CHOOSING SCHEDULES OF SIGNED APETITIVE EVENTS OVER SCHEDULES OF UNSIGNED ONES

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Two experiments were completed allowing albino rats to choose between signaled and unsigned reward conditions. These experiments examined the effects on preference of (1) response dependent versus response-independent reward and, (2) food pellets versus chocolate milk as the reward. All subjects preferred the signaled condition over the unsigned condition, whether exposed to response-dependent, or to response-independent delivery of rewards. Preference was controlled most effectively by presenting both the signal itself and the correlated stimulus identifying the signaled condition. The signal presented alone (Extinction 3) controlled preference more effectively than did the stimulus correlated with the signaled condition (Extinction 2). The second experiment showed that the quality of the reinforcer (pellets and chocolate milk) did not affect preference for signaled reward since all subjects preferred the signaled condition at levels comparable to those observed in Experiment 1, with food pellets. These results, along with others, argue against species differences, response-dependency, and reinforcer quality as variables affecting the direction of preference.

Key words: signaled food, preference, predictability

Predictable situations, either aversive or appetitive, usually involve two discriminable and informative components. One component signals the occurrence of an event (e.g., food or shock) whereas the other component signals the non-occurrence of the event. A number of researchers have studied how these components affect preference for predictable situations. An extended review of the literature dealing with aversive stimulation by Badia, Harsh, & Abbott (1979) concluded that predictable situations are preferred and that stimuli identifying shock-free periods control preference. The present study deals with choosing between signaled and unsigned appetitive conditions, for which published results have been less consistent. Some investigators report that subjects choose an unsigned over a signaled schedule (e.g., Hershisier & Trapold, 1971) where others report that subjects choose the opposite (e.g., Lewis, Lewin, Muehleisen, & Stoyak, 1974; Prokasy, 1956).

In general, when preference for the unsigned

condition is found investigators stress the importance of stimuli identifying the food-free period (e.g., Hershisier & Trapold, 1971). When preference for the signaled condition is found, however, investigators usually stress the importance of stimuli identifying the food period (Perkins, 1955). We do not know the conditions leading to these conflicting findings and identifying them is difficult since signal parameters, reinforcers, and procedures have varied among these studies. For example, some studies used contingent reward (Bower, McLean, & Meacham, 1966), others noncontingent reward (Hershisier & Trapold, 1971). In some cases food pellets were used (Prokasy, 1965), whereas in others liquid reinforcers were used (Hershisier & Trapold, 1971); some have used a commitment procedure (e.g., Lewis et al., 1974), others a noncommitment one (Hershisier & Trapold, 1971).¹ The research below assesses

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¹Two studies have reported a preference for signaled conditions using a noncommitment procedure that conflict with Hershisier and Trapold (1971). These studies used appetitive electrical stimulation of the brain as a reinforcer (Cantor & LoLordo, 1970, 1972). However, Cantor (1979) has argued that these conclusions should be questioned since the outcome of these studies may have been affected by an artifact related to the electrode and plug assembly. The end result of this artifact was a greater magnitude of reinforcement under the signaled schedule.

two of these procedural differences: (1) response dependent and independent reward, and (2) quality of the reinforcer.

EXPERIMENT 1

As noted, choosing between signaled and unsignaled conditions has been investigated with response-independent reward in some studies (e.g., Hershisser & Trapold, 1971) and response-dependent reward in others (e.g., Lewis *et al.*, 1974). Substantial differences in choice procedures preclude cross-study assessment of the role played by response-dependent or independent reward. Our first experiment, then, used a single procedure to examine choosing between signaled and unsignaled food deliveries when the reinforcer was contingent (response-dependent) and when it was noncontingent (response-independent).

METHOD

Subjects

Seven experimentally naive female albino rats (90 to 120 days) of the Sprague-Dawley strain (Holtzman Co.) were maintained at approximately 80% of their free-feeding weights. The subjects were individually housed with free access to water.

