EXPLORATORY AND RELATED BEHAVIOR: A NEW TREND IN ANIMAL RESEARCH

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Representative of a large amount of animal research are experiments where the subjects, usually rats, learn one or more of a variety of mazes for food or water reward. Or, in keeping with the growing interest in avoidance behavior, animals might be trained to make a specific response in order to avoid either pain or the threat of pain. In almost every instance, the investigator has been concerned with some aspect of the learning phenomenon. The use of biological drives such as hunger, thirst, or escape from pain is merely a convenient way to motivate animals to learn those responses desired by the experimenter. The complete reliance of animal behavioral studies upon the biological drives, however, has had some unfortunate consequences. Many psychologists believe that it restricts severely the generality of the experimental findings, maintaining that the drives of animals differ in kind from the motives of man. And, while few critics would question the primacy of the biological drives in situations involving, say, extreme hunger or thirst, they would argue that such emergencies rarely arise in our society. Indeed, the statement has often been made that modern man's relative independence of the biological demands, as much as anything else, distinguishes him from lower animals.

Within the last few years, an interesting and important development in animal research has taken place. Motivating conditions other than the biological drives are being explored with exciting results. These researches were mentioned briefly by White in a recent article published in this Journal (25). The purpose of the present paper is to describe more completely the relevant experiments and suggest their implications for man's behavior.

The main impetus for the development has been a general dissatisfaction on the part of many investigators with the thesis that a reduction of a drive is a necessary condition for learning; i. e., responses that lead to drive reduction are reinforced, thereby increasing the probability of their occurrence. Researchers have sought to find out whether learning in animals can occur when there is no apparent connection between performance and reinforcement derived from drive reduction. In carrying out this program, they have collected information which provides an entirely different perspective on the kinds of rewards that influence animal behavior.

EXPERIMENTS WITH RATS

This new trend in animal research can best be illustrated by starting with a relatively simple and thoroughly studied situation—the white rat in a maze. When attention is focussed upon what a rat actually does in a maze rather than upon the rapidity with which he learns it, an interesting phenomenon has been observed: Rats tend to enter those maze units least recently occupied (17). It is unlikely that the animals are searching for food or water, since both are continuously available in their home cages. A more adequate explanation is that the opportunity to explore is a rewarding experience for the rat, and that the amount of exploratory behavior is influenced by the relative novelty of the environment. How, then, can this notion be handled experimentally? The solution to the problem by Montgomery and Segall (18) represents an intriguing turn of events. They trained rats in a simple T-maze to choose the alley holding a black card and to avoid that which held a white card. Each correct response on the black-white discrimination task was rewarded not by food, but by a one-minute venture into a complex maze which was attached to the appropriate arm of the T-maze. The results demonstrated that the rats learned the discrimination task presumably for the privilege of exploring the adjoining maze. Others have gone on to show that novelty is an extremely important factor not only for eliciting, but also for maintaining exploratory behavior (1, 2, 10).

Among all of the studies on rats, one merits special consideration because it illustrates the omnipresence of exploration. This experiment was designed specifically to find out whether rats would acquire a drive based on food reward (19). Briefly, hungry rats were trained to turn a wheel in order to gain access into an adjacent compartment and obtain food. As a control, some animals did not receive food for their efforts. Later, all animals were placed in the same apparatus, but under a different set of conditions: They were not hungry; they had to press a bar instead of turn a wheel to get into the other compartment; and, once there, no food was available. The question asked was whether rats had acquired a drive, through previous experience with food reward to go to the adjoining compartment. The results were surprising. All animals learned to press the bar to gain entrance into the adjacent compartment, but those that had never received food worked as diligently as did those that had. When the experiment was repeated, omitting the original hunger-reward training, it was again found that rats learned a new response in order to gain access to the other compartment. From one viewpoint, this experiment was a failure because there was no evidence for the acquisition of an approach drive. On the other hand, it clearly demonstrates the incentive value intrinsic to exploratory activities.

