Hallucinations Produced by Electrical Stimulation of the Temporal Lobes in Schizophrenic Patients

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Electrical stimulation of the temporal lobe was performed in chronic schizophrenic patients to treat the auditory hallucinations. During electrical stimulation, there appeared different kinds of hallucinations.

The characteristics of the hallucinations produced by the temporal lobe stimulation greatly differ from those of the schizophrenic hallucinations. Visual and auditory hallucinations by the temporal lobe stimulation might depend on different pathophysiological mechanisms. The kinesthetic and vestibular hallucinations could be considered as a basis of the pathophysiological mechanism of the auditory hallucinations. The temporal lobe stimulation for the auditory hallucinations in schizophrenic patients showed some therapeutic effectiveness.

By electrical stimulation of the human temporal lobe, some sorts of perceptual phenomena might be observed occasionally. These perceptual phenomena were considered similar to hallucinations in respect to the absence of the perceptual objects. Williams and Freeman⁶ have reported that chronic auditory hallucination is suppressed by amygdaloidection. Endo et al.¹⁻⁵, observed that chronic auditory hallucinations might be suppressed by electrical stimulation of the temporal lobe cortex of schizophrenic patients instead of amygdaloidection. On the other hands, Penfield⁷, Jasper⁸ and Delgado et al.⁹, observed different reactions produced by electrical stimulation of the cerebral cortex and its deep portion in epileptic patients. The authors have also observed the same reactions by electrical stimulation of the temporal lobe not only in epileptic but also in schizophrenic patients.

In this report, hallucination-like phenomena caused by the electrical stimulation of the temporal lobes in schizophrenic cases will first be mentioned. Further therapeutic effects on chronic auditory hallucinations of schizophrenics will be discussed. Needless to say, the temporal lobe would play an important part in memory. In fact, some of the authors have attributed temporal lobe hallucina-
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Systhips and Methods

The total number of cases was 17 (male: 8, female: 9), consisting of chronic schizophrenic patients aged from 18 to 46 years. All of the cases were not improved with physical, psychopharmacological and even psychosurgical treatments.

In most of these cases, craniotomy of the non-dominant side was performed, and the exposed temporal lobe cortex was electrically stimulated directly. In other cases, multi-electrode needles were implanted in the temporal cortex or the deep portion\(^\text{10,11}\) of the temporal lobe and then electrical stimulation was given through each electrode a few days after operation. In either of the above cases, different response and changes of auditory hallucinations during electrical stimulation were observed. Electrical stimulation consisting of square waves at 100 cps 3 msec in duration and at 4-8 volts in intensity, was repeated for a period of 5 sec.

In rare cases, clouding of consciousness, fever and psychomotor phenomena were noted, but these unpleasant symptoms disappeared shortly after the removal of the electrodes.

Results

In these procedures, different perceptual phenomena were sometimes produced during electrical stimulation of the temporal lobe. These perceptual phenomena include hallucination proper, pseudo-hallucination and illusion.

The perceptual phenomena were considered as hallucination-like phenomena, as they had no perceptual objects and were resultant exclusively from the electrical stimulation. This concept is in good agreement with Niedermeyer's\(^\text{12}\) view in the sense that the hallucination is defined in a broader sense and is not rigidly distinguished from pseudo-hallucination and illusion.

1. Types and Contents of Hallucinations

The types of hallucinations resulting from electrical stimulation of the temporal lobe were observed in the order of the visual hallucinations, hallucinations of bodily sense and auditory hallucinations as shown in Table I. On the contrary, hallucination of taste scarcely appeared and hallucination of smell did not appear at all. Although changes in perception of exterior sounds and in emotion are not real hallucinations, these are taken up in this paper in connection with hallucinations. A case shown in Fig. 1 was operated upon trepanation and the exposed temporal cortex was electrically stimulated. The stimulating point was marked “\(\times\)” as shown in Fig. 1, and the electrical stimulation resulted in
**TABLE I. Type of Hallucinations by Electrical Stimulation of the Temporal Lobe**

