MESENCEPHALIC RETICULAR INFLUENCE ON ELECTRICAL ACTIVITIES OF THE PONTINE RETICULAR FORMATION

Yasumasa HAYASHI* AND Naosaburo YOSHII

Department of Physiology, Osaka University Medical School, Kita-ku, Osaka

Recently evidence has accumulated that there are various interactions between the different levels of the central reticular core of the brain stem (DELL, BONVALLET and HUGELIN 1961; MORUZZI 1964).

The present study was initiated to know how the mesencephalic reticular formation (MRF) acts to regulate activity of the pontine reticular formation (PRF). This MRF-originated, descending effect constitutes one part of the interactions within the reticular core. The results obtained suggest that the descending connection from the MRF to the PRF was not diffuse, but rather specific.

METHODS

Sixty-one adult cats, male and female, were used in this experiment. Under ether anesthesia, the animal was placed on a stereotaxic apparatus. A canula was connected with the trachea and a polyethylene tube was inserted into the femoral vein. The occipital bone was removed and small holes were bored through the parietal bone for insertion of electrodes to the MRF and the hippocampus. These electrodes were oriented stereotaxically. After these procedures had been finished, pressure points were infiltrated with procaine, and then ether inhalation was stopped. The animal was immobilized with succinyl choline chloride (Flaxedil in later experiments) and maintained on artificial respiration.

For stimulation of the MRF and recording the field potentials from the PRF, bipolar electrodes were used which were made of two insulated steel wires cemented side by side with exposed tips of about 0.5 mm. For recording the PRF unit discharges glass micropipettes filled with 3M KCl were used. Tungsten electrodes, 5 μ in diameter and insulated by glass except the tip, were also used. As a reference, a steel needle was fixed to the frontal bone. Stimulation of the MRF was applied to the region which had the coordinates of F 2 to 3, L 2 to 5 and H 0 to -4 in the stereotaxic atlas of JASPER and AJMONE MARSAN (1954). The superficial radial and sciatic

Received for publication November 18, 1965.

* Present Address: Laboratory of Neurophysiology, Institute of Higher Nervous Activity, Osaka University Medical School, Kita-ku, Osaka.

335
nerves were laid on thin silver wire electrodes for electrical stimulation. Electrical activity of the medial and lateral PRFs, mainly in the side contralateral to peripheral stimulation, was explored at the level of the abducens nerve and the trapezoid body. This level has been reported to contain many ascending neuron populations (Brodal 1957).

The stimulus was delivered by a Nihon-Koden electronic stimulator. R-C-coupled amplifiers in conjunction with a dual beam cathode ray oscilloscope (Nihon-Koden, type VC 6) were used. The background EEGs of the cerebral cortex and the hippocampus were monitored with an ink-writing recorder.

After the experiment, the brain was perfused with 10% formalin. Frozen sections, stained with thionine, were examined histologically to identify the positions of the tips of gross electrodes.

RESULTS

I. PRF response to stimulation of the peripheral nerves and the MRF.

The potential recorded from the PRF upon stimulation of the sciatic and the superficial radial nerve had an initial positive component and a following slow negative one. The positive component had a latency of 10–20 msec, sometimes 30–40 msec, and its duration was 10–30 msec. The negative com-

![Fig. 1. PRF potentials elicited by stimulation of the sciatic (1) and the superficial radial nerves (2). Recordings were made from two different points of the PRF (A: lateral PRF, B: medial PRF) at the level of the abducens nerve and the trapezoid body. A histological picture indicates the recording points of the PRF. In this and all subsequent figures, negativity was indicated downwards.](image-url)
ponent had a duration of 40-75 msec (Fig. 1). Though the recording electrodes were moved widely either mediolaterally or dorsoventrally, this potential did not change appreciably. This is exemplified by Fig. 1 where the responses to sciatic and superficial radial stimulation were recorded from the PRF points, the one medial and the other lateral. With increasing the intensity of the stimulation, there was sometimes an increase of the negative component without a marked change in the entire potential pattern. When the peripheral nerve was stimulated repetitively with increasing frequencies up to 100 c/s, the negative component disappeared except the one evoked by the first stimulus. The positive one followed the stimulus up to 20 c/s with a reduced amplitude. Examining the responses to paired stimuli of varying inter-shock intervals, it was seen that the refractoriness produced by the first shock lasted for 30-70 msec with regard to the positive component. The refractory period of the negative component was 90-100 msec. These findings may suggest that the negative and positive components of the field potential are distinguishable from each other in the origin. This is also supported by the experiment in which effects of anoxia were examined upon these potential components. In two experiments anoxia was induced by stopping artificial respiration. The negative component disappeared within 4 min after stopping the artificial respiration, whereas the positive component was maintained with a gradually decreasing amplitude until about 10 min.

