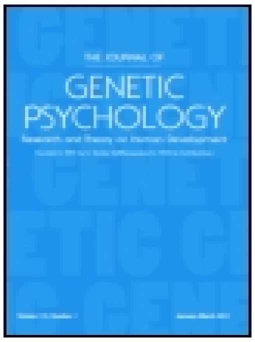

The Pedagogical Seminary and Journal of Genetic Psychology

ISSN: 0885-6559 (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/vzpg20

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To cite this article: Henry W. Nissen (1930) A Study of Exploratory Behavior in the White Rat by Means of the Obstruction Method, The Pedagogical Seminary and Journal of Genetic Psychology, 37:3, 361-376, DOI: 10.1080/08856559.1930.9944162

To link to this article: https://doi.org/10.1080/08856559.1930.9944162

Published online: 13 Jul 2010.

A STUDY OF EXPLORATORY BEHAVIOR IN THE WHITE RAT BY MEANS OF THE OBSTRUCTION METHOD*[1]

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HENRY W. NISSEN

INTRODUCTION

The tremendous amount of activity expended by rats in "exploring" a novel situation or environment can hardly escape the notice of anyone working with these rodents in the laboratory. When one of these animals is placed into a new cage or when it is merely replaced into its old, unaltered cage after an absence of 10 or 15 minutes, it spends a considerable length of time in a hurried albeit rather thorough survey of the enclosure. Dashiell (1) has recorded the common observation that even a hungry animal will forego food until after it has completed its investigation of the renovated nest box. The writer (4), in the course of his study of the sex drive, found that a certain amount of exploratory activity—sometimes continuing for 10 minutes or more—usually preceded any attempts at copulation on the part of sexually vigorous animals placed in an unfamiliar situation.

In spite of the frequency with which this characteristic form of behavior is encountered, few if any studies have been directed specifically towards its analysis or measurement. It is taken for granted and it is exploited; certainly the "curious behavior" of rats was a factor not of the least importance in determining the widespread adoption of these animals for laboratory use, especially in studies of learning.

Even the terminology to be employed in designating the behavior here under consideration presents difficulties, for it is not known

*Received for publication by C. J. Warden of the Editorial Board, June 25, 1929.

[1]This report covers one major topic in a project on animal drives (under the general direction of Professor C. J. Warden), supported by the Council for Research in the Social Sciences of Columbia University.

exactly what intra-organic and environmental conditions are requisite for its manifestation. Apparently a novel situation—one which does not frighten the animal—provokes exploration, the expression of other drives, as illustrated above, being temporarily deferred. Thus by a crude application of the method of choice we have some indication of the intensity of the exploratory tendency. Although such an uncontrolled observation cannot be taken too seriously, it suggested to the writer that exploration is more than a mere general activity drive which finds its outlet in the most common activities in the repertory of the animal, such as running, climbing, sniffing, and moving the vibrissae. If exploration is in fact a dynamic form of behavior akin to the hunger, thirst, sex, and maternal drives, it seems that when put to the test the animal would overcome a certain obstruction in order to explore. If, on the other hand, exploratory behavior is nothing more than the chance manifestation of a tendency towards the activity or exercise of the effector mechanisms, it does not seem reasonable to suppose that the animal would repeatedly overcome its negative reaction to such an obstacle or obstruction in order to reach an external situation which is especially favorable to exploration. In the latter case, indeed, the term "exploratory activity" would prove to be a misnomer, a result of misinterpretation.

It was in the light of these considerations that the present experiment was planned. The Columbia Obstruction Method was employed; a group of animals was given the opportunity to cross an electrified grid in order to reach a novel and "interesting" situation, and the scores of this group were compared with those of other animals, in a similar physiological condition, tested to a situation in which the novelty factor of the incentive was relatively insignificant. A further discussion of the theoretical aspects of the problem will be deferred until after the details of procedure and of results have been presented.

