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THE RELATIVE AVERSIVENESS OF SIGNALLED VS UNSIGNALLED AVOIDANCE

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Subjects avoided shock by pressing on one lever under an unsignalled condition, but by pressing a separate lever they changed the condition to signalled avoidance for 1-min periods. Signalled avoidance periods were identified by a correlated stimulus. All eight subjects responded to change the unsignalled schedule to a signalled one. Once contact with signalled avoidance was made, subjects continued responding to remain in that condition. Other tests showed that changeover responding was greater when the correlated stimulus was presented without the signal than when the signal was presented without the correlated stimulus. An analysis based upon shock and shock-free periods is presented.

A considerable body of literature exists that describes the different behavioral characteristics generated by signalled and unsignalled Sidman avoidance. It has been found that subjects under discriminated avoidance consistently "wait" for the signal, (Hyman, 1969; Sidman, 1955; Ulrich, Holz, and Azrin, 1964) rather than avoid in its absence. It has also been shown that both response and shock rates are lower when signals are used. Based upon these findings it would be reasonable to assume that, given a choice, subjects would prefer signalled over unsignalled avoidance. The present research tested this assumption and focused on factors thought to affect relative aversiveness of signalled and unsignalled avoidance conditions. Specifically, this study attempted to determine whether a situation involved signalled free-operant avoidance was preferred to one involving unsignalled avoidance. A changeover procedure was introduced that allowed subjects to control the condition in effect. This procedure required that subjects avoid unsignalled shock by pressing on one lever (avoidance) but by pressing on a second lever (changeover) they could convert the schedule to signalled avoidance for 1-min periods.

METHOD

Subjects

Eight experimentally naive female albino rats of the Sprague-Dawley strain (Holtzman) between 90 to 125 days old served.

Apparatus

All subjects were tested in Foringer operant conditioning chambers modified so that the grid bars were perpendicular to the levers. Two boxes, each with two levers, were enclosed in IAC acoustical chambers. The third was housed in a Foringer acoustical apparatus. All three were 14.5 in. (36.8 cm) long, 10 in. (25.4 cm) wide, and 5 in. (12.7 cm) high. The levers required about 20 g (0.196 N) to depress and were 2 in. (5.08 cm) from the side along the 10 in. (25.4 cm) wall, 3 in. (7.65 cm) above the grid floor. The right lever was used for avoidance responding and the left lever for changeover responding. A 1400-Hz tone (86 db) served as the preshock warning stimulus for two boxes and a sonalert (76 db) for the third. In all boxes offset of a 0.5 in. (1.27 cm) white jeweled light above the left bar signalled the beginning of the experimental session and its onset signalled the end. A 1-in. (2.54 cm) white jeweled houselight (24 v) mounted above the right lever served as the correlated stimulus. For six subjects, the correlated light stimulus was always on wherever signalled avoidance was in effect and off under unsignalled avoidance. Two subjects had this reversed, the light was off for signalled avoidance and on for unsignalled avoidance.

For two boxes, a constant wattage shock

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source (BRS Inc.) delivered 0.32-sec shock at 75 mW. Shock in the third box was delivered by a Lehigh-Valley constant current source for 0.32 sec at 1 mA. Grid bars were 0.25 in. (0.64 cm) stainless steel spaced 0.5 in. (1.27 cm) apart center to center. The walls and response levers served as one contact in the grid scrambling circuit.

Procedure

Subjects were run in sessions 6 hr long every other day and six received the same conditions but often in a different order. (The two subjects that had the signal condition identified with light off were given only Extinction 2 and 3 described below). The following intervals prevailed for signalled avoidance: response-shock = 20 sec, shock-shock = 5 sec, response-signal = 15 sec, and signal-shock = 5 sec. For unsignalled avoidance, the response-shock interval was 20 sec and the shock-shock interval 5 sec. In the signalled condition, every response reset the response-shock (or response-signal) interval. The signal came on if 15 sec passed without a response. If subjects allowed 20 sec to elapse, shock was delivered and the shock-shock interval began. Signals were not presented during the shock-shock interval. During signalled avoidance, subjects 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.

Signalled Avoidance—Initial Training

At the beginning of the experiment, all subjects received signalled avoidance training identified by the correlated stimulus. Responses on the changeover bar and "time spent in changeover" were recorded, though these responses produced no stimulus change.

