REFLEX EMG ACTIVITY IN RATS WITH LESIONS OF MEDIAL AMYGDALA

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Abstract. Lesions effects of the medial amygdala on spinal reflexes were studied in 6 rats using chronic EMG recording and were not found influential. These results suggest that behavioral changes previously observed in such rats were not produced by sensory-motor disturbances.

Lesions of the medial amygdala in rats produce changes in instrumental performance and locomotor activity (6–8). It seems possible that these changes may be in part produced by a sensory-motor deficit, particularly since Turner (12) obtained such deficit in amygdalar rats. It has been also reported that the so-called lateral hypothalamic syndrome that resembles the dorsomedial amygdalar syndrome in many characteristics (2, 3) is related to somatosensory neglect in various aspects (11, 13).

Our research (4) on dogs showed that electromyography is profitable in the neurological evaluation of various reflexes and the estimation of their disturbances after amygdalar and hypothalamic lesions. Accordingly, it was of interest to check the effect of medial amygdala lesions on spinal reflexes in rats using chronic polyelectromyography (5).

The rats were individually housed on an inverted light-dark cycle with full access to water and food. The temperature and humidity were kept constant. The experiment was done on six male, hooded rats weighing 300–350 g at the start of the experiment. The rats, anesthetized
with Nembutal (50 mg/kg), were chronically implanted with electrodes according to the method described by Hnik et al. (5). The recording system consisted of a percutaneous connector and leads of steel wire (0.1 mm) wound into a fine spiral ($\Omega = 0.6$ mm) and terminated with a bar platinum wire. Leads were inserted into silicone tubing ($\Omega = 1.0$ mm), while the electrodes and connector were covered with Silastic Medical Adhesive, type A (Dow Corning). Such electrodes are very flexible and do not restrict the free movements of an animal's limbs. The animals after implantation manifested the entire range of normal movements. During the experiment we examined the reflex activity of hind limb muscles, i.e., the tibialis anterior and soleus. During implantation the connector was put low on the back in the sacral region. The leads were pulled in under the skin to the shank. Then, the electrode to the m. tibialis anterior was placed on the muscle under the aponeurosis over the muscle and stitched to it. Electrodes for the m. soleus were fastened to the fibula. The method of electrode fixation depends on the anatomical conditions. Fixation to the bone is the best approach but, unfortunately, it cannot be used with all muscles. The details of all of the procedure are fully described elsewhere (5).

Two weeks after electrode implantation, observations began. During the first two weeks the animals were handled and accustomed to the recording procedure. When they became tame (i.e., they could be kept motionless longer than 30 s), the experiment began. Muscle activity during various reflexes, evoked by non-painful stimulation, was investigated. During examination the animals were elevated by the scruff of the neck and kept in the air.

The experimental sessions were performed twice a week. Each session consisted of several neurological tests in which the mono- and polysynaptic reflexes were examined. As a model of the monosynaptic reflex we analyzed the tendon and stretch reflexes. The tendon reflex was evoked by quick, moderate stroking of the Achilles tendon. The stretch reflex was evoked by dorso- and ventroflexion of the foot performed by hand. Polysynaptic reflexes were evoked by an air-puff directed at the animal, stimulation of the vestibular apparatus, or the skin and hair. The vestibular system was activated by rapid falling or lifting of the animal by the experimenter. Skin and hairs were stimulated by stroking with a thin wooden bar.

After five or six experimental sessions the animals were again subjected to surgery. Stereotaxic, bilateral lesions of the medial amygdala were produced by a method described earlier (7, 8). The coordinates of the lesion were: $AP = 5.7$, $H = -2.7$, $L = 3.2$, according to the König and Klippel (9). Using a tungsten electrode of 0.5 mm
diameter, anodal direct current of 2.0 mA was passed for 10 s to the animals under Nembutal anesthesia (50 mg/kg). One week later the procedure of neurological testing was repeated. After finishing the experiment the animals were sacrificed by an overdose of ether, the brains were removed and fixed in 10% formalin. Frozen sections were cut and stained by the Klüver or Nissl method for histological verification of the lesions. In all animals the lesions were confined to the medial amygdala and did not extend from it dorsally (Fig. 1).

