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THE EFFECT OF THE BLACKOUT METHOD ON ACQUISITION AND GENERALIZATION[1]

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In discrimination training with the Lyons' blackout method, pecks to the negative stimulus are prevented by darkening the chamber each time the subject approaches the negative stimulus. Stimulus generalization along a stimulus dimension was measured after training with this method. For comparison, generalization was also measured after reinforced responding to the positive stimulus without discrimination training, and after discrimination training by extinction of pecks to the negative stimulus. The blackout procedure and the extinction of pecks to the negative stimulus both produced a peak shift in the generalization gradients. The results suggest that after discrimination training in which the positive and negative stimulus are on the same continuum, the blackout method produces extinction-like effects on generalization tests.

Lyons (1969*a*, 1969*b*) demonstrated that consistently blacking out the chamber for 2 sec when a pigeon approaches a negative stimulus (S−) results in a discrimination. Since the key is not struck during the S−, Lyons referred to this "blackout" method as an "errorless" procedure. Moreover, he obtained a flat generalization gradient with the blackout method when the S− was on a dimension orthogonal to the positive stimulus (S+) dimension. A similar flat gradient of inhibition has been found after errorless discrimination training with the fading technique (Terrace, 1972). When a discrimination is established using extinction of responses in the presence of an S−, generalization tests on the S− dimension produce U-shaped gradients of inhibition (*cf.*, Jenkins and Harrison, 1962; Honig, Boneau, Burstein, and Pennypacker, 1963; Hearst, 1968).

There are, as yet, no data on stimulus generalization following discrimination training with the blackout procedure when the S+ and S− are on a single dimension. Does the blackout procedure produce the peak shift, a shift in the mode of responses away from the S− and beyond the S+, normally found with extinction of responding to S− (*cf.*, Hanson, 1959)? Or will there be no peak shift, a finding that would be consistent with the flat gradient of inhibition found by Lyons?

Whether the blackout method is in fact itself descriptively an extinction procedure is a semantic question. Since the key and the chamber are darkened when the bird approaches the key, there are in fact few or no pecks on S−, and thus no key pecks go unreinforced in the presence of the S−. There are, however, approaches to the key that go unreinforced when the chamber is blacked out. Since approaching the key is surely a part of the chain of behavior that in other circumstances, such as the presence of the S+, results in a key peck, there should be little surprise if peak shift occurred. Moreover, the bird may occasionally complete the pattern and strike the key in the darkened chamber. Although it is not normal for birds to respond in the dark, in this procedure the chamber is darkened after the bird has initiated movement toward the key. Interest in the shape of the generalization gradient after training with the blackout

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method is therefore increased by the apparent flat inhibition gradient it produced and the lack of a compelling reason to consider the procedure to be functionally free of extinction of responding to S−.

The present study provided a measure of the shape of the generalization gradient after training by the blackout method in discrimination between an S+ and an S− on the same dimension. For comparison purposes, generalization gradients were measured for S+ training without discrimination and for traditional discrimination training with extinction of responding to S− with both early and late introduction of S−. During the blackout training procedure, approaches and pecks after S− terminated were recorded.

METHOD

Subjects

Sixteen adult, experimentally naive White Carneaux pigeons and four naive Silver King pigeons were all maintained at approximately 80% of their free-feeding weights.

Apparatus

A Grason-Stadler single-key chamber was employed throughout training and testing. The single transparent key, 1 in. (2.5 cm) in diameter was mounted in the center of the stimulus surface and 9 in. (23.5 cm) above the floor. The key required a minimum force of 0.196 N for operation and could be illuminated by white circles of different diameters projected on a black background by a 28-V inline projector (Industrial Electronics Engineers, Inc., Series 10-1820). The brightness of the particular stimulus was made an irrelevant dimension during training by randomly presenting any of four stimulus intensities. Four resistors of 0, 22, 47, or 150 ohms were inserted into the projector circuit to achieve this intensity variation. This procedure was employed to ensure that subjects were responding on the basis of size, rather than intensity. The chamber was located in a darkened room and had a 6 by 5 in. (15 by 23 cm) window through which the experimenter could observe the subject. A diffuse 7-W houselight illuminated the chamber. A hopper filled with mixed grain could be made available through a 1.75 by 2 in. (4.4 by 5 cm) opening located 2.25 in. (5.7 cm) above the floor. Reinforcement was a 3.75 sec period of access to the hopper of grain. During the reinforcement cycle, the houselight and keylight were turned off, and a 7-W bulb directly above the grain was turned on. The chamber was in an air-conditioned room masked by white noise.

