Functional Significance of the Corpus Callosum Based on the Analysis of Rhythmic Capabilities in the Split-Brain Patients

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We carried out our Systematic Rhythm Test for the Brain-Damaged Patients named "The Asian Rhythm Test" on our four patients with lesions of the corpus callosum, and analyzed their rhythmic capabilities — their performances in rhythm perception (auditory distinction) and in rhythm expression (rhythm-tapping) — in accordance with the neuropsychological model proposed in 1980 by us. All our partial split-brain patients showed the abnormal one-ear inferiority (superiority) and the one-hand inferiority under our testing conditions. The patients with lesions of the anterior corpus callosum showed the interhemispheric (the left-to-right) transfer-dysfunction of motor-programming information, while the patient with the lesion of the posterior corpus callosum showed the interhemispheric transfer-dysfunction of auditory information. The patients with lesions including the truncus showed the interhemispheric integration-loss in the process of rhythm perception and its expression. And moreover, we could see the specific auditory interruption between the ipsilateral and the contralateral systems in the patient with the lesion including the anterior commissure. Based on these our findings, the roles of the corpus callosum and the anterior commissure were discussed.

rhythm test; corpus callosum; anterior commissure; hemisphere dominance; interhemispheric integration

The function of the corpus callosum in man has long remained somewhat obscure. Recently, there have been many reports on the split-brain patients and the agenesis cases, and much information of the callosal function could be provided (Geschwind 1965; Sperry 1965, 1970; Gazzaniga, Bogen and Sperry...
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1965; Sperry, Gazzaniga and Bogen 1969; Bryden and Zurif 1970; Gordon 1975; Zaidel and Sperry 1977; Iwata 1980; Sugishita et al. 1980; etc.). We could have much knowledge about the anatomy and physiology of the corpus callosum (Cumming 1970), and our understanding of the role of the corpus callosum has been greatly enriched and clarified. But, there remain many unresolved issues, because in numerous cases of callosal disease the expected disconnection signs were not elicited (Gordon et al. 1971; Bogen 1979). Then, we cannot get the steady view and the data to explain the role of the corpus callosum. Previous studies of the split-brain patients, through some special psychological tests, can suggest that the corpus callosum is functional only in transfer of information; visual information (Sperry 1970; Gazzaniga and Freedman 1973; Iwata 1980; Sugishita et al. 1980), verbal one (Gazzaniga et al. 1979; Gazzaniga 1982), and tactile one (Sperry et al. 1979; Sperry 1970) etc. The findings of previous studies can reveal only the fact that the callosal functions may not be crucial for the “common activities of daily human’s life” (Selnes 1974; Bogen 1979).

In our present study, our rhythm test “The Asian Rhythm Test — The Systematic Rhythm Test for Brain-Damaged Patients” was performed to analyze the rhythmic capabilities of four split-brain patients and 10 normal controls. And, here we describe the results on their performances, and discuss the functional significance of the corpus callosum and the anterior commissure.

CASES

Case 1. A 41-year-old right-handed female was admitted with a two days history of severe headache. The CT scan revealed a high density lesion localized from the anterior commissure to the genu of the corpus callosum (Fig. 1).

Case 2. A right-handed female, aged 31, who was admitted with nausea and vomiting, and diagnosed as brain tumor. The CT scan after operation showed localized enhanced lesion with contrast medium from the genu to the anterior truncus of the corpus callosum (Fig. 1).

Case 3. A 27-year-old right-handed male was admitted with headache and diagnosed as arterio-venous malformation. The CT scan after operation showed localized enhanced lesion with contrast medium from the genu to the truncus of the corpus callosum (Fig. 1).

Case 4. A 48-year-old right-handed male was diagnosed as brain tumor on the basis of cerebral angiography and CT scan. CT scan disclosed the brain tumor to infiltrate from the median truncus to the splenium (Fig. 1).

