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aldosterone when animals are fed 0.1% propylthiouracil (Fregly *et al*, 1965).

#### ACKNOWLEDGEMENTS

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## Electroencephalograms of Kittens Exhibiting Spastic Behavior

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WADE L. COLLIER<sup>2</sup>

*Abstract.* Examination and comparison of some basic reflex tests and of the electroencephalograms of five kittens showing spastic behavior with a control permitted the grouping of these animals into categories which were in accord with those previously determined on the basis of behavioral observation only.

Observations made of a litter of kittens showed varying degrees of lack of coordination in feeding and general behavior. It was decided to extend the scope of the observations by subjecting the animals to an established general static reflex test, a righting test, and a pupil constriction test as well as by the recording of electroencephalograms.

#### METHODS

Five spastic<sup>3</sup> six-week old kittens from the same litter and one

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<sup>3</sup> Spastic is defined here in a general sense denoting uncoordinated and at times jerky behavior.

control kitten of unknown age but approximately the same weight, height, and size were kept in three cages as follows. The control was isolated, the two most spastic animals were kept in one cage along with one other animal, and two other animals were kept in a third cage. The animal kept with the most spastic kittens was rotated so that each of the other three animals of the litter had equal contact with them. The animals were kept in a thermoregulated room, maintained at  $25 \pm 2^\circ\text{C}$  which was illuminated for approximately nine hours per day. At feeding time, the kittens were taken out of their cages and allowed to play as well as eat. They were fed commercial kitten food with milk three times a day. One animal had to be fed by medicine dropper and spoon. Body weights were taken on a standard animal balance after the first meal of each day.

Periodically, various reflexes were examined in the kittens. The general static reflex test used involved the change in the extremities when the position of the head in space was changed. According to Greisheimer (1963), if the head is lowered, the front legs of a cat are flexed and the hind legs extended; and if the head is raised, the front legs are extended, and the hind legs flexed. The righting reflex involved placing an animal on its back and noting how it turned itself right side up. The pupil constriction test consisted of shining a pencil flashlight into the animal's eyes and noting the size of the pupils. The time required to get to the constricted state was obtained during the last run of this test.

The kittens were also tossed into the air, dorsal side up, and their reactions noted prior to their being caught after a drop of about two feet.

Electroencephalograms were obtained by use of an ink-writing polygraph<sup>4</sup>, a high-gain preamplifier, and pin electrodes of 10 mm. length. The electrodes were first placed beneath the scalp behind the ears, a location designated as occipital leads, and then the same electrodes were placed beneath the scalp in front of the ears, a location designated as frontal leads. The electrodes were between the scalp and the skull according to the prescribed technique (E&M Laboratory Manual, 1965). Each lead setting was run for approximately three minutes and included recordings taken at 25 mm./sec. and 50 mm./sec. paper speeds.

The animals had to be restrained during the measurement of the electroencephalograms. Use was made of a strong piece of canvas arranged so as to wrap around the animal and allow just the head to protrude. Thumb tacks held the canvas down.

<sup>4</sup> Polygraph "Six", E. & M. Instrument Company, Inc. Houston, Texas.

During the preliminary work, a local anesthesia was used to lightly anesthetize the scalp prior to insertion of the pin electrodes but this procedure upset the animals and was discarded.

### RESULTS

All of the kittens presented normal responses to the part of the general static test involving the raising of the head; that is to say, the front legs were extended and the hind legs flexed. The control and three of the spastic animals showed a normal response to the other portion of the general static test; when the head was lowered, the front legs were flexed and the hind legs extended. However, kittens number 3 and 5 responded abnormally with 5 being the more abnormal.

All of the animals were able to right themselves when placed on their backs.

In the pupil constriction test, the control kitten, number 6, had a constriction time average of 1.1 seconds, nearly twice as fast as the average of the spastics as seen in Table 1. Kitten number 5, the worst of the spastic animals, had the longest of the reaction times.

Table 1. Constriction Reflex Times<sup>5</sup>

Animal:	Time in Seconds:
Control:	
Kitten #6	1.1
Spastics:	
Kitten #1	1.8
Kitten #2	1.9
Kitten #3	1.7
Kitten #4	1.7
Kitten #5	3.0
	Average 2.0

<sup>5</sup> Average of five trials, timed by two individuals.