Changeover for Discriminated Avoidance (CO)

After signalled avoidance responding stabilized (never fewer than three 6-hr sessions), subjects began the next session with unsignalled avoidance. With unsignalled avoidance subjects continued to avoid on the right bar; however, depression of the left (changeover) bar resulted in immediate onset of the correlated stimulus and put into effect the signalled avoidance schedule. One changeover response produced the correlated stimulus and a signalled avoidance schedule for 60 sec; additional responses on this lever within this 60-sec period were ineffective. At the end of the 60-sec period, the correlated stimulus terminated and subjects could remain in the unsignalled condition or reinstate the signal condition by making another changeover response.

Changeover Extinction #1 (EX1)

All extinction procedures refer to the changeover response and not the avoidance response. The order of presenting extinction conditions varied but stable changeover responding was re-established before another extinction procedure was introduced.

Under this (EX1) extinction procedure, subjects were placed in unsignalled avoidance and neither the correlated stimulus nor the signal were presented following a response on the changeover lever. With this procedure, subjects always remained in the unsignalled situation. This condition allowed evaluation of the effects on changeover responding exerted by both correlated stimulus and signal and whether chaining problems existed.

Changeover Extinction #2 (EX2)

Evaluation of the effects of the correlated stimulus alone was provided by the second extinction procedure. Under this extinction, subjects were placed in the unsignalled condition; however, a response on the changeover lever produced only the correlated stimulus for 60 sec, and not the signal. Subjects in this condition again received only unsignalled avoidance.

Changeover Extinction #3 (EX3)

Effects of presenting signal alone without the accompanying correlated stimulus were examined under the final extinction procedure. With this extinction, a changeover initiated the signalled schedule for 60 sec, but did not produce the correlated stimulus. Thus, by maintaining a sufficient rate of changeovers subjects could remain in signalled avoidance but without the correlated stimulus to identify it.

Subjects Trained Initially on Unsignalled Avoidance

Two additional subjects (A92 and A93) were pretrained first with unsignalled avoidance. They were then placed into the signalled

Table 1A

Time spent in changeover for all subjects is shown for last three days of training and changeover, compared with first three days of extinction conditions. Maximum duration was 360 min (6-hr sessions). Only the first two changeover and extinction replications are shown.

	Training Last 3 Days			*Changeover* Last 3 Days			*EX 1* First 3 Days			*EX 2* First 3 Days			*EX 3* First 3 Days		
Subject	*1*	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*3*
A74 Exposure 1	13	66	55	297	312	332	72	40	52	346	340	256	234	149	147
A74 Replication				305	275	305							43	12	2
A78 Exposure 1	3	90	47	242	313	331	108	35	8	339	352	341	34	16	16
A78 Replication				330	330	334				349	335	67			
A82 Exposure 1	222	30	12	334	304	310	159	33	16	312	265	221	94	145	97
A82 Replication				262	235	255							178	200	228
A84 Exposure 1	71	21	4	294	321	316	45	76	82	334	333	305	102	49	90
A84 Replication				320	322	326	149	17	9	227	313	285	69	22	68

condition to determine if they would changeover to the unsignalled one. This condition evaluated whether subjects might simply prefer the original training condition. Following this, subjects were given the option to change from the unsignalled to signalled condition. Each option procedure was repeated twice, *i.e.*, changeover from signalled to unsignalled and changeover from unsignalled to signalled conditions.

RESULTS

The data clearly indicate that given a choice, all subjects preferred the signalled over unsignalled avoidance condition. All subjects, when placed into the unsignalled condition, acquired the changeover response within the first 6-hr session and all stabilized within three sessions. These latter statements include Subjects (L20 and L21) which were given light-off as the correlated stimulus for the signal schedule. It is apparent that neither onset or offset of illumination affected changeover responding (Table 1B).

Acquisition of the changeover response showed a clear pattern. Once contact with the changeover contingency was made, rate of changeover responding immediately increased. By the end of the first changeover session,

Table 1B

Time spent in changeover for all subjects is shown for last three days of training and changeover, compared with first three days of extinction conditions. Maximum duration was 360 min (6-hr sessions). Only the first two changeover and extinction replications are shown.