There were no abnormal findings remarkably in these cases from the neurological aspects, while neuropsychologically they showed abnormal findings as seen in Table 1. But, the remarkable disconnection signs could not be seen definitely in Cases 2 and 3 by the standardized examinations, in spite of the fact that their behaviors were changed remarkably after callosal section. Then, we carried out our rhythm test on these patients, because in our previous studies we found that the rhythmic capabilities had very much to do with the brain function in each hemisphere, and also because we anticipated that the disturbance of timing mechanism (rhythm-disturbance) should be associated with the lesions in the corpus callosum.
Rhythmic Capability of Split-Brain Patients

METHODS

Our test battery was based on our neuropsychological model which was proposed for the relationship between the rhythmic capabilities and the highly functional system in the brain. It is composed of 6 items including 40 questions (Table 2). This rhythm test was carried out on our four split-brain patients and 10 normal right-handed controls with the procedure as follows:

**Instrumentation**

*Perception rhythm test.* A high drum and a buzzer were required to produce the auditory rhythmic patterns and sequences. The auditory inputs of the Test A-(1) and the Test A-(3) were presented with the drum sounds, while the buzzer was employed in presenting the auditory input of the Test A-(2). These auditory inputs of the rhythmic pattern and its sequences for the complete experiments were prerecorded on magnetic tape and played to the subjects.

**Table 1. Neuropsychological findings in each case**

<table>
<thead>
<tr>
<th>Case</th>
<th>Neuropsychological findings in each case</th>
<th>1. Short-term memory-loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>Motor apraxia of the left hand (severe)</td>
<td>(2) Thinking-loss (logical)</td>
</tr>
<tr>
<td>Case 2</td>
<td>Motor apraxia of the left hand (moderate)</td>
<td>(3) Writing-loss (spontaneous)</td>
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<tr>
<td></td>
<td>Personality change (moderate)</td>
<td></td>
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<tr>
<td>Case 3</td>
<td>Severe memory disturbance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Personality change (severe)</td>
<td></td>
</tr>
<tr>
<td>Case 4</td>
<td>Topographical disorientation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Disconnection sign (Dichotic listening test)</td>
<td>(4) Loss of associating ideas</td>
</tr>
</tbody>
</table>

Fig. 1. CT scan of each case.
Expression rhythm test. The instrumentation to measure the performance of rhythm expression (finger-tapping) was required. We devised the instrument “Tapping-Measure” (Nakamura et al. 1981a, patent pending), and it was employed in the present study. The “Tapping-Measure” includes an electronic key, a pen-recorder, a transducer, and an auditory feedback circuit. Tapping pressure and its duration were automatically recorded as the tapping-waves on the recording paper by the pen-recorder of our instrument. The auditory feedback circuit of the instrument can produce what the subject taps in concurrent with the subject’s tapping. The reproduced sounds are presented to the subject just the same condition as the human’s speech mechanism can give us.

Test administered

The rhythmic patterns employed in our test were based on the linguistic theories (Liberman and Prince 1977; Nakamura and Kuwahara 1979; Nakamura 1980). These patterns can be usually found out in our daily speech activities, and each rhythmic pattern is composed of two, three, or four rhythmic constituents, corresponding to the structure of a syllable or a word. These rhythmic patterns were presented almost at the same speed as our normal speech (750 msec-1.5 sec/one rhythmic pattern, 185-555 msec/one rhythmic constituent). They were tested with each trial after some training trials.

Perception rhythm test

Test A–(1). This test consisted of 10 pairs of the identical rhythmic patterns or the different ones with an interpulse interval of 2 sec and then the subjects were required to report if the two rhythmic patterns of a pair were the ‘same’ or ‘different (not same)’. Each rhythmic pattern was repeated four times with about 200 msec interval.

Test A–(2). The rhythmic pattern was repeated seven times successively without an interval. Then, the subjects were required to report if the rhythmic patterns were ‘changed’ or ‘no changed’ in the middle of the rhythmic sequence. Each rhythmic sequence was presented once per trial, and five trials were undergone.

Test A–(3). This test consisted of 5 pairs of the identical rhythmic structures or the different ones with an interval of 2 sec; the subjects were required to report if the two rhythmic structures of a pair were the ‘same’ or ‘different’. To say more precisely, in four pairs, the rhythmic patterns of both rhythmic structures were same, but both rhythmic structures of each pair were different in the position of the accents. Then, the subjects were required to notice such a structural change in the rhythmic sequences.

