**SHOCK AS A SIGNAL FOR SHOCK OR NO-SHOCK:
A FEATURE-NEGATIVE EFFECT IN
CONDITIONED SUPPRESSION**

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Rats were trained in conditioned suppression discriminations where shock at the beginning of a trial signaled either shock or no-shock at the end of the trial. In the *shock-positive* condition, shock at the beginning of a presentation of white noise signaled that noise would end with shock; noise that did not begin with shock did not end with shock. In the *shock-negative* discrimination, shock at the beginning of noise signaled that noise would not end with shock; presentations of noise that did not begin with shock ended with shock. In *shock-random* training, shock at the beginning of noise did not reliably signal whether the noise presentation would or would not end with shock. Most subjects in shock-negative training quickly developed a differential pattern of suppression on positive (shock reinforced) trials and no suppression on negative (nonreinforced) trials. The shock-positive discrimination was much more difficult to establish and was not acquired by the majority of the rats. This "feature-negative" effect is a clear exception to the general superiority of feature-positive learning commonly observed in discriminations based on a single distinguishing feature. The results are discussed in terms of Pavlovian stimulus-shock contingencies in the shock-positive and shock-negative paradigms, which appear to favor rapid development of the shock-negative discrimination.

Key words: feature positive effect, conditioned suppression, sign tracking, discrimination learning, bar press, rats

Jenkins and Sainsbury (1969, 1970) gave pigeons successive discrimination training between two visual displays (AX and A) where A was an illuminated response key and X was a visual feature such as a small dot. In feature-positive discriminations (denoted AX+/A-), X was correlated with reinforcement. In feature-negative discriminations (denoted A+/AX-), X was correlated with nonreinforcement. Jenkins and Sainsbury found that pigeons quickly reached high levels of discrimination performance in feature-positive training, but that they either failed to master the feature-negative discrimination altogether or reached very poor performance levels. That result has become known as the feature-positive effect. Subsequent research has confirmed the superiority of feature-positive learning within a variety of commonly used experimental arrangements (e.g., conditioned sup-

pression; Reberg, 1978; Reberg & LeClerc, 1977), and the feature-positive effect seems to have emerged as a general phenomenon of operant and Pavlovian discrimination learning (see Hearst, 1978).

This paper concerns Pavlovian feature-positive and feature-negative discriminations in which the occurrence of an unconditioned stimulus (US) at the beginning of a trial provides discriminative information about the occurrence of that US at the end of the trial. Terry and Wagner (1975) studied such discriminations in Pavlovian conditioned eye-blink procedures with rabbits. One of their discriminations may be called *shock positive* and denoted sh→A+/A-. Positive trials in shock-positive training began with a shock to the eye region. A randomly varying delay of 2, 4, 8, or 16 sec was then followed by a 1-sec presentation of a vibratory stimulus (A) which terminated with another shock. Presentations of A that were not preceded by shock did not end with shock. In *shock-negative* training, notated A+/sh→A-, presentations of A that were preceded by shock did not end with shock. Differential responding was stronger in shock positive training, particularly in the 8-sec delay condition.

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A recent experiment by Bottjer and Hearst (1979) provided similar results in autoshaping discriminations with pigeons, where food was the feature that predicted whether a trial would end with food. In the *food-positive* (Food $\rightarrow$ A+/A-) discrimination, positive trials began with a 3-sec presentation of food accompanied by a clicker. After a brief delay, the key was illuminated for 6 sec, then food was presented again. Negative trials began with a 3-sec clicker, then the key light, followed by no food. In the *food-negative* (A+/Food $\rightarrow$ A-) discrimination, trials that began with food did not end with food, but trials that began with no food (i.e., only the 3-sec clicker) ended with food. Bottjer and Hearst found that pigeons learned the food-positive discrimination much more rapidly than the food-negative discrimination. Like the Terry and Wagner experiment, Bottjer and Hearst's results suggest that the feature-positive effect may occur in A vs. US $\rightarrow$ A discriminations where a US presentation at the start of the trial signals the occurrence or nonoccurrence of the US at the end of the trial.