	Training Last 3 Days			*Changeover* Last 3 Days			*EX 1* First 3 Days			*EX 2* First 3 Days			*EX 3* First 3 Days		
Subject	*1*	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*3*
L20 Exposure 1	8	15	40	337	317	316				337	297	203	31	11	13
L20 Replication				262	297	281									
L21 Exposure 1	17	5	1	337	334	341				345	339	318	13	108	45
L21 Replication				337	343	341									
A67 Exposure 1	85	56	56	330	330	334	87	163	51	269	117	97	198	214	180
A67 Replication				301	301	309				238	204	273			
A70 Exposure 1	5	11	6	176	218	218	40	24	65	116	52	70	24	44	10
A70 Replication				182	213	243	49	45	36	323	270	209			

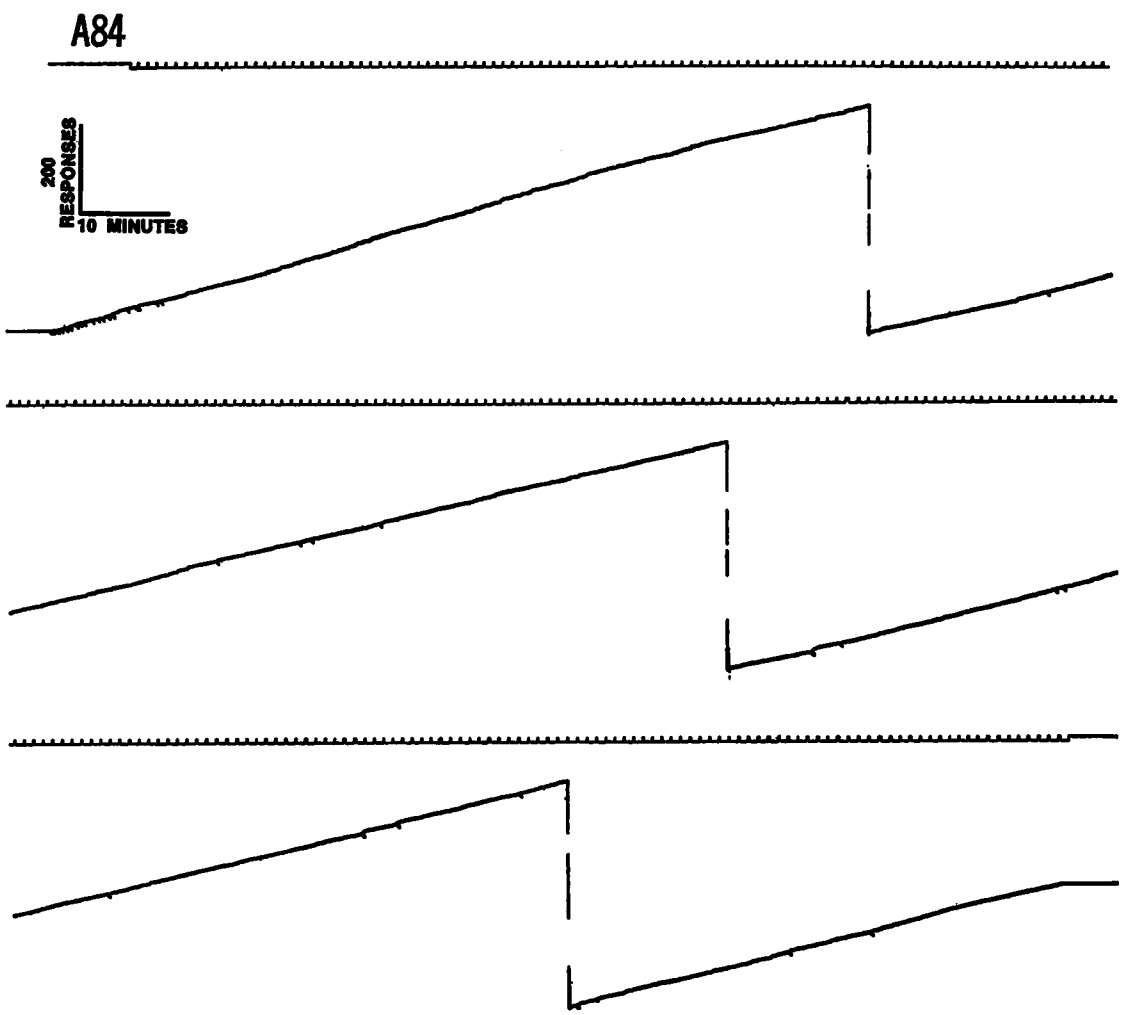

Fig. 1. A representative cumulative record (Subject A84) showing warm-up and the emergence of changeover and avoidance responding after considerable training. Avoidance responses are indicated by the stepping pen and a slash identifies shock. Downward deflections of the event pen (top line) represent successive 60-sec changeover periods.