Our present study employed three testing conditions; where input of the rhythmic sounds was presented to right-ear, left-ear, and both-ears. At first, we provided the input to both-ears simultaneously (binaural presentation) in a free field situation. Then, we
provided the input to each ear monaurally through earphone, while another ear non-provided the input was masked with the white-noise (monaural presentation). The auditory input of rhythmic sounds was presented to the subjects at a sound pressure level of 60–80 db SPL basically, but we also tried to present the input at the efficient score of the audiometry.

Expression rhythm test

Test B-(1). The rhythmic pattern was presented three times successively with 400 msec intervals, and then the subjects were required to produce one time the same rhythmic pattern that we presented: The subjects were required to tap the electronic key with the index finger in order to reproduce the rhythmic pattern. Ten trials were undergone.

Test B-(2). The rhythmic pattern was presented three times successively with no interval. Then, the subjects were required to repeat the same rhythmic pattern as we presented, and also required to keep on tapping it until the 'stop' sign was presented: The subjects had to produce the rhythmic sequence. Six trials were undergone.

Test B-(3). Each auditory stimulus consisted of 8 rhythmic sequences, and each sequence was composed of two, three, or four rhythmic patterns. Each auditory stimulus was presented twice per trial. At the first presentation, the subjects were required to follow the examiner's hand-clapping to keep times. Then, at the second presentation, the subjects were required to keep times by themselves to the presented rhythmic sounds with hand-clapping. Four trials were undergone.

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**Fig. 2.** Results of perception rhythm test. The three bars for each figure indicate respectively one of these three perception tests. The dots show the left-ear performance, the lateral stripes show the right-ear performance, and the solid color presents the performance under the condition of binaral presentation.
RESULTS

Perception rhythm test

The results of this procedure are illustrated in Fig. 2, which contains the performance-scores of our cases on three perception tests under three testing conditions above mentioned.

In Case 1, the rhythmic capability in perception process was basically intact, when input was presented to both ears simultaneously (binaural presentation). But, Case 1 showed the reduced rhythmic capability, especially the right-ear inferiority, when input was presented with the use of monaural technique (monaural presentation); the rhythmic sounds were presented to one-side ear, while the white noise (masking tone) was presented to the other side of the ear. This suggests that the auditory interruption between the contralateral pathway and the ipsilateral one can be seen in each hemisphere, especially in the left hemisphere. Such a type of auditory abnormality that Case 1 showed can be seen neither in normal subjects nor three other cases. It would seem, therefore, that the lesion of the anterior commissure has very much to do with this auditory interruption between the contralateral and the ipsilateral systems.

Cases 2 and 3 showed reduced performances in rhythm perception, when input was presented to both ears simultaneously. But, their performance-scores of each ear were close to normal range under the testing condition of monaural presentation. In contrast, Case 1, Case 4 and normal subjects showed the best score under this testing condition. This suggests the clash of auditory performances between the right-ear (left-hemisphere) mechanism and the left-ear (right-hemisphere) one, that is to say, both auditory informations processed in each hemisphere cannot be integrated into a total information, when inputs are presented to both ears simultaneously. It would seem, therefore, that the lesion from the anterior to the median truncus of the corpus callosum causes the disturbance in integrating both hemisphere’s activities, so called the “inter-hemispheric integration-loss” in the auditory process of rhythm perception.

There is also evidence that Cases 2, 3, and 1 (above mentioned) showed the significant left-ear superiority in the auditory process of rhythm perception, in spite of the fact that Case 4 and normal subjects didn’t show it: Normal subjects showed a slight right-ear superiority or showed perfect performance of both ears; Case 4 showed the remarkable right-ear superiority. This suggests that the performance of the left hemisphere which usually dominates rhythm perception in normal subjects tends to be inferior to the performance of the right hemisphere in these three cases. It would seem, therefore, that lesions of the anterior half of the corpus callosum cause the disruption of the cerebral dominance.

