Sensory stimulation and timing behavior¹

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The response rate of six male albino rats was studied during an 80 second fixed-interval operant response situation under conditions of light and dark, quiet and noise. The inter-reinforcement interval was divided into four sub-intervals of 20 seconds each. A significant illumination effect was obtained as well as significant differences within the inter-reinforcement interval. A significant interaction between illumination and sub-intervals was obtained. The results are discussed in relation to arousal and an "internal clock" mechanism.

It has been demonstrated that ambient sensory stimulation influences the level of cage activity of animals (Hunt & Schlosberg, 1939; Isaac & Devito, 1958; Isaac & Reed, 1961; Alexander & Isaac, 1965), escape times (Isaac, 1960), and modifies the length of the interoperative interval required for the sparing of a preoperatively learned response in the two-stage surgical procedure (Isaac, 1964). These data, obtained in disparate experimental situations, have been related (Isaac, 1964) by utilizing the concept of arousal, as first demonstrated by Moruzzi & Magoun (1949), and the subsequent demonstration of the role of afferent activity in its production (Starzl, Taylor, & Magoun, 1951).

If ambient sensory stimulation alters the activity of the nervous system and consequent behavior in the manner posited (Isaac, 1960), its effects should be manifested in situations in which reward, rather than escape, determines the response. Similarly, discussions concerning an alteration in the rate of ongoing activity within the nervous system as a function of sensory input (Isaac, 1964), would predict that time dependent responses should be sensitive to the influences of different levels of ambient sensory stimulation.

To evaluate the hypothesis concerning the relationship of ambient sensory conditions to a reward motivated response, as well as its effect upon a time dependent response, behavior in a fixed-interval operant response situation was studied. The specific hypothesis was (a) overall rate of responding will be influenced by ambient sensory input, and (b) the temporal patterning of responses within the inter-reinforcement interval will also be influenced by ambient sensory conditions.

Subjects

Six male albino rats (Holtzman strain) served as Ss.

Apparatus

A standard living cage 8 in. wide, 10 in. long, and 7 in. high served as the test chamber. The two longer sides and one end were of sheet metal; the bottom and one end were of hardware cloth. The top was covered by Plexiglas. A lever, 4 in. long and 3/4 in. wide, was

mounted 2 in. above the floor parallel to the narrow sheet metal side of the cage. The interior of the cage was painted gray.

Water reinforcement was delivered to the S through a small plastic pedestal that extended up through the floor of the cage at the end opposite the lever. A pump was adjusted so that only a small quantity of water was delivered to the S each time. A relay next to the cage, wired in parallel with the pump, signalled the delivery of a reinforcement to the S.

Fluorescent lighting provided 100 ft.-c. of illumination at the floor of the apparatus. Background noise level provided by an exhaust fan was 60 dB, to which a white noise could be added making a noise level of 80 dB.

A fixed interval of 80 sec. was obtained by a constant speed motor which activated a stepping relay each 20 sec. A single reinforcement was available only during the first 20-sec. interval. Separate counters obtained a cumulative record of the number of responses made during each quarter of the interval, as well as the total number of reinforcements obtained.

Procedure

Ss were adapted and tested under the four combinations of light and noise: light-noise (LN), light-quiet (LQ), dark-noise (DN), and dark-quiet (DQ). A Latin square design was used to arrange the order of presentation of sensory conditions. Each S was adapted by being run four 1-hr. sessions under each sensory condition, or four replications, each containing the four sensory conditions. Following these sessions the Ss were run for another 16 1-hr. test sessions, or four replications of 1-hr. test sessions under each of the sensory conditions. The data obtained during the post-adaptation sessions were evaluated by analysis of variance.

All Ss were deprived of water for a period of 23 hr. before each test session. Immediately following the completion of a session each rat was removed to his home cage. Water was available between 30 min. and 60 min. after the end of each session. Food was always available in the home cage.

Results

The responses made in each of the four intervals as a function of the sensory conditions are shown in Fig. 1. In addition to the main effects of the four sensory conditions, four intervals, and Ss, the confounded effects of orders and replications were partitioned by analysis of variance. The first order interaction of the main effect in question with its interaction with the S variable served as the error term in all comparisons; interactions were evaluated

Fig. 1. Mean number of responses during the four inter-reinforcement intervals in the rat as a function of sensory stimulation.

by comparing the interaction between the variables in question with their interaction with the S variable.

Of the sensory conditions, illumination effects were found to be significant at less than the 1 percent level ($F=8.753$, $df=1/5$); noise was found to produce a non-significant effect. The differences in response rates during the four intervals were significant at less than the 1 percent level ($F=39.683$, $df=3/15$). The interaction between illumination and intervals was found to be significant at less than the 1 percent level ($F=10.960$, $df=3/15$). Noise did not produce a significant interaction effect with either illumination or intervals.

To further evaluate the change in response rate in the intervals as a function of illumination, the linear and quadratic components of the interaction were evaluated through the use of orthogonal polynomials. The linear component was found to be significant at less than the 1 percent level ($F=26.305$, $df=1/15$), and the quadratic component was found to be significant at less than the 2-1/2 percent level ($F=6.478$, $df=1/15$).

Discussion

The total number of responses made during the 80-sec. interval between reinforcements varied as a function of illumination. Such an effect might have

been expected on the basis of similar effects on other performance measures (Isaac & Devito, 1958; Isaac, 1960; Isaac & Reed, 1961). The significant difference observed in the linear component of the interaction between sensory conditions and portions of the interval also might indicate an influence upon response rate that would be expected on the basis of a straightforward effect upon performance. The significant quadratic component of the interaction, however, suggests an additional factor. The increased rate of responding that precedes reinforcement begins earlier or later, as a function of sensory conditions, during the inter-reinforcement interval, indicating an alteration in a timing mechanism.

It has been assumed that level of arousal may be manipulated by varying sensory input (Isaac & Devito, 1958; Isaac & Reed, 1961), since it has been shown that sensory input does alter the activity of the reticular formation (Starzl, Taylor, & Magoun, 1951). A change in arousal results in an alteration in the pattern of activity of single units within the central nervous system (Hubel, 1959; Evarts, 1960). Thus, assuming some sort of "internal clock" within the animal related to neural activity, it might be expected that a time dependent behavior such as the one employed in this study would be altered by varying sensory input.

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Note

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