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Special Feature Article

Imaging Study for the Effect of Psychoanalytic Psychotherapy

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Abstract

Although a relationship between the mirror neuron system and transference-countertransference in psychoanalytic psychotherapy has been suggested, how psychoanalytic psychotherapy alters the mirror neuron system remains unknown. We reconstructed the tracts interconnecting cortical regions believed to be part of the mirror neuron system associated with schizophrenia and anxiety. Here we discuss the findings of an imaging study on the effects of psychoanalytic psychotherapy for several psychiatric disorders obtained from previous research on the mirror neuron system.

Keywords: psychoanalytic psychotherapy, mirror neuron system, diffusion tensor imaging, autism spectrum disorder

Introduction

The author has been working to visualize the neural fibers related to the mirror neuron system, considered to be related to transference-countertransference, in order to clarify

the neuroscientific basis of transference-countertransference, which is the core of psychoanalytic psychotherapy. Transference-countertransference refers to the emotional reactions that occur in the

mutual relationship between the therapist and patient, but it is not exclusive to psychoanalytic psychotherapy. Transference-countertransference takes place in all therapeutic situations. Transference is the emotion patients feel toward therapists in the context of their mutual relationship, while countertransference is the emotion therapists feel toward patients.

This paper focuses on and outlines the following three topics as image-based studies on the effects of psychoanalytic psychotherapy: I. The Mirror Neuron System and Psychoanalytic Psychotherapy; II. Visualization of Mirror Neuron System-related Nerve Fibers; III. The Mirror Neuron System and Autism Spectrum Disorder.

The research on mirror neuron-related nerve fibers before and after psychoanalytic psychotherapy described in this paper was conducted by the author with the approval of the Kansai Medical University Ethics Committee. The author obtained verbal and written consent from the subjects themselves and their guardians to protect their personal information at the time of publication.

I. The Mirror Neuron System and Psychoanalytic Psychotherapy

The mirror neuron system (MNS) is a neural network related to neurons that

fire together when performing an action and watching someone perform an action, like a mirror image. MNS, in conjunction with the mentalizing system,¹⁾ plays a role in “imitation” and “empathy”, which are essential for human sociality. The phenomenon of a person's feelings being transmitted from one to another, such as through yawning, can be explained by MNS. When someone is crying in front of you, you may feel sad even if you do not know the circumstances. Empathy through MNS is a different kind of empathy from that which comes from understanding the circumstances of the person who is crying. It is a type of empathy similar to yawning, where seeing someone crying causes you to become like the person in front of you at a deep muscle level through MNS, and the emotions corresponding to the crying expression are picked up by the limbic system, causing you to feel the same emotions as the person in front of you.^{11) 19)}

Gallese, V. et al. suggested that MNS may be related to the “transference-countertransference” theory proposed by Freud, S.⁹⁾ “Transference-countertransference” refers to unconscious communication between therapists and patients. Modern psychoanalysis is based on the hypothesis that countertransference offers the most important information for understanding what is happening in

the patients' mind. Gallese and colleagues believe that this psychoanalytic hypothesis is supported by the discovery of unconscious communication through embodied simulation via MNS. They point out that “transference-countertransference” occurs in a two-way interaction between therapists and patients. They add that in psychoanalytic treatment, the use of a couch and therapists being out of sight to observe patients may be a way of minimizing the amount of information flowing from the therapists to patients, making the therapist more like a blank screen for the patient, and so it is easier to draw out the patient's fantasies. They also suggest that there may be harmful effects of the therapist being out of sight of the patient using a couch, and that this may prevent the patient from understanding and internalizing the therapist's reactions. Incidentally, there is a tendency in Japan for psychoanalytic psychotherapy to take place face-to-face once a week without the use of a couch.²³⁾ According to Fukumoto, psychoanalytic psychotherapy is a treatment in which patients undergo transformation and deepen their understanding of themselves and others through sharing experiences and having emotional contact with the therapist, who is a stranger.⁸⁾

