A TEST OF THE REINFORCING PROPERTIES OF STIMULI CORRELATED WITH NONREINFORCEMENT¹

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The information hypothesis of conditioned reinforcement predicts that a stimulus that "reduces uncertainty" about the outcome of a trial will acquire reinforcing properties, even when the stimulus reliably predicts nonreinforcement. Four pigeons' key pecks produced one of two 5-sec stimuli with 0.50 probability according to a discriminated variable-interval schedule. One stimulus was followed by reinforcement; a second stimulus was followed by blackout. To the same extent, therefore, both stimuli reduced uncertainty about the possibility that food would arrive at the termination of the schedule interval. When a second key in the chamber was lighted, each peck on it could produce the stimulus preceding reinforcement, the stimulus preceding nonreinforcement, a novel stimulus, or no stimulus, across separate conditions. The stimulus preceding food maintained responding at substantial levels on the second, stimulus-producing, key. Such responding was not maintained by other stimuli. These data, replicated when the stimuli were reversed on the variable-interval schedule, do not support the prediction that uncertainty-reducing stimuli are necessarily conditioned reinforcers.

Key words: conditioned reinforcement, information hypothesis, reduction of uncertainty, key peck, pigeons

Historically, procedures for generating stimuli with positive conditioned reinforcing properties involved pairing a "neutral" stimulus with a known positive reinforcer (*e.g.*, Hull, 1943; Kelleher and Gollub, 1962). The importance of pairing in establishing a neutral stimulus as a conditioned reinforcer has been questioned (Egger and Miller, 1962, 1963; Hendry, 1969; Neuringer and Chung, 1967; Stubbs, 1971). A major alternative is the information hypothesis (Egger and Miller, 1962, 1963; Hendry, 1969; Lieberman, 1972; Schaub, 1969; Schaub and Honig, 1967), which suggests that a crucial aspect of the pairing procedure is that the neutral stimulus reliably predict a biologically important event (*e.g.*, delivery of food, receipt of shock); this predictive aspect of a stimulus, not temporal

pairing, establishes the stimulus as a reinforcer. The information approach to conditioned reinforcement has produced predictions (*e.g.*, Hendry, 1969) incompatible with the traditional associative-pairing view. In particular, the information hypothesis suggests that a predictive stimulus should acquire positively reinforcing properties even when the event predicted is the *absence* of a primary positive reinforcer (Hendry, 1969; Lieberman, 1972; Schaub, 1969). The demonstration of reinforcing properties of such stimuli is crucial to the validity of the information analysis, and Dinsmoor, Browne, and Lawrence (1972) noted that without this hypothesis, "it is difficult to see how the information hypothesis can be distinguished from earlier accounts of the circumstances under which a stimulus gains reinforcing properties . . .".

Hendry and Coulbourn (1967), Schaub and Honig (1967), and Lieberman (1972) have presented studies supporting this prediction. Hendry and Coulbourn (1967), using pigeons, examined the "reinforcing effect of an informative stimulus that is not a positive discriminative stimulus". Food occurred irrespective of behavior at the end of some 75-sec trials. Each trial began with illumination of the key with white light for 65 sec, followed by a 10-

¹This report is based on a doctoral dissertation by the author submitted to the Department of Psychology, Florida State University, Tallahassee, Florida. The research was supported by National Science Foundation Grant GB-28224 to Florida State University (Dr. Michael E. Rashotte, principal investigator). The author wishes to acknowledge his appreciation to M. E. Rashotte for guidance and assistance in this research. Reprints may be obtained from Harold Katz, Hammond State School, Route 3, Box 165-P, Hammond, Louisiana 70401.

sec key-color change, green when no food was presented, red when food was presented. From the thirtieth to the forty-fifth second after the illumination of the white key, on positive trials only, the first peck immediately changed the key to green for 5 sec. The authors argued that the only consequence of pecking the white key was a cue associated with nonreinforcement (green), although it is reasonable to suggest that during the white-key portion of positive trials the green light maintained responding because it signalled that the trial was positive (*i.e.*, that the key would turn red and food would be presented) and was thus serving as a positive discriminative stimulus.

