

OVERT ACTIVITY DURING CONDITIONED SUPPRESSION: A SEARCH FOR PUNISHMENT ARTIFACTS¹

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Pigeons, previously trained to peck a key (using food as the reinforcer), were permitted unlimited access to food and, concurrently, key pecking was allowed to go unreinforced until all pecking ceased. A tone ending with electrical shock was then repeatedly presented in an effort to establish the tone as a potentially suppressing stimulus. When key pecking was later reestablished, tone presentation (without shock) sharply reduced the rate of pecks. At selected points throughout the experiment, special observation procedures supplemented the recordings of key pecks and provided detailed fine-grain protocols of the birds' overt movements during the periods before, during, and after tone presentations. Results indicated that neither punishment of key pecks nor punishment of other overt movements was a necessary precursor to the conditioned suppression observed in the final stage. As such, the findings support interpretations of conditioned suppression that characterize the phenomenon as reflecting a conditioned emotional reaction that either directly or indirectly inhibits overt activity.

In the typical procedure for developing conditioned suppression, subjects are exposed to a classical aversive conditioning procedure while they are concurrently engaged in performing positively reinforced behavior. Conditioned suppression describes the reduction in the rate of the positively reinforced response that eventually occurs during presentation of the conditioned stimulus. The procedure was first employed by Estes and Skinner (1941), and because it provided a simple and direct method for quantifying the subject's reactions, it has since been widely used in the study of aversive control. In accordance with this usage, the observed suppression is frequently interpreted to reflect the occurrence of an emotional or fear-like response that presumably inhibits the subject's overt activity. Although the details of this hypothetical inhibitory process have not been specified, the notion that fear-induced inhibition can occur is consonant with common conceptions of emotional reactions; for this reason the measured suppression is often employed as a more or less direct index of the level of fear controlled by the condi-

tioned stimulus (Brady and Hunt, 1955; Estes and Skinner, 1941; Hoffman, 1969).

Despite its intuitive appeal, interpretation of suppression as reflecting a classically conditioned emotional response that inhibits overt activity has been open to several lines of objection. The first argues that the observed reductions in the rate of the reinforced operant might in fact reflect increases in the rate of other (generally unmeasured) behaviors (Weiskrantz, 1968). For example, during the conditioned stimulus, suppression of a food-reinforced response would occur if the subject were attempting to escape from the apparatus or otherwise to avoid the noxious event. Under such circumstances, it would be incorrect to characterize the conditioned stimulus as exerting an inhibitory influence on the subject's overt activity.

In a recent study, Stein, Hoffman, and Stitt (1971), examined this objection by providing a fine-grain analysis of the stream of activities during conditioned suppression. It was found that the dominant effect of stimulus presentation was to reduce all overt movements; hence, it was clear that suppression of the reinforced operant did not reflect an increase in other, presumably incompatible, behaviors.

The second objection argues that even if conditioned suppression involves a reduction in all overt activity, the effect need not reflect an inhibitory process that has been classically

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conditioned (Dinsmoor, 1955). The critical issue here is whether or not, during conditioning, overt movements of the subject are inadvertently punished. If, for example, the noxious event occurs while the subject is moving about (as would be expected if suppression is developed while the subject is engaged in the baseline operant), movement *per se* might frequently be punished. Under such circumstances, analysis of the behavior stream during suppression could reveal a reduction in all observable movements, but that decrement might reflect the pairing of the noxious event with a response (*i.e.*, punishment) rather than the pairing of a stimulus with a noxious event (*i.e.*, classical conditioning).

In the study by Stein, *et al.* (1971), conditioning occurred while the subjects were engaged in the reinforced operant; hence, the contribution of punishment to their findings is unknown. A number of other investigations have, however, provided data that bear on this kind of question (for example, Blackman, 1968; Geller, Sidman, and Brady, 1955; Rescorla, 1968). In studies of this type, classical conditioning procedures are conducted in situations that preclude performance of the baseline operant. Because such studies have uniformly reported suppression of the baseline operant during subsequent presentations of the conditioned stimulus, one is tempted to conclude that punishment need play little, if any, role in the conditioned suppression phenomenon. Unfortunately, this conclusion goes beyond the available data. There is no question but that off-baseline conditioning precludes punishment of the baseline operant, but this factor does not necessarily mean that the procedure precludes punishment of other movements. As noted above, if during classical conditioning, movements *per se* are consistently punished, a subject might exhibit few operants (of any kind) during later suppression trials, but the effect could be due to prior punishment of movement (as a class of behaviors) rather than prior classical conditioning.