The PRF responded to stimulation of the MRF. Sample records of the PRF potential to a single shock applied to the MRF are reproduced in Fig. 2. In this experiment, two pairs of stimulating electrodes were placed in the MRF with a separation of about 1 mm (stimulating points, A and B). The recordings of the PRF potential were made from two points about 2 mm apart (upper and lower traces in each record of Fig. 2). As seen in the bottom two records of Fig. 2 where the highest intensity of stimulation was applied, the evoked PRF potential was triphasic starting with the initial positivity. The initial positive component was found to be superimposed by some spike-like activities. The latency and the duration of the initial positive component were one to several msec and 20 msec, respectively. The corresponding figures of the negative wave were about 20 and 30-50 msec, respectively. This centrally evoked PRF potential is distinguished from the peripherally evoked one in the following two points: the negative component of the centrally evoked potential had a shorter duration than that of the peripherally evoked one and there was no deflection in the peripherally evoked potential corresponding to the last positive deflection of the centrally evoked one.

Comparing the two columns of records with each other in Fig. 2, one can see that the stimulating point A (column A) exerted a weaker effect than the point B (column B) at three different levels of the stimulus intensity. Since this was found very commonly in the present experiment, it is sug-
suggested that the descending connection from the MRF to the PRF is not diffuse but rather specific.

When activity of the PRF was examined with microelectrodes, it was found that most of the units encountered could be fired by peripheral nerve stimulation. Examining many neurons activated by single shock stimulation of the peripheral nerves, the firing pattern could be classified into two types. The unit response of the first type (73 out of 131 units) occurred with a burst of several spikes which started 10-30 msec and ended about 40 msec after the peripheral shock. When the PRF unit responding with the first type showed the spontaneous discharges during the resting state, it took at least about 40 msec for the spontaneous discharges to appear following the end of the initial evoked burst of the spikes (Fig. 3, column 1). An example of the unit discharging with the second type is shown in column 2 of Fig. 3. This type was found in 58 out of 131 units. The discharges evoked by the peripheral shock occurred with latencies of 10-30 msec and continued for 70-150 msec. The relation of evoked unitary activity to the field potential is as follows: In the first type, the burst of evoked discharge occupies the initial positive component and the increasing phase of the negative component of the field potential, while the evoked discharges of the second type are disseminated in the entire time course of the field potential.

Most of the PRF units encountered could be fired by a single shock to
MESENCEPHALIC RETICULAR INFLUENCE

FIG. 3. Unit PRF activity, spontaneous (A) and evoked (B). Two types of the unit response (1B, first type; 2B, second type) to single shock stimulation of the superficial radial nerve.

FIG. 4. Two types of the PRF unit response to stimulation of the MRF. (1, first type; 2, second type). In A and B, different intensities of stimulus were applied. The strength of stimulus in A is weaker than in B.

The PRF unit response of the first type occurred with a short latency of one to several msec, being sometimes accompanied with one or two spikes after various time intervals (Fig. 4, 1A). When the highest intensity of stimulation was applied, this unit discharged a burst of several spikes which was confined within about 15 msec. There were no marked after-discharges (Fig. 4, 1B). The second type unit response was characterized by a burst of spikes which continued for about 150 msec with a gradually decreasing frequency (Fig. 4, 2B). The latency of the spike burst was decreased by increasing the intensity of MRF stimulation, but it could not be reduced below 10 msec even with the highest intensity. The unit responding
with the second type seemed to have a higher threshold of activation than the unit responding with the first type. The relations between the field potential and the unit response in the case of MRF stimulation was as follows: In the first type the burst of spikes was confined in the phase of the initial positivity, while in the second type unit response, the spike discharges were maintained throughout the entire time course of the field potential.

In preceding section we have shown that there are two types of the discharge pattern of the PRF unit to MRF stimulation. But, it was not infrequently found that a given PRF unit changed its discharge pattern from the first type to the second one or vice versa according to the sites of stimulation in the MRF. This suggests that the pattern of discharge of a given PRF unit is not rigidly fixed. It is suggested that the firing pattern of the PRF unit is determined by the mode of connection with the MRF.

