Changeover from unsignaled to signaled avoidance with and without a feedback stimulus in rats*

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Two experiments are reported in which, by pressing a lever, unsignaled avoidable shocks could be changed to signaled avoidable shocks for periods of 1 min, after which unsignaled avoidance was automatically reinstated. A correlated stimulus identified the signaled schedule. Under these conditions, Ss changed over at a rate sufficient to remain in the signaled schedule more than 90% of the time. Both experiments showed that changeover performance was under the control of the correlated stimulus. Presenting the signaled schedule without the correlated stimulus did not maintain changing over. The second experiment showed that a 1-sec presentation of the correlated stimulus was sufficient to maintain changeover performance. The results were attributed to the conditioned reinforcing properties of the correlated stimulus.

Previous research has shown that Ss will change from a situation in which shocks are unsignaled to one in which they are signaled. The degree of control Ss had over shock was not a factor since Ss chose the signaled condition whether shocks were avoidable (Badia, Culbertson, & Lewis, 1971), escapable, or inescapable (Badia & Culbertson, 1972). In this earlier research, it was difficult to assess whether choice of the signaled condition was controlled by the stimulus (signal) identifying a shock period or the stimulus identifying a shock-free period (safety). The two experiments reported here deal with signals identifying shock periods, while the second experiment deals with the conditioned reinforcing properties of a stimulus identifying safety.

In the study by Badia et al (1971), Ss were given signaled shock for several sessions after which they were given unsignaled shock. While in the unsignaled condition, a response on a changeover lever immediately produced a correlated stimulus and changed the condition to signaled shock for fixed 1-min periods. In the presence of the correlated stimulus, each shock was preceded by a signal. After showing that Ss changed to the condition that included both correlated stimulus and signal, the separate control exerted by these stimuli was assessed. Badia et al report two unexpected findings. First, considerable control over changeover responding occurred when only the correlated stimulus was presented while the signaled schedule was withheld. Second, little control over changeover occurred when the signaled schedule was presented while the correlated

stimulus was withheld. It was noted by Badia et al that the control exerted by the correlated stimulus alone was similar to that of the regular changeover condition where both the correlated stimulus and the signaled condition followed a response. Thus the correlated stimulus, and not the signaled schedule, seemed to be the reinforcer maintaining changeover performance.

In their account of these two findings, Badia and Culbertson (1972) suggested that the control exerted by the correlated stimulus was based upon its establishment as a conditioned reinforcer. They argued that the correlated stimulus acquired its reinforcing properties because under the signaled schedule shock occurred only in the presence of the compound of correlated stimulus and signal and never in the presence of the correlated stimulus alone. Therefore, the correlated stimulus alone reliably identified a shock-free (safe) period, and the compound of correlated stimulus and signal identified a shock (unsafe) period. The authors also speculated about why the signal condition without the correlated stimulus failed to control changeover performance. They concluded that when the correlated stimulus was no longer part of the contingency, a changeover response no longer provided immediate reinforcement (i.e., the correlated stimulus) indicating that a shock-free period was in effect.

It was assumed by Badia et al (1971) that the reinforcing event controlling changeover performance was the immediate presentation of the correlated stimulus (safety). Given this assumption, it might be expected that changing from unsignaled to signaled avoidance may be controlled as effectively with an immediate 1-sec presentation of the correlated stimulus as with one lasting the entire 1-min changeover period. The second experiment dealt with this issue, while the first served another purpose.

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EXPERIMENT I

The first experiment investigated the procedure whereby the signaled schedule without the correlated stimulus was contingent upon a changeover response. In the previous experiment (Badia et al, 1971), changeover responses resulted in 1-min presentations of the signaled schedule with a response-shock interval of 20 sec. Under this condition, Ss could receive a maximum of only three signals per changeover, and the delay between a changeover response and signal (maximum 15 sec) may have been a factor. Perhaps Ss would continue changing to the signaled schedule without the correlated stimulus if the delay period between a response and the signaled schedule were reduced. Therefore, the response-shock interval in Experiment I was reduced to 10 sec. This reduction resulted in a maximum delay of only 5 sec between a changeover response and signal and increased the maximum number of signals per changeover period (1 min) from three to six.

