The experimental study of the hunger therapy IV - Effect of starvation upon discrimination learning -

THE EXPERIMENTAL STUDY OF THE HUNGER THERAPY*

IV EFFECT OF STARVATION UPON DISCRIMINATION LEARNING

By

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Two experiments using albino rats as subjects were carried out, in which the effect of starvation upon discrimination learning was studied, and the mechanism of its effects was considered. In the first experiment the animals were subjected to the visual discrimination training, employing a discrimination-box similar to the one described by Hammes, and giving them two kinds of discrimination task with different degrees of difficulty. The results demonstrated that at a relatively easy task level the hunger-treatment did not affect the discrimination learning, but that at a difficult task level it had an improving effect on the discrimination learning.

In order to explore this improving mechanism of starvation upon the process of learning, the second experiment was carried out. Assuming that this improving effect was due to the broadening of cue utilization in the hunger-treated animals, we undertook to impose a problem involving redundant relevant cues on the animals and to test the degree of transfer of discrimination learning to the previously minor cue in the absence of the major cue. But the results obtained failed to verify the above mentioned hypothesis, necessitating another further refined experiment.

Sato and Murai previously reported that the extinction of the conditioned emotional response and that of the avoidance response were accelerated after a long-term starvation (1965, 1966*b*). On the assumption that the extinction may involve in its process an element of counter-conditioning, it is supposed from earlier findings that the process of acquisition is also influenced by the starvation.

In order to study the effects of starvation upon the learning process, it is most appropriate to investigate systematically the effect of starvation on each of various

* This is formerly a kind of therapy which has been employed in several countries as a treatment for some kinds of disease. It was improved by Katsuji Kushima, M.D., Professor of School of Medicine, Tohoku University, and has been employed as a new method of treatment for psychosomatic disease.

fundamental forms of learning. In our previous report (Murai, N. and Sato, T., 1965), it is mentioned that the procedure of starvation has a slight effect to facilitate the acquisition of avoidance learning, one type of learning in the unitary situation.

Here, as the second stage, the present study was designed to investigate the effect of starvation on the discrimination learning which is a representative type of learning in the choice situation.

Experiment I

In this experiment the effect of starvation on discrimination learning was explored, using two kinds of discrimination task with different degrees of difficulty.

Method

Subjects and apparatus

The subjects were 35 naive male albino rats of Wistar-strain. They were about three months old and their average body weight was about 160 gm., ranging from 140 to 205 gm. at the beginning of the experiment.

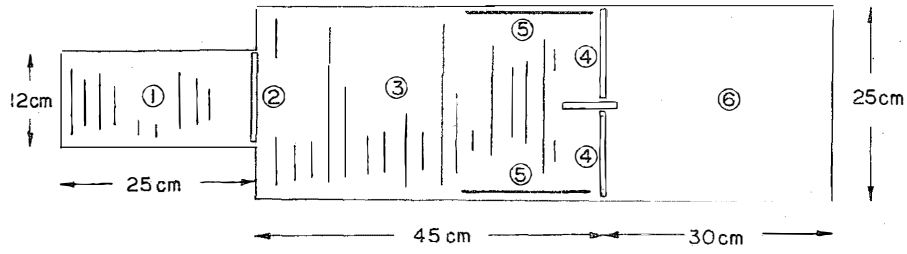
The apparatus used was a discrimination-box, which was essentially the same with the one described by Hammes (1956). It consisted of the following three parts; starting box, shock box, and escape box. The inside dimensions of each box were illustrated in Figure 1 and the height of these boxes was evenly 20 cm.. The boxes had the grid floors, except for the escape box. The inside of the starting box and the shock box was painted neutral gray and that of the escape box unpainted. The lids of the starting box and the shock box were made of transparent plastic, through which the subject was observed. The starting door was a sliding-door, which was also of transparent plastic. The illumination was provided by two 100-watt electric bulbs placed 50 cm. above the top of the apparatus.

The square stimulus cards hung on the escape doors at the end of the shock box. The escape doors were swing-doors made of plywood. When the subject was placed in the starting box, he was delivered an electric shock through the grid floor. A 700-v a-c transformer activated the grid and the current in the circuit was 200-μA. When the subject ran into the shock box, he confronted the positive and negative stimulus cards which were presented on the escape doors. If the subject chose the door with the positive stimulus, he could push the door open and run into the escape box. But if he chose the door with the negative stimulus, he could not push the door open, because the door was locked. Then, he had to choose another door (correction method).

Procedure

1) Preliminary training

Before the discrimination training all animals were accustomed to E by being handled for 15-min. period a day, for three days. From the fourth day they were given 30-min. period of free exploration in the apparatus, for three consecutive days.



