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Effect of Unilateral Lesion of Amygdala on Unmanifested Response to Matatabi (*Actinidia polygama*) in Cats

KIYOAKI KATAHIRA and EIICHI IWAI*

Second Department of Physiology, Fukushima Medical College, Fukushima and Tokyo Metropolitan Institute for Neurosciences, Tokyo*

KATAHIRA, K. and IWAI, E. *Effect of Unilateral Lesion of Amygdala on Unmanifested Response to Matatabi (Actinidia polygama) in Cats.* Tohoku J. exp. Med., 1975, **115** (2), 137-143 —— The experiment was designed to elucidate the question whether the unilateral ablation of the amygdala significantly affects sexual behavior or not. For this purpose, the effect of the unilateral amygdalectomy upon Matatabi-response was investigated in the cat (R-cat), particularly in cats which showed unmanifested Matatabi-response in the innate status (NR-cat). Following the unilateral damage to the amygdala, NR-cats showed a significant manifestation in their Matatabi-response behavior, while R-cats indicated no change in it, their performance level being the same as preoperatively. It is concluded from the present results that even the unilateral ablation of the amygdala affects sexual behavior significantly, this being in contrast to many previous reprots. The present finding implies that individual differences in sexual behavior appear to depend on the neural basis of the amygdala, supporting an assumption that the amygdala is a controlling center of sexual and emotional behaviors. ———— amygdala; unilateral lesion; Matatabi response; sexual behavior

Since Klüver and Bucy (1939) reported the appearance of significant change in sexual behavior (one of so-called Klüver-Bucy Syndrome) following a large bilateral resection of the temporal lobe in monkeys, it has been confirmed by many investigators (Schreiner and Kling 1953, 1956; Green et al. 1957) that, regardless of animal species, a bilateral lesion of the rhinencephalic structures, particularly involving the amygdala in primates, carnivores, rodents, etc., produces remarkable changes in sexual and emotional behavior.

On the other hand, it has been reported that unilateral damage to the rhinencephalon or amygdala shows no noticeable change in sexual behavior (Klüver and Bucy 1938). However, it seems needless to suppose that the neural activity of the unilateral rhinencephalon or amygdala is sufficient to control the sexual behavior. Before reaching a conclusion, it appears to be desirable to reinvestigate the above question using more sensitive experimental procedures that may make it possible to find out and follow subtle behavioral changes. The main purpose of

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* Request for reprints should be sent to Eiichi Iwai, Tokyo Metropolitan Institute for Neurosciences, Fuchu, Tokyo, Japan 183

the present experiment was to investigate the question whether unilateral damage to the amygdala significantly affects sexual behavior in the cat, by examining behavioral change indicated by response to Matatabi (*Actinidia polygama*, Japanese plant).

It is well-known that the Matatabi substance is very attractive and potent for the cat and is thus considered as so-called aphrodisiac substance for that animal. When the Matatabi is present, the cat generally responds to it quickly (Matatabi response) and is fascinated by it as if in an ecstatic state (Sakan 1967; Hayashi 1968). The notion that the Matatabi substance is closely correlated with the sexual behavior and thus with the function of the amygdala is supported not only by the behavioral observations as mentioned above, but also by the electrophysiological studies. Yoshii et al. (1963, 1964) reported that Matatabi influenced the electrical activities of the rhinencephalon, particularly of the amygdala and hippocampus in the cat. For the investigation of the sexual behavior in the cat, therefore, the presence or absence of Matatabi-response appears to be a more adequate and sensitive test than the mounting behavior criterion employed as an index in the previous studies.

Recently, it was observed that quite a small number of cats did hardly indicate Matatabi-response, three out of 31 cats observed in our laboratory were the cases (NR-cat), while the other 28 cats behaved as described in the literature (R-cat). No previous report mentioned NR-cats as observed by us, and thus there has been no investigation of the neural basis of behavioral differences in the response to Matatabi in NR- and R-cats. A possible reason for lack of Matatabi-response in NR-cats is that the neural inhibitory control of their sexual behavior by the amygdala may be stronger than in average cats in the periods except for breeding seasons. The present experiment examined the above possibility in order to elucidate the neural basis of differences of sexual activity between NR- and R-cats.