EXPERIMENTS WITH MONKEYS

Exploratory behavior of the laboratory rat may represent no more than a species peculiarity. It is conceivable, however, that the propensity of rats to investigate is a rudimentary expression of the curiosity-investigative tendencies that characterize so much of the young child's activities. Whereas the latter notion would be attractive to many biologically oriented scientists, the leap from rat to man is admittedly an enormous one. Working with animals phylogenetically closer to man would be much more desirable if one is interested primarily in discovering important behavioral determinants common to both. The rhesus monkey is an excellent candidate for this endeavor. Neuroanatomically, it is not essentially different from man, although those differences that do exist are, no doubt, of great significance. Behaviorally, rhesus monkeys exhibit many of the investigative responses that are observed in young children. They are extremely alert to new sounds and sights and they spend a large amount of their waking hours manipulating objects found in their environment. And, from casual observation, the so-called primary biological drives seem to be unrelated to a great deal of the on-going behavior of monkeys.

On the basis of these considerations, a series of experiments has been carried out with monkeys. In every study, the performances of the animals have been rewarded either by the opportunity to see, to hear, or to manipulate.

Manipulative incentives. Harlow and his associates (13) were first to engage in this line of research. They placed a three-part interlocking mechanical puzzle in the monkeys' living cages. Puzzle solution consisted of pulling out a pin, disengaging a hook from an eye, and lifting a hasp, all in strict serial order. Touching any of the component parts out of order constituted an error. The monkeys soon learned to work the puzzle without mistakes. More important was the persistence with which the animals performed the task. In one study, the puzzle was reset every six minutes throughout the course of a ten-hour test session. And, although there was a decrease in the actual number of devices manipulated as the session progressed, one or more devices were manipulated nearly every time the puzzle was reset (11).

Harlow and McClearn (14) also showed that monkeys would learn a color discrimination problem for manipulative incentives. Here a monkey was presented with a board containing several pairs of screw eyes. Whereas all of them were attached to the board, some were removable while others were not. The only cue as to whether a screw eye could be removed was its color. For example, red ones could be taken out, but the green ones were fixed. A correct response was defined as touching the red screw eyes; an error was recorded if the monkey touched a green screw eye. After a few test sessions, the subjects reached only for the red ones. The reward for correct responses on this problem was not a particularly handsome one, but it was certainly sufficient to produce color discrimination learning: The monkeys were permitted to inspect and play with a screw eye after they had removed it from the board. Infant monkeys work for manipulative rewards even before they have ever handled solid foods (12), a finding which strongly suggests that manipulation can be self-rewarding and not dependent upon rewards associated with the satisfaction of biological drives.

Visual incentives. In addition to their manipulative activities, rhesus monkeys are well-known for their visual curiosity. They are keen observers, attending closely to any changes occurring in their vicinity. I would like to call your attention at this time to some studies that I have done on the observing behavior of monkeys.

Monkeys were placed in an enclosed box from which they could look out by merely pushing against a small door. In the original experiment, the box was located in a large room where people were constantly milling about (4). Two doors were available for watching these activities. A blue card was attached to the inside of one door and a yellow card was attached to the other. The differently colored cards could be switched from door to door. Now, the door with the blue card was always unlocked and the door with the yellow card was always locked. This experimental situation posed an interesting question: Would monkeys learn the blue-yellow discrimination problem when the only reward for correct responses was a view of the outside environment? The results not only showed that the monkeys learned this and several other color discrimination problems, but that they worked unflaggingly for visual reward throughout prolonged and repetitive test sessions (9). One monkey performed for nearly twenty continuous hours before finally refusing to push open the door!