Apparatus

Subjects were tested in standard Foringer operant conditioning chambers (25 by 23 by 25 cm) housed in sound attenuating boxes. Two levers were mounted on the 25-cm wall, 7 cm above the floor and 4 cm from either side. Each chamber was fitted with a Plexiglas ceiling 12 cm above the grid floor. The beginning of an experimental session was identified by the termination of light provided by a 24-V dc bulb, capped by a 1.27-cm jewelled lens, and mounted 6 cm above the right lever; the onset of this light identified the end of the session. A tone generator (Mallory Sonalert) mounted 10 cm above the right lever produced a 4500-cps tone at 80 db and served as the prefood signal. The correlated stimulus identifying a condition (signaled or unsignaled) was the onset of light provided by two 24-V dc bulbs each with a 2.5-cm white jewelled lens cap. These lights were mounted 16 cm above each lever. The other correlated stimulus was darkness. Reinforcers consisted of Noyes food pellets (45 mg) delivered via a Davis feeder into a food cup

situated midway between the two response levers. Water was available throughout the session.

Procedure

Subjects E20, E23, E41, and E50 were tested using a response-dependent procedure. Each was trained to bar-press for food in the presence of the stimulus correlated with the unsignaled condition and the average interfood interval was gradually increased to 60 sec (VI 60-sec) over six sessions. The right lever served as the food lever and the left served as the changeover lever. The three additional subjects, S1, S2, and S3, were tested in a response-independent procedure. Reinforcers for these subjects were delivered independently of responding (VT 60-sec). Except for the initial bar-press training for subjects under the response-dependent procedure, all subjects were treated in an identical manner. Light was the stimulus correlated with the signaled condition for Subjects S1, E20, and E44, for other subjects it was darkness.

Subjects were tested in 3-hr daily sessions. Food pellets were delivered on an average of once a minute, according to a schedule generated by the Fleshler and Hoffman (1962) tables modified to accommodate a minimum interfood interval of 6 sec. One variable interval 60-sec tape was used to program both signaled and unsignaled reinforcers.

Training-Baseline. Subjects received a minimum of six training-baseline sessions consisting of an equal number of exposures to both a signaled and an unsignaled condition with the signaled condition presented on alternate sessions. For some subjects, darkness was correlated with the signaled condition and light was correlated with the unsignaled condition. For other subjects this was reversed. During the signaled condition, food was always preceded by a signal. For subjects in the response-dependent procedure, the first response on the food lever following the termination of a 5-sec signal was reinforced. Subjects in the response-independent procedure received reinforcers at the termination of the signal.

Responses on the changeover lever did not produce a stimulus change, but responses and the time that would have been spent in the changeover condition had the responses been effective were recorded and served as baseline data. The requirement for stability for this

condition and all others described below was three consecutive sessions in which the percent of time in the changeover condition varied no more than 10% between sessions (session to session). Exceptions to this criterion were allowed if performance variability persisted over many sessions. These exceptions were very infrequent and the few instances can be seen in the figures.

Changeover. Following the training-baseline sessions, subjects were given the opportunity to change from the unsigned condition to the signed condition and vice versa. A response on the changeover lever terminated the existing condition and produced the alternate condition for one minute. Further responding on the changeover lever during this period had no effect. At the end of the changeover period, the alternate conditions and the stimulus associated with that condition terminated and the initial condition was reinstated. Subjects could remain under this initial condition or they could reinstate the alternate one. Changeover responding had no effect on the delivery of reinforcers. Preference for one condition over the other was assessed by recording the percent of time subjects spent in the alternate condition during each session. As indicated earlier, a given procedure was continued until the stability criterion was met.

Changeover Extinction #1 (EXT 1). Subjects were placed in the unsigned condition and neither the stimulus correlated with the signed condition nor the signal preceding food was present following a changeover response. This condition allowed evaluation of the combined effects of the stimulus identifying the signed condition and the signal itself on changeover responding.

Changeover Extinction #2 (EXT 2). Subjects were placed in the unsigned condition and changeover responses produced the stimulus correlated with the signed condition but not the signal. Effects of the correlated stimulus alone were evaluated with this procedure.