each subject was spending virtually all its time in the signalled avoidance condition. Event records for each subject clearly illustrated the degree of behavioral control exerted by the correlated stimulus and the efficient changeover behavior that developed. Immediately after offset of the correlated stimulus, subjects reactivated it by making a single changeover response. During warm-up, little or no changeover responding occurred. Figure 1 shows a typical cumulative record illustrating warm-up for Subject A84. The pattern of responding seen in Fig. 1 is representative of all subjects in that both avoidance and changeover responding emerged at about the same time. However, as shown in Fig. 1, avoidance responding typically preceded changeover responding. Table 2 contains data taken from cumulative records of three subjects (A78, A82, A84) selected to show low, medium, and high warm-up times. Since changeover and avoidance responding tended to emerge at the same time, from the beginning of the session to the first changeover period defined warm-up. A comparison of number of shocks and shocks per minute (density) for signalled and unsignalled conditions can be made from Table 2. Table 2 shows that warm-up time varied from 1 to 53 min among subjects and that shock density was greatest during warm-

Table 2

Data taken from cumulative records of three 6-hr changeover sessions for subjects (A78, A82, and A84) selected to show low, medium, and high warm-up times. These data show, in minutes, time in warm-up, time in the unsignalled condition excluding warm-up, changeover time, and shocks received during these periods. Shock density (shocks per minute) is also shown.

	Warm-Up Period			*Unsignalled Condition Excluding Warm-Up*			*Changeover Condition*		
Subject	*Time*	*Shocks*	*Shock Density*	*Time*	*Shocks*	*Shock Density*	*Time*	*Shocks*	*Shock Density*
	1.87	22	11.7	74	23	0.31	284	51	0.18
A78	7.50	82	10.9	69	17	0.25	284	68	0.24
	5.93	51	8.6	57	4	0.07	297	116	0.39
	22.25	204	9.2	76	79	1.04	262	79	0.30
A82	53.12	226	4.3	72	59	0.82	235	123	0.52
	36.25	118	3.3	69	41	0.59	255	108	0.42
	1.87	10	5.3	37	0	0	321	17	0.05
A84	1.25	15	12.0	42	16	0.38	316	40	0.13
	1.87	6	3.2	38	14	0.37	320	17	0.05

up. The latter was true for all subjects. When warm-up is excluded from the analysis it can be seen also that subjects tended to have a higher shock density during the unsignalled condition, although some reversals did occur.

A relatively complete record of the duration of time spent under discriminated avoidance for Subject A84 can be found in Fig. 2. This figure includes only the last three days of each condition for the entire experiment and is

