Modification of Visual, Auditory, and Somatosensory Evoked Responses in Cortical Primary Receiving Areas by Nigral Stimulation

The substantia nigra has been thought to be part of the extrapyramidal motor system[1], and little attention has been paid to its participation in sensory activities. In our previous studies[2-4] effects of stimulation of the lenticular, caudate, and red nuclei on the visual cortical activity were investigated, and enhancement of the photically evoked potential was observed. As fiber connections between striatum and substantia nigra were established[1], in this study an attempt was made to investigate effects of stimulation of the substantia nigra on visual, auditory, and somatosensory evoked responses in cortical primary receiving areas.

Methods. Experiments were performed on 30 cats anesthetized lightly with hexobarbital. A silver ball electrode, 1 mm in diameter, was used to record visual, auditory, and somatosensory evoked responses from the lateral, ectosylvian, and coronal gyri, respectively. The indifferent electrode was placed on the frontal sinus. The electrodes were connected to a preamplifier system and variations of the potential were displayed on a Nihon-kohden dual beam oscilloscope. The visual stimulus was a single flash delivered from a xenon flash lamp facing the atropinized eyes at a distance of 30 cm. The auditory stimulus was a click presented by a loudspeaker through a hollow earbar contralateral to the recording cortex. The somatosensory stimulus was an electrical shock (0.05–0.1 msec; 1.0–2.0 V) applied to the contralateral radial nerve. An antero-posterior row of a pair of insulated stainless steel needles, 0.1 mm in diameter, was stereotaxically placed in the substantia nigra[5] and used for stimulation. The distance

[1] R. JUNG and R. HASSLER, in: *Handbook of Physiology, Sec. 1, Neurophysiology*, vol. 2 (Eds. J. FIELD, H. W. MAGOUN and V. E. HALL; Am. Physiol. Soc., Washington 1960), p. 863.
[2] I. KADOBAYASHI, Pflügers Arch. ges. Physiol. *332*, 10 (1972).
[3] I. KADOBAYASHI, Y. AMANO, H. YAMANE and Y. MIYAMOTO, Folia Psychiat. Neurol. Jap. *26*, 95 (1972).
[4] I. KADOBAYASHI, Exp. Neurol., in press (1973).
[5] H. H. JASPER and C. AJMONE-MARSAN, *A Stereotaxic Atlas of the Diencephalon of the Cat* (National Research Council of Canada, Ottawa 1954).

