Chulalongkorn Medical Journal

Volume 35
Issue 1 *January 1991*

Article 4

1-1-1991

Role of fastigial nucleus in the control of groomingbehaviour in the cat

Vilai Chentanez

Naiyapinit Kotchabhakdi

Recommended Citation

Chentanez, Vilai and Kotchabhakdi, Naiyapinit (1991) "Role of fastigial nucleus in the control of groomingbehaviour in the cat," *Chulalongkorn Medical Journal*: Vol. 35: Iss. 1, Article 4.
DOI: 10.58837/CHULA.CMJ.35.1.4
Available at: https://digital.car.chula.ac.th/clmjournal/vol35/iss1/4

นิพนธ์ต้นฉบับ

Role of fastigial nucleus in the control of grooming behaviour in the cat.

Vilai Chentanez*
Naiyapinit Kotchabhakdi**

Chentanez V, Kotchabhakdi N. Role of fastigial nucleus in the control of grooming behaviour in the cat. Chula Med J 1990 Jan; 35(1): 17-26

The role of fastigial nucleus in the control of grooming behaviour in the cat had been studied by implanting the bipolar microelectrodes into the fastigial nuclei in fifteen cats. Three weeks later, electrical stimulation were performed and the results noted. We observed the grooming behaviour of licking and biting of the forepaw and the body fur, turning and circling movement of the head and the body towards the opposite side. Additionally, electrolytic and kainic acid injection which produced lesions in both fastigial nuclei were done. The quantitative grooming behaviour observation was done in the pre and post lesion periods and showed slight difference. Therefore the role of the fastigial nucleus appeared to exert a modulatory action on these response systems

Reprint request : Chentanez V, Department of Anatomy, Faculty of Medicine, Chulalongkorn University, Bangkok 10330, Thailand.
Received for publication. August 16; 1990.

* Department of Anatomy, Faculty of Medicine, Chulalongkorn University.
** Neuro-Behavioural Biology Center. Institute of Science and Technology for Development, Mahidol University.

วิไล ชินธเนศ, นัยพินิจ คชภักดี. บทบาทของฟาสทิเจียล นิวเคลียส ในการควบคุมพฤติกรรมกรูมมิ่งในแมว. จุฬาลงกรณ์เวชสาร 2534 มกราคม; 35(1): 17-26

ได้ทำการศึกษาถึงบทบาทของฟาสทิเจียล นิวเคลียส ในการควบคุมพฤติกรรมกรูมมิ่งในแมวจำนวน 15 ตัว โดยการฝังอิเลคโทรดเข้าไปในฟาสทิเจียล นิวเคลียส ทั้งสองข้าง แล้วกระตุ้นด้วยกระแสไฟฟ้า ดูพฤติกรรมที่เกิดขึ้น ซึ่งพบว่ามีพฤติกรรมกรูมมิ่ง ได้แก่ การเลีย และกัดขนตามร่างกาย รวมทั้งการหมุนของศีรษะและลำตัวไปทางด้านตรงข้ามกับที่กระตุ้นในสัตว์ทดลองที่อิเลคโทรดอยู่ที่ส่วนหน้าตรงกลางของนิวเคลียส ถ้าเป็นส่วนอื่น ๆ จะเกิดพฤติกรรมการหมุนของศีรษะและลำตัว นอกจากนี้ยังได้ศึกษาถึงผลของการทำลายฟาสทิเจียล นิวเคลียส ต่อพฤติกรรมกรูมมิ่ง โดยได้ทำลายนิวเคลียสนี้ทั้งสองข้างโดยใช้กระแสไฟฟ้าและใช้สารเคมีชื่อ ไคนิค แอซิด ซึ่งเป็นสารที่ทำลายเซลล์ประสาทที่มีกลูทาเมทรีเซฟเตอร์ ซึ่งพบว่าหลังจากทำลายกลุ่มนิวเคลียสนี้ทั้งสองข้าง พฤติกรรมกรูมมิ่งยังคงเกิดขึ้นได้ตามธรรมชาติ และได้เปรียบเทียบเวลาที่สัตว์ทดลองใช้ในการทำพฤติกรรมนี้ และจำนวนครั้งที่เกิดพฤติกรรมนี้ ภายในระยะเวลา 6 ชั่วโมงติดต่อกัน ทั้งก่อนและหลังทำลายนิวเคลียส ซึ่งพบว่ามีความแตกต่างกันน้อยมาก ผลการทดลองแสดงให้เห็นว่ามีบริเวณที่จำเพาะมากใน ฟาสทิเจียล นิวเคลียส ที่สามารถกระตุ้นแล้วเกิดพฤติกรรมกรูมมิ่งครบถ้วน บริเวณอื่น ๆ ของฟาสทิเจียล นิวเคลียส จะทำหน้าที่เป็นตัวทำให้เกิดการเคลื่อนไหวของลำตัวและศีรษะ ซึ่งเป็นส่วนหนึ่งของพฤติกรรมนี้