Automatic equipment, housed in a separate room, controlled reinforcement contingencies, stimulus changes, and recording of responses except that blackouts for the blackout-method birds were manually initiated by the experimenter.

Procedure

The 20 subjects were randomly assigned to the four experimental conditions, except that one Silver King pigeon was used in each condition. Sessions were conducted daily and terminated after 50 reinforcements. Table 1 shows the diameters of the circles used in this experiment.

During the first three days of training, all stimuli were at their full intensities; on subsequent days of training, the stimulus intensities were varied randomly from trial to trial through the four resistance values. This variation in the intensity of each stimulus was performed to ensure that stimuli from the size dimension, rather than stimuli from an irrelevant brightness dimension, were the controlling stimuli.

After magazine training, all subjects were trained to peck the S+. On the first day of training, each response to the S+ was rein-

Table 1

Stimuli Diameters

	Stimulus									
	1	*2*	*3*	*4* S−	*5*	*6* S+	*7*	*8*	*9*	*10*
in.	0.185	0.220	0.255	0.290	0.325	0.360	0.395	0.430	0.465	0.500
mm	4.70	5.59	6.48	7.37	8.26	9.14	10.0	10.9	11.8	12.7

forced. In the second session, a variable-interval 15-sec schedule (VI 15-sec) of reinforcement was employed; in all subsequent training sessions, a VI 30-sec schedule was used. Trials were 30 sec in duration and followed by a 10-sec intertrial interval during which the chamber and key were dark. Throughout discrimination training, S+ and S− trials were randomly alternated except that no more than three trials of any type could occur in succession. Discrimination training was continued until the total number of responses during S+ was at least 10 times greater than the number of responses during S−.

For the early traditional group, the first S− trial was introduced after 15 responses to the S+ had been reinforced. Responses to the S− were extinguished. For the delayed traditional group, however, S− trials were not introduced until Session 17. For the S+ control group, only S+ trials were presented. Each S+ control subject had the same number of training sessions as a respective subject in the delayed traditional group. For the blackout method group, S− trials were also introduced in Session 17. Emission of pecks on the S− was prevented by darkening the chamber whenever a subject in this group approached the S−. For this group, an experimenter observed each subject, and when a subject made any movement toward the S−, the experimenter manually closed a switch, which darkened the chamber for 2 sec. Criterion was reached when the total number of responses to S+ during one session was at least 10 times greater than the number of approaches to the S−.

On the day after criterion performance, each subject was presented with the 10 stimuli in a generalization test conducted with no reinforcement. Within each series of 10 stimuli, the order of stimulus presentations was randomly determined. Ten of these series comprised this test. During the test, stimuli were at their full intensities.

RESULTS

Acquisition

Table 2 shows acquisition and test measures for each subject together with the average values for each group. Although there were individual differences within groups, each group had approximately the same average rate of S+ responding (see Table 2); thus, there was little evidence of positive contrast (*i.e.*, an increase in the rate of responding to S+ as a result of the introduction of the S−). Each of the discrimination groups also required an approximately equal number of days of discrimination training on VI 30-sec to reach the criterion. For the early, delayed, and blackout groups, the mean days to criterion were 8.4, 10.2, and 9.4 respectively. Although the average number of S− pecks during discrimination training was greater for the delayed traditional group than for the early traditional group (8427 and 7161 respectively), these differences were not significant ($t = 0.332$, $df = 8$, $p > 0.05$). The average number of S− approaches for the blackout group (3050), however, was significantly lower than the number of S− pecks emitted by the delayed traditional group ($t = 5.85$, $df = 8$, $p < 0.01$).

On some approaches to the S−, the blackout-method birds would follow through with a peck on the darkened key. Since the key and chamber were dark when these "follow-through" responses occurred, they were not visible to the experimenter, but they were recorded. The "follow-through" responses were less than one-third of the number of S− approaches in all cases. The average number of "follow-through" responses was 832, a value somewhat inflated by the large number of "follow-through" responses emitted by SK-45 (see Table 2). Occasionally, a blackout-method bird would strike the key just as the S− reappeared, and these responses were recorded as S− pecks. The average number of these S− pecks for the blackout-method subjects was 32.

