Some effects of short-term immediate prior exposure to light change on responding for light change*

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The present experiment was designed to test the prediction that short-term immediate prior exposure to one light change will reduce not only the reward value of that light change but also a light change in the opposite direction. The prediction arises from explanations of sensory reinforcement in terms of a single general need for stimulus change. Each 20-min LCBP (light-contingent barpressing) session was divided into halves (exposure and test periods, respectively). Rats received either light onset or light offset as the reinforcer in the two halves according to a 2 by 2 design. The prediction was confirmed for the first 10 of 15 LCBP sessions, but thereafter exposure to one direction of light change had little or no effect on responding for light change in the other direction. The results were interpreted in terms of (a) an increase across sessions in the level of novelty and change the animals were capable of accommodating and (b) separate reinforcing effects for different sensory changes.

Comparatively little attention has been given in the sensory reinforcement literature to the nature of the motivational state underlying the reinforcing effect of response-contingent sensory change. From the limited evidence available, Kish (1966) concluded that the most parsimonious way of viewing sensory reinforcement behavior was in terms of "a single 'stimulus hunger' or drive for stimulation rather than a series of drives specific to different test situations, or sensory modalities, or perhaps both [p. 127]." Others have also postulated a single general need for stimulus change in accounting for sensory reinforcement (e.g., Isaac, 1962; Frieman, 1967; Thor & Hoats, 1968). The basis for this need is often in terms of a parallel between the sensory deprivation studies (e.g., Brownfield, 1965) and the research on curiosity-exploratory behavior, with both phenomena seen as stemming from a general need for exteroceptive stimulus change (e.g., Jones, 1966; Riesen, 1966; Schultz, 1965, 1967).

The hypothesis that the reward in sensory-contingent barpressing (SCBP) is mediated by the reduction of a single general need for stimulus change leads to the prediction that exposure to one kind of stimulus change will reduce the need and, hence, the reward value of other stimulus changes. The present experiment investigated this prediction with respect to different sensory changes within the one sensory modality (visual). Light onset and offset were the stimuli used. Immediately before each test session in which the reward value of light onset and offset was assessed, animals were given short-term exposure to either light onset or offset. If a single general need for stimulus change underlies sensory reinforcement, it would be

predicted that prior exposure to one direction of light change (e.g., onset) would not only reduce the reward value of that change but also the reward value of change in the opposite direction (offset).

METHOD

Subjects

The Ss were 80 female Wistar hooded rats, approximately 160 days of age at the start of the experiment. They were obtained from the University colony at about 100 days of age, routinely handled, and kept on ad lib food and water prior to and throughout the experiment. The animals were caged singly in an air conditioned room at 70°F on a 12-h light-dark cycle. All animals were run during the light part of the cycle.

Apparatus

The apparatus consisted of five light-tight, air conditioned, and sound-insulated chambers containing single-level Skinner boxes 21.6 x 20.3 x 22.9 cm, constructed from unpainted aluminum panels, with a Perspex door and ceiling. Two lights (Philips 0.8 V, 0.82 A) were mounted 2 cm below the top of the box and 5 cm from the sides on the wall facing the lever. A 5 x 1.3 cm metal lever protruded 1.3 cm from a wall, 7.5 cm above the floor. Approximately 20 g weight was required to operate the lever. The light changes used were light onset, a change from darkness to 71.58 lx, and light offset, a change from 71.58 lx to darkness. The light levels were measured in the vicinity of the lever by a Lunasix photometer. All light changes lasted for a fixed duration of 3 sec. A response during the period of change was recorded but did not affect the duration of that change.

Procedure

Design. The experiment was designed as a complete 2 by 2 by 2 factorial study with repeated measures over sessions. A summary of the design is set out in Table 1. Each session lasted for a total of 20 min. This was divided into two 10-min periods: the first, the "exposure" period, the second, the "test" period. During the exposure period, half of the Ss were given response-contingent (RC) exposure and half noncontingent (NC) exposure. The two methods of exposure were introduced mainly because it seemed possible that the effects of exposure might differ according to whether the animals actively exposed themselves to the light change (RC) or were passively exposed,

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with no control over the occurrence of the stimulus (NC). For NC animals the lever was covered with an aluminum panel which prevented responding and they were yoked to a RC animal for light change. Each NC S was yoked to the same RC animal throughout the experiment. Half of the Ss were exposed to light onset and half to light offset. At the commencement of the test period, the panel in the NC treatments was removed and all Ss responded for either light onset or offset.