Paleocerebellar structures, including the anterior vermis and fastigial nucleus, have wide spread interconnections with all major levels of the neuraxis. In particular, fastigial projections have been shown to terminate heavily in areas that have been implicated in the behavioural regulation including the septum, hippocampus, amygdala, hypothalamus and the brain stem reticular formation[1-4]. Consistant with this pattern of projection, and expanding body of evidence now implicates the fastigial nucleus in many behavioural functions. For example, stimulation of the fastigial nucleus can induce complex and serially ordered behaviours such as eating, grooming and gnawing in several species such as rat, cat and opossum[5-8]. In cat, Berntson[6] found that the orientation of elicited grooming generally shifted progressively from one region of the fur to another with a prolongation of the stimulation. However the grooming elicited by the cerebellar stimulation was different from those produced by the hypothalamic stimulation in many ways. First, the grooming elicited by the cerebellar stimulation was vigorous, reliable and stimulation bound. Secondly, the grooming of the face and head with forepaws, which is a salient component of natural grooming was not observed. Berntson suggested that the cerebellar stimulation might not induce a generalized "grooming drive" typical of those elicited by the hypothalamic stimulation but rather produce a strong facilitation of specific sensori-motor mechanism for the licking and biting components of grooming behaviours located in the areas of the cerebellum and the brain stem.

In this investigation, the microelectrodes were chronically implanted into the fastigial nuclei and electrical stimulation were performed in the awake or unanesthesized state. We used both electrolytic lesion and kainic acid injection, the latter method can produce selective degeneration of the nerve cells and their processes without damaging the passing fiber[9,10]. The quantitative data were obtained from behavioural observation in cats after bilateral fastigial lesions.

Materials and Methods

A. The experimental animals

All experiments were performed on adult cats of both sexes weighing from 2-4 kilograms. Before the experiments, these animals were examined closely to exclude any visible neurological deficits and abnormal behaviours. The animals were fed ad libitum, and were housed individually in cages.

B. Stimulation Experiments

The stimulating microelectrodes were made from stainless steel needles insulated with epoxy resin except for the fine tip. Two pairs of bipolar microelectrode were implanted into the fastigial nucleus on both sides in fifteen anesthetized cats and fixed in a stereotaxic apparatus. The animals made an unremarkable post-surgical recovery and behaved normally within 1-2 days.

Three weeks after the operation, the implanted animal was brought into the laboratory and housed in an experimental cage. The electrodes were then connected to the Grass S8 stimulator through a stimulus isolation and constant control unit by a bundle of thin and flexible wires which allow the animal to move freely in the cage. The stimulus used in the experiment was a train of 30 seconds duration of monophasic rectangular pulses of 0.3 msec pulse duration of varying frequencies from 10-100 Hz. The stimulus intensity was adjusted by variation of the stimulus voltage between 2-50 volts with the current density limiting between 0.06-0.2 mA. The behavioural responses of the freely moving animal were observed, and recorded by both still camera and cinematographic recording.