Table 2 indicates the weight of the animals when they were first brought into the laboratory and at the end of the observations. The per cent increases in body weight indicate that each of the abnormal kittens ate well, except for kitten number 3 who was more interested in playing than eating. The control

Table 2. Per Cent Increases of Body Weights

Animal:	Original Weight	Final Weight	Per Cent Increase
Control:			
Kitten #6	776.5	812.0	4.6
Spastics:			
Kitten #1	681.0	859.5	20.6
Kitten #2	680.0	808.5	18.8
Kitten #3	644.0	742.0	15.2
Kitten #4	492.0	589.5	19.8
Kitten #5	492.0	596.0	21.2

animal was rather shy and did not adapt well to the laboratory schedule, including meal times.

The behavior of the control animal and three of the spastic animals appeared to be normal as the animals were tossed into the air. On the way down these animals all extended both sets of their legs. Kitten number 5, while falling, grouped its feet together, a response judged abnormal. Kitten number 4 did about the same thing except not to the same extent number 5 did.

During the tests and during feeding periods additional notes were made on the spastic animals. They are as follows:

*Kitten # 1:* The only abnormality noted was when it walked, its middle swung like a rope.

*Kitten # 2:* The only difficulty this animal encountered was when running. His hind feet tended to slide out from under him.

*Kitten # 3:* This kitten had great difficulty in coordination with its front and hind limbs. Frequently, one paw shook violently when it was extended. While running, it lost control of its hind limbs and rolled onto its side. When slapping at an object with its front paws, it tended to over-aim.

*Kitten # 4:* Although not as poor as kitten number 5, this animal was greatly affected as could be seen when it walked. Instead of traveling in a forward direction, it went sideways, falling down every few paces.

*Kitten # 5:* At the beginning of the observations, this kitten could not feed itself. During the experiment, the animal learned to eat by itself while frequently falling into the dish of food. However, this was the only improvement noted in this kitten. Kitten number 5 seemed to lose consciousness every few seconds and fall down. Once down, it would awake and start a series of rapid, uncontrollable motions which seemed to be an attempt by the animal to compensate for its actions. This kitten was so uncoordinated that it could not climb out of a basket 12 cm. high, something easily done by its littermates.

Electroencephalograms were examined in accord with established rules of electroencephalography on humans (Gibbs and Gibbs, 1951).

The number of brain waves per second and their relative amplitude were determined from representative parts of the electroencephalograms. This material is presented in Table 3.

As noted all occipital lead frequencies were higher than frontal frequencies were. Amplitudes of brain waves were lowest

Table 3. Comparison of Brain Waves in A Normal and Spastic Kittens

Animal	Occipital Leads Amplitude	Leads Waves/sec.	Frontal Leads Amplitude	Leads Waves/sec.
Control:				
Kitten #6	Low	23.0	Low	17.5
Spastics:				
Kitten #1	Lower	21.4	Low	15.4
Kitten #2	Lower	20.8	Low	12.6
Kitten #3	Lower	14.8	Low	12.2
Kitten #4	Low	15.6	High	6.5
Kitten #5	Low	15.2	High	8.7

in spastic kittens number 1, 2, and 3 for the occipital leads and for the same animals along with the normal kitten for the frontal leads. The frontal leads for kittens number 4 and 5 showed high voltage amplitudes which were also saw toothed in many cases. The frequencies of occipital lead brain waves decrease in such a way as to allow a division into the control kitten, kittens number 1 and 2, and kittens number 3, 4, and 5; the frequencies of the frontal lobe brain waves also decrease and allow a grouping into the control kitten, kittens number 1, 2, and 3, and kittens number 4 and 5. Representative pictures of the electroencephalograms of the control kitten and spastic kitten number 5 are shown in Figures 1 through 4.

