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ORIENTING RESPONSE HYPERNORMALITY IN FRONTAL CATS

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Abstract. Results obtained in collaboration with B. Dreher are summarized. Ocular fixation was the indicator of the orienting response, and pupillary dilatation and ECoG arousal to olfactory stimuli were the indicators of the arousal response. To make precise recording possible, animals with pretrigeminal brain stem transection were used. After ablation of the anterior sigmoid gyrus or proreal gyrus the fixation response was enhanced and its resistance to habituation was strongly increased. On the other hand, the pupillary dilatation and ECoG arousal to olfactory stimuli and the background pupillary diameter and ECoG activity were unaffected. The hypernormality of the orienting response can be partially responsible for the disinhibition of the locomotor responses in go–no go differentiation and for the impairment of locomotor delayed responses in frontal carnivores.

It is convenient to distinguish in reflexes (in a broad sense of this word) specific component, orienting component and arousal component (*see* Żernicki 1972). In the conditioned-reflex situation, for example, the specific component may be manifested overtly by lifting the leg or by the run to food, the orienting component by directing the head and eyes toward the source of the conditioned stimulus, and the arousal component by pupillary dilatation. These components interact strongly with each other and obviously the specific component can be influenced by the orienting and arousal components. Consequently, after a brain lesion the deficit in the specific response may be partially or totally caused by a primary defect in the orienting component or in the arousal component or in both.

Recently Dreher and I (1969) investigated the orienting and arousal responses in frontal cats. For this purpose we used animals with pretrigeminal brain stem transection. In contrast to the intact animal, in such a preparation the ocular fixation and pupillary dilatation, i.e., the important parts of the orienting and arousal responses, can be precisely recorded (*see* Żernicki 1968).

The experiments were carried out on 47 cats. In 36 animals bilateral frontal ablation was made. In 9 cats the lesion involved the anterior sigmoid gyrus on the lateral and medial aspects of the hemisphere (Fig. 1). In 12 cats the anterior sigmoid gyrus was ablated only laterally and in 5 cats medially (Fig. 2 and 3). In 5 cats proreal gyrus was ablated (prefrontal ablation) and in 5 cats the lateral part of the posterior sigmoid gyrus was removed (Fig. 4 and 5). The ablations of the anterior sigmoid gyrus covered roughly the frontal oculomotor area (Fig. 6). The prefrontal ablation also involved this area, in particular on the medial aspect of the hemisphere and in the presylvian sulcus (*see* Schlag and Schlag-Rey 1970). The control group consisted of 11 animals.

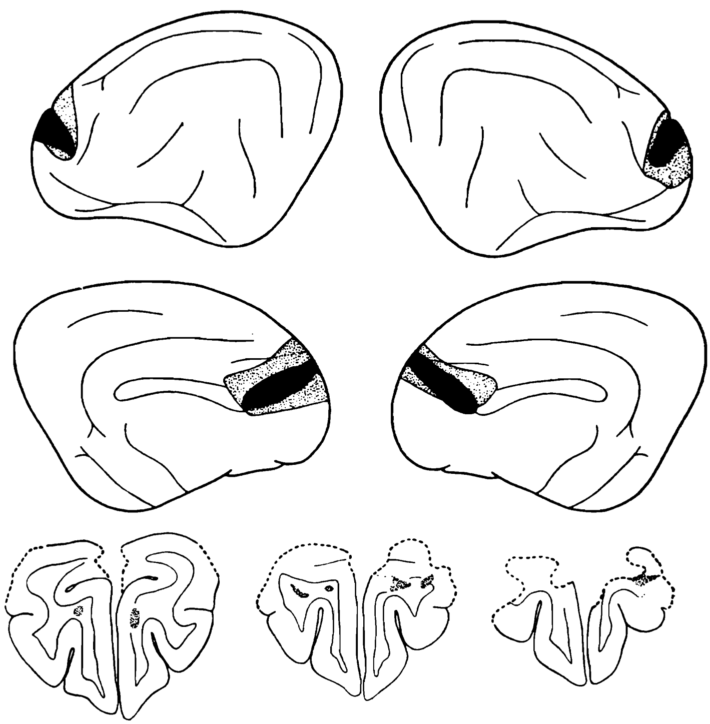

Fig. 1. The ablations of the anterior sigmoid gyri. Above, reconstructions of maximal (stippled area) and minimal (shaded area) lesions. Below, representative cross sections (stippling indicates gliosis). (From Dreher and Żernicki 1969.)