C. Lesion methods

1. Electrolytic lesion of the fastigial nucleus

After the microelectrodes had been implanted into the fastigial nucleus, as described previously, a current of 2 mA. with a duration of 0.5 second was passed into each pair of microelectrodes in an anesthesized cat. (Cat KF-45)

2. Chemical lesion with kainic acid

3 μL of 1% solution of kainic acid (Sigma) in normal saline was injected through the canulas which were implanted in the fastigial nucleus bilaterally in the anesthetized cat. (Cat KF-46)

D. Behavioural Observation

The quantitative grooming behaviour observations were performed before and twenty-four days after lesioning. The observation period was for six hours, from 9.30 AM to 3.30 PM. All the behaviours were divided into four categories according to Swenson and Randall[11]

E. Histological verification of the extent and location of the stimulating electrodes and the lesion

After the experiment, the animal was deeply anesthetized with sodium pentobarbital and perfused through cardiac catheter with approximately two liters of fixative solution containing 10% formaldehyde in normal saline. The brain was removed and cut into serial sections of 50 μ in thickness in a freezing microtome. Sections were later stained with cresyl violet. The localization of the tips of the stimulating microelectrode and the lesion site were examined and mapped in detail on the diagram.

Results

A. Motor behavioural responses following electrical stimulation of the fastigial nucleus

The electrical stimulation of the fastigial nucleus with a brief train of square pulses (2 msec. pulse duration) with the current density varying from 0.04 to 0.30 mA produced turning of the head and/or the whole body to the opposite side and frequently, caused the cat fall onto the same side that being stimulated and also circular movement of the whole body. The localization of the stimulating electrode tips in the cerebellum and the corresponding behavioural responses in each individual case were illustrated in figure 1. The tips of the electrode were localized in the rostral part of the fastigial nucleus (KF 5, KF 14, KF 30, KF 34, KF 37, KF 45, KF 46) and the cerebellar vermis (KF 3, KF 6, KF 8, KF 9, KF 14, KF 17, KF 25, KF 28)

In Cat KF-5, the electrical stimulation of the rostral part of the fastigial region produced a consistent pattern of grooming behaviour. With a brief train of pulse at low intensity the animal lowered the head and licked the forepaw on the contralateral side of the stimulating electrode (Fig.2). With a longer train of pulses at higher stimulus intensity the same sequence of groom licking behaviour were followed by turning of the head toward the opposite side and licking of the body fur and, then, a circling movement occured (Fig.3,4). The localization of the microelectrodes were shown in the x-ray film and also in the transverse section of the cerebellum (Fig.5)