1 starting box 2 starting door 3 shock box 4 escape door (12×12 cm)
5 additional stimulus card (19×19 cm) (used in Experiment II) 6 escape box
||| grid floor

Fig. 1. The top view of the apparatus

After the completion of the exploration training, the animals were trained to push the escape door open and escape from the shock. During the preliminary training a partition was inserted to divide the length of the shock box into two alleys leading to an escape door at the end of each. The alley used in each trial was shifted according to the Gellermann's orders (1933), for the purpose of making alike the subject's experience to either door. The training trials were continued in ten trials per day, until each subject fulfilled the criterion of ten successive errorless escapes.

2) Procedure of starvation

After the completion of the preliminary training the subjects were divided into four groups, matched as closely as possible for their performance of the preliminary training. Two were experimental groups which were to be treated with the procedure of starvation, and the other two were control groups which were without starvation.

The experimental groups were treated with the procedure of starvation for eight days, which consisted of a four-day period of complete deprivation of food followed by another four-day period of recovery. On the other hand, the control groups were allowed to eat at will during eight days corresponding to those periods. The detailed account of this procedure was given in our previous paper (Murai, N. and Sato, T., 1965).

Among four groups they were evenly treated in various treatments such as the measurement of body weight and so on, so that their experience during the pre-training period might be similar.

3) Discrimination training

There were two tasks in this experiment, which involved a discrimination between two patterns, respectively; one task was the discrimination between black and white cards, another was between vertical and horizontal striped patterns of black and white. These two tasks were expected to differ in their degrees of difficulty in discrimination; the former was relatively easy, the latter more difficult. In the black and white discrimination task, the white card represented the correct pattern and in another task the card with horizontal stripes represented the correct pattern.

The subject was placed in the starting box, the door was raised, and the electric shock given immediately. The shock was continued until he escaped. According to the Gellermann's orders the position of the correct pattern was shifted. The subject was allowed to stay for 30-sec. in the escape box, then removed to a retaining box for 60-sec., to await the next trial. The training trials were continued in ten trials per day, until the subject fulfilled the criterion of ten successive errorless escapes.

Results

The performance of discrimination learning, at both easy and difficult task levels, and in both experimental and control groups, is demonstrated in Figure 2 in terms of percentage of correct response in the daily trials. And Table 1 shows the mean number of trials to reach the criterion.

In the black and white discrimination task, the daily performance of the experimental group was consistently superior to that of the control group, except for on the

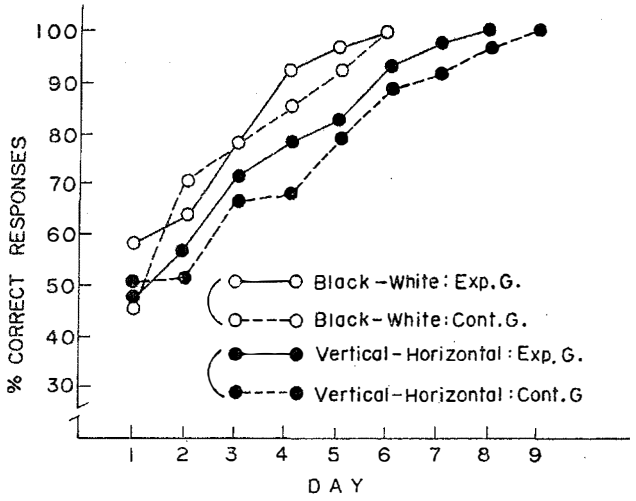


Fig. 2. The percentage of correct response in the daily ten successive trials

Table 1 Mean number of trials to reach the criterion

Group	Discriminiaton task					
	Black-White			Vertical-Horizontal		
	N	M	SD	N	M	SD
Cont. G.	7	42.9	8.8	11	51.8*	14.7
Exp. G.	7	42.9	14.8	10	69.0	14.5

* Difference between two groups significant at 0.02 level
N: number of rats M: mean SD: standard deviation

second day. But as is shown in Table 1, there was no significant difference in the mean number of trials to reach the criterion between two groups.

Also in the discrimination between vertical and horizontal striped patterns, the daily performance of the experimental group was consistently superior to that of the control group. And further, there was a significant difference between two groups in the number of trials to reach the criterion (t=2.578, df=19, $p<.02$).

These two discrimination tasks in the present experiment were selected on the assumption that there might be a difference of difficulty in learning between the two; that is, it was expected that the black and white discrimination task would be easier to learn than the discrimination of striped patterns. Because, in both experimental and control groups, the black and white discrimination was learned faster than that of striped patterns, the selection of these two kinds of discrimination task is considered to be appropriate. Therefore, it may be concluded that the procedure of starvation did not affect the discrimination learning at an easy task level, but that at a difficult task level it had an improving effect on the discrimination learning.