Case 4, on the other hand, showed neither the left-ear dominance nor the most reduced performance under the testing condition of binaural presentation. Then, it seems that the lesion from the posterior truncus to the splenium is correlated
neither with the reversal of hemisphere dominance nor with the interhemispheric integration-loss between both ears’ performances. Case 4 showed poor performance in the rhythm perception under every testing condition. And, especially Case 4, under the condition of monaural presentation, showed the left-ear inferiority, in other words, the right-ear superiority. This suggests that the auditory information presented to each hemisphere tends to be unable to be transferred from one hemisphere to the other, especially from the left hemisphere to the right. It would seem, therefore, that the lesion from the posterior truncus to the splenium of the corpus callosum causes interhemispheric transfer-dysfunction of auditory

Fig. 3. Results of the expression rhythm test. The three bars for each figure indicate respectively one of these three expression tests. The dots represent the left-hand performance, and the solid color represents the right-hand performance.
information in the process of rhythm perception, that is, a kind of the disconnection symptoms which have been widely accepted.

**Expression rhythm test**

The results of this procedure are summarized in Fig. 3, which contains every performance-score of our cases on three expression (rhythm-tapping) tests under three testing conditions above mentioned.

In Cases 1, 2 and 3, their left-hand scores were remarkably reduced, though their right-hand scores were close to normal range under every testing condition. Especially, in Case 1, we can see the significant difference in type and degree between the left-hand performance and the right-hand one: Her left-hand score on Test B–(2) was zero under the condition of the right-ear (left hemisphere) input, in spite of the fact that her right-hand score was close to normal range under every testing condition. This suggests that the motor-programming information about the left-hand tapping cannot be transferred from the left hemisphere to the right which has strong connection with the left-hand movements.

There is also evidence in these three cases that their left-hand scores vary with the three testing conditions, whereas their right-hand scores do not vary with these conditions. This suggests that information about the left-hand tapping cannot be obtained normally under every condition, whereas information about the right-hand tapping can be obtained. Especially we can see such a tendency in Case 1 with the lesion including the most anterior part of the corpus callosum and the anterior commissure. It would seem, therefore, that the lesions of the anterior corpus callosum cause dysfunction of the left-to-right transfer of motor-programming information in regard with rhythm-tapping.

Cases 2, 3 and 4 showed the left-hand superiority in some tasks of our test battery: Case 2 showed the left-hand superiority in Test B–(3), when input was presented to the right ear and to both ears; in Case 3, the left-hand performance was elevated under the condition of left-ear input, in spite of the fact that the right-hand performance was reduced in this situation; Case 4 showed the left-hand superiority in Test B–(3) under the testing condition of monaural presentation. Normal subjects never showed such an abnormal left-hand superiority under any testing condition. Normal right-handed subjects always showed the slight right-hand advantage: The performances of both hands showed almost the same scores and nearly perfect. This suggests that the scores of these three cases tend to be reverse to the fact that they are naturally right-handers, that is to say, their right hemispheres which have very much to do with their left-hand performances tend to be superior to their left hemispheres which have naturally played a dominant role. It would seem, therefore, that the lesions including the median truncus of the corpus callosum cause the tendency of reversing hemisphere-dominance.

There is also evidence in Cases 3 and 4 that their left-hand performances were
reduced, when input was presented to both ears simultaneously, whereas their left-hand performances were rising when input was presented to the left ear. Normal subjects and two other cases didn't show such a result: In Cases 1 and 2, the scores were rising when input was presented to both ears simultaneously, whereas their scores tend to be reduced under the testing condition of monaural presentation. This suggests that Cases 3 and 4 have some difficulties in programming their left-hand movements on the basis of both hemispheres' information, whereas they have less difficulty in doing them on the basis of only the right hemispheres' information. It would seem, therefore, that the lesions of the posterior truncus of the corpus callosum cause the interhemispheric integration-loss and the right-hemisphere advantage in sensory-motor process of rhythm expression. And, this right-hemisphere advantage seems to be correlated with such an interhemispheric integration-loss in these two cases.