Generalization

Figures 1 and 2 show the results of the generalization tests. The top-left gradient in each condition shows that group's average gradient, calculated from the percentage of responses emitted by each subject to each stimulus. These average group gradients, therefore, adjust for absolute differences in the number of test responses emitted by each subject. The remaining gradients in each condition show the percentage of responses emitted by each subject to each stimulus. The vertical line in each gradient represents the mean value for that gradient.

As Figure 1 shows, the S+ control subjects emitted more of their test responses to stimuli 4, 5, and 6 than to the other test stimuli. Three

Table 2

Acquisition and Test Measures for each Subject

Subject	Total S+ Pecks	Total S− Pecks	Total S− Approaches (Blackouts)	Total "Follow-Through" Responses	Sessions to Criterion	Average Per Second Rate of S+ Responding	Total Test Responses	Percentage of Responses to Stimuli 7-10
				S+ Control Subjects				
SK-43	15,840[b]				9[a]	1.31[b]	1859	19
142	14,047				10	0.83	1437	37
152	33,376				15	1.42	2199	30
162	13,240				6	1.35	1089	25
172	31,010				11	1.68	705	15
Group Average	21,503				10.2	1.32	1458	25.2
				Blackout Method Subjects				
SK-45	28,916[c]	59	4,313	1,743	13[c]	1.45[c]	785	61
141	10,023	20	2,033	249	7	0.85	1458	57
149	25,695	27	3,173	678	11	1.56	2621	53
161	14,010	26	1,660	714	5	1.81	2692	55
212	24,832	29	4,071	775	11	1.24	2470	59
Group Average	20,695	32	3,050	832	9.4	1.38	2005	57
				Early Traditional Subjects				
SK-40	36,350[c]	9,459[c]			9[c]	2.40[c]	4627	75
168	6,388	1,772			4	0.50	808	70
169	6,173	1,889			6	0.58	769	79
170	7,925	1,827			7	0.64	1082	86
215	51,095	20,859			16	1.93	6481	71
Group Average	21,586	7,161			8.4	1.21	2753	76.2
				Delayed Traditional Subjects				
SK-42	29,127[c]	7,861			11[c]	1.45[c]	1478	75
140	28,797	10,457			10	0.85	2012	76
147	23,531	8,413			15	1.56	1888	70
160	25,238	6,003			6	1.81	2314	68
214	29,885	9,402			9	1.24	3917	80
Group Average	27,316	8,427			10.2	1.38	2322	73.8

[a]Determined by the yoked partner in the delayed traditional group.
[b]During the yoked control sessions.
[c]Discrimination training with the VI 30-sec schedule of reinforcement.

subjects in this group had modes of responding at Stimulus 6, the S+ value, while two subjects had modes at stimuli smaller than S+. The mean gradient value for this group, shown by the vertical line in the average group gradient, was 5.2. Subjects in this group emitted relatively few responses to stimuli larger than S+. As Table 2 shows, an average of only 25.2% of their test responses were emitted to Stimuli 7 to 10.

The generalization gradients for the blackout-method subjects showed peak shift. As Figure 1 shows, only Subject 141 had a mode of responses at the S+ value. All other subjects in this group had modes at Stimulus 7, indicating this peak shift. Both the average mean gradient value (6.8), and the percentage of responses to Stimuli 7 to 10 (57%) also reflected this peak shift.

Figure 2 shows that subjects in the early and delayed traditional groups had the greatest amount of peak shift. The gradients for these two groups were similar. Four of the five subjects in the early traditional group and all five of the subjects in the delayed traditional group had gradient modes at Stimulus 9. The

