). The rats which received drugs repeatedly became intoxicated, and displayed some stereotyped behaviors such as biting, licking, and glooming; so called amphetamine stereotypia, while other types of behaviors were suppressed. Furthermore, they became afterwards inclined to display similar symptoms, when the drugs were administered repeatedly even at low doses. Likewise, when monkeys received methamphetamine for a long period, they exhibited abnormal types of social behavior resembling the symptom of autism together with particular manners of peeping and body-scratching. It was thought biologically that hypersensitivity of dopamine receptors was formed. Pharmacologically, this is called as "reversed tolerance phenomenon" in the sense that it is reversed to the drug tolerance . This terminology is deeply related to the term "remembrance of the previous history" advocated by Utena (1979) in the meaning that previous histories of schizophrenia and/or drug-intoxication are likely to prepare the readiness of recurrence in inducing the symptoms of the disease and the stimulant-intoxication.

Repetitive uptake of amphetamine, similar to the over-dose dopamine, stimulates dopamine receptors (as an agonist), resulting in the hypersensitive state to the drug. Medication of chlorpromazine acts as a blocker or antagonist to the dopamine type 2 receptors and thus effective for the mitigation of positive symptoms of schizophrenia as well as for the abnormal psychic states of experimental animal models.

Recently, the relationships between the dependency to the drug and the age of experimental animals have been examined by Nishikawa and his coworkers. It was found that rats in puberty are most likely to show schizophrenia-like symptoms after repetitive administration of the drugs. The age of the rats used in the experiments were postnatal days of 25 and afterward, the periods of puberty and young adolescence. At synaptic levels, amphetamine activates dopamine (DA) receptors and produce positive symptoms of schizophrenia, while phencyclidine (PCP) blocks the NMDA type of glutamate receptors and exhibits negative symptoms. The former is reactive and the latter is resistant to the anti-psychotic agents/medicines.

In experimental animals, behavioral and biological abnormalities induced by drug injections showed apparent changes according to the developmental stages. For example, unlike the period of maturity (after the postnatal day 25), the reversed tolerance phenomenon by methamphetamine does not occur in the juvenile (newborn) rats (at postnatal days 1-21).

Based upon these data, Nishikawa and colleagues searched for genes, whose activation is dependent on the development by injection of amphetamine and also are responsive to anti-psychotics. These genes can be closely involved in the reverse tolerance phenomenon. Considering the fact that schizophrenia in many cases develops after the age of a certain degree of brain maturation; puberty, it can be thought that some kinds of disturbances are occurring in the neural net-work system in the brain, particularly in the forebrain. The neuro-circuitry develops in the course of maturation from the infancy to the puberty and adulthood. The pattern of expression of c-fos genes; immediate early genes, in the striatum and the cerebral cortex was conspicuously different between mature and immature brains (Nishikawa et al.,). The cloning of the genes and formation of antibodies will further promote the study of the schizophrenic brain.

The human brain becomes mature as it develops from the baby/childhood to the puberty/adult. Neuronal processes develop, and glial cells maturate to form myelin in the brain. Various types of neuronal circuitries in the brain are activated and strengthened by means of active and passive interactions with environment through communication and co-working in the society. Thus, in the process of constant activation of neural networks in the cerebral cortex, based on the mechanical basis of the conditioned reflex, particularly with the help of the second signal system, people can be educated intellectually and emotionally. This is the fundamental basis of human activities to create art, music and science.

When the brain is damaged, mental disorder can appear as a consequence. How are cognitive abnormalities such as illusion and hallucination formed in psychotic patients? It is evident that loci of the mental disease, for instance in the schizophrenia, do not lie in the primary sensory areas nor in the primary motor cortex, not in the least in the brainstem/spinal cord, but do lie in the association cerebral cortex. Considering the symptomatology of cognitive disturbance, whether visual or auditory, it is the malfunction of comprehending objects as a whole in a gestalt way, judging the value and meaning of surrounding events or objects referring to the previous memory. Patterning of the stimuli from environments, the conceptualization or generalization of ideas, and the building up the stream of thought, these are the products of recognition mechanism, the central role of which is the activities of the linguistic center in the brain.