Changeover Extinction #3 (EXT 3). A changeover response produced the signed condition but did not produce the stimulus correlated with it. That is, a tone always preceded food but there was no correlated stimulus to explicitly identify the signed condition. This procedure evaluated the effects of the signal without the accompanying correlated stimulus.

The same stability criterion used for the changeover condition was used for the extinc-

tion conditions, i.e., three consecutive sessions (9 hrs minimum) in which the percentage of time spent in the changeover condition did not vary more than 10%. The changeover condition was reinstated for a minimum of three sessions following each extinction condition and then a different extinction condition was presented. This sequence was followed until all three extinction conditions separated by the changeover condition was run. Tables 1 and 2 depict the orders in which the first series of extinction conditions was run.

RESULTS

The percentage of time spent in changeover, for the last three days of the initial baseline condition, changeover (CO) from the unsigned to the signed condition, and for each extinction condition is presented in Tables 1 and 2. Table 2 presents data from subjects tested in the response-dependent procedure and Table 1 presents data from subjects tested in the response-independent procedure.

Training Baseline

Inspection of Tables 1 and 2 indicates that responding on the CO lever during the baseline condition occurred only at a low rate whether reward was response-dependent or response-independent. For response-dependent subjects, response rate on the food lever revealed a clear discrimination between signed and unsigned conditions. Subjects tended to respond throughout the unsigned condition but under the signed condition, responding was reduced in the absence of the signal but occurred at a high rate in its presence (cf. Lewis et al., 1974). Subject E41 is representative of subjects in the response-dependent condition. This subject responded an average of 4350 times in the unsigned condition and an average of 2000 times in the signed one.

Observation of subjects experiencing the signed condition in the response-independent procedure also indicated a clear discrimination between signal and signal-absent periods. The onset of the signal consistently resulted in an increase in activity level with behavior directed towards the food cup (e.g., biting at cup). During the signal-absent periods of the signed condition, subjects generally moved about the chamber, only occasionally stopping at the food cup (cf., Green & Rachlin, 1977). Behavior during the unsigned condition was

Table 1

Percentage of session time spent in changeover is shown the last three days of each test condition for subjects receiving response independent food. Number in parentheses refer to the number of sessions in that condition.

Conditions	Last 3 Days											
	S1				S2				S3			
	1	2	3		1	2	3		1	2	3	
Baseline	10	4	11	(4)	3	6	11	(7)	16	13	11	(5)
CO to Unsig	10	7	7	(3)	10	12	10	(3)	9	18	12	(4)
Baseline	7	3	2	(4)	9	9	8	(4)	14	10	10	(8)
CO to Sig	Exposure #1											
	84	89	89	(8)	80	78	79	(11)	84	84	80	(10)
	94	95	91	(4)	92	94	91	(5)	90	92	94	(3)
EXT 1	Replication											
	Exposure #1											
	7	4	6	(8)	9	6	12	(10)	25	19	25	(28)
EXT 2	26	22	25	(10)	14	17	7	(8)	16	12	7	(8)
	Replication											
	Exposure #1											
EXT 3	56	50	54	(8)	56	66	60	(17)	44	41	42	(7)
	58	62	57	(10)					44	48	53	(22)
	Replication											
EXT 3	Exposure #1											
	66	69	69	(10)	62	64	62	(10)	58	58	62	(6)
	79	71	74	(11)					64	59	61	(6)
EXT 3	Replication											

Table 2

Percentage of session time spent in changeover is shown the last three days of each test condition for subjects receiving response dependent food. Numbers in parentheses refer to the number of sessions spent in that condition.