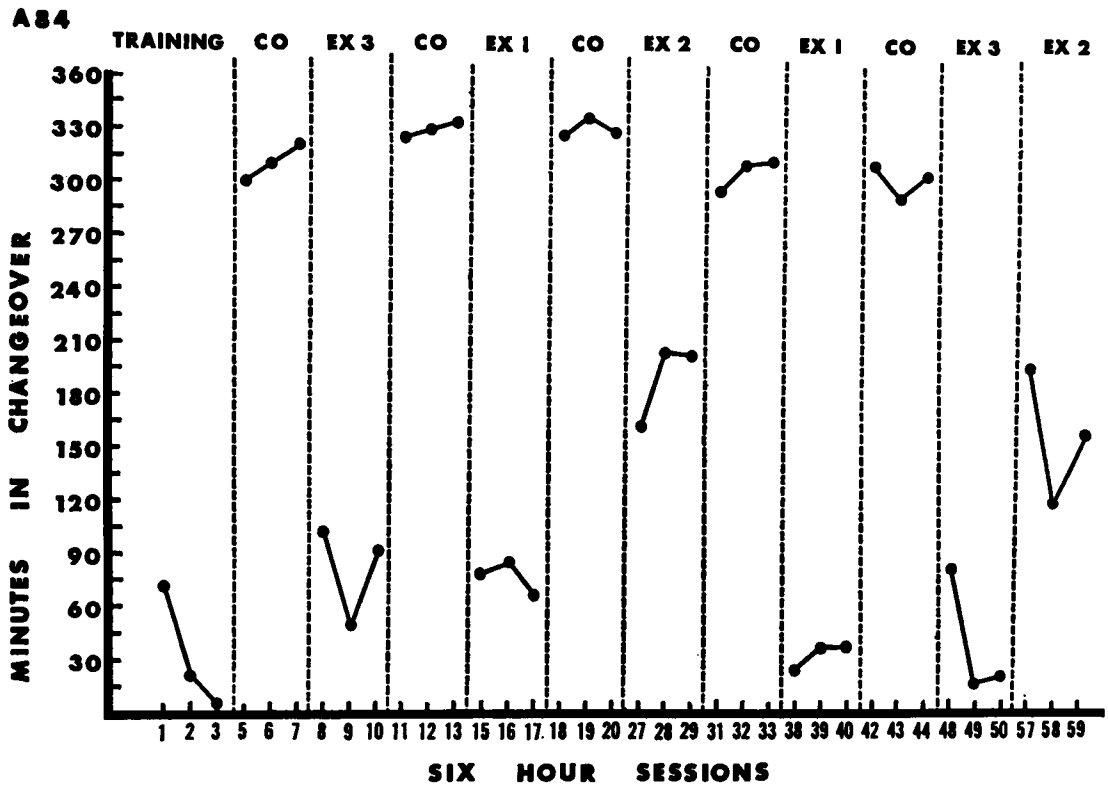

Fig. 2. Time spent in changeover for the last three sessions of each condition. Conditions appear in the order they were administered. Except for the last EX2 condition, all extinction procedures were preceded by regular changeover until responding stabilized.

typical of all subjects under changeover and EX1 conditions. The first three sessions illustrate baseline performance on the changeover lever. Within the first session (not shown in figure) of the changeover contingency, changeover duration increased from about 10 min (baseline) to about 200 min. Virtually all of the next three sessions were spent under the signalled avoidance condition (Sessions 5, 6, 7). Changeover time continued at a high level until the first changeover extinction procedure (EX3). As noted, with the EX3 procedure a changeover response changed the schedule from unsignalled to signalled avoidance but no correlated stimulus was presented.

Figure 2 indicates that under EX3 changeover responding for Subject A84 was sharply reduced. However, when the regular changeover condition was reinstated, *i.e.*, both correlated stimulus and signal, changeover responding again quickly increased and stabilized at a high level and remained high until the next extinction procedure (EX1). When neither correlated stimulus nor signal were scheduled to follow a changeover response (EX1) a reduction in responding occurred more rapidly and completely than with any other extinction procedure.

After EX1, stable changeover responding was re-established and then the next extinction procedure was introduced (EX2, correlated stimulus presented without the signal schedule). The results for Subject A84 were surprising and found in six of eight subjects (Table 1 A and B). Figure 2 shows the extent to which the correlated stimulus alone controlled behavior. Even after a total of nine days (54 hr) of this extinction procedure, changeover responding continued at a fairly high level.

The remainder of Fig. 2 shows that all three extinction procedures were repeated interspersed with reacquisition of the changeover response and the results were very similar. Table 1 (A and B) contains data on all subjects under changeover and extinction conditions for the first time that condition was presented and its first replication. Based upon the data in this table, it can be concluded that changeover responding showed greatest resistance to extinction when the correlated stimulus alone (EX2) was presented, followed next by the signal without the correlated stimulus (EX3) and least resistance to extinction when neither the stimulus or signal were presented (EX1). Exceptions to this conclusion were found in two of eight subjects (A67 and A82), in that both performed about equally under EX2 and EX3.

Other measures reflect the degree of behavioral control exerted by the various experimental conditions. Table 3 (A and B), contains data recorded on the last day that Subjects A78 and A84 were exposed to each condition. Except for differences noted in the text, the data for all eight subjects were very similar.

Table 3 shows that these subjects received fewer shocks and made fewer avoidance responses under changeover conditions than during extinction periods. With either the correlated stimulus-alone, signal-alone, or neither, both shock and avoidance response rates increased relative to rates under the changeover condition. Cumulative and event records suggested that the increase in response rate was general and not a function of response bursts following shocks.

The change in the interresponse time (IRT) distribution resulting from the signal schedule can be inferred from the number of potential signals (Table 3 A and B) each subject experienced. Potential signals include the total number of times the subject waited 5 sec before shock before responding. It is clear that the subjects "waited" (15 sec or more) for the signal while in that condition and generally responded in less than 15 sec while in an unsignaled condition.

