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The Cerebral Structure and the Inner World

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The brain is still mysterious; especially the frontal lobe is not understood well (Funahashi, 2005). The basic idea of the model presented in Sato (1995) is how the linguistic model can be constructed by only using the parts that have been found in the brain so far: neurons, synaptic connectivity, networking, neurotransmitters and so forth. The model has been applied to the various problems in the fields of linguistics, psychology and so on. In this paper, the discussions which have been conducted on the basis of the language model are devoted to the problems in the brain sciences. Because the eyes are a sensory organ and are only an input unit, there should be a "screen" in our brains. The screen is used to manipulate the Inner World which exists in our brains. Through the manipulations, human beings can experience various kinds of things which relate to our daily lives. The experiences allow us to act unconsciously. Such phenomena are actually observed in the brain sciences. For example, without using the frontal lobe, which is usually taken as the place of intelligence, a graduate student who specializes in mathematics can perform relatively simple tasks in mathematics. If the existence of IW and the screen is postulated, the facts which have been observed in the brain sciences can be explained just in one model. A rough description of the cerebral structure is shown in the conclusions.

Key Words: the cerebral structure, the Inner World, the brain, psychology, linguistics

Introduction

In the bulk of the papers which I have published so far, the linguistic model that is presented in Sato (1995) is applied to the problems in the fields of linguistics, psychology and so on. The basic idea of the model is how the linguistic model can be constructed by only using the parts that have been found in the brain so far: neurons, synaptic connectivity, networking, neurotransmitters and so forth.

In linguistics, nowadays, there are two main streams of study. Linguists in the stream of generative grammar postulate Language Acquisition Device (LAD) to explain language development, which functions only for language and is shared only among human beings. On the other hand, in the stream of cognitive linguistics, the researchers think that language can be acquired through the general cognitive system. The discussions have continued between the two streams. Furthermore, psychologists have criticized the discussions in linguistics because they think the discussions lack psychological reality.

Sato (1995) is an attempt to explore the psychological reality of linguistic knowledge. Sato (2013) postulates the existence of the Inner World (IW) and discusses the psychological reality of syntax on the basis of the language model presented in Sato (1995). Sato (2014) talks about psychological time in IW and applies the discussion to the problems such as infantile amnesia and theory of mind. Sato (2015) deals with the problems of unconsciousness discussing the meaning of 500 milliseconds which are confirmed through experiments by Dr. Libet (Libet, 2004). Sato (2016) shows that the concept of IW is indispensable to materialize second or foreign language acquisition.

On the fundamental premise that different regions are specialized for certain functions, the brain sciences began to reveal the structure of the brain gradually in virtue of the development of noninvasive brain imaging technologies such as functional magnetic resonance imaging (fMRI). However, when the term, *prefrontal association area*, is used, it usually denotes the lateral part of the frontal lobe, and not all the functions of specialized areas in the brain have been identified

yet. Especially in the frontal lobe, many mysterious things remain to be explained (Funahashi, 2005). In this paper, the discussions which have been conducted in my papers will be applied to the explanation of the cerebral structure, so as to systematically explain what have been found in the brain sciences so far.

The Inner World (IW)

IW in the brain is a copy of the real world, and it is used for human beings to live in various societies (Sato, 2013).

Language works in the brain so as to make IW function effectively (Sato, 2013). Words are indexes of experiences that are accumulated in the brain, and they are used in order to pigeonhole and retrieve the memories efficiently. Syntax is used to manipulate *Image*s, or pictures of the experiences in IW, and the manipulations can lead to the human creativity (Sato, 1995). Language is also used to communicate and share, in a certain linguistic society, personal past experiences and what are experienced in a person's IW originally and creatively through the manipulations (Sato, 1995).

In IW, habitual behaviors are always checked, and they are modified if necessary. The mechanism allows human beings to act subconsciously and efficiently (Sato, 2015).

These are the brief explanation and description of the functions of language and IW in the brain. What kind of overall perspective of the brain structure emerges when what have been found in the brain sciences are discussed on the basis of the explanation and description?