The intersession interval was 48 h, with half of the Ss run on any one day. The experiment was run at the same time each day. The number of barpresses in the exposure period (for RC treatments) and the test period were recorded. The experiment was conducted in two phases.

Phase 1 (Operant). The animals were randomly assigned to one of the light treatment groups. No light changes were given. In the 10-min exposure period, the lever was covered for all animals. In the test period, barpressing produced no light change. The cover over the lever was removed manually. The ambient light conditions (71.58 lx or darkness) were the same as those scheduled for the LCBP phase. Five sessions were run.

Phase 2 (LCBP). The experimental conditions outlined in the design commenced on the sixth session. To control for possible effects of opening the Skinner box and removing the cover over the lever in the NC treatments, the box was opened at the end of the exposure period and the cover placed over the lever and immediately removed again in the RC treatments. Fifteen sessions were run.

RESULTS

Over the initial sessions of Phase 2, a number of RC animals did not respond and, therefore, their yoked partners did not receive prior exposure to light change. Because these NC animals were responding without receiving light change exposure, they could not be included in the analysis. Consequently, if a NC S commenced responding in the test period before its RC partner started responding during the exposure period, both Ss were removed from the analysis. Of the four treatment combinations of exposure by type of test light change, three pairs of animals from three of the treatment combinations had to be removed for this reason. Two pairs had to be removed from the fourth treatment combination. To facilitate analysis, a third pair of animals was removed (randomly selected) from

the latter. This left seven animals in each of the eight treatments. The data analyzed were for these 56 animals. It might be claimed that this selection of Ss could have selectively eliminated "stronger" responders in the NC treatments. Additional evidence from the experiment suggests this is not so. The Ss removed from the analysis were allowed to continue in the experiment. By Sessions 11-12 all RC animals were responding in the exposure period. Analysis of data for all 80 animals over the last five sessions yielded precisely the same relationships between treatments as reported here for the reduced sample and exactly the same significant effects. This, of course, was not so for the first five sessions of Phase 2 for the reasons given. Any analysis of shifts in the effects of exposure across sessions necessitates the selection of Ss in the way described.

The main analyses were performed on responses in the exposure and test periods separately using repeated-measures procedures. The within-treatment response distributions were positively skewed. Hence, to match the assumptions of the repeated-measures analysis of variance (Winer, 1970), all the response data were subjected to a square-root transformation.

Phase 1 (Operant)

The analysis of responses in the 10-min *test period* over all sessions in Phase 1 yielded a significant effect for the dummy "Type of Exposure by Type of Test Light Change" interaction ($F = 13.22$, $df = 1/48$, $p < .01$). This indicates that, when the ambient light condition was constant throughout the session, fewer operant responses were made than when the ambient light condition changed from light to darkness, or vice versa, after 10 min. Inspection of the data revealed that the mean number of responses in all treatments was about one response per session (see Table 1). This low rate arose because on any one session a proportion of animals did not respond. The significant effect obtained reflects the fact that a larger proportion of animals responded if the ambient light condition changed after the first

Table 1
Summary of Mean Number of Responses in Phases 1 and 2 for All Treatments

Method of Exposure	Type of Exposure	Type of Test	Phase 1		Phase 2					
			Sessions 1-5		Sessions 6-10		Sessions 11-15		Sessions 16-20	
			Exposure Period	Test Period	Exposure Period	Test Period	Exposure Period	Test Period	Exposure Period	Test Period
R-C	Onset	Onset		0.5	9.0	2.8	15.0	2.8	13.6	3.9
N-C	Onset	Onset		1.2		3.3		3.2		3.2
R-C	Offset	Offset		0.6	12.8	4.4	12.7	3.2	14.3	3.6
N-C	Offset	Offset		1.0		1.1		4.0		4.2
Mean				0.8	10.9*	2.9**	13.8*	4.1**	13.9*	3.7**
R-C	Onset	Offset		1.5	17.8	6.2	14.8	10.8	12.6	13.4
N-C	Onset	Offset		1.8		6.9		6.2		17.0
R-C	Offset	Onset		2.1	14.6	7.0	13.2	6.5	14.8	9.1
N-C	Offset	Onset		2.3		7.6		7.9		9.7
Mean				1.9	16.2*	6.9**	14.0*	7.8**	13.7	12.3

Exposure vs test period; comparisons *** $p < .001$ in all cases (two-tailed t test)

10 min of the session. The analysis also showed that operant responding declined over the five sessions ($F = 3.12$, $df = 4/192$, $p < .05$).