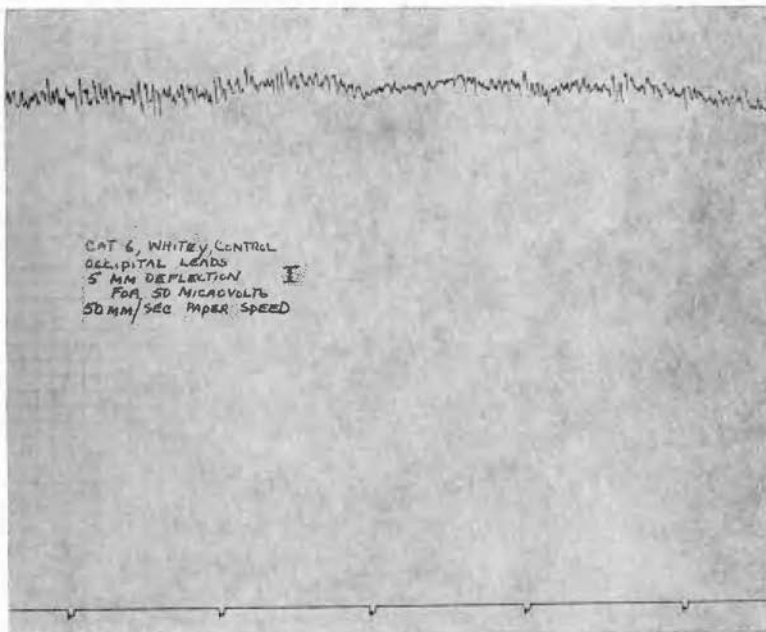


Figure 1. Electroencephalogram of normal animal, number 6, occipital leads. Fast waves of low amplitude.

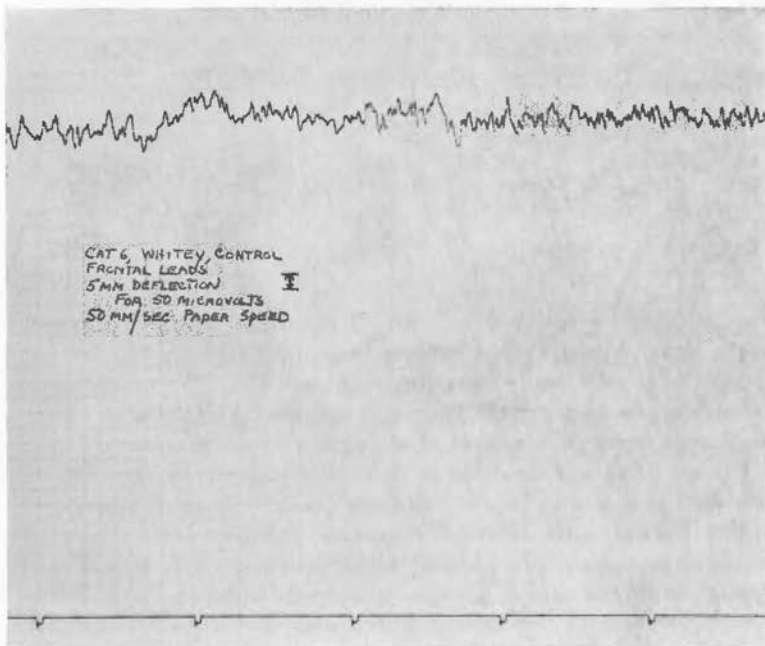


Figure 2. Electroencephalogram of normal animal, number 6, frontal leads. Fast waves of low amplitude.

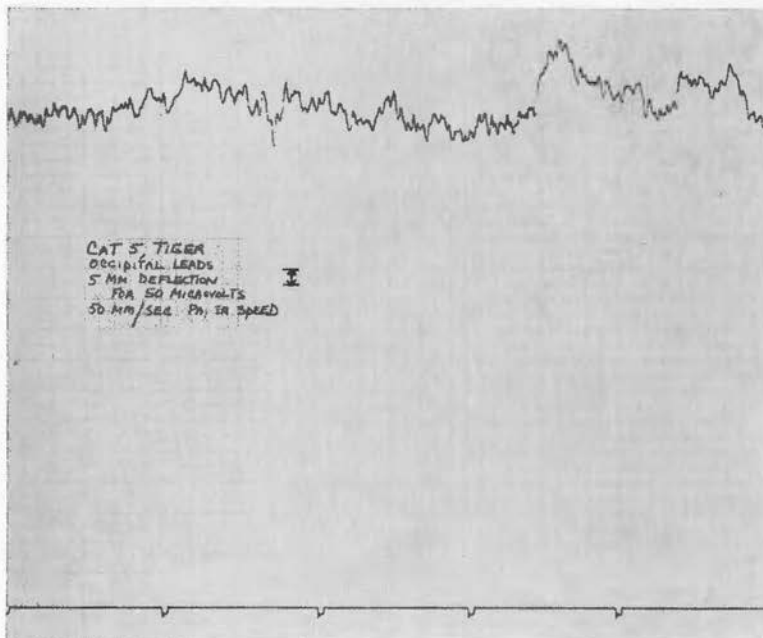


Figure 3. Electroencephalogram of spastic kitten, number 5, occipital leads.

