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The system of nerve cells that forms concept of language expression
－Layered overlapped impulsive activities of cells for intelligent activities－

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Abstract The layered overlapped activities exist in a brain simultaneously through rounding of impulses between areas of nerve cells. A production rule is carries out by the cell that is possessing with same attribute is organized by an interneuron. A reliable action is carried out by reticular connections among the cells in a region. The concept of a word is formed as a representative of an activated area of the neurons. The universal grammar is concerned with the real phenomena. The mechanisms of language and thought are explained as such activities in a brain.

Keyword Neuron, Neurotransmitters, Auditory area, Neocortex, Hippocampus, Short term memory, Universal grammar

1. Introduction

Although the neural network approach has taught us little about the brain, the complexity of the cell emerged in molecular biology of the cell, and the observations by transmission electron microscopy (TEM). Investigating the properties of the neurotransmitter of each neuron reveals how it works in a brain [1].

The brain mechanism e.g. “language use as element of thinking” has remained unclear. The world of language has been acquired by only human being during very short period of billion years of evolution. It was considered that a word was used as a representative of nerve network for the intelligence that was implemented heuristically That is, the meaning of word depended on the nerve cells.

Although S. Karasawa et al reported a brain mechanism for recognition [2], the model was insufficient as for reticular connections.

This paper reports a model by which the concept of word is formed in the plural of cells. That is, reliable reactions are achieved by plural neurons by reticular connections to many neurons in an area formed by an interneuron.

2. Reticular connections of a cell for reliability

2.1. Temporary activated areas of cells

[Functions of area of concurrent activated neurons]

The plural neurons that have the simultaneous attribute are activated by an interneuron. A reliable reaction is achieved by reticular connections among the areas. Also, rounding of an activity is realized among these areas i.e. a short-term memory is realized by the multiple cellular systems. If there are overlapping layered areas of activities, the whole area or a part of the area are perceived by changing the segmentations. Such system of the visual perception existed before the acquisition of language use.

[Operations of interneuron]

There are input terminal and output terminal at each connection of interneuron. When the integrated value of inputs from the connected neurons increased over the threshold value the interneuron outputs impulsive neurotransmitters to all connected neurons at once. The activation of all connected neurons is affected by the effects of the neurotransmitters. A positive-feedback for the depolarization of neuron forms an area for concurrent attributes. The contrast of activations in an area is emphasized via a negative-feedback effect on the area.

[Operations of the hippocampus]

The hippocampus is a net of granule neurons. The network materializes a shift register. Moreover, it controls the activity by cutting off the transmission if the indispensable activity does not exist. So, the continuation of activation linked to neocortex is controlled at the hippocampus by absence of necessary activations.

[Operations of the thalamus]

The thalamus regulates plural of voluntary activities in a body by using the lateral inhibition which functions as an algorism of the winner-take-all. It decides which activity gives priority at the moment. Here, the conditions for the next action are changed by the result of action.

2.2. Adjustments by antagonized reactions

A cell carries out the next reaction by itself. The activity that became unnecessary by the result of the

activity must be stopped, and the reaction that disposes of the activity is necessary in order to continue the activities of life. So, each cell possesses plural cycle of chain-reactions including antagonized reaction, and the operation depends on the situation.

Sensitivity of a sensory neuron must be adjusted precisely. There are ligand-activated ion channels and voltage-activated sodium ion (Na^+) channels in a photoreceptor and the sensitivity is adjusted as follows.

1) The ligand-activated ion channels of photoreceptor are opened by the ligand of cGMP (cyclic Guanosine Mono-Phosphate). Decrease in internal concentration of cGMP is triggered by light via rhodopsin. Increase of cGMP takes place in the dark. The membrane potential of a photoreceptor becomes high in the dark, because Na ions flow into the cell via cGMP. Then, the cell is depolarized in the dark. [1] pp.570.
2) Opening of voltage-activated sodium channels emphasizes the depolarization. An adjustment of sensitivity for the voltage-activated sodium channels is carried out by shifting of the membrane potential by cGMP-activated ion channels. The frequency of spike caused by voltage-activated Na^+ channel relies on difference of the potential [3] .