Apparatus and Method

This study is one of a series of investigations of drive behavior in the white rat using the Columbia Obstruction Method. As far as possible, all factors, with the exception of the variable being tested, have been kept constant throughout this larger project. The apparatus and testing technique employed have been fully described in earlier reports of the series (2, 3, 5), hence only a short account of the more important features will be given here, together with a description of certain modifications introduced because of the special nature of the present problem.

In the ground plan shown in Figure 1 the sections marked, *A, B, C,* and *D* represent the extent of the Obstruction Apparatus proper. The test animal passes from the entrance compartment (*A*) to *B* and thence to *C*; the floor of *B* is an electric grid and constitutes the "obstruction." In all studies thus far reported, compartment *D* contained the incentive (food, water, sex object, etc.). In the present case the incentive—marked *"E"* in the accompanying diagram—was a situation designed to stimulate exploration and to offer opportunity for the partial "satisfaction" of any exploratory drive which might be operative in our test animals. Section *E* was constructed after a plan designed by Dashiell (1) for an apparatus to demonstrate spontaneous activity in rats under various conditions of internal stimulation. Several modifications of Dashiell's design were introduced. The walls (solid lines in Figure 1) were made of galvanized sheet iron rising 5½ inches above the pine wood base.

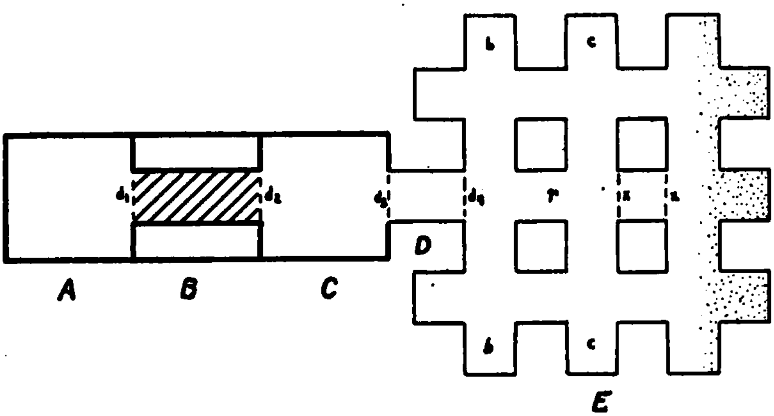

FIGURE 1

DIAGRAM OF THE FLOOR PLAN OF THE OBSTRUCTION APPARATUS WITH SPECIAL INCENTIVE COMPARTMENT

A, entrance compartment; *B*, obstruction compartment; *C, D*, divided incentive compartment as used in sex, hunger, thirst drive studies; *E*, specially constructed incentive compartment used only in this study; d_1, d_2, d_4, manually operated doors; d_3, automatic door operated by release plate which is not shown in the diagram; *c*, *c*, corks; *b*, *b*, blocks of wood; *r*, small rubber mat; *x*, *x*, wire mesh walls; stippled area represents wood shavings.

All pathways were 4 inches wide so that the floor space consisted of 32 squares, each with an area of 16 square inches. In this way the total area of the apparatus to which the test animal had access after crossing the grid was approximately six times as great as it was in previous studies of the series. The entire top of the incentive compartment was covered by a large sheet of rigid wire mesh which was so hinged that it could be easily lifted up by the experimenter for removal of the test animal. Small pads of felt were fastened to the underside of the mesh cover so that its movement did not cause any appreciable amount of noise.

Preliminary observations with several rats confirmed the writer's guess that the many pathways and corners in compartment *E* would provoke a great amount of exploratory activity. Several features were added to further enhance the "interest value" of the situation: Wood shavings were piled up to the top of the walls in the back part of the incentive chamber (shown by stippling in Figure 1). In two of the square areas, blocks of wood (b) were placed, and a cork (*c*) in each of two others. There was a small rubber mat (*r*) in one alley-way; two walls (*x*) were formed of wire mesh. In the experience of the writer all of these items were of the nature to stimulate exploratory behavior in rats.

