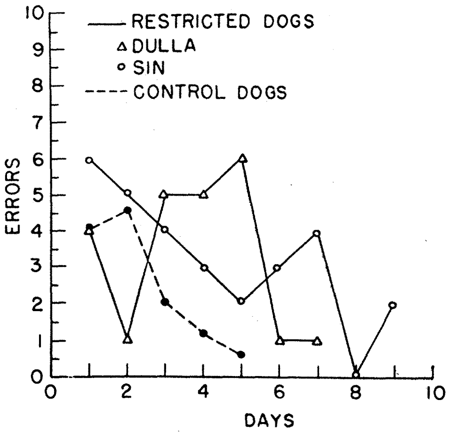

Fig. 1. Errors made by restricted and control dogs during white (+) vs. black (−) discrimination training.

rors, while both restricted dogs made significantly higher error scores ($t = 4.1$; $p < .02$) for a prolonged period. The plateaus in the curve reflect a position habit that was developed by both dogs during the training. One ran to the right side only and the other to the left side only on nine or ten trials each day. Both dogs also showed a high level of excited behavior during the entire training period. Only after one of the dogs was permitted to correct its errors (on the 22nd day) was it able to learn the reversal problem.

The next discrimination, between a horizontal and vertical line (a 1- by 5-inch white line on a black ground), failed to reveal a clear-cut difference between the two groups. The primary reason for the failure was unexpected.

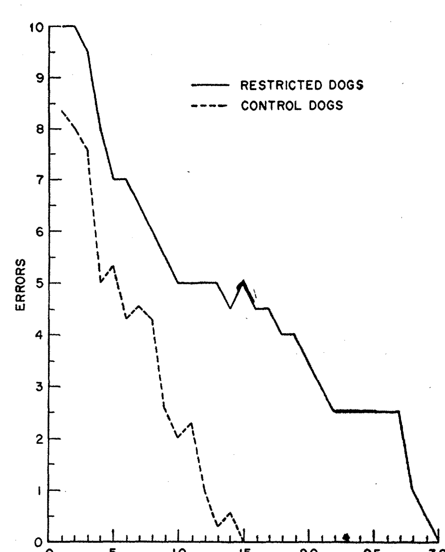

Fig. 2. Errors made by restricted and control dogs during black (+) vs. white (−) reversal training.

One of the "normal" control dogs underwent a remarkable change in "personality" in the course of the training, and became almost indistinguishable from the restricted dogs. It showed an increasingly high level of behavioral excitement and struggled violently when it was picked up. At the same time it developed a strong position habit, and "superstitious" behavior patterns, such as turning two complete circles before responding to the stimuli. In the course of this dramatic behavioral change, this dog's error scores shifted into the range of the restricted dogs.

Dogs raised in a restricted environment, then, encounter more difficulty than normally reared littermates in learning a simple visual discrimination and in utilizing it in a new situation (the reversal problem). Since the restricted dogs were exposed to patterned visual stimulation in their cages, their difficulty cannot be attributed to a deficit in pattern perception. Rather, the explanation may lie in the exceptionally high level of emotional excitement—including "whirling fits" similar to a seizure (*1*)—that pervades all the behavior of restriction-reared dogs. It is possible that the dogs are so "aroused" and distracted by the unfamiliar environment surrounding them that they have difficulty in attending selectively to the "cue" properties of the stimuli which are to be discriminated. The effects of restriction thus seem best explained in terms of Hebb's (*3*) cue-arousal model, which suggests that high levels of arousal interfere with discrimination and selection of relevant cues from the environment. Indeed, even the increase in emotional excitement in one of the control dogs was accompanied by a marked rise in errors during discrimination learning.

These results have important implications for Riesen's (*4*) reports in which he states that animals deprived of patterned visual stimulation fail to discriminate between simple visual patterns at maturity. These effects are generally attributed to an absence of pattern perception.

Deprived animals, however, are also restricted to small cages or rooms and show hyperexcitability, seizure activity and other emotional abnormalities that resemble those observed in restricted dogs. Moreover, Riesen has observed that visually deprived animals have much less difficulty in discriminating patterns if the differences to be discriminated are replicated throughout the stimulus figures. It seems reasonable, then, that at least part of their difficulty in discrimination may be attributed to inability to select relevant patterns from the total sensory input (because of the high level of arousal) rather than to absence of pattern perception per se.