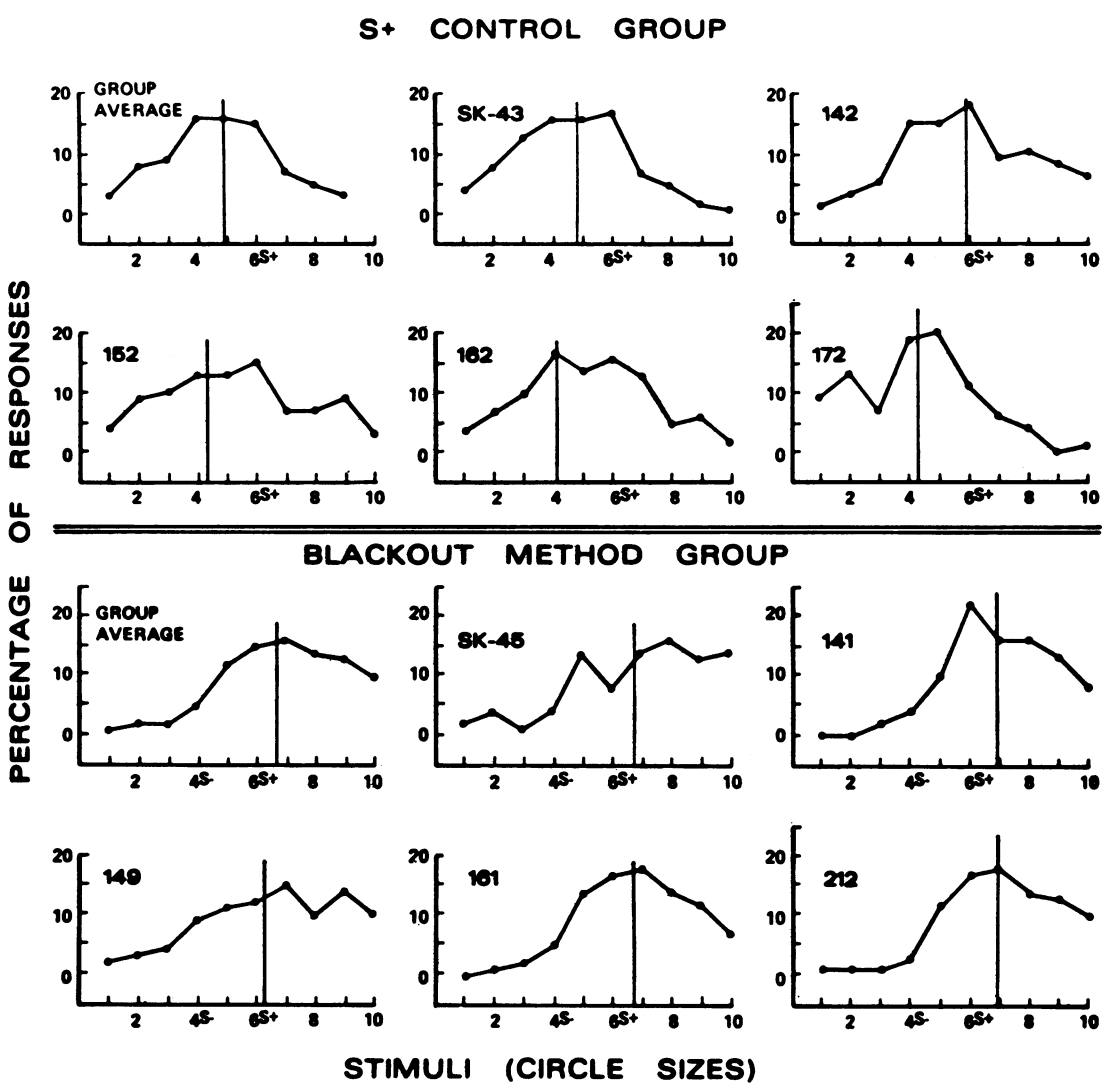

Fig. 1. Percentage of the test responses emitted to each stimulus by the S+ control subjects and the blackout-method subjects during the generalization test. The upper-left gradient is the average gradient for each group. The vertical line in each gradient represents the mean value of that gradient.

means of the early and delayed traditional groups were 7.7 and 7.8 respectively while the percentage of responses to Stimuli 7 to 10 were 76.2% and 73.8% respectively. Thus, discrimination training that extinguished pecks on the S– produced the largest peak shift. A one-way multivariate analysis of variance showed that the test response distributions were significantly different ($F\ [30,21.2] = 3.04$, $p = 0.005$). *Post hoc* comparisons between all possible pairs of gradients showed that all gradients, except the early and delayed traditional gradients, were significantly different from each other at an overall error rate of 0.01. Thus these tests confirmed the significance of the results shown in Figures 1 and 2.

Finally, all of the discrimination groups emitted more test responses than the S+ control group. The average number of test responses for the S+ control group, the blackout group, and the early and delayed traditional groups were 1458, 2005, 2753, and 2322 respectively. These differences among subjects in the total number of test responses, however, were not significant ($F\ [3,16] = 0.664$, $p > 0.05$).

