Japanese Language and Cerebral Function-brief review based on a few recent Japanese literatures

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1.Comprehension and Expression of Language

How does a human being understand and express words? I am going to summarize it briefly. First, we will describe how comprehension works. Sound travels in the form of vibrating air and is captured by the ear, where this vibration is transmitted via the ear ossicles to the inner ear fluid. It is then converted into nervous impulses, which travel through the cochlear nucleus of the brain stem, upper olivary nucleus, lower colliculus, medial geniculate body, and through the acoustic radiations it reaches the cerebral cortex's auditory area in the temporal lobe, under the lateral fissure. This is primary auditory area, surrounded by the secondary auditory area. The secondary auditory area includes the Wernicke area, the posterior motor speech center. Sound arriving the auditory area is recognized as human speech and these signs (words) are converted into concepts and their meaning is understood.

Now we will describe how word expression works. When an individual understands the meaning of the words he is listening, a desire to speak is generated. Depending on the content of such desire, strings of phonemic signs are formed in the motor speech center (left motor speech center for right handed individuals). An expression order is transmitted through the brain stem and is transmitted to the phonetic organs through various cranial nerves, including the trigeminal, facial, and glossopharyngeal nerves. Phonetic sound waves (words) are formed as a result of the complex coordinated movement of the muscles controlled by these nerves.

When words are used as a form of communication, processes that occur from the moment the speaker's transmission is expressed as words, up to the point where his interlocutor understands them, are called chain of words. There is a close relation between the comprehension route and the expression route. We not only speak but we listen to ourselves while we speak. Listening to our own voice while we speak we can adjust its tone, rise or lower its volume, and control its speed. The process by which the speaker listens to his own voice is called auditory feedback. It is thanks to this function we can avoid speaking with an inappropriate tone or voice. Besides this function, some tongue and lip muscles continuously sense elasticity and transmit this information to the brain through sensory nerves to further control our voice.

When a human being listens and understands words or articulates them, the central nervous system and peripheral muscles carry out many functions in an instant. Slight changes in the way they interact can result in profound alterations.

2.Reading

We have briefly described comprehension and expression of words. We will now describe how the brain works when a human being reads. The article studies brain processes during loud and silent reading. It can be summarized as follows:

Methods

In 1992 and 1993 a group that included the author published the results of PET studies during aloud reading of Kanji (Chinese characters, representing meaning and sound) and Kana (Japanese alphabet representing sound only). In that study, groups of 5 individuals were formed and they were asked to read aloud words consisting of 2 Kanjis, 3 Kanas, and 3 Kana strings with no meaning. They were instructed to fixate their sight on a control point. Regions showing increased blood flow during loud reading as compared to when looking at the control point were analyzed and designated regions of interest (ROI). The test was conducted three times on each individual and 31 regions of interest were determined, each one with a 16mm diameter.

Results

1) While Kanji words activated the infero-posterior portion of both temporal lobes, Kana words and meaningless Kana strings activated the lateral portions of both occipital lobes and infero-posterior portions of the left temporal lobe.

2) There was little activity of the gyrus angularis in all tests.

3) Regarding the motor system, the infero-posterior portion of the frontal gyrus including Broca's area, supplementary motor area, and basal nuclei were active during all loud reading tests.

The drawback of this method of analysis is that blood flow changes can only be determined in a limited number of regions and the extent of activated regions is unknown. In order to determine the extent of activated regions, data was analyzed once again using the Statistical Parametric Mapping (SPM) software, version 1996.

Extent of activated regions during loud reading:

Activated region images were rendered on top of images of the resting brain cortex. In Kanji word, Kana word, and meaningless Kana string tests, activation of the posterior portion of the inferior frontal gyrus, the posterior portion of the superior temporal gyrus, and areas around the central sulcus was noted. While in Kanji word tests activation of the inferior, posterior, and lateral portion of the occipital lobe was documented, in the Kana word tests there was no activation of the posterior and lateral portions of the occipital lobe, only of its inferior portion. In the meaningless Kana string tests there is a broader activation of the occipital lobe. The regions activated during the Kanji and Kana tests can be considered areas related to existing word processing and are the aggregate of two tests. Areas activated during Kana word and meaningless Kana string tests can be considered areas related to sound processing, and are close to areas used during the meaningless Kana string tests.

According to coronal cut images gyrus fusiformis is utilized mainly during Kanji reading and inferior occipital gyrus during Kana reading. Common areas for Kana and meaningless Kana strings include lateral and superior regions of the deep portion of the posterior branches of the lateral fissure of Sylvius.

If the Kanji images are subtracted from the Kana images, the middle occipital gyrus remains. The middle occipital gyrus together with the inferior occipital gyrus and later occipital gyri including the two aforementioned areas are important for loud Kana reading. On the other hand, if Kana images are subtracted from the Kanji images, no area remains. Therefore, Kanji word areas are included within the Kana word areas. If Kana images are subtracted from meaningless Kana images, the posterior portion of the inferior temporal gyrus remains, but somewhat anterior to the Kanji areas. We assume this area is related to visual image meaning processing required for Kana words.