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References and Notes

1. R. Melzack and T. H. Scott, *J. Comp. Physiol. Psychol.* **50**, 155 (1957); W. R. Thompson and W. Heron, *Can. J. Psychol.* **8**, 17 (1954); W. R. Thompson, R. Melzack, T. H. Scott, *Science* **123**, 939 (1956).
2. This study was supported in part by the U.S. Army Signal Corps, the Air Force Office of Scientific Research, and the Office of Naval Research, and in part by grants from the National Institutes of Health (M-4235-[C1]) and from the U.S. Air Force (AF 49 [638]-898). I thank Joseph Mendelson for his assistance in carrying out this experiment.
3. D. O. Hebb, *Psychol. Rev.* **62**, 243 (1955).
4. A. H. Riesen, in *Functions of Varied Experience*, D. W. Fiske and S. R. Maddi, Eds. (Dorsey, Homewood, Ill., 1961), p. 57; A. H. Riesen, in *Sensory Deprivation*, P. Solomon, P. E. Kubzansky, P. H. Leiderman, J. H. Mendelson, R. Trumbull, D. Wexler, Eds. (Harvard, Cambridge, Mass., 1961), p. 34.

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Myotonia in a Horse

Abstract. Congenital myotonia, similar to that which has been reported in humans and in goats, is here reported for the first time in another species. Evidence is given to show (i) that the myotonic phenomenon is present despite complete block of neuromuscular transmission; (ii) prior to injection of curare, synchronous activity of muscle fibers may result not only from ephaptic stimulation of neighboring fibers but also from reflex firing; and (iii) water deprivation does not relieve the myotonia.

The myotonic phenomenon—which consists of prolonged contraction of skeletal muscle upon mechanical, electrical, and chemical stimulation—has been shown to be accompanied by bursts of high-frequency muscle action potentials when a needle is inserted into the muscle (the so-called "myotonic discharge" or "dive-bomber" pattern described by the electromyographer) (*1*). This phenomenon has been reported in humans and in goats. In both these species myotonia may occur as a congenital abnormality of the muscle (*2*).

We wish to present data to support the finding of myotonia in a registered thoroughbred horse. The filly was first noted to be lame at age 3 weeks. The