Methods

Subjects

The subjects used in the present experiment were seven experimentaly naive and adult cats weighing from 1.8 to 4.2 Kg at the period of surgery; three were NR-cats and four were typical R-cats chosen from 28 R-cats in our laboratory.

Testing procedures

Tests were conducted in a wire cage of $38.5 \times 51.0 \times 33.0$ cm. Matatabi used here for testing the response was a piece of dried branch, about 10 to 15 cm long and about 5 to 10 mm thick, and it was bought from a market dealer. A branch of Matatabi was displayed about 15 to 20 cm apart from the face of cat. Testing was performed once everyday to once a week (in NR-cat 1, once everyday to once 4 weeks in the preoperation). It was judged as presence of the Matatabi-response when cats approached quickly to a Matatabi branch and tried to bite it within 3 min from the presentation of the Matatabi branch (R-cats). If cats failed to show Matatabi-response in at least any of six consecutive trials, or in 10 out of 11 trials, they were classified as NR-cats in the preoperative stage.

The subjects were neither rewarded nor punished following response or no response.

Surgery

All the subjects received a unilateral ablation of the amygdala and a small amount of its adjacent cortical and subcortical areas. The extra-areas invaded were parts of the inferior temporal neocortex, temporal pole, hippocampus and pyriform cortex, etc. All the operations were performed in one stage using aseptic technique with the subjects anesthetized with Nembutal (30–35 mg/Kg). Brain tissues were removed with a small gauge sucker under visual exposure, bleeding being controlled with electrocautery and gelfoam, and wound being closed in anatomical layers with silk sutures. Following about one week recovery period, testing was commenced again in the same manner as in the preoperative stage. The tests for Matatabi-response in the postoperative stage were performed over 3 to 6 month-period.

Histology

The brains were fixed in 10% formalin for one week, and then were cut in about 5 mm blocks. Each block was cut in sections of 10 μ thickness by means of the paraffin section technique. The section provided two parallel series, one of which was stained with Nissl's method, and the other with Klüver-Barrera's method. Lesion effects were assessed by comparing the stained sections to Snider and Niemer's atlas (1970).

Fig. 1 shows two representative brain photographs and reconstructions of the lesions from each one of the NR- and R- groups, indicating the extent and locus of the lesion by dotted lines and black areas. It was confirmed that the lesions of both NR- and R- cats affected the amygdaloid complex, pyriform cortex, a part of the hippocampal formation with gyrus dentatus and of the temporal lobe including the temporal pole.

Results

The results of NR-cats were shown in Fig. 2. NR-cats 1 and 2 showed Matatabi-response clearly 7 and 6 days respectively after the unilateral amygdalectomy, and also responded to Matatabi in all presentation trials over a 5 month period. NR-cat 3 also responded to Matatabi 32 days after the operation and continued to respond in all presentation trials thereafter. As may be seen by comparing the response scores in the preoperative and postoperative stages in Fig. 3, all the three NR-cats showed a marked enhancement of Matatabi-response following the amygdalectomy. NR-cat 1 responded to Matatabi once out of 11 trials (9% response score) in the preoperative stage, indicating this cat had a weak preference for Matatabi, whereas after the amygdalectomy, the cat responded to the matatabi in any of 32 presentations over a 6 month period (100% response score) in the same way as the R-cat did. NR-cats 2 and 3 never responded to Matatabi in the preoperative stage (0% response score). Following the operation, as with NR-cat 1, they changed their Matatabi-behavior and tended to respond to Matatabi substance. Their response scores were not maximum, being 89% and 69% respectively; these being less than the maximum response score shown by NR-cat 1. These results appeared to imply that in NR-cats the unilateral lesion of the amygdala affected their behavioral attitude, changing it from a weak preference for the matatabi substance into a strong one.