An automatic device (not shown in Figure 1) for the control of the door (d_3) leading to compartment *D* was used throughout the tests—not because it was necessary for our purposes but in order to keep whatever effect this mechanism may have the same as in the other drive studies in which this general method has been used.

Animals and Procedure

Twenty male albino rats about 185 days old (range, 179 to 191 days) were used in the experiment. All of them were born in this Laboratory, being the descendants (first and second generations) of animals procured from the Wistar Institute of Anatomy, Philadelphia. Males were used exclusively in order to avoid the complications introduced by the oestrous cycle of female animals, but also because it was planned to use all females available in the Laboratory at the time this study was made for another investigation. The living conditions of our animals, described below, were planned with two requirements in view: (*a*) strict comparability with the groups to be used as controls for our results; (*b*) reduction to a minimum of the operation of other drives (hunger, thirst, sex, general activity) in the test situation. The success of our attempt to meet these demands can be judged from the following account and by reference to previous reports in which are described the conditions of testing the control groups (5, 6, 7).

The animals were not weaned (artificially, at least) until about 60 days old; from that time until about the 150th day of life they were kept with an equal number of females in cages containing 6 to 8 animals each. Beginning approximately 35 days before the test, the males were separated from animals of the other sex; Warner (5) has shown that the sex drive of male albino rats is at a fairly low level of intensity after such a period of segregation.

The cages were supplied at all times with an abundance of the standard food, McCollum's mixture. Greens were given once a week and, until the animals were 135 days old, a meat and bone powder was fed about every 10 days. Plenty of fresh water was always available in the cages. Since the animals were taken directly from their living cages to the testing apparatus, it would seem that the hunger and thirst drives did not enter as contributing factors into our results. Any social drive which may be operative in these animals in addition to the specific sex drive was probably kept at a low degree of intensity by the living conditions above described. The cages, each housing about seven animals, were large enough (5900 cubic inches capacity) to insure ample opportunity for exercise so that any activity drive which may (and I believe does) exist in addition to the other, more specific tendencies, should have been pretty well "satisfied" at the time of the test.

Excepting the fact that care was taken not to clean the living cages or to otherwise disturb the animals for a period of two days immediately preceding the test, no special arrangements were taken to control the little-known intra-organic conditions influencing the exploratory tendency. It is quite possible, of course, that the past history of the animal—the opportunities which it has had for exploration, the kind of environment in which it has lived, and so on—is an important influence in determining the intensity of this drive, but this is a matter for future work to decide. Regarding the present experiment we can say that the test animals had lived in a highly uniform environment, giving little chance for unusual exploration and offering no definite rewards or incentives for such activity. It is probable, therefore, that our pre-testing conditions were generally unfavorable to the drive being measured.

All tests were conducted in the evening, usually between 9 and 11 o'clock and never before 8 o'clock. The same technique of handling the animals and the same precautions to avoid emotional disturbances were observed as in previous studies (2, 5) of this general project.