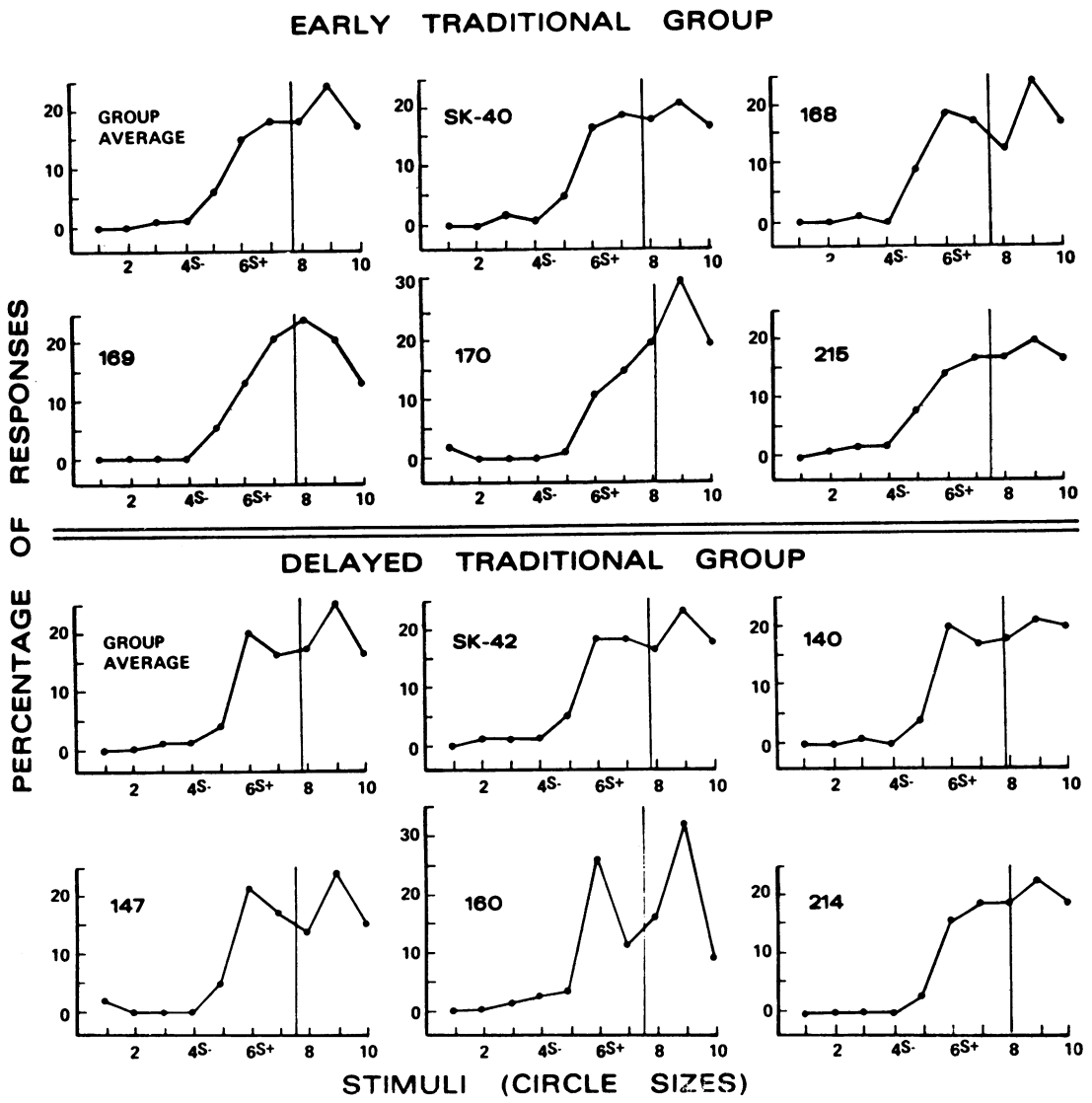

Fig. 2. Percentage of the test responses emitted to each stimulus by the early and delayed traditional subjects during the generalization test. The upper-left gradient is the average gradient for each group. The vertical line in each gradient represents the mean value of that gradient.