On the other hand, as being expected, unilateral amygdalectomy in the R-cats did not affect their Matatabi-response and also their general behavior. They had

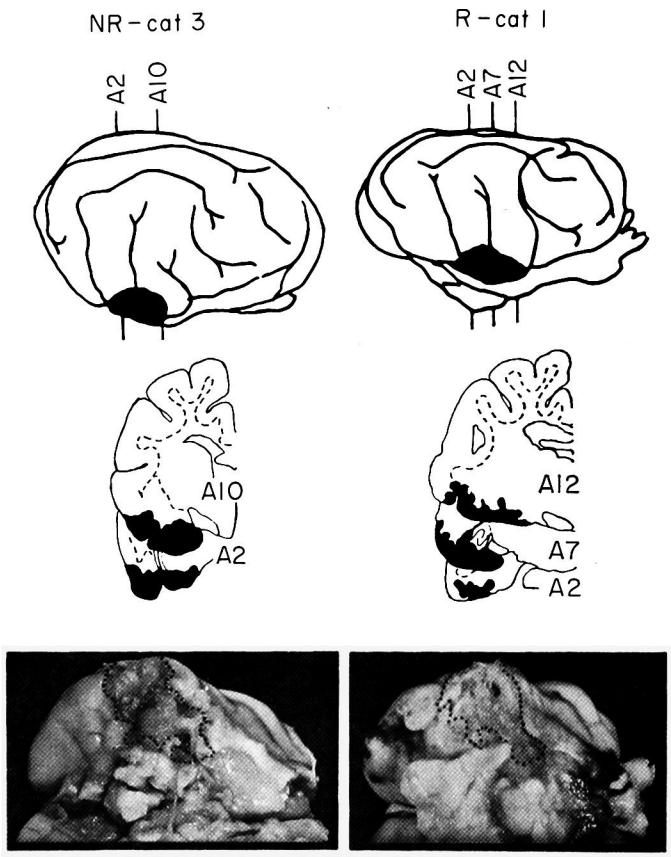

Fig. 1. Representative brain reconstructions with lateral view (top), cross sections (middle), and photographs with ventral view (bottom) of right hemispheres of a cat with unmanifested (NR-cat 3; left column) and of one with manifested (R-cat 1; right column) Matatabi-response. Extent and locus of lesions is indicated by black areas in reconstructions and sections, and by dotted in photographs. Cross sections are numbered in accordance with their stereotaxic positions (Snider and Niemer, 1970). Left hemisheres were not presented here, since, after completion of present experiment, those of all cats were received different lesions for other different experimental purposes.

kept their response levels in the postoperative stage at the same levels as in the preoperative stage (Fig. 3).

Discussion

It is clear from the present results that even unilateral amygdalectomy significantly enhanced Matatabi-response. The finding was in contrast to the previous reprots that the unilateral ablation of the amygdala or rhinencephalon resulted in no effect (Klüver and Bucy 1938, 1939; Schreiner and Kling 1953, 1956; Green et al. 1957). It should be noted here, however, that even in the present experiment the