The screen in the brain

Where do human beings "see" the pictures, or the images, of the real world? The eyes are a sensory organ and are only an input unit. They do not receive the feedback signals from the brain at all (cf. Pinel, 2003/2005; Carter, Aldridge, Page & Parker, 2009/2012). That is to say, the representation is not projected on to the eyes.

There should be a region on which pictures can be projected somewhere in the brain: *the screen* in the brain, if the signals processed in the brain do not return to the eyes. When the screen exists right behind the eyes, human beings will be able to feel that they see the world with their eyes.

The frontmost part of the frontal lobe has not been much understood yet. Funahashi (2005) says that the frontal lobe is still mysterious, although the function began to be understood little by little. According to Funahashi, the region is divided into three parts: the multimodal association area, the orbitofrontal area and the medial prefrontal area, and the term, *prefrontal association area*, is usually used to refer to the multimodal association area.

There are no canonical maps of the functional localization for the frontal lobe (Osaka, 2010). Osaka says that because, though some regions can be identified as a region of interest, the canonical maps cannot be used for the frontal lobe, the lobe should be researched carefully through the noninvasive brain imaging technologies. It seems that the parts which are mainly researched at present in the frontal lobe are those of prefrontal association area (cf. Osaka, 2010; Kawashima, 2002). Thus, it can be said that, although the brain itself has not been understood well yet, especially the frontal lobe is even more mysterious than the other parts.

In order to confirm the place of the screen, the flow of information in the brain is discussed in the next section.

The flow of information in the brain

The visual perception can be treated as a representative of the senses. Sakata (2006) explains the flow of information in the brain, particularly the visual perception. Komachiya (1997) says that, discussing the eyes from the evolution right down to the function, the visual pathway in the brain is the longest among all the senses. Komachiya also says that the sense of sight is the most important for human beings and what can be seen are the things which human beings can accept as true. The flow of visual information in the brain is mentioned next.

On the whole, the sensory information is processed from the back to the front in the brain. Sakata (2006) describes the flow. The process begins at the primary visual cortex in the occipital lobe. Then, the signals are sent toward the front of the lobe. At the place, the flow is divided into two routes: the dorsal path and the ventral path. The dorsal path leads to the parietal lobe and is divided further upward and downward. The ventral path reaches to the front of the temporal lobe. Finally, all the processed signals go to the frontal lobe. Funahashi (2005) says that all the flows of the signals converge at the frontal lobe.

The information is processed in parallel in the brain (Pinel, 2003/2005). The upper flow of the visual sense, or the

dorsal path, is related to the spatial perception, and the flow of the ventral path is responsible for the object perception (Sakata, 2006). The stimuli from the sense organs are analyzed into various kinds of information such as inclination, shape and color, and they are processed in parallel and integrated in some measure at the association areas (Funahashi, 2005; Pinel, 2003/2005). The association areas are frontal, parietal, temporal and occipital (Funahashi, 2005).

Qualia are also processed in parallel. Mogi (2004) says, "'consciousness' is filled with qualia" (p.23). Mogi explains qualia: the textures which appear in concurrent with the appearance of consciousness. The textures are also analyzed and processed in parallel in the brain. The signals are finally integrated and become part of a representation. Neurons which react to various types of textures (Sakata, 2006) and those which react to various sorts of movements (Rizzolatti & Sinigaglia, 2006/2009) have been found in the brain.

The discussions above lead to the logical hypothesis that the screen must be placed in the forefront of the frontal lobe. If the screen is just behind the eyes, we are to feel as if pictures were projected on the eyes. The flows of signals travel from the back to the front in the brain, analyzed into various kinds of constituent elements, and are synthesized to a certain degree in the parietal, temporal and occipital association areas. They finally reach to the prefrontal association area. Sakai (2015) says that because given any tasks, the frontal lobe reacts at any time, it appears to be related to all the faculties. It is spontaneously explained if all the processed signals converge at the frontal lobe. There, visual images are projected on the screen with the other kinds of sensory images. It will be very natural to think that the screen exists in the frontal lobe.

The brain's features

When the existence of the screen is hypothesized, what can be discussed further? The features which have been found in the brain sciences are taken up for discussion.