Fonagy, P. et al. conducted a randomized controlled trial involving 129 treatment-resistant depressed patients, dividing them into a treatment-as-usual (TAU) group and long-term psychoanalytic psychotherapy (LTPP) group (which involved the addition of psychoanalytic psychotherapy (50 minutes once a week/60 times, over about 18 months) to TAU). Two years after the treatment had ended, the partial remission rate as measured by the Hamilton Depression Rating Scale was 4% in the TAU group and 30% in the LTPP group.⁶⁾ The results of this study suggest that the effects of psychoanalytic psychotherapy are more likely to be maintained over the long term than those of standard treatment. The author believes that the “transference-countertransference” relationship between the therapist and patient, which is the essence of psychoanalytic psychotherapy, may induce structural neural changes in parts of the patient's brain that maintain its effectiveness over the long-term, and this led to the MNS research using two-tensor tractography presented in the next section.

II. Visualization of Mirror Neuron System-related Nerve Fibers

The author has worked to visualize MNS-related nerve fibers using diffusion tensor imaging analysis of

brain MRI. The visualization of nerve fibers by diffusion tensor imaging analysis is based on the movement of water molecules measured by MRI. In nerve fibers, water molecules form a sharp ellipsoid along the fiber wall. In well-developed nerve fibers, the extension of myelin causes water molecules to form a more sharply defined ellipsoid. The main parameters used in this diffusion tensor imaging analysis are fractional anisotropy (FA) and trace. As the name suggests, the FA value is a parameter that indicates slight anisotropy. The FA value ranges from 0 to 1, and the closer the diffusion of the water molecules is to being free and spherical, the closer it is to 0. Nerve fibers are visualized by connecting voxels whose FA values are close to 1. If there are voxels with FA values close to 0, the visualization of nerve fibers is interrupted. In single-tensor tractography, if there are crossing fibers, the FA value becomes close to 0 and visualization of nerve fibers is interrupted. The analysis software used by the authors, two-tensor tractography, has been improved to detect crossing fibers and visualize each fiber. MNS-related nerve fibers are long nerve fibers bridging brain regions that are far apart, and in single-tensor tractography, this visualization is interrupted by crossing fibers.

MNS-related nerve fibers depicted using two-tensor tractography are shown in the figure. In this figure, MNS-related nerve fibers (green fibers within yellow circles) cross over the MNS-related gray matter (blue area: premotor cortex, pink area: inferior parietal lobule). MNS is a neural circuit that includes brain regions related to perception and execution, such as the premotor cortex and inferior parietal lobule.^{12) 24)} Mukamel, R. et al., using single-cell recording, showed that the supplementary motor area, which is part of the premotor cortex, contains mirror neurons that discharge both during execution and observation,¹⁸⁾ and fMRI has also been shown to mirror neurons that may be present in the inferior frontal gyrus, which includes the premotor cortex,¹³⁾ and inferior parietal lobule.³⁾ According to a study by Mars, R.B. et al. using resting-state fMRI to investigate functional connectivity of the parietal lobes of humans and rhesus macaques, functional connectivity of the human parietal lobe and premotor cortex was stronger than that of the rhesus monkey.¹⁷⁾¹⁷⁾

The authors used two-tensor tractography to successfully visualize MNS-related nerve fibers connecting the premotor cortex and inferior parietal lobule in patients with schizophrenia, and reported that FA of

MNS-related nerve fibers in schizophrenia was correlated with the sense of familiarity felt by patients.²¹⁾ At the 117th Annual Meeting of the Japanese Society of Psychiatry and Neurology, the author reported on the interim results of a study of MNS-related nerve fibers in patients with anxiety disorders before and after psychoanalytic psychotherapy.²²⁾ Although the number of patients with anxiety disorders studied was small (10) and the results were still preliminary, FA of MNS-related nerve fibers on the left side of the brain increased in 8 out of 10 patients with anxiety disorders. In healthy people, FA of the superior longitudinal fasciculus, which contains MNS-related nerve fibers, reaches its peak on average in one's 20s.¹⁵⁾ Five of the eight patients whose FA increased were in their 40s, when FA is considered to decrease with age. The author hopes that the experience of a “transference-countertransference” relationship through psychoanalytic psychotherapy may bring about changes in the brain that defy the effects of aging. As described above, the degree of “transference-countertransference” considered to be related to MNS may correspond to changes in FA of nerve fibers, so it will be necessary to develop a psychological scale that can quantify the “transference-countertransference” relationship in the future.