II. MRF influences upon peripherally evoked PRF activities

1) Studies on field potentials. Single shock stimulation of the MRF exerted a marked influence upon PRF response evoked by a single shock stimulus to the peripheral nerves. An example of the results is shown in Fig. 5 which illustrates the time course of the MRF-conditioning effects upon the peripherally evoked, PRF response.

In this experiment the testing response was produced by the maximal stimulation of the sciatic nerve at varying time intervals after a maximal conditioning shock to the MRF. As seen in the bottom record of the specimen series, this conditioning shock of the MRF caused an apparent evoked response which was distorted by a large artefact in this particular case.

The effect triggered from the MRF was more or less suppression of the peripherally evoked PRF response in both the positive and negative components. Mostly the suppression of the evoked response was complete for 30 msec after the MRF shock, and then there occurred a gradual recovery. The effect of the MRF stimulation disappeared about 100 msec after its initiation. These features will be seen in the graphs of Fig. 5 showing the recovery course of the testing response, with the positive component (upper graph) and the negative one (lower graph) separately.

When the intensity of the conditioning shock to the MRF was reduced to a submaximal level, the suppressing effect could be detected only with the negative component of the testing response. If the intensity of the MRF shock was further reduced to a level which was insufficient to evoke the field potential, there was found no trace of suppression of the testing response.

In some experiments, examinations were made to determine whether there is a laterality between the conditioning point of the MRF and the testing point of the PRF. It was found that when the intensity of the MRF condi-
FIG. 5. Time courses of the conditioning effects of MRF stimulation upon two components of the PRF potential tested by sciatic nerve stimulation. Ordinate: amplitude of two components in per cent of control. Abscissa: interval between conditioning and testing stimuli in msec. Time intervals below 20 msec were omitted. Plotted points were derived from five different experiments. In specimen records, C and T mean conditioning and testing response, respectively. Numbers attached mean the conditioning-testing intervals in msec.
tioning stimulation was kept weak, the suppression of the PRF testing response occurred more markedly on the side ipsilateral to the MRF stimulation than on the contralateral side. However, this sort of laterality was lost when a very strong conditioning shock was used.

Fig. 6 mounts sample records showing effects of repetitive stimulation of the MRF upon the PRF testing response which was produced by a single shock stimulation of the peripheral nerve. Records A, B and C were obtained by using 10, 50 and 100 c/s stimulation of the MRF, respectively. In record A, there was no significant effect. Record B shows that the testing response was affected in both the negative and positive components in the first sweep during the MRF stimulation, but it is seen in the second sweep that the positive component tended to escape from the MRF suppressing effect. In the record C where the MRF effect appeared most markedly in this series, the testing response was kept suppressed during the MRF stimulation and such suppression continued for a while after a withdrawal of the MRF stimulation. The suppression occurred more markedly in the negative component than in the positive one both during and after the MRF stimulation. Thus

![Fig. 6. Effects of repetitive stimulation of the MRF upon the PRF testing response to a single sciatic shock. Record A, B and C show the effects of different frequencies of MRF stimulation applied (10, 50 and 100 c/s, respectively). Peripheral nerve stimulation was delivered once every 3 sec.](image-url)
it is seen that the positive component is more difficult to be suppressed by
the MRF effect than the negative one. Throughout all the experiments, we
have not encountered the case where the peripherally evoked PRF response
is facilitated by activation of the MRF either with a single shock or repeti-
tive ones.

The relation between EEG and suppression of the PRF activity is as fol-
lows: Most of the MRF points were effective to induce both EEG arousal
and suppression of the PRF activity. There were found, however, some ex-
ceptional MRF points which were capable of triggering the ascending EEG
arousal effect but not of exerting the descending suppressing effect upon the
evoked PRF activity. When both the ascending and descending effects were
elicited from the same PRF points, it was most usual that the both effects
had about the same threshold for elicitation and increased their strengths in
parallel with increasing the intensity of the MRF stimulation. The two
effects lasted for about the same length of time, but in some occasional cases
the EEG arousal effect outlasted suppression of the evoked PRF activity.

