SUMMATION OF PUNISHMENT SUPPRESSION¹

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In two experiments, eight rats were trained to lever press with food on a variable-interval schedule. Bar pressing produced shock on a variable-interval schedule in the presence of two independently presented stimuli, a light and a tone. Two rats in each experiment received alternative presentations of the light and the tone and were consequently always in the presence of a stimulus that signalled variable-interval punishment. The other two rats in each experiment were treated similarly except that they received periods in which neither light nor tone was present. During these periods, bar pressing was not punished. The two stimuli that signalled punishment were then presented simultaneously to evaluate the effect of stimulus compounding on response suppression. The subjects trained without punishment-free periods did not show summation to the compound stimulus; the subjects trained with punishment-free periods showed summation of suppression. The major difference between the two experiments was the longer mean interval of variable-interval punishment used in the second experiment. This manipulation made the summation effect more resistant to extinction and thus increased its magnitude.

Animals trained to emit the same response during the presentations of two different stimuli can be tested with the compound of these training stimuli. During such tests, animals often show more responding to the compound than to either of the individual stimuli (Cornell and Strub, 1965; Wolf, 1963). This outcome is termed summation (Wolf, 1963).

In studies that showed summation of food-reinforced behavior, a third stimulus condition was present. Responding during this stimulus condition was never reinforced. Subjects either spent half of each session in extinction (Cornell and Strub, 1965; Wolf, 1963) or had to cease responding for a specified period of time before the next discriminative stimulus would begin (Weiss, 1964, 1969).

Weiss (1968) investigated the effect of the extinction component on summation of appetitive behavior. He found that rats trained with an extinction component demonstrated reliable summation to compound presentations, but rats trained without extinction did not.

The rats trained without an extinction component either emitted a response rate intermediate to its high and low rate or responded at a rate essentially equivalent to its high rate.

The purpose of the present experiment was to replicate Weiss's (1968) phenomenon with a punishment procedure. Weiss showed that the presence or absence of an extinction component determines whether or not summation of responding occurs for food. Thus, it was reasoned by analogy that the presence or absence of a stimulus that signals the absence of punishment would also determine whether or not summation of punishment suppression is obtained. That is, if an animal were trained with a stimulus that signals the absence of punishment, it should show summation of punishment; if an animal were trained without this stimulus condition, summation should not be obtained.

EXPERIMENT I

METHOD

Subjects

Four male Sprague-Dawley albino rats were maintained at 80% of their free-feeding weights. They were approximately 18 weeks old at the beginning of the experiment.

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Apparatus

The experimental chamber was a Scientific Prototype A-102 rodent test cage housed in a ventilated, sound-deadened enclosure. The houselight, a 28-v bulb located 2.75 in (7 cm) above the lever, was always on. One stimulus, an 80-db, 1200-Hz tone, was delivered by a Hewlett-Packard 204C oscillator through an 8-ohm speaker. The sound intensity measurements were taken with a General Radio 1551 sound level meter, scale C, with the microphone located 2 in (5 cm) above the grid floor in close proximity to the response lever. The ambient noise in the chamber with the exhaust fan running was 68 db. The second stimulus was a 25-w overhead light source diffused by a sheet of lucite 3 mm thick. The lucite sheet was 10 in (25 cm) above the floor of the apparatus. Scrambled shock was delivered by a Grason Stadler Model 700 shock generator to the grid bars. Reinforcers provided were 45-mg Noyes rat pellets.

Procedure

Basically, the experimental procedure consisted of conventional magazine training and bar-press shaping, followed by variable-interval training. Bar presses were then punished for all subjects in the presence of light alone and tone alone. Half the subjects also received a third component signalled by the absence of both tone and light, during which responding was never punished. All subjects were then tested for summation of punishment suppression with the tone-light compound during the extinction of punishment.

