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Observations upon Conduct of a Thalamic Dog.* Hearing and Vision in Decorticated Animals.†

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Some time ago one of us observed conditioned visceral responses in rabbits with extensive pallial destruction.¹ Acting upon this evidence and with the knowledge that the cortex was considered the usual if not only locus of the conditioning process by Pavlov² on the basis of work by Zeliony³ we attempted to secure a decorticated animal higher in the evolutionary scale, and here describe the behavior of a decorticated dog with intact thalamus. Almost a hundred animals were utilized in this work which extended over a period of nearly 3 years.

A detailed record of the behavior of the animal was kept beginning with the time of operation (done in 2 stages). The day after operation the animal was able to stand rigidly on its feet when put in that position (extensor hypertonia) but slowly sank to the floor under its own weight without moving. Rigidity of the extremities with clasp-knife reflexes (Creed⁴) was observed until

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¹ Unpublished observations by Fred A. Mettler.

² Pavlov, I., *Conditioned Reflexes*, Oxford University Press, 1927.

³ Zeliony, T. N., *Trans. Soc. Russian Physicians of St. Petersburg*, 1911-12, 50, 147.

⁴ Creed, Denny-Brown, Eccles. Liddell and Sherrington. *Reflex Activity of the Spinal Cord*. Oxford, Clarendon Press. 1932.

its death. In 3 days, the animal was able to move with difficulty (which is exactly the time Goltz gives), in 5, it would stand for hours without motion but when in motion moved in a straight line. For 8 days no reaction to pistol shots nor a flash lamp beam was discerned, but on the ninth day a pupillary reflex was present and on the tenth the animal reacted to sound (same day Rothmann's dog registered). It grew to use its muzzle sensibility for purposes of directing its locomotion (Rothmann⁵) keeping its head low to the floor. The animal reacted to olfactory sensations on the ninth day but never ate or drank spontaneously. On the tenth day circus movements appeared and grew stronger with occasional convulsions and somatic weakening until killed on the 19th day. During its life it showed marked resistance to impressed movements, was unable to respond promptly to stimulation nor could it cease its own activity until this wore off gradually. (Efforts were made to observe sympathetic excitation and phenomena which might be considered sham rage.)

Conditioned training was begun on the 11th day according to a usual technique (Girden and Culler⁶) and before death, the animal gave definite evidence of conditioning to sound. Light was also used, but more complete records were kept on sound. Before conditioned training was begun the animal reacted to a loud bell merely by moving the ears. This sound was used as the conditioned stimulus in association with a shock to the forepaw. On the last day tested the animal evinced motor reactions which had developed during the conditioned training 20 times out of 25 trials with 2 doubtful and 3 negative reactions.

Postmortem examination disclosed enormous thickening of the dura, intracranially, especially over the basis cranii. There was a thick fibrous pad over the remnants of the brain which pad extended by trabeculae into the brain substance and was continuous with a cyst situated in the medullary center of the left hemisphere. This cyst extended from the situation of the presylvian sulcus to the situation of the posterior lateral gyrus. A tab of the frontal lobe on both sides was adherent to the piriform area but the connections were severed and it was later seen to be more or less acellular. A similar situation maintained with regard to a tab of cortex in the depth of the left Sylvian sulcus. The head of the caudate nucleus was invaded by fibrous tissue on the left side and the third ventricle

⁵ Rothmann, H., *Z. f. d. ges. Neur. u. Psychiat.*, 1923, **87**, 247.

⁶ Girden and Culler, *Am. J. Roent. and Rad. Ther.*, 1933, **30**, 215.

had also been invaded. A complete microscopic study of the brain has been made by the Marchi method (Mettler⁷).

There can be no doubt from this and accompanying experiments that deafness and blindness produced by cortical removal are not identical with destruction of the peripheral apparatus. Although there is an initial period of complete deafness, this passes away (Rothmann's⁵ animal gave evidence of hearing on the same day after operation as ours) very suddenly. Although the animal above could smell (tests for taste were unsatisfactory) it would not eat spontaneously. The reason for this is not immediately apparent but sometimes occurs in dogs when only one frontal lobe is injured. (Further work on this point is in preparation.) Evidence is available to show that the behavior of this animal was modifiable by training. Recently Zeliony in association with Poltygrew^{8,9} has reversed his earlier view. Rothmann⁵ states too that his animal was able to learn to do simple tricks. Herrick has long called attention to modifiability of behavior at thalamic levels and vicarious functioning of cortical tissue has been for some time open to serious question. The conditioned reaction in this animal was in the form of a pattern rather different from the usual and suggested nervous mediation by an intrinsic spinal mechanism (Creed et Alius⁴) rather than the corticospinal tract. Zeliony himself wrote "We have to keep in mind that our dog was abnormal and therefore it would be possible that some deviation from the normal response would be expected if conditioned reflexes were possible." The specific qualities of the "motorium" were absent in this animal, *i. e.*, it was unable to activate a movement suddenly or to stop its own activity suddenly. There appeared to be autonomic overactivity in this and similar animals as would be expected from the results of Fulton and Ingraham.¹⁰ The above results must be interpreted to mean that decorticated animals can distinguish sound and may be conditioned to it. As nearly as the authors are aware, this is the first presentation of positive evidence of conditioning in a thalamic animal with post-mortem examination and microscopic study.

⁷ Mettler, Fred A., *Stain Tech.*, 1932, **7**, 95.

⁸ Poltygrew and Zeliony, *Am. J. Phys.*, 1929, **90**, 475.

⁹ Poltygrew and Zeliony, *Z. J. Biol.*, 1930, **90**, 157.

¹⁰ Fulton and Ingraham, *Proc. Phys. Soc.*, in *J. Physiol.*, 1929, **67**, 27.