Generally, reflex EMG activity was estimated on the basis of two

![Fig. 1. Examples of typical lesions of the medial amygdala in three rats.](image)

![Fig. 2. Reflex EMG activity evoked by the air puff (AP) before (A) and after (B) the medial amygdala lesion in the same rat. TA, the tibialis anterior; S, the soleus; t, time in seconds. The first two EMG beams refer to the left side, the next two for the right one.](image)
parameters; duration and amplitude of the response. The first part of our results consisted of the responses of normal animals. In our conditions responses to the types of stimuli described were repeatable from one session to the next. Having a general pattern of normal reactivity, we compared it to the reflex responses obtained after bilateral medial amygdala lesions. We found that both reflexes evoked on the supraspinal and spinal level were unchanged. This observation was equally valid for reflexes elicited by all kinds of stimuli. An example of polysynaptic, supraspinal response before and after operation is shown in Fig. 2. In both cases the air-puff evoked a generalized jerk of the animal. The amplitude and duration of EMG responses were also very

Fig. 3. Reflex EMG activity evoked by Achilles tendon tap (arrow) before (A) and after (B) the medial amygdala lesion in the same rat. The characters designate the side stimulated. Denotations as in Fig. 2.

Fig. 4. Reflex EMG activity evoked by dorsi- and ventro-flexion of the foot in the normal rat (A) and after lesion of medial amygdala (B). First column — left side stimulated, second — right side. Arrows, beginning of dorso- and ventro-flexion (D or V). Denotations as in Fig. 2.
similar. Figures 3 and 4 show examples of monosynaptic spinal responses evoked by phasic and tonic stimulation of muscle receptors. The responses before and after surgery were also very similar in either cases.

Summarizing, the reflex reactivity of the animals was not evidently influenced by medial amygdala damage. However, small changes of reactivity cannot be excluded, which could be demonstrated by precise quantitative methods of data evaluations (i.e., by using digital techniques).

Although in this experiment other aspects of the animals' behavior were not carefully tested, we did not notice changes in either the emotional or the motivational states of the rats. Accordingly, in another study (10) of rats after cortico-basomedial amygdalar lesions, we have found only a short transitory decrease in emotionality tests. From our other investigations (6–8), it is known that medial amygdala lesions in rats have only a weak and transitory effect on unconditioned alimentary behavior. Thus, it may be suggested that changes in instrumental and locomotor activity after medial amygdala lesions (6–8) depend on other than primary sensory-motor mechanisms.

However, the lack of an effect from medial amygdala lesions on the reflexes tested cannot exclude the possible regulatory role of the sensory-motor mechanisms related only to the upper part of the brain stem, especially involving cranial nerves (see 12). The neurological deficits in medially lesioned rats described by Turner (12) might be partially due to extraamygdaloid lesions extending dorsally from the amygdala to the internal capsula. Some support for this suggestion is offered by other results of Korczyński and Fonberg (unpublished) and Dacey and Grossman (1) which showed that dorsally extended destruction of the amygdala evoked sensory-motor deficits.

Nevertheless, the influence of the emotional system (including the amygdala) on the brain stem and spinal cord structures seems obvious. At the beginning of our pilot experiment we found that the reactivity of the animal was very dependent on its emotional state, and the EMG responses were either exaggerated or inhibited. They were also often masked by volitional muscle activity. Thus, the perfect taming of the animal prior to the investigation of reflexes was essential for repeatable results. Perhaps if the animals were in a more unusual situation (i.e., in heightened emotional state) it might be possible to detect the probable changes in reactivity.

Manually suspending subjects in the air by the scruff of the neck may have influenced the results, particularly since this maneuver is known to have a profound generalized effect on reflex behavior, such as in the common mammalian pattern of maternal carrying of the young or
the male's biting the neck of the female prior to copulation. This procedure might be another explanation of the difference between our results and those of Turner (12).

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