2) Studies on unit responses. Among the unitary discharges recorded from
the PRF, we studied those satisfying the following criteria: i) The units
responded to single shock stimulation of the sciatic and superficial radial
nerves. ii) The units changed their firing rates upon repetitive stimulation
of the peripheral nerves. iii) When the PRF points very close to the record-
ing site were stimulated repetitively with a pair of gross electrodes while
holding the unitary activity or after the microelectrode was withdrawn, there
occurred a cortical EEG desynchronization.

An example of the records showing the response pattern to peripheral
nerve stimulation is reproduced in FIG. 7. This unit responded to single
shock stimulation of the peripheral nerves with 3 to 5 spikes, and upon re-
petitive stimulation it increased the firing rate above 100 c/s initially and

---

FIG. 7. PRF unit response to single shock and repetitive stimulation of
both the sciatic and the superficial radial nerves. To the left, a single shock
of the nerves was marked with arrow. Repetitive nerve stimulation was
marked by horizontal line. In continuous records, upper trace shows the PRF
unit response and lower trace frontal EEG.
maintained the discharge with decreasing frequencies while the peripheral stimulation continued. There were the PRF units which responded with several spikes to single shock stimulation of the peripheral nerves but decreased their firing rates upon high frequency stimulation. Though this type of the unit was encountered very rarely, it was used as the test object of the present study.

When the animals were left undisturbed, the PRF units which met the above criteria showed spontaneous discharges at variable frequencies. The discharge pattern differed from neuron to neuron. In most cases, the PRF neurons fired spontaneously with the maximum frequency of 10 c/s and with

![Graph showing facilitatory effect of MRF repetitive stimulation upon spontaneous activity of the PRF neuron. Records A, B and C show continuous records before, during and after MRF stimulation. Record D was obtained 13 sec after cessation of MRF stimulation. The graph shows the time course of MRF facilitatory effect upon the PRF unit. Ordinate: discharge numbers of the PRF unit per second. Abscissa: time before and after the beginning of MRF stimulation.](image-url)
irregular patterns. Less often, there were encountered the neurons which showed relatively regular patterns with frequencies of 30-60 c/s.

Repetitive stimulation of the MRF caused a marked change in the discharge frequency of the PRF neuron, associated with EEG arousal. Among 66 PRF neurons examined, the firing rate was increased in 61 units and it was decreased in 5 units. An example of results showing an increase of the discharge frequency with EEG arousal is seen in Fig. 8. This unit fired only occasionally before the MRF stimulation (A), but increased the firing rate up to 20 c/s upon repetitive stimulation of the MRF (B). Though the firing rate was decreased slightly toward the end of the stimulation, it increased again for a short while upon withdrawal of the stimulation (This phenomenon was commonly seen in many PRF units). The return of the firing rate to the resting level was attained about 15 sec later (D). Such changes in the firing rate are shown graphically in the bottom of this figure.

Fig. 9. Inhibitory effect of MRF repetitive stimulation upon spontaneous activity of the PRF neuron. A: before MRF stimulation. B and C: during and after MRF stimulation. D: 15 sec after MRF stimulation. Spikes were retouched. The graph shows the time course of MRF inhibitory effect upon the PRF unit. Ordinate: discharge numbers of the PRF unit per second. Abscissa: time before and after the beginning of MRF stimulation.
Fig. 9 illustrates a behavior of a unit which showed a decrease of the firing rate upon the MRF stimulation. During the resting stage (A), this unit showed spontaneous discharges at 20-30 c/s with a slight fluctuation. The MRF stimulation was effective to reduce the rate of firing down to about 10 c/s, and further to a minimal frequency of 2-3 c/s within 1 sec after the stimulation (C). Following this, the rate of firing increased progressively and regained its initial level of activity about 12 sec later (D).