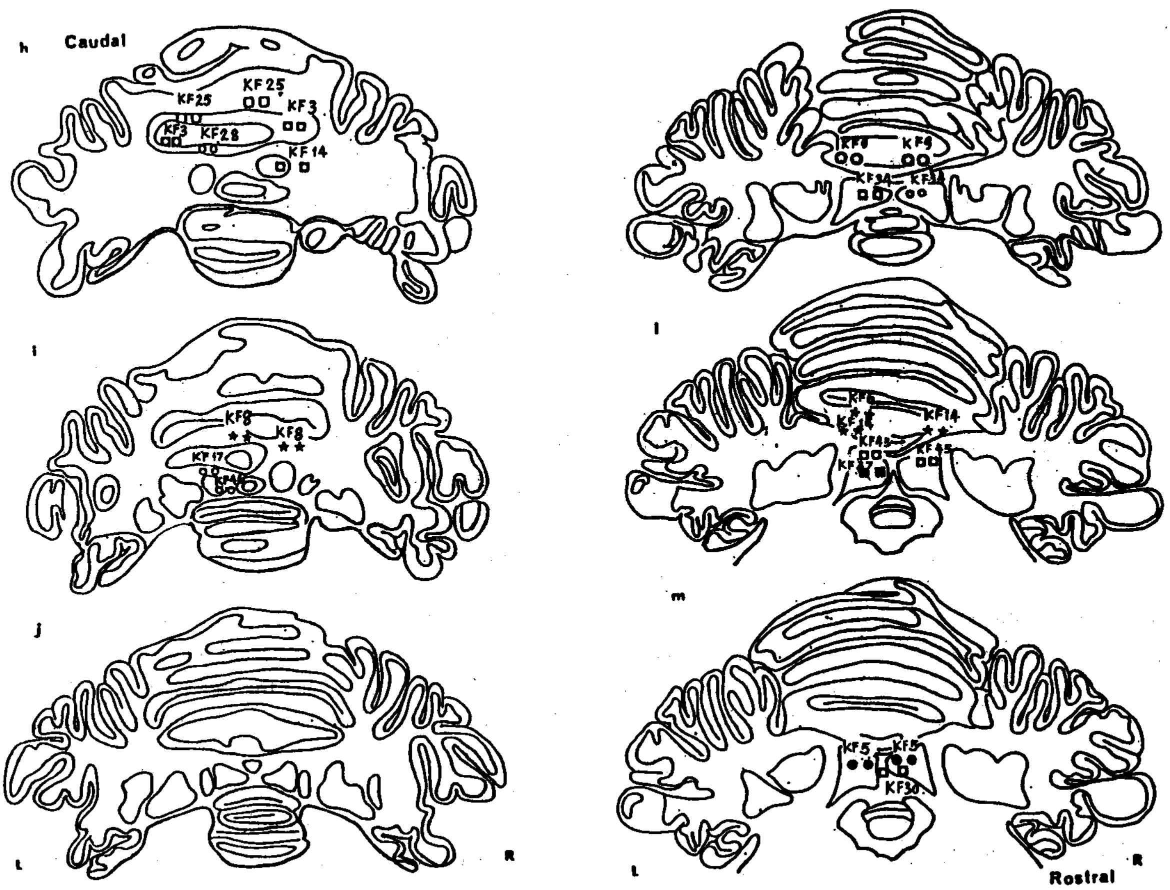

Figure 1. A summarizing diagram of equally serial sections of the cerebellum showing the location of the electrodes which produced various motor behaviours.

● = Grooming
□ = Turning of the head to the contralateral side
○ = Circling movement to the contralateral side
★ = Falling to the same side
✪ = Circling and falling
◘ = Circling and turning
⯀★ = Turning and falling
◉ = Grooming and circling

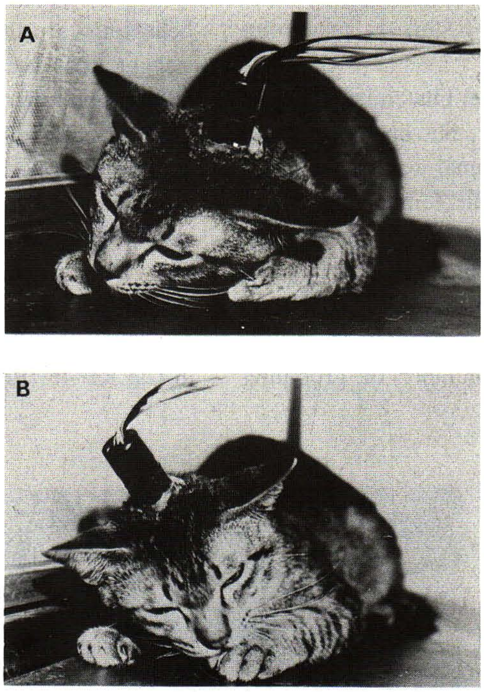

Figure 2. Groom licking of the contralateral forepaw and foreleg following electrical stimulation in the fastigial nucleus in Cat KF-5.
A. = Stimulate the left electrode.
B. = Stimulate the right electrode.