Preliminary crossings. In order (*a*) to adapt the test animal to the experimental situation, (*b*) to get the connection, other-side-of-the-grid—incentive, established, and (*c*) to exhaust as far as possible the influence of a conceivable auxiliary drive (exploration), the usual technique of the Columbia Obstruction Method calls for five preliminary crossings from the entrance to the incentive compartment; four of these crossings are allowed without any current passing through the grid, and on the fifth the shock is introduced after the animal is already in the obstruction chamber. After each of these preliminary crossings the animal gets a certain amount of stimulation from the incentive; food, water, sex-object, or litter, as the case may be. The analogous procedure in the present study would have been, perhaps, to allow the animal to advance a certain distance—or for a certain length of time—into compartment *E* at the end of each preliminary crossing, as well as after each crossing during the test proper. The following considerations, however, caused the writer to modify the preliminary procedure to the extent of allowing the animal to proceed only as far as d_4 (see Figure 1) after each of the first three crossings and to enter *E* only after each of the last two preliminary runs: (*a*) The novelty of the incentive obviously decreases with each opportunity to explore it. The procedure adopted preserved the stimulating effectiveness of compartment *E* inasmuch as when the test proper began the animal had been in it only twice. (*b*) In order to legitimately compare our data with those of other studies (thus giving the only possible basis for evaluating our results) it was necessary to equate approximately the length of the preliminary period. If door d_4 had been left open throughout this period—so it was found in preliminary work—the animals would have gone right through to *E*, stopping in *C* and *D* hardly at all. Then it would have been necessary to remove the animals rather quickly in order to prevent too much exploration of *E* [reason (*a*) above], and this, of course, would have meant that the preliminary period of our experimental animals would have been much shorter than that of their controls. (*c*) Preliminary work had demonstrated that if the animal were given no access to *E* at any time *before* the test period proper, it would often

TABLE 1
DISTRIBUTION TABLE COVERING APPROACHES, CONTACTS, AND CROSSINGS

Number of responses	Approaches	Contacts	Crossings
0	3	6	
1		4	2
2	2	4	1
3	3	2	3
4	2	2	5
5	1	2	1
6	4		2
7			1
8			1
9	2		1
10	1		
11			1
12	1		1
13			
14	1		
15			
16			
17			
18			
19			
20			
21			
22			
23			1

not even attempt to cross the grid *during* the test. Naturally the animal would need to have been previously stimulated in *E* if the latter was to function as an incentive and induce crossings in the test. (*d*) It had been found in studies of other drives that during the first few preliminary crossings the animal paid attention to the specific incentive only after it had thoroughly investigated compartments *C* and *D*. It seems, therefore, that our modified procedure gave sufficient opportunity for the formation of the association between the further side of the grid and the incentive, and at the same time equated fairly well the preliminary practice given to the experimental and control groups.

At the end of each of the first three preliminary crossings the test animal was given 3 minutes in *C, D*. This was more time than was given to most of the animals of the control groups, but the difference, if effective at all, influenced the results in a direction unfavorable to the exploratory drive. After each of the last two preliminary runs the animal was allowed to explore *E* for 10 seconds. During the

TABLE 2

SHOWING MEASURES OF CENTRAL TENDENCY AND OF VARIABILITY

Approaches						Contacts						Crossings					
Median	Range	Average	Average Deviation	Standard Deviation	Coefficient of Variation	Median	Range	Average	Average Deviation	Standard Deviation	Coefficient of Variation	Median	Range	Average	Average Deviation	Standard Deviation	Coefficient of Variation
4.5	0—14	5.20	3.12	3.85	74	1.5	0—5	1.80	1.40	1.66	92	4.0	1—23	6.00	3.40	4.89	81

test proper the animal was removed after 8 to 10 seconds in *E;* during this time it was able to traverse from 5 to 15 of the square areas (see Figure 1). If the rat made no attempts to explore it was removed anyway at the end of 30 seconds [compare (2) p. 485]. It may be said that on the average the amount of time allowed the test animal in the incentive compartments after each crossing, both in the preliminary period and during the test itself, was about the same in this study as in previous investigations of this series.

Results

The results for the group of twenty male albino rats tested are given in Tables 1, 2, 3, and 4. Of the three types of scores yielded by the method used, crossings probably have the greatest significance; they show how many times the animals actually crossed the electrified grid and reached the incentive. Contacts and approaches, while probably indicating a tendency to cross, may be, conceivably, only the expression of spontaneous, non-directed activity. The major portion of our discussion, therefore, will be based on scores in crossings.