Schaub and Honig (1967) attempted to separate the discriminative and reinforcing functions of the stimuli in a discrimination procedure. Pairs of master-yoked pigeons were exposed to positive periods when food was available on a variable-interval 1-min schedule, and negative periods of extinction. Pecks by the master bird also produced stimuli associated with each schedule (red during positive periods, green during extinction). Stimulus changes produced by the master birds were simultaneously displayed to the yoked birds. The master birds responded more rapidly than the yoked birds during extinction periods. These results, like data from similar procedures (Schaub, 1969, Experiment 3A), were interpreted to indicate that extinction behavior was supported by the reinforcing aspect of the green stimulus. Nevertheless, it has been suggested (Dinsmoor *et al.*, 1972) that the discriminative effects of the stimuli, rather than their reinforcing effects, can adequately account for the data.

Lieberman (1972) used an observing-response procedure in which monkeys could simultaneously respond on one lever to produce food according to a mixed variable-ratio extinction schedule, and on a second lever to produce the discriminative stimuli (S+ and S-) associated with the components of the mixed schedule. Within this procedure, Lieberman varied the ratio value, added additional informative stimuli, and eliminated the discriminative stimulus correlated with the extinction components. Lieberman argued that the information hypothesis and the "secondary reinforcement" hypothesis of the maintenance of observing responses made pre-

dictions that would generate opposite effects on observing-response rates for the three manipulations employed. Although the changes in observing-response rates were consistent with the predictions derived from an informational analysis, it is unclear that these were the only alternative interpretations. For example, when the ratio value was decreased, it was argued that a secondary reinforcement explanation would predict increased observing-response rates because the density of reinforcement in S+ would increase. An alternative explanation might be considered: as the ratio requirement decreased, the monkeys were increasingly made to choose between one response that produced a stimulus *versus* a few additional responses that produced a primary reinforcer. Because monkeys, in a single-response choice situation, will produce a primary reinforcer in preference to a secondary reinforcer immediately exchangeable for food (Cowles, 1937), the informational analysis may be unwarranted. Certain details of the procedures used by Lieberman have also been questioned, specifically the use of a fixed-ratio 50 schedule of primary reinforcement (Mulvaney, Dinsmoor, Jwaideh, and Hughes, 1974) and the method by which S- was eliminated as a consequence of observing responses (Dinsmoor *et al.*, 1972).

Several additional attempts to verify the information hypothesis produced data more closely supporting conditioned-reinforcement predictions. Dinsmoor, Flint, Smith, and Viemeister (1969) used an observing-response procedure to investigate the differential reinforcing effects of stimuli associated with the presence or absence of a schedule of punishment. The observing response was not maintained when only the stimulus associated with the punishment schedule was available. Mulvaney *et al.* (1974), also using an observing-response procedure, concluded that the stimulus associated with the nonreinforced component of a variable-interval extinction schedule suppressed observing behavior, and served as a punisher rather than a reinforcer. Both Dinsmoor *et al.* (1972) and Jenkins and Boakes (1973) failed to generate data supporting the information hypothesis, but rather concluded that stimuli acquire their reinforcing abilities through their relation to reinforcement.

The present study measured the reinforcing potencies of stimuli associated with reinforce-

ment and nonreinforcement, while simultaneously maintaining discriminated operant behavior. Several procedures have been developed for the chronic study of conditioned reinforcing stimuli. Zimmerman (1963) showed that pigeons will produce a conditioned reinforcer in a two-key pigeon chamber in which a schedule of primary reinforcement is arranged on one key and a schedule of conditioned reinforcement alone is arranged on the second key. This situation produced low, steady rates of pecking for indefinite periods on the conditioned-reinforcement-producing key. This pecking appeared to be due solely to the production of the conditioned reinforcer, in that responding was controlled by the schedule of conditioned reinforcement, and responding extinguished when either the conditioned reinforcer was not produced or a novel stimulus was produced.

