

*THE RELATIVE AVERSIVENESS OF SIGNALLED VS  
UNSIGNALLED ESCAPABLE AND INESCAPABLE SHOCK*

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In the first study, subjects escaped shock by pressing on a lever under an unsignalled condition. By pressing a different lever they changed the condition to signalled escape for three minute periods. The second study used the changeover procedure to study inescapable-unavoidable shock. Seven rats were used in each study. All subjects in both studies changed over from unsignalled to signalled conditions. Once contact with the signal condition was made, subjects responded to remain in that condition. The three different extinction conditions showed that the correlated stimulus without the signal had greater control over responding than the signal without the correlated stimulus. An analysis based upon shock and shock-free periods was presented.

A recent study by Badia, Culbertson, and Lewis (1971) used a choice technique (changeover) in which animals responded on one bar to avoid unsignalled shock, but by responding on a second bar they could change the schedule to signalled avoidance for 1-min periods. The results of that study showed clearly that subjects chose signalled over unsignalled avoidance and that strong control over changeover responding was exerted by the stimulus correlated with the signalled schedule.

In their avoidance study, Badia *et al.*, analyzed the data in terms of shock and shock-free periods and suggested that the reinforcement for changeover responding was related to stimuli that identified these periods. However, since both shock and response frequencies were also lower under signalled avoidance, these factors could be considered plausible alternatives to the analysis in terms of shock and shock-free periods. The present study attempted to extend the Badia *et al.*, findings to both escapable and inescapable shock situations and in doing so, rule out differential shock and response frequencies as factors in choosing signalled over unsignalled conditions.

## EXPERIMENT 1

### METHOD

#### *Subjects*

Seven experimentally naive female, albino rats of Sprague-Dawley strain (Holtzman Co.)

90 to 120 days old at the start of the experiment were used.

#### *Apparatus*

Subjects were tested in two Foringer operant conditioning chambers containing two levers. Both chambers, enclosed in IAC acoustical boxes, were modified so that the grid bars were perpendicular to the levers and each measured 9.5 in. (24 cm) long, 10 in. (25 cm) wide, and 5 in. (13 cm) high. Levers required about 20 g (0.20N) to depress and were located 2 in. (5 cm) from the side along the 10 in. (25 cm) wall, 3 in. (7.6 cm) above the grid floor. The right lever was used for escape responding and the left for changeover responding. A 1400-Hz tone (86 dB) served as the preshock warning stimulus for both boxes. In each box, offset of a 0.5 in. (1.2 cm) white jewelled light (24 v) mounted above the left bar identified the beginning of the experimental session. Onset of a 1 in. (2.5 cm) jewelled light (24 v) mounted above the right lever served as the stimulus correlated with signalled shock for some subjects and offset of this light for others. Shock was delivered by a constant wattage shock source (BRS Inc.) set at 75 mw. Grid bars were constructed of 0.25 in. (0.64 cm) stainless steel spaced 0.5 in. (1.2 cm) apart center to

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center. The walls and response levers served as one contact in the grid scrambling circuit.

#### *Escape Procedure*

All subjects were run in sessions lasting 6 hr every other day. Signalled or unsignalled shock was delivered on a variable time schedule ranging from 30 to 210 sec in 30-sec blocks. These intervals were measured from shock offset to onset. The mean intershock interval was 120 sec and subjects received approximately 180 shocks per session. When in the signal condition, the tone preceded shock by 5 sec and terminated with shock. Only responses on the right lever (escape bar) terminated shock. To avoid spurious contingencies developing between the termination of shock and the changeover contingency, a 2-sec delay was scheduled for the changeover lever beginning with shock onset. During this delay, changeover responses did not produce the signalled schedule.

#### *Initial Training*

Three subjects (E47, E31, and E48) initially received four sessions of signalled shock in the presence of the correlated stimulus. Following this training, these subjects were given repeated exposure to the changeover condition and the three extinction conditions. The other four subjects (E13, E14, E16, and E17) received initial training for four sessions with a multiple schedule where signalled shock alternated every hour with unsignalled shock. These subjects were then exposed to the conditions of changeover, extinction, and reacquisition of changeover. During training, for all subjects, responses on the changeover bar and "time spent in changeover" were recorded, though these responses produced no stimulus change.