<table>
<thead>
<tr>
<th>Case</th>
<th>Temporal lobe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stimulation of cortex</td>
</tr>
<tr>
<td>Visual hallucination</td>
<td>5 (29.4%)</td>
</tr>
<tr>
<td>Auditory hallucination</td>
<td>3 (17.6%)</td>
</tr>
<tr>
<td>Hallucination of taste</td>
<td>1 (5.9%)</td>
</tr>
<tr>
<td>Hallucination of smell</td>
<td>0</td>
</tr>
<tr>
<td>Hallucination of bodily sense</td>
<td>4 (23.5%)</td>
</tr>
<tr>
<td>Other responses</td>
<td></td>
</tr>
<tr>
<td>Changes of exterior sounds</td>
<td>5 (29.4%)</td>
</tr>
<tr>
<td>Changes in emotion</td>
<td>3 (17.6%)</td>
</tr>
</tbody>
</table>

Fig. 1. Responses by electrical stimulations of the temporal lobe cortex and the deep temporal portion.

1. Blue light is seen in front of the eyes. Oblivion of memory of numbers.
2. The body as a whole is shrunken. Oblivion of memory of numbers.
3. The body is swung. (Pitching). Alteration in the order of numbers.
4. The body is swung at angle of 45° in the center of the head.
5. The body is shifted backward. The body is lifted up.
6. Vocal tone changes lower.
7. “Splendid, splendid” heard.
8. “It’s so strange” heard.
9. The sound becomes vague.
10. Speech arrest (1234567......forgotten).
11. Alteration in the order of numbers.
12. The body becomes vague. The body becomes smaller.
13. Inserted point of the deep electrode.
hallucinations with the following expressions; “the body is moving backwards,” “the body is lifted up”, “the body becomes vague” and “the body becomes smaller”. These are the hallucinations of bodily sense and bodily movement. In a case, there was such an expression as “the sound becomes vague”, showing a change to external sounds. The so-called “speech-arrest” phenomenon was also noted in a case when electrically stimulated during repeating a series of numbers. In this case were implanted multi-electrode needles on the temporal cortex and its deep portion. During electrical stimulation of the temporal cortex, auditory hallucinations such as saying “it’s so strange” and “splendid, splendid” were observed. At the same time there occurred a lowering of the vocal tone and alteration of the order of numbers of 5 digits. Electrical stimulation of the deep temporal portion resulted in elementary visual hallucinations such as “blue light is seen in front of the eyes” and the hallucinations of bodily sense such as “the body as a whole is shrunken” and “the body is swung slowly”. At the same time, when

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**Fig. 2. Responses by electrical stimulations of the deep temporal portion.**

1. Eyes are brightening. Round brightness. The inner part of the eyes is painful. It is a shock (raises the body and breathes deeply).
2. The part at the depth of 2 cm is painful. Feel acute pains. Pains are scattered. Ultra-violet rays.
4. Unresponsiveness: looks strange. “I see a woman in the head” (grinning). Raises the upper part of the body. Movements like sucking.
a series of numbers were repeated, there appeared not only an alteration of the order but also some oblivion of numbers. Although the temporal lobe has been known to play a great role in memory, it will not be discussed here in further detail.

Fig. 2 shows the result of electrical stimulation through the two multi-electrode needles being inserted parallel into the deep temporal portion. There appeared simple visual hallucinations such as “the eyes are brightening”, “round brightness”, “ultra-violet rays”; and vague somatic sensations such as “shock”, “scattered pains” and “sense of hurt”. This patient laughed saying “I am delightful”.

Change in emotion such as grinning was observed following a complicated visual hallucination with the expression, “I saw a woman in the head”.

Contents of these different hallucinations are summarized in Table II. Among visual hallucinations there appeared various types from elementary ones such as “round brightness” to complex ones such as “the profile of my attending doctor” and scenic ones such as “several men talking around the speaker are seen.”