Method

Subjects. Three female albino rats of the Sprague-Dawley strain (Holtzman), between 130 and 160 days old, served as Ss.

Apparatus. All Ss were tested in operant chambers modified so that the grid bars were perpendicular to the levers. Two boxes, each with two Gerbrands levers, were enclosed in IAC acoustical chambers. These chambers were 36.8 cm long, 25.4 cm wide, and 12.7 cm high. The levers required about 20 g (0.196 N) to depress and were 5.08 cm from the side along the 25.4-cm wall, 7.65 cm above the grid floor. The right lever was used for avoidance responding and the left for changeover responding. A 1,400-Hz tone (86 dB) served as the preshock warning stimulus. Termination of a lamp (28ESB) with a 1.27-cm jeweled lens, located above the left bar, signaled the beginning of the experimental session, while its onset signaled the end of the session. A 2.54-cm white jeweled lens, illuminated with a 24-V bulb (S09K), was mounted above the right lever and served as the correlated stimulus. The correlated stimulus was always on during signaled avoidance, and off during unsignaled avoidance. A constant wattage shock source (BRS Inc.) delivered a .32-sec shock at 75 mW. Grid bars were of 0.64-cm stainless steel and were spaced 1.27 cm apart, center-to-center. The walls and response levers served as one contact in the grid scrambling circuit.

Procedure. Ss were run in 6-h sessions every other day. The following intervals prevailed for signaled avoidance: response-shock = 10 sec, shock-shock = 5 or 10 sec, response-signal = 5 sec, and signal-shock = 5 sec. For unsignaled avoidance, the response-shock interval was 10 sec and the shock-shock interval was 5 or 10 sec. Two Ss (A89 and A90) first received a shock-shock 5-sec interval and later received a shock-shock 10-sec interval, while one S (B11) received the reverse. In the signaled condition, every response reset the response-shock (or response-signal) interval. The signal came on if 5 sec passed without a response. If Ss allowed 10 sec to elapse, shock was delivered and the shock-shock interval began. Signals were not presented during the shock-shock interval. While in signaled avoidance, Ss could respond in the absence of the signal and avoid both the signal and shock, or respond in the presence of the signal to terminate it and avoid shock.

Initial Training: Signaled Avoidance. At the beginning of the experiment, each S received signaled avoidance training identified by the correlated stimulus. Responses on the

changeover lever, and the consequent amount of time that would have been spent in the changeover condition had these responses been effective, were recorded, though these responses produced no stimulus change. This latter measure served as the operant level baseline.

Changeover for Signaled Avoidance (CO). After signaled avoidance responding stabilized (stabilization never requiring fewer than three 6-h sessions), Ss began the next session with unsignaled avoidance. With unsignaled avoidance, Ss continued to avoid on the right lever; however, depression of the left (changeover) lever resulted in immediate onset of the correlated stimulus and put into effect the signaled avoidance schedule. A changeover response produced the correlated stimulus and the signaled avoidance schedule for a 1-min period; additional responses on this lever within the 1-min period were ineffective. At the end of this period, the correlated stimulus terminated and Ss could remain in the unsignaled condition or reinstate the signaled one by making another changeover response.

Changeover Extinction (Correlated Stimulus But No Signal—EX 2). The effects of presenting the correlated stimulus alone were revealed by the EX 2 extinction procedure. Ss were placed in the unsignaled condition, and a response on the changeover lever produced only the correlated stimulus for a 1-min period, and not the signal. In this condition, Ss received only unsignaled avoidance.

Changeover Extinction (Signal But No Correlated Stimulus—EX 3). The effects of presenting the signal alone on changing over were examined by allowing response to initiate the signaled schedule for 1-min periods, but without the correlated stimulus. Thus, by maintaining a sufficient rate of changeover, responding Ss could remain in signaled avoidance, but without the correlated stimulus to identify it. It should be noted that extinction always refers to changeover responding and never to avoidance responding.