Our interest in A vs. US $\rightarrow$ A discriminations was prompted by an earlier experiment in this laboratory (Memmott & Reberg, 1977) involving a shock-negative (A+/sh $\rightarrow$ A-) discrimination in conditioned suppression. A+ trials were 1-min presentations of tone (A) followed by shock, and sh $\rightarrow$ A- trials were 1-min presentations of tone preceded, but not followed, by shock. That procedure quickly produced differential suppression (i.e., greater suppression on N+ trials than on sh $\rightarrow$ N- trials), indicating that rats can easily learn a feature-negative discrimination in which shock is the feature that signals the nonoccurrence of shock. Our purpose in this experiment was to determine if rats would also learn a sh $\rightarrow$ A+/A- shock-positive discrimination in which shock signals the occurrence of shock. Feature-positive effect research [particularly the previously noted experiments of Bottjer and Hearst (1979) and Terry and Wagner (1975)] led us to predict that the shock-positive discrimination would be acquired even more quickly than the shock-negative discrimination. In contrast to that prediction, this experiment demonstrated a clear feature-negative effect. In shock-negative training, rats quickly developed a pattern of differential suppression, but the shock-positive

discrimination was not acquired by the majority of the rats.

METHOD

Subjects

The subjects were 19 male adult albino rats, experimentally naive, purchased from the Woodlyn Breeding Farm, Guelph, Ontario. They were individually caged and food deprived to 80% of free-feeding weights (mean = 373.7 g, sd = 23.6). In the main experiment, 12 rats were used; 7 rats were used in a partial replication.

Apparatus

Four experimental chambers (24.1 cm by 22.9 cm by 30.3 cm) were used. Each chamber had Plexiglas side walls and top and stainless steel end panels. The floor was a grid of 19 stainless steel rods through which scrambled shock could be delivered from Grason-Stadler Model 700 shock generators.

Centered on one wall 9.1 cm from the floor was a rat lever, 5.1 cm by 1.2 cm by 1.5 cm, that required a force of about .25 N for activation. In the lower left corner of the same wall was a small food cup into which 45-mg Noyes food pellets could be delivered. A 7-W houselight was mounted outside each box. The conditioned stimulus (CS) was white noise (75 dB re: 20 N/m²) presented through a 10.2-cm speaker positioned directly over each box.

Procedure

After preliminary bar press training, the three groups of rats ($n = 4$) in the main experiment were given variable interval 30-sec bar press training in ten 2-hour sessions. The rats in replication groups 1A ($n = 3$) and 2A ($n = 4$) received nine 2-hr sessions of VI 30-sec training. During each of the next two 2-hr sessions, six 60-sec pretest presentations of noise occurred at irregular intervals while the rats barpressed for food.

Conditioned suppression training. Six 60-sec presentations of noise occurred during each 2-hr VI 30-sec bar press session. Shock at the beginning or the end of a trial occurred during the first 2 sec or the last 2 sec, respectively, of noise at an intensity of 1 mA. Six irregular sequences of conditioning trials were alternated over 32 days of training.

Fig. 1. Diagram of training procedures. See text for details.

The training procedures are illustrated in Figure 1. Subjects in Group 1 and replication Group 1A received shock-positive training ($sh \rightarrow N^+/N^-$), where three of the six presentations of noise (N) in each session began and ended with shock ($sh \rightarrow N^+$), and the other three presentations of noise neither began nor ended with shock (N^-). Subjects in Groups 2 and 2A received shock-negative ($N^+/sh \rightarrow N^-$) training, where three of the six presentations of noise in each session did not begin with shock but ended with shock (N^+), and the other three presentations of noise began with shock but did not end with shock ($sh \rightarrow N^-$). Subjects in Group 3 received shock-random training, in which shock at the beginning of noise did not reliably signal whether shock would occur at the end of the trial. That was accomplished by presenting N^+ , N^- , $sh \rightarrow N^+$, and $sh \rightarrow N^-$ trials in every session. Each session of shock-random training included at least one but no more than two of each type of trial, arranged so that three trials began with shock and three ended with shock.

