Autism as seen from the field of neuroscience

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Introduction

Neuroscience is a field of study with the aim of clarifying the workings of the brain, which has many unknown areas. Research which shows in images how the human brain actually functions (brain imaging research) is technically called "research on the mapping of high-level functions in the human brain using non-invasive brain function examination methods" (functional brain mapping research), but it has a short history, and only began in the early 1980s.

From the 1990s, neuroscanning technology advanced in leaps and bounds, and with the use of PET (Positron Emission Tomography) and MRI (Magnetic Resonance Imaging), it even became possible to visualize the appearance of a living brain on a screen. So far, what researchers have been able to elucidate is likely not even 10% of the whole, but we would like to explore the relationship between "autism and brain functions", which has been clarified through their research.

To begin with, the human brain is divided into the cerebrum, the cerebellum, and the brain stem, and these do not function together as one large entity, but have different functions depending on the area. This is called functional localization, and it is well known that this was discovered more than 50 years ago by Canadian neurosurgeon Dr. Penfield. Based on this functional localization, let us touch briefly upon the functions of each region of the brain.

The cerebrum is divided into four main parts, the frontal lobe, parietal lobe, the temporal lobe and the occipital lobe. In the frontal lobe can be found the motor area, which principally moves the body; Broca's area, which controls speech and language; and the frontal lobe, which is related to thought and memory, the most important functions in the cerebrum, making human beings what they are. The parietal lobe contains the sensory cortex, which is related to the body's sensations, including tactile sensation (touch, thermal sensation) as well as deep sensation (depth perception, vibration); a frontal association cortex to recognize direction or the location of object; and also the angular gyrus, which functions during calculations. In the temporal lobe, there is the auditory cortex, for recognizing external sounds; the inferior temporal cortex, which recognizes visually perceived forms; and furthermore, the memory storage area is also found here. The occipital lobe has the visual cortex, related to vision. As well, in the area where the back of the temporal lobe and the bottom of the parietal lobe overlap, there is the Wernicke's area, which controls the understanding of meaning in language. The cerebellum is the area that controls the force or extent of movement and is deeply involved in

what we have been learning about movement. For example, if the cerebellum does not function properly, we can only make stiff movements, like robots. Recently, it has been proved that this area is also related to "thinking", or "remembering how to do something".

If we chart out which part of the brain's areas are damaged in autistic people, the theories that these areas are the limbic system and the cerebellum, or areas in the frontal lobe or temporal lobe, are the most convincing. Meanwhile, research relating to the neurochemical substances that transmit messages within the brain, and research related to the biological measurements of the brain's activity, as well as hormones, are also attracting interest.

Limbic System and Cerebellum damage theory

To begin, we will have a look at the research that was undertaken after the deaths of the 6 Kanner syndrome patients, who were the forerunners of autism research. The research on their brains was undertaken by Margaret Bauman and Thomas Kemper [1)] at the Massachusetts General Hospital, and their method was to dissect the brain and observe it in a microscope examination. As a result, it was discovered that the cerebellum and the limbic system contained undeveloped nerve-cell bodies. The fact that there were abnormalities in these areas before birth means that the processing of all of the information received through the senses is hindered, and that there is a high possibility that this has a notable impact on learning, emotional responses, and general conduct. As well, autistic people excel in one specific skill, and while they may have astounding memory or calculating ability, extraordinary talent in art and absolute hearing, or may make remarkable achievements in those fields, their memory, which requires the processing of information items by association, is weak, and they have a tendency to focus their attention on parts rather than the whole. This means that the central coherence is weak, but this finding may be related to those points.[2)]

Eric Courchesne [3)] has also pinpointed the cerebellum's abnormalities through the use of MRI ,particularly in the part of the cerebellum known as vermal lobules VI-VIII. They showed that the loboules seem to be smaller in these cases of autism but several other researchers have failed to identify cerebellar abnormalities of this type in the autistic patient. So this result is still controversial. In the research using mice and cats, it was found that the vermis at the center of the cerebellum had the function of controlling the volume of sensations[4)] . An abnormality at the bottom-centre area in the brain is thought to trigger confusion or sensory overreaction.[5)]

The frontal lobe damage theory

Let us next take a look at the theory advocated by many researchers, which is that autism arises as a result of damage to the frontal lobe,.

Autistic people often cannot be independent, even if they have a high level of ability, since they have difficulty making plans in daily life.

