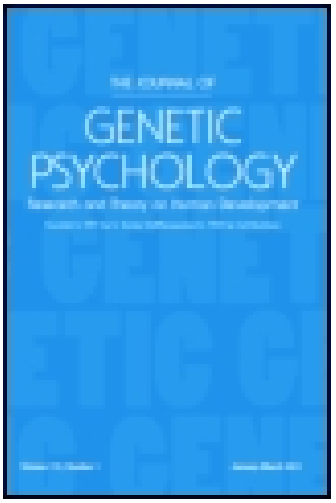

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An Experimental Study of the Defense Mechanism in the Opossum, with Emphasis on Natural Behavior and its Relation to Mode of Life

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AN EXPERIMENTAL STUDY OF THE DEFENSE MECHANISM IN THE OPOSSUM, WITH EMPHASIS ON NATURAL BEHAVIOR AND ITS RELATION TO MODE OF LIFE*[1]

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W. T. JAMES

The avoiding or escape response in different animals has been studied mainly with a single reaction system. Most of these have employed the withdrawal of one of the legs away from a pain producing object. This procedure was used satisfactorily in experiments on the dog, sheep, and goat, by Liddell, James, and Anderson (3). In a later study (1) I found that this method was not adequate when dealing with a lower order of animals, such as the guinea pig. The flexion of the foreleg of the guinea pig could not be conditioned. From this we might be led to infer that the guinea pig is inferior to the other animals in its ability to become conditioned to dangerous objects. This is not true since the natural escape reaction from pain producing and dangerous objects for the guinea pig is to withdraw the entire body by running, and this response was easily conditioned. The cortical mechanism of the guinea pig is sufficient therefore to signal its natural modes of response, and it is only on this basis that this animal may be compared with those of different orders. The total situation, under conditions natural to the animal, is under observation rather than the general response to an isolated adjustment.

From this point of view it is interesting to consider the behaviors of animals of still lower orders than the guinea pig. Behavior phenomena and the significance of nervous development in evolution and mode of life can be understood only if emphasis be placed on natural reactions. In this report we deal with the behavior of the Virginia opossum. The opossum is largely nocturnal, while its principal habitat is the dark of caves and hollow trees. Among the many primitive forms of behavior which this animal exhibits, is an extremely passive defense reaction. When the opossum is surprised

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by a strange animal, instead of attempting to run away, it lies down, curls up, and remains motionless. It is difficult to imagine how such a reaction contributes to the survival of the animal. Is this behavior an extreme form of inhibition, the same general reaction as is observed in other animals to a less degree; or is it a special protective phenomenon peculiar to the opossum? What nervous or anatomical structures are correlated with this reaction which might help us to understand it? These questions cannot be answered until the animal's ability to defend itself and to escape from dangerous situations have been studied experimentally. The present experiments are concerned with: *first,* the conditioned flexion of the foreleg to an electric shock; *second,* the total running response to an electric shock; and *third,* the passive defense and attack reaction.

Experiment I

In the study of the flexion response of the foreleg, the procedure was the same as that used in the experiment of the guinea pig (1). The animal was confined on a platform by a cord passing from the neck of the animal to a horizontal beam just above it (Figure 3). The hind legs were tied loosely to two pegs. By this arrangement the animal was free to move within limits but could not escape. The flexion of the leg was recorded on a kymograph in an adjoining room. The breathing was recorded by a pneumograph of the type regularly used in experiments with the dog.

When the front leg was shocked electrically, the foot was lifted and then replaced slowly. There was no intense excitement or after discharge of excitation as observed in the sheep and dog. A bell was sounded three seconds before the application of the shock. After more than three hundred applications of the bell signal there were no indications of a conditioned leg reaction. There was some breathing response to the signal, but it may be definitely concluded that the foreleg reaction of the opossum cannot be conditioned (Figure 1).

Experiment II

In the second experiment the running response to an electric shock was observed. A two compartment box was used with an electric grill on the floor of one compartment. The animal was free to escape into the second compartment when the current was applied to the grill. It was found that the opossum would not run off the grill

Fig I

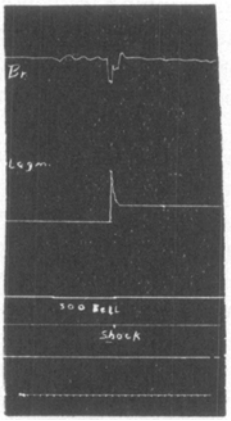

Fig II

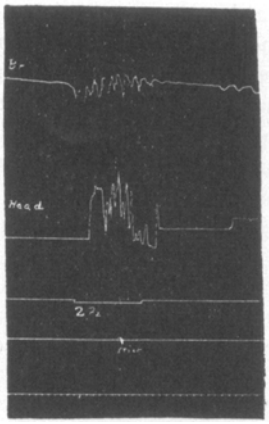

Figure 1 shows the behavior of the opossum after 300 applications of the bell and shock. The response of the leg occurs simultaneously with the shock although the bell precedes it by 8 seconds. Note that there is a conditioned breathing reaction. Figure 11 shows the conditioned reaction of the head to the stick on the second application of the buzzer. The head movement occurs to the buzzer rather then the stick.