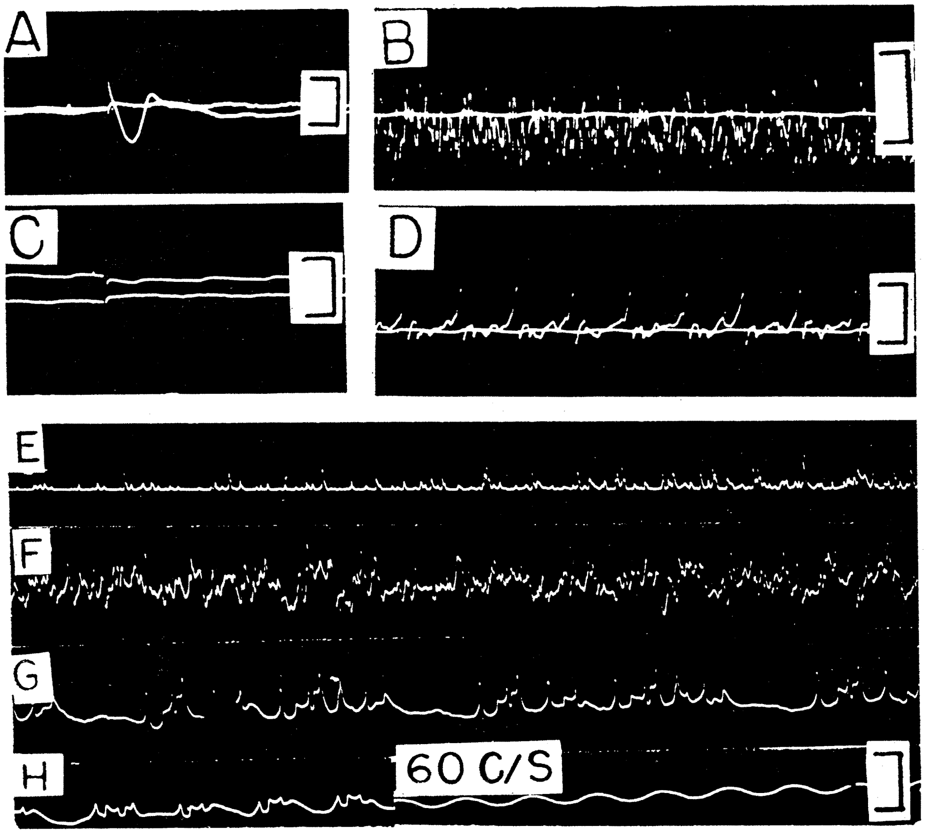

Fig. 1. *A* and *C*: Action potentials recorded from bipolar needle electrodes in right biceps femoris muscle upon single shock supramaximal stimulation of right superficial peroneal nerve (dot indicates stimulus artifact, and action potential is downward). Remaining records: Action potentials recorded from concentric needle electrode in right semimembranosus muscle after mechanical stimulation by needle movement. *A* and *B* before and *C* and *D* during curare block; *B* and *D* were taken when electrical activity was maximal (1.25 seconds after needle movement). *E, F, G,* and *H* are portions of a continuous record taken during water deprivation. With respect to needle movement: *E* immediately after; *F* during maximal activity, that is, 2 seconds after; *G* 19 seconds after; and *H* 24 seconds after. Brackets indicate 500 μvolt in all records.

lameness increased to the extent that it was deemed wise to sacrifice her at age 7 months, at which time we saw her. The symptoms markedly resembled those of human myotonia congenita in that the lameness was most marked after a period of rest and was decreased after periods of activity. Various muscles (notably the semimembranosus, semitendinosus, superficial gluteal, and gracilis—bilaterally) were found to be hyperexcitable so that mechanical stimulation produced a sustained contraction. After concentric needle electrodes were inserted into the hyperexcitable muscles, typical myotonic discharges were seen on the cathode-ray oscilloscope (Fig. 1) and heard on the loudspeaker (with appropriate amplification).

In order to prove that the myotonic phenomenon was associated with an abnormality of the muscle rather than of the nervous system, we injected the horse with curare. Under chloral hydrate anesthesia, a total of 99 mg of *d*-tubocurare was given intravenously in three doses in a period of 22 minutes. This amount of curare produced cessation of respiration (which was then maintained artificially) and loss of palpebral and corneal reflexes. To establish the completeness of the neuromuscular block, muscle action potentials were recorded from needles inserted into the belly and tendon of the right biceps femoris muscle when the right superficial peroneal nerve was stimulated percutaneously (Fig. 1). During complete neuromuscular block we were unable to detect any change in the degree or duration of the prolonged contraction or of the audible signal. However, although the total duration of the burst of potentials and the amplitude of individual potentials were not diminished, the frequency of the spikes decreased from a maximum of 240 per second before to 60 per second during curare block (Fig. 1). It has been suggested that these spikes represent synchronous activity of muscle fibers which is produced by the action potential of one muscle fiber stimulating neighboring fibers (*3*). It is unlikely that antidromic firing can explain this synchronous activity since the amplitude of the potentials was not decreased by an injection of curare. We believe that the decline in spike frequency during curare block may indicate that some of the potentials recorded prior to the injection of curare resulted from reflex excitation of muscle fibers.

Recently Hegvelli and Szent-Györgi reported that the myotonic phenomenon disappeared in congenital myotonic goats which were deprived of water (*4*). An attempt to deprive this horse of water was made. She was given no water for 72 hours, at which time she was permitted to drink 2 liters of water. The horse was then deprived of water for an additional 18 hours. During this time her hematocrit rose from 37 to 46 percent. At no time during the 90 hours of water deprivation was there any decrease in duration or magnitude of lameness or of the mechanical or electrical myotonic phenomenon (Fig. 1).

At 12 months of age, the horse still continues to show the myotonic phenomenon but is otherwise well. Because of the early onset of signs and myotonic phenomenon associated with myotonic discharge, which persisted despite complete block of neuromuscular transmission, we believe that congenital myotonia may be an affliction of horse as well as of man and goat. It is possible that this congenital abnormality of muscle may occur more frequently throughout the animal kingdom than has heretofore been believed.

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References

1. A. A. Rodriquez and Y. T. Oester, *Electrodiagnosis and Electromyography*, S. Licht, Ed. (Waverly, Baltimore, Md., 1956), p. 226.
2. G. L. Brown and A. M. Harvey, *Brain* **62**, 341 (1939); A. Lanari, *Science* **104**, 221 (1946).
3. W. M. Landau, *Neurology* **2**, 369 (1952).
4. A. Hegvelli and A. Szent-Györgi, *Science* **133**, 1011 (1961).

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