#### *Changeover for Signalled Shock (Changeover)*

Following initial training, subjects began the next session with unsignalled shock. With unsignalled shock, subjects continued to escape from shock on the right lever. However, a response on the changeover lever resulted in the immediate onset of the correlated stimulus and initiated the signalled shock schedule. One changeover response produced the correlated stimulus and signalled schedule for a 3-min period. Additional responses within this 3-min period were ineffective. At the end of the 3-

min period, the correlated stimulus terminated and subjects could remain in the unsignalled schedule or reinstate the signalled one by making another changeover response. Changeover responding determined only whether a signal would precede shock and did not change the program of shock delivery.

#### *Changeover Extinction #1 (EXT 1)*

The order of presenting the extinction conditions varied for the three subjects receiving all conditions but stable changeover responding was always re-established before another extinction procedure was presented.

Under this extinction procedure (EXT 1), subjects were placed in the unsignalled shock condition and neither the correlated stimulus nor the signal was presented following changeover responses. With this procedure, subjects always remained in the unsignalled condition. This condition allowed evaluation of the effects on changeover responding exerted by both correlated stimulus and signal.

#### *Changeover Extinction #2 (EXT 2)*

Effects of the correlated stimulus alone were evaluated with this procedure. In this extinction condition, subjects were placed in the unsignalled condition and changeover responses produced only the correlated stimulus for 3-min periods but not the signal. Subjects in this condition again received only unsignalled shock.

#### *Changeover Extinction #3 (EXT 3)*

Effects of presenting the signal alone without the accompanying correlated stimulus were examined under the final extinction procedure. With this procedure, a changeover response initiated the signalled schedule for 3-min periods, but did not produce the correlated stimulus. Thus, by maintaining a sufficient rate of changeover responding, subjects could remain in the signalled condition but with no correlated stimulus to identify it.

### RESULTS (ESCAPE)

The data revealed clearly that all subjects chose signalled over unsignalled escape from shock. Each of the seven subjects acquired the changeover response within the first three sessions and each stabilized within four sessions. When the changeover contingency was removed, changeover responding extinguished

E 47 ESCAPE

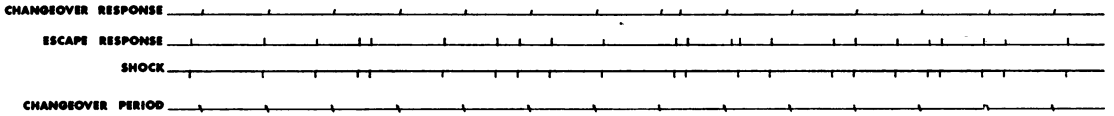


Fig. 1. A representative event record (Subject E47) showing the temporal relations that developed under escape conditions.

but was quickly reacquired when the contingency was reinstated. In addition, choice of signalled shock was not affected by the training procedure since subjects trained under different conditions performed in a similar manner.

Acquisition of the changeover response under escape conditions showed the same clear pattern for all subjects. This pattern was similar to that found under avoidance conditions (Badia, *et al.*, 1971). Once contact with the changeover contingency was made, rate of changeover responding increased immediately and usually stabilized within a few sessions (four subjects acquired changeover on the first day, two on the second day, and one on the third day). Under changeover conditions, each subject spent nearly the entire session in the signal condition. Shown in Figure 1 is a portion of a typical event record (Subject E47)

illustrating changeover responding. Two features of this record are informative. First, it can be seen that as soon as the changeover period timed out (termination of correlated stimulus), the subject reinstated it immediately and usually with a single response. This reflects the high degree of stimulus control exerted by the correlated stimulus. Second, it can be seen that changeover responding occurred independently of escape responding. The independence of these responses indicates that changeover responding was controlled by the changeover contingency and not spurious contingencies between the two levers.