Results

The data from each of the three animals are contained in Table 1. A relatively complete record for S A90 is found in Fig. 1. As shown, the response pattern across the various conditions for each S was similar for each of the measures. The most important measure was the amount of time spent in the signaled condition. Within three sessions after introducing the changeover condition (CO), Ss were spending from 85%-95% of the time in the signaled condition (Table 1).

After changeover responding stabilized under the changeover condition (CO), the EX 3 condition was put into effect. Under this condition, the changeover contingency consisted of presenting the signaled avoidance schedule but withholding the correlated stimulus which identified it. With this condition, changeover responding dropped to, or near, baseline levels (Table 1). When the regular changeover contingency was reinstated (i.e., both correlated stimulus and signaled schedule), changeover responding increased to a point where Ss were spending between 90% and 95% of the time in the signaled condition. Additional replications of these conditions gave identical results. In each instance, when the correlated stimulus was not part of the changeover contingency, changeover responding dropped to baseline levels. These results are identical to those reported by Badia et al (1971) for four of their Ss. In an effort to insure that Ss came into

Table 1
Data from the Last Three Days of Each Condition*

Data from the Last Phase Days of each condition											
		Baseline for CO)	Experimental Conditions								
	Days	CO	EX 3	CO	EX 3	CO	CO	EX 3	CO	EX 2	
S B11											
Changeover Times (Min)	1	111	340	46	343	20	342	332	10	345	279
	2	48	348	35	348	6	312	244	24	343	346
	3	64	348	46	347	13	343	345	6	343	345
Changeover Responses	1	181	510	134	385	24	353	341	13	350	286
	2	75	464	118	375	14	326	347	37	348	372
	3	111	389	79	362	11	339	348	7	345	354
Shocks	1	19	51	609	93	64	78	31	91	217	113
	2	21	62	156	23	73	137	21	95	11	83
	3	32	37	131	41	59	29	212	216	17	96
Avoidance Responses	1	3642	4929	3559	4108	5988	4527	5011	6695	4390	4697
	2	3616	3857	4923	3966	7268	4893	4526	6192	3907	5343
	3	3802	3747	4396	3965	6897	5065	5230	6228	3824	5195
S B12											
Changeover Time (Min)	1	44	121	10	337	3	296	325	7	310	276
	2	9	309	4	320	3	302	306	8	274	284
	3	3	312	7	348	3	295	315	3	315	277
Changeover Responses	1	119	156	36	351	5	302	329	8	321	279
	2	10	317	10	358	5	329	309	7	278	309
	3	6	318	9	393	6	328	347	4	324	287
Shocks	1	125	77	181	85	178	194	250	329	260	249
	2	33	39	264	84	156	120	227	291	301	202
	3	42	81	159	67	199	188	271	363	260	250
Avoidance Responses	1	4597	5184	4921	4430	7878	7089	8636	8807	4324	9306
	2	4014	4183	4104	4234	9576	7164	9374	7553	4687	8930
	3	3454	4215	4735	4099	10110	7341	6698	6934	5138	8320
S A90											
Changeover Time (Min)	1	55	341	110	349	11	348	348	10	347	348
	2	31	350	106	351	8	349	344	7	349	347
	3	16	348	66	350	6	349	348	7	347	347
Changeover Responses	1	172	802	252	445	34	357	446	21	448	383
	2	95	421	171	383	38	374	447	12	479	434
	3	47	390	79	399	11	544	522	17	475	391
Shocks	1	122	115	85	77	149	119	189	154	155	121
	2	75	97	95	48	140	105	150	143	202	157
	3	53	86	84	81	124	137	233	172	156	285
Avoidance Responses	1	3102	3394	4152	3250	3880	3291	3373	3508	3428	3799
	2	3315	3087	3715	3145	3715	3333	3433	3911	3306	3840
	3	3159	3302	3779	3131	3787	3345	4017	3706	3403	3728

*Maximum changeover time was 360 min. Regular changeover (CO) refers to the contingency in which the correlated stimulus was presented immediately following a changeover response for a 60-sec period during which the signal preceded shock. The EX 3 contingency refers to the condition in which the signal preceded shock but the correlated stimulus was not presented. Under the EX 2 contingency, the correlated stimulus was presented but the signaled schedule withheld.

contact with the condition of signal alone (EX 3), the particulars of the present experiment differed from those of Badia et al. As noted, shorter R-S and S-S intervals were used, and several replications of the EX 3 condition were given in the present experiment. However, as seen in Table 1, these changes had little effect on the time spent in the changeover condition. It is clear that some stimulus other than the signal maintains changeover performance.