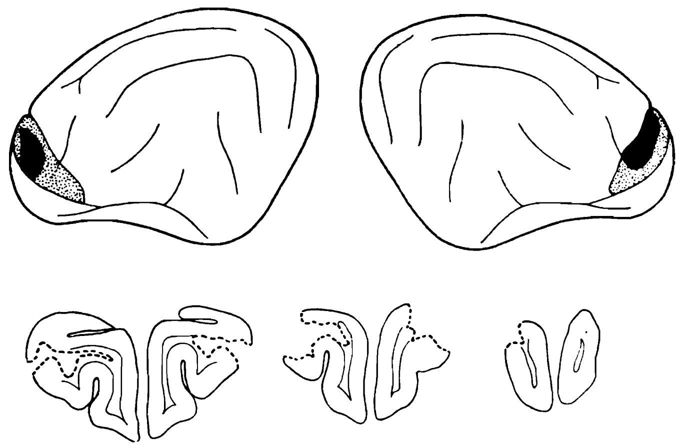

Fig. 2. The ablations of the lateral part of the anterior sigmoid gyri. Other denotations as in Fig. 1. (From Dreher and Żernicki 1969.)

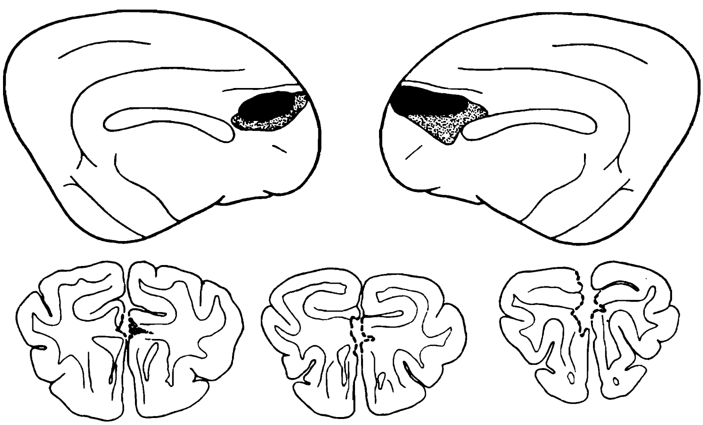

Fig. 3. The ablations of the medial part of the anterior sigmoid gyri. Other denotations as in Fig. 1. (From Dreher and Żernicki 1969.)

Tracheotomy and the pretrigeminal cut were made in all the animals (in frontal cats 7–17 days after cortical removal). Two hours after transection the cat, remaining in the stereotaxic apparatus, was placed in a small, optically isolated chamber, which was strongly illuminated to allow filming of the eyes. During the experimental sessions "neutral" visual and olfactory stimuli, which evoke "pure" orienting and arousal responses, were applied. The visual stimulus was 3 sec rotation of a black "X" shaped figure. Two such figures were located permanently on a white screen, one above and one below the animal's eyes. In the pretrigeminal as well as in the intact cat this stimulus produces clear-cut fixa-

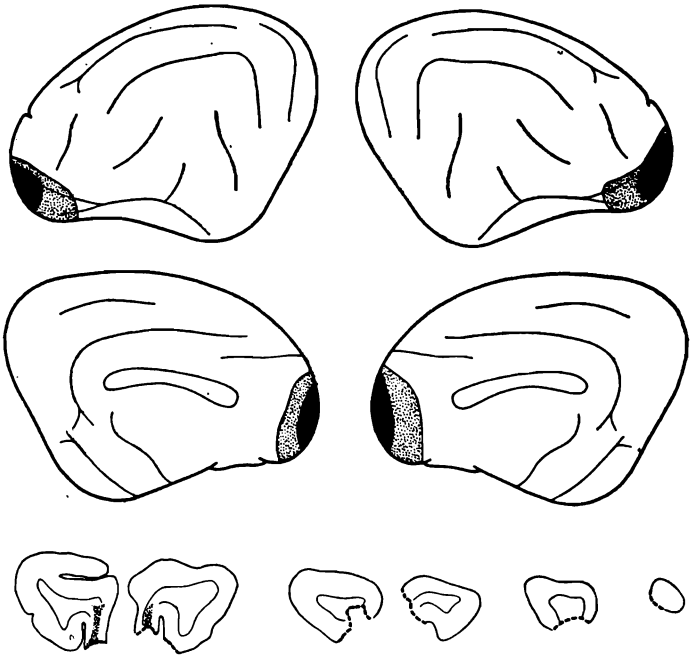

Fig. 4. The ablations of the proreal gyri. Other denotations as in Fig. 1. (From Dreher and Żernicki 1969.)