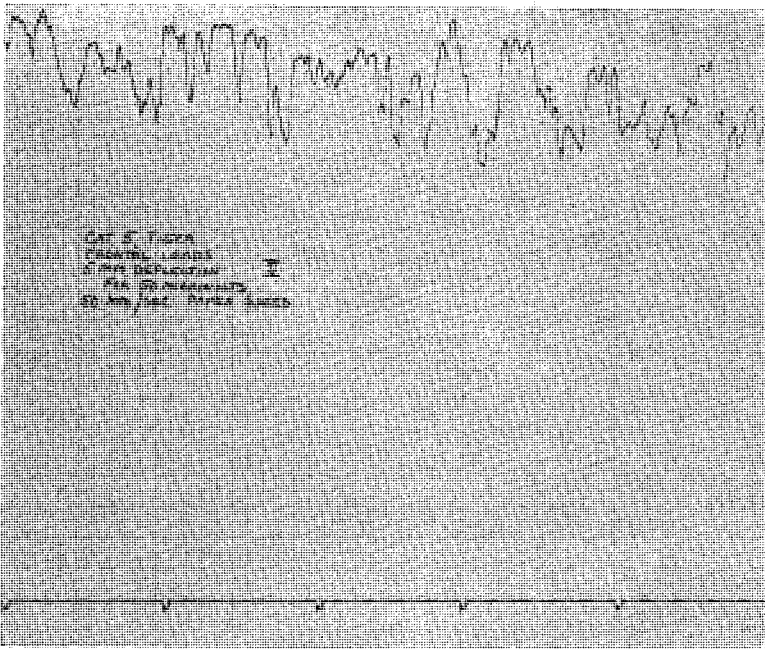


Figure 4. Electroencephalogram of spastic kitten, number 5, frontal leads. Slow waves of high amplitude.

#### DISCUSSION

The spastic kittens were ranked 1 through 5 on the basis of a comparison to what was considered to be normal behavior with 1 being the most normal behavior and 5 the most abnormal. Wherever it was possible to make a judgment as to the degree of efficiency in performing reflex tests the arbitrary ranking was confirmed. Spastic animal 5 was always the least coordinated in performing reflexes. In the measurement of brain waves with the frontal leads, animals number 4 and 5 showed high voltage, low frequency, flat and saw-toothed waves which is typical of the psychomotor epilepsy picture in human beings (Gibbs and Gibbs, 1951; Guyton, 1956). These two animals frequently appeared to lose consciousness during various kinds of activity and, as noted previously, had great difficulty with motor behavior, all of which is described by Guyton (1956) as being characteristic. Guyton speculates the possibility of lower brain center damage in these cases of psychomotor disturbances. In later investigations, Collier *et al.* (1966) determined that animals numbered 3, 4, and 5 all had an underdeveloped cerebellum and varying degrees of cerebral damage. Thus, all attributes measured, that is to say, reflexes, electroencephalograms, and the



gross anatomical picture of the brains correlated with the degree of difficulty the kittens had.

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## Histological and Gross Studies of Brain Tissue of Kittens Exhibiting Spastic Behavior

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*Abstract:* Histological and gross studies of brain tissue revealed lowered brain weight, lower brain weight to body weight ratios, and poor brain development in relation to the degree of spasticity exhibited in kittens but did not reveal any definite histological changes.

Examination of five spastic<sup>4</sup> kittens from the same litter and one normal kitten of approximately the same age from another litter had revealed abnormalities of the spastic animals in general behavior, reflex tests, and electroencephalograms (Drexler *et al.*, 1966; Cook and Collier, 1966). At the conclusion of these observations it was decided to sacrifice the animals so as to observe the extent of gross and histological changes within the brains, if any.

### METHODS

After the completion of the behavioral observations on the animals, they were sacrificed by ether inhalation and weighed. Brains were then removed and weighed, and the sex of the kittens was ascertained. Brain weight per 100 grams of body weight ratios were calculated.

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<sup>4</sup> Spastic is defined here in a general sense denoting uncoordinated and at times jerky behavior.