Phase 2 (LCBP)

The Exposure Period. A summary of the response data from the exposure period for all treatments is presented in Table 1. The analysis of variance showed that there were no significant differences between treatments and no trends over sessions. This indicates that light onset and offset were equally reinforcing and that the amount of prior exposure to light change (i.e., the frequency of light change in the exposure periods) did not differ from treatment to treatment or over sessions.

The Test Period. The analysis of responding in the test period over all sessions in Phase 2 showed that there were no differences according to the method of exposure ($F < 1$), the type of exposure light change ($F < 1$), or the type of test light change ($F < 1$). This indicates that (a) the effects of prior exposure to light change were the same for RC and NC exposure, (b) light onset and offset did not differ in reinforcing value, and (c) there were no differential effects according to whether the prior exposure was to light onset or offset.

The only treatment effect to emerge was an interaction of Types of Exposure Light Change by Type of Test Light Change ($F = 11.41$, $df = 1/48$, $p < .01$), demonstrating that more responses were made if the test light change was different from the exposure light change (see Fig. 1, Table 1).

In general, responding increased over sessions ($F = 6.29$, $df = 14/672$, $p < .01$). However, trends over sessions differed according to the method and type of exposure ($F = 2.18$, $df = 14/672$, $p < .01$) and the type of exposure and type of test light change ($F = 2.11$, $df = 14/672$, $p < .05$). More detailed analyses of the differences in trends using orthogonal polynomials revealed that the treatments differed in terms of both linear ($F = 2.36$, $df = 7/48$, $p < .01$) and quadratic trends ($F = 2.40$, $df = 7/48$, $p < .01$) over sessions.

The Decline in the Reinforcing Value of Light Change from the Exposure to the Test Period

The analyses to this point have shown that there were differences in responding among the treatments in the test period and that these were related to whether the exposure and test light changes were the same or different, rather than to such factors as passive vs active exposure and the number of changes given in the exposure period. The purpose of the present analyses was to examine this result more closely, especially to determine whether the reward value of change in one direction was significantly reduced by exposure to change in the opposite direction. If this is the case, it would be predicted that significantly fewer responses would be made in the test period than in the exposure period. Exposure and test period responding were compared by difference *t* tests for all treatments in

Fig. 1. Responding in the test period for all animals as a function of type of exposure and type of test light change.

which the exposure and test change was the same and all treatments in which the exposure and test change was different. Because of the obvious shifts in this difference over sessions, separate analyses were performed on the data for Sessions 6-10, Sessions 11-15, and Sessions 16-20. To include the NC treatments in these analyses, the difference between the number of responses in the exposure period of the RC S to which it was yoked was taken. The results of these analyses are presented in Table 1, where it can be seen that (a) the reinforcing value of light change declined markedly from the exposure to the test period when the same light change occurred in both periods, as expected. This shows the normal within-session decline (Roberts, Marx, & Collier, 1958; McCall, 1965; Carlton, 1966; Russell, 1971), with about 78% of responses being made in the first 10 min; (b) the reinforcing value of light change significantly declined from the exposure to the test period when a different light change occurred in the two periods, during Sessions 6-10 and Sessions 11-15 but (c) not during Sessions 16-20. Thus, during Sessions 16-20 short-term immediate prior exposure to one direction of light change had no significant effect on the reward value of light change in the other direction.

DISCUSSION

The results from the initial and middle sessions showed that immediate prior exposure to one direction of light change reduced the reinforcing effects of light change in the opposite direction. This is clearly consistent with the proposition of a single general need for stimulus change underlying sensory reinforcement. However, this effect was only transitory. With repeated exposure and test sessions, the different directions of light change in the exposure and test periods had virtually independent reinforcing effects. Thus, the results for the terminal sessions are consistent with the position of separate "drives" for different sensory

stimuli. The overall findings of Berlyne, Koenig, and Hirota (1966) using visual and auditory sensory changes also support the position of separate "drives" for different changes. Woodworth (1958) seems to have drawn the same conclusion with respect to exploratory behavior when he said, "What becomes satiated . . . is not the exploratory tendency in general, but the exploring of a particular place or object [p. 83]."