The functional localization is for reflecting a diversity of changes and movements in the actual world. It is unquestionable that the various functions appear to be localized in the brain. Why should they be so localized? When pictures are finally projected on the screen, it would be against the reality if a certain person had the same look at any time. Various combinations of colors, forms, movements and so on should be needed when, human beings manipulating IW, IW is adjusted to the real world, when, human beings combining several things, something new is created, and so forth. If many materials, or elements, exist separately in the brain for manipulation, it will become easier and more skillful to manage IW with language. Analyzing information into many elements makes it possible. Sensory information is analyzed and processed in parallel in the brain, and the signals are finally put together in the frontal lobe.

The optic chiasm is needed in order to evade getting mirror images when pictures are projected on the screen in the brain. The information from the left sensory organs is sent to the right hemisphere and the one from the right to the left. Why, although the description also appears to be common knowledge? It ought to be naturally explained when the ideas that the real world around us is projected on the screen of IW and that the optic chiasm is necessary so as to avoid mirror images are conceived as a fact.

Unconscious actions

If they are the acts that are repeated in a certain situation, the actions can be controlled unconsciously only through the parietal, temporal and occipital association areas without using the frontal association area. Sato (2015) discusses the problem that is taken up in Libet (2004): the processes of voluntary acts start in the brain at about -400 msec (without preplanning) or at about -900 msec (with preplanning), and the processes can be noticed consciously at about -150 msec before the acts actually begin. Because human beings can experience almost all the actions in IW before they actually do, they can control their actions unconsciously. They can decide their reactions beforehand by themselves in their IWs. Thus, they can believe in their free will (Sato, 2015). Such phenomena are actually reported in the brain sciences.

Sakai (2015) introduces two persons who perform tasks that need mental faculties of a high order, without much using the frontal lobe, and tries to discuss what using the frontal lobe means. A graduate student who specializes in mathematics can perform relatively simple tasks in mathematics without much using the frontal lobe. Yoshiharu Habu is a master of *shohgi*, a Japanese board game resembling chess. Even when he is making clever moves in shohgi, the frontal lobe is not much used. Their frontal lobes would have worked much in the same way as the other

subjects' lobes. However, the student has learned the patterns of problems and keeps them in the other association areas through the math research in his graduate school. It is very natural to think that s/he has been able to respond to the problems unconsciously. The case of the master also will be explained in the same way. He has played shohgi many times for practice and in competition. Through the experiences, he has been able to master a massive number of patterns and moves of shohgi. He is indeed a great master because he can respond to many situations by using the experiences unconsciously. If so, the cases of the two persons are to be explained clearly and naturally.

The working parts in the brain shift gradually from the prefrontal area to the parietal association area as subjects repeat a certain task several times (Kawashima, 2002). In this case again, although the subjects did the task managing pictures in IW in the frontal lobe at first, they began to do it unconsciously with the parietal lobe later as they got accustomed to it. This is also explained naturally with the idea presented in Sato (2015).

Kawashima (2002) thinks it strange that the frontal lobes of female subjects do not respond at all to their judgements of dislike in the task where they should judge their likes or dislikes or neither as for men's faces. Sato (2009) discusses the affect. Consisting of both emotions and moods, it is an experience which has the duration. Emotions are judgements on whether a stimulus ought to be reacted to aggressively. If it is judged "yes," a certain stimulus is accompanied by very strong reaction. In IW, the stimulus is processed through the reaction and is changed gradually into the one that is easily acceptable, and the experience is finally stored as a mood. It will be used when similar stimuli are experienced next. Through such experiences, human beings begin to be able to respond placidly and unconsciously to any stimuli that they face repeatedly in a daily life.

Infants and children use many more cerebral areas than adults when they do the same tasks (Japan Society of Developmental Psychology [JSDP], 2015). JSDP discusses the development of the brain from various perspectives. The brain begins developing from the rear of the brain, and the frontal lobe is the last part in the process. It is inferred that the brain is functionally completed around twenty years old. It is also observed that the way infants' and children's brains work is different from that of adults even in the same information processing tasks. When the young in early adolescence are given the tasks concerning theory of mind, their brains are activated more widely than adults', especially the prefrontal area. Compared with adults, infants in their first year of age use their frontal lobes more actively in meaning processing. Those observations will be explained convincingly on the supposition that infants and children need to process information much more consciously than adults because they do not have a wide variety of experiences to be used as previous examples, or their behavioral standards.