The elementary visual hallucination did not result from electrical stimulation of the temporal cortex, but from that of the deep temporal portion. The auditory hallucination included simple ones such as “sounds from a speaker”, human voices such as “someone is murmuring in the ceiling”; and moreover, with some meaning such as “it’s so strange”. Thus, different auditory hallucinations, from simple to complicated, were observed. The patient perceived these auditory hallucinations in neither way of being “spoken to” nor “made”, but merely received it as human voice. Further, it should be noted that these auditory hallucinations were induced not by electrical stimulation of the deep temporal lobe, but by that of the temporal cortex. Change in exterior sounds, as shown in the table, is the phenomenon that the pure tone (given as exterior sounds) is perceived in alterations during the electrical stimulation. For example, when a patient was subjected to electrical stimulation of the temporal lobe at the intensity of 6 volts while listening to a pure tone of 2000 cps, this tone was perceived respectively as “loud”, “strong” or “low”. These phenomena were almost always observed with the temporal cortical stimulation. The correlation between changes of exterior sounds and auditory hallucinations during electrical stimulation of the temporal lobe will be discussed later.

The hallucination of taste was also produced as the result of deep temporal stimulation, but it occurred only once in one case. Penfield has reported it “bad taste” as the characteristic of the hallucination of taste, but it was as “taste of an egg” in the present experiment.

The hallucination of smell was not observed. This might be related as described previously, to the area stimulated, that is, the functional localization of the brain.
Hallucinations by Electrical Stimulation of Temporal Lobe

<table>
<thead>
<tr>
<th>Table II. Contents of the Hallucinations</th>
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</table>

**Visual hallucination**

**Temporal lobe cortex**
The speaker hanging from the sky. I see several men talking around the speaker. I see a man with a straw rice-bag and an apron on. Profile of my attending physician. I see something like a bell. Two or three men are listening to me (points out to the ceiling).

**Deep temporal lobe**
Ultra-violet rays. Eyes are brightening. Brightness round. I see a woman in the head. Blue light is seen in front of the eyes. Golf links are seen. I see a house where I lived once. An egg is seen. Cake, rice and marshmallow are seen. I see graves, men, funeral and several men walking in a line.

**Auditory hallucination**

**Temporal lobe cortex**
I hear, "it is so strange". It says, "splendid, splendid". Someone is murmuring in the ceiling. Sounds from the speaker (i.e. auditory hallucination) are echoed around. Pitches of sounds of the speaker are recognized. I cannot hear the speaker (temporal suppression of the auditory hallucination).

**Deep temporal lobe**
Yes

**Changes in perception of the exterior sounds**

**Temporal lobe cortex**
2000 cps (exterior sounds of pure tone)
Loud, strong and low. (changes in perception)

1000 cps Up and down in sounds. Becomes stronger at the end. Intermittent sounds in the middle. Roaring sounds at some intervals.

500 cps Curvatures in sounding. Foreign sounds are added. Becomes lower.

300 cps Become a little lower.