III. The Mirror Neuron System and Autism Spectrum Disorder

Autism spectrum disorder (ASD) is a neurodevelopmental syndrome characterized by: (i) impaired social communication, and (ii) particular and repetitive behaviors. MNS is impaired in patients with ASD.⁵⁾ There are many reports on the impairment of MNS in those with ASD, but the results vary. In fMRI studies, increased blood flow in the MNS region was commonly observed in ASD patients during behavioral observation, while significant decreases in blood flow were observed in multiple brain regions not related to MNS.²⁾ In a volumetric study, it was reported that the volume of gray matter in the MNS region actually increased in ASD patients.¹⁶⁾ In a connectivity study using fMRI, functional connectivity between the mentalizing system and MNS did not work as in healthy individuals.⁴⁾ In a diffusion tensor imaging study, it was reported that FA of MNS-related nerve fibers was decreased in ASD patients.⁵⁾ Variations in the results of imaging studies are considered to be due to differences in the types of exposure stimuli used in each study, differences in the age of patients, and fact that disorders of ASD extend not only to the MNS region, but also to surrounding

regions connected to MNS and connective tissue in these regions.²⁾

The author has administered psychoanalytic psychotherapy to multiple patients with ASD. She has reported on changes in social skills of such patients through psychoanalytic psychotherapy and the long-term maintenance of these effects at JAAPP and the Japan Psychoanalytical Association. From this clinical experience, it can be hypothesized that psychoanalytic psychotherapy for patients with ASD in whom MNS-related nerve fibers are impaired may lead to strengthening of MNS-related nerve fibers and improved quality of life through the transference-countertransference relationship. In the future, the author hopes to apply the two-tensor tractography method described above to patients with ASD and clarify whether psychoanalytic psychotherapy for such patients contributes to the improvement and maintenance of their social skills by strengthening MNS-related nerve fibers through myelination and other means.

As a form of psychotherapy for patients with ASD, treatment based on applied behavioral analysis is more widely known than psychoanalytic psychotherapy. Treatment based on applied behavior analysis is a form of psychotherapy that uses operant conditioning to focus on “what the

patient does, when, and how it turns out” and is quite different from psychoanalytic psychotherapy, which uses the “transference-countertransference” relationship to understand and perceive the patient. An increase in FA of MNS-related nerve fibers in ASD patients after treatment based on applied behavioral analysis has already been reported.²⁰⁾ However, there is also active debate in the field of psychoanalysis about the effectiveness of psychoanalytic psychotherapy for ASD patients. Fukumoto notes that the core triangular principle of psychoanalytic approaches, which involves relating to the other person and understanding that relationship from a bird's-eye view, is difficult to apply for ASD patients. Conversely, the psychoanalytic approach, based on its other characteristic stance of value neutrality, not only seeks to interact with non-autistic aspects of the patient, but also to understand the various manifestations of the autism spectrum as a unique way of life, and has the potential to help promote mutual coexistence.⁷⁾ Hirai states that psychoanalytic psychotherapy can be an irreplaceable experience for ASD patients, like being taught how to play a sport if you are not good at physical exercise.¹⁰⁾ Kinugasa proposed “layered-clothes syndrome” and stated that identifying autistic spectrum

tendencies is important for psychoanalytic psychotherapy for this type of patient, and that therapeutic ingenuity is necessary, such as setting goals that differ from those for neurotic patients.¹⁴⁾ Since Kinugasa's proposal of "layered-clothes syndrome", it has become known that even when psychoanalytic psychotherapy is carried out for patients with ASD, it is difficult to achieve the same results as with neurotic patients. The author believes that psychoanalytic psychotherapy, unlike the educational training and treatment practiced by the majority of society, can sometimes slowly change the behavior of ASD patients. This process involves looking at the patient's inner world together with the therapist through "transference-countertransference," which helps ease the tension inherent in object relations. A treatment goal for psychoanalytic psychotherapy tailored to ASD patients has not yet been fully established. However, even individuals with ASD may at times gain some introspective insight, if they are able to engage with their inner world. When setting treatment goals, therapists should understand the patient's limitations and needs, and collaboratively consider them as the patient gradually changes.