Variable-Interval Training

Preliminary bar-press training consisted of approximately 100 reinforced bar presses on Day 1. Subjects then received 100 reinforcements a session for four consecutive days according to the following schedules: Day 2, each of the first 10 bar presses were reinforced, the remaining 90 reinforcers were delivered on a VI 10-sec schedule; Day 3, 10 reinforcements VI 10-sec and 90 reinforcements VI 15-sec; Day 4, 10 reinforcements VI 15-sec and 90 reinforcements VI 20-sec; Day 5, 10 reinforcements VI 20-sec and 90 reinforcements VI 30-sec. Following this five-day preliminary training period, all subjects received three 1 hr sessions on VI 30-sec.

Punishment Training

On Day 9, punishment suppression training was initiated during the daily, bar-press sessions. All subjects received five 5 min presentations of the tone alone and five 5 min presentations of the light alone during each session. In the presence of either tone or light, all subjects received response-dependent shock on an intermittent schedule. In addition, half the subjects (Subjects 3 and 4) also received ten 5 min presentations of the absence of both tone and light (No Stim) signalling the absence of punishment. Subjects 1 and 2 received alternate presentations of tone and light. Subjects 3 and 4 received periods of No Stim after each tone or light presentation. Therefore, Subjects 3 and 4 were trained with a stimulus condition (the absence of the tone and light) that signalled the absence of punishment, while Subjects 1 and 2 were always in the presence of a stimulus that signalled punishment. The VI 30-sec food reinforcement schedule was in effect throughout all of the stimulus presentations.

During training, the intensity and mean interval of the punishment schedule were gradually increased in order to insure baseline stability as well as substantial resistance to extinction of punishment suppression. On the first day of the punishment training (Day 9), the shock intensity was 0.05 mA delivered on a VI 20-sec schedule of punishment. When all subjects showed stable responding (Day 18) the punishment schedule was increased to VI 75-sec. Over Days 10 to 30, shock intensity was gradually increased to 0.4 mA. Since this intensity did not suppress Subject 4's responding, the shock intensity was increased to 0.8 mA for this rat. All subjects were run at the terminal shock intensity for the last 10 sessions before testing. The shock duration was fixed at 0.5 sec.

Extinction Test

The extinction test for Subjects 1 and 2 consisted of ten 1-min presentations of each of the following: tone alone, light alone, and tone-light compound, all without punishment. These stimuli were presented once in each block of three test trials. The order of stimulus presentations within blocks was random. The VI 30-sec food reinforcement schedule remained in effect throughout the test.

The extinction test for Subjects 3 and 4 was identical to that given Subjects 1 and 2 with one exception. After each stimulus presentation, the subjects received a 1-min presentation of No Stim. This was done in order to keep the test condition as similar as possible to the training condition.

RESULTS AND DISCUSSION

The average rates in the presence of each stimulus over the five sessions before testing are presented in Table 1 for each subject.

Table 1

Responses per minute during each of the three stimulus conditions for each subject averaged over the last five days of training. The absence of the tone and light is designated by No Stim.

	S1	S2	S3	S4
Tone	9.3	5.8	4.4	6.8
Light	6.4	5.5	4.4	5.7
No Stim			11.8	18.3

Fig. 1. Cumulative responses of Subjects 1 and 2 to each of the test stimuli. Each stimulus presentation lasted 1 min.

Fig. 2. Cumulative responses of Subjects 3 and 4 to each of the test stimuli. Each stimulus presentation of the tone, light and compound lasted 1 min. Since three presentations of the absence of tone and light (No Stim) were presented for each presentation of the other stimuli, the number of responses in this stimulus was divided by three. Thus, the data points for No Stim represent the average 1-min response rate over each block.

Both Subjects 3 and 4 had higher rates in the non-punishment components than in the punishment components. All subjects had similar rates during the stimuli that signalled punishment.

The results of the extinction test for subjects trained without a stimulus correlated with the absence of punishment (Subjects 1 and 2) are presented in Fig. 1. The rates during the three stimulus conditions were essentially equal. Thus, subjects in this condition did not show summation of punishment suppression.

The results for subjects trained with a punishment-free component are presented in Fig. 2. Both Subjects 3 and 4 exhibited summation of punishment suppression in that their rates to the tone-light compound were less than their rates to either tone alone or light alone.

Though the magnitude of the summation effect was not large, it was significant in comparison with the results obtained from Subjects 1 and 2. Subjects 3 and 4 also showed a higher rate of responding when the absence of punishment was signalled (No Stim).