RESULTS

The results will be presented in two parts. The first will show acquisition of the discriminations in terms of mean suppression ratios for each group. The second part will show rates of bar pressing that developed for individual rats.

Acquisition of Discriminations: Group Suppression Ratios

Figure 2 shows the results for each group plotted as mean suppression ratios averaged

over blocks of two sessions. The ratios were calculated for each session according to the formula $a/(a + b)$ where a = the mean number of bar presses that occurred during 1-min presentations of noise and b = the mean number of bar presses that occurred during 1-min periods that immediately preceded noise. Suppression ratios of .00 indicate complete suppression and ratios of .50 indicate no suppression. Acquisition of a discrimination is indicated by ratios approaching .00 on positive (shock-reinforced) trials and ratios approaching .50 on negative trials.

The individual points at the left of each graph show suppression ratios for pretest trials. Noise did not produce substantial pretest suppression in any group.

There were very clear differences in acquisition of the discriminations. Groups 1 and 1A were slow to develop suppression in shock-positive training. In Group 1, there were no consistent differences in suppression on $sh \rightarrow N^+$ and N^- trials at any point in training. The shock-negative discrimination developed more rapidly. Group 2 showed less suppression on $sh \rightarrow N^-$ trials than on N^+ trials as early as Block 3, and Group 2A showed a similar pattern beginning in Block 6.

The data from Group 3 in Figure 2 show the results of shock-random training. Suppression ratios were combined for trials that began with shock ($sh \rightarrow N^+$ and $sh \rightarrow N^-$) and trials that did not begin with shock (N^+ and N^-). With the exception of the first block of sessions, trials that began with shock produced slightly less suppression on the average than those that did not begin with shock. However, that pattern did not occur in all animals in Group 3 (see below).

Acquisition of Discriminations: Response Rates

Rates of bar pressing for individual rats are shown in Figure 3. Each graph shows baseline (pre-CS) rates and rates during noise presentations, averaged over blocks of two sessions. Table 1 shows the same data for each rat averaged over all sessions.

Observe first that pre-CS baseline rates for all animals except Rat 4 decreased early in training. There were two cases where baseline rates remained substantially suppressed throughout training (Rats 2A and 9), but the other rats eventually recovered to levels ap-

Fig. 2. Mean suppression ratios for blocks of two sessions.

proximating those observed in pretest. Inasmuch as comparable ranges of baseline rates occurred in all groups, differences in the acquisition of differential control cannot be attributed to baseline differences.

Observe also that positive trial rates in shock-positive training (sh→N⁺ trials) were about the same as positive trial rates in shock-negative training (N⁺ trials). Those rates, in turn, were comparable to those that occurred

during all trials in shock-random training. Therefore, differences in the acquisition of differential suppression cannot be attributed to stronger suppression that might have, for example, occurred in shock-positive training wherein shock deliveries were more closely spaced than in the other procedures.

To evaluate the discrimination performances of individual rats, we established an arbitrary set of criteria for distinguishing

Fig. 3. Bar-press rates for all rats averaged over blocks of two sessions. For Rat 2, only pre-CS rates are shown for Block 16 because of an apparatus failure that spoiled trials for that rat in Sessions 31 and 32.

