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A Screen in the Brain: The Executive Control and Function of the Frontal Association Cortex

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Animals including human beings get some information around them through sensory organs. However the sensory organs are never given the feedback of the information analyzed in the brain. We, human beings, actually see and feel the outside world. Accordingly, human beings need to see and feel it somewhere in the brain. The mechanism and place to see and feel the surroundings should be needed somewhere in the brain. The fact that BA10 is developed before the development of the areas behind BA10 such as BA9, 45, 46 and 47 sounds mysterious for some brain scientists. If something like a screen exists around BA10 and the frontal association area works in order to make the screen function, BA10 ought to develop before the areas behind it. Because the areas behind BA10 need the screen so as to be completed.

Key Words: the brain, the functional localization, the prefrontal cortex, the cerebral inner world

Introduction

The theory of the brain localization of function has played a key role in the studies of brain sciences. However, how can the information which is analyzed in such a way be utilized in the brain in the end? When the present author repeatedly stares at the functions which are localized in the brain, it seems that the analyses can be conducted in order for the brain to capture an image of its surrounding world depending on the situation. As a matter of fact, we, human beings, actually see and feel the surrounding worlds outside us. What brains do must be understood if it is imagined that the surrounding worlds are reproduced and presented somewhere in the brain. In order to understand it in such a way, a mechanism and a place through which the surrounding worlds outside us are reproduced and presented will be needed in the brain.

Sato (2017) discusses that something like a screen ought to be needed in our brains on the assumption that the inner world is in action in the brain, and it seems that cerebral functions and their networks have been understood rather clearly through the studies of the brain localization of function. In this paper, where a screen can exist in the brain and how the localized functions and their networks can work in totality in the brain will be discussed.

"A conductor" in the brain

What makes the localized functions and their networks operate as a whole in the brain?

Funahashi (2005) and Mushiake (2019) introduce localized functions and their networks in detail which the studies in the field have clarified so far. However, they both indicate how the localized functions and the networks which have been clarified in such a way finally work in the brain in total and harmoniously has not been understood well and such a situation is problematic for the field of the brain sciences.

Mushiake (2019) compares the functions and the networks in the brain to an orchestra and wonders what makes the functions and the networks operate harmoniously. Mushiake says someone like a conductor has not been found in the brain so far and discusses some possibilities.

Nevertheless, why has the brain developed the functions and networks in such a way? Why did the brain need such functions and networks in the process of the development?

What the brain is for animals will be reconsidered at this point.

Localized functions

In order to think over what the localized functions are, some examples of them will be adduced here.

Kinno and Sakai (2021) discusses the localization of the verbal processing module. The grammar center is around the inferior frontal gyrus, the reading-comprehension center is around the ventral side of the inferior frontal gyrus, the word (vocabulary) center is around the parietal association area, and the phonological center is around the temporal association area (p.81).

However, at what time do human beings "use" the module? Wouldn't they use it when they manipulate images in the brain with something motive (Sato, 1995), when they have someone to talk to in their visual fields, and so forth?

Mushiake (2019) says that the supplementary eye field has performance monitoring function. It uses the scene in which a monkey gets a bunch of bananas from one of four banana trees so as to explain the function. Two methods are introduced in that situation: exploration and exploitation. In the method of exploration, the monkey ought to look for the bunch directly from tree to tree. In exploitation, it knows the tree on which the bunch is, and it uses the knowledge to get a bunch. Mushiake says that the two methods are in the relation of a tradeoff. The supplementary eye field will monitor the scene and let the monkey decide appropriately what kind of behavioral pattern it needs to take for such a situation (pp81-83). The field does its part in such a function.

Nonetheless, when does a monkey "activate" the function of the supplementary eye field? It may go without saying. It would activate the function when it is aware of the sight where it can get food such as a bunch of bananas from one of the similar four trees.

In the experiments and observations where the scientists check the actuality of the cerebral localization, visual scenes are mainly given and the participants such as monkeys and mice are made to recognize the experimental situations through an organ of vision. Of course, as for human beings, what they have to do can be given verbally (cf. Funahashi, 2005; Mushiake, 2019: Kawamura, 2021).

The animal brains

The conductor must be in the surrounding world, outside a human being, which is recognized and depicted in the brain. The brain, considering a number of things in the scene fully from every angle, calculates what the human being should do with the surrounding world by using the body which the brain can use rather freely.

Animals are called *dohbutsu (動物)* in Japanese, which means, to the letter, things moving about. By using their brains in an attempt to get information on the world, they have to go around in their environment. In other words, the animal brains have developed, according to need, so as to facilitate their relations to the surroundings. The brain did not have all the functions from the beginning which it needs in order to move around in all the situations. A certain function develops and exists in the brain because it is necessary to move about in a certain environment. A certain thing in the environment builds up a certain function in the brain. If a scene is recognized in the brain, it can collectively and harmoniously activate necessary functions or essential networks to deal with the scene. Something in the scene or a whole scene must be a conductor for the functions and networks in the brain.