**Deep temporal lobe**
2000 cps The width of sound becomes broadened.

**Hallucination of taste**

**Temporal lobe cortex**
No

**Deep temporal lobe**
Taste of an egg.

**Hallucination of smell**

**Temporal lobe cortex**
No

**Deep temporal lobe**
No

**Hallucination of bodily sense**

**Temporal lobe cortex**
Floating, moving, swinging, rotating, reversion, pendular movement and shrinkage of body.

**Deep temporal lobe**
Schok, shrinkage of body. Swinging of body.
<table>
<thead>
<tr>
<th>Case I</th>
<th><strong>Auditory hallucination</strong></th>
<th><strong>Visual hallucination</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The speaker announced “Formosa is bombed. Chiang Kai-Chek is killed by the woman’s army”</td>
<td>My house. Airport. Figures of people.</td>
</tr>
<tr>
<td></td>
<td>I no longer hear the speaker (auditory hallucination).</td>
<td></td>
</tr>
<tr>
<td>Before operation</td>
<td>During electrical stimulation</td>
<td>After operation</td>
</tr>
<tr>
<td>Case II</td>
<td><strong>Auditory hallucination</strong></td>
<td><strong>Visual hallucination</strong></td>
</tr>
<tr>
<td></td>
<td>Voice reading a Karte (hypnagogic state). Open the window to look into the heart.</td>
<td>Fox. Flying sparrow (hypnagogic state).</td>
</tr>
<tr>
<td></td>
<td>Someone is murmuring at the ceiling.</td>
<td></td>
</tr>
<tr>
<td>Case III</td>
<td><strong>Auditory hallucination</strong></td>
<td><strong>Visual hallucination</strong></td>
</tr>
<tr>
<td></td>
<td>You are the worst schizophrenic. You shall be sent to a syphilis village.</td>
<td>Something like a picture. A child’s foot is hurt. I am sterilizing surgical instruments.</td>
</tr>
<tr>
<td></td>
<td>Isn’t it so strange? Splendid, splendid.</td>
<td>Blue light in front of the eyes.</td>
</tr>
<tr>
<td>Case VII</td>
<td><strong>Auditory hallucination</strong></td>
<td><strong>Visual hallucination</strong></td>
</tr>
<tr>
<td></td>
<td>Don’t make me laugh. Try the electroshock for a week and more again.</td>
<td>No</td>
</tr>
<tr>
<td>Hallucination of taste</td>
<td><strong>Auditory hallucination</strong></td>
<td><strong>Visual hallucination</strong></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Taste of egg.</td>
<td>No</td>
</tr>
</tbody>
</table>

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The hallucination of bodily sense, which consisted of hallucinations of vestibular and kinesthetic sensation such as the elevating sensation of body, moving sensation of body and swinging sensation of body, and also of the hallucination of somatic sensation or of body schema such as the sensation of body-shrinking and the hallucination of vague somatic sensation such as “feeling of a shock”.

2. Comparison of Schizophrenic Hallucination with Hallucination by Electrical Stimulation of the Temporal Lobe

A comparison of hallucinations observed in schizophrenic patients and hallucinations produced by electrical stimulation of the temporal lobe of the same patients is indicated in Table II. In case I there showed the same contents of auditory hallucination before and after stimulation. These hallucinations disappeared during electrical stimulation. There were no significant correlations between contents of schizophrenic visual hallucinations and electrically induced visual hallucinations.

In case II, the visual hallucination of “a fox” was observed before and after electrical stimulation. On the contrary, the other visual hallucination with the expression that “a man listening to something” was induced independently during electrical stimulation.

In case III, there were auditory hallucinations such as “you are the worst schizophrenic” or “you shall be sent to a syphilis village”. It might be considered important that these auditory hallucinations have a feature of being “spoken to” or “made”, and there is also a feature of schizophrenic auditory hallucinations. On the other hand, such a significance was not observed among the electrically induced auditory hallucinations; the patient merely heard someone talking “it’s so strange” or “splendid, splendid”.

Case VII had no hallucinations as a pathological symptom, but experienced the hallucinations only during the electrical stimulation. The patient showed visual hallucinations in expressing “golf links” or “the house where I lived before”.

From the findings mentioned above it may be concluded that essential correlations can hardly be found between the hallucinations resulting from electrical stimulation of the temporal lobe and the hallucinations as a pathological sign of the schizophrenic process.

3. Characteristics of the Hallucination Produced by Electrical Stimulation

The hallucinations produced by electrical stimulation of the temporal lobe were investigated whether they were characterized chiefly by perception or image.

The results are indicated in Fig. 3 as a three-dimensional diagram. The general characteristics of the hallucination by temporal lobe stimulation were as follows: all the hallucinations cannot be distinctively attributed to perception and image, but they were more perceptual than imaginary.
Fig. 3. Characteristics of the hallucinations by electrical stimulation.