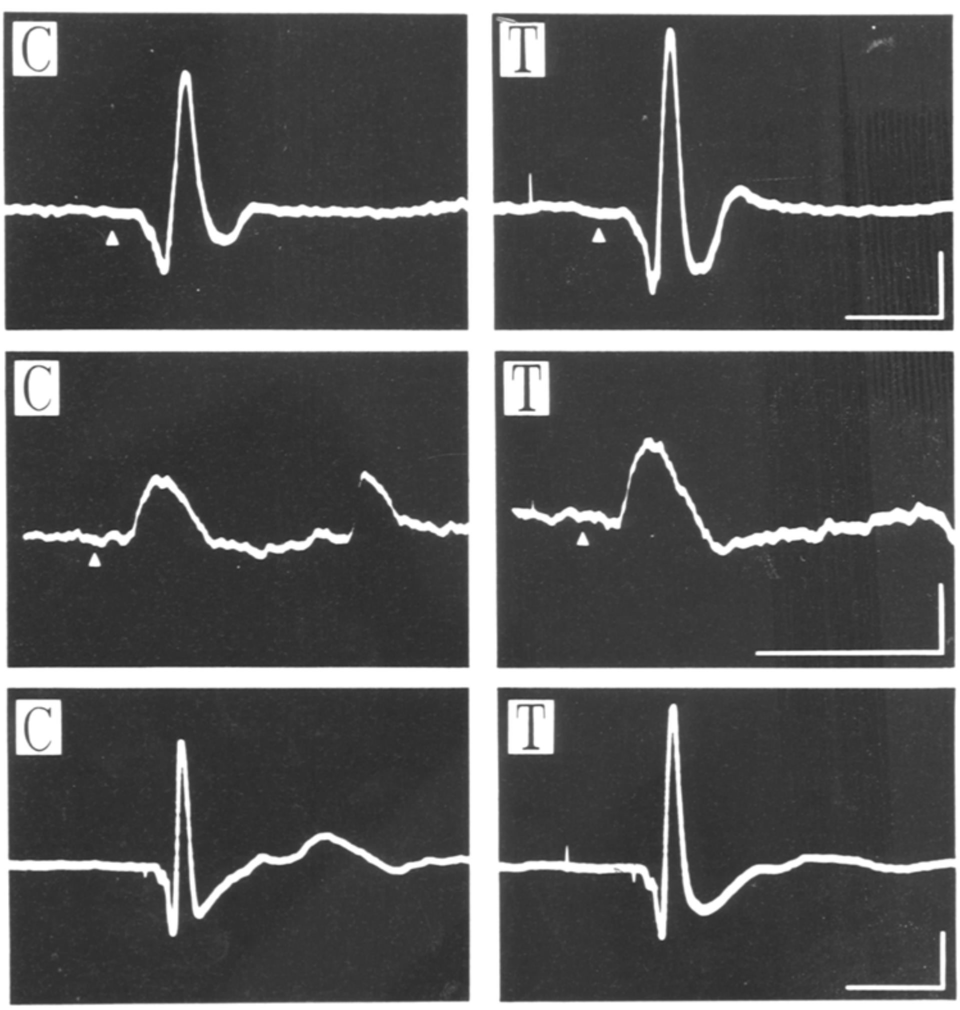

Fig. 1. Effects of nigral stimulation on visual, auditory, and somatosensory evoked responses in cortical primary receiving areas. The upper, middle, and lower rows present visual, auditory, and somatosensory evoked responses, respectively. Triangles represent flash (in the upper row), and click (in the middle row). Each C shows control record of response, and each T enhancement of the response by nigral stimulation. Conditioning-test intervals are 35, 13, and 35 msec, respectively. Calibration: 100 μV; 50 msec (in the upper and lower rows), 50 μV; 50 msec (in the middle row). Negative upward.