The reaction of a photoreceptor is controlled by cGMP.

a) [Negative feedback for sensitivity by Na, K-Pump]
   The ability of nerve cells is maintained by the constant transport of Na^+ and K^+ by the Na-K pump. When it is bright, the rhodopsin triggers decrease of cGMP and it closes Na^+ channel. Then, the cell is hyperpolarized by the operation of Na-K pump.
   (There are ON receptive field in a retina. APB (2-amino-4-phosphonobutyrate) receptor, found on ON-bipolar cell dendrites, is coupled to the synthesis of cGMP. The APB receptor of ON-bipolar cell is the metabolism type glutamate receptor which is active through an indirect metabotropic process. At these receptors, glutamate increases cGMP formation leading to the open of ion channels. APB abolishes light responses in an ON bipolar cell and depolarizes the membrane potential [4].)
b) [Light adaptation by Ca^{2+}]
   The production of cGMP is restrained by calcium ion (Ca^{+2}) that mixes to Na^+ through voltage-activated Na^+ channels. Decrease in internal concentration of cGMP closes Na^+ channel, and the cell is hyperpolarized. This reaction transfers the membrane potential toward middle level, and it has effects of the adaptation to brightness.

2.3. Data processing by the system of neurons

The life is an aggregate of the catalyst that matches to continue the activities of life. The impulse is the activity unit in a brain. When a neuron outputs an activity potential of an impulse, it returns to the original state after several milli-seconds of refractory period. Owing to the refractory period, the impulse advances along one way. The impulse leaves a change of real world and it fades away. The impulse operates one production rule described by an IF-THEN-rule as “If A=B, Then X=Z”. The function presents relay, control, and recognition.

The operation includes a process of pattern matching. Here, normalization, segmentation and alignment of position are necessary for the process of pattern matching. Serial data are transferred to parallel data by a shift register and the parallel data on a data path are decoded by decoders connected.

2.4. Feedback Effects via interneuron

There are 2 kinds of feedback effect via interneuron.

[Effects of positive feedback via an interneuron]

This is the case that the membrane potential of every cell in an area increases at an addition of impulse. The activation of every cell in an area is the segmentation at a moment. This positive feedback reinforces the activity and the reaction has the function of selection on the area.

[Effects of negative feedback via an interneuron]

In this case, membrane potential of every cell in the area is decreased at addition of an impulse. Here, the total value of activation on cells in an area decreases each bais membrane potential. This phenomenon has the effect that restrains fluctuation of the bias potential. Moreover, the negative feedback adjusts the contrast of the electric potential differences from the bias potential in an area.

2.5. Overlapped activities of layered decoders

The perception is carried out by many kinds of decoder that is realized by a pattern-matching. The processing needs the segmentation and the strict adjustment of sensitivity. As for the segmentation for voice recognition, the minimum segmentation is that of phoneme. Each phoneme needs several steps of intermittent operations.

As shown in Fig.1, the system of overlapped layered decoders is used in a brain. The segmentation of data compression depends on the demand.

The context effect is carried out in the overlapped system by mutual connections between an activated area in upper layer and activated areas in the lower layer.

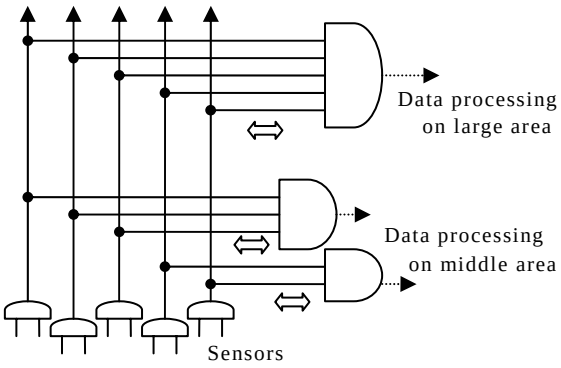

Fig.1. Overlapped activation in a system of layered decoders

3. Cellular processing for auditory system

3.1. Electromechanical transduction by hair cells

The auditory signal is provided by means of hair cells in the inner ear. The hair cell responds to bending of bundle of cilia on their apical surface. The cilia are arrayed in order of length.

Each hair cell is attached to the next at their apical end, and the longest cell is attached to the overlying tectorial membrane. By the tension that occurs due to the apical thread when the basilar membrane bends, stretch-sensitive ion-channels in the cell membrane are opened [3] pp.273.

The influx of K occurs at the vibration, because the hair cell is dipped in the scala media in which density of K is high. The depolarization due to influx of K yields the frequent discharge of neurotransmitters.