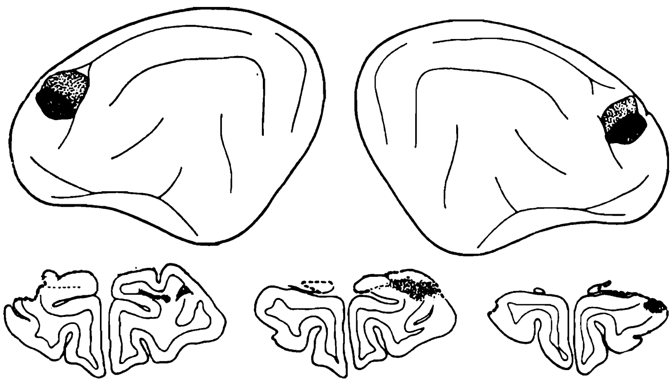

Fig. 5. The ablations of the lateral part of the posterior sigmoid gyri. Other denotations as in Fig. 1. (From Dreher and Żernicki 1969.)

tion response, which usually outlasts the stimulus duration and may be followed by a number of after-fixations (Żernicki and Dreher 1965). In addition it produces pupillary dilatation which, however, during concurrent eye movement, could not be precisely recorded under our experimental condtions. The olfactory stimuli were the odor of valerian and the odor of butyric acid introduced into the cat's nostrils with

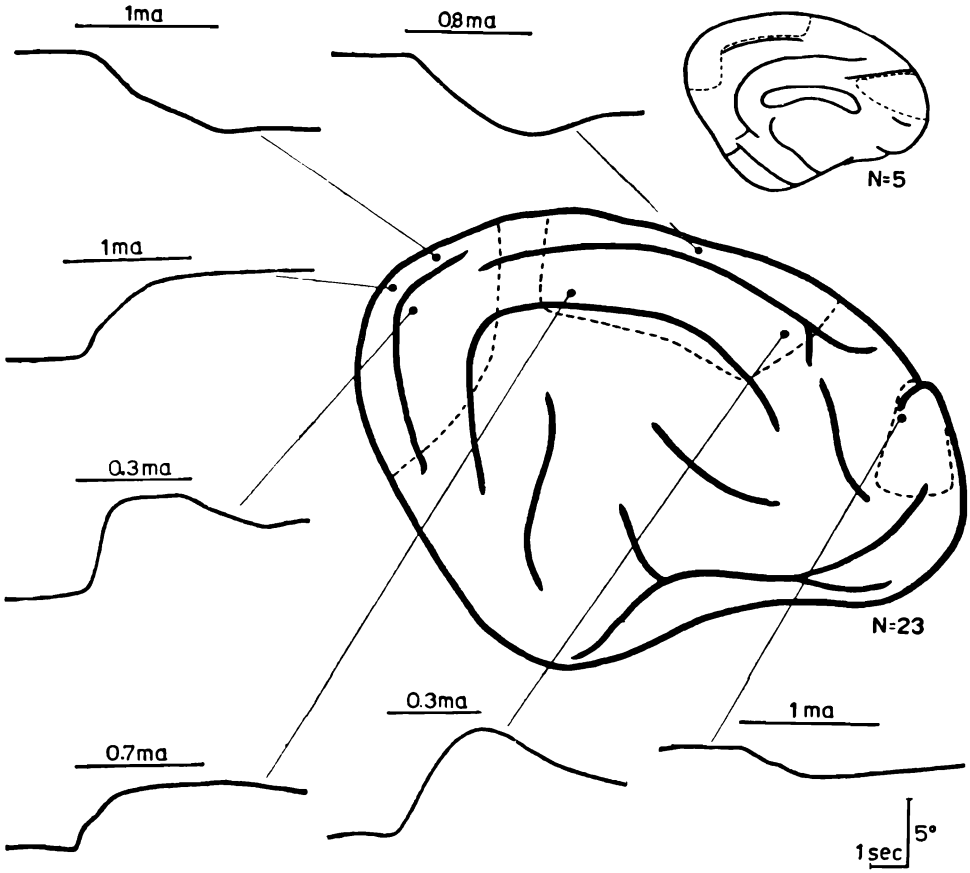

Fig. 6. Cortical oculomotor areas in the pretrigeminal cat. For the lateral aspect of the hemisphere the data from 23 cats are summarized and for the medial aspect the data from 5 cats. All illustrative records are taken from one preparation. The stimulation is marked with a heavy line. (From Dreher et al. 1970.)

the blast injection method. Two habituation sessions with one of the "X" figures and one habituation session with the odor of valerian were performed. The interval between "visual" sessions was 2 hr, which usually allowed for full recovery of the fixation response. The intertrial intervals were 1 min in the visual session and 2 min in the olfactory session. After 30 trials they were, however, shortened to 30 sec and 1 min respectively.