Figure 2 shows a relatively complete record of the time spent in signalled escape under the various conditions of the experiment for Subject E47. Performance on the changeover lever is illustrated in the order that the conditions were presented but only the last three

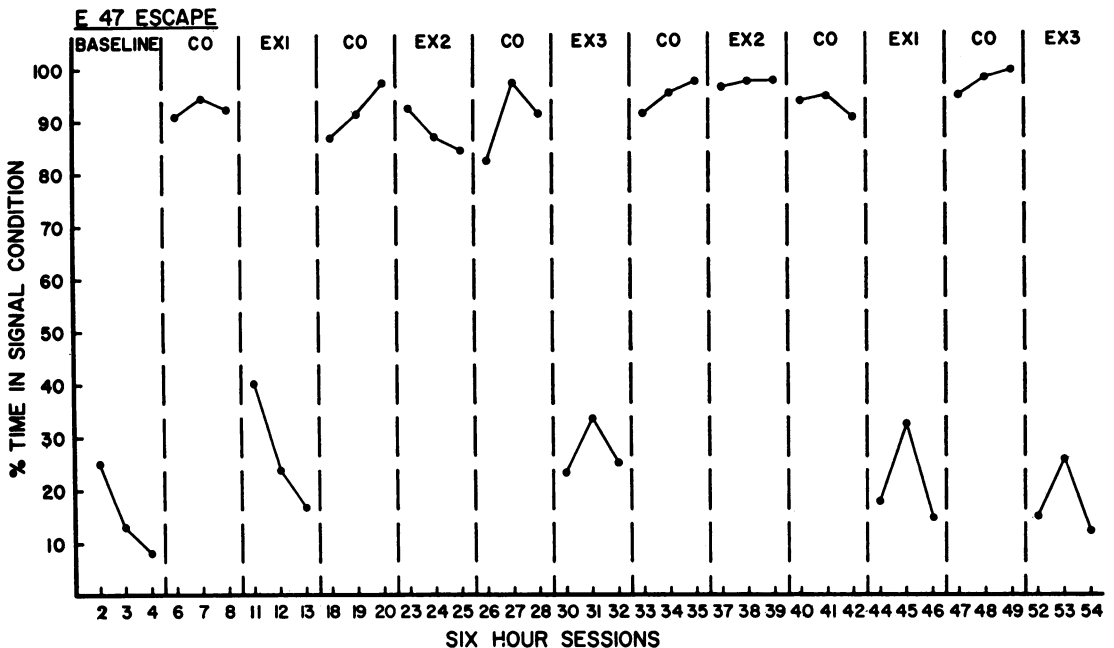


Fig. 2. Per cent of session time spent in changeover for the last three sessions of each condition. Conditions appear in the order they were administered. Each extinction condition was preceded by regular changeover until responding stabilized.

days of each condition are shown. While not shown in the figure, the first time changeover testing occurred for Subject E47 (Session 5) the percentage of time spent in the signal condition increased from the baseline of 8% (28 min) to about 69% (250 min). Subject E47 continued changeover responding at a high rate and nearly the entire next three sessions (Sessions 6, 7, and 8) were spent in the signalled condition, *i.e.*, 91, 94, 92% respectively. When the first extinction procedure was introduced (EXT 1), changeover responding dropped back to baseline levels. As noted, with EXT 1 procedure, neither the correlated stimulus nor signal were scheduled to follow a changeover response.

Following EXT 1, the changeover contingency of correlated stimulus and signal was reinstated until stable changeover responding was re-established. Sessions 18, 19, and 20 show the terminal effects of reinstating the contingency. As shown in Figure 2, nearly the entire period was spent in the signal condition during these three sessions.

The extent to which the correlated stimulus alone (EXT 2) controlled changeover responding was evaluated next for Subject E47 (Figure 2). After five 6-hr sessions of this extinction procedure, little change in responding occurred and the subject was still responding at a rate sufficient to spend 80% of time in this condition. As shown in Table 1, all three subjects exposed to this condition showed a similar pattern. However, the control exercised by the correlated stimulus alone was especially

marked for Subjects E31 and E47 (Table 1). Even after nine days (54 hr) of EXT 2, Subject E31 continued spending about 95% of the time in that condition.

Following EXT 2, the changeover contingency was again presented until changeover responding stabilized; then EXT 3 was introduced, *i.e.*, signal condition without the correlated stimulus. Within three sessions, changeover responding dropped to a point where Subject E47 was spending only between 25 and 30% of session time in the signal condition (Figure 2).