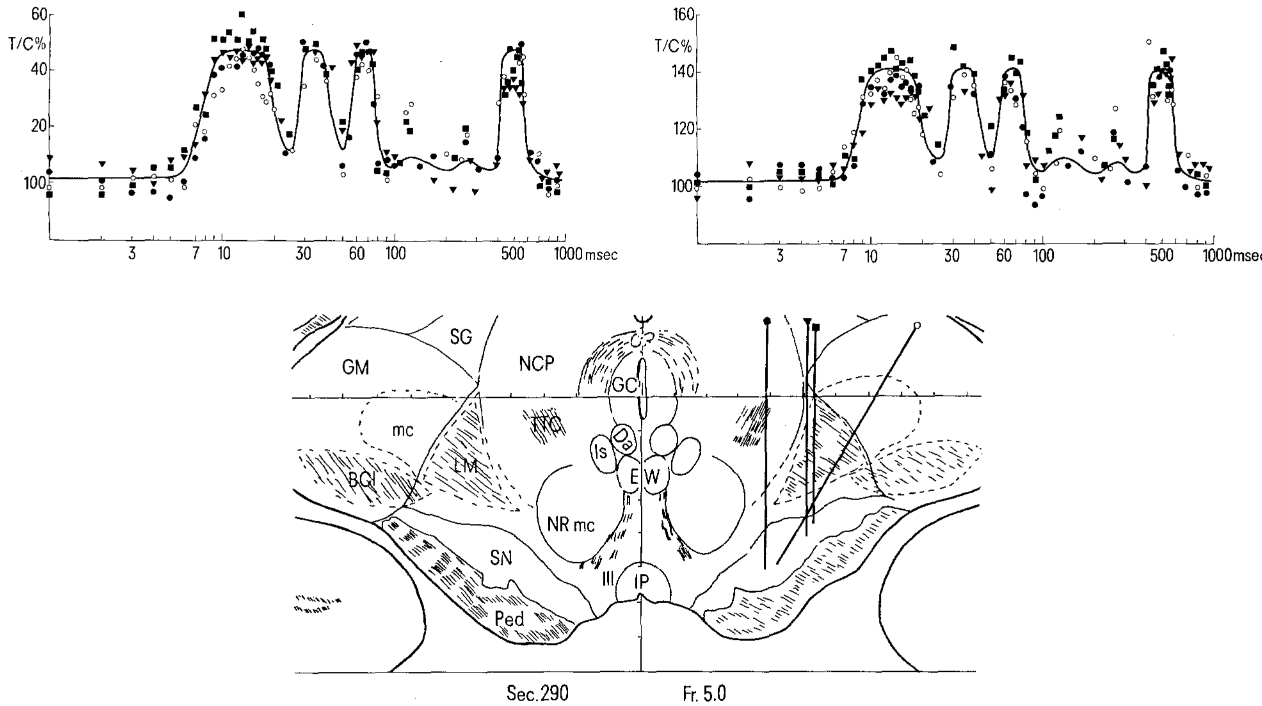

Fig. 2. Time course of effects of nigral stimulation on the visual evoked response in the ipsilateral lateral gyrus. Abscissa: Interval. logarithmic scale in milliseconds, between conditioning and test stimulation. Ordinate: Amplitude of the visual evoked response conditioned by nigral stimulation as percentage of control response amplitude. Left graph shows the positive component of the response and right graph the negative one. ○ ● ▼ ■ represent values from different animals, and each electrode placement is illustrated in the lower diagram.