Table 1
Bar Press Rates Averaged over Sessions

Shock positive				Shock negative				Shock random			
Rat	PRE	Sh→N+	N-	Rat	PRE	N+	Sh→N-	Rat	PRE	Sh→N+	N+
1	26.88	2.44	14.69	5	28.18	3.63	16.63	9	10.71	2.50	2.87
2	18.29	1.00*	3.93*	6	32.11	6.25	24.63	10	42.65	8.75	7.75
3	24.71	6.06	5.38	7	24.47	2.00	16.81	11	27.00	3.63	3.75
4	75.58	8.31	7.94	8	27.41	2.63	6.81	12	23.47	5.50	8.81
1A	26.88	5.25	5.63	5A	24.47	1.25	1.56	Mean = 25.96		5.09	5.79
2A	8.18	.63	.38	6A	27.11	4.25	7.00	Med = 25.23		4.57	5.75
3A	40.47	4.06	7.06	7A	29.88	1.56	11.19				
Mean = 31.57	4.39	6.43		8A	39.35	2.06	18.10				
Med = 26.88	4.06	5.63		Mean = 29.12	2.95	12.84					
				Med = 27.80	2.35	14.00					

*Mean excluding Sessions 31 and 32.

among strong, moderate, and weak levels of differential suppression. These criteria were based on positive and negative trial rates expressed as percentages of baseline rates. *Strong* differential suppression was judged if, in a particular block of sessions, positive trial rates subtracted from negative trial rates (each expressed as a percentage of baseline) yielded a difference of at least 75%. For example, the final block of sessions for Rat 1, in which the sh→N+ rate was 6% of baseline and the N- rate was 138% of baseline, was classified as an instance of strong differential suppression (difference = 132%). Other levels of performance were defined as follows: *moderate* differential suppression—the difference was at least 50% but no greater than 74%; *weak* differential suppression—the difference was at least 25% but no greater than 49%; and *nondifferential* suppression—the difference was less than 25%. Each rat's performance in terms of those criteria is summarized in Table 2.

Only Rat 1 mastered the shock-positive discrimination to the point where strong differential suppression occurred. Two other shock-positive subjects (Rats 2 and 3A) developed moderate differential suppression, but the other subjects (Rats 3, 4, 1A, and 2A) maintained nondifferential suppression throughout training. Thus, the majority of rats failed to master the shock-positive discrimination and, as assessed by Wilcoxon's matched-pairs signed-ranks test, averaged N- rates (see Table 1) were not reliably greater than average sh→N+ rates [$T(7) = 7, p > .05$].

By the same criteria, six shock-negative subjects (Rats 5, 6, 7, 8, 7A, and 8A) mastered the discrimination to the point where strong differential suppression occurred in at least one block of sessions. The discrimination was not easily established in all subjects: Rat 6A developed only weak differential suppression, and Rat 5A maintained nondifferential suppression throughout training. However, aver-

Table 2

Maximum level of differential suppression and blocks in which it occurred. (S = strong; M = moderate; W = weak, N = nondifferential.)

Shock positive			Shock negative			Shock random		
Rat	Maximum	Blocks	Rat	Maximum	Blocks	Rat	Maximum	Blocks
1	S	14, 15, 16	5	S	13, 16	9	M	16
2	M	14, 15	6	S	10, 12, 13, 15, 16	10	N	—
3	N	—	7	S	12, 13, 14, 16	11	N	—
4	N	—	8	S	16	12	M	6
1A	N	—	5A	N	—			
2A	N	—	6A	W	13, 14, 16			
3A	M	16	7A	S	14, 15			
			8A	S	14, 15			

age $sh \rightarrow N-$ rates (see Table 1) were reliably greater than $N+$ rates [Wilcoxon's $T(8) = 0$, $p = .01$], and the general pattern is clearly that shock negative training produced more consistent and more substantial differential suppression than shock positive training.