The remainder of Figure 2 shows that the three extinction procedures interspersed with reacquisition of the changeover response were repeated for Subject E47 and the results were very similar. Especially interesting were the data obtained under the repeated EXT 2 condition (correlated stimulus alone). Subject E47 (see E31 also) continued responding on the changeover lever at a rate sufficient to spend nearly 100% of time in the EXT 2 condition even after four 6-hr sessions.

Table 1 contains data for the three subjects that performed under all conditions of the experiment. This table includes all replications of the extinction conditions but only the first two replications of the changeover condition. Presented in Table 2 are data for the other four subjects that had the changeover condition replicated but that were given only one extinction condition (EXT 1).

The mean number of changeover responses over the last three sessions of each condition

Table 1

Per cent of time spent in changeover is shown for last three days of training and changeover compared with last three days of extinction conditions. Percentages are based upon 360 minutes (6-hr sessions). Only the first two changeover replications are shown. Numbers in parenthesis refer to number of sessions spent in that condition.

Subject	Last Three Days in Condition														
	Training			Changeover			EXT 1			EXT 2			EXT 3		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Exposure 1 E47	25	13	8(4)	91	94	92(4)	40	23	17(5)	92	86	84(5)	23	33	25(4)
Replication				87	91	97(4)	18	32	14(4)	96	97	97(4)	15	26	12(5)
Exposure 1 E48	12	6	20(4)	83	85	89(4)	32	15	14(4)	24	51	46(7)	17	23	31(8)
Replication				79	91	95(3)									
Exposure 1 E31	2	0	0(4)	79	94	96(8)	12	21	22(5)	96	91	93(6)	28	14	27(8)
Replication				94	91	96(5)	13	16	3(4)	90	92	95(9)	24	25	40(9)

Table 2

Per cent of time spent in changeover is shown for last three days of training, followed by changeover, EXT 1, and a repeat changeover. Percentages are based upon 360 minutes (6-hr sessions). Numbers in parenthesis refer to the number of sessions spent in that condition.

Subject	Last Three Days in Condition											
	Training			Changeover			EXT 1			Changeover		
	1	2	3	1	2	3	1	2	3	1	2	3
E13	1	12	12(4)	89	81	85(6)	32	30	21(7)	79	92	83(5)
E14	17	2	13(3)	77	73	78(5)	34	20	18(7)	68	63	70(4)
E16	18	30	29(4)	97	96	97(6)	18	26	11(6)	96	95	95(4)
E17	68	13	9(3)	92	94	96(5)	22	31	24(9)	87	94	94(4)

was examined for subjects exposed to the three extinction conditions. High response rates occurred for these subjects under both changeovers and EXT 2 conditions. Under EXT 1 and EXT 3 conditions, response rate dropped considerably for Subject E31 and E47. The mean number of responses over the last three days for Subject E31 was 202 in changeover and 199 in the EXT 2 condition. Under the EXT 1 and EXT 3 conditions, the mean number of responses for E31 was 35 and 34 respectively. Subject E48 showed a pattern of responding similar to the others except under the EXT 3 condition. For this latter subject, a relatively large number of responses was made even though only a short time was spent in the EXT 3 changeover condition. Analysis of the event records indicated that the large number of responses was due to occasional bursts of responding.

It is clear from Tables 1 and 2 that changeover responding is controlled most effectively by the contingency of both correlated stimulus and signal. Also apparent is that the correlated stimulus alone (EXT 2) controlled changeover responding more effectively than the signal alone (EXT 3). Little difference was found between the signal alone condition (EXT 3) and the condition in which neither the correlated stimulus nor signal were presented (EXT 1).