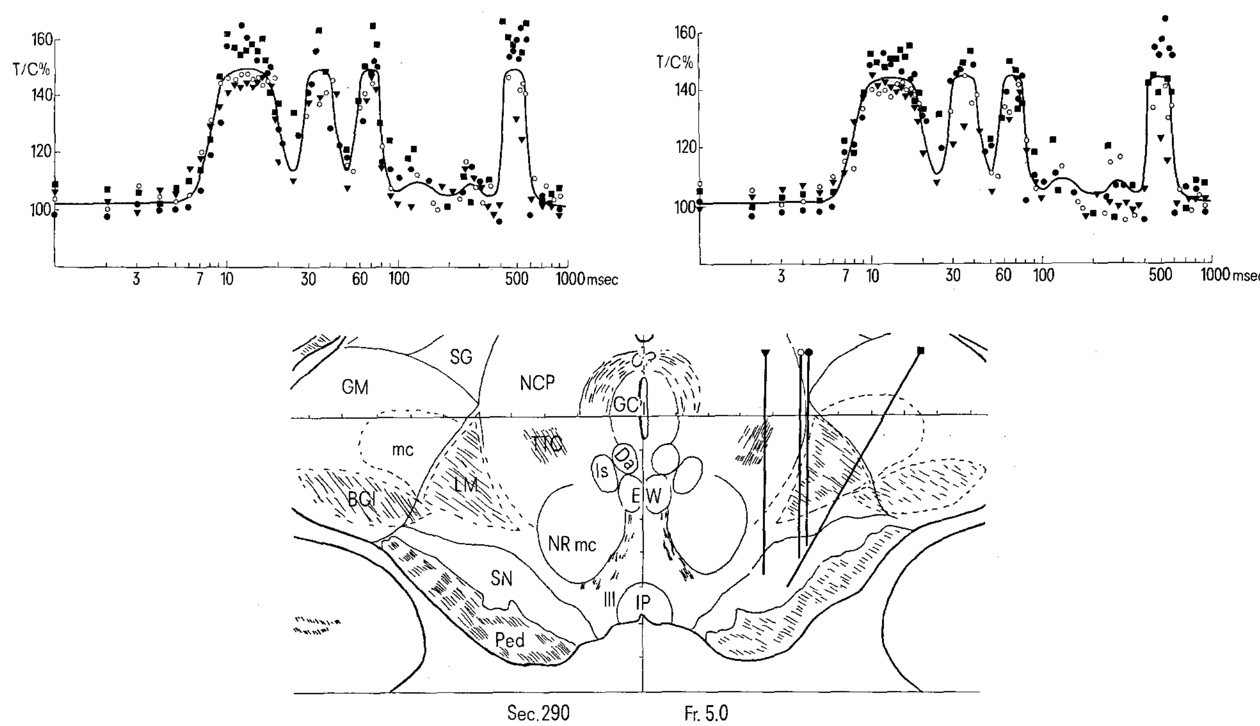

Fig. 3. Time course of effects of nigral stimulation on the visual evoked response in the contralateral lateral gyrus. The same sign as the preceding figure is used.

between their exposed tips measured 0.5 mm. The substantia nigra was stimulated with a 0.1–0.15 msec pulse of 4.5–5.0 V. The conditioning stimulus to the substantia nigra preceded the test stimulus by an interval varying between 1 and 1000 msec. After a waiting period of 75 sec or longer, the next stimulus combination was given. At the end of the experiment the brain was removed and prepared for frozen sections. All stimulating electrode placements were verified histologically.

Results and discussion. Stimulation of the substantia nigra resulted in an increase in amplitude of primary components of visual, auditory, and somatosensory evoked responses in cortical primary receiving areas bilaterally. This is illustrated in Figure 1. The upper row shows the visual evoked response (C), which was enhanced by nigral stimulation (T). The middle, and lower rows represent auditory, and somatosensory evoked responses, respectively. Both were enhanced by conditioning stimulation of the *substantia nigra* (T). Nigral stimulation alone produced no response in each recording site.

The time course of effects of nigral stimulation on the visual evoked response in the ipsilateral lateral gyrus is shown in Figure 2. The left graph presents the positive component of the response and the right graph the negative one. ○ ● ▼ ■ represent values from different animals, and each electrode placement is illustrated in the lower diagram. Polyphasic curves could be seen, and a marked increase in amplitude of the response occurred at conditioning-test intervals of 9–19, 30–40, 60–75, and 410–590 msec. Figure 3 shows the time course of effects of nigral stimulation on the visual evoked response in the contralateral lateral gyrus. The effective conditioning-test interval ranges were the same.

Modification of sensory impulses both by the reticular formation and by the nonspecific thalamic nuclei has been well established[6–9]. In the last decade effects of caudate stimulation on sensory activities have been studied[10–12]. In our previous studies[2–4] enhancement of photically evoked potentials by lenticular, caudate, and rubral stimulation was observed, and in this investigation that of visual, auditory, and somatosensory evoked responses by nigral stimulation was found. The anatomical findings[13–15] that the *substantia nigra* receives afferent fibers from the *striatum, globus pallidus*, etc., and sends efferents to the *striatum, globus pallidus*, reticular formation, etc. seem to support the results obtained in the present study. The first effective conditioning-test interval range of nigral stimulation is similar to that of rubral stimulation[4], and longer than that of lenticular and caudate stimulation[2,3]. The second, third, and fourth ones are similar to those of lenticular, caudate, and rubral stimulation[2–4]. This suggests an intimate functional relation between these structures.

Since it has been asserted that the destruction of the *substantia nigra* is responsible for parkinsonism, its role in motor function has been investigated[1]. On the other hand, TATETSU[16] reported psychological symptoms, such as personality changes, disturbance of the self, and delusions, that were associated with damage of the *substantia nigra*. From this and our findings, it can be said that the *substantia nigra* functions as 'nonspecific' in the brain stem.