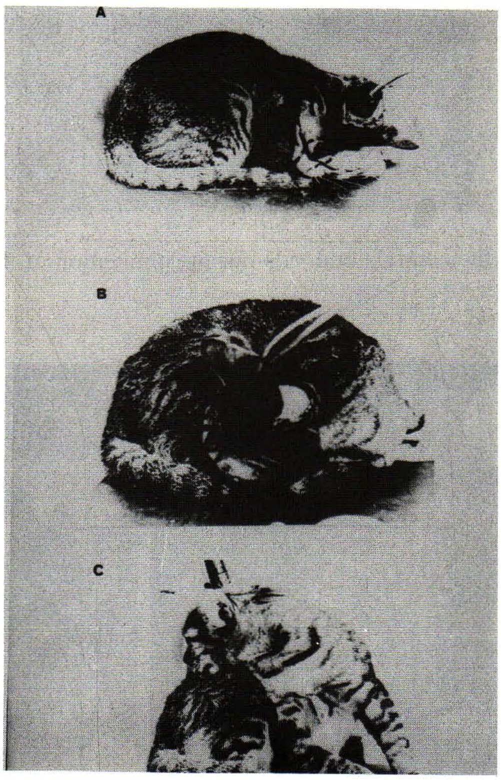

Figure 3. Sequences of (A) licking (B) grooming (C) turning of the head and body during stimulation of the contralateral fastigial nucleus with a long train of impulse in Cat KF-5.

B. Effect of bilateral fastigial lesion on grooming behaviour

In Cat KF-45, one day after bilateral electrolytic lesion, the animal was conscious, but unable to stand upright. On the fourth day the animal was able to stand up and walk with a slight ataxic gait. Similar patterns of behaviours were also observed in Cat KF-46, inwhich bilateral injection of 3 μL of kainic acid solution was performed. Quantitative grooming behaviour observations were done before and 24 days after lesioning. The mean duration of grooming and the number of grooming behaviours are shown in table 1. In Cat KF-45, there is a slight difference between the mean duration of grooming before and after the lesion. The mean duration of grooming in the anterior third and posterior third were slightly increased, but slightly decreased in the middle third (Fig. 6). In Cat KF-46, the mean duration of grooming in various parts were slightly decreased (Fig. 6). When the number of grooming behaviour in both cats are considered, there were slight decrease in numbers, in every parts except for grooming of the middle third in Cat KF-45 (Fig. 7)

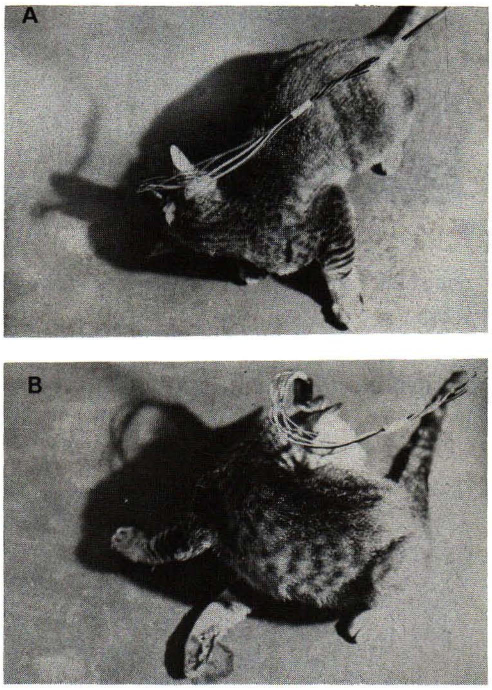

Figure 4. Circling movement to the contralateral side during stimulation of the fastigial nucleus in Cat KF-5.