3.2. Principle on annex parts in a nerve circuit

A renewal of nerve circuit is carried out by the fundamental function through the operation. The configuration of circuit for advanced judgment is a form of extension. The priority is given to the judgment that was added newly. But, it is given to a fundamental reaction when it is urgent. That is, a neuron is able to transmit the signal in the afferent pathway, and it is able to reflect in the efferent pathway. The action depends on the situation of the neuron.

A route of nerve system is illustrated in Fig.2.

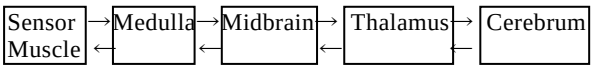

Fig.2 A route of nerve system

3.3. Control of utterance by neocortex

The utterance is controlled by serial patterns of the contraction on muscles in vocal organs in the following manner.

1) A reaction is presented by a series of transition of poses. 2) The pose is designated with the pattern of the angle of joint. 3) The angle of joint is adjusted by servo mechanism.

The voice is uttered by frequent outputs under the condition that each precondition is satisfied. Each action is decided in the real world. The serial patterns of data for language use are memorized in nerve circuits via hippocampus.

3.4. Control of utterance by cerebellum

A routine of reaction does not need to confirm at each step by the monitor. A muscle is controlled by a line of impulses in serial of patterns. The line of date is a timing control of a muscle. The system for timing control needs the circuits for timer and the circuits for memory.

The cerebellum is the organ of annex. In the cerebellum, the parallel fibers from granule cells are used for timer. Prukinje cell is used for a main element of memory.

Each parallel fiber is connected to the Prukinje cell for a reaction selectively. Since the output of Prukinje cell is GABA that opens Cl^- channel, it controls the activity by inhibition. The synaptic connection must be inhibition from DeMorgan's theorem for OR operation. That is, the Prukinje cell is depolarized at absence of input, and it suppresses the activity. Prukinje cell is hyperpolarized by the presence of input, and it allows the activity.

This mechanism of cerebellum is confirmed as follows.

1) Many parallel fibers are connected to Prukinje cell.
2) The parallel fiber is the output of a granule cell.
3) The granule cell receives excitative input by way of mossy fiber from the spinal cord and brainstem nuclei.
4) Purkinje cell receives excitative input from climbing fiber that arises from the inferior olive.
5) The inferior olive receives the data that control the muscle.

4. Control of activities in a cellular system

4.1. Associational activities by the neocortex

The cerebral cortex processes and analyses the inputs from sensors. The analysis is activities for sufficient understanding. Our consciousness is focused to one thing at an instant. But we can integrate and compare the thing that focused point with the surroundings. That is, there

are plural activated areas in a brain.

Owing to the refractory period, a cell can not always produce impulse promptly. The plural neurons that have the simultaneous attribute are able to produce impulse promptly. Such cellular system realizes a short-term memory by rounding of activity among these areas.

A structure called as column is formed in the new cortex of the cerebrum. The activities of short-term memory via columnar structure must be associated with the other activities. The interconnections from each columnar structure are the thalamus and the other area in a neocortex. The columnar structure and thalamus receives reciprocal signals among them. The thalamus receives signals from the cerebellum and basal ganglia and sends result of coordination to motor cortex.

There are overlapped layered areas of activities in the neocortex. The whole area or parts of the area are perceived by changing the segmentations. Such interactive operations are supported by interneurons.

4.2. Functions of the midbrain

A neuron is able to transmit the signals in the afferent pathway, and it is able to reflect signals in the efferent pathway. Each reaction depends on the situation.

Although the midbrain controls reflex motion, it relays the visual stimuli to visual cortex, and it relays the audio stimuli to auditory cortex. On the other hand, when the reticular formation in the center of midbrain is selectively excited by eye movements, the reticular formation sends the stimuli to the cerebral cortex. The vision changed by the eye movement is reflected to visual cortex, and the picture in visual cortex and the data on eye movement interacts in the brain.

From the fishes to birds, the visual information is gathered mainly to the midbrain. The midbrain controls the body unconsciously by using visual information. The area for the visual reflex is colliculus superior at the back of midbrain. [5] pp.7. The superior colliculus in the mammal is comparatively small and it mainly controls the movement of eye unconsciously.

4.3. Functions of the thalamus

The thalamus receives reciprocal signals from the cerebrum, basal ganglia, brain stem, and spinal cord. In the thalamus, there are the regions of neurons specialized by each attribute and it roughly analyzes the signal from sensors, and the outputs control the activities in the neocortex.