Adapting Zimmerman's approach to the information-hypothesis prediction, pigeons trained in a two-key operant chamber pecked for grain on a modified multiple schedule. Pecking in the presence of the prevailing stimulus produced either of two stimuli, one (S+) that was followed by food and another (S-) that was not. The probability that a trial would produce reinforcement (or nonreinforcement) was 0.50. The advent of the S+ (or S-) altered this probability to 1.0 (or 0.0) if reinforcement (or nonreinforcement) was to follow. Both of these latter probabilities are equidistant from 0.50, and the uncertainty during the prevailing stimulus was thus equally reduced by presenting either the S+ or the S-. According to the information hypothesis, the S+ and the S- should be equally strong conditioned reinforcers. On the second key, the only consequence of pecking was the presentation of the S+ or S- stimuli. This technique allowed the S+ and S- stimuli to maintain their informative and/or associative functions on the food key. At the same time, chronic assessment of the conditioned reinforcing value of the predictive stimuli was possible on the second key.

METHOD

Subjects

Four experimentally naive male White Carneaux pigeons (P2602, P2668, P9391, P9668), approximately 8 to 12 months old at the be-

ginning of the experiment, were individually housed in a constantly illuminated, temperature-humidity controlled colony room and were maintained at 75% of their free-feeding weights. Water and grit were constantly available, and Purina Pigeon Grain was used both for grain presentations in the experimental chamber and for additional maintenance feedings in the home cages.

Apparatus

In a Lehigh Valley Electronics Model 1519 two-key pigeon chamber, Industrial Electronics Engineer inline display units transilluminated both keys, which were activated by a minimum force of approximately 0.15 N. White masking noise was continuously present, except during auditory stimuli. Experimental control and data recording were accomplished by standard electromechanical equipment in a separate room.

Procedures

Pretraining. The pigeons' pecks on a white food-producing (FP) key were shaped and responses were then reinforced on a series of variable-interval (VI) schedules until stable responding on VI 2-min was displayed. The VI schedules were constructed using the distributions of Fleshler and Hoffman (1962), and reinforcement consisted of 5-sec access to the raised grain hopper. The final sessions of pretraining were terminated by the first reinforcement following 1 hr. Sessions were conducted six days per week, unless the bird's weight was outside the range of 75% free-feeding weight ± 15 g. Such deviations occurred only twice.

Phase 1: discrimination. The VI 2-min schedule on the white FP key was replaced by a discriminated, 0.50-reinforced VI 2-min schedule. Whereas the first FP key peck after the interval elapsed produced food during pretraining, in the discrimination phase, an FP key peck produced a 5-sec stimulus followed by either 5-sec access to grain or 5-sec of blackout, during which all lights in the chamber were darkened. Once stimulus onset had occurred, food or blackout followed independent of the pigeon's behavior. Food consistently followed S+ stimuli, and blackout consistently followed S- stimuli. The S+ for P9691 consisted of a horizontal white line on the black background of the key, the removal

Table 1
Summary of Experimental Conditions

<i>P2602</i>			<i>P9691</i>		
<i>Phase</i>	<i>Number of Sessions</i>	<i>Condition*</i>	<i>Phase</i>	<i>Number of Sessions</i>	<i>Condition*</i>
1	14	OFF	1	14	OFF
	10	S+		11	S+
	6	S-		6	S-
	10	S+		10	S+
	7	S-		4	S-
	8	S ^N		4	S ^N
	3	S-		9	S-
2	11	S(-)+	2	10	S(-)+
	10	S(+)-		10	S(+)-
	10	OFF		11	OFF
	10	S(-)+		10	S(-)+
	4	S(+)-		6	S(+)-
	5	EXT		10	EXT
	3	OFF		3	OFF
	3	S(-)+		3	S(-)+
3	20	S(-)+ unpaired	3	9	S(-)+ unpaired