Conditions	Last 3 Days											
	E20				E23				E41			
	1	2	3		1	2	3		1	2	3	
Baseline	Exposure #1											
	36	39	38	(4)								
	19	28	22	(4)								
CO to Unsig	Replication											
	Exposure #1											
	31	29	33	(3)								
Baseline	32	42	34	(10)								
	Replication											
	Exposure #1											
CO to Sig	9	7	6	(8)	5	9	4	(10)	16	14	12	(4)
	10	12	16	(8)	31	41	31	(16)	23	19	18	(4)
	Replication											
EXT 1	Exposure #1											
	69	73	75	(3)	72	73	80	(7)	78	82	78	(6)
	72	86	84	(8)	72	72	79	(5)	79	78	84	(4)
EXT 2	Replication											
	Exposure #1											
	64	65	67	(4)								
EXT 3	71	77	73	(4)								
	Replication											
	Exposure #1											
EXT 3	44	42	43	(5)	39	37	44	(4)	22	26	28	(3)
	21	22	17	(7)	12	10	13	(7)	22	20	18	(7)
	61	59	63	(7)	61	70	63	(10)	46	50	54	(6)
EXT 3	Replication											
	Exposure #1											
	59	59	57	(4)								

similar to the latter in that subjects generally moved about the chamber.

Changeover

As seen in Tables 1 and 2, all subjects preferred signaled over unsigned food whether the procedure was response-dependent or response-independent. All subjects responded on the changeover lever at a rate sufficient to remain in the signaled condition 65 to 95% of the session. Subjects E20 and E50 in the response-dependent procedure and Subjects S1, S2, and S3 in the response-independent procedure were also given the opportunity to changeover from the signaled to the unsigned condition. None did so. Table 1 shows that changeover responding for Subjects S1, S2, and S3 remained at near baseline levels. Changeover responding for Subjects E20 and E50 also remained at baseline levels.

Extinction

Performance under EXT 1 in which neither the signal nor the correlated stimulus was produced following a CO response, resulted in considerably less time spent in the changeover condition without these stimuli than during the changeover conditions with them (Tables 1 and 2). This was expected since the subject effectively remained in the unsigned condition following a CO response.

During EXT 2, a response produced only the stimulus identifying the signaled condition and not the signal. Subjects tested in the response-dependent procedure spent an average of 20.7% of the time in the changeover condition (Table 2). In contrast, subjects tested in the response-independent procedure spent an average of 52.0% of time in the changeover condition during the initial EXT 2 series and an average of 54% (two subjects) during replication (Table 1).

The extent to which the signal alone controlled CO responding was evaluated under EXT 3. A CO response produced the signaled condition without the correlated stimulus identifying it. In both response-dependent and response-independent procedures, the signal maintained the greatest control over CO responding. Performance under EXT 3 was only slightly reduced from that seen when both the correlated stimulus and the signal occurred following a CO response.

DISCUSSION

These results show that preference for the signaled condition is obtained whether the procedure is response-dependent or independent. Further, changeover responding is controlled most effectively by the contingency of both correlated stimulus and signal. In addition, the signal alone (EXT 3) controlled CO responding more effectively than the correlated stimulus alone (EXT 2) and the degree to which the correlated stimulus alone controlled behavior was less with a contingency than without. Comparison of EXT 2 data under both procedures suggests that the presence of a response contingency may have increased the aversive characteristics of the food-free period identified by the correlated stimulus in the absence of the signal. Such an increase may have been due to the effect of nonreinforced responding occurring during the food-free period (e.g., Blanchard, 1975). These findings support and extend those of Lewis et al. (1974).

EXPERIMENT 2

The extent to which variations in reinforcer quality affect choice between signaled and unsigned deliveries of reinforcers is unknown. Hershisser and Trapold (1971) used a sucrose solution with rats and found preference for the unsigned condition while Lewis et al. (1974) used mixed grain with pigeons and found preference for the signaled condition. However, each study also used a different procedure to assess preference; thus, the different outcomes may have resulted from different species, reinforcers, or procedures. The present Experiment 1 used food pellets to assess preference. In Experiment 2, chocolate milk served as the reinforcer under both response-dependent and response-independent conditions. Comparison of Experiments 1 and 2 in which the same procedures and species were used allows an assessment of reinforcer quality, as it affects preference for signaled vs. unsigned delivery of reinforcers.