DISCUSSION

Peak shift was found with the blackout method. The blackout technique, therefore, seems to share some of the properties of traditional discrimination training with extinction of S– pecks. This finding is not surprising if the S– peck is the terminal component of a response chain. To respond on the key, a bird orients toward the key, moves its head toward the key and finally strikes the key. With Lyons' blackout method, the blackout occurs after the initial components of this chain but before the final component of striking the key. Since the S– approaches are never followed by reinforcement, the early components of the response chain may be extinguished in a manner similar to the extinction of S– pecks in traditional learning. In other words, the blackout method may in fact be a traditional extinction method with respect to the behavior precursory to key pecking. An extinction-like effect may also result from "follow-through" pecks on the darkened key

just after the S– is turned off. In regard to these "follow-through" responses, it should be noted that Lyons (1969*a*, 1969*b*) did not report any "follow-through" responses, but since they occurred when the chamber was dark, they may have occurred without being observed or recorded.

It has been suggested (Grusec, 1968; Terrace, 1964, 1966, 1972) that peak shift results from the S– becoming an aversive stimulus. With the blackout procedure, it is quite possible that the blackout functions as a punishment that causes the S– to acquire aversive properties. The blackout-method birds developed "emotional" behaviors in the presence of the S–, such as moving their heads back and forth along a wall, occasionally looking briefly at the S– and sometimes rushing at the key. These birds also frequently flapped their wings during S– trials but not during S+ trials. In contrast, Terrace (1963, 1972) reported that when the fading method was used to train a discrimination, the birds stood passively in front of the key during S– trials.

In Lyons' (1969*a*) study, the blackout technique apparently did not produce effects like discrimination training with extinction. Lyons tested for a gradient of inhibition along a line orientation dimension after establishing a vertical line on a dark background as the S–. The S+ was a key illuminated by a solid color (555 nm) presumably orthogonal to line orientation. He obtained equal responding at all test values for a group trained with the blackout method and for a control group trained with only the S+, but found a gradient of inhibition for a third group trained with extinction of responses to the vertical line. Lyons (1969*a*) stated: "the fact that the gradient for the errorless blackout group is similar to that for the control suggests that insofar as angularity is a 'neutral' stimulus for the control group it is also a neutral stimulus for the errorless group [p. 491]." Unfortunately, his published data make evaluation of this interpretation difficult. Because he reported only percentages of responses and averages for groups of 10 subjects, there is no way to determine the absolute level of responding. It is possible that response rates were very low; indeed it is possible that response rates were zero for many subjects, making it impossible to show a decrease in responding to the S–. Hearst, Besley, and Farthing (1970), in reviewing the literature on the use of orthogonal dimensions in measuring inhibition, called attention to the frequency of such a "floor" effect and the difficulty it presents in measuring a gradient of inhibition. Lyons (1969*a*) pointed out that "Terrace's errorless group may have been due to the extremely low responding maintained by his testing procedure [p. 491]." If Lyon's (1969*a*) conclusion that the blackout method "is more flexible than those used by Terrace, and it produces the same results [p. 491]" is taken literally, it suggests that Lyons' results were also produced by low response rates.

In an attempt to overcome this floor effect, Lyons added other conditions in which he tested for a gradient of inhibition with different line orientations superimposed on the training S+. Paradoxically, a peak in responding occurred at the S– value for both the group trained with extinction and the group trained with the blackout technique. Although the reporting only of group averages, the reporting only of percentages of responses without absolute values, and the questionable assumption of additivity of the components of the test stimuli obscure the significance of these findings, the finding that the blackout condition was like the "error" condition is compatible with the suggestion of the present study that the blackout procedure may be similar to an extinction procedure with respect to early components of the response chain, which includes pecking the key.

In the present study, both immediate and delayed introduction of discrimination training produced no positive contrast, approximately equal numbers of S– responses, and equal peak shift, while Terrace (1963) found that the delayed introduction of the S– produced both behavioral contrast and increased errors. These differences may be due to the different stimulus dimensions and the different reinforcement schedules used in the two studies. For example, Terrace employed a VI 60-sec schedule. At least one other study has also reported no contrast when a high-density schedule of reinforcement was in effect during S+ (*cf.*, Reynolds, 1963).

One precautionary note about the present results should be mentioned. Circle size has rarely, if ever, been used as a dimension along which to measure generalization. Thus, the fading method has not been tested on this dimension, and there is a possibility that peak

shift might occur on this dimension after training with the fading method.

The failure of Lyons' blackout technique to prevent peak shift is disappointing. Otherwise, it would be especially valuable because it would free the experimenter from the often tedious job of developing a good fading sequence and because it could easily be used for any stimulus continuum. It would also have important practical implications for programmed instruction. However, if, as we now suggest, this method is in fact based on extinction, then it has little to commend it over traditional learning.

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