<i>P9391</i>			<i>P2668</i>		
<i>Phase</i>	<i>Number of Sessions</i>	<i>Condition*</i>	<i>Phase</i>	<i>Number of Sessions</i>	<i>Condition*</i>
1	15	OFF	1	14	OFF
	9	S-		9	S-
	10	S+		6	S+
	9	S-		2	OFF
	4	S ^N		3	S-
	4	S-		2	OFF
	10	S+		10	S+
				4	S-
2	10	S(+)-	2	10	S ^N
	10	S(-)+		5	S-
	10	OFF		10	S+
	8	S(+)-		4	S-
	10	S(-)+		10	S ^N
	9	EXT		5	S-
	3	S(+)-		10	S+
	1	S(-)+			
	3	OFF		21	S(+)-
	3	S(-)+		9	S(-)+
				10	OFF
3	23	S(-)+ unpaired	3	14	S(+)-
				10	S(-)+
				6	EXT
				3	S(-)+

*See text for definitions.

of white noise, and an 87-dB, 800-Hz tone. The S- for P9691 consisted of a green key, the removal of white noise, and a 70- to 80-dB, 5-Hz click. The green key/click stimuli served as S+ for P9391, P2602, and P2668. The line/tone stimuli served as S- for P9391, P2602, and P2668. For P9691 and P9391, the FP key

was located on the right side of the panel; for P2602 and P2668, the FP key was located on the left.

After differential rates of responding developed in the presence of S+ and S- on the FP key, the second key was illuminated throughout each session, except during reinforcement

and blackout. The major experimental manipulation was the consequence of a peck on this second, stimulus-producing (SP) key. The different consequences of pecks on the SP key and the sessions of each condition, for all phases, are shown in Table 1. The schedule on the SP key was fixed-ratio (FR) 1. The stimuli produced by pecks on the SP key were either the S+ and S- stimuli used on the FP key, or a novel stimulus (S^N), which consisted of a white cross on a red background and the absence of scheduled auditory stimuli. Pecks on the SP key in the presence of a produced stimulus had no scheduled effects. A 2-sec changeover delay was used in all phases to prevent adventitious reinforcement of SP key-peck-FP key-peck chains. The changeover delay began with each peck on the FP key that followed a peck on the SP key. Only after the changeover delay had elapsed could a scheduled stimulus presentation occur.

Each condition in which stimuli were available on the SP key continued for 10 sessions or until the range of SP key productions was three or fewer over three consecutive sessions. Sessions in this and following phases were terminated by the first reinforcement or blackout after 1 hr.

Phase 2: discrimination reversal. Immediately after Phase 1, the relation between the stimuli and the reinforcement conditions on the FP key was reversed: the former S+ now preceded the blackout periods and signalled nonreinforcement, and the former S- now preceded reinforcement. These stimuli are designated S(+)- and S(-)+ in Phase 2, the symbol in brackets indicating the Phase 1 value, and the final symbol indicating the Phase 2 value of the stimuli. These stimuli continued to be available according to a discriminated VI 2-min schedule on the FP key. During this phase, each bird was exposed to conditions in which pecking the SP key produced no consequences, as indicated by the extinction (EXT) conditions in Table 1. In addition, conditions in which the SP key was not illuminated occurred once for P2668 and twice for P2602, P9391, and P9691. These conditions are indicated by OFF in Table 1.

Phase 3: nondiscrimination. Throughout the final phase, S(+)- and S(-)+ were never presented on the FP key. A single stimulus, a 1-Hz flashing white light of 5-sec duration on the FP key, preceded both reinforcement and

blackout periods on the nondiscriminated, 0.50 reinforced VI 2-min schedule. Only the S(-)+ of Phase 2 was produced by SP key pecks in this phase. The stimulus produced on the SP key has been termed the S(-)+ unpaired stimulus.