In Table 5 are shown the differences—and the reliabilities of these differences—between the average score of the exploratory drive group and the average of each of the following: (*A*) A group of 10 males tested to a food incentive immediately after being removed from a living cage well supplied with food. (*B*) A group of 10 males tested to water immediately after being taken from a cage in which an ample supply of fresh water was available. (*C*) A group of 20 males tested to a small empty incentive compartment at a period of maximum sexual vigor (24 hours after a two-hour copulatory period). In all cases the members of the comparison groups were of the same age and sex as were the animals tested to the exploratory incentive;

TABLE 3

Showing Temporal Distribution of Approaches, Contacts, and Crossings during the Twenty-Minute Test Period in One-Minute Intervals

Activity	1st minute	2nd minute	3rd minute	4th minute	5th minute	6th minute	7th minute	8th minute	9th minute	10th minute	11th minute	12th minute	13th minute	14th minute	15th minute	16th minute	17th minute	18th minute	19th minute	20th minute
Approaches	12	7	9	1	9	6	2	11	5	5	2	4	4	5	4	2	4	2	4	6
Contacts		3	4	4	1	2	2	6	1	1	1		1		2	4	1	1	2	
Crossings	12	14	7	7	8	6	8	7	5	3	6	4	3	6	4	3	3	4	4	6

TABLE 4

Showing Temporal Distribution of Approaches, Contacts, and Crossings during the Twenty-Minute Test Period in Five-Minute Intervals

Activity	0 to 5th minute Number	0 to 5th minute Per cent	6th to 10th minute Number	6th to 10th minute Per cent	11th to 15th minute Number	11th to 15th minute Per cent	16th to 20th minute Number	16th to 20th minute Per cent	Total Number
Approaches	38	36.5	29	27.9	19	18.3	18	17.3	104
Contacts	12	33.3	12	33.3	4	11.1	8	22.3	36
Crossings	48	40.0	29	24.1	23	19.2	20	16.7	120

Table 5

Showing the Reliability of the Differences Between the Average Number of Crossings of the Exploratory Group and of the Three Comparison Groups

Exploratory group and comparison group:	Difference between the averages*	Standard Deviation of the difference	$\frac{Difference}{S.D._{diff.}}$	Chances in 100 of a true difference greater than 0
A—ten males tested to food without previous starvation period (6)	3.30	1.52	2.16	98.46
B—ten males tested to water without previous water-deprivation interval (7)	2.30	1.67	1.38	91.62
C—twenty males tested to small empty incentive compartment during period of maximum sexual vigor (5)	3.05	1.16	2.63	99.57

*In all cases the score of the exploratory drive group is higher than those of the several comparison groups.

TABLE 6

SHOWING THE RELATIVE DEGREE OF VARIOUS KINDS OF STIMULATION OPERATIVE IN THE THREE COMPARISON GROUPS OF MALE RATS, USING THE EXPLORATORY DRIVE GROUP AS THE STANDARD

Comparison Groups*	Intra-organic stimulation				External stimulation			
	Sex	Hunger	Thirst	Explora-tory	Sex	Food	Water	Explora-tory
A—ten males tested to food without previous starvation period (6)	=	=	=	=	=	+	=	—
B—ten males tested to water without previous water-deprivation interval (7)	=	=	=	=	=	=	+	—
C—Twenty males tested to small empty incentive compartment during period of maximum sexual vigor (5)	+	=	=	=	=	=	=	—

*Tested by Dr. L. H. Warner (5, 6, 7). The writer is grateful to Dr. Warner for permission to use these data in the present report.

the physiological condition of the animals of the first two comparison groups was as similar to that of our animals as possible. A summary of the internal and external stimulating conditions pertaining to the several groups is presented in Table 6; a plus, minus, or equal sign indicates that the given condition is presumably present in greater, lesser, or equal measure, respectively, as compared to the exploratory group.