Case 4 showed tremendously reduced performances in each-hand tapping under every testing condition, and we can see a remarkable difference in type and degree of rhythm-disturbance between Case 4 and the other three cases: Case 4 never showed the nearly normal scores on any expression test under any testing condition, whereas the other three cases showed the nearly normal scores on some tests under some testing conditions. His abnormal performance in rhythm expression obviously seems to result from the auditory (sensory) disturbance above mentioned in this report. This finding can be further confirmed by the tapping-

<table>
<thead>
<tr>
<th></th>
<th>L-Hand</th>
<th>R-Hand</th>
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<tbody>
<tr>
<td>Case 1</td>
<td><img src="image1" alt="Waveform" /></td>
<td><img src="image1" alt="Waveform" /></td>
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<tr>
<td>Case 2</td>
<td><img src="image2" alt="Waveform" /></td>
<td><img src="image2" alt="Waveform" /></td>
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<tr>
<td>Case 3</td>
<td><img src="image3" alt="Waveform" /></td>
<td><img src="image3" alt="Waveform" /></td>
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<tr>
<td>Case 4</td>
<td><img src="image4" alt="Waveform" /></td>
<td><img src="image4" alt="Waveform" /></td>
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</tbody>
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Fig. 4. *Tapping-waves in each case.* These waves were recorded by our Tapping-Measure (patent pending). The degree of tapping-pressure is recorded on the vertical line, while the degree of tapping-duration is recorded on the horizontal line.
<table>
<thead>
<tr>
<th>Table 3. Summary of results in each case</th>
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<tbody>
<tr>
<td><strong>Auditory performance (perception)</strong></td>
</tr>
<tr>
<td>----------------------------------------</td>
</tr>
<tr>
<td>Normal</td>
</tr>
<tr>
<td>1 Each performance was almost perfect</td>
</tr>
<tr>
<td>2 No remarkable difference between both-ears performance</td>
</tr>
<tr>
<td>3 Binaural performance was better than monaural (each-ear) performance</td>
</tr>
<tr>
<td>Case 1</td>
</tr>
<tr>
<td>1 Left-ear performance and right-ear one were reduced, but the binaural performance was close to normal (auditory interruption between the ipsilateral &amp; the contralateral pathways in each hemisphere)</td>
</tr>
<tr>
<td>2 Left-ear performance &gt; Right-ear performance</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Case 2</td>
</tr>
<tr>
<td>1 Left-ear performance and right-ear one were close to normal</td>
</tr>
<tr>
<td>2 The binaural performance was lower than each-ear (monaural) performance (interhemispheric integration-loss)</td>
</tr>
<tr>
<td>Case 3</td>
</tr>
<tr>
<td>1 Left-ear performance and right-ear one were almost normal, but the binaural performance was lower than each-ear (monaural) performance (interhemispheric integration-loss)</td>
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<td></td>
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<tr>
<td></td>
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<tr>
<td>Case 4</td>
</tr>
<tr>
<td>1 Binaural performance was better than monaural (each-ear) performance</td>
</tr>
<tr>
<td>2 Each-ear performance was reduced (Right-ear performance &gt; Left-ear performance)</td>
</tr>
<tr>
<td>3 1 &amp; 2 indicate “interhemispheric transfer-dysfunction”</td>
</tr>
</tbody>
</table>
waves of both hands in each case (Fig. 4). These three cases (Cases 1, 2 and 3) with lesions related to the anterior corpus callosum showed the remarkable difference in the pattern of tapping-waves between their both hands. We can also see the remarkable difference in it between these three cases and Case 4: Cases 1, 2, and 3 showed the irregular pattern of tapping-waves in their left hands, whereas Case 4 didn’t show such an irregular pattern. This suggests that the lesion including the posterior part of the corpus callosum has very much to do with transfer-dysfunction of auditory information between both hemispheres, rather than with transfer-dysfunction of motor-programming information. The above-mentioned results of all our subjects are summarized in Table 3.