Figure 3 also shows response rates for rats in Group 3 during shock-random training. As in the suppression ratio analysis, combined data are shown for trials that began with shock ($sh \rightarrow N+$ and $sh \rightarrow N-$) and trials that did not begin with shock ($N+$ and $N-$). Rat 12 consistently showed higher bar-press rates during trials that began with shock, exhibiting differences in the sixth block of sessions that satisfied our criterion of moderate differential suppression. For the other three rats, higher rates sometimes occurred during trials that began with shock and sometimes during trials that did not begin with shock. Of those subjects, only Rat 9 met any of the criteria for differential suppression (moderate differential suppression in Block 16, in which response rates were higher on trials that did not begin with shock). Overall, shock at the start of a trial had weak and inconsistent effects on bar-press rates in shock-random training.

Cumulative records for a rat from each group are shown in Figure 4. Records marked A are from early training, records marked B are from midtraining, and those marked C are from late training. Intertrial responses have been deleted from the records to show details of responding immediately before, during, and after noise presentations.

Note first the absence of postshock bursts that might indicate bar presses directly elicited by shock. In general, more bar pressing occurred in the first half of noise presentations than in the second half. That pattern was particularly noticeable in shock-negative training, wherein the discrimination initially appeared in the first half of $sh \rightarrow N-$ trials (see Rat 5, record B). The discrimination extended to the second half of $sh \rightarrow N-$ trials later in training (see Rat 5, record C).

DISCUSSION

The major result of this experiment was that the shock-positive discrimination was much more difficult for rats to acquire than the shock-negative discrimination. As noted earlier, Bottjer and Hearst (1979), as well as

Terry and Wagner (1975) obtained rapid acquisition of discrimination similar to the shock-positive discrimination. Thus, there are two major questions to consider: (a) Why did the feature negative effect occur in the present experiment? and (b) Why did the present results differ from those obtained by Terry and Wagner and by Bottjer and Hearst? We will consider three answers to those questions. First, we will examine our N vs. $sh \rightarrow N$ procedures to see if they violated the design of feature discriminations in a way that could account for the feature negative effect. Second, we will consider if the feature negative effect is an artifact of shock presentations. Third, we will propose an associative explanation of the feature negative effect.

N vs. sh → N Procedures as Feature Discriminations

The feature-positive ($AX+/A-$) and feature-negative ($A+/AX-$) discriminations introduced by Jenkins and Sainsbury (1969, 1970) were symmetrical and reversed: that is, the events that occurred during $S+$ in one procedure were exactly the same as those that occurred during $S-$ in the other. That symmetry permits direct and unambiguous comparison of the procedures. It can be said, for example, that the only difference between symmetrical feature-positive and feature-negative discriminations is that the feature signals reinforcement in one case and nonreinforcement in the other.

The present experiment is very much in the tradition of Jenkins and Sainsbury's "feature" discriminations, in the sense that tasks based on positive and negative predictive information were compared. Close inspection of the shock-positive and shock-negative discriminations, however, reveals that they were not symmetrical. The asymmetry can be seen clearly in the diagrams in Figure 1; the $S+$ for shock-positive training, for example, was not exactly the same as the $S-$ for shock-negative training. The overlapping terminal shock was responsible for that asymmetry. If the terminal shock had been presented after trial termination, the events during $S+$ in one procedure would have been exactly the same as the events during $S-$ in the other, and the discriminations would then technically have been symmetrical. Note that any feature-discrimination programming reinforcement dur-

RAT 1 **RAT 5** **RAT 10**

Fig. 4. Sample cumulative records for Rat 1 (shock-positive training), Rat 5 (shock-negative training) and Rat 10 (shock-random training). Each record shows the six trials that occurred during single sessions early in training (A), in midtraining (B), and late in training (C). Intertrial responses have been deleted so that each record shows responding immediately before, during, and after presentations of N. N presentations are indicated by displacements of the recording pen in records marked A for all rats and B for Rat 5, and by displacements of the superimposed event marker tracing in all other records. The dots indicate shocks. Brief displacements of the pen indicate food deliveries (not shown in records A for all rats and record B for Rat 5).

ing stimulus presentations (such as a free-operant procedure) would face the same potential problem of asymmetry.