In the cats with lesions of the anterior sigmoid gyrus or proreal gyrus the fixation response to rotation of the "X" figure was clearly enhanced: the fixations lasted longer and the after-fixations occurred more frequently (Table I). The most dramatic effect, however, was the increase of resistance to habituation of the fixation response. Although after 30

TABLE I

The intensity of the fixation response and its resistance to habituation[a]

Ablation	Median duration of the first fixation in the first trial of a session (in sec)	Percentage of cats with after-fixations in at least one trial	Median resistance to habituation (in trials)[b]	N
None	6.7	18	14	11
Anterior sigmoid	10.5	55	61	9
Lateral anterior sigmoid	8.0	75	38	12
Medial anterior sigmoid	7.5	40	40	5
Proreus	8.6	100	34	5
Lateral posterior sigmoid	7.2	60	23	5

a Data from two sessions.
b The intertrial intervals were 60 sec in the first 30 trials and 30 sec afterwards.

trials the intertrial intervals were shortened from 60 to 30 sec, in the cats with total removal of the anterior sigmoid gyrus the average number of trials needed for full habituation was four times greater than in the controls (Table I). In two cats the fixation response was still present after 250 trials. These results are in full agreement with the description of fixation response in frontal cats by Jeannerod, Kiyono and Mouret (1968).

On the other hand, the pupillary dilatation and ECoG arousal to the olfactory stimuli, i.e. the indicators of the arousal response, and the resistance to habituation of these responses seemed to be unchanged (Table II). An exception was the unexpectedly strong resistance to habituation of pupillary dilatation in cats with ablation of the posterior sigmoid gyrus. The background diameter of pupils and ECoG activity (the indi-

TABLE II

The intensity of the pupillary dilatation to the odor of valerian and its resistance to habituation

Ablation	Median dilatation in the first trial (in mm)	Median resistance to habituation (in trials)[a]	N (different for each test)	
None	0.8	11	5	6
Anterior sigmoid	0.7	5	3	7
Lateral anterior sigmoid	0.6	9	9	10
Medial anterior sigmoid	—	16	0	5
Proreus	0.5	10	5	5
Lateral posterior sigmoid	0.8	36	5	5

a The interial intervals were 2 min in the first 30 trials and 1 min afterwards.

cators of background arousal) also did not seem to be affected by any ablation (Table III). These results are important for the interpretation of the fixation reflex enhancement, which might be simply effect of increased background arousal.

TABLE III
Background arousal

Ablation	Median diameter of pupils (in mm)	Percentage of cats with permanent ECoG desynchronization	N
None	0.8	54	11
Anterior sigmoid	0.7	44	9
Lateral anterior sigmoid	0.5	42	12
Medial anterior sigmoid	0.7	20	4
Proreus	0.6	80	5
Lateral posterior sigmoid	0.9	20	5

This enhancement of the orienting response may play a role in mechanisms of some other frontal symptoms. In this respect the relations between the orienting and specific responses are critical. Three situations can be distinguished: (i) the orienting response is synergic with the specific response, (ii) the orienting response is antagonistic to the specific response, and (iii) the orienting and specific responses are rather independent each from other.

1. The synergism between the orienting and specific responses occurs when the animal is trained to perform the locomotor response toward the cue and, therefore, the specific response is superimposed upon the orienting one. Although in this situation the hypernormal orienting response cannot considerably affect the specific response itself, it can contribute to the disturbance in the go–no go differentiation (the symptom of prefrontal lesions in dogs and cats) initiating the locomotor response to the negative stimulus. This mechanism, however, is less likely to operate in the disinhibition of the intertrial responses.

It is also possible that the enhancement of the orienting response is partially responsible for the impairment of the locomotor delayed responses, the syndrome present in dogs and cats after proreal lesions. We know that then the animal shows a tendency to approach that feeder to which it is turned at the moment of release (Ławicka and Konorski 1959). Such an error can obviously be initiated by the orienting response.

2. The possible antagonism between the orienting and specific responses is well illustrated by the experimental situation in which the animal is trained to a cue by walking to a feeder located in a direction

opposite to that of the source of the cue. Irena Stępień and her associates (1966) have shown that after medial prefrontal ablation, dog and cat approach indeed the cue instead of the feeder. The authors call this symptom "magnet-reaction".

3. The orienting and specific responses may be mutually rather independent when the manipulatory response is required from the animal. Then the increase of the orienting response cannot considerably affect the specific response.

We can conclude, therefore, that in some experimental situations the hypernormality of the orienting response can be one of the causes of some other frontal symptoms, in particular it can contribute to the disinhibition of the locomotor responses in go–no go differentiation and to the impairment of the locomotor delayed responses.

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