**DISCUSSION**

For the first time, in 1749 Zinn (Elliott 1969) performed the operative section of the corpus callosum in a dog, and reported that the sense and the power of movement remained intact after callosal section. After that, Trevarther (1965) remarked that a cat, a monkey, or a man retained all sensory faculties and the automatic motor function. In contrast, Liepmann and Maas (1907) described left-side apraxia in right-handed patients with infarction of the corpus callosum. In 1931, Dandy first remarked that the callosal section caused the absence of gross mental, motor, or sensory defects in man. Dandy’s describing has since been confirmed by Akelaitis (1944), Sperry (1965, 1970), Sperry, Gazzaniga, and Bogen (1979), Geschwind (1965), Gazzaniga, Bogen and Sperry (1965), Bryden and Zurif (1970), Zaidel and Sperry (1977), Bogen (1979), Iwata (1980), and Sugishita et al. (1980), etc.

Bryden and Zurif (1970) reported that lack of the corpus callosum made it difficult to integrate complex verbal information presented to the two ears simultaneously.

Zaidel and Sperry (1977) reported that it was difficult for split-brain patients to perform the bimanual or the manual tasks requiring the motor co-ordination and the independent motor-control.

Sidtis et al. (1981) reported on the functional significance of the anterior corpus callosum, and indicated that the anterior portion of the corpus callosum played a role in the integration between cognitive systems in two hemispheres.

While, Gazzaniga and Freedman (1973) reported on the functional significance of the posterior corpus callosum. They indicated that interhemispheric visual communication, especially visual discriminating information was severely disrupted with section of the posterior corpus callosum. So, it was suggested that interhemispheric communication involving visual information normally coursed through the posterior third of the corpus callosum.

In contrast, Hecaen et al. (1964) claimed that any types of lesion of the corpus callosum never could produce an apraxic syndrome which was described by Liepmann and Maas (1907).
Gordon, Bogen and Sperry (1971) have also negated sharply the previous studies. They reported that two commissurotomy patients with surgical section of the anterior two-thirds of the corpus callosum and anterior commissure showed hardly any of the cross-integration deficits. Then, they suggested that the posterior one-third of the corpus callosum could maintain the effective cross-communication without the anterior two-thirds of the corpus callosum.

Various ideas have been reported on the functional significance of the corpus callosum up to date, and recently above all the view so-called the "two-brain theory" has been widely accepted (Bogen 1979). This theory suggests that effective functioning can occur independently in the two hemispheres, and also that each of the disconnected hemisphere can act independently of the other, then in this theory the corpus callosum is only defined as one of a number of integrative mechanisms.

In contrast to these previous studies, our present study demonstrated some new evidence (Table 3), so the following discussion can be deemed to be likely.

First of all, the result of Case 1 suggests that the anterior commissure may have some role in controlling the relation between the ipsilateral and the contralateral auditory systems in both hemispheres, then it would seem that the anterior commissure is employed in transmitting the auditory input to the primary auditory area of each hemisphere. This finding fits nicely with Pandya's anatomical data (Pandya et al. 1969); the anterior commissure has the auditory fibers. This Pandya's indication has not been so far known from the clinical examination. Our former suggestion is supported by Risse et al. (1977). They reported that the anterior commissure could be considered as a possible interhemispheric route for auditory information. And our latter suggestion is supported by Gordon (1975). He reported that the remarkable difference in performance-speed between the ipsilateral and the contralateral auditory systems could be seen in the patients with complete surgical division of the forebrain commissures. In contrast to the result of Case 1, Case 4 showed another type of auditory disturbance in rhythm perception; the splenium seems to be employed in interhemispheric-transfer mechanism for auditory information. Therefore, it would seem, on the basis of the results of Cases 1 and 4, that the role of the anterior commissure is different from that of the splenium in the auditory process.

Secondly, based on each case's result of the expression rhythm test (tapping), the significant difference in type and degree of tapping-disturbance can be seen between Case 4 and three other cases. This finding suggests that the role of the anterior corpus callosum including the anterior commissure is different from that of the posterior corpus callosum in the sensory-motor process. The anterior corpus callosum seems to play a role in interhemispheric-transfer (the left-to-right transfer) of motor-programming information in regard with the left-hand tapping. This suggestion is supported by Preilowski (1972). His report suggested that the lesions of the anterior corpus callosum including the anterior commissure eliminat-
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...ed a control mechanisms involving direct interhemispheric interaction of motor corollary outflow.