Discussion

In this study it was proved that the process of discrimination learning at a relatively easy task level was not influenced by the procedure of starvation, but that of a relatively difficult task level was improved after the experience of starvation. These findings seem to support our hypothesis that the learning process will be improve by the procedure of starvation. However, the fact that the starvation had an effect on the discrimination learning only at a difficult task level raises further questions as to which of various variables of behavior will be regulated by the effect of starvation and in what way, and so on.

Hammes (1956) found that the improved performance of discrimination learning activated by electric shock was the function of intensity of shock and of difficulty of task. He demonstrated that in a high-shock situation the discrimination learning of easy task was improved but that of difficult task was rather inhibited.

From this finding it follows that the increased motivation may be able to improved the performance of discrimination learning. Therefore, we can not exclude the possibility that the difference in performance obtained in our present experiment derived largely from the difference in motivation. This possibility is to be taken into consideration and the difference of the performance in the present experiment can be explained from that the identical level of electric shock was more painful to the hunger-treated animals.

But the increased motivation hypothesis can not explain the fact that the performance of the black and white discrimination learning was not influenced at all in the present experiment. In other words, if such difficult learning as the discrimination between vertical and horizontal striped patterns is improved by the increased motivation in the hunger-treated animals, an easy learning such as the discrimina-

tion between black and white will necessarily be improved. But such was not the case. Therefore, we can not attribute the cause of this improving effect of starvation to the increased motivation.

And even if we do assume that learning ability will be improved by the starvation, we can not explain the fact that the discrimination learning of the easy task was not improved after the starvation.

Experiment II

The faster learning rate of the hunger-treated animals may be due to increased ability of animals to select and utilize the discriminative cue. This assumption leads us to a hypothesis that the hunger-treated animals will be better learners in a problem with "redundant relevant cues" (Trabasso, T. and Bower, G.H., 1968). An example of this type of discrimination task involving, say, geometric figures would be one in which an animal was to learn to choose black circle against white square. Here both color and shape are relevant dimension, and also perfectly redundant. Thus, by forcing the animal to learn this discrimination, we are forcing him to associate his response to either one or both of this redundant dimension. The stimulus control exerted by the particular cues can be evaluated by transfer tests, by seeing how the animal will be able to maintain the learned discrimination during test using each cue singly while removing the other redundant relevant cue. If the hunger-treated animals showed better performance in the transfer tests, they can be regarded as having learned to utilize more cues than control group.

Method

Subjects and apparatus

Twenty female albino rats were used. They were about five months old, weighing 150–200 gm. at the beginning of the experiment. They were all experimentally naive. The subjects were divided into two groups, containing ten rats each, matched in their body weight. One group was the experimental group and the other was the control.

The apparatus used in Experiment I was modified so that additional stimuli could be presented, and an error was identified by a click which was generated when the subject's nose touched the negative door.

One door was black and the other was white. They served as stimuli to be discriminated. Each door was positive stimulus for half member of each group. The additional stimulus was a horizontally striped pattern and a vertically striped one. The positive door was always accompanied by the former pattern, and the negative door by the latter. The locations of additional stimuli were intended to make the stimulus on the door more salient and the additional less salient.

Procedure

The procedure for training rats to escape from the shock box to the escape box was identical with that of Experiment I except that the starvation treatment preceeded the pre-training. The experimental group was first treated by starvation for five days, while the control group was allowed to eat ad lib. throughout the corresponding period. After two days of recovery period for experimental group, all the subjects began training on discrimination problem. The procedure was to place the rat in the starting box for five seconds, then raise the door, charge the grid floor, force the rat to choose the correct door, and allow it to escape into the escape box. The subjects were given ten trials per day for seven days (70 trials in all). Intertrial interval was about five minutes.

On the day following the last discrimination training, the additional stimulus on the side wall was removed and the subjects underwent ten trials of training using the door stimulus only, for the purpose of seeing to what degree the additional stimulus was utilized as a cue for discrimination by the subjects. Next day, the door stimuli were replaced by two striped patterns which were formerly redundant with the black and the white ones, and the subjects were required to try to discriminate them ten times, the negative door being locked. On the day following, the subjects were allowed to choose either door ten times, both doors being unlocked. This procedure was regarded as a transfer test.

Results

Results are summarized in Figure 3. The learning rate of this discrimination task does not differ between two groups.