RESULTS

The rate of stimulus production was used to measure the reinforcing potency of stimuli explicitly paired and unpaired with food. Figure 1 presents the mean terminal rate of stimulus production for each pigeon in all phases. The highest rates of stimulus production in Phase 1 occurred when S+ was produced, and these relatively high rates were recovered after conditions in which S- or S^N were produced. Pigeons 2668 and P9391 had S+ available in the final condition of Phase 1, after 95 to 103 experimental sessions, and rates of production in that condition were comparable to earlier S+ condition rates. Only P2668 failed to respond on the SP key when S+ was first available in Phase 1. Generally, transitions from an S+ to an S- condition were followed by a rapid and substantial decrease in stimulus-production rates, while the reverse transition showed less rapid increases in rate with more variability from session to session. This is reflected by the actual termination criteria employed. In all cases but one, S+ production conditions were continued for the maximum number of sessions (10). For conditions in which S- or S^N stimuli were produced, the stability criterion was met in fewer than 10 sessions, with one exception.

In the initial session when a novel stimulus was available on the SP key in Phase 1, all birds produced the S^N at rates higher than the terminal rates in the preceding S- condition. By the last three sessions, however, all birds responded at rates substantially below their prior rate of S+ production.

The left panel of Figure 2 presents the rates of responding in the presence of S+ and S- on the FP key during the initial 15 sessions and the final 10 sessions of discrimination training. Three pigeons clearly acquired differential responding to the two stimuli during the first 15 sessions. Pigeon 9391 did not develop differential responding to the two stimuli in the same manner as the others, there

Fig. 1. Terminal rate of stimulus production on the stimulus-producing (SP) key for all Phase 1, 2, and 3 conditions (see text for definitions). The mean terminal rate was calculated over the final three sessions of each condition. Each rate was determined by dividing the total number of stimulus productions by the total session time less the duration of all blackout and reinforcement periods.

being a near-zero rate during S- from the first session. Because P9391 may have responded to a stimulus property other than the stimulus-food relation, this relation was reversed in Session 7. Pigeon 9391 again rapidly acquired differential responding and this stimulus-food relation was maintained throughout Phase 1.

Rates during the final 10 sessions showed that the discriminative behavior on the FP key endured throughout Phase 1 for all but P9691.

The left panel of Figure 3 summarizes the terminal rate of responding on the FP key during S+ and S- in all conditions. In all but two conditions for P9691, each pigeon showed

Fig. 2. Rate of responding during the 5-sec stimuli on the food-producing (FP) key during selected sessions.

Fig. 3. Terminal rate of responding on the food-producing (FP) key during S+ and S- stimuli, during all conditions of Phases 1, 2, and 3.

a higher terminal rate of responding during S+ than during S-.

In summary, Phase 1 indicates that SP-key

responding was maintained throughout numerous sessions, and that S+ stimuli supported higher rates of responding than did S- or S^N

stimuli. Rates of production of S- and S^N stimuli were not systematically different. Rates on the SP key in the presence of the stimuli produced on the key were generally consistent with rates during these stimuli on the FP key, in that higher rates occurred in the presence of the S+ than the S- or S^N stimuli (Katz, 1973).

In Phase 2, the relation of the stimuli and food/blackout was reversed on the FP key and conditions equivalent to those in Phase 1 were conducted to replicate the finding that behavior maintained by the stimuli on the SP key was controlled by the food-signalling function of the stimuli. Figure 1 presents the terminal rates of stimulus production for each pigeon, in all Phase 2 conditions. The second S(-)+ and S(+)- conditions were conducted after a 10-day condition with the SP key darkened and inoperative. Data from this phase reaffirm the general finding of Phase 1 that production of the S(-)+ supports more responding on the SP key than does S(+)- production.