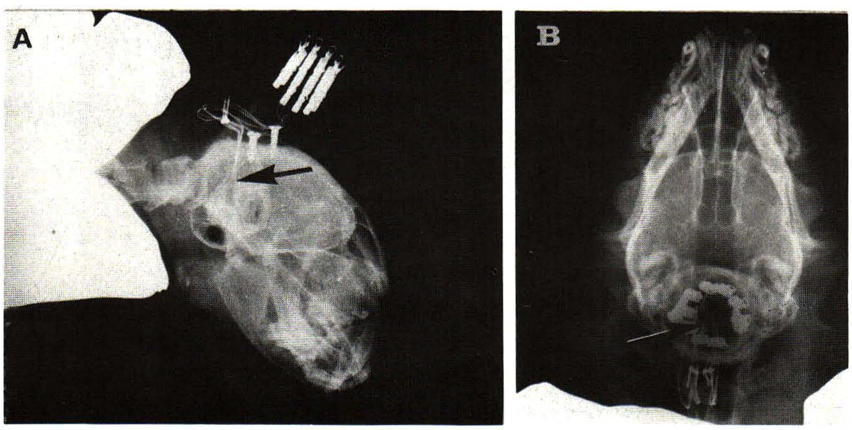

Figure 5. X-ray photographs of the lateral view (A) and the top view (B) showing the localization of the electrodes (arrow) in the posterior cranial fossa in Cat KF-5.

Table 1 A. Mean duration and standard error of the grooming before and after fastigial lesion.

		KF-45 (sec)	KF-46 (sec)
Anterior third	Before lesion	8.80 ± 1.38	8.60 ± 1.03
	After lesion	10.26 ± 1.65	6.02 ± 0.92
Middle third	Before lesion	11.96 ± 3.08	12.29 ± 2.24
	After lesion	9.30 ± 1.28	7.08 ± 1.31
Posterior third	Before lesion	13.00 ± 1.85	11.16 ± 1.84
	After lesion	17.12 ± 2.84	7.86 ± 1.07

Table 1 B. Number of grooming before and after lesions.

		KF-45	KF-46
Anterior third	Before lesion	51	52
	After lesion	47	42
Middle third	Before lesion	29	17
	After lesion	18	18
Posterior third	Before lesion	33	25
	After lesion	28	22

Discussion

The grooming behaviour obtained from the electrical stimulation was similar to Berntson's results[6] The movement may be mediated via direct fastigiospinal pathway which had been demonstrated both anatomically and physiologically[3,12,13], or indirectly via the fastigioreticulo-bulbar and the fastigio-reticulo-spinal systems.

In the present investigation we found that electrodes which were placed in a certain area in the fastigial nucleus could produce grooming behaviour, while in other areas of the fastigial nucleus and the adjacent area of the cerebellum around the fastigial nucleus produced only some motor responses. This finding differed from Berntson's and may be related to the varying techniques between the our investigation and Berntson's experiment. Bipolar stimulation was used in our study whereas monopolar stimulation was used by the Berntson. The brain tissues under the influence of the stimulating current are more confined with bipolar stimulating electrodes, thus may allow better localization of the active region in the present investigation. Secondly, the stimulus intensity in the present investigation was rather weak when compared with that of Berntson's experiments. Therefore a difference in the amount of excited neuronal tissue may have occured.

Considering the mapping of the tips of the electrodes, the electrodes that yeilded complete grooming behavioural response must be located in the rostral part of the fastigial nucleus. In some cases such as Cats KF-37, KF-30 and KF-34, (Fig. 1) eventhough the electrodes were placed in the nearby area in the rostral part of the fastigial nucleus grooming response was not obtained in a complete pattern and only some components e.g. turning

or circling were observed. This observation suggests that there is a specific point in the fastigial nucleus that elicits the grooming behaviour. We suggest that a group of fastigial neurones located in the rostromedial part of the nucleus are responsible for the mediation of grooming behaviour. In cases with electrodes placed in the posterior vermis (Cats KF-3, KF-25 and KF-28), only motor response such as turning and falling were obtained. This might be due to this part of the cerebellum being shown to send, in addition, the efferent connections to the vestibular nuclei[14,15]. The similar responses were obtained from cats with electrodes in the caudal part of the fastigial nucleus (Cats KF-16 and KF-46). This part of the nucleus had also been shown to project to the vestibular nucleus[2,15], In Golgi's study[16] these cells send their axon laterally to join the cerebellocortico-vestibular fibers. This may result in changes in posture such as falling or turning following electrical stimulation. Hence, it was shown that the medial region of the rostral part of the fastigial nucleus was responsible for grooming behaviour.