They have difficulty taking out the trash, and even going to see a doctor, when they feel sick. Also, they are sometimes not flexible at all. For example, they always take only certain streets, go through exactly the same routines before they go to bed and so on. It is thought that there is some problem with their executive function. Executive function is a comprehensive term which includes all of the high levels of cognitive processes, such as the stopping of an inappropriate action6). Recently, psychological research has uncovered severe difficulties planning skills in children with autism. This is probably the reason why some inflexible and stubborn attitudes appear when they try to solve a problem. This type of damage is called executive problems, which is considered to be caused by damage to the frontal lobe of the brain. It is highly likely that this psychological abnormality causes the inflexible action pattern that is typically seen in autistic people.[7)]

Likewise, the frontal lobe functions related to psychology are very complex, and they are not at all at the level of switching on and off in only one of the brain modules. Nevertheless, it has been shown to be taking place often here and there in the following study, conducted by psychologists UtaFrith and Francesca Happé, in collaboration with other researchers from Welcome Department of Cognitive Neurology.[6)8)]

A group of normal people read a series of two types of story as they lay in a PET scanner. The following is an example of the first type:

A burglar who has just robbed a shop is making his getway. As he is running home a policeman on the beat sees him drop his glove. He does not know the man is a burglar, he just wants to tell him he dropped his glove. But when the policeman shouts out to the burglar: 'Hey! You! Stop!' the burglar turns round, sees the policeman and gives himself up. He puts his hands up and admits he did the break-in at the local shop.

The following is an example of the second type of story:

A burglar is about to break into a jeweller's shop. He skilfully picks the lock, then crawls under the electronic detector beam. If he breaks this beam, he knows it will set off an alarm. Quietly, he opens the door to the storehouse and sees the gems glittering. As he reaches out, however, he steps on something soft. He hears a screech and something small and furry runs out past him towards the shop door. Immediately the alarm sounds.

Then the researchers ask them questions, scanning their brains while they are thinking about the answers. The question for the first story is, “Why did the burglar give up?” And the question for the second story is, “Why did the security alarm go off?” The former has to take into account the burglar's psychological considerations, whereas the latter only needs common sense.

The results of the experiment show that people without any problem use one part of the brain to answer one question and another part to answer the other. In answering the question about other people's psychological conditions (the burglar's misunderstanding), the mid-frontal part, which is the most advanced part of the brain, lit up the brightest on the scanned chart. However, there

is no such change when they answered the second question.

The prefrontal area that lit up during the story has wide-ranged connections to other areas on the brain, in particular those needed to pull in stored information and personal memories in order to 'read between the lines' of a story or 'see behind' the face value of that is presented. These skill are closely related to the theory of mind, and are also starkly absent in autism.

Upon using the “skills to see behind”, isn't a critical area of the brain inactive in autism? An experiment to back this up has also been conducted. The same kind of stories were told only to a selected group of people with Asperger's syndrome. Asperger's syndrome is a condition that is characterized by autistic qualities combined with a normal or high IQ. As expected, they were able to find answers even if it took them a substantial amount of time to speculate regarding the burglar's psychological condition. However, they were using a different part of the brain from the one that is normally used by people without any problem. There was no change in the part which lit up during the previous experiment but the part below it lit up this time. This area is known from previous studies to be concerned with general cognitive abilities9) This indicates that Asperger's syndrome patients speculated what the burglar was thinking, using the part of the brain normally used to find out simple cause and effect relationships. In other words, it is thought that they reached the right answer much like figuring out a crossword puzzle by using another part of frontal area to overcome their psychological damage.

Another study successfully narrowed things down to an extremely limited area of frontal lobe. It is implied that this would likely produce action and ability patterns unique to Asperger's syndrome, if the middle part of the frontal lobe called Brodman's area 8 is damaged early in the infantile period. (Fletcher P.C. et al.1995[9],McKelvey J.R. et al..1995[10], Happe et al.1996[11], Volkmar,F.R. et al.1996[12]) There also exists some evidence that in Asperger's syndrome, functional damage to the right hemisphere of the cerebral cortex appears, in the same manner as that seen in non language learning disability (NLD) syndrome(McKelvey J.R. et al..1995[10])[13].

The frontal and temporal lobe damage theory

Along with their inability to read other people's mind intuitively, people with Asperger's syndrome are extremely poor at reading body language and facial expression. According to Simon Baron-Cohen and colleagues at the Department of Experimental Psychology at Cambridge,people with Asperger's syndrome do not seem to know "language of the eyes". On the basic expressions, such as sadness,happiness and anger, they could read faces as well as normal people. For basic emotion, the technique seemed to be to read the whole face-seeing the eyes or the mouth alone was less helpful. But when expressions became complicated, such as scheming, admiration and interest, they could not make them out. When expressions became complicated, normal people found it just as easy to read the expression at looking at the eyes

alone as by lookin at the whole face but people with Asperger's syndrome were particularly perplexed when they tried to read the eye alone[6)14).]

Baron-Cohen advocates 4 systems and their related mechanisms with respect to reading the state of the mind. According to the theory15), in autism, ID (Intentionality Detector) and EDD (Eye－Direction Detector) are in working order, while SAM(Shared－Attention Mechanism) and ToMM (Theory－of－Mind Mechanism) are in disorder. And the locations of each system are indicated as following.

ID (Intentionality Detector) is located inside the superior temporal sulcus.

The location of SAM (Shared-Attention Mechanism) is unknown.

* SAM is considered to be supported by the superior temporal sulcus, and is closely related to EDD in its function, however, further studies will be needed in this regard.

EDD (Eye-Direction Detector) is located on the superior temporal sulcus and the amygdala.