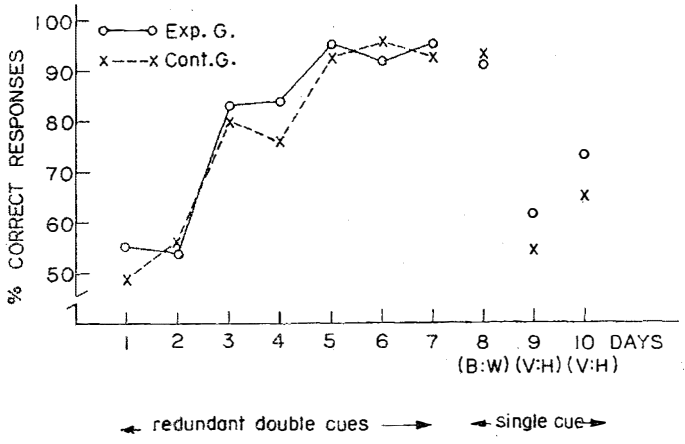


Fig. 3. Mean percent correct responses in discrimination training on "redundant cues" task, in subsequent training on either single cue and in transfer test in which both doors being unlocked.

The removal of redundant striped pattern had little affected the performance of the subjects. Accordingly, the stimulus component which controlled the behavior of the subjects was evidently the black and the white door. When the door was replaced by the striped pattern, the performance of both groups dropped to chance level. On the transfer test, the average percent of correct response was 66% and 73% for the control and the experimental group, respectively. This difference was, however, not significant (t=0.94, df—18).

The number of the subjects that chose the correct door a number of times beyond chance-level was two in each group. In this respect also, the two groups might be said to have a similar performance level.

Discussion

The similar rate of the two groups in the discrimination learning is not inconsistent with the earlier finding that the hunger-treated subjects were better learners in the discrimination of striped patterns, because, as the cue utilized by the subjects was mainly the door stimulus, the task in this experiment was substantially no more than the black and white discrimination of which the two groups had showed an identical learning rate. The highly salient character of the door stimulus seemed to have reduced the attention value of the additional stimulus and made the subject key their response to the door stimulus only. Such an inference is substantiated by invariably high level of performance in the trials removing the additional stimuli, and by inversely low level of performance in trials using the striped pattern singly. Such a reduced utilization level of the additional stimuli was out of experimenters' intention to determine the location of these stimuli in the apparatus. If the additional stimuli were more salient, some of animals would be expected to be "double-cue solvers" (Trabasso, T. and Bower, G.H., 1968). A further refined experiment is needed.

Concluding Remarks

The findings in Experiment I indicate a favorable effect of the hunger-treatment upon the discrimination learning subsequent to that treatment. This effect was, however, evident only in training of the striped pattern discrimination; the black and white discrimination was not affected. These apparently contradicting findings posed a new problem about the mechanism of this facilitating effect of hunger-experience. The present writers assumed the breadth of cue utilization (Bruner, J.S., Matter, J. and Papeneck, M.L., 1955) would be wider in the hunger-treated animals than the control, and undertook to impose a problem with "redundant relevant cues" on the subjects, and to test the degree of transfer of discrimination learning to the previously minor cue in the absence of the major cue.

As the spatial relation of two redundant cues in the apparatus was not necessarily adequate to test our hypothesis, a further refined experimental arrangement is needed to reveal the mechanism in question.

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Zusammenfassung

Mit weissen Ratten haben wir zwei Experimente durchgeführt, wobei wir zuerst den Einfluss des Hungers aufs Diskriminierungslernen untersucht, dann den Mechanismus und Prozess dieses Einflusses betrachtet haben. Im ersten Experiment wurden die Versuchstiere im Diskriminierungsapparat, der Hammes'schem Apparat ungefähr ähnlich ist, dressiert, bei dem elektrischen Schlag zu entkommen und in die gefahrlose Zone zu laufen. Danach wurden sie in vier Gruppen geteilt. Zwei Gruppen unterzogen sich vier Tage lang der Deprivationsprozedur von Futter, die anderen Gruppen waren Kontrollgruppen. Nach der Deprivationspozedur hatten alle Ratten zwei Arten Aufgaben von verschiedenen Schwierigkeitsgraden zu lernen. Aus den Ergebnissen folgt die Deprivation von Futter verbessert nicht den Lernprozess des Diskriminierungslernens von der leichteren Aufgabe, aber verbessert den Lernprozess von der schwereren.

Um diesen auf den Lernprozess erförderlich einflussenden Mechanismus und Prozess klarzumachen, wurde der zweite Experiment durchgeführt. Unter der Voraussetzung, dass dieser verbessernde Einfluss eine Folge von dem Verbreiten der Winksutilisierung (cue utilization) in hungrigen Tieren sei, bürdeten wir den Tieren ein Problem mit überflüssigen und erheblichen Winken (redundant relevant cues) auf, und untersuchten den Übertragungsgrad vom Diskriminierungslernen zu dem kleineren Wink, nachdem der grössere aufhörte. Aber die Versuchsergebnisse haben die oben erwähnte Hypothese nicht bestätigt. Ein anderer, weiter verfeinerter Versuch ist zu erfordern.

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