AN ASSESSMENT OF THE ROLE OF HANDLING CUES IN
"SPONTANEOUS RECOVERY" AFTER EXTINCTION

DAVID R. THOMAS AND LESLIE SHERMAN

UNIVERSITY OF COLORADO-Boulder

Three experiments examined the assertion that pre-session handling cues that accompany training with reinforcement might account for spontaneous recovery when they reoccur following extinction. In Experiment 1, after extensive training on a variable-interval schedule, key pecking in pigeons was extinguished following either normal or distinctively different handling and transportational cues. Those cues resulted in enhanced spontaneous recovery 24 hr later when normal cues were reinstated. In Experiment 2, however, subjects tested following the normal handling cues showed no more spontaneous recovery than did subjects that spent the entire extinction-test interval in the experimental chambers and thus were tested without handling cues altogether. In Experiment 3, a group whose test for recovery began 10 min after being placed in the chambers yielded as much spontaneous recovery as did a group tested normally. Furthermore, a group for which extinction began at mid-session and for which handling therefore could not be a discriminative cue for extinction showed no more spontaneous recovery than did the other two groups. Handling cues thus contributed to spontaneous recovery only after explicit discrimination training, as provided in Experiment 1.

Key words: spontaneous recovery, handling cues, transportational cues, retrieval cues, extinction, discrimination training, key pecking, pigeons

In his well known article, "Are theories of learning necessary?," Skinner (1950) offered a stimulus-control interpretation of spontaneous recovery as an alternative to the view of Pavlov (1927) and others (e.g., Hull, 1943), which attributed the phenomenon to the dissipation of internal inhibition. Skinner proposed that handling and other cues that accompanied the start of a session of reinforced responding may account for spontaneous recovery following extinction when they reoccur at the start of an additional extinction session. For this account to be tenable, the handling cues would have to be more strongly associated with reinforcement than with extinction. This situation would presumably obtain if we assume that the handling cues have primarily local effects and that it takes some time for the subject's behavior to make contact with the extinction contingency, which is certainly the case following training on intermittent schedules.

Skinner's position on spontaneous recovery can be appreciated in the context of his more

general assertion that inhibition is best understood as the absence of excitation rather than as a psychological process in its own right. The intervening years have seen the accumulation of overwhelming evidence contrary to Skinner's position on inhibition (see, for example, Boakes & Halliday 1972; Hearst, Besley, & Farthing, 1970), and it is therefore timely to reconsider his view on spontaneous recovery as well as the evidence purported to favor it.

The first thing that should be pointed out about Skinner's interpretation of spontaneous recovery is that it is not definitively testable. There can be no doubt that operant responding is controlled by discriminative stimuli, whether these are explicitly manipulated by the experimenter or whether they consist of contextual stimuli in the experimental environment. A change in such cues as the house-light, keylight, or masking noise would almost certainly reduce the rate of responding during a given session whether or not the subject had previously experienced extinction. The mere fact of discriminative-stimulus control is as consistent with the interpretation of Pavlov and Hull as it is with that of Skinner, and those earlier S-R theorists would certainly not have denied a role for stimuli in the generation of responses. More importantly, the fail-

Howard Aposhyan, Todd Stengel, and Margaret Woodford assisted in the running of subjects. Requests for reprints should be addressed to David R. Thomas, Department of Psychology, Campus Box 345, University of Colorado, Boulder, Colorado 80309.

ure to demonstrate control by a particular discriminative stimulus cannot be considered a refutation of Skinner's position because it can always be maintained that the critical discriminative cue was not the one that was manipulated by the experimenter.

While acknowledging that Skinner's general position on this issue is not falsifiable, we may still inquire as to what stimuli control operant responding, whether after extinction or at other times, and under what conditions these stimuli acquire and exercise that control. In his 1950 paper Skinner called particular attention to a potential discriminative role for the handling cues that precede experimental sessions, yet very little attention has been paid to such cues within the operant tradition. It is important to point out, therefore, that Skinner's view is not the only one that might attribute a vital role to extraexperimental events in producing spontaneous recovery. Spear (1967, 1971), for example, proposed that spontaneous recovery might profitably be viewed as a memory effect, more specifically as proactive interference. Training with reinforcement precedes extinction, and with a delay period the relative strengthening of the memory of that prior training should interfere with memory of subsequent extinction, thereby leading to enhanced responding. In our laboratory, Thomas, McKelvie, Ranney, and Moye (1981) have shown that proactive interference can be enhanced by testing subjects in the presence of "retrieval cues" that had accompanied initial training. In particular, we trained pigeons on a wavelength discrimination and then its reversal, each in a different environmental context. When subjects were tested without reinforcement in the presence of the context that had been present during initial training, they performed in accordance with that context. It might be proposed that handling and transportation cues would play a similar role in tests of spontaneous recovery because they are presumably more strongly associated with reinforced than with nonreinforced responding.