The lateral geniculate nucleus in the thalamus relays visual stimuli to visual cortex, and the medial geniculate nucleus relays audio stimuli to auditory cortex.

The activity that satisfies the conditions in the neocortex is transferred to the thalamus, and the most prime voluntary reaction is transferred to actuators if it satisfies the conditions to be executed. The deletion of activity is carried out by the neurons of GABA receptor.

4.4. Functions of limbic system and basal ganglia

The basal ganglia and the limbic system are located under the neocortex in a cerebrum. The basal ganglia are interconnected with the corticospinal system. It plays a major role in the regulation of limb movements such as balance of the body at the voluntary action.

The limbic system of cerebrum surrounds the brain stem. Although the limbic system in human brain is enclosed with the large neocortex, it controls the behavior. The place in which judgment for itself is carried out is the limbic system.

The hippocampus is formed at sinking of the center of archicortex. It is divided in front part of the hippocampus, but those are connecting at the back part.

4.5. Serial-in / parallel-out converter

The speech voice is serial. The circuit of decoder treats parallel data. Then the serial-in / parallel-out converter is indispensable to form the circuit for a long term memory. This data processing of speech voice includes the segmentation, and a matrix form dot pattern is used like pins of a music box.

If a sheet of data is used for a word, a sheet form of register and many sheets of data are necessary to treat many words. By using a scanning mechanism, a word is uttered by using a sheet form of register and a matrix form of data sheets. A pattern of serial inputs is decoded by using a scanning mechanism on a sheet form of register and many matrix forms of data sheets.

The intermittent activities of voluntary muscles for a speech are treated in the cerebrum. The matrix forms of data sheet are memorized in the temporal lobe in which Wernicke’s area is included. The plentiful granule cells in a hippocampus are able to play the role of the elements of a sheet of register.

The action of muscle requires the timing control and it depends on the dynamic characteristics of the organ. The segmentation of data processing should be adjusted to the timing control of speech.

4.6. Activities of neocortex via hippocampus

As shown in Fig.3, the hippocampus is linked to neocortex, and thalamus and brain stem are connected with it.

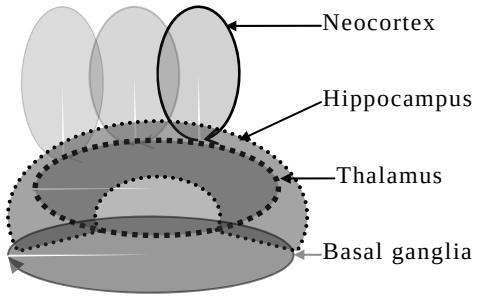

Fig.3. Flow of the activities in the brain that hippocampus is a part of a loop of activity

There are photographs of the evidence that the hippocampus transfers the group of activities spirally [6]. Impulse group circulates as a pace maker across many circulation impulses. Such structure of the hippocampus is able to conduct many activities including serial of phenomena.

The transmission of lines made of granular cells for serial impulses operates as a function of serial-in/ parallel-out shift-register. Overlapped connections are carried out on the paralleling data bus. The function of this hippocampus forms a circuit in new cortex. That is indispensable to the memory for long time.

4.7. Production of receptors for memory

The LTP (long-term potentiation) is a long-term increase in the excitability of a neuron to a particular synaptic input caused by 400Hz frequency stimulation with duration of 30 sec.

The phenomenon of LTP is concerned with neurotransmitter of NMDA (N-methyl-D-aspartic acid) receptor channel

1) AMPA(α -amino-3-hydroxy-5-methyl-4-isoxazole propionic acid) receptor passes through Na^+ and K^+ and it blocks Ca^{+2}. AMPA receptor possesses a selective permeability.
2) The block of Mg^{+2} is canceled by continuous activation of AMPA receptor and NMDA receptor passes through Na^+, K^+ and Ca^{+2}.
3) Ca^{+2} activates second messenger system i.e. a series of molecular reaction leads to responses, such as forming of AMPA receptors, and producing of the messenger for presynapses. It promotes discharge of neurotransmitters for a long period [3] pp.187. The number of NMDA receptors is decreased rapidly after the critical state period of the memory of the brain.

5. Language use for information processing

5.1. The idea included in language expression

The human being before language use judges the reaction by using visual information. The language in beginning was the role like a file name that initiates a subroutine of reaction.