The marked control of the correlated stimulus on changeover responding was also reflected by performance under the EX 2 condition. This finding suggests the source of control over changeover

responding. Under this condition, the changeover contingency consisted of presenting the correlated stimulus but withholding the signal (i.e., unsignaled avoidance remained in effect). With this contingency in effect, each S continued changing over at a rate nearly equal to that under the regular changeover condition (Table 2). The control exerted by the correlated stimulus alone is not surprising. As noted earlier, shock almost invariably occurred in the presence of both correlated stimulus and signal, or in the absence of both of them. In contrast, the correlated stimulus in the absence of the signal identified a relatively shock-free (safe) period and, based upon this, it may have acquired

Fig. 1. Percent of session time spent in the changeover condition for the last three sessions of each condition. Conditions appear in the order that they were administered.

conditioned-reinforcing properties. This analysis suggests further that the compound of the correlated stimulus and signal should be aversive.

In general, both shocks and avoidance responses tended to be higher under the unsignaled condition, and it is tempting to attribute changeover responding to these factors. One could argue that when the signaled condition was changed, Ss received fewer painful shocks and expended less energy. The strongest argument against this interpretation is that Ss behave identically when shock is unavoidable but escapable and when shock is unavoidable and inescapable (Badia & Culbertson, 1972). Under the latter conditions, shock and response rates are the same for both the signaled and unsignaled conditions.

EXPERIMENT II

Changeover responding dropped markedly under the signal-alone condition (EX 3) even though the signaled avoidance schedule continued to be presented following

a changeover response. In contrast, when only the correlated stimulus was presented and the signal withheld, changing over occurred at a high rate. The importance of the correlated stimulus in controlling changeover responding is apparent, but the specific role it plays is puzzling. One important function that it may serve is that of providing the S with immediate feedback (reinforcement) that a shock-free period is in effect. Thus, the continued presence of the correlated stimulus may be unnecessary. To test this notion, both feedback and no-feedback conditions were presented. Under the feedback condition, the correlated stimulus was presented for only a 1-sec period following a changeover response. The no-feedback condition was the same as EX 3 of the first experiment in that the signaled avoidance schedule was presented, but the correlated stimulus was withheld following a changeover response. The remaining condition consisted of presenting the 1-sec correlated stimulus, but withholding the signaled schedule. The Ss used in the first experiment were also used in the second one.

Table 2
Data from the Last Three Days of Each Condition*

		Experimental Conditions						
	Days	CO	EX 3 FB	EX 3	EX 3 FB	EX 2 FB	EX 3 FB	EX 2 FB
S B11								
Changeover	1	342	312	61	333	329	321	324
Time (Min)	2	346	317	36	356	301	326	302
	3	345	318	33	334	273	325	309
Changeover	1	346	609	131	689	900	641	700
Responses	2	377	469	57	689	639	766	585
	3	364	460	64	711	542	874	693
Shocks	1	25	41	70	29	53	28	108
	2	20	59	43	36	37	27	202
	3	20	114	47	24	109	22	35
Avoidance	1	4468	5152	6652	4881	5491	4830	4637
Responses	2	4245	4604	7748	5335	7028	4984	4213
	3	3957	4231	7353	4765	6881	5230	5867
S B12								
Changeover	1	237	240	84	285	100		
Time (Min)	2	254	250	74	278	89		
	3	246	261	84	273	81		
Changeover	1	247	452	98	427	226		
Responses	2	255	401	91	357	150		
	3	241	489	100	325	150		
Shocks	1	209	320	517	266	343		
	2	237	326	474	378	331		
	3	317	387	508	313	373		
Avoidance	1	4531	4991	4866	4881	5080		
Responses	2	4625	5192	4741	4803	5031		
	3	4690	4901	5150	4706	5231		
S A90								
Changeover	1	341	277	183	304	108		
Time (Min)	2	342	293	183	314	101		
	3	345	294	186	290	91		
Changeover	1	512	617	386	542	625		
Responses	2	498	473	311	580	377		
	3	437	598	308	494	478		
Shocks	1	193	217	212	171	303		
	2	218	245	166	179	296		
	3	148	118	204	241	281		
Avoidance	1	3547	3987	4309	4105	3867		
Responses	2	3586	3967	4196	3838	3994		
	3	3162	3803	4246	4133	3877		