Whether one chooses to view handling and transportation cues as discriminative stimuli or as retrieval cues, it should be of interest to determine empirically what role, if any, they play in spontaneous recovery. This was the purpose of the series of experiments to be presented in this paper. Because most of the stud-

ies we will be discussing were conceptualized as tests of Skinner's position, we will use his orientation and language throughout this paper with the recognition that a translation to the language of memory retrieval can easily be made. A study purported to provide direct support for Skinner's interpretation, with particular regard to the role of handling cues, was reported by Welker and McAuley (1978). These investigators first exposed rats to several sessions in which bar pressing was reinforced under a variable-interval (VI) reinforcement schedule and then was extinguished in five separate sessions. For one group, each extinction session was preceded by distinctively different handling and transportation cues; for a second group, pre-session cues were the same as during prior conditioning. On a test day the reintroduction of the cues that had accompanied conditioning for the former group led to greater spontaneous recovery in that group. Inasmuch as those cues had never been paired with extinction in this group, it follows that they would more effectively reinstate previously reinforced responding.

In Experiment 1 we tested in several ways the generality of Welker and McAuley's (1978) findings. First, we used pigeons as subjects rather than rats. More importantly, extinction was carried out in a single session, as is typical in studies of spontaneous recovery (e.g., see Ellson, 1938; Graham & Gagné, 1940; Lewis, 1956).

EXPERIMENT 1

METHOD

Subjects

The subjects were 16 experimentally naive pigeons obtained from a local supplier and maintained at 75% of their ad-lib weights. They were housed in individual cages in a colony room with a 16:8 hr light/dark cycle.

Apparatus

The apparatus consisted of a set of four standard operant conditioning chambers as described by Thomas et al. (1981). The stimulus on the response key throughout the experiment was a white line, 0.32 cm wide by 2.5 cm long, in a horizontal position with a dark surround. Reinforcement consisted of 3-s access to a food hopper filled with mixed grain.

Experimental events were controlled by relay equipment in an adjacent room.

Procedure

For all training and test sessions, the birds were placed in the experimental chambers and then the houselight, keylight, and masking noise were turned on. These stimuli were turned off at the end of each session before the birds were removed from the chambers.

On Day 1 all subjects were magazine trained; key pecking was hand shaped, and then 60 peck-contingent reinforcers were delivered on a VI schedule with a gradually increasing mean interreinforcement interval. On Day 2 the mean interreinforcement interval was again increased until VI 30 s was in effect and the subjects had received 60 reinforcers. Then eight daily half-hour sessions of a VI 30-s schedule of reinforcement were administered with the key stimulus presented for 55-s periods separated by 5-s timeouts. During the timeout periods a printing counter recorded the number of responses emitted in the preceding 55-s stimulus-on period, thus permitting us to trace performance changes on a minute-by-minute basis. This also enabled us to calculate when subjects had reached the extinction criterion so that training could be suspended immediately thereafter.

On the day after completion of training with reinforcement, the subjects were divided into two groups matched on the basis of their response rates during the preceding sessions. Group 1 was subjected to extinction following the normal handling and transportational cues. The subjects in this group were carried to and from the experimental chambers in the plastic juice containers normally used for this purpose. The subjects in Group 2 were removed from the home cages and placed in distinctively different cages, were placed on a cart that was rolled a distance of approximately 60 ft to the experimental chambers, and then were removed from those cages and placed directly into the chambers. At the end of the session they were returned to their home cages in the same manner.

The extinction session was divided into blocks of 10 stimulus periods each. Subjects were run until their total responses in a given block were less than 25% of the total responses emitted in the first block. On the next day

spontaneous recovery was measured in a single 10-min block of extinction that for all subjects followed the normal handling and transportational cues.