Discussion

It appears from Table 6 that in each of the three principal comparisons to be made we are dealing with more than one variable. The difference in intra-organic stimulation found in comparison Group *C*, indeed, makes any very significant conclusions impossible here; we can only say that the external factor, exploratory incentive, results in a greater number of crossings than the internal condition of sexual excitation. The two variables in comparison Groups *A* and *B*, on the other hand, are both external factors, and in each of these groups one variable may be disregarded; food and water may probably be considered as of zero stimulating value to animals which are neither hungry nor thirsty. Arguments denying this point will, of course, strengthen the conclusion drawn by the writer below. The only significant difference to be considered between the exploratory and the first two comparison groups, then, is the incentive which presumably is related to the exploratory tendency. This one important disparity in the experimental conditions resulted in a difference in scores in both cases favorable to the group tested with the exploratory incentive. In other words, our animals overcame their negative reaction to an electrified grid more often, within a stated period of time, if by crossing that grid they reached a situation affording opportunity for exploration than if the further side of the obstruction compartment was less conducive to exploratory activity. This suggests—although it does not prove, since complete statistical reliability is lacking—that exploration is a definite form of dynamic behavior similar to the hunger, thirst, sex, and maternal drives.

It should be remembered that the physiological-neurological condition related to exploration, whatever it may be, was not controlled in such a way as to certainly obtain a maximum expression of the drive. Probably the scores of the exploratory group would have been higher had we restrained the animals in a small opaque enclosure, giving a minimum of exteroceptive stimulation, for some time before the test. The writer had considered this procedure but abandoned it because of the necessarily concomitant variation in the possible activity tendency—the drive towards the exercise of the neuromuscular mechanisms—whose importance in influencing behavior in the Obstruction Apparatus is not known. It may be argued that, even under our actual experimental conditions, the incentive used was more favorable not only to exploration but also to muscular activity (running, etc.). This is true to a certain extent, but consideration of the following facts makes it appear improbable that the activity drive entered as an important factor into our results: (*a*) our animals had ample opportunity for muscular exercise in their cages until just before the test (see p. 365); (*b*) the entrance compartment of the apparatus, while not as large as the living cages, is extensive enough (10x10x10 inches) to permit free movement. We discuss below the possibility of considering exploration as an activity drive of a special kind.

In behavior tendencies like those of hunger and sex there are certain fairly definite physiological conditions related to each specific drive. Is there a comparable intra-organic mechanism in the exploratory drive—assuming that our results justify the use of this term? The answer to this question is so utterly remote that a few speculations may be permissible. Just as the muscles apparently require a certain optimum amount of exercise, may not the receptor organs and their more central connections also require stimulation? If this be considered a reasonable assumption, we may go a step further and suggest two possible modes of origin of this tendency or trend towards stimulation: (*a*) A fundamental tendency inherent in all living tissue towards the expression of its characteristic activity; a basic drive towards functioning. (*b*) A derivative tendency; in the early life history of the animal (or of the species) specific intra-organic stimuli (hunger contractions, for instance) led to random movements and these, in turn, to various kinds of external stimulation and to "satisfaction of internal needs." With repetition of such sequences the novel situation—i.e., novelty—became conditioned to the primary drives and thus became of itself efficient in arousing a new type of drive behavior.

It has been shown (2, 5) that sex behavior is dependent upon two factors: environmental and intra-organic stimulation. The same is true of hunger drive (6) and thirst drive (7) behavior. To a limited extent the intra-organic factor may be measured in the absence of the related external stimuli, since an internal tension (or condition of excitation) has the tendency to express itself in spontaneous, non-directed activity when the proper incentive object is not present or available. Without both factors in the experimental situation, however, drive behavior, capable of measurement in terms of an obstruction overcome, is apparently impossible. We cannot, therefore, agree with Warner (5, p. 4) when he says, speaking of the physiological condition of the animal and of the related external stimuli, that "Of these two factors implied by the term, drive, the first is essential, the second non-essential." The writer holds that both are essential.[2] Nevertheless it seems to be true that in some cases the external factor is of greater relative importance, in other cases the internal factor. Warner (p. 65) appears to mean this when he says, "The behavior data indicate that sex activity is initiated rather more by the external stimulus situation in the male than in the female, and rather more by internal stimulation in the female than in the male." In the exploratory drive we have, perhaps, the case in which the external stimulus situation is of the greatest relative importance, whereas the activity drive (tendency towards the exercise of the neuromuscular mechanisms) possibly offers one of the best illustrations of the predominance of the intra-organic factor.