Thirdly, in Cases 2 and 3, we can find out the abnormally reduced scores in rhythm perception under the testing condition of binaural presentation. This finding suggests that the median part of the corpus callosum plays a role in the interhemispheric-integration mechanism in the auditory process. This suggestion can be supported by Bryden and Zurif (1970) mentioned above.

Finally, in every case, we can see the abnormal one-ear superiority (inferiority) or one-hand superiority (inferiority): Case 1 showed the right-ear inferiority and the left-hand inferiority; Cases 2 and 3 showed the left-ear superiority and the left-hand superiority under the testing condition of monaural presentation; Case 4 showed the right-ear superiority and the left-hand superiority under the condition of left-ear input. These results suggest that the lesions of the corpus callosum can cause the disruption or the reversal of the hemisphere-dominance in the process of rhythm perception and its expression. All our partial split-brain patients showed the right (minor)-hemisphere superiority or the left (dominant)-hemisphere inferiority in the sensory-motor process of the brain mechanism. This finding seems to fit nicely with Gazzaniga’s reports (Gazzaniga et al. 1979; Gazzaniga 1982). They reported that the right hemisphere rather than the left hemisphere tended to dominate responses (language function) and that they had caught the left hemisphere behaving as if it were a right half-brain. It would seem, on the basis of our finding, that the corpus callosum is employed in maintaining or controlling the hemisphere dominance to keep our daily behavior normally and intellectually (Zaidel 1978).

On the basis of the above-mentioned discussion, a model of the “functional localization within the corpus callosum” can be obtained as illustrated in Fig. 5.

![Fig. 5. Functional localization within the corpus callosum. MP inform, motor-programming information; A inform, auditory information.](image-url)
Thus, our investigation into rhythmic capabilities of the partial split-brain patients brought us such a crucial conclusion.

The rhythmic capabilities in man have very much to do not only with fluency and prosody of speech and with music activities, but also with the whole cerebral functions (Lashley 1951; Luria 1966; Martin 1972). And, our previous studies (Nakamura et al. 1980, 1981a, 1981b) concluded as follows: The rhythmic capabilities function with priority of the dominant hemisphere, and they function also the right hemisphere, so both hemispheres individually function and are correlated to each other as illustrated in Fig. 6. Leek and Brandt (1983) also reported similar investigation. They suggested that speech hemisphere could be considered well-practiced in temporal order discrimination and that this discrimination task had a close relationship not only with speech hemisphere but also with non-speech hemisphere. The ability of temporal order discrimination, that is, a kind of the rhythmic capabilities does not seem to be a lateralized factor such as the language function or the spacial one. The rhythmic capabilities seem to be effectually bilateralized in the brain. So, it would seem that the rhythm-performance of the split-brain patients can tell us the new dimension of the disconnection symptoms on which had never been shed light with the use of standardized neuropsychological techniques. Our present study revealed that the corpus callosum played an important role not only in integrating and transferring interhemispheric information but also in maintaining and controlling hemisphere

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Fig. 6. Model of the rhythm-pathway in the brain (Nakamura et al. 1981a).

A1, the primary auditory system; A2, the secondary auditory system; MP, the system of motor programming; M1, the contralateral motor control; M2, the ipsilateral motor control.
dominance. Further investigation and more data will be needed before the experimental implications of our findings become clear.

Acknowledgments

We are indebted to Professor D.F. Benson (UCLA, School of Medicine) for his thoughtful advice. We also would like to thank to Dr. K. Nagae (Kyūshū-Rōsai Hospital) and Dr. M. Sugishita (Tokyo Metropolitan Institute) for their comments. And, moreover we would like to thank to Professor J. Suzuki, Dr. Y. Sakurai and Dr. J. Saito (Tohoku University) for permission to examine their patients.

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