THE EFFECTS OF SHOCK INTENSITY ON DISCRIMINATED REARING AVOIDANCE CONDITIONING IN RATS

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Discriminated rearing avoidance conditioning was studied using a 2x2 factorial design in which the two factors were levels of shock intensity and presence or absence avoidance contingency. Two avoidance groups of rats were trained to avoid shocks by their upward movement which cut the invisible beams running at 15 cm above the floor. The other two groups were trained by signaled escape training procedure without avoidance contingency. The CS-US interval was 5 sec and a total of 300 trials were run over five days. The avoidance groups showed increase of avoidance over five days and the level of avoidance was positively related to shock intensity. The number of responses which occurred within 5 sec after the CS onset in the nonavoidance groups decreased over five days. In the high shock avoidance group, the topography of avoidance was rearing but the escape response was mostly jumping.

The effects of shock intensity upon avoidance behavior have been shown to depend upon types of conditioning situation and the topography of the required avoidance. In a one-way shuttle box situation, the rate of avoidance has been shown to be positively related to the US intensity, whereas in a two-way shuttle box situation the avoidance rate decreased as the US intensity increased (e.g., Theios, Lynch, & Lowe, 1966; Shishimi & Imada, 1972). In a lever-press avoidance situation, D'Amato and Fazzaro (1966) have found that the acquisition of discriminated lever-press avoidance response was inversely related to shock intensity. Recently, in the present writers' laboratory, a new response or a rearing behavior was successfully conditioned using both discriminated and nondiscriminated avoidance paradigms (Shishimi & Imada, 1977; Shimai, 1977). In this situation the rats were required to avoid shocks by their rearing behavior which cut the invisible light-beams running at 15 cm above the grid-floor. The situation is more akin to the lever-press avoidance situation than to the shuttle box situation in that in both lever-press and rearing situations rats have to remain in the same situation even after the required response has been made.

A question asked in the present study was: What would be the effects of shock intensity upon rearing avoidance conditioning? In view of scantiness of the basic data regarding our newly developed avoidance task as well as its practical and theoretical significance, the present experiment was designed in a 2x2 factorial manner and the effects of shock intensity and the presence or absence of avoidance contingency upon discriminated rearing...
avoidance were studied. Groups having no avoidance contingency, but having escape contingency, served as control groups in the present experiment.

METHOD

Subjects

The subjects were thirty-six experimentally native male albino rats of Sprague-Dawley strain. All subjects weighed between 269 g and 345 g at the start of the experiment (mean was 307 g) and had free access to food and water in their home cages throughout the experiment.

Apparatus

The experimental chamber was the same as that used in the previous experiments (Shishimi & Imada, 1977). The inside dimensions were 20 cm x 14.8 cm x 30 cm. The floor consisted of copper grid bars (d = 3 mm), 13 mm apart from center to center. Along the three outside walls of the chamber was a U-shaped arm, on which a set of light-source and light-receiver and two small pieces of mirror were attached. An invisible light beam emitted from the light-source was received by the light-receiver after five reflexions on the mirrors. Thus rats' upward movements of greater than the height of the beams counted as the response. The height of the beams was set at 15 cm in the present experiment. Twenty-six cm directly above ceiling of the chamber were 20 W and 40 W electric bulbs and the former served as a constant source of illumination and the latter as a feedback stimulus which stayed on as long as the beams were interrupted. The CS was a 1000 Hz 85 dB pure tone presented through a speaker 29 cm directly above the ceiling of the chamber. The US was constant current scrambled grid shock and the intensity was 0.8 mA or 0.3 mA.

All the time regulations, presentation of the CS and US, and recordings of the responses were done automatically.

Procedure

A subject was placed in one of four groups. Nine subjects in each group were matched for body weight. Two of the four groups were trained with a standard escape/avoidance training procedure and the other two with a signaled escape training procedure without avoidance contingency. Two groups trained with the same training procedure differed only with respect to the shock intensity used. The present experiment was, hence, of a 2 x 2 factorial design. The four groups were designated as Groups HA (high-shock avoidance), HNA (high-shock nonavoidance), LA (low-shock avoidance) and LNA (low-shock nonavoidance).