Attempts to explain the shift across sessions of the effects of immediate prior exposure can only be speculative. However, it seems reasonable to argue that the experience of novelty and change (especially in those treatments receiving both directions of light change) could have increased across sessions the organisms' preferred level of change and novelty or their capacity to readily accommodate increased amounts of stimulus change (Dember & Earl, 1957; Glanzer, 1958; Munsinger & Kessen, 1964; Thomas, 1969a, b; Eisenberger, 1972). The light changes would also have become more familiar to the animals with repeated experience of them.

The reduction in the reward value of the opposite direction of light change during the test period over the initial sessions might thus be accounted for by claiming that the animals were unable readily to accommodate the level of novelty and change arising from the switch in the direction of light change after the 10-min exposure period. There are no powerful constraints on the animal to respond in LCBP and, until the LCBP phase commenced, the animals were almost totally naive to light changes. From the present argument, it would be predicted that, if two light changes of smaller magnitude were used, it would be possible to obtain independent reinforcing effects for them from the first session. Equally, it would be predicted that, if the capacity of the organism to accommodate novelty and change could be raised prior to the commencement of the experiment, independent reinforcing effects for the present light changes might also emerge on the first session.

In a further breakdown of their data, Berlyne, Koenig, and Hirota (1966) found that animals housed in a noisy room responded more for a stimulus that had been experienced in the "exposure" period than for one to which they had not been previously exposed. The opposite occurred for animals housed in a quiet room. Berlyne et al interpreted their data in terms of differing arousal levels for animals housed in different environments. This seems to be compatible with the present argument that organismic variables will affect the level of novelty and change the organism can accommodate. The conclusion to be drawn is that different sensory changes, even within the one modality, can have independent reinforcing effects but that further research is needed on the conditions under which this effect will emerge. The evidence is increasing that sensory reinforcement is motivated by more than a general need for sensory variation (e.g., Kavanau, 1967; Eisenberger, 1972; Glow & Russell, 1972).

The method of prior exposure (active or passive) was not significantly related to the effects of prior exposure. For example, animals did not have to respond for a change in order for its reward value to be reduced in the subsequent test session. Responding per se in the exposure period was not a significant factor in any reduction of LCBP in the test period. This finding is not compatible with the hypothesis that the within-session decline in LCBP is "a function of the occurrence of the operant rather than its consequences [Roberts, 1962, p. 379]."

In the operant phase it was found that animals for which the ambient illumination changed at the end of the exposure period gave more operant responses than animals for which the ambient illumination was constant throughout the session. This suggests that the complete change in the ambient illumination acted as an arousal stimulus, possibly initiating further exploration of the environment and, hence, more operant responses. If it is assumed that the level of responding for light change is mainly a function of the reward value of LCBP, it would follow that the operant differences had little bearing on the LCBP results. That is, the factors controlling operant responding are different from those determining the level of LCBP behavior.

The conclusions advanced here are predicated on the assumption that it is the light changes which occurred during the exposure period that were related to LCBP in the test period. However, a close examination of the exposure period shows that a light change occurred, on the average, only every 40-45 sec. Therefore, more than 90% of the exposure period was spent in the background or ambient illumination. As it was possible that the ambient illumination of the exposure period may be itself related to responding for light change in the test period, it was necessary to investigate this parameter.

A second experiment was conducted using the same apparatus and general procedures as already outlined. Using a 2 by 2 design and five rats per cell, Ss were either given constant light or darkness during the exposure period and then responded for light onset or offset in the test period. Five operant sessions and 15 LCBP sessions were given. It was found that the illumination conditions during the exposure period were not significantly related to LCBP in the test period ($F < 1$ for all comparisons between treatments over the 15 LCBP sessions). It can be concluded, therefore, that the main variables in modifying the reward value of LCBP in the first experiment were the light changes and not the nature of the ambient illumination during exposure.

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