The language has been developed by human through community life. Here, each member acquires common intelligence in the community. That is the base of language acquisition.

An interneuron connects nerve cells activated concurrently. The group of neurons forms an area. Each area is able to associate with the other area through overlapping of areas. A representative of the area is idea or concept. The representative of concept is conducted as language. The meaning of concept is engraved in the original nerve circuit. The attribute of concept is implemented through the real life.

The behavioral control is connected to the formation of language as shown in Fig.4.

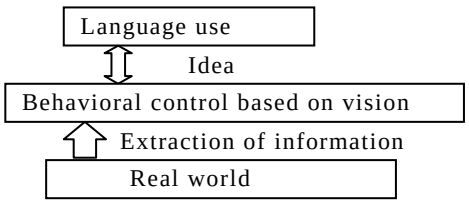

Fig.4. Language activity was incorporated in behavioral control based on vision.

Since the language is a representative of the area that links the other area, every word has associational attributes. Since the language is a representative of the area, a language is able to translate to the other language. A word is able to translate the other words.

Since the language is a representative of the real affair, there is a subject and the predicate that shows an action in an expression of activity. There is an object in expression of the action that exerts to the other. There is the attribute such as future at present, past, in the expression of an action.

5.2. The segmentation due to utterance

There are linkages between Boca's area for speech production and Wernicke's area for comprehension of

speech. The utterance has segmentations and a rhythm. The processing for speech recognition must adjust to the utterance of speech. As shown in Fig.5, inputs are able to refer to the memorized data in a brain.

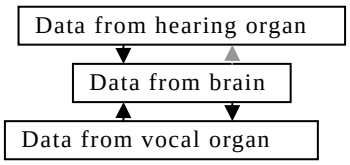

Fig.5. The linkages of data sources for language use

5.3. Independent meaning of language

There are sensory cortex, motor cortex, and association cortex in a neocortex. In the human brain, 2/3 of whole of a neocortex is occupied by the association cortex. The association cortex makes interact to the other area in neocortex without contacting outer world.

The associational activities of language use can be separated from the activity of muscles. The speech voice has the meaning that is independent from the speaker. The language has meaning of effects for member of the community.

5.4. Visual perception and language expression

The sharing system of decoders for elements forms a layered structure of recognition. The layered system economizes the circuits, and it increases the efficiency of use. The layered mechanism of recognition is carried out in not only language but also vision.

As shown in Fig.6, right brain and left brain assist each other. The activity in the left hemisphere is logical, but the activity of right hemisphere is intuitive.

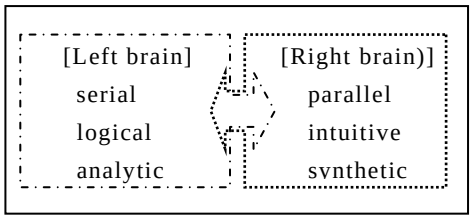

Fig.6. Complementary relationships between right brain and left brain

6. Conclusions

Why synaptic connections of a neuron are a reticular form, why the system of overlapped nerve networks was structured, and how language use was realized in it are explained in this paper.

The individual nerve cell conditionally outputs an impulse. An individual nerve cell has some mechanism of detailed sensitivity adjustments. Each function is carried out by discharging the neurotransmitter that each cell is possessing according to the situation.

The nerve cell group that occurs simultaneously forms an area by support of interneuron. The reticular connections to an area of neurons with the same attributes and parallel line of the neuron contribute to increase the reliability of the processing.

A short-term memory of circulating activity is realized by the multiple cellular systems. If there are overlapping layered areas of activities, the whole area or a part of the area are perceived by changing the segmentations. Such associational activities for the visual perception existed before the acquisition of language use.

The basal ganglia and limbic system are concerned with body control. The hippocampus is able to conduct many activities including serial of phenomena i.e. a transmission of line for a serial impulses operates as a function of a serial-in/ parallel-out shift-register. The thalamus receives reciprocal signals from the cerebrum, basal ganglia, brain stem, and spinal cord. It roughly analyzes the stimuli, and it controls those activities.

The concept is formed as a representative of an activated area of the neurons. The use of representatives is a powerful tool to deal with intelligence. The universal grammar is concerned with the real phenomena.

The author hopes that this report can contribute to clarify the intelligent activities of human being and the development of the system that understands the language.

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