Phase 2 was structured so that two pigeons continued to produce the prefood stimuli of Phase 1 (now the preblackout stimuli of Phase 2), while two pigeons produced the preblackout stimuli of Phase 1 (now the prefood stimuli of Phase 2). Both P9391 and P2668 produced the Phase 1 S+. Although P9391 and P2668 initially displayed SP key rates similar to the prior S+ condition, the S(+)- production rate gradually decreased to a lower level. This low rate, however, was greater than the S- rate of Phase 1, and was higher than rates in later S(+)- conditions.

Pigeons 9691 and P2602, whose initial Phase 2 SP key pecks produced the S- of Phase 1, failed to generate terminal rates as high as those in Phase 1 S+ conditions. Terminal rates in later S(-)+ conditions, for both pigeons, were more similar to Phase 1 S+ condition rates.

When pecks on the SP key no longer produced any stimuli (denoted by the NO column in Figure 1 and the EXT condition in Table 1), the rate decreased regardless of whether the SP key pecks in the previous condition produced prefood or preblackout stimuli. The rates of those pigeons shifted from S(+)- to NO stimulus conditions decreased to rates lower than in any previous Phase 2 condition. For those pigeons exposed to the NO stimulus condition following an S(-)+ condition, rates

during the NO stimulus condition were about equal to, or slightly higher than, rates during the preceding S(+)- condition. This condition was terminated in fewer than 10 sessions for P2602, P2668, and P9391.

During the final S(-)+ condition of Phase 2, all pigeons responded on the SP key at rates about those in the prior S(-)+ condition, indicating the continuing ability of the S(-)+ stimuli to maintain SP key behavior.

Reversal of the discrimination on the FP key during Phase 2 was determined by rates of responding in the presence of the S(-)+ and S(+)- stimuli. These latter rates are shown in the central panel of Figure 2, which presents the initial 20 sessions and the final 10 sessions of discrimination reversal. The duration of the initial Phase 2 condition differed across pigeons to allow differential responding in the presence of the prefood and preblackout stimuli to develop. Such responding is evident (see Figure 2) for P9691, P2668, and P9391 by the end of the first 20 sessions, although these differences continued through Phase 2 only for P9391 and P9691. The middle panel of Figure 3 summarizes the mean terminal FP key response rates during S(+)- and S(-)+ by condition. In this measure, only P2602 failed to show reversal. As in Phase 1, all pigeons evidenced generally higher rates while S(-)+ was present on the SP key than while S(+)- was present, with the exception of P9691.

Throughout Phase 3, the pigeons' rates on the FP key during the prefood and preblackout periods were not systematically different (see Figures 2 and 3). When pecks on the SP key produced the S(-)+ stimuli, which were no longer associated with reinforcement on the FP key, the rate of S(-)+ unpaired production for P2602 and P9691 gradually decreased to low, stable, terminal levels. The rates for P2668 and P9391 first declined to low values, then displayed extreme variability until the experiment was terminated. At that time their terminal rates, as shown in Figure 1, were substantial, although the final S(-)+ unpaired rates were considerably below the final S(-)+ rates in all cases.

Figure 4 shows sample cumulative records from the entire last session of the final S+ production condition in Phase 1. All pigeons responded at stable rates on the FP key, and produced the S+ stimuli on the SP key intermittently in various parts of the session.

Fig. 4. Sample Cumulative Records—Phase 1. Stimulus-producing (SP) key pecks are indicated by downward strokes of the event pen (lower tracing). Food-producing (FP) key pecks are shown cumulatively in the upper tracing. Reinforcements are indicated by downward strokes of the FP key response pen.

GENERAL DISCUSSION

This experiment allowed pigeons, across successive conditions, to produce two stimuli that were equally informative on the food-producing (FP) key but that carried no information about the occurrence of food when produced on the stimulus-producing (SP) key. The stimuli produced on the SP key did not affect frequency of primary reinforcement, other than by occasionally imposing a short changeover delay. The responding maintained on the SP key by each of the stimuli was taken as evidence of the reinforcing strength of the two stimuli. The S+ stimulus supported more responding than the S- stimulus in this situation, and these differences in reinforcing effectiveness could not be attributed to the physical characteristics of the stimuli or to stimulus change. The proposal that stimuli that reduce uncertainty about impending reinforcement and nonreinforcement will acquire equivalent conditioned reinforcing properties was not supported.