The frontal association area

The frontal association area works so as to make the cerebral screen function. The function of the frontal lobe is reasoned so as to get an overall picture of the brain.

Area 46 on the Brodmann's brain map fulfills more than the function of the central executive of the working memory (Rizzolatti & Sinigaglia, 2009). Human mirror neurons are found in the areas immediately before the Wernicke's area and in and around Broca's area (Rizzolatti & Sinigaglia, 2009). On the basis of the fact, Rizzolatti & Sinigaglia pays attention to area 46. Generally, the area is discussed as a place related to the central executive function of the working memory (Kawashima, 2002); however, Rizzolatti & Sinigaglia explains as follows. In the task of imitating guitar chords, area 46 is only activated briskly just before the imitation, but the motor area is active throughout the movement regardless of whether the task is imitation or not (p.166). Therefore the conversion of visual information into appropriate movements is carried out through the mirror neuron system (p.166). It means that the system is controlled by area 46. Rizzolatti & Sinigaglia concludes that the function of area 46 is beyond the central executive of the working memory. Area 46 is immediately before Broca's area (areas 44 and 45). Sato (1995) says that IW is manipulated by language. Area 46 and areas 44 and 45 are linked to each other (Carter, Aldridge, Page & Parker, 2009/2012). Naturally, the system must be able to change language stimuli into visual images of movements.

Hara (2005) explains the functional localization by using the Brodmann's brain map and highlights the function of area 8 connecting it to eye movement in a table (pp. 66 - 67).

Kawashima (2002) says that the polus frontalis has the function of memory comparison. The part is closely linked to the prefrontal area through the association fiber called uncinate fasciculus (Hara, 2005).

Osaka (2010) says that the symptoms of visual field defects are different between when the focus is in the occipital lobe and when it is in the frontal lobe. Osaka also says that the patients are actually aware of the symptom in the case of the occipital lobe, although the patients are not in the case of the frontal lobe. Maeda (2008) says that the hemispatial agnosia caused by the focuses in the frontal lobe shows a wide variety of symptoms by the difference of the places of focuses. In the case of the occipital lobe, the information processing of vision itself must be damaged. In the case of the frontal lobe, the damages are against the screen itself or against the regions around the screen. In some cases, the screen itself is damaged and, in other cases, the functions that help the screen work will go wrong. Thus, the focuses in the frontal lobe can cause a variety of symptoms.

The frontal association area appears to work so as to make the screen function.

Networks in the brain

The networks in the brain are prerequisite for the functional localization. The strong version of the conception of the localization has not been insisted recently, and that of the networks attracts the researchers' attention (Oozeki, 2016). All manner of regions are connected to each other with an enormous number of fascicular fibers (Hara, 2005). The frontal association area has firm interactive relations with the other areas in the brain, and it sends strong output especially to the multimodal association areas: the parietal and temporal association areas (Funahashi, 2005, pp.32-33). The brain localizes its functions and the localized regions are intimately connected to each other.

The cerebral structure

The overall picture of the cerebral structure tries to be constructed here on the basis of the discussions so far. The brain receives signals from the sensory organs. The signals are analyzed into their various elements, are processed in parallel, and are integrated to a certain degree in the multimodal association areas: the parietal, temporal and occipital association areas. The processed signals are finally sent from the areas to the frontal association area. Then, the signals are projected on the cerebral screen, where the processed signals consisting of the information from all the senses are perceived consciously as a picture of the world around a perceiver. The projected pictures are used to be compared with accumulated world pictures of the perceiver. If necessary, the information is manipulated and the results are reflected in the IW. The renewed information is fed back from the frontal lobe to the parietal, temporal and occipital association areas, and so forth. The renewed information is further used to be compared with the pictures that will be continuously experienced one after another, and it can lead to the human unconscious behaviors with a feeling of the free will.