Clinical significance of activated regions during loud reading:

When the gyrus fusiformis or inferior temporary gyrus (activated during Kanji reading) is damaged, selective Kanji alexia and agraphia occur. It is known that this region (Brodmann area 37) is activated when writing Kanji, and therefore the author believes Kanji spelling information process is carried out mainly in this region. The middle/inferior occipital gyrus (activated during Kana reading) rarely suffers isolated damage. However, another researcher recently had the opportunity to examine a patient with pure selective Kana alexia due to a middle/inferior occipital gyrus subcortical hemorrhage. The author believes Kana shape information exists in this region. It has also been suggested that inferior occipital gyrus or lateral occipital gyrus play a role in the first stage of symbol shape processing. The middle/inferior occipital gyrus plays an important role in Kana reading.

Comparison between reading aloud and silently:

As it was previously described, during loud Kana reading the occipital lobe and the region surrounding the central sulcus were activated. During silent reading, the central sulcus area was not activated, only the lateral occipital gyrus. If images taken during silent reading are subtracted from those taken during loud reading, regions related to articulation and phonation remain, including the primary sensitive/motor area, a portion of Broca's area, supplementary motor area, and the frontal part of the insular gyri. Common regions activated both for reading aloud and silent reading include the occipital lobe, precentral gyrus adjacent to the middle frontal gyrus, operculum parietalis, and superior temporary gyrus.

Clinical significance of activated regions:

The opercular region of the precentral gyrus and the frontal region of the insular gyrus within the primary sensation/motor area remain when silent reading images are subtracted from loud reading images. When these regions are damaged, verbal apraxia occurs. If the supplementary motor area is injured, there is a temporary delay and speech turns slow. It is believed that regions activated during loud and silent reading are regions related to reading itself but not with articulation or phonation. The precentral gyrus adjacent to the posterior region of the medial frontal gyrus is supposed to be the place where visual images of words or symbols arrive from posterior regions. On the other hand, if damage is inflicted on the operculum parietalis or frontal parietalis causes phonemic distinction difficulties. Shape and phonemic information coming from posterior regions is processed in the regions commonly activated during loud and silent reading and are then transmitted to the primary motor area.

It has not been defined, however, if the different mechanisms observed during loud and silent reading are specific to Japanese or if it is applicable to other European languages. :

In order to further interpret the results of these tests, additional relation with clinical cases must be evaluated. Therefore, it is considered necessary to evaluate more cases.

3.Recognition of phonemes:

The relation between word and symbol reading and writing learning and phoneme recognition has recently been brought into attention. An article titled as"Measurement of brain activity related to inner language and Kana written word and symbol processing" by Norio Fujimaki in Journal of Linguistic Phonetics Medicine, studies brain activity during phoneme processing. It is summarized below:

Tests were conducted in which shape, phoneme, and meaning processing were progressively changed displaying Kana symbols, similar symbols and symbol strings. Activated areas and times were measures using fMRI and MEG. In order to further divide phoneme processing other tests were carried out in which only inner language is required.

Regarding shape processing, increased activity was registered in the lateral and frontal visual area, gyrus fusiformis, and inferior occipital lobe 200ms after a stimulus was provided.

(1) No difference was noted between Kana symbols and similar symbols.

(2) No difference in activity between the left and right hemispheres when a single symbol was presented, however, the left hemisphere had greater activity when symbol strings were presented.

During phoneme processing, activity was registered in Wernicke's area, supramarginal gyrus, and Broca's area 200ms after the stimulus was presented. In phonemic processing subdivision tests, the 3 areas related to phoneme processing (Wernicke's area, supramarginal gyrus, and Broca's area or insular gyri) showed noticeable load dependence, therefore concluding they are activated in conjunction.

Meaning processing could not be separated in these tests, but is possible that there was activity in the same areas as for phoneme processing, such as Wernicke's area.

This article attempts to draw light over temporal and spatial brain activity by comparing the results of fMRI and MEG. Improved study methods and new tests are expected to generate detailed studies and analysis of language processing.

Discussion

Cases with middle/inferior occipital gyrus lesions (activated during loud Kana reading) demonstrate:

- Difficulty to read Kana and a tendency to confuse symbols with similar shapes (for example, i and ko).
- Slight deterioration in shape discrimination, such as circles from ovals.

These findings are similar to those displayed by children with LD (learning disabilities),
who have a diminished spatial and visual sensation capacity, have trouble recognizing shapes and symbols, and have a diminished basic language capacity for reading and writing. It can therefore be postulated that these children with LD might have a problem with their middle/lower occipital gyrus function. As for the tendency to confuse similar symbols such as i and ko during reading, children with LD mix up these symbols or write them inversely, as if looking at them in the mirror. Is there a difference in brain function when reading and writing? As the author states, these regions transmit information regarding Kana symbol shape, and they are activated in the first stages of symbol shape processing. It is therefore theorized that they have some relation to LD.

New understanding of brain reading and writing functions has increased accordingly with the development of new cerebral function imaging techniques. Clinical cases presenting focal injuries have also been observed. If brain function were further deciphered, this new information would be of great value in the early detection of children at high risk for disability, so that adequate education is provided. If the cause can be determined by which a child views and recognizes things differently, a better understanding of children with disabilities will prove very useful for them.

Referance

Yasuhisa Sakurai: Neural functions during silent and oral reading determined by PET. "Approach to Linguistic Functions Through Images and Brain Processes" in Linguistic Phonetics Medicine,Vol. 42 No 2, 2001.

Norio Fujimaki