RESULTS AND DISCUSSION

The results of this experiment are presented in Table 1. For each subject for each block of 10 stimulus periods ("10-min blocks"), the number of emitted responses is recorded, along with the number of responses in the single 10-min test block (indicated by T in the table). For comparison purposes, the number of responses in the last session of training under reinforcement conditions is also presented for each subject (designated by R). Note first that there was substantial variability in response rates during training, but the two groups were well matched in relation to their training performances. As may be seen, the data on resistance to extinction also were highly variable. One would expect greater resistance to extinction following the normal handling procedure. In the first 10-min block, Group 1 emitted a mean of 461.4 responses whereas Group 2 emitted a mean of 409.0 responses. The difference between means is in the expected direction but is not statistically significant ($t < 1$). Similarly, the subjects in Group 1 emitted a mean total of 1,047.5 responses before meeting the extinction criterion, compared to 805.4 in Group 2 ($t < 1$). The difference in mean number of 10-trial blocks to extinction, 4.25 and 3.75 in Groups 1 and 2, respectively, also failed to reach statistical significance [$t(14) = 1.25, p > .05$].

The data of primary interest are the spontaneous recovery scores obtained during the 10-min test block, and these are computed as proportions of the number of responses emitted during the first 10-min block of initial extinction. This procedure eliminates the problem of widely discrepant response rates and it reveals a substantial group difference. The mean recovery score in Group 1 was .34 compared to .75 in Group 2. This difference is highly significant [$t(14) = 6.67, p < .01$] and it indicates that, as predicted, the use of unique and distinctive handling cues preceding extinction led to enhanced spontaneous recovery when the normal handling cues were later reinstated.

These results are consistent with those reported by Welker and McAuley (1978) except that in their experiment the rats received five

Table 1

Responses per 10-min block of stimulus presentations for each subject in Experiment 1. The value designated by "T" refers to the single test block. The value in parentheses is the ratio of number of test responses to the number emitted in the first block of original extinction. The value designated by "R" refers to the number of responses emitted during the last training session under VI 30-s reinforcement.

Normal Handling (Group 1)									
	#141	#142	#143	#144	#131	#136	#137	#138	$\bar{X}$
R	2,283	971	1,350	1,723	1,540	1,320	1,471	753	1,426
10-min blocks									
1	715	230	540	520	524	482	463	217	461
2	475	292	420	340	407	305	517	120	
3	285	95	32	123	235	163	324	84	
4	180	159			31	83	197	85	
5	82	52					113	10	
T	248	85	147	138	261	178	145	60	
	(.35)	(.37)	(.27)	(.26)	(.51)	(.38)	(.31)	(.28)	(.34)
Distinctive Handling (Group 2)									
	#145	#146	#147	#148	#125	#127	#129	#130	$\bar{X}$
R	1,563	2,339	1,292	1,160	1,399	1,651	893	1,394	1,461
10-min blocks									
1	373	702	402	367	428	420	203	376	409
2	227	340	400	240	215	127	145	179	
3	129	166	214	123	80	63	87	83	
4	79	67	97	43			45		
5	23								
T	204	634	208	265	371	340	189	276	
	(.55)	(.90)	(.52)	(.72)	(.87)	(.81)	(.93)	(.73)	(.75)

daily sessions of extinction with the unique handling cues prior to the critical test with the original cues reintroduced. The present study suggests that repeated extinction sessions are not necessary for distinctive cues to acquire discriminative control through correlation with extinction; at least for pigeons, a single extinction session appears to suffice. This makes the finding more relevant for an interpretation of spontaneous recovery, for that phenomenon is more typically observed following a single extinction experience.

Although these findings successfully demonstrate a role for handling and transportation cues in spontaneous recovery in pigeons, they do so under special circumstances. In most studies of spontaneous recovery, the subjects do not experience extinction under conditions of explicitly altered cues; rather, the same cues usually precede reinforced and extinguished training sessions. The procedure used in Experiment 1 may constitute discrimination training that might be expected to enhance the effectiveness of the manipulated

cues. The result is consistent with the view of Kamin (1969) and others on the role of "surprise" or the "violation of an expectancy" in enhancing learning. According to this view, when responding that had previously been reinforced is now extinguished, the distinctive cues that had preceded the extinction session are strongly associated with the extinction contingency.