Effects of repetitive stimulation of the MRF were examined upon the evoked unitary activity to peripheral nerve stimulation. First, we picked up the PRF units which responded to peripheral stimulation, without regard to their discharge patterns. Then, a single shock was applied to a fixed MRF point to see how the testing units are activated from given MRF stimulating points. If the PRF units were activated by a single MRF shock of a low intensity with the discharge pattern of the first type, they were grouped as low-threshold units, in distinction from the high-threshold ones which did not show the first type discharge pattern to a MRF shock. Finally, we examined effects of repetitive stimulation of the fixed MRF points upon peri-

![Fig. 10. Effects of MRF repetitive stimulation upon the PRF unit response to stimulation of the sciatic nerve. Peripheral nerve stimulation was applied once every 3 sec. These data were taken in different experiments.](image)
pherally evoked PRF activity. The intensity of the repetitive stimulation was kept about the same as used for determining the unit discharge pattern with a single shock. Among 66 PRF units, 17 units showed no changes in their testing responses. In the remaining 49 units, there could be seen either facilitation (28 units) or inhibition (21 units) (Table 1). A sample record showing the facilitation is shown in record A of Fig. 10. The unit which responded with several spikes to stimulation of the sciatic nerve increased the firing rate immediately after the onset of MRF stimulation. This augmented firing, associated with a decrease of the latency, lasted a long time after the cessation of the MRF stimulation. Record B of Fig. 10 is an example showing the inhibitory effect of the MRF stimulation. The unitary activity appearing at the peak of the negative component of the field potential was inhibited during and after the stimulation. It was recovered in the last sweep of the record. Though the field potential was also suppressed during and after the MRF stimulation, the first sign of its recovery was seen in the second sweep after the cessation of the MRF stimulation. There were some PRF units which were rather facilitated during the MRF stimulation but suppressed after its withdrawal.

Whether the peripherally evoked, PRF unit response is facilitated or inhibited by repetitive shocks of the MRF, seems to depend upon whether or not the testing unit is easily activated by a single shock of the MRF. As shown in Table 1, the facilitation is found more frequently in the high-threshold units than in the low-threshold ones whereas this relation is reversed with the inhibition. The unit shown in Fig. 10A belonged to the high-threshold group and the unit shown in Fig. 10B to the low-threshold one.

Table 1.

<table>
<thead>
<tr>
<th>Threshold of MRF single shock for activation</th>
<th>facilitation</th>
<th>inhibition</th>
<th>none</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>9</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>high</td>
<td>19</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>total</td>
<td>28</td>
<td>21</td>
<td>17</td>
</tr>
</tbody>
</table>

Discussion

1. Field potentials of the PRF. Three types of the RF potentials evoked by stimulation of the peripheral nerves have been reported (Collins and O'Leary 1954; Magoun and McKinley 1942). Magoun and McKinley (1954) recorded the potential with a long latency in the neighborhood of the centre médian
nucleus ("Centre médian (CM) potential"). COLLINS and O'LEARY (1954) recorded the "midbrain potential" from a discrete region of the MRF which differed from the "CM potential" in the potential form and latency. MAGOUN and McKinley (1942) reported that they sometimes observed evoked potentials intermediate in character between those of the lemniscal system and those of the CM upon stimulation of face as well as limb nerves. The PRF field potentials obtained in our study were very similar to the "CM potential". Large spike-like potential similar to the "midbrain potential" could not be observed. The latency of our PRF potential was 10–20 msec generally, being consistent with the latencies of the CM potential and other similar RF potentials studied by previous workers (FRENCH, VERZEANO and MAGOUN 1953; HARA, FAVALE, Rossi and SACCO 1961; HERNÁNDEZ-PEÓN and HAGBARTH 1955). The positive component of the PRF potential was found to follow peripheral repetitive stimuli up to 20 c/s. This is consistent with the previous finding that the evoked potential of the midbrain tegmentum followed up to 30–40 c/s stimulation of the peripheral nerve (STARZL, TAYLOR and MAGOUN 1951). COLLINS and O'LEARY (1954) found that the midbrain potential is set in the absolute refractoriness for 30 msec and recovered following a similar time course to that seen in the specific potential of the nucleus ventralis posterolateralis. The positive component of the PRF potential has been found to have an absolute refractory period of 30–70 msec. With regard to the excitability cycle, our PRF potential is similar to the "midbrain potential". The latency of the PRF potential to single shock stimulation of the MRF is between 1 and several msec. Rossi and ZANCHETTI (1957) have suggested the possibility to evoke a short latency potential of the PRF by stimulating the MRF, on the basis of their finding that the MRF responded with a short-latency, spike-like response to stimulation of the PRF.