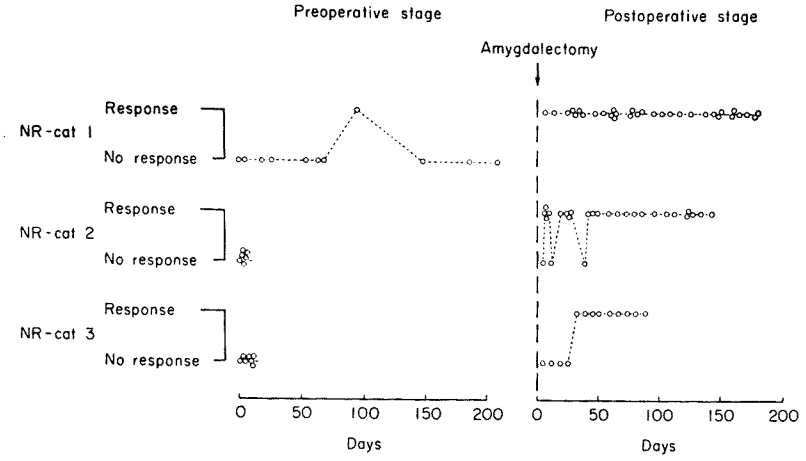

Fig. 2. Individual preoperative and postoperative response chart of Matatabi-behavior in NR-cats. RESPONSE denotes an appearance of Matatabi-response in behavioral criterion, and otherwise NO RESPONSE is indicated. Abscissae show time courses by days from first testing in preoperative stage and from operation in postoperative stage. Preoperatively, NR-cat 1 was tested for long series with longer intervals, in order to compare effects of amygdalectomy based on differences of preoperative testing schedule.

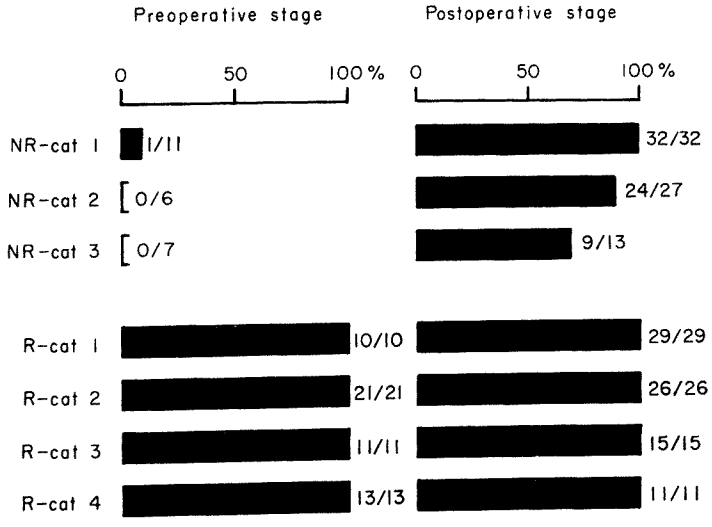

Fig. 3. Individual matatabi response score for cats with unmanifested (NR-cats) and with manifested (R-cats) matatabi response. Horizontal black bars denote percentage of Matatabi-responses for each subject in preoperative (left) and postoperative stages (right). Numbers indicate actual response numbers and test trials, from which response percentage is derived. As seen, all NR-cats showed manifested Matatabi-responses after amygdalectomy.

effect of the unilateral ablation of the amygdaloid complex upon Matatabi-response was not found in the R-cat but was observed only in the NR-cat. The effect was found clearly only in such sensitive or special ways as indicated in the NR-cat in the present study, but it appears not to be uncovered in the usual ways as shown in the R-cat in the present study or in the previous experiments reported.

As far as the authors know, the present finding is probably the first one that the unilateral amygdalectomy produces a significant change in sexual behavior. Therefore, a question about the present results may be raised; whether the results shown by the NR-cat are possibly attributed only to the effect of the unilateral lesion of the amygdala itself, or to false effects attributed to some temporal or absurd factors. Generally speaking, brain damage usually results in impairment or defective behavior. In the present study, NR-cats which showed a kind of deficit in Matatabi-response in the preoperative or intact status, indicated a significant appearance of Matatabi-response following the brain operation. The appearance of Matatabi-response shown by NR-cats following the operation may be difficult to explain in terms of the effects of repeated presentation or testing paradigm with Matatabi substance. This is because an application of cocaine to the olfactory mucosa in the operated NR-cats disrupted temporarily their Matatabi-responses which were manifested after the operation (unpublished data). Furthermore, the above notions for exclusion of false effects may be supported by the finding that the stronger inhibition to Matatabi shown by NR-cats (e.g. NR-cats 2 and 3) in the preoperative testing stage, the less effective Matatabi-response following the unilateral ablation of the amygdala.

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