ToMM (Theory－of－Mind Mechanism, pretend in playing) is located on the orbital surface of the frontal lobe cortex.

His views are based on the logic that autism is caused by a disorder located somewhere in the circuit connecting the orbital surface of frontal lobe cortex, the superior temporal sulcus and the amygdala

That is because this circuit relates exclusively to reading the state of mind, and autistic children cannot read the state of mind. There are a number of reports available regarding a malfunction of the frontal lobe, but none of them identifies which particular area of the brain is damaged and in disorder. However, the Baron-Cohen model identifies the area to be orbital surface of frontal lobe cortex and superior temporal sulcus quite accurately.

For example, typical symptoms of the orbital surface of the frontal lobe cortex are anticipated when orbital surface of frontal lobe cortex is damaged. These symptoms include disorder in social judgment, exploitative actions (the patients cannot control their contextual misuse of terminology), extraordinary use of language, decrease in aggressiveness, disinterest, decrease in recognition of danger, excessive sniffing and excessive activities. These symptoms have been proved to be the results of a damaged orbital surface of frontal lobe cortex and are also seen in autistic patients.

Typical symptoms of disorder in social perception, a failure to recognize the emotional meaning of stimuli, a decrease in aggressiveness and fear, and a decrease in associated actions can be seen when the amygdala is damaged. All of these symptoms can also be seen in autistic patients. Finally, it is thought that the damage to the superior temporal sulcus causes not only an EDD deficiency but deficiencies in the related facial information management. Also, it is thought that it causes a speech disorder, depending on the degree of damage to the temporal lobe. (This has something to do with the fact that the speech center called Wernicke's area is located in temporal lobe.) These problems are also seen in autism.[15)]

Thus, Baron-Cohen advocates that autism is caused by specific damage to the frontal and

temporal lobes.

Language area and surrounding region damage theory

Babies are ready to speak a language from birth, or even when they are inside the utero. It is about 2 years old, however, when they start developing verbal transmittion skills, after the two primary language areas, neighbouring area on the side of the brain, become active. One of them is Wernicke's area, where language comprehension is dealt with, and the other is Broca's area, where speech articulation is dealt with exclusively. Although both sides of the brain develop similarly at first, the left hemisphere outgrows the other by the age of 5 in 95% of people, and the speech area in the right hemisphere starts being used for other purposes, such as making gestures. [6)]

According to some research findings, right-handed people use their frontal lobe on the left side of the brain to carry verbal transmittions, and the one on the right side of the brain to understand others' feelings through non-verbal transmittions such as facial expressions, body movements and tone of voice.

Broca's area is located further forward of Wernicke's area, in the side of the frontal lobe. It is located adjacent to the part which controls motor areas such as the jaw, the pharynx, the tongue and the lips. When there is damage to Broca's area, people simply cannot speak even though they completely understand what is being said to them and know exactly what to say. What comes out of their mouth are only fragmentary words, making them sound like a sentence in a telegram. On the other hand, the speech disorder called "Wernicke aphasia" occurs when there is damage to Wernicke's area. Since there is nothing wrong with these patients' speech, it is hard to tell them from people without any problem. It is, however, nothing more than the enumeration of meaningless words, in which incorrect words and mere sounds, not even words, take the place of proper words, not making any sense. Since they do not understand what they are saying themselves, they cannot get a grip on their speech, and they are not even aware that they are making no sense. This is because speech itself is managed outside of Wernicke's area of the brain.

There is a bridge called the "Insula" to connect these two speech areas of Wernicke and Broca. This is a hidden expanse of cortex that lies within the great infold, known as the Sylvian fissure, that divides the temporal and frontal lobes. Where there is damage to this surrounding area, many speech disorders occur. For example, people can not repeat what they have just heard when there is something wrong with the connection of these two areas. This is because words heard (recorded in Wernicke's area) can no longer reach Broca's area, where speech is dealt with. On the other hand, there are some people who keep repeating what they have just heard. This is damage called echo speech, in which a word that comes into one area is automatically sent to the other, and other areas on the cortex cannot interfere because the connection between the two areas becomes

excessively active. [6)]

As the abovementioned transmission related symptoms can also be seen in some autistic patients, a theory of autism and damage to the language area in the left frontal and temporal lobes and the surrounding region, is advocated.

Relevance of neurotransmitter substances

Neurotransmitter substances refer to chemical substances radiating from one neuron to another, and approximately 50 of them are functioning inside the human brain. There are preferences for these, depending on the location, and the specific receptors to handle each type substances are known. There are at least 3 to 4 kinds of receptors corresponding to each neurotransmitter substance. The way each one of them is received is unique, and also it causes a different phenomenon in the cells of a receptor.[15)] The only neurotransmitter substance which is seen at an unusually high level in the brain of autistic patients is serotonin. It was discovered that the serotonin concentration in the blood was unusually high in 30 to 50% of autistic children. It is thought that this unusually high level of concentration results from abnormal functions of the blood platelets, in the absorption and storage of serotonin. The unusually high level of serotonin can also be seen in children with only a mental disorder, however, there is no clear reason for this.[7)]

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