Conclusions

As stated above, if the existence of IW and the screen is postulated, the facts which have been observed in the brain sciences can be explained just in one model. They can converge into one flow of information processing in the brain. It seems that so far no models can uniformly deal with the problems of linguistics, psychology, brain sciences and so on; however, the model presented in Sato (1995) can be used as the comprehensive one of the brain.

Notes

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References

Carter, R., Aldridge, S., Page, M., & Parker S. (2012). *burein bukku* [The brain book] (T. Youro, Y. Uchiyama, & M. Yuzaki Trans.). Tokyo: Nankodo. (Translated from The brain book., by R. Carter, S. Aldridge, M. Page, & S. Parker, 2009, London, UK: Dorling Kindersly).

Funahashi, S. (2005). *zentouyo no nazo wo toku* [Solving the mysteries of the frontal lobe]. Kyoto: Kyoto University Press.

Hara, K. (2005). *noh no chizucho* [The atlas of brain]. Tokyo: Koudan Sha.

Japan Society of Developmental Psychology (Ed.). (2015). *noh no hattatsu kagaku* [The developmental science of the brain]. Tokyo: Shinyo Sha.

Kawashima, R. (2002). *koujikino no burein imeijingu* [The brain imaging of the higher order functions]. Tokyo: Igaku Shoin.

Komachiya, A. (1997). *me no fushigi sekai* [Wonder world of the eyes]. Kyoto: Jinbun Shoin.

Libet, B. (2004). *Mind time: The temporal factor in consciousness*.

Cambridge, MA: Harvard University Press.

Maeda, S. (2008). hansoku mushi [Hemispatial agnosia]. *Higher Brain Function Research, 28*, 214-223.

Mogi, K. (2004). *nohnai gensho: "watashi" ha ikani tsukurareruka* [The phenomena in the brain: How does "I" develop?]. Tokyo: NHK Publishing.

Oozeki, Y. (2016, June). riron gengogaku to ninchi shinkei kagaku [Theoretical linguistics and cognitive neuroscience]. *The proceedings for the 153rd Meeting of the Linguistic Society of Japan* (358-361), Tokyo, Japan.

Osaka, N. (Ed.). (2010). *noh imeijingu* [Brain imaging]. Tokyo: Baifukan.

Pinel, J. P. J. (2005). *baiosaikorojii* [Biopsychology] (K. Sayo, K. Wakabayashi, M. Wakui, & N. Asukai, Trans.). Tokyo: Nishimura Shoten. (Translated from Biopsychology [5th ed.], by J. P. J. Pinel, 2003, New York, NY: Pearson Education).

Rizzolatti, G. & Sinigaglia, C. (2009). *mirah nyuron*[Mirror neuron] (Y. Shibata. Trans.). Tokyo: Kinokuniya Shoten. (Translated from So quelnche fai: Il cervello che agisce e i neuroni specchio, by G. Rizzolatti & C. Sinigaglia, 2006, Milano, Ital: Raffaello Cortina Editore).

Sakata, H. (2006). *touchouyo* [The parietal lobe]. Tokyo: Igagu Shoin.

Sakai, K. (2015). *noh kagaku no shinnjitsu: noh kennkyusha ha naniwo kanngaeteiru no ka* [The truth of the brain science: what do brain scientists think?] [Kobo ebook edition]. Retrieved from http://books.rakuten.co.jp/e-book/

Sato, K. (1995). A model of language acquisition and the language system. *Miyagi National College of Technology Research Reports, 32*, 59-71.

Sato, K. (2009). The mind. *Miyagi National College of Technology Research Reports, 45*, 23-27.

Sato, K. (2010). On grammar. *Miyagi National College of Technology Research Reports, 46*, 37-42.

Sato, K. (2013). What do human beings talk about? : In the search for the psychological reality of syntax. *Sendai National College of Technology, Natori, Research Reports, 49*, 7-10.

Sato, K. (2014). Psychological time in the inner world. *Sendai National College of Technology, Natori, Research Reports, 50*, 11-15.

Sato, K. (2015). Dr. Libet's five hundred milliseconds: Why can human beings check watches? *Sendai National College of Technology, Natori, Research Reports, 51*, 1-4.

Sato, K. (2016). Language acquisition and the Inner World. *Sendai National College of Technology, Natori, Research Reports, 51*, 1-4.