As might be expected, what the monkey sees when he opens the door influences his responsiveness in the test situation. Among the several visual incentives studied thus far, the sight of another monkey has been the most effective for eliciting door-opening responses (5). A fear evoking experience such as the sight of a large dog, on the other hand, completely suppresses investigative behavior (7). Although seeing palatable food certainly should call forth "pleasant memories," monkeys much prefer to watch instead an operating toy electric train (5). Barring fear producing situations, a dynamic scene appears to possess greater reward value than one that is static. Monkeys, for example, spend significantly more time watching a motion picture than viewing a set of photographs (8).

Auditory incentives. In the experiments on visual reward, the subjects were exposed to a rather drab environment—an enclosed box—and they proceeded to rectify the situation. This technique of restricting sensory experiences has been extended to the investigation of auditory rewards with successful results. Before describing these experiments, it should be emphasized that the monkeys' responsiveness to sights and sounds is not an artifact of the testing technique. Only by isolating the animal can we clearly appreciate the reward value of visual and auditory experiences.

In the auditory reward studies, monkeys were tested in a sound-attenuated environment (6). They were placed in a box containing two levers. If the monkey pressed one of the levers, he was rewarded by 12 seconds of sounds emanating from a monkey colony housed in an adjacent room. To provide this form of sound reward, a microphone was placed in front of the colony and a speaker was fixed to the test apparatus. No sounds were presented when the animal pressed the other lever. What happened was that the monkeys selected the lever which enabled them to hear the vocalizations of the monkey colony. Sufficient controls were instituted to ensure that the results could not be accounted for in terms of a preference for a particular lever.

The type of sound a monkey receives makes a real difference with respect to how persistently he will work for it. The opportunity to hear the vocalizations of a "lonely" monkey consistently elicits more lever responses than the opportunity to hear a meaningless sound such as white noise. If the vocalizations of a monkey colony are recorded when one of its members is being molested, the animals, when tested subsequently, exhibit a reluctance to hear these sounds (7).

EXPERIMENTS WITH CHIMPANZEES

The chimpanzee, by nature of its phylogenetic position, should show strong curiosity-investigative tendencies. Unfortunately, little formal research along this line has been done with these animals. Those data that are available, however, are in accordance with both the experimental results from monkey research and the observational data on young children. The Kelloggs (15), rearing a chimpanzee and child together, observed a considerable degree of behavioral similarities between the two. Both were about equally attentive to new objects, toys and pictures. Both spent the major part of their waking hours in play behavior. Indeed, according to the investigators, "The liking for playful activity and companionship was surely as basic in the case of the ape as it was with the child, and each was almost continually playing—except when very hungry or very sleepy—either by himself, or with each other, or with elders" (15, p. 119).

Of course, it should be clearly pointed out that important differences existed within the very area of behavior where the greatest degree of similarity was evidenced. In contrast to the child, the attention of the ape to objects and events in her surroundings shifted rapidly. Moreover, the ape seemed more concerned with the details and less concerned with the larger general items. For example, a new bolt on the kiddy-car would excite the ape while the child would remain oblivious to it. The child, on the other hand, would more quickly notice, say, changes in the activity of the ape or the experimenter, or the over-all social situation.

The role of visual and auditory incentives in the behavior of chimpanzees has not been treated experimentally. Welker (23), however, has worked with manipulative incentives. He was able to sustain manipulative behavior throughout an extensive series of repetitive test sessions, provided he periodically introduced new and novel objects into the test situations. Parents and nursery school teachers continually rely upon this technique for keeping young children occupied. And, in this connection, Welker (24) found that the amount of manipulative activity was related to the age of the subjects, with the younger animals (3 to 4 years) being much more responsive to the manipulanda than the older ones (7 to 8 years).

DISCUSSION OF EXPERIMENTAL RESULTS

The results of these studies present a compelling argument against the contention that animal behavior is based exclusively upon the so-called primary biological drives. Not only can new responses be learned without recourse to the customary rewards such as food, water, sex, or escape from pain, but they can be maintained without the use of extrinsic reinforcement.