Human brains have also developed their functions and networks as necessary in relation to both the world outside human beings and the world inside their bodies. They have built up the association areas more than any other animals and, as a result, can keep quite a number of memories in the brain. They have also advanced the frontal lobe to get language function and, as a consequence, can manage a great amount of memorized information more efficiently (Sato, 2021). So much memory provides the basis for the estimation in daily life at the scenes in which a human being should judge something in order to live. Humanity have made up complicated communities in a relationship to others (Kikusui, 2019). Such humanity also have their brains function collectively and harmoniously so as to have a part in a number of scenes in dairy life in accordance with the way of cognizance of environment. In short, the functions and networks in the brain have developed affected by surroundings. So, the conductor for the brain exists in the scenes perceived and represented in the brain. People live the scenes in daily life in their own ways.

Almost all people can see and feel the surrounding world outside them. Input signals from the sensory organs are used in a self-contained manner in the brain. There are no feedback signals to the organs (cf. Kandel, Schwartz, Jessell, Siegelbaum & Hudspeth, 2014). It means that human beings actually see and feel the surrounding world inside their brains (Sato, 2017).

The brain and the environment

The brain has developed in accordance with its surrounding world, or its environment. It is molded and modulated by the world. Lundborg (2020) says that seeing is believing but touching is understanding (p.89) and discusses the relation between the hand and the brain. It says that the hand has molded the brain. Hands are assigned a relatively large area in the brain for their activity as compared with the other parts of the body because the hands are far more active than the other parts. Synapses of a mouse that is raised in much more stimulative space are far more activated than those of that which is raised in far less stimulative space. Various activities can develop the brain well. Moreover, the hands which are mainly related to tactile sensation operate in concert with the other senses so as to display the surrounding world inside the brain. Tools can work as an extension of hands. The representation of a hand in a perception area of the cortex is changed by having a tool in the hand. It means that an area of the brain has molded by the hand, and it will be altered in accordance with the way hands are used.

The words which are used predicatively are acquired through forming new mirror neurons in the brain. Sato (2021) discusses where and how linguistic syntax can exist in the brain. Predicate words are able to fix sentence patterns for all the sentences and give an interpretation to the sentences (Pinker, 2007). Although they are known as mirror systems in the case of human beings, mirror neurons of a monkey can work like words of motor acts in the brain (Rizzolatti & Sinigaglia, 2009). They can have a function of something like a predicate word. A new act gets entry into vocabulary through forming new mirror neurons or new connections of neurons. In sum, the changes in the surrounding world can alter a linguistic word system in the brain.

As discussed above, an interaction between the surrounding world and the brain is able to change the world itself. The brain also varies in accordance with the changing environment. It means that the world which is recognized and represented in the brain naturally lets the necessary cerebral functions and networks begin to work.

The frontal pole

The frontal pole has strong reciprocal connections with the inside itself and many other parts of the brain. It is said that the pole is concerned with the selection and control of various superior functions. The description can be understood clearly when it is thought that all sorts of information of the surrounding world are drawn together around the frontal pole as the cerebral reproduction of the world.

The frontal pole is known as Area 10 (Brodmann area 10: BA10) on Brodmann's map. Although the area has a relatively low concentration of neurons in the brain, the length of the dendrite in BA10 is quite long and the number of dendritic ramifications is large in comparison (Umeda, 2017). It means that the area has optimal structure for the purpose of putting so much information together.

Umeda (2017) summarizes the cognitive functions of BA10 as follows, although it emphasizes mutual strong connections with the other areas in the brain: (1) the executive function such as working memory and the remembering function of episodic memory including the remembrance by familiarity and the conscious recollection (2) the mentalizing function related to *theory of mind* (3) the multitask function like complicated parallel management (4) the predictive function through which the futures are imagined and the prospective memory function through which what should be done in the future is memorized and recollected properly (pp.356-359). All the four items above are related to the human memory: recollecting something, representing the surrounding world and so forth.

Mushiake (2019) explains the function of BA10. If there is a task set of several attributes such as color and shape, BA10 switches from one task to another, and it selects either the default mode network (DMN) or the dorsal attention network (DAN). DMN is related to the tasks in which the memories in the brain ought to be recollected, and DAN deals with the information from the surrounding world. It will be understood if it is considered in this way: BA10 can choose what kind of information should be projected on the cerebral screen on each occasion.

As discussed above, BA10 is related to the perceived information of the surrounding world moment to moment and the remembering information from past memories.

Working memory

Funahashi (2005) introduces Goldman-Rakic's discussion about working memory. The hypothesis is called *domain-specific working memory*, that is to say, there are, around the frontal association area, several working memory systems for each sort of information: the spatial visual

information processing, the nonspatial visual information processing, language information processing and so on. The systems work parallel and simultaneously (pp.90-92).