Zusammenfassung. Nachweis einer «unspezifischen» fördernden Wirkung von Stimulation der Substantia nigra auf «evoked potential» in den primären sensorischen Zentren des Grosshirns.

IWAO KADOBAYASHI and MICHIHIKO NAKAMURA[17,18]

Department of Psychiatry,
Kyoto Prefectural University of Medicine,
Kawaramachi-hirokoji, Kamigyo-ku, Kyoto (Japan),
23 July 1973.

6 F. BREMER and N. STOUPEL, Acta Neurol. belg. *58*, 401 (1958).
7 S. DUMONT and P. DELL, J. Physiol., Paris *50*, 261 (1958).
8 H. H. JASPER and C. AJMONE-MARSAN, Res. Publ. Ass. nerv. ment. Dis. *30*, 493 (1952).
9 R. G. LONG, J. Neurophysiol. *22*, 412 (1959).
10 N. A. BUCHWALD, L. RAKIC, E. J. WYERS, C. HULL and G. HEUSER, Exp. Neurol. *5*, 1 (1962).
11 M. DEMETRESCU and MARIA DEMETRESCU, Electroenceph. clin. Neurophysiol. *14*, 37 (1962).
12 S. S. FOX and J. H. O'BRIEN, Science *137*, 423 (1962).
13 M. B. CARPENTER and R. E. MCMASTERS, Am. J. Anat. *114*, 293 (1964).
14 N.-E. ANDÉN, A. DAHLSTRÖM, K. FUXE, K. LARSSON, L. OLSON and U. UNGERSTEDT, Acta physiol. scand. *67*, 313 (1966).
15 S. MASUDA, Adv. Neurol. Sci., Tokyo *12*, 839 (1968).
16 S. TATETSU, Adv. Neurol. Sci., Tokyo *2*, 741 (1958).
17 Supported by a grant from the Japanese Ministry of Education.
18 Acknowledgment. We thank Prof. N. KATO, Prof. Y. IWASE, Dr. S. TAKAHASHI, and Dr. N. TANI for their help.

Effects of Octanoate on the Electrical Activity of Purkinje Fibres

Much discussion has recently centred around a possible arrhythmogenic effect of increased circulating free fatty acid (FFA) levels in acute myocardial infarction. On one hand, an association between high serum-FFA concentrations and incidence of serious arrhythmias and death has been found in patients with coronary occlusion[1], and even a causative role for increased FFA-levels has been suggested by results obtained in dogs with experimental infarction[2,3]. other observations, however, argue against such a direct arrhythmogenic effect of FFAs both in clinical situations[4,5] and under experimental conditions[6]. Increased ectopic pace-maker activity, orginating mainly from terminal Purkinje fibres, is known to play an important part in the development of severe ventricular arrhythmias following acute coronary occlusion[7]. The present investigation was undertaken, therefore, to study the effect of a FFA on the electrical activity of Purkinje fibres. To perform such experiments seemed worth-while, all the more because no information is as yet available on the electrophysiological effects of FFAs in single cardiac fibres. The preliminary results to be

1 M. F. OLIVER, V. A. KURIEN and T. W. GREENWOOD, Lancet *1*, 710 (1968).
2 V. A. KURIEN, P. A. YATES and M. F. OLIVER, Lancet *2*, 185 (1969).
3 V. A. KURIEN, P. A. YATES, M. F. OLIVER, Eur. J. clin. Invest. *1*, 225 (1971).
4 H. L. RUTENBERG, J. C. PAMINTUAN and L. SOLOFF, Lancet *2*, 559 (1969).
5 P. G. NELSON, Br. med. J. *3*, 735 (1970).
6 L. H. OPIE, R. M. NORRIS, M. THOMAS, A. J. HOLLAND, P. OWEN and S. VAN NORDEN, Lancet *1*, 818 (1971).
7 P. L. FRIEDMAN, J. STEWART, B. F. HOFFMAN and A. L. WIT, Circulation *46*, Suppl. *2*, 10 (1972).