2. Unit discharges of the PRF. MORUZI and his associates (MOLLICA, MORUZI and NAQUET 1953; MORUZI 1956) reported that there are four types of spontaneous discharges in the reticular core of the brain stem. We observed in the PRF the following two types of the spontaneous activity: 1) irregular discharges at frequencies below 10 c/s and 2) regular discharges at 30–60 c/s. These two types most probably correspond to MORUZI's first and second types of the spontaneous activity. We failed to see his third type (the spike burst at 50–70 c/s arising from a background of the low frequency discharge and lasting approximately one second) and fourth type (short lasting, high frequency (up to 500 c/s) outbursts, often separated by silent intervals). This discrepancy may be due to the difference of condition of the experimental animals; MORUZI and his associates used not only intact curarized animals but also decerebrate and encéphale isolé animals, whereas our observations were made exclusively on intact animals immobilized with suc-
cinylcholinechloride and Flaxedil. In addition to this, since our observations were limited to the PRF, chances to see many varieties to the spontaneous discharges might be reduced.

We classified the firing patterns of PRF unit response to single shock stimulation of the peripheral nerve into two types. The first type discharge shows an initial burst of several spikes, and if there are spontaneous discharges during the resting state, they are recovered after a pause following the initial bursts. The second type discharge is such that an initial burst is followed by continuous discharge with a gradually decreasing frequency. Similar two types of the PRF unit response were reported by Pompeiano and Sweet (1963a, 1963b). They obtained the first type response to stimulation of muscular afferent fibers of the deep radial and hamstring nerves, and the second type one to stimulation of cutaneous afferent fibers of the superficial radial nerve. Amassian and DeVito (1954), Bell et al. (1964) and Machne et al. (1955) reported the unitary response of the MRF to peripheral nerve stimulation. But their observations were confined to the type which corresponds to our first type.

3. Relation of the PRF field potential to the PRF unit response. The temporal relation of the unitary evoked activity to the field potential has been found as follows; the first type unit shows its initial burst during the initial positive component and the increasing phase of the negative component of the field potential, while the evoked discharges of the second type are found throughout the entire time course of the field potential. According to Machne et al. (1955), the MRF unit response evoked by sciatic nerve stimulation is such that there are repetitive discharges during the initial negative phase of the evoked potential, no discharges during the following positive deflection and finally after-discharges. These data are consistent with our findings on the first type. But the field potential to which they attempted to correlate the evoked unitary activity is recorded with the polarity which is reversed to our PRF field potential. This point remains unexplained.

4. Effect of MRF stimulation. Single shock stimulation of the MRF has been found to evoke the PRF activity which can be recorded both as field potentials and unitary discharges. The pattern of the field potential to a MRF shock is similar to that obtained by a single shock to peripheral nerves. This similarity is extended to the level of the unitary activity, because there are two types of MRF-induced unitary activity as in the case of peripheral activation (first and second types). This may suggest that mode of activation of the PRF unit is not essentially different between the MRF and the peripheral nerves. However there is an indication that the discharge pattern of a given PRF unit to a MRF shock is not fixed but variable depending
upon the sites of stimulation in the MRF, whereas there are no appreciable changes in the discharge pattern if the site of peripheral stimulation is altered.

It has been found in this experiment that stimulation of the MRF with repetitive shocks as well as with a single one reduces the peripherally evoked PRF potential, this effect being parallel to induced EEG arousal. There are at least three mechanisms to account for this suppression. First, the inhibitory influence of the brain stem reticular formation upon the specific sensory transmission system may be responsible. As shown by Hagbarth and Kerr (1954), there is a possibility that the testing impulses arising from peripheral nerves are stopped from entering the PRF because they are suppressed at the first relay nucleus of the spinal cord by the descending effects of MRF activation. Secondly, since some of the PRF units are equally activated by peripheral and MRF stimulation, there may occur occlusion of the stimulating effects when the PRF units are activated from both sides. Finally, the MRF may exert an active inhibitory process upon the PRF units. Magni and Willis (1964) have found that stimulation of the central tegmental tract at the level of the brain stem produces the IPSPs in some of the PRF units. Though the MRF effect upon the PRF activity has been found to be of inhibitory nature so far as the peripherally evoked field potential is used as a testing response, the situation is different when the testing response is the unitary activity, either spontaneous or evoked. In the latter case there is found in the MRF effect a facilitatory action which increases the unit response of the PRF to peripheral stimulation. For the moment, there is no reasonable explanation for the fact that the facilitatory effect of MRF origin can not be detected by recording the field potential. This is because the essential nature of the field potential remains unsolved from the view point of membrane activity.