The use of massed extinction in the presence of an altered stimulus does not always produce results similar to those obtained with discrimination training as normally administered. For example, Honig, Thomas, and Guttman (1959) followed VI reinforcement in the presence of a keylight of 550 nm with massed extinction in the presence of 570 nm. The result was not a peak shift and an increase in response rate, as occurs following typical successive discrimination training, but rather an overall reduction in the rate of responding during generalization testing in extinction. Whether it is reasonable to think of the procedure used in Experiment 1 as dis-

crimination training is perhaps best decided by determining whether the result obtained depended on the use of that procedure. This was the purpose of Experiment 2.

EXPERIMENT 2

Experiment 2 was an attempt to demonstrate the role of handling cues in a more typical study of spontaneous recovery. To this end, Experiment 1 was replicated except that following extinction, birds in one group were returned to their home cages so that their session that tested for recovery started on the next day in the normal manner. For the other group, when extinction was completed the birds remained in the darkened chambers for the entire 24-hr interval; thus their subsequent recovery test was not preceded by handling cues at all. If handling cues are effective discriminative or retrieval cues, then the handled group should show greater spontaneous recovery than the nonhandled group.

The procedure used in Experiment 2 differed from that used in Experiment 1 in two additional ways. The stimulus on the pecking key was a light of 490 nm, as produced by Kodak Wratten Filter No. 75, and subjects were given 16 rather than 8 sessions of training on the VI schedule, the latter change designed to reduce variability.

METHOD

Subjects and Apparatus

The subjects were 16 experimentally naive pigeons maintained as in Experiment 1. The apparatus was the same as in Experiment 1.

Procedure

The subjects were divided into two groups matched on the basis of response rates during sessions with reinforced responding. The procedure for Group 1 ($n = 8$) was the same as that for Group 1 of Experiment 1. The birds received the normal handling procedures preceding all sessions, including the extinction and the test sessions. The subjects in Group 2 ($n = 8$) were treated in the same manner as those in Group 1 except that when their performances met the extinction criterion, they were retained in the experimental chamber with the keylight, white noise, and houselight off but the ventilation fan on throughout the 24-hr

delay period. The birds in Group 1 received no supplementary feeding after the extinction session so that both groups were equally food-deprived at the time of testing 24 hr later.

RESULTS AND DISCUSSION

The results of this experiment are presented in Table 2 in the same format as for Experiment 1 in Table 1. Again the groups were well matched in relation to their training performances and their performances in the initial extinction session also were comparable. For Group 1, the mean number of responses in the first 10-trial block was 441.4, and the mean number of 10-trial blocks to meet the extinction criterion was 4.35. Comparable mean values for Group 2 were 471.5 responses and 4.63 10-trial blocks. For both comparisons, $t < 1$. Similarly, the two groups did not differ appreciably in total responses to extinction, with means of 1,173.5 and 1,182.5 for Groups 1 and 2, respectively ($t < 1$). The comparison of greatest interest, of course, is of the recovery scores for the two groups. The mean recovery score was .45 in Group 1, compared to .52 in Group 2. This difference was not significant ($t < 1$), and it indicates that the handling experience had no demonstrable effect on spontaneous recovery.

The mean recovery score for Group 1 was somewhat higher than that of the comparable group in Experiment 1 (.45 vs. .34). The difference is not statistically significant [$t(14) = 1.83$, $p > .05$] but is in a direction that might be expected in view of the fact that subjects in Experiment 2 received twice as many sessions of exposure to the VI schedule. The increased training did not produce any noticeable decrease in within-group variability, however.

It should be noted that the procedure used in Experiment 2 was actually biased in favor of finding evidence for the effectiveness of handling and transportation cues. During 24 hr in the dark, the pigeons in Group 2 roosted; therefore, at the onset of the spontaneous recovery test there was often a delay of from several seconds to a minute before responding commenced. Such delays were more rare in Group 1, and had this difference been taken into account, the subjects in Group 2 would actually have shown (insignificantly) more spontaneous recovery than those in Group 1. The lack of a statistically significant

Table 2

Responses per 10-min block of stimulus presentations for each subject in Experiment 2. The value designated by "T" refers to the single test block. The value in parentheses is the ratio of number of test responses to the number emitted in the first block of original extinction. The value designated "R" refers to the number of responses emitted during the last training session under VI 30-s reinforcement.