An exception to the general finding of Phases 1 and 2 occurred during the initial Phase 2 condition. Although all but one pigeon displayed discriminated responding on the FP key by the end of this condition, those pigeons that produced the S(-)+ stimuli did so at terminal rates below their prior S+ condition rates, while those that produced the S(+)- stimuli did so at terminal rates above prior S- condition rates. It is possible that after a discrimination reversal, either an amount of training greater than that which occurred during the original discrimination training is required, or the exposure to a condition in which SP key pecks produce the S(+)- stimuli is necessary, before consistent SP key behavior is evidenced.

In the final condition, during which the pigeons produced a conditioned reinforcer no longer associated with food on the FP key, the rate of extinction of SP key responding varied widely across subjects. This was reflected both in the range of sessions conducted during this phase (9 to 23) and the terminal rates of responding on the SP key. Similar difficulties in extinguishing the response that produced a stimulus previously paired with a primary reinforcer were reported by Zimmerman (1969) using similar procedures.

Previous experiments interpreted as demonstrating that S- stimuli have positive reinforcing properties should be re-examined in view of the present findings. Lieberman's (1972) observing-response study with monkeys was procedurally the most thorough attempt to verify the information-hypothesis prediction of the reinforcing potency of an S-. The conflict between his positive results and the present negative results may be due to species or procedural differences. The present experiment used a new response technique in which the stimuli produced by SP key responses neither yielded information concerning the reinforcement state of any schedule interval, as was the case in Lieberman, nor were ever positively correlated with food reinforcement.

Dinsmoor *et al.* (1972) used pigeons to test the reinforcing effects of S- within an observing response procedure similar to Lieberman's and were unable to maintain observing responses that produced only S- stimuli, although the observing responses could be maintained when only S+ stimuli were produced. The discrepancy between Lieberman and Dinsmoor *et al.* may again lie in species differences or in minor procedural differences (*e.g.*, the schedule on the observing response key was continuous reinforcement in Lieberman and VI 1-min or VI 2-min in Dinsmoor *et al.*). The present results are consistent with the conclusion of Dinsmoor *et al.*

On the basis of the present data, it was concluded that S- is less reinforcing than S+. A relevant question is whether S- remains neutral or acquires any aversive properties. The association-based formulation of conditioned reinforcement suggests that stimuli paired with nonreinforcement acquire aversive or inhibitory properties (Amsel, 1958; Levy, 1959; Rilling, Askew, Ahlskog, and Kramer, 1969). Although comparison of rates between pairs of conditions was expected to yield data bearing on this issue, the comparison of terminal rates of each pigeon from the S-, S(+)-, S^N, and NO stimulus conditions revealed no systematic differences in SP key responding. Rates during these conditions are based on small numbers of responses, and procedures that provide a higher baseline rate are necessary to demonstrate whether the stimulus correlated with nonreinforcement would support SP key responding at NO stimulus or novel stimulus condition rates.

In addition to invalidating the information hypothesis prediction, the procedures of this experiment provided a powerful, chronic situation in which to test hypotheses concerning conditioned reinforcers. These discrimination procedures demonstrated that key color and auditory stimuli may serve as the conditioned reinforcing stimuli within the Zimmerman (1963) procedures, which used hopper-related stimuli.

The present experiment provided a particularly stringent test of the reinforcing properties of S—, because it assessed the reinforcing properties of both S+ and S— on the same baseline and thereby showed the asymmetry in the reinforcing potential of the two stimuli. This demonstration is consistent with the "associative" view of conditioned reinforcement, which proposes that reinforcing properties are acquired by arbitrary stimuli through temporal pairing with a known reinforcer.

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Received 29 July 1974.

(Final Acceptance 16 March 1976.)