The present results demonstrated that the presence or absence of punishment-free periods determines whether or not summation of punishment suppression is obtained. However, the magnitude of the summation effect was small. In the next experiment, an attempt was made to increase the strength of the effect.

EXPERIMENT II

One possible explanation for the weakness of the summation effect in Exp. I was the rapid extinction of both the summation and punishment suppression effects. Therefore, in this experiment the mean interval of the punishment schedule was increased in order to increase the effects' resistance to extinction.

A second purpose of this experiment was to determine whether the individual stimuli control punishment suppression when there are no punishment-free periods. Hence, all animals were tested with the absence of both the tone and light. If the tone and light control punishment suppression, the animals trained without shock-free periods should respond at a higher rate in the absence of these stimuli.

METHOD

Subjects

Four male Sprague-Dawley albino rats were maintained at 80% of their free-feeding weights. They were approximately 26 weeks old at the beginning of the experiment.

Procedure

The procedure was identical to that in Exp. I, with two exceptions. First, during punishment suppression training, the terminal punishment schedule and intensity were VI 3-min and 0.8 mA for all subjects. Second, the generalization test differed slightly for subjects trained without periods signalling the absence of punishment—Subjects 5 and 6—in that they were tested with all four test values *i.e.*, tone alone, light alone, the tone-light compound, and the absence of both tone and light. These stimuli were presented once in each block of

Table 2

Responses per minute during each of the three stimulus conditions for each subject averaged over the last five days of training. The absence of the tone and light is designated by No Stim.

	S5	S6	S7	S8
Tone	2.3	3.5	0.2	1.2
Light	3.5	3.4	0.1	1.1
No Stim			7.5	5.3

four test trials. This procedure differed from that of the previous experiment in that animals were tested with the absence of both the tone and light even when they were not absent during training. Subjects trained with periods signalling the absence of punishment—Subjects 7 and 8—were tested in the same manner as in Exp. I.

RESULTS

The average rates during each stimulus over the five sessions before testing are presented in Table 2 for each subject.

Fig. 3. Cumulative responses of Subjects 5 and 6 to each of the test stimuli. Each stimulus presentation lasted 1 min. The absence of both the tone and light is represented by No Stim.

Fig. 4. Cumulative responses of Subjects 7 and 8 to each of the test stimuli. Each stimulus presentation of the tone, light, and compound lasted 1 min. Since three presentations of the absence of tone and light (No Stim) were presented for each presentation of the other stimuli, the number of responses in this stimulus was divided by three. Thus, the data points for No Stim represent the average 1-min response rate over each block.

Both Subjects 7 and 8 had higher rates in the unpunished components than in the punished components. All four subjects in the present experiment suppressed more to the individual stimuli than did the subjects in the previous experiment.

The results of the extinction test for subjects trained with punishment correlated stimuli always present (Subjects 5 and 6) are presented in Fig. 3. The rates in the four stimulus conditions were essentially equal and therefore the animals do not show summation of punishment suppression. It is also clear from the results that the absence of the tone and light did not control greater responding than the presence of either or both of these stimuli.

The results for subjects trained with a punishment-free component (Subjects 7 and 8) are presented in Fig. 4. Both Subjects 7 and 8 exhibited summation of punishment suppression: their rates to the tone-light compound were considerably lower than their rates to either tone alone or light alone. These subject suppressed longer to the compound than did Subjects 3 and 4 of the previous experiment.

DISCUSSION

Both experiments demonstrated summation of punishment suppression. It was also shown that the presence or absence of punishment-free periods during training determines whether or not summation of punishment suppression occurs. These results replicated Weiss's (1968) findings, but utilized an aversive control paradigm. Thus, they demonstrated the functional similarity of stimuli that signal the absence of punishment and stimuli that signal the absence of food.

One possible explanation for the failure to obtain summation in subjects trained without a stimulus signalling the absence of punishment is that the two stimuli correlated with punishment did not control response suppression. This hypothesis is supported by the fact that the tone and light did not control more suppression than the absence of tone and light in subjects trained without shock-free periods in Exp. II.

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