METHOD

Subjects

Six experimentally naive female Sprague-Dawley (Holtzman Co.) rats (90 to 120 days) were maintained at 80% of their free-feeding

weights. Subjects were individually housed with free access to water.

Apparatus

The apparatus was the same as that used in Experiment 1 except that 72-db white noise was presented through a speaker mounted on the ceiling of the operant chamber.

Commercially available lowfat (.05% milk-fat) chocolate milk was used as a reinforcer. A solenoid mounted on the outside of the sound attenuating box delivered .10-cc injections of chocolate milk into the brass cup through a drinking tube (.8 cm in diameter with a .3 cm tapered tip) located between the two levers. The drinking tube was shielded so that the animal could not lick the tip thereby draining the tube of the liquid.

Procedure

Subjects COT2, COT3, and COT4 were tested in a response-independent procedure and Subjects MKT2, MKT3, and MKT4 were tested in a response-dependent procedure.

Apart from the bar-press training given Subjects MKT2, MKT3, and MKT4, all subjects were treated in a similar manner. Reinforcers for all subjects were delivered on a variable interval (VI) 60-sec schedule generated by the Fleshler and Hoffman (1972) tables modified to accommodate a minimum interfood interval of 6 sec. For all subjects the signal consisted of a 5-sec tone.

Each subject was given opportunities to respond for the unsignaled condition and opportunities to respond for the signaled condition. The order in which these changeover conditions were presented differed among subjects (see Figures 1 and 2). The criterion for stability was the same as in Experiment 1. Light was the stimulus correlated with the signaled condition for Subjects COT2 and MKT2 and darkness was the correlated stimulus for all other subjects.

RESULTS

Figure 1 represents the performance of subjects in the response-independent procedure.

Fig. 1. Percentage of session time spent in changeover for the last three days of each test condition for subjects given response-independent chocolate milk. The order of presentation of the test conditions can be determined from session numbers on the horizontal axis.

As shown in the figure, all subjects responded to produce the signaled condition; they did not respond to produce the unsignaled condition. Comparison of subjects receiving food pellets (Table 1) with subjects receiving chocolate milk (Figure 1) in a response-independent procedure shows little difference in strength of preference.

Figure 2 presents data for subjects tested in a response-dependent procedure. As can be seen, the presence of a contingency does not alter the preference for signaled chocolate milk. Subjects preferred the signaled condition at a level comparable to that of subjects receiving chocolate milk in a response-independent procedure (Figure 1). The number of responses during the baseline condition for subjects tested in the response-dependent procedure again showed that a discrimination between the signaled and unsignaled condition occurred. Response rates during the signaled condition were far lower than response rates during the unsignaled condition. Since little difference was found in preference as a function of reinforcer quality, it was decided that

extinction procedures similar to those in Experiment 1 would not be necessary. The results of Experiment 2 when considered with those of Experiment 1 indicate that preference for the signaled condition occurs with response-dependent and independent procedures and with different types of reinforcers.

GENERAL DISCUSSION

In previous investigations of choice between signaled and unsignaled appetitive conditions, Lewis et al. (1974) found that pigeons spent more time under signaled schedules of response-dependent mixed-grain presentations, while Hershisier and Trapold (1971) found that rats spent more time under unsignaled schedules of response-independent delivery of sugar water. A choice procedure similar to that used by Lewis et al. (1974) was adopted for the present investigations but with rats. Both experiments showed that choice of the signaled condition did not depend upon the quality of the reinforcer or upon response-dependency or response-independency. Thus, these data ex-

Fig. 2. Percentage of session time spent in changeover for the last three days of each test condition for subjects receiving response-dependent chocolate milk. The order of presentation of the test conditions can be determined from session numbers on the horizontal axis.

tend the generality of the findings of Lewis *et al.* and rule out response-dependency, reinforcer quality, and species as variables critically related to the direction of choice.