1'. Being figurative.
2. Appearance in external objective space.  
2'. Appearance in inner subjective space.
3. Being full and fresh of sensory elements.  
3'. Not being full and fresh of sensory elements.
4. Standing before us in a detailed fashion.  
4'. Coming before us incomplete, only individual details evident.

(from K. Jaspers: General psychopathology, translated by J. Hoenig and N.W. Hamilton)

Fig. 4. General view of the hallucinations by electrical stimulation of the temporal lobe.
4. General View of Subjects

The hallucinations produced by the temporal lobe stimulation in all the cases are summarized in Fig. 4. These cases were chronic schizophrenics with a history from 1 to 13 years. In this figure, it was noted that electrical stimulation of the temporal lobe did not always produce hallucinations or other responses (Cases X-XVII). However, in Cases I-IX, different types of hallucinations and other responses were observed at the same time. This might be due to “Pluri-sensoriell” characteristic of the temporal lobe hallucination.

5. Location of the Electrically Induced Hallucinations

The location of the temporal lobe where the hallucinations and other responses were produced by electrical stimulation is plotted in Fig. 5. As illustrated in this figure, all the responses to electrical stimulation appeared in the gyrus temporalis superior, but they were not observed in the gyrus temporalis medius and inferior.

These effective stimulating points were found only in the cortical area located on the extended line of sulcus Rolandi to the gyrus temporalis superior and the posterior cortical part of the gyrus temporalis superior.

There was some relationship between location of the temporal cortex and contents of these hallucinations. In general, the visual hallucinations were observed widely in the gyros temporalis superior by stimulation. On the other hand, auditory hallucinations were only seen in the anterior part of the gyrus temporalis superior and the hallucination of bodily sense on its posterior part.

Electrical stimulation of the deep temporal portion caused visual hallucina-

![Diagram of brain regions](image)

Fig. 5. The location where the hallucination appeared by electrical stimulation.

Sagittal section of 25-30 mm forward from pineal body
(from Spiegel E.A.: Stereencephalotomy)
tions on a wide scale, but it resulted in no auditory hallucinations. The hallucination of taste and change in emotion were observed in particular localities, but these responses were not produced by cortical stimulation of the temporal lobe.

It might be noteworthy that the auditory hallucinations occurred selectively by cortical stimulation of the temporal lobe, not by deep temporal stimulation.

6. Relationship between Hallucinations and After-Discharges by Electrical Stimulation

The relationship between hallucinations or other responses by electrical stimulation and after-discharges of EEG was examined. The results are summarized in Table IV. The twitch of body, the masticatory movement and somatosensory response had a close relationship with seizure discharges, while the hallucination and other responses (change in emotion, etc.) were not closely related to them.

Further analysis of responses will lead to the following interesting results: the visual hallucinations, hallucinations of taste and changes in emotion were closely related to the seizure discharges, while the auditory hallucinations and somatosensory responses were less related to them.

This may be ascribed to the pathophysiological difference in brain mechanism to produce the visual and auditory hallucinations.

7. Relations between Hallucinations and Emotional Changes

The Correlation between hallucinations and emotional changes produced by electrical stimulation will be described as follows.

In Case VII, the change in emotion such as “I am afraid of iron” and visual hallucinations such as “golf links” and “the house where I lived once” and also hallucinations of taste such as “taste of an egg” were produced at the same time. But no correlation was considered between contents of these emotional changes.