*Maximum changeover time was 360 min. Regular changeover (CO) refers to the contingency in which the correlated stimulus remained on for 60 sec during which the signal preceded shock. The EX 3 contingency refers to the condition in which the signal preceded shock but the correlated stimulus withheld. Under the EX 3 FB contingency, the signal preceded shock and a 1-sec correlated stimulus followed the changeover response. Under the EX 2 FB contingency, a 1-sec correlated stimulus followed the changeover response but the signaled schedule was withheld.

The conditions were identical to those of the first experiment except for the duration of the correlated stimulus. A changeover response produced only a 1-sec presentation of the correlated stimulus, but produced the signaled schedule for a 1-min period. Additional responses within this 1-min period were ineffective (i.e., did not alter the 1-min interval or result in further presentations of the 1-sec correlated stimulus).

Results

The data for the three Ss of the second experiment are found in Table 2 and Fig. 2. It is evident that when

the changeover contingency consisted of a 1-sec correlated stimulus and the signaled avoidance schedule (EX 3 FB), responding for each S remained at a high level. However, when the 1-sec correlated stimulus was removed from the contingency and only the signaled avoidance condition presented (EX 3), changeover responding dropped to near baseline levels for all Ss.

For two of the three Ss (B12 and A90), simply presenting the 1-sec correlated stimulus, without providing the signaled avoidance condition, was not sufficient to maintain responding. Under this condition, changeover responding dropped to baseline levels. This

Fig. 2. Percent of session time spent in the changeover condition for the last three sessions of each condition. Conditions appear in the order that they were administered.

was not the case for S B11. The 1-sec exposure of the correlated stimulus alone (EX 2 FB), without the signaled schedule, was apparently sufficient to maintain changing over at a high level for this latter S. Changeover responding for this S continued at a high level for the last six 6-h sessions of the experiment, three of which are shown in Fig. 2.

Relative to the regular changeover condition, the number of changeover responses, avoidance responses, and shocks increased under the EX 3 FB condition. The increase in these response measures suggests that, while this condition will maintain changeover responding, the efficiency of performance is reduced. The most obvious reason for the latter is that the shock-free periods are no longer as identifiable with the 1-sec stimulus relative to the regular changeover condition.

GENERAL DISCUSSION

It is apparent that when both the correlated stimulus and signal were presented, in contrast to either one being presented alone, control over changeover responding was

greatest. Whether the correlated stimulus remained on throughout the changeover period or whether it was presented for a 1-sec period had little effect on the time spent in the changeover condition if the signaled schedule was also presented. In contrast, presenting the signaled schedule and withholding the correlated stimulus resulted in a marked decrease in changing over. However, presenting the correlated stimulus for the entire changeover period but withholding the signaled schedule had little effect (EX 1), since Ss continued changing over. In the second experiment, this latter finding occurred for only one of the three Ss. However, it took over several 6-h sessions for the two Ss which did not continue changing over before a decrement in changeover responding occurred. Based upon these data, it would appear that the correlated stimulus acquires properties similar to those of a conditioned positive reinforcer. In this regard, the data support the earlier interpretation of choice, which suggests that the preference for a signaled shock situation is maintained by stimuli identifying shock-free (safe) periods (Badia et al, 1971; Badia & Culbertson, 1972).

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NOTE

1. The notation identifying the conditions is the same as that used in previously published studies. We have retained the notation here to facilitate comparisons between them.

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