Normal Handling (Group 1)									
	#203	#206	#207	#209	#222	#227	#228	#281	$\bar{X}$
R	1,253	1,023	1,326	2,325	1,656	1,721	2,112	1,242	1,582
10-min blocks									
1	442	369	372	633	419	429	582	285	441
2	283	212	197	573	338	277	486	310	
3	165	50	58	489	313	348	375	83	
4	153		19	250	162	129	45	55	
5	107			178	46	57			
6				79					
T	309 (.70)	118 (.32)	175 (.47)	347 (.55)	158 (.38)	214 (.50)	268 (.46)	63 (.22)	(.45)
Held in Experimental Chamber (Group 2)									
	#204	#205	#208	#210	#223	#226	#229	#280	$\bar{X}$
R	1,650	971	1,211	2,152	1,323	1,951	1,584	2,140	1,622
10-min blocks									
1	524	220	324	561	435	758	429	521	472
2	563	185	310	587	416	408	415	457	
3	382	58	295	356	358	525	133	333	
4	223		150	121	25	266	28	217	
5	52		73			178		46	
6						85			
T	296 (.44)	106 (.48)	181 (.56)	390 (.66)	281 (.61)	576 (.76)	99 (.23)	219 (.42)	(.52)

between-group difference in Experiment 2 cannot be attributed to insensitivity of the measure of spontaneous recovery to experimental manipulations inasmuch as the same measure had revealed a highly significant effect in Experiment 1. It seems unlikely that the failure to find a difference between the spontaneous recovery scores resulted because subjects in Group 2 did not have access to water during their 24-hr confinement to the experimental chambers, but this confound was eliminated in Experiment 3.

EXPERIMENT 3

In Experiment 3 a possible role of handling cues in spontaneous recovery was assessed in two additional ways. One reason for the failure of normal handling cues to contribute to spontaneous recovery in Experiment 2 may have been the recency of the extinction experience. Although the handling cues had pre-

ceded extinction only once, that experience, because it occurred on the previous day, may have been sufficient to cancel out the effect of the 16 earlier sessions of reinforced responding. It would be an atypical procedure, but it would be of interest to see if handling cues could contribute to spontaneous recovery if they had been paired only with the reinforcement procedure and not with the extinction procedure. This was accomplished by preceding extinction with 10 min of reinforced responding, on the assumption that the handling cues would then be too remote from the extinction procedure to function discriminatively with respect to it.

This same assumption enabled us to test another group for spontaneous recovery in the absence of handling cues. These subjects were exposed to extinction in the normal manner, but on the next day they were placed into the experimental chambers 10 min prior to the start of testing for spontaneous recovery. The

rationale for this was that this procedure would be less disruptive than the overnight stay in the chambers used in Experiment 2, and yet would minimize the role of handling cues. Indeed, pilot work had indicated that if the birds are placed in the darkened chambers for 10 min prior to the start of a session, and if the ventilation fan is turned on and the houselight, keylight, and white noise are turned on several seconds thereafter, the birds initiate responding as quickly as they would if the session had started immediately upon their being placed in the chambers. For a third (control) group of birds, both extinction and testing for spontaneous recovery were carried out in the normal manner.

Another change from Experiment 2 was a reprogramming of the equipment such that there were no timeout periods during any phase of Experiment 3. It is unclear what effect, if any, timeout periods would have had on the possible role of handling cues, but because they have not typically been employed in other studies of spontaneous recovery, it was thought desirable to eliminate them.

METHOD

Subjects and Apparatus

The subjects were 24 experimentally naive pigeons, maintained as in Experiment 1. The apparatus was the same as in Experiment 1.

Procedure

The subjects were given 16 sessions of exposure to the VI schedule of reinforcement, and then were divided into three groups matched on the basis of their response rates. The procedure for Group 1 ($n = 8$) was the same as that for Group 1 of Experiment 2. The birds were given the normal handling procedure prior to each session, including the extinction and the test sessions. The subjects in Group 2 ($n = 8$) were treated in the same manner as those in Group 1 on the day of testing, except that during the preceding session, extinction was initiated after 10 min of exposure to the reinforcement procedure. The subjects in Group 3 ($n = 8$) were exposed to extinction in the normal manner, but for purposes of testing for spontaneous recovery on the next day, they were placed in the chambers 10 min before the session began. Extinction was carried out to the same 25% criterion used in the preceding experiments, and for all

groups the test for spontaneous recovery consisted of 10 min under extinction conditions.