Could this asymmetry somehow have been responsible for the feature-negative effect? Previous experiments in this laboratory (Reberg, 1978; Reberg & LeClerc, 1977) using A vs. AX conditioned suppression procedures also included shock that overlapped the last portion of positive trials, which meant that those discriminations were also technically asymmetrical. But those experiments produced robust feature-positive effects and the present experiment produced a feature-negative effect. Consequently, it does not seem possible to attribute the present results to the overlapping terminal shock and any resulting asymmetry.

Nonassociative Explanations of the Feature-Negative Effect

It is conceivable that our feature-negative effect is an artifact of shock presentations. For example, shock might directly elicit bursts of bar pressing (Weiss & Strongman, 1969) or induce a state of postshock "relief" (perhaps through an opponent-process mechanism, e.g., Solomon & Corbitt, 1973). Such unconditioned effects could produce more bar pressing during trials that begin with shock. This would tend to facilitate the $N+/sh \rightarrow N-$ shock-negative discrimination and impede the $sh \rightarrow N+/N-$ shock-positive discrimination.

Three sources of evidence in the present data argue against the nonassociative interpretation. First, the data from shock-random training shown in Figure 2 indicate that shock at the beginning of a trial reliably facilitated bar pressing for only Rat 12. Second, inspection of cumulative records (see Figure 3) did not reveal postshock bursts that might have indicated elicited bar pressing. Third, we analyzed the response rates that occurred during 1-min posttrial periods for Groups 1, 2, and 3. If shock had an unconditioned facilitating effect on bar pressing, consistently higher rates should have occurred after trials that ended with shock. That effect occurred reliably only in Rats 3 and 12. The other rats often bar pressed at higher rates after trials that ended with shock (particularly in early blocks of sessions), but lower rates after shock were also very common. Our conclusion is that nonassociative mechanisms cannot provide a full ex-

planation of the feature-negative effect obtained in this experiment.

Associative Explanations of the Feature-Negative Effect

We propose that the feature-negative effect may be understood in terms of the Pavlovian stimulus-reinforcer contingencies in shock-positive and shock-negative training. We will present our argument in two stages. First we will briefly discuss Pavlovian contingencies in conventional A vs. AX feature-positive and feature-negative discriminations and show how those contingencies favor the development of feature-positive discriminations. Then we will discuss the Pavlovian contingencies in A vs. $sh \rightarrow A$ discriminations, and show how those contingencies seem to favor the acquisition of shock-negative discriminations.

In this discussion, positive contingencies (in which, for example, event X predicts the occurrence of shock) will be represented by the probability of shock given X [$p(sh/X)$]. Negative contingencies (in which, for example, event X predicts the nonoccurrence of shock) will be represented by the probability of "no-shock" given X [$p(\bar{sh}/X)$]. In conditioned suppression experiments, positive contingencies would normally be expected to produce excitatory effects (i.e., suppression) and negative contingencies would be expected to produce inhibitory effects (i.e., effects that oppose suppression).

Pavlovian contingencies in A vs. AX discriminations. A vs. AX discriminations may be described in terms of the probabilities of shock associated with A and X. In $A+/AX-$ feature negative discriminations, 50% of A presentations are followed by shock and 100% of X presentations are followed by no-shock. Those contingencies may be represented:

$$A+/AX- \quad \begin{array}{l} p(sh/A) = .5 \\ p(\bar{sh}/X) = 1.0 \end{array}$$

Many investigators (see Rescorla, 1969, for review) have found that $A+/AX-$ training typically results in A developing excitatory control and X developing inhibitory control.