Conclusion

In this paper, after outlining the relationship between MNS and psychoanalytic psychotherapy, we discussed representative imaging studies on MNS to date, as well as the author's attempts to visualize MNS-related nerve fibers, and then discussed the author's plans to investigate MNS-related nerve fibers in ASD patients before and after psychoanalytic psychotherapy.

The author has been working to visualize MNS-related nerve fibers in the brain, considered to be related to transference-countertransference, in order to clarify the neuroscientific basis of transference-countertransference, which is central to psychoanalytic psychotherapy. Research that bridges psychoanalysis and neuroscience through the application of brain imaging analysis is relatively new and a challenge in an unknown field, but the author will continue research in this field and work to obtain results that contribute to the selection of treatments and improvement of the prognosis in psychoanalytic psychotherapy.

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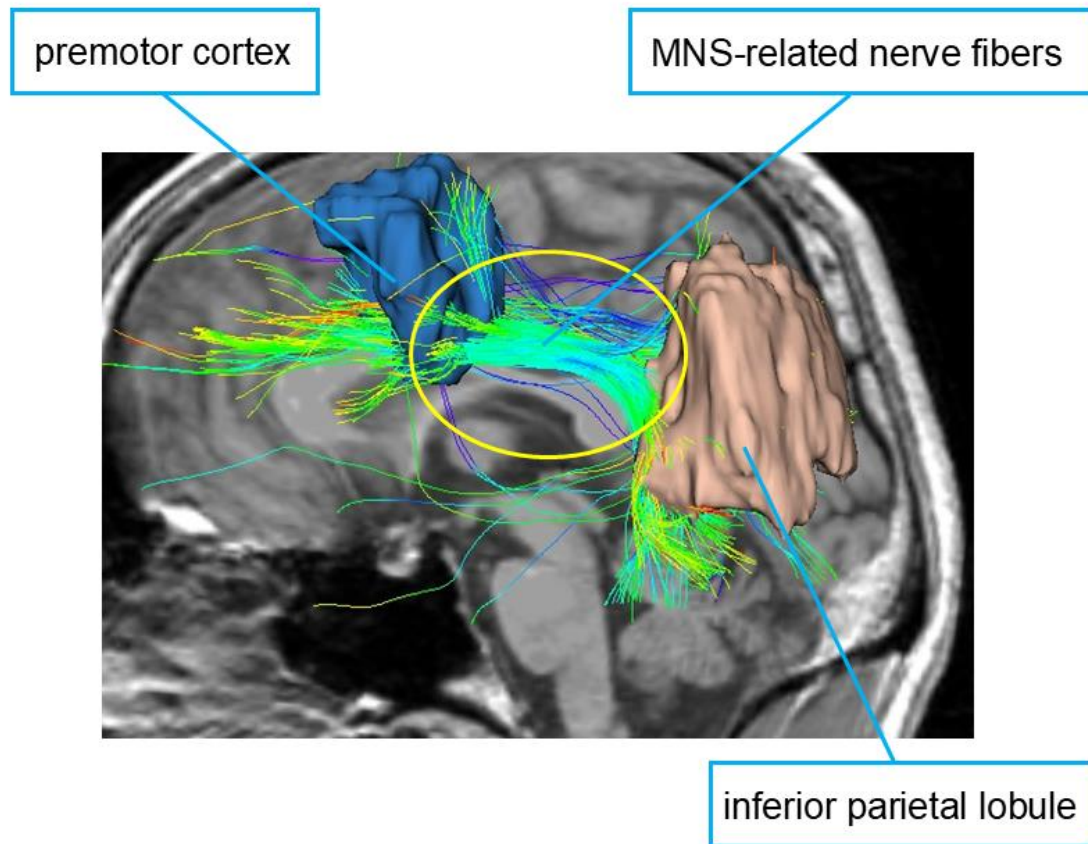


Figure: Neural fibers related to the mirror neuron system visualized by two-tensor tractography