RESULTS AND DISCUSSION

The results of this experiment are presented in Table 3 in the same format in which those of the earlier experiments were presented in Tables 1 and 2. The three groups were well matched in relation to their training performances. Group 2, which was exposed to extinction immediately after 10 min of reinforced responding, showed greater resistance to extinction than did the other two groups. The subjects in Group 2 required a mean of 6.50 10-trial blocks to meet the extinction criterion, compared to 4.63 and 4.63 blocks for Groups 1 and 3, respectively [$F(2, 21) = 4.12$, $p < .05$]. Similarly, for Group 2 the mean number of responses during extinction was 2,101, compared to 1,619 and 1,494 responses in Groups 1 and 3, respectively [$F(2, 21) = 1.66$, $p > .05$]. The differences in both measures are in the expected direction. All previous training sessions had lasted 30 min, so for Group 2 the initial period with reinforcement should have served as a discriminative cue predicting the availability of continued reinforcement.

The three groups did not differ significantly in the mean number of responses made in the first 10-trial block of extinction. Groups 1, 2, and 3 yielded means of 599, 533, and 514 responses, respectively ($F < 1$). The comparison of greatest interest, of course, is of the recovery scores for the three groups. The mean recovery scores were .50, .53, and .58 in Groups 1, 2, and 3, respectively ($F < 1$). The failure of Group 2 to show more spontaneous recovery than Group 1 is strong evidence against a role for handling cues. In Group 2 those cues had been paired only with reinforcement and never with extinction; yet they did not produce enhanced responding in comparison with Group 1, the control group, nor with Group 3, which was tested in the absence of handling cues altogether. In one respect, Group 2 in Experiment 3 was analogous to Group 2 in Experiment 1: In both cases the normal handling cues had accompanied reinforcement and not extinction. This was not sufficient for those cues to enhance responding in Experiment 3, indicating that the critical feature in Experiment 1 was the use of discrimination training. The failure of Group 3

Table 3

Responses per 10-min block of stimulus presentations for each subject in Experiment 3. The value designated by "T" refers to the single test block. The value in parentheses is the ratio of number of test responses to the number emitted in the first block of original extinction. The value designated "R" refers to the number of responses emitted during the last training session under VI 30-s reinforcement.

Normal Handling (Group 1)									
	#23	#24	#25	#26	#1	#3	#4	#5	$\bar{X}$
R	1,420	1,652	2,352	2,104	1,352	2,017	1,323	1,217	1,680
10-min blocks									
1	350	490	1,040	761	529	711	455	452	599
2	322	504	872	729	407	700	301	389	
3	158	315	94	313	495	300	349	163	
4	10	42		0	217	53	333	190	
5					162		52	53	
6					306				
7					282				
8					56				
T	149 (.43)	294 (.60)	425 (.41)	433 (.57)	354 (.67)	186 (.26)	158 (.35)	331 (.73)	(.50)
Extinction after 10 min (Group 2)									
	#6	#7	#8	#9	#10	#11	#12	#13	$\bar{X}$
R	1,247	2,114	1,620	1,512	2,421	2,072	978	1,347	1,664
10-min blocks									
1	441	610	534	459	760	599	388	473	533
2	443	513	468	473	586	512	449	429	
3	411	328	422	512	433	397	268	379	
4	325	109	162	210	88	452	261	245	
5	226		142	272		377	20	273	
6	170		303	190		418		147	
7	132		187	244		241		230	
8	5		20	46		36			
T	281 (.64)	344 (.56)	366 (.68)	84 (.18)	425 (.56)	340 (.57)	248 (.64)	197 (.42)	(.53)
Test after 10 min (Group 3)									
	#19	#20	#21	#22	#27	#28	#29	#30	$\bar{X}$
R	2,113	2,473	1,347	1,412	2,621	977	1,628	1,173	1,718
10-min blocks									
1	725	698	546	252	907	231	405	350	514
2	721	600	297	173	599	193	176	505	
3	511	547	212	170	361	158	88	61	
4	507	363	84	82	713	12		0	
5	134	170		0	273				
6	41				94				
T	325 (.45)	426 (.61)	281 (.52)	150 (.59)	447 (.49)	156 (.68)	232 (.57)	242 (.69)	(.58)

to show reduced spontaneous recovery replicates the results obtained with the overnight group (Group 2) in Experiment 2. This also indicates that the use of timeout periods in Experiment 2 played no role in the results obtained. The three experiments, taken in combination, make it clear that in the absence of explicit discrimination training the han-

dling cues that precede reinforced training sessions for pigeons gain no discriminative control over responding.