Each subject was handled for 10 min before the first training session. Then the subject was put into the experimental chamber and was habituated to the chamber for 5 min, after which the first trial began. For Groups HA and LA, conventional avoidance conditioning paradigm with the CS-US interval of 5 sec was used; the subjects could avoid the shock by making a beam-cutting response in less than 5 sec after the CS onset. The CS, in the case of avoidance, or the CS and US, in the case of escape, terminated simultaneously with the response. For Groups HNA and LNA, any response occurring within 5 sec after the CS onset was ineffective in avoiding the shock, and the subjects could only terminate the invariably given shock by its response, which also terminated the CS. For all groups when the subjects did not respond within 10 sec after the US onset, both the CS and US were terminated automatically and then the next trial began. In the descriptions to follow the response which occurred within 5 sec after the CS onset was called CR even for Groups HNA and LNA.

The intertrial interval was variable, ranging 10–40 sec and averaging 25 sec. Sixty trials were run approximately 23 hr apart for five sessions.

RESULTS

The mean number of CRs in each group is presented in blocks of 10 trials in Fig. 1. The acquisition of CR is evident both in
Groups HA and LA which show within session improvement of performance on each day, followed by an overnight decrement. These groups also show a gradual increase in the number of CRs across sessions, Group HA consistently showing higher level of performance than Group LA. On the other hand, both Groups HNA and LNA show a gradual decrease across sessions, the two groups differing not markedly. The $2 \times 2 \times 5$ Lindquist's (1956) Type III ANOVA was performed on the number of CRs over five sessions and the main effect of the presence or absence of avoidance contingency was highly significant ($F(1/32) = 16.3$, $p < .001$). The main effect of shock intensity did not reach the conventional level of significance ($F(1/32) = 3.3$, $p < .10$). The interaction of the presence or absence of avoidance contingency with sessions was significant ($F(4/128) = 7.9$, $p < .001$), indicating that the groups having avoidance contingency improved performance over sessions while those having no avoidance contingency did not.

Although the main effect of shock intensity did not reach the conventional level of significance by the $F$ test, this was obviously due to large within-groups variances and the $U$ tests were conducted in order again to test the shock intensity effect. The differences in the total number of avoidances between Groups HA and LA turned out to be significant both on Days 4 and 5 ($U_{9,9} = 15$, $p < .05$; $U_{0,9} = 12$, $p < .02$, respectively). The corresponding $U$ values for Groups HNA and LNA were not significant as Fig. 1 suggests.

To analyze the effects of shock intensity on the acquisition of avoidance in more detail, the data of CRs were analyzed by the $2 \times 6 \times 5$ (shock intensity x blocks within session x sessions) Lindquist's (1956) Type VI ANOVA for avoidance groups and nonavoidance groups separately. Disregarding the groups effects, which were non-significant in both cases for the reason described above, the following terms were significant. For Groups HA and LA, the main effects of blocks and sessions were significant ($F(5/80) = 24.26$, $p < .001$; $F(4/64) = 4.24$, $p < .005$, respectively). The interaction effect of blocks and shock intensity was also significant ($F(5/80) = 3.14$, $p < .025$), indicating the greater steepness of within-session acquisition curve of Group HA as compared with the steepness of the curve of Group LA. With regard to the data for Groups HNA and LNA, the main effects of blocks and sessions were significant ($F(5/80) = 3.96$, $p < .005$; $F(4/64) = 6.08$, $p < .001$, respectively). Figure 1 suggests that in these groups, the CRs decreased significantly over sessions but increased significantly within a session.

In Table 1, the results regarding the topography of both CRs and escape responses (Res) in each group are summarized. In all groups,
the topography of CRs was mostly rearing. On the other hand, the topography of escape responses showed a marked interaction of this factor with the shock intensity: In groups trained with low shock intensity, most of the Res were rearing while in groups trained with high shock intensity, considerable number of Res were jumping.

**Discussion**

The results of the present experiment confirmed the findings of the previous two experiments using the same task and the rearing behavior was successfully avoidance-conditioned (Shishimi & Imada, 1977; Shimai, 1977). The general pattern of the acquisition curve of the present experiment was more similar to that obtained by Shishimi and Imada (1977) in that in both studies remarkable overnight decrements were observed. This may probably be due to the fact that in both of these studies Sprague-Dawley strain was used. Shimai (1977) has found that with the Long-Evans rats this overnight decrement was less marked. Also in line with Shimai (1977) is the fact that groups of rats having no avoidance contingency did not develop rearing CRs, which significantly decreased over five sessions.