In $AX+/A-$ feature-positive training, 50% of A presentations are followed by shock and 100% of X presentations are followed by shock:

$$AX+/A- \quad \begin{array}{l} p(sh/A) = .5 \\ p(sh/X) = 1.0 \end{array}$$

Several experiments (e.g., Wagner, Logan, Hamberlandt, & Price, 1968; cf. also Rescorla & Wagner, 1972) have found that discriminations of that type usually result in X developing strong excitatory control while A, a redundant stimulus, becomes comparatively neutral.

According to this analysis, feature-positive training results in the feature developing excitatory control, and feature-negative training results in the feature developing inhibitory control. Since inhibitory control usually develops more slowly than excitatory control (cf. Blough, 1975; Hearst, 1978), that difference is probably a major reason for the slow acquisition of conventional feature-negative discriminations (for further details see Jenkins, 1973; Reberg, 1978; Reberg & LeClerc, 1977).

Pavlovian Contingencies in A vs. sh→A Discriminations. In A+/sh→A− shock-negative discriminations, A is followed by shock in 50% of presentations, and shock is always followed by no-shock:

$$\begin{array}{l} A+ / sh \rightarrow A- \quad p(sh/A) = .5 \\ \quad \quad \quad \quad \quad p(sh/sh) = 1.0 \end{array}$$

The objective of shock-negative training appears to be establishment of shock as an inhibitory signal for no-shock. In that respect, shock-negative training resembles conventional A+/AX− feature-negative training. But in shock-negative training, the subject is exposed to the negative sh/sh contingency on every trial because shock on sh→A− trials is followed by no-shock, and shock on A+ trials is followed by a shock-free intertrial interval (Ayres, Mahoney, Proulx, & Benedict, 1976; Memmott & Reberg, 1977; cf. also Davis, Memmott, & Hurwitz, 1975). That characteristic of shock-negative training may very well contribute to the rapid development of inhibitory control by shock as a signal for no-shock.

In sh→A+/A− shock-positive training, 50% of A presentations are followed by shock. Since shock occurs at both the beginning and end of sh→N+ trials, 50% of shock presentations are closely followed by shock and 50% are followed by a shock-free intertrial interval. The resulting Pavlovian contingencies may be represented:

$$\begin{array}{l} sh \rightarrow A+ / A- \quad p(sh/A) = .5 \\ \quad \quad \quad \quad \quad p(sh/sh) = .5 \end{array}$$

Shock-positive discriminations seem to re-

quire that shock develop strong excitatory control as the dominant predictor of shock. In that respect, shock-positive training resembles conventional feature-positive training. But the contingencies in shock-positive training clearly do not favor shock acquiring the dominant share of excitatory control because shock predicts shock no more reliably than A predicts shock. From that perspective, it is not surprising that rats have difficulty mastering shock-positive discriminations.

A similar analysis of the shock-random procedure gives the following probabilities:

$$\begin{array}{l} sh \rightarrow A+ / sh \rightarrow A- / A+ / A- \quad p(sh/A) = .5 \\ \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad p(sh/sh) = .75 \end{array}$$

From those probabilities one might expect at least some differential suppression in shock-random training. Since shock is not a perfect predictor of no-shock, however, it is understandable that it would take longer to develop than the 32 sessions studied in this experiment.

Related Experiments and Further Questions

As we noted in the introduction to this paper, Bottjer and Hearst (1979) and Terry and Wagner (1975) obtained excellent learning of discriminations similar to the shock-positive discrimination that was so difficult to establish in this experiment. What could be responsible for those discrepancies? There were many differences among the experiments, since Terry and Wagner studied conditioned eyeblink discriminations in rabbits, Bottjer and Hearst studied autoshaped discriminations in pigeons, and this experiment studied conditioned suppression discriminations in rats. At this point, however, we believe that the most likely reason for the difference is that trial durations were quite short in the Terry-Wagner and Bottjer-Hearst experiments (varying randomly among 3, 5, 9, or 17 sec in the former and fixed at 9 sec in the latter) and quite long in the present experiment (1 min). The advantages of feature-positive training in Terry and Wagner's experiment were most evident when trial durations were comparatively short. One obvious line of investigation, then, is to study how different trial durations affect A vs. sh→A discriminations in conditioned suppression. In shock-positive training, for example, shorter intervals between shock presentations might

facilitate the detection of shock as a signal for shock (perhaps through an organizational principle of temporal proximity). It remains to be seen if shorter trial durations can facilitate conditioned suppression discriminations to the point where shock-positive training progresses more rapidly than shock-negative training.