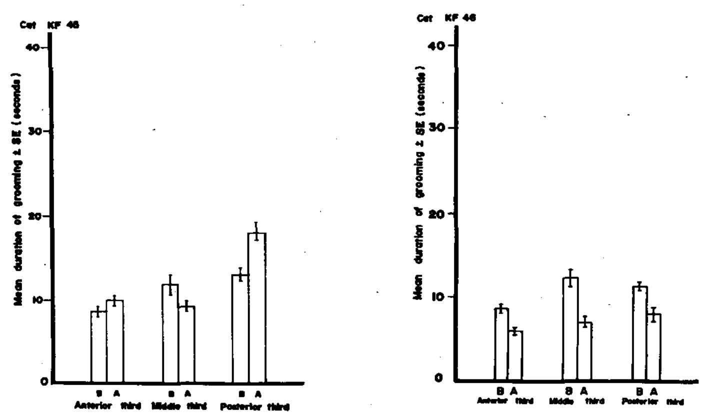

Figure 6. Histogram showing the mean duration of grooming and the standard error (A = after lesion, B = before lesion).

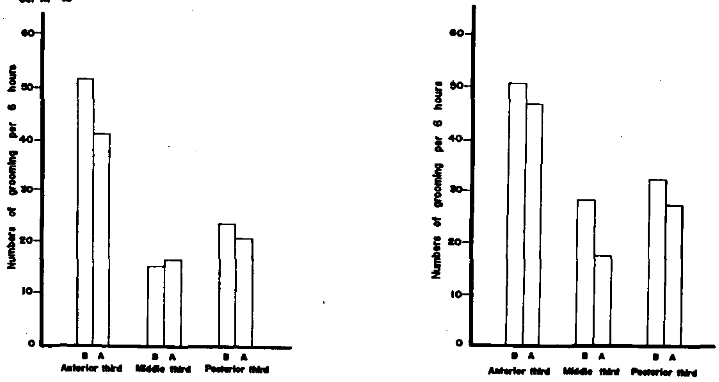

Figure 7. Histogram showing number of grooming in 6 hours (A = after lesion, B = before lesion).

It should be noted that following bilateral electrolytic lesion of the fastigial nucleus in Cat KF-45, grooming behaviour still remained. The deficit of motor activity was similar to that described by Sprauge and Chamber[17], and Carpenter[16]. The quantitative grooming behaviour changes was only slightly different in the two periods before and after lesioning. This finding was similar to previous reports[19]. In case of kainic acid injection, similar results were obtained. Therefore the available avidence indicates that the fastigial nucleus is not essential for the initiation of the grooming behaviour. The role of the fastigial nucleus appeared to exert a modulatory action on these response systems.

Conclusions

Electrical stimulation of the rostromedial region of the fastigial nucleus in cats produced a groom licking and biting of the body fur, turning and circling movement to the opposite side. However, lesioning of the fastigial nucleus by electrical current or the injection of kainic acid did not abolish the spontaneously occuring grooming behaviour. These data indicate that there is a very specific point in the rostromedial region of the fastigial nucleus that can elicit grooming behaviour. The other regions of the fastigial nucleus may play an important role in coordinating various components and the spatiotemporal pattern of the grooming behaviour.

Acknowlegements

This research work was supported partly by a research grant from the National Research Council of Thailand and by a cooperation with the Anatomical Institute, University of Oslo under the financial support from the Norwegian Agency for International Development. (NORAD). We wish to thank Miss Sunant Thongmak for typing this article.