As to the effect of shock intensity upon rearing avoidance, the present experiment demonstrated that the discriminated rearing avoidance was facilitated significantly by increasing the shock intensity from 0.3 mA to 0.8 mA. Although an experiment has to be run, in which shock is varied at several different levels, before any conclusion is drawn regarding the general relationship between shock levels and rearing avoidance performance, the present finding is quite in contrast with the facts obtained by D'Amato and Fazzaro (1966) in a lever-press situation. They showed, using a continuous shock as used in the present experiment, low shock (0.16-0.25 mA) group reached over 40% of avoidance response in the final block, while moderate shock (0.6 or 0.5 mA) and high shock (2.0 or 3.0 mA) groups only reached approximately 20% of avoidance in the final block of training.

Although the time is not ripe yet, due to the scantiness of basic data, to make any detailed theoretical discussion regarding the effect of shock intensity upon rearing avoidance performance, a study by Feldt and McCann (1977) is suggestive in interpreting the present facts. They investigated the degree of compatibility between defensive responses and lever-press topography by varying lever position and shock intensity in a nondiscriminated lever-press avoidance situation. The results showed first that the rate of avoidance was greater in the high lever-position condition, and second that the rearing and jumping behavior were observed more frequently in the

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**Table 1**

<table>
<thead>
<tr>
<th>Group</th>
<th>HA</th>
<th>LA</th>
<th>HNA</th>
<th>LNA</th>
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<tbody>
<tr>
<td>CR</td>
<td>Rearing</td>
<td>1122 (94.4)</td>
<td>750 (99.3)</td>
<td>312 (90.2)</td>
</tr>
<tr>
<td></td>
<td>Jumping</td>
<td>65 (5.5)</td>
<td>4 (0.5)</td>
<td>34 (9.8)</td>
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<tr>
<td></td>
<td>tail†</td>
<td>1 (0.0)</td>
<td>1 (0.1)</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>1188</td>
<td>755</td>
<td>346</td>
<td>253</td>
</tr>
<tr>
<td>Re</td>
<td>Rearing</td>
<td>616 (41.0)</td>
<td>1255 (89.3)</td>
<td>617 (23.0)</td>
</tr>
<tr>
<td></td>
<td>Jumping</td>
<td>828 (55.2)</td>
<td>116 (8.3)</td>
<td>2000 (74.6)</td>
</tr>
<tr>
<td></td>
<td>tail†</td>
<td>57 (3.8)</td>
<td>34 (2.4)</td>
<td>63 (2.4)</td>
</tr>
<tr>
<td>Total</td>
<td>1501</td>
<td>1405</td>
<td>2680</td>
<td>2013</td>
</tr>
</tbody>
</table>

† The beams were cut by tail movement.
‡‡ The number in the parenthesis indicates the percentage of each response topography against total number of CRs or Res.
high position than in the low position condition. They explained the higher rate of avoidance in the high lever-position condition in terms of the compatibility of the required avoidance response with defense responses i.e. rearing or jumping. The same relationship between the rate of avoidance and lever-position was found in the discriminated lever-press avoidance situation by one of the present authors (Shimai, 1973). Feldt and McCann (1977) also found that strong shock facilitated avoidance at high lever-position, but not at low lever-position. They observed that the rearing and jumping behavior occurred more frequently in high shock condition than in low shock condition. Accordingly, they suggested again the relationship between the rate of avoidance response and shock intensity depended upon the compatibility of required avoidance response with defense responses elicited by different intensities of shock. Assuming that the required beam-interrupting-response was more compatible with defense responses elicited by strong shock than those elicited by weak shock, the present findings are congruent with the explanations offered by Feldt and McCann (1977).

A final brief remark may have to be made with reference to the response topography data shown in Table 1. It can be seen that Group HA subjects jumped to escape but reared to avoid. This discrepancy of the topography of escape and avoidance was observed by Shishimi and Imada (1977). These facts are congruent with the facts obtained by Bolles (1969) and Shimai and Shishimi (1976) who have shown that avoidance responses of some topography were successfully acquired no matter what topography was required for escape. Table 1 also shows that the topography of Re of the high shock groups was mostly jumping but that of the low shock groups was mostly rearing. This fact does not contradict with the now classic data of Kimble (1955) who has shown that the percentage of jumping response unconditionally elicited by shock increased monotonically with the shock intensity up to .9 mA.

Further accumulation of empirical data is awaited in order better to understand the mechanism whereby the rearing avoidance is acquired.

**References**