GENERAL DISCUSSION

It would be premature to conclude that because handling cues play no role in sponta-

neous recovery in pigeons that the same would be true of other animals as well. Rats, for example, may be more sensitive than pigeons to such effects. So far as we know, however, there have been no direct tests in rats comparable to our Experiments 2 and 3. The Welker and McAuley (1978) study used a procedure similar to our Experiment 1, and it is subject to the same criticism—that is, it employed explicit discrimination training. Two other studies have often been cited in the literature as offering support to Skinner's position on spontaneous recovery. A study reported by Kendall (1965) gave pigeons VI training followed by three 2-hr sessions of extinction during which 1-min stimulus periods were alternated with 1-min timeout periods. When the timeout periods were discontinued during a test session, responding recovered. Kendall claimed that this finding supports Skinner's (1950) analysis of spontaneous recovery. Note, however, that this interpretation assumes that timeout periods (or more specifically, their absence) function analogously to handling and transportational cues. More important is the fact that the birds received extensive "discrimination" training that enabled timeouts to become discriminative stimuli with respect to extinction. Thus the absence of timeouts was positively correlated with availability of reinforcement, thereby generating enhanced responding. Kendall's experiment is analogous to our Experiment 1 except that he manipulated cues that *accompanied* training sessions, whereas we manipulated cues that *preceded* training sessions.

Similar criticisms apply to the experiment that Skinner (1950) reported as evidence for his position on spontaneous recovery. Pigeons' pecking at a yellow triangle was intermittently reinforced, and then a red triangle was presented, accompanied by extinction. Reintroduction of the yellow triangle temporarily reinstated a high rate of responding. Aside from the problem of the use of explicit discrimination training, this experiment requires the assumption that handling and transportational cues, which are not very salient and which precede the behavior in question, will function analogously to a highly salient cue, key color, which accompanies the behavior in question. More importantly, one may question whether Skinner's experiment demonstrates spontaneous recovery at all. This phenomenon is typically defined as the recovery,

with a rest, of a previously extinguished response. If we define the response as pecking at a yellow triangle, then the recovery of responding upon reintroduction of this stimulus does not constitute spontaneous recovery because key pecking was never extinguished in the presence of this stimulus. In an experiment by Burstein and Moeser (1971), pigeons showed substantial responding to a distinctive stimulus (colored light) that had signaled the start of a series of reinforced trials. As in the case of Skinner's experiment, however, because responding to the distinctive stimulus had never been extinguished, such responding may be a phenomenon distinct from spontaneous recovery.

The various experiments we have analyzed demonstrate discriminative stimulus control in the sense that in each case stimuli correlated with reinforcement generate higher levels of responding than do stimuli correlated with extinction. The claims that these studies support Skinner's (1950) analysis of spontaneous recovery are unjustified, however, because they all involve explicit discrimination training. Not only is such training not usually involved in the study of spontaneous recovery, the very opposite is, in fact, usually the case. That is, the same stimuli that normally accompany the start of a session of reinforced responding also accompany the start of one or more extinction sessions. This should reduce the cue value of those stimuli, relative to what it was prior to extinction. Evidence consistent with this point is the suggestion from Experiment 1 that responding during extinction is disrupted by the change from normal handling cues; yet those cues did not contribute to spontaneous recovery in Experiments 2 and 3.

Note that our results do not support the interpretation that handling and transportational cues might serve as retrieval cues in memory. Thus the present results are inconsistent with our other research (see Thomas et al., 1981) on retrieval of discriminative performance by the contextual stimuli that had accompanied acquisition. Herein may lie a critical difference: Cues that accompany a training procedure may be more effective (either as discriminative stimuli or as retrieval cues) than are cues such as handling and transportational stimuli that precede training sessions and quickly dissipate. In demonstrating the ineffectiveness of such cues, we cannot refute the possibility that the other cues that

we were unable to manipulate are critical to spontaneous recovery. It seems fair to conclude, however, that no direct evidence seems to exist that this is so. Even if we had been successful in demonstrating a role for extraexperimental cues in producing recovery, there would have remained the problem of explaining the fact (see Ellson, 1938) that the magnitude of spontaneous recovery increases systematically with the amount of time elapsed subsequent to extinction. It must be admitted that a convincing theoretical treatment of spontaneous recovery is not yet within our grasp.

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