<table>
<thead>
<tr>
<th>Seizure discharges</th>
<th>(+)</th>
<th>(-)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stimulated area</td>
<td>Cortex Deep portion</td>
<td>Cortex Deep portion</td>
<td></td>
</tr>
<tr>
<td>Visual hallucination</td>
<td>2</td>
<td>3</td>
<td>14</td>
</tr>
<tr>
<td>Auditory hallucination</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Hallucination of taste</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Hallucination of bodily sense</td>
<td>0</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Changes of exterior sounds</td>
<td>1</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Changes in emotion</td>
<td>2</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>22(56.4%)</td>
<td>17(43.6%)</td>
<td>39</td>
</tr>
<tr>
<td>Somatosensory and motor response</td>
<td>19(76.6%)</td>
<td>6(24.0%)</td>
<td></td>
</tr>
</tbody>
</table>
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and the hallucinations.

On the contrary, in Case IX, visual hallucination such as "a woman is seen in the head" was followed by grinning. And after exclaiming "shock", the patient suddenly got up on the bed and tried to escape. This shows an expression of fear following a vague somatosensory hallucination. In these cases, it appears that there was some meaningful correlation between contents of the hallucinations and emotional changes.

From another point of view, these changes in emotion have been observed after or simultaneously with the occurrence of hallucinations. In other words, hallucinations would not take place by changes in emotion.

8. The Problem of Consciousness

Only one of the cases (Case X) showed clearly clouding consciousness, and was not delirious because the hallucinations have never been produced except by electrical stimulation.

Except for this case, all the cases were normal in orientation and accurate in answers to questions. Though these responses were more or less retarded and mild reduction of the level of consciousness could not be denied, at least all the responses were not those observable under severe disturbance of consciousness.

The electroencephalographic findings were as follows: only one case (Case VII) showed diffuse slow waves, but all other cases showed normal patterns and only a little alteration in the frequency of α-β band.

The therapeutic effects for the auditory hallucinations

In 11 out of 17 cases, the alteration of auditory hallucinations had been observed at least more than 6 months after electrical stimulation of the temporal lobe. This therapeutic effect of electrical stimulation to the auditory hallucinations as a symptom of schizophrenic process is summarized in Fig. 6.

One or two weeks after stimulation, the auditory hallucinations were completely suppressed in 8 of 11 cases; 2 cases were improved, but one case was aggra-
vated. On the contrary, 7 cases relapsed within 2 months and 1 case after 3 months. Namely, 8 of 10 cases which had been suppressed by electrical stimulation relapsed 3 months later, and the remaining 2 cases were continuously improved. The hallucinations were completely suppressed in one of the relapsed cases by using tranquilizing agents. It was noteworthy that the drugs were not effective without electrical stimulation.

Finally, it was in 3 cases out of 11 cases that electrical stimulation was effective for the therapy of auditory hallucinations lasting over 6 months.

CONCLUSION AND DISCUSSION

The above-mentioned observations will be summarized and discussed especially with regard to some characteristics of the electrically produced hallucinations.

Among the hallucinations induced by electrical stimulation of the temporal lobe, the visual hallucinations were most frequent. In general the hallucinations which are more frequently observed by exogenic attacks to the brain are usually of visual hallucinations.

The auditory hallucinations by electrical stimulation of the temporal lobe were not revealed in the form of being “spoken to” or “made”. As compared with this, the auditory hallucinations as a symptom of the schizophrenic process have occasionally been characterized by “spoken to” or “made”.

The hallucinations produced by electrical stimulation of the temporal lobe had the characteristic of more perceptual rather than imaginary, in contrast to the schizophrenic hallucinations which might be more imaginary than perceptual.

The contents of the electrically produced hallucinations were little related to the hallucinations as a pathological symptom of the schizophrenic process.

Furthermore, the change in emotion did not play any significant role in the occurrence of the hallucinations.

It might be concluded from these results that the characteristics of the hallucinations produced by electrical stimulation of the temporal lobe greatly differ from those of the hallucinations which appeared as a symptom of the schizophrenic process. In other words, electrical stimulation of the temporal lobe does not seem to “induce” the schizophrenic hallucinations, but to “produce” another hallucinations independently. This might exhibit a contrast to Jasper’s report on the recurrence of the habitual attacks by electrical stimulation of the temporal lobe of epileptic patients.