The hypothesis means that human beings and laboratory animals in their actual life actually encounter the situations in which they need such working memory systems when they come into contact with the surrounding world around them. Although it might be continuously argued whether such separate systems exist in actuality in the brain, why should they need such separate systems? It will be because the situations where they need such systems exist actually in their real life and they would experience such situations routinely. What can make a number of working memory systems function in parallel and at the same time? Only such a situation as those systems are needed will be able to let several systems function parallel and simultaneously. It will be possible only if such a situation is revived as an image and represented in the brain. What are needed in order for several working memory systems to work are all contained in the situation. When human beings and laboratory animals take action in such a situation, their brains should make necessary systems work for the situation.

The developmental course of BA10

It has recently begun to be known that the area, or BA10, develops earlier than the aeras behind it: BA9, BA45, BA46 and BA47, although it is known that the areas in the brain always develop from the back to the front in sequence (Shaw, Kabani, Lerch, Eckstrand, Lenroot, Gogtay, Greenstein, Clasen, Evans, Rapoport, Giedd & Wise, 2008). Fukuda and Kashima (2010) says that the experimental result for BA10 was difficult to be expected because it has been known that the areas develop much later which possess more complicated or advanced function phylogenetically and ontogenetically. In addition, Fukuda and Kashima says that the reason of the result needs to be considered fully.

The frontal association area

Kawashima (2002) explains that BA46 works pertaining to the function of the central executive in working memory system. There are BA44 and BA45 behind BA46. They are thought to be closely related to the language function especially to syntax (Sato, 2021). Sato (1995) argues that language can be used so as to manipulate images that are retained in human memory. There is BA8 behind BA9 successively. It is called the frontal eye field and is said to be related to the ocular movement (Hara, 2005). The examples of the fields in the frontal association area are linked up with manipulating images on the cerebral screen by using language, shifting the line of sight by using the ocular movement and so forth, that is to say, the frontal association area will be used in order to function the cerebral screen (Sato, 2017). If the function of the association area is taken in that manner, the cerebral screen must be developed earlier than the other areas in the prefrontal cortex. Before the completion of it, several other functions of the association area cannot develop because the functions mature using the screen, or in relation to the screen. If it is discussed like this, the fact that BA10 is completed earlier than the areas around it can be understood naturally.

The executive control and the executive function

Funahashi (2005) says that the most important function of the frontal association area is the executive control. The control makes multifarious functions and networks in the brain work cooperatively and harmoniously in order to accomplish certain intentions and goals in a daily life. The functions and networks in the brain is essential so as to live a daily life. In the course of a daily life, human beings have to, for example, forecast outcomes of behaviors, make a number of decisions, make a lot of choices and so on. The executive function is produced as a consequence of the control.

Funahashi (2005) also gives consideration to the symptoms that appear when the frontal association area is hurt. Although each individual faculty is not damaged such as movement, language, long-term memory and learning, people with the problems may show personality changes. They are enervated due to shortage of autonomy and initiative, do not show much interest in what happen around them, begin to use childish speech and behavior and so on. Funahashi finally says that these symptoms are caused because the function of the executive control is not fulfilled properly.

The facts that are shown in this section will be understood well when it is considered that the frontal association area works in order to make the cerebral screen operate correctly and effectively for human activities and the surrounding world is reproduced and represented on the screen by making use of various types of information from the localized functions and networks. In other words, when the

localized functions and networks operate properly, but the information they supply is not represented properly on the cerebral screen and when something is relevantly represented on the screen, but the representation cannot be utilized as usual, it is able to be adequately explained that the symptoms Funahashi (2005) describes appear, and it is understood sufficiently that each individual function and network are operating properly at that moment.

Conclusions

Brain sciences have so far confirmed the existence of the localized functions and networks in the brain. The reason for the existence of the functions and networks is discussed in this paper. We, human beings, actually see and feel the surrounding world, or the environment, around us. Of course, the information of the world is brought through sensory organs. The signals from the sensory organs are analyzed in the brain. However, there is no feedback of the analyzed information from the brain to the sensory organs such as eyes. The signals that are processed in the brain are utilized exclusively in the brain. It means that we, human beings, have to see and feel the surrounding world around us somewhere in the brain.

In this paper, some topics which should be argued in brain sciences are discussed: how the localized functions and networks operate harmoniously in the brain, what sorts of symptoms appear through the problems in the front association area and so forth. What are discussed in this paper will be understood when it is considered that there is a cerebral screen somewhere in our brains and the surrounding world, or environment, is reproduced and represented on the screen by making use of the information synthesized through the sensory signals which are analyzed in our brains.

It has been said that it is so difficult to understand the function of the front association area. However, as the discussion in this paper shows, the function of the front association area will be to make the cerebral screen operate properly. In order for human beings to get about and be active, the brain has developed what it needs for the purpose. The discussion in this paper with what has been so far discussed successively in Sato's several papers will lead to a better understanding of the whole picture of the brain.

The cerebral screen seems to exist around BA10 when its position in the brain and its structural features are given consideration to.

Notes

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