References

1. Harper JW, Heath RG. Anatomic connections of the Fastigial Nucleus to the Rostral Forebrain in the cat. Exp Neurol 1973 Mar-Apr; 39(2) : 285-92
2. Batton III RR, Jayuraman A, Ruggiero D, Carpenter MB. Fastigial Efferent Projections in the Monkey : An Autoradiographic Study. J Comp Neurol 1977 Jul 15; 174(2) : 281-305
3. Walberg F, Pompeiano O, Westrum LE, Hanssen EH. Fastigioreticular fibers in the cat. An experimental study with silver methods. J Comp Neurol 1962 Oct; 119(2) : 187-99
4. Newmann PP, Reza H. Functional relationships between the hippocampus and the cerebellum. An electrophysiological study of the Cat. J Physiol (Lond) 1979 Feb; 287 : 405-26
5. Ball GG, Micco DS, Jr. Berntson GG. Cerebellar stimulation in the rat: complex stimulation-bound oral behaviour and self-stimulation. Physiol Behav 1974 Jul; 13 : 123-27
6. Berntson GG, Potolicchio SJ, Miller NE. Evidence for higher functions of the cerebellum. Eating and Grooming elicited by cerebellar stimulation in Cats. Proc Natn Acad Sci USA 1973 Sep; 70(9) : 2497-99
7. Watson PJ. Behaviour maintained by electrical stimulation of the rat cerebellum. Physiol Behav 1978 Nov; 21(5) : 749-55
8. Buchholz DJ. Spontaneous and centrally induced behaviours in normal and thalamic opossums. J Comp Physiol Psychol 1976 Sep; 90(9) : 898-908
9. Olney JW, Rhee V, Ho OL. Kainic acid a powerful neurotoxic analogue of glutamate. Brain Res 1974 Sep 13; 77 :507-12
10. Coyle JT, Molliver ME. Kuhar MJ. In situ injection of kainic acid. A new method for selectively lesioning neuronal cell bodies while sparing axons of passage. J Comp Neurol 1978 Jul; 180(2) : 301-23
11. Swenson RM, Randall W. Grooming behaviour in cats with pontile lesions and cats with tectal lesions. J Comp Physiol Psychol 1979 Apr; 91(2) : 313-26
12. Fukushima K, Patterson BW, Uchino Y, Coulter JO, Wilson V. Direct fastigiospinal fibers in the cat. Brain Res 1977 May; 126(3) : 538-42
13. Wilson VJ, Uchino Y, Maunz RA, Susswein A, Fukushima K. Properties and connections of cat fastigiospinal neurons. Exp Brain Res 1978 May; 32(1) : 1-7
14. Angaut P, Brodal A. The projection of the "vestibulocerebellum" onto the vestibular nuclei in the cat. Arch Ital Biol 1967 Nov; 105 : 441-79
15. Walberg F. The vestibular nuclei and their connections with the eighth nerve and the cerebellum. In : Naunton RF ed. The Vestibular System. New York : Academic Press, 1975; 31-53
16. Matsushita M, Iwahori N. Structural organization of the fastigial nucleus. I. Dendrites and axonal pathways, II. Afferent fiber system. Brain Res 1971 Feb 5; 25 : 597-610
17. Sprauge JM, Chambers WW. Regulation of posture

in intact and decerebrate cat; cerebellum, reticular formation, vestibular nuclei. J Neurophysiol 1953 Sep; 16(5) : 451-63

18. Carpenter MB, Brittin GM, Pines J. Isolated lesions of the fastigial nuclei in the cat. J Comp Neurol 1958; 109(1) : 65-90

19. Berntson GG, Schumacher KM. Effects of cerebellar lesions on activity, social interactions and other motivated behaviours in the rat. J Comp Physiol Psychol 1980 Aug; 94(4) : 706-17