The stimuli maintaining preference in the present experiments provide an interesting contrast to those maintaining preference in the aversive situation (Badia & Culbertson, 1972; see also Lewis & Gardner, 1977). Badia and Culbertson reported that responses that had previously changed an unsignaled condition to a signaled one persisted in the presence of the correlated stimulus but with signals removed (EXT 2). In contrast they found that responding dropped to baseline levels when signals were available, but with the correlated stimulus absent (EXT 3). Experiment 1 in the present series revealed the reverse outcome. That is, changeover behavior was maintained at a high level when the signal was available, but not the correlated stimulus (EXT 3) and dropped to a lower level (more so with the response-dependent than the response in independent procedure) when the correlated stimulus was available but not the signal (EXT 2). Taken together, these sets of data indicate that the stimulus factors maintaining choice for signaled over unsignaled conditions depend on the sign of the signaled event.

Theoretical views based on information and preparation are inadequate to organize the data on choice between signaled and unsignaled conditions. In general terms, information theory (e.g., Hendry, 1969) emphasizes the value of stimuli that reduce uncertainty about the presence or absence of important events, whereas preparatory response views (cf. Perkins, 1955) focus on stimuli that precede important events and permit the precise timing of responses that maximize the value of positive events or minimize the value of negative ones. Both of these views predict preference for signaled conditions and cannot readily account for Hershiser and Trapold's (1971) findings. Additionally, neither view can account for the observation that stimuli that identify shock-free periods rather than signals that precede shock maintain responding in aversive situations (see Badia *et al.*, 1979).

Another theoretical view that is sufficiently developed to organize some of the appetitive choice data is the delay-reduction hypothesis of conditioned reinforcement offered by Fantino (1977). According to this view, the conditioned

reinforcing value of a stimulus is a function of the reduction in time to reinforcement correlated with its onset. In the present experiments, food was delivered on an average of once every 60 sec during the stimulus identifying the unsignaled condition, however onset of the signal indicated food delivery in 5 sec. Thus, onset of the signal following a changeover response was correlated with a 92% reduction in time to primary reinforcement. Conditioned reinforcement then, presumably provides the basis for explaining the preference observed for the signaled condition and also the control by the signal during EXT 3 sessions (see Tables 1 and 2).

The delay-reduction hypothesis cannot accommodate the findings of Hershiser and Trapold showing a preference for the unsignaled condition. However, as noted, Hershiser and Trapold used a noncommitment procedure and the delay-reduction hypothesis was developed for a commitment one (i.e., concurrent chains). Differences exist between these procedures which may be important. For example, in the present experiments responses changed an unsignaled condition to a signaled one for 1-min time intervals, i.e., subjects were committed to the signaled condition for a 1-min period. With a noncommitment procedure no time commitment is required and subjects may switch conditions at any time. Some have questioned whether a noncommitment procedure can be used as a meaningful test of preference (Marcuella & Margolius, 1978). Since subjects can switch freely from one condition to the other, switching may be controlled more by stimuli identifying the probability of reinforcement (e.g., S^D or S^A) than by other factors. For example, when in an unsignaled condition, subjects can switch freely to the signaled one. In the case of food reward the signal or its absence identifies respectively, food and food-free periods. If the signal is present when the switch is made the subject may remain (prefer) that condition because of the correlated reduction in time to reinforcement or because the probability of food in the presence of the signal equals 1.00. If the signal is absent when the switch is made, the subject may change freely back to the unsignaled condition. This change would be expected since, as noted, food occurs only in the presence of the signal ($p = 1.0$), never in its absence ($p = 0$), and the probability of food in the unsignaled condition is

always some non-zero value. The study by Hershiser and Trapold does not provide the necessary data to assess whether this switching pattern of responding occurred, but others have reported such as pattern when studying mixed vs. multiple schedules (e.g., Dinsmoor, Browne, Lawrence, & Wasserman, 1971). In addition, Marcucella and Margolius (1978) appeal to a similar pattern to account for responding under concurrent VI VI schedules. Obviously further assessment of commitment and noncommitment procedures are needed as they relate to studies of preference.

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