The nature of the reinforcement so effectively employed in these researches cannot, at present, be adequately specified. It is suggested, however, that the *perceptual* consequences of behavior served as the reward, and no concommittant reduction of drive is postulated. As a matter of fact, the reinforcing effect of perception *per se* is not necessarily confined to these types of experiments. Even in studies utilizing the primary biological drives to motivate behavior, it appears that the immediate perceptual consequences of actions are reinforcing. For example, Sheffield and associates (21, 22), working with rats, found that eating without hunger satisfaction and sexual behavior without sexual gratification can reinforce behavior.

Obviously, the perceptual consequences of activity vary widely with respect to their reward value. Those resulting, say, from drinking on the part of a severely water-deprived man or animal probably represent one extreme on the continuum of perceptual reward. But this and other situations involving biological emergencies are special cases with low frequencies of occurrence. Infinitely more common are those perceptual rewards resulting from minute-to-minute contact with the environment. The assumption here is that continuous ongoing behavior is rewarded behavior in its own right and not conditioned upon, or derived from, the operation of those homeostatic drives studied by the physiologists. The problem for present-day research in this area is that of identifying situations where the intrinsic reinforcement is sufficient to maintain behavior. These animal studies represent a significant step in this direction. Activities that led to new or more dynamic experiences were shown to predominate over those that did not. In a two-choice situation, rats chose the alley which led to a complex maze. Monkeys chose the door which permitted them to view the surroundings, selected the lever which enabled them to hear environmental events, and preferred those objects which could be manipulated. Under other experimental conditions, behavior that failed to bring about new experiences did not persist.

The investigative activities of rats and the manipulative activities of chimpanzees tended to extinguish unless new objects were introduced.

IMPLICATIONS FOR MAN'S BEHAVIOR

It may well be that these experiments are dealing with a phenomenon of fundamental evolutionary importance. Piaget's (20) observations eloquently attest to the prevalence of manipulative activities in young children which result in novel sights, sounds and tactile perceptions. Moreover, novel experiences are frequently accompanied by expressions of delight which argues further for their positive reinforcing effect. The apparent functional significance of these activities in higher animals and man is indeed elegant: Behavior that results in further investigation of the environment is continually promoted. Perhaps the enormous amount of information that a child, in particular, acquires about his surroundings within the first 18 to 24 months is directly traceable to behavior being selectively reinforced by novel experiences.

This phenomenon does not seem to be as striking in adult behavior probably because those perceptual rewards that appreciably influence man's behavior are extremely subtle and hence the situations giving rise to them are difficult to identify. In addition, they are confounded by a wealth of previous experiences, some of which undoubtedly serve to suppress the positive, out-going responses to the world. It is most unlikely, however, that perceptual rewards intrinsic to situations ranging from the unusual to the less familiar play a minor role in adult behavior. Maslow (16) approaching the problem from a distinctly different orientation, has deemed it necessary to postulate a separate need, viz. to know and understand, in an attempt to account for man's inquisitiveness. Although much of man's behavior can reasonably be subsumed under such a label, experimental data supporting this thesis are conspicuously absent. An interesting investigation, however, has recently been carried out by Berlyne (3) which may mark the beginning of a research project on man's attentiveness to the unusual features of his surroundings. He sought to find out whether adults would respond differentially to the more complex of two stimulus configurations, a question which is essentially similar to those asked of animals. In this study, a series of two-stimulus configurations was presented simultaneously. Each member of the pair differed from the other with respect to either irregularity of arrangement, amount of material, heterogeneity of elements, irregularity of shape, or incongruity. The length of time that the subjects fixated visually on each configuration was recorded during a ten-second exposure period. And, in every case, the subjects attended longer to that pattern which possessed greater complexity.

There is little doubt that experiments along the line of those described in this paper will flourish within the next few years. The problems are numerous and important, for they are relevant to the basic question of man's orientation toward his world. A comparative approach which emphasizes the rewards derived from continuous interchanges with the environment should provide valuable information on the motivational basis of behavior.

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