Summary

1) The tendency of 20 male albino rats approximately 185 days old to explore a novel situation was measured in terms of the number of times they crossed an electrified grid in order to reach an incentive especially designed to furnish favorable opportunity for exploration. The results of this group were compared with those of other animals tested under conditions varying only in respect to the exploratory "value" of the incentive employed.

2) The results indicate that use of an incentive offering opportunity for exploration increases the tendency of the animals used to cross the standard shock employed in the Columbia Obstruction Method. This indication is not entirely reliable statistically, variability in performance being very great.

3) Insofar as the finding reported in the preceding paragraph

[2]I do not mean, of course, that the incentive object must be immediately present to the animal. It is sufficient if the immediately present situation is capable of initiating fairly specific "preparatory reactions" which lead to the necessary environmental factor.

is considered reliable, we are justified in speaking of an exploratory drive in rats of the age, sex, and strain used.

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UNE ÉTUDE DU COMPORTEMENT EXPLORATEUR CHEZ LE RAT BLANC AU MOYEN DE LA MÉTHODE DES OBSTACLES

(Résumé)

La tendance de vingt rats blancs mâles âgés d'environ 185 jours à explorer une situation nouvelle a été mise à l'épreuve au moyen de la Columbia Obstruction Method (méthode des obstacles). On a noté les résultats en termes du nombre de fois que les animaux ont traversé une grille électrique pour atteindre un stimulant surtout choisi dans le but de permettre l'exploration. On a comparé les résultats de ce groupe à ceux d'autres animaux mis à l'épreuve dans des conditions variant seulement dans la "valeur" exploratrice du stimulant employé.

Les résultats indiquent que l'usage d'un stimulant qui permet l'exploration augmente la tendance des animaux employés à traverser l'obstacle étalon. Cette indication n'est pas absolument constante statistiquement, puisque la variabilité du rendement est très grande. Selon que l'on considère constantes les données de cette expérience, on peut parler d'une impulsion exploratrice chez les rats employés du même âge, du même sexe, et de la même race.

Nissen

EINE UNTERSUCHUNG DES ENTDECKUNGSVERHALTENS DER WEISSEN RATTEN MITTELS HINDERNISMETHODE

(Referat)

Es wurden 20 männliche Albino im Alter von etwa 185 Tagen auf ihre Neigung geprüft, neue Situationen zu erforschen, und zwar mittels der Columbia Hindernismethode (Columbia Obstruction Method). Es wurden Zählungen vorgenommen, wie oft die Tiere ein elektrisches Blech (grid) überliefen, um einem Antrieb zu folgen, der so geplant war, dass er die Erforschung begünstigte. Die Ergebnisse dieser Gruppe wurden mit denen anderer Tiere verglichen, die unter Bedingungen geprüft wurden, die sich nur in Bezug auf den Erforschungs "Wert" des Antriebes unterschieden.

Die Ergebnisse zeigen, dass der Gebrauch eines Antriebes, der die Gelegenheit für Entdeckungen gibt, die Neigung solcher Tiere erhöht die gewohnt sind das Normalhindernis zu überschreiten. Dieses Anzeichen ist statistisch nicht ganz zuverlässig, da die Unbeständigkeit der Ausführung sehr gross ist. Insofern als die durch das Experiment gewonnenen Angaben als zuverlässig betrachtet werden, sind wir berechtigt von einem Entdeckungstrieb der Ratten zu sprechen, in dem Alter, des Geschlechtes und der Spannung, wie sie im Experiment gewählt wurden.

NISSEN