## EXPERIMENT 2

Signalled aversive events, as opposed to un-signalled ones, provide information about two time periods. In the presence of the correlated stimulus, the signal identifies a period of aver-

sive stimulation while the absence of the signal identifies a period free of aversive stimulation. In addition to identifying these time periods, the signal may also permit some degree of control over the aversive events. The degree of control would be related to the particular paradigm used. For example, with shock avoidance the signal allows the subject to reduce both shock and response rates (Badia, *et al.*, 1971). Using an escape procedure prohibits avoidance responding and holds shock frequency equal, but the signal may allow faster or less effortful escape. Even less control over the aversive event would result from a non-escape-nonavoidance procedure. In this latter instance, no response would be required and the signal would simply identify shock and its absence would identify shock-free periods. The question asked in the second study deals with whether changing to a signal condition is related to the degree of control a subject has over the aversive event.

### Subjects

Seven experimentally naive female, albino rats of the Sprague-Dawley strain (Holtzman Co.) 90 to 140 days old at the start of the experiment were used.

### Procedure

The same procedure and parameters were used except shock (0.5 sec) was inescapable and unavoidable. In addition, both levers served an identical function, *i.e.*, changed the schedule from un-signalled to signalled shock. As in the previous study, three subjects were given initial training under the signal conditions and then tested under all conditions of

Table 3

Per cent of time spent in changeover is shown for last three days of training, followed by changeover, EXT 1, and a repeat on changeover. Percentages are based upon 360 minutes (6-hr sessions). Number in parenthesis refer to the number of sessions spent in that condition.

Subject	Last Three Days in Condition											
	Training			Changeover			EXT 1			Changeover		
	1	2	3	1	2	3	1	2	3	1	2	3
I20	11	7	4(3)	82	83	84(7)	22	15	23(6)	82	84	86(8)
I22	34	41	27(4)	89	91	88(5)	26	13	12(7)	87	91	91(5)
I23	10	12	18(4)	97	96	96(7)	28	13	13(5)	93	96	96(5)
I24	9	21	8(3)	77	80	79(7)	39	28	38(10)	79	71	74(6)

the experiment. The other four subjects were trained under a multiple schedule and then tested on changeover, EXT 1, and reacquisition of changeover. A changeover delay of 2 sec following shock was used with all subjects.

#### RESULTS (UNAVOIDABLE)

The effects on changeover responding obtained with the nonescape-nonavoidance procedure were virtually the same as with the escape procedure of this study and the avoidance procedure reported by Badia *et al.*, (1971). Again, all subjects began changing over from the unsignalled to signalled condition within the first 6-hr session and within a few sessions, all subjects were spending from about 80 to 95% of session time in the signalled condition. Table 3 contains data for the four subjects that received only the changeover condition,

EXT 1, and then a repeat on the changeover condition. Table 4 contains data for the three subjects that received all three extinction conditions interspersed with repeated changeover sessions.

Acquisition of the changeover response showed the same pattern previously noted with the escape procedure and elsewhere with avoidance (Badia, *et al.*). Rate of changeover responding increased sharply once contact with the contingency occurred. The control over changeover responding exerted by the correlated stimulus was marked. Immediately following termination of the correlated stimulus, a single changeover response reactivated it. In addition, subjects responded on only one of the two levers during most of the time and these responses were independent of shock.

Table 4

Per cent of time spent in changeover for all subjects is shown for last three days of training and changeover compared with last three days of extinction conditions. Percentages are based upon 360 minutes (6-hr sessions). Only the first two changeover replications are shown. Numbers in parenthesis refer to the number of sessions spent in that condition.

Subject	Last Three Days in Condition														
	Training			Changeover			EXT 1			EXT 2			EXT 3		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Exposure 1	19	24	15(6)	89	94	92(4)	20	13	6(12)	58	73	70(12)	21	32	26(5)
I52 Replication				68	74	72(4)							37	14	10(4)
Exposure 1	5	4	1(4)	93	93	93(4)	39	32	32(7)	97	92	76(6)	22	24	17(6)
I56 Replication				97	97	99(3)	35	33	36(5)	93	75	83(6)	14	11	8(3)
Exposure 1	29	19	11(6)	88	96	94(3)	16	20	21(7)	94	93	91(6)	14	17	3(4)
I57 Replication				93	92	92(4)	24	29	15(4)						