Fig III

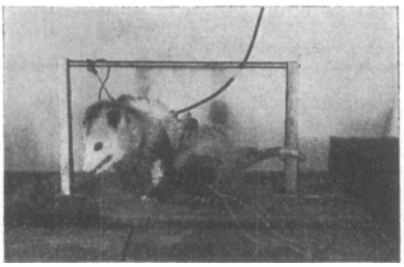

Figure 111 shows the opossum in the apparatus used in the first and third experiments. In the former the recording string was tied to the foreleg while in the latter the string was fastened to the head.

FIGURES 1-3

when shocked on the feet. It would curl up and turn over on its side. In this position the shock was avoided because the animal's fur coating provided insulation. Every effort was made to lead or push the opossum toward the second compartment, but the animal never of itself tried to escape. If the opossum was held upright so that

the feet were shocked, its legs would be raised alternately in a slow forward movement, not at all the brisk running response shown by the guinea pig. The conclusion is that the running reflex is unnecessary as a means of escape when another form of response serves to protect the animal. The opossum does not resort to running as a mode of defense.

Further study has brought out another reaction. When one foreleg is shocked the opossum always turns his head toward this leg and holds the mouth wide open. Raising the leg and turning the head with open jaws seems to be a definitely composite or combined reaction. When the animal was on the electric grill it would open its mouth wide during the shock and at times would even bite at the walls of the box. The shock brought the animal out of the passive defense attitude which it ordinarily maintains and the biting reaction was exhibited as a basic behavior. There is a possibility that this behavior, together with the passive defense attitude, constitutes the chief protective responses of the opossum. A further effort was made to determine whether these reactions could be conditioned.

Experiment III

The simplest way to elicit the head and mouth reaction is to move a stick toward the head of the opossum. When the approach of the stick was signalled by a buzzer, the attack behavior became conditioned after only one application of the conditioned stimulus (Figure 2). A test was again made with the animals which had already been used on the grill and in the foreleg experiments, and in no case did they give the running reaction or the flexion reflex. The attack behavior is very easily conditioned, and is probably of high value as a survival reaction.

Discussion and Conclusions

In the present experiments withdrawal and escape as well as defense reactions of the opossum were studied. In order to compare this animal with others which have been studied, similar procedures were used. The experiments conclusively show that, with the opossum, the leg reaction to an electric shock cannot be conditioned. The animal could not even be taught to progress forward on an electric grill. Thus withdrawal by running would seem to be almost absent as a means of protecting this animal from pain producing objects.

According to Langworthy (2) the foreleg segments have a cortical representation early in the development of the opossum brain. In the marsupial it is necessary that the forelegs become active early in development in order that the immature young may crawl up to the pouch. Although these cortical centers are highly significant for survival in early life they lose their significance later in maturity. On the other hand, the hind legs are not represented in the cortex by a motor point at all. The low stage of segmental relation to the cortex and the fact that the segments cannot be conditioned is probably one of the neurological factors which predisposes the animal to its nocturnal habits. An animal with the escape reaction in such a low stage of development depends entirely on another form of avoidance for protection. The well known "death feigning" or "opossuming" is a true avoidance which is effective in times of danger. When the enemy is within close range the opossum displays a strong attack reaction. This attack reaction can be readily conditioned. If the death feigning is merely an extreme form of inhibition, then it is difficult to understand how the attack reaction can be so readily induced. On this account the passive defense behavior seems rather to be a protective reaction correlated entirely with the inability of the opossum to run. The animal feigns death in order to escape notice. It is unable to escape by progressive movements, yet by becoming inactive and still, it survives.

If many animals with peculiar modes of life, for protecting, avoiding, etc., were carefully studied, it is possible that the neurological organizations which determine these modes of life could be specifically indicated. It might be determined whether there are specific differences in the nature of the nervous phenomena or whether the differences are in neural organization. The reptiles, for example, are slow in movement and assume fixed postures which may be held for hours. They use this slow action and fixed posture in stalking their prey, yet when an enemy is near the reptile strikes swiftly. These special modes of action may be correlated with a peculiar balance between excitatory and inhibitory systems, or it may be that this nervous adjustment is like that of animals of a higher order but is expressed differently because of its anatomical make up. Reptiles, like the opossum, are not swift runners, therefore their peculiar modes of defense and attack may be correlated with an anatomical deficiency, or in other words, nervous action is directly influenced and determined by ana-

tomical development. In studying the reaction of these animals special attention also must be given to the environmental situation.

It should be emphasized that interpretation of conditioned reaction must take into account the nervous development of the animal, its anatomical construction, and the environmental aspect. Animals with a nervous system only in a low stage of development have certain reflex phenomena that are readily conditioned, and in such animals these reflexes are exhibited under all changes in the environment. On the other hand, animals of a higher order may show variable responses to the same stimulus or may give the same response to different stimuli. Animals of a lower order show a range of reflex action very limited in its nature. Such differences among animals must always be kept in mind in comparing the members of one group with another, as well as in drawing conclusions regarding the behavior of one species on the basis of knowledge derived from a different species.

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