Up to the present, there has been the well-established concept that the ascending effect originating in the MRF is diffusely acting upon the rostral brain. However, this concept seems not to hold with the descending effect. Single shock stimulation applied to two different points of the MRF, which are situated as close as 1 mm, produces in one point of the PRF the activities which are different from each other in the intensity or in the unitary discharge pattern. This is revealed by the unitary recording as well as by the field potential recording. For example, as shown in Fig. 2, the same PRF point is activated very strongly from one point of the MRF, while stimulation of the very close but different MRF point is much less effective. Also it is shown in the unitary recording that when the same PRF point is activated from two MRF points which are very close to each other, there is found a more or less difference in the threshold of activation with or without change in the pattern of discharges. These facts make us to suppose that the connection between the MRF and the PRF is not diffuse but rather
specific. On the basis of this notion the results shown in Table 1 seem to be understandable. In the studies on the regulatory effects of MRF origin upon the PRF activity of the unitary level, we classified the testing PRF units into two types (low-threshold and high-threshold ones) using a single MRF shock. It is suggested that the difference of threshold of activation may reflect the difference in the density of connection between a PRF testing unit and a MRF stimulating point. In other words, if a PRF unit is connected closely to a given MRF stimulating point, it is activated with low-intensity stimulation, whereas a PRF unit connected loosely to the same MRF stimulating point requires high-intensity stimulation for activation. It is seen in Table 1 that the number of the PRF units which receive the MRF regulatory effect, either facilitatory or inhibitory, is relatively greater in the low-threshold group than in the high-threshold one. This means that when the regulatory effect is triggered from one point of the MRF, it does not act diffusely upon all the PRF units but it is confined to the PRF units which are closely connected to the site of its origin. Since this is the case, the suggestion that the MRF regulatory effect upon the PRF activity is realized not within the PRF but at a lower level of the sensory transmission system is not sufficient to explain all the results relating to the MRF regulation of the PRF activity.

SUMMARY

Some characteristics of the electrical activities of the pontine reticular formation (PRF), recorded with gross- and micro-electrodes following stimulation of either the sciatic or the superficial radial nerve, were studied under the effects of stimulation of the mesencephalic reticular formation (MRF). The experimental animals were exclusively unanesthetized cats, immobilized with succinylcholine chloride or Faxedil.

1. The peripherally evoked PRF potentials were composed of the initial positivity and the following negativity, this potential form being independent of the site of stimulation. The latency and the duration of the initial positive component were 10-20 msec and 10-30 msec, respectively, while the negative component had a duration of 40-75 msec. The MRF-induced, PRF potential was triphasic having the initial positivity. The threshold intensity of stimulus for eliciting the PRF potential was dependent on stimulating sites of the MRF.

2. The peripherally evoked PRF unit response was classified into two types. The first type unit response occurred with an initial burst of spikes without being followed by after-discharges, whereas in the second type an initial burst of spikes continued to regular discharges with gradually decreasing frequencies. The mode of activation of the PRF unit was not essentially different between the MRF and the peripheral nerves. For a given stimulat-
ing point of the MRF, two types of the PRF unit were distinguished according to the threshold of activation (low-threshold and high-threshold). The discharge pattern of a given PRF unit to MRF stimulation was not fixed but variable depending on the site of stimulation.

3. There are two types of spontaneous discharges in the PRF, the one with an irregular pattern of less than 10 c/s and the other with a relatively regular pattern at 30-60 c/s. The firing rates of the PRF unit were mostly increased by MRF arousal stimulation.

4. A single shock applied to the MRF with strengths sufficient for eliciting the PRF potential suppressed the peripherally induced, PRF potential for 10-40 msec.

5. The peripherally induced, PRF potentials were suppressed during and after repetitive stimulation of the MRF, this being parallel to EEG arousal.

6. Repetitive stimulation of the MRF increased the peripherally evoked, PRF unit response. The facilitatory effect was found more frequently in the high-threshold units than in the low-threshold ones, whereas this relation was reversed with the inhibition.

7. It was suggested that the descending connection from the MRF is not diffuse, but rather specific.

The authors' grateful acknowledgement is made to Dr. K. IWAMA for his essential service in criticising and editing the manuscript.

REFERENCES


10) Jasper, H.H. and Ajmone Marsan, C. A stereotaxic atlas of the diencephalon
MESENCEPHALIC RETICULAR INFLUENCE