Initial Training on Unsignalled Avoidance

After training first under unsignalled avoidance, Subjects A92 and A93 were placed into the signalled condition to determine if they would change back to the unsignalled one. Neither subject changed to the unsignalled condition. Instead, fewer changeover responses were made under this changeover condition than under baseline conditions. However, when subjects were given the option to change from unsignalled to signalled conditions, both changed. On the first day of changeover to signalled avoidance, Subject A92 went from a baseline of 0 min (no changeover responses) to 210 min (607 changeover responses). Subject A93 went from a baseline of 23 min (25 changeover responses) to 268 min (346 changeover responses). In subsequent sessions, both

Table 3A

Data from the Last Day of Each Condition Listed in Order Obtained for Subject A78

	Training	*CO*	*EX2*	*EX1*	*CO*	*EX2*	*CO*	*EX3*	*CO*	*EX2*
Sessions*	3	3	4	3	3	4	6	3	3	7
CO Responses	202	614	417	20	364	338	321	19	322	47
AV Responses	2827	2239	4355	4016	1982	2389	1808	2133	1706	1675
Shocks	244	136	56	418	171	765	202	586	259	792
Actual Signals	895	755			978		758	45	946	
Potential Signals	895	782	99	210	979	481	857	605	1032	811

*Total number of sessions subjects spent in that condition.

Table 3B

Data from the Last Day of Each Condition Listed in Order Obtained for Subject A84

	Training	*CO*	*EX3*	*CO*	*EX1*	*CO*	*EX2*	*CO*	*EX1*	*CO*	*EX3*	*EX2*
Sessions*	3	4	3	3	4	3	9	4	7	4	6	9
CO Responses	7	368	169	350	82	344	231	318	48	330	25	126
AV Responses	1634	2284	3775	1763	3446	1770	3095	1764	2893	1815	2875	3007
Shocks	80	71	53	34	54	50	61	54	69	94	98	57
Actual Signals	1116	784	76	948		905		855		789	38	
Potential Signals	1116	846	287	987	301	963	249	933	229	894	301	184

*Total number of sessions subjects spent in that condition.

animals spent over 300 of the possible 360 min in the signal condition. Subjects were run for twenty-one 6-hr sessions and each option was repeated twice. Results were highly similar for each replication. It was apparent that the pretraining condition had little or no effect on choice of signal condition.

DISCUSSION

The major findings of this study can be briefly summarized: (1) all subjects changed over to the stimulus situation that included both the correlated stimulus and signal, *i.e.*, chose signalled over unsignalled avoidance; (2) six of eight subjects did not changeover to signalled avoidance in the absence of the correlated stimulus; (3) the correlated stimulus in the absence of the signal did acquire some control over behavior.

One possible factor controlling changeover responding could be response effort, since subjects generally made fewer avoidance responses in the signalled than in the unsignalled condition (Table 3 A and B). Another important variable could be shock density within a session. Since subjects typically did not make changeover responses during warm-up, many shocks occurred during this short unsignalled period (Table 2). In contrast, shocks received while in the signal condition were distributed over a considerably longer period. Furthermore, even when warm-up shocks were excluded from the analysis and only shocks occurring subsequently were analyzed, within-session shock density in the unsignalled condition tended to be greater.

Subjects may have changed over to the signalled avoidance situation for other reasons. It could be that the signal predicts shock and that some form of preparation, following signal onset, reduced the aversiveness of this time period (Perkins, 1955). Another possibility is that the absence of the signal clearly identifies shock-free from shock periods, thus reducing the total period of time spent under aversive stimulation. In this latter instance, both signal and its absence provide information leading to behavior appropriate for the existing condition. It should be noted that this latter interpretation is not incompatible with a preparatory one. Data are available that support the notion that information provided by presence and absence of the signal results in different behavior. A recent study of signalled *vs.* unsignalled escape from shock (Badia and Culbertson, 1970) showed that both signal and its absence acquired control over different forms

of behavior. These investigators found that animals under signalled escape conditions explored more, and bar-held less, than when given unsignalled escape. Furthermore, exploration occurred in the absence of the signal (shock-free period) but immediately terminated in its presence (shock period). In addition, signal-onset often resulted in freezing or bar holding.

