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Nigrohypothalamic Fibers in the Cat.

DONALD L. KIMMEL. (Introduced by Harry A. Davis.)

From the Department of Anatomy, School of Medicine, Louisiana State University, New Orleans.

Marchi experimental studies (Papez,¹ Bodian,² Fox³) have shown that the mammillary peduncle is an ascending fasciculus. According to Ganser⁴ the fibers constituting the mammillary peduncle arise from the *Substantia nigra*. Recently Papez⁵ also has suggested that the *Substantia nigra* contributes to the formation of this peduncle. Others (see Raymon y Cajal⁶), although not denying the presence of the nigral component of the peduncle, have reported that fibers from the contralateral nucleus gracilis course forward with the medial lemniscus, and then pass through the nigra to enter the mammillary peduncle.

This report is based upon the results of experiments performed in an attempt to determine the efferent connections of the *Substantia nigra*. It is primarily concerned with fibers of nigral origin contained within the mammillary peduncle and the termination of such fibers in the hypothalamus.

Materials and Methods. Employing the Horsley-Clark apparatus, lesions were produced in the brain stems of 27 cats. Operations were performed under sodium barbiturate anesthesia using aseptic technic. All animals were sacrificed on the twelfth to fourteenth day postoperatively and the desired portions of the brains treated according to the Swank and Davenport⁷ modification of the Marchi technic. Nitrocellulose was used for embedding and every third-40 μ section was mounted for study. Nuclear relations were

checked in a normal cat brain, sectioned transversely and stained with cresyl violet.

In 22 animals the lesions involved the *Substantia nigra*; in 3, the lesions were located in the mesencephalic tegmentum just dorsal to the nigra and in 2, multiple lesions were located in the basilar and the ventral tegmental areas of the pons.

Observations and Discussion. Fibers arising from the *Substantia nigra* course to the hypothalamus by way of the homolateral mammillary peduncle. Such fibers are degenerated in all experimental animals which have lesions in the *Substantia nigra*, and they vary in quantity directly with the degree of involvement of the nigral complex.

These fibers reach the mammillary peduncle by two routes. Some pass directly medialward to the peduncle through the nucleus interpeduncularis transversi and the nucleus of the mammillary peduncle. Others pass ventromedially to enter the medial part of the basis pedunculi within which they ascend for variable distances and then turn medially into the peduncle.

These two groups of fibers intermingle in the lateral part of the mammillary peduncle as they ascend to the hypothalamus. They are supplemented by additional fibers from the *Substantia nigra* at each successive rostral level throughout the length of the nigral complex. Thus, the nigral component accounts to a large extent for the increase in the size of the peduncle as it proceeds rostrally (Ganser⁴).

The degenerated nigral fibers are distributed within the hypothalamus to the following homolateral cell groups: 1, the lateral mammillary nucleus; 2, the medial mammillary nucleus; 3, the supramammillary nucleus; 4, the lateral hypothalamic nucleus (the lateral hypothalamic area); and 5, the ventrolateral hypothalamic nucleus. A large number of the degenerated fibers continue directly for-

¹ Papez, J. W., *Anat. Rec.*, 1923, **25**, 146.

² Bodian, D., *J. Comp. Neur.*, 1940, **72**, 207.

³ Fox, C. A., *J. Comp. Neur.*, 1941, **75**, 411.

⁴ Ganser, S., *Morph. Jahrb.*, 1882, **7**, 591.

⁵ Papez, J. W., *J. Comp. Neur.*, 1938, **69**, 103.

⁶ Raymon y Cajal, S., *Histologie du système nerveux de l'homme et des vertébrés*, 1911, A. Maloine, Paris.

⁷ Swank, R. L., and Davenport, H. A., *Stain. Tech.*, 1935, **10**, 87.

ward from the peduncle to terminate in the lateral mammillary nucleus. Others swing ventromedially through the lateral mammillary nucleus to terminate in the ventrolateral hypothalamic nucleus. Still other fibers course dorsomedially and terminate both in the rostral part of the medial mammillary nucleus and in the supramammillary nucleus. Laterally located degenerated fibers of the mammillary peduncle continue forward to terminate in the lateral hypothalamic nucleus. These fibers are distributed throughout the lateral hypothalamic area forward almost to the level of the optic chiasma.

The available experimental material indicates that the *Substantia nigra* does not contribute to the crossed component of the mammillary peduncle. Lesions in the *Substantia nigra* produce no degeneration which terminates in the contralateral hypothalamus excepting when they are located in the caudomedial part of the nigra. Lesions in this part of the nigra interrupt fibers entering the mammillary peduncle from the ventral tegmental nucleus (Fox³). The crossed degeneration present in 4 of our animals can be attributed in each case to the interruption of these fibers. The distribution of the fibers of the mammillary peduncle presented here is in agreement with the termination of the peduncle as de-

scribed by other investigators (see review of Huber and Crosby⁸).

Careful consideration has been given in the present study to determine the exact origin of degenerated fibers in the mammillary peduncle. Experimental evidence indicates that the peduncle arises in part from the mesencephalic tegmentum. Fox³ has shown the ventral tegmental nucleus to be the specific nucleus of origin for these fibers. Tegmental lesions located lateral and rostral to this nucleus produce no degeneration in the mammillary peduncle. Likewise no degeneration occurs in the mammillary peduncles of animals with multiple lesions in the pons, caudal to the nigra. Thus the degeneration produced within the mammillary peduncle in animals with nigral lesions apparently results from injury to the nigral cells.

Summary. Degenerated fibers, resulting from lesions located in the *Substantia nigra*, ascend to the hypothalamus by way of the homolateral mammillary peduncle. These fibers terminate in homolateral nuclei of (a) the mammillary bodies, (b) the infundibular region and (c) the lateral hypothalamic area. None of the degenerated nigral fibers appear to enter the contralateral hypothalamus.

⁸ Huber, G. C., and Crosby, E. C., *Arch. Neur. and Psychiat.*, 1929, **22**, 187.

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Influence of Respiratory Inspiration on the Heart Rate.

J. J. LEWIS, A. E. LEWIS AND V. E. HALL.

From the Department of Physiology, Stanford University, Calif.

It is well known that deep sustained inspiration is associated with a slowing of the heart rate. Of the recognized mechanisms having this effect the following may be mentioned: (1) overdistention of the lungs, evoking the cardioinhibitor reflex described by Anrep, Pascual and Rössler¹ and by von Saalfeld;² (2) the "Lungenentlastungsreflexe" of

Schwiegk,³ in which an increase of pressure in the pulmonary vessels slows the heart; and (3) the carotid sinus and aortic cardioinhibitor reflexes activated by a rising systemic arterial pressure. Certain effects of inspiration would tend to accelerate the heart: (1) increased venous inflow into the thorax evoking the Bainbridge reflex; (2) moderate distention of the lungs, stimulating the accelerator reflex of Anrep *et al.*¹ and von Saalfeld;² (3) inhib-

¹ Anrep, G. V., Pascual, W., and Rössler, R., *Proc. Roy. Soc.*, 1936, **119B**, 191, 218.

² von Saalfeld, E., *Pflügers Arch.*, 1932, **231**, 724.

³ Schwiegk, H., *Pflügers Arch.*, 1935, **236**, 206.