REFERENCES

- Ayres, J. B., Mahoney, W. J., Proulx, D. T., & Benedict, J. O. Backward conditioning as an extinction procedure. *Learning and Motivation*, 1976, 7, 368-381.
- Blough, D. S. Steady state data and a quantitative model of operant generalization and extinction. *Journal of Experimental Psychology: Animal Behavior Processes*, 1975, 104, 7-21.
- Bottjer, S. W., & Hearst, E. Food delivery as a conditional stimulus: Feature-learning and memory in pigeons. *Journal of the Experimental Analysis of Behavior*, 1979, 31, 189-207.
- Davis, H., Memmott, J., & Hurwitz, H. M. B. Auto-contingencies: A model for subtle behavioral control. *Journal of Experimental Psychology: General*, 1975, 104, 169-188.
- Hearst, E. Stimulus relationships in feature selection. In S. Hulse, H. Fowler, & W. K. Honig (Eds.), *Cognitive processes in animal behavior*. Hillsdale, N.J.: Erlbaum Associates, 1978.
- Jenkins, H. M. Noticing and responding in a discrimination based on a distinguishing element. *Learning and Motivation*, 1973, 4, 115-137.
- Jenkins, H. M., & Sainsbury, R. S. The development of stimulus control through differential reinforcement. In N. J. Mackintosh & W. K. Honig (Eds.), *Fundamental issues in associative learning*. Halifax: Dalhousie University Press, 1969.
- Jenkins, H. M., & Sainsbury, R. S. Discrimination learning with the distinctive feature on positive or negative trials. In D. I. Mostofsky (Ed.), *Attention: Contemporary theory and analysis*. New York: Appleton-Century-Crofts, 1970.
- Memmott, J., & Reberg, D. Differential conditioning in the Konorski-Lawicka paradigm. *Animal Learning and Behavior*, 1977, 5, 124-128.
- Reberg, D. The feature positive effect in conditioned suppression: Effects of simultaneous and sequential compound stimuli. *Psychological Record*, 1978, 28, 595-604.
- Reberg, D., & LeClerc, R. A feature positive effect in conditioned suppression. *Animal Learning and Behavior*, 1977, 5, 143-147.
- Rescorla, R. A. Pavlovian conditioned inhibition. *Psychological Bulletin*, 1969, 72, 77-94.
- Rescorla, R. A., & Wagner, A. R. A theory of Pavlovian conditioning: Variations in the effectiveness of reinforcement and nonreinforcement. In A. H. Black & W. F. Prokasy (Eds.), *Classical conditioning II*. New York: Appleton-Century-Crofts, 1972.
- Solomon, R. L., & Corbitt, J. D. An opponent-process theory of motivation: II. Cigarette addiction. *Journal of Abnormal Psychology*, 1973, 81, 158-171.
- Terry, W. S., & Wagner, A. R. Short-term memory for "surprising" versus "expected" unconditioned stimuli in Pavlovian conditioning. *Journal of Experimental Psychology: Animal Behavior Processes*, 1975, 104, 122-133.
- Wagner, A. R., Logan, F. A., Hamberlandt, K., & Price, T. Stimulus selection in animal discrimination learning. *Journal of Experimental Psychology*, 1968, 76, 171-180.
- Weiss, K. M., & Strongman, K. T. Shock-induced response bursts and suppression. *Psychonomic Science*, 1969, 15, 238-240.

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