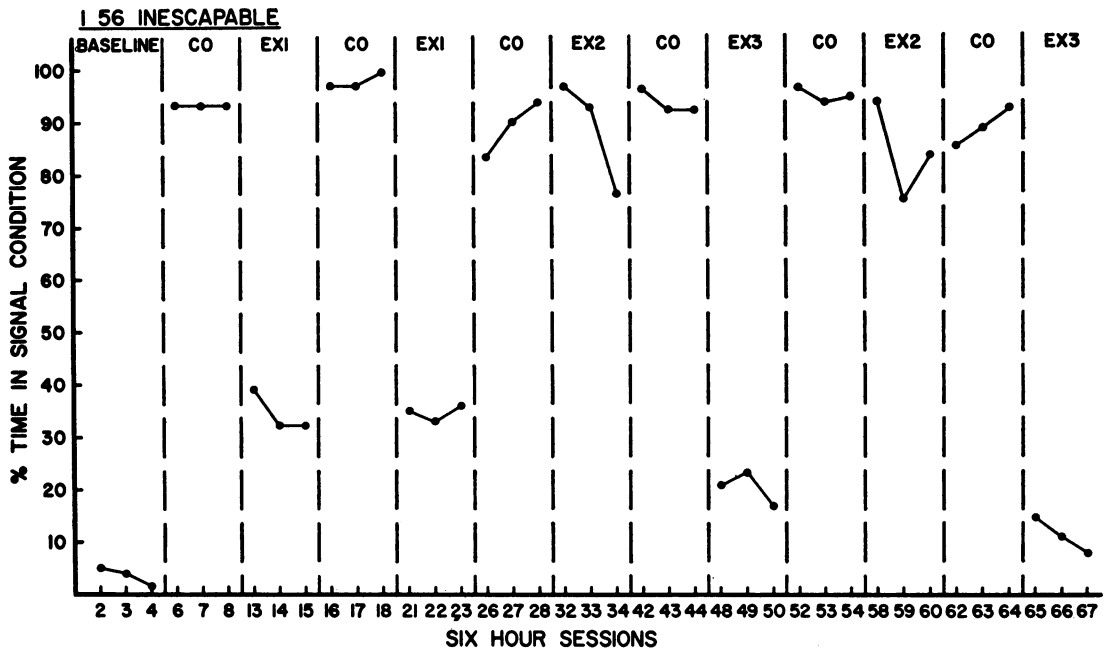


Fig. 3. Per cent of session time spent in changeover for the last three sessions of each condition. Conditions appear in the order they were administered. Each extinction condition was preceded by regular changeover until responding stabilized.

Figure 3 contains a relatively complete record of time spent in the signal condition under different conditions of the experiment for Subject I56. Changeover performance of this subject under the nonescape-nonavoidance procedure can be compared to that of Subject E47, which performed under the escape procedure (Figure 2). The behavior pattern for these two subjects is basically the same. The changeover contingency of correlated stimulus and signal acquired the greatest control over behavior for both subjects. Also, when neither stimulus was presented (EXT 1) or when only the signal was presented (EXT 3) changeover responding dropped sharply. In contrast, however, the correlated stimulus alone (EXT 2) exerted nearly as much control over changeover responding as the contingency of correlated stimulus and signal.

## DISCUSSION

The results of both escape and nonescape studies can be summarized: (1) all 14 subjects in both studies changed from an unsignalled situation to one that included both correlated stimulus and signal (CO); (2) when neither cor-

related stimulus nor signal was presented (EXT 1) changeover responding decreased sharply to or near baseline levels; (3) reinstating the contingency (CO) resulted in reacquiring the changeover response. Six of the subjects experienced all three extinction conditions with changeover sessions interspersed. For these subjects it was also obvious that the greatest control over changeover responding was exerted by the correlated stimulus and signal contingency. However, the condition of correlated stimulus alone (EXT 2) also exerted considerable control over changeover responding. Finally, when neither stimulus was presented (EXT 1) or when only the signal without the correlated stimulus was presented (EXT 3), changeover responding decreased to or near baseline levels.

The result of the two studies reported here are marked in their similarity. When comparisons are made of these results with those derived from an avoidance procedure (Badia, *et al.*) the similarity is no less marked. It is obvious that subjects choose signalled over unsignalled conditions whether the aversive control paradigm involves avoidable, escapable, or inescapable shock. Apparently, the degree of control a subject has over an aver-

sive event is not a crucial factor affecting choice of the signalled condition.