Data related to the present study and which deal with shock and shock-free periods are available, *e.g.,* Azrin, Hake, Holz, and Hutchinson, 1965; Azrin, Holz, Hake, and Ayllon, 1963; Verhave, 1962; Weisman and Litner, 1969*a, b*. These studies have shown that operant responses can be maintained by stimuli that identify shock-free periods. In particular, Azrin et al. (1963) showed that shock-free periods could reinforce fixed-ratio escape responding from stimuli that signalled shock periods. Similarly, Verhave (1962) found that timeout from avoidance was reinforcing. The two studies reported by Weisman and Litner (1969*a, b*) showed that stimuli correlated with shock (CS+) and shock-free (CS−) periods during differential Pavlovian conditioning affected subsequent avoidance responding. In the Weisman and Litner studies, the CS+ stimulus increased responding over a baseline when superimposed on unsignalled Sidman avoidance, but responding fell below the baseline when CS− was presented.

The present data tend to support an interpretation that deals with shock and shock-free periods. That the correlated stimulus presented alone continued controlling behavior (EX2) after many sessions suggests the importance of this condition. This latter finding is similar to those of Weisman and Litner (1969*a, b*) who found that CS− continued to affect avoiding responding across 14 avoidance sessions after Pavlovian conditioning was discontinued. The following illustrates why the correlated stimulus in the present study may have acquired its control. As noted, shock density was highest for subjects during the warm-up period of each session before changeover responding began to occur. Therefore, these shocks occurred in the absence of the correlated stimulus (unsignalled condition). Once changeover responding began, shock almost invariably occurred in the presence of the correlated stimulus and signal or their absence. Under these circumstances, the compound of correlated stimulus and signal would be expected to be aversive. Also, the absence of the correlated stimulus would be expected to acquire a relatively high aversive loading because the unsignalled schedule was in effect and, in addition to shocks during warm-up, more shocks generally occurred during this condition. It would seem that only the correlated stimulus in the absence of the signal identified a relatively shock free or safe period. Therefore, it should not be surprising to find that subjects preferred the changeover situation and to find that the correlated stimulus presented alone acquired considerable control over behavior.

A point not yet discussed concerns the performance of several subjects when, following a changeover response, the correlated stimulus was withheld and only the signal was scheduled (EX3). Except for Subjects A67 and A82, duration of time spent in changeover deteriorated considerably (dropped to baseline) when under EX3. For Subjects A67 and A82, time spent in changeover under EX3 also deteriorated slightly even though changeover responding increased. In some ways this deterioration was surprising, especially since the signal condition continued to be presented for 1-min periods following a changeover response. One obvious factor that may have facilitated extinction is that no immediate change in stimulation (feedback) occurred after a changeover response. Evidence indicating that feedback is a factor would not be incompatible with the explanation presented here.

REFERENCES

Azrin, N. H., Hake, D. F., Holz, W. C., and Hutchinson, R. R. Motivational aspects of escape from punishment. *Journal of the Experimental Analysis of Behavior,* 1965, **8,** 31-44.

Azrin, N. H., Holz, W. C., Hake, D. F., and Ayllon, T. Fixed-ratio escape reinforcement. *Journal of the Experimental Analysis of Behavior,* 1963, **6,** 449-456.

Badia, P. and Culbertson, S. Behavioral effects of signaled vs. unsignaled shock during escape training in the rat. *Journal of Comparative and Physiological Psychology,* 1970, **72,** 216-222.

Hyman, A. Stimulus characteristics of the pre-shock warning stimulus in free operant discriminated avoidance behavior. *Journal of the Experimental Analysis of Behavior,* 1969, **12,** 641-647.

Perkins, C. C., Jr. The stimulus conditions which follow learned responses. *Psychological Review,* 1955, **62,** 341-348.

Sidman, M. Some properties of the warning stimulus

in avoidance behavior. *Journal of Comparative and Physiological Psychology,* 1955, **48,** 444-450.

Ulrich, R. E., Holz, W., and Azrin, N. H. Stimulus control of avoidance behavior. *Journal of the Experimental Analysis of Behavior,* 1964, **7,** 129-133.

Verhave, T. The functional properties of a timeout from an avoidance schedule. *Journal of the Experimental Analysis of Behavior,* 1962, **5,** 391-422.

Weisman, R. G. and Litner, J. S. Positive conditioned reinforcement of Sidman avoidance behavior. *Journal of Comparative and Physiological Psychology,* 1969, **68,** 597-603. (*a*)

Weisman, R. G. and Litner, J. S. The course of Pavlovian excitation and inhibition of fear in rats. *Journal of Comparative and Physiological Psychology,* 1969, **69,** 667-672. (*b*)

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