Next, the correlation between visual hallucination and auditory hallucination by temporal lobe stimulation should be dealt with. The former appeared over the whole temporal cortical area and the wide range of the deep temporal portion, while the latter appeared only in the anterior cortical part of the gyrus temporalis superior, not in the deep temporal portion.
On the other hand, the visual hallucinations by electrical stimulation had a close correlation with after-discharges from the electroencephalographic point of view, but the auditory hallucinations had little related to them.

Namely, the visual and auditory hallucinations produced by electrical stimulation could be considered to depend on different pathophysiological mechanisms of the brain.

Then, changes of perception to the exterior sounds will be discussed. The perception of given exterior sounds (pure tone) was altered during the temporal lobe stimulation. This phenomenon could also be observed selectively during cortical stimulation of the temporal lobe.

As seen in Fig. 7, given exterior pure tones of different cycles were experienced

1. The body and bed are swung. My thought is understood. Someone is murmuring in the ceiling. A different sound is added.
2. The bed rocks. Up and down in sounds.
5. Two or three men are listening to me. (points out to the ceiling). The width of sounds becomes broad.
6. The sound becomes lower a little. The sound becomes high or low. Sounds become a little lower.
7. Twitch of the left hand.
8. Twitch of the angle of the mouth.
9. Movement of the tongue.
as "strong sound", "low sound", "changed sound" and "different sound added".

When stimulated the same point on the temporal cortex without the exterior sounds, there were produced the auditory hallucinations and somatic sensations such as "someone is murmuring in the ceiling", "the body is floating" and "the body and bed are swung" without giving any exterior sounds.

From these facts, it appears that there is some connection between the perceptual change to exterior sounds and the auditory and cenesthetic hallucination through the function of the temporal lobe cortex.

When the temporal lobe cortex of a schizophrenic patient is stimulated while suffering from the auditory hallucinations, the patient experienced the change in sounds from a speaker as shown in Fig. 8. This represents a change in sounds from the speaker, that is, the alteration in the auditory hallucinations. Sometimes the sound was no longer heard, indicating that the auditory hallucination was completely suppressed.

In this way, both perception of given exterior sounds and auditory hallucina-

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Fig. 8. Electrical stimulation of the temporal cortex during the continuous auditory hallucination.

1. The speaker hanging from the sky. I no longer hear the speaker (suppression of the auditory hallucination).
2. I see a speaker.
3. I see several people talking around the speaker. I see a man with a straw rice-bag and an apron on.
4. I see a profile of my attending physician. Sounds sticking to the speaker.
5. Sounds from the speaker are entangled. Feel like the bell is seen. Recognized the pitch of the sounds of the speaker (auditory hallucination).
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Hallucinations were changed by electrical stimulation of the temporal lobe, especially of gyrus temporalis superior. In short, the aforementioned facts may support the conclusion that the kinesthetic and vestibular hallucination is a basis of physiological mechanism of the auditory hallucination. A hypothesis may be established here that auditory hallucinations are produced by a change in perceptual mechanism, with the participation of psychological factors, following a change in physiological mechanism.

The therapeutic effect of electrical stimulation of the temporal lobe on the auditory hallucination has not been satisfactory at all, compared with the psychophysiological results mentioned above. During a few weeks after temporal stimulation, the hallucination was completely suppressed in 8 out of 11 cases, 2 were improved and one was advanced. These results seem quite satisfactory, but after 3 months the hallucination relapsed again in 8 of 10 cases. Eventually only 3 of 11 cases showed the therapeutic effectiveness over 6 months (marked improvements in one case; fairly improved 2 cases). These patients, however, were all chronic schizophrenics whose auditory hallucinations had never been suppressed for a long time by different treatments. For this reason, the temporal lobe stimulation may be effective for particular cases.

References

4) Endo, K., ibid., 1958, 60, 1027.
5) Hori, H., ibid., 1962, 64, 1010.