Badia *et al.*, (1971) reported that choice of the signal condition in their study may have occurred because subjects made fewer responses and received slightly fewer shocks with signalled avoidance. In the present study, choice of signalled shock cannot be attributed to differences in shock and response rates since either an escape or nonescape procedure was used.

It has been suggested that the reinforcement for choosing the signalled situation is related to discriminable shock (unsafe) and shock-free (safe) periods (Badia, *et al.*). This safety signal analysis is a variant of that put forth by Seligman (1968). The argument presented by these authors is also applicable to the present studies. Under the signal condition (CO), the compound of correlated stimulus and signal identified a shock period while the correlated stimulus in the absence of the signal identified a shock-free period. Therefore, when subjects were in the signal condition, the shock period was predictable and relatively brief, at most, lasting as long as the signal duration. Further, the shock-free period, identified by the correlated stimulus alone, was also predictable and considerably longer than the shock period because it consisted of the total intershock time minus the signal duration. In contrast to the two conditions in the signal situation, neither shock nor shock-free periods could be identified in the unsignalled situation and the entire intershock interval may have acquired the properties of a shock period. Therefore, the signalled situation may have been chosen over the unsignalled one because the unsafe period was shorter or, conversely, because the safe period was greater.

The extinction data of both studies also support a shock and shock-free period analysis. In contrast to the marked decrement in changeover responding under EXT 1 and EXT 3, changeover responding was affected very little by EXT 2. That the correlated stimulus alone (EXT 2) continued controlling changeover responding after many sessions should not be surprising, since it was this stimulus that identified the shock-free period during the changeover condition. It is possible that stimuli that identify shock-free periods may also acquire

reinforcing properties similar to discriminative stimuli in appetitive situations.

When the correlated stimulus was withheld but the signal presented (EXT 3), changeover responding dropped to a level comparable to EXT 1. This finding is also compatible with a shock-free period analysis. Since the shock-free period was not identifiable under either of these conditions, changeover responding would be expected to decrease. It should be noted that the EXT 3 data are not compatible with the preparatory response notion that has often been used to interpret choice of signalled aversive events (*e.g.*, Perkins, Levis, and Seymann, 1963). According to a preparation analysis, changeover responding under this condition (EXT 3) should have continued, since the signal was still scheduled to precede shock. However, it is possible that preparatory responses become conditioned to the compound of signal and correlated stimulus and thus the signal alone is not effective.

Other studies have shown that operant responses can be maintained by stimuli that identify shock-free periods (*e.g.*, Azrin, Holz, Hake, and Ayllon, 1963; Dinsmoor, 1962; Sidman, 1962; Verhave, 1962). In particular, the EXT 2 data are similar to those of Weisman and Litner (1969*a*, 1969*b*). These researchers found that a stimulus (CS-) identifying a shock-free period exerted a decremental effect on avoidance responding for 14 avoidance sessions after Pavlovian conditioning was discontinued. A related finding published by Weisman and Litner (1971) is that the duration of the shock-free period is also important. In some ways the data of this study are similar to those of Dinsmoor, Flint, Smith, and Viemister (1969) and of Defran (1971). These investigators used the observing response paradigm and found that subjects would respond for stimuli identifying food periods (Dinsmoor, *et al.*) or shock-free periods (Defran) but they would not respond for stimuli identifying shock periods.

The present data and those of others suggest the importance of considering the role of both positive and negative components in aversive control research. While this role is presently unclear, perhaps analyses that stress both shock and shock-free periods and the stimuli associated with each will help to clarify the issues. The question of why subjects prefer signals



before an aversive event is a case in point. For example, questions have been raised dealing with the properties acquired by preshock stimuli. Although some investigators have emphasized the cue properties of these stimuli (Herrnstein, 1969), others have attributed aversive properties to them. Given the latter statement, the fact that subjects choose signalled over unsignalled shock is not understandable. However, an analysis in terms of stimuli that identify shock and shock-free periods makes the present findings predictable.

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