The kind of information needed to resolve this question requires an experiment in which classical conditioning trials occur off baseline (to preclude adventitious punishment of the baseline operant) and the behavior stream during classical conditioning trials is monitored (to determine whether or not other movements are in fact coincident with the noxious event).

To date no such study has been done. The present investigation sought to provide information relevant to this question by applying the observational techniques developed by Stein, *et al.* (1971) to a suppression paradigm that employed off-baseline conditioning.

METHOD

Subjects

Six experimentally naive male homing pigeons, approximately 3-yr-old at the beginning of the research, were used.

Apparatus

The apparatus has been described fully in Stein, *et al.* (1971). Briefly, it consisted of a Foringer pigeon chamber, equipment to schedule reinforcement, tones, and electrical shocks and a closed-circuit television monitoring system to permit unobstrusive visual observation of the subjects.

Procedure

The initial key-peck training proceeded as in the study by Stein, *et al.* (1971). Since those methods are also described fully in that paper they are outlined here.

Subjects were first deprived to 80% of their free-feeding weights; using 3.5 sec of access to grain as the reinforcer, they were gradually brought to a stable key-peck performance on the variable-interval 60-sec schedule of reinforcement described in Fleshler and Hoffman

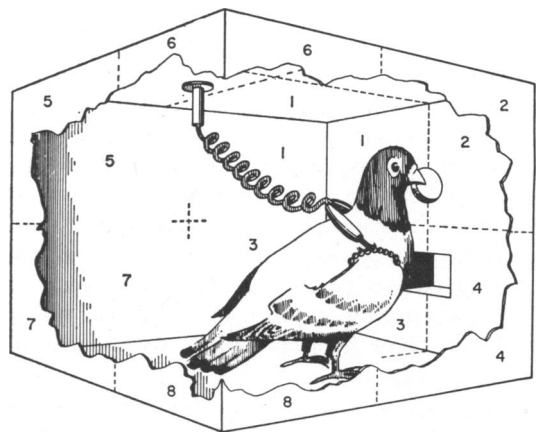


Fig. 1. A scale drawing showing the salient features of the experimental chamber and the regions used for categorizing the bird's movements. Each region was approximately 5.75 by 5.75 by 5.75 in. (14 by 14 by 14 cm).

(1962). When the baseline key-peck rate was stable (approximately 75 responses per minute across all subjects) the birds were permitted to adapt to the stimulus that later was to serve as a warning of impending shock. As in earlier studies in this laboratory, the pre-aversive stimulus consisted of a 1000-Hz tone at an intensity of approximately 90 dB (re 0.0002 dyne cm²) when measured directly in front of the key. In a single tone adaptation session, ten 69-sec 1000-Hz tones were presented at intervals of approximately 10 min while the birds pecked the key on the previously established variable-interval schedule of reinforcement. For each bird the final two tone presentations were monitored on the television system and recordings of ongoing behavior was recorded.

The method of assessing ongoing behavior has also been described fully by Stein, *et al.* (1971). It consisted of an observational procedure specifically designed to document the rapid and varied head movements that often accompany key pecking and which, during suppression, might displace that response. The birds' chamber was divided into eight visually distinctive regions by means of markings on its walls (see Fig. 1). During observation periods, two practiced observers, each in a separate acoustically isolated room, watched the subject on closed-circuit television and called out the numbers of the regions that the bird's head entered as it moved about. These verbal running accounts were tape recorded and later transcribed onto strip charts to provide a complete detailed picture of the sequential order of head movements throughout the recorded interval. As documented in Stein, *et al.* (1971), the procedure yields readily interpreted records that, despite their focus on head movements, accurately depict the essential features of the stream of observable activities occurring within the chamber.

Upon completion of the adaptation sequence, the subjects were returned to their home cages and were given continuous access to food for five days to permit body weights to attain normal levels. The birds were then returned to the apparatus for approximately 1 hr each day, during which time they were permitted to key peck but no reinforcement occurred; nor were tones ever presented. After 17 sessions of this combined satiation and extinction procedure, all birds had ceased peck-

ing and would stand relatively immobile in the apparatus. In the next phase of the experiment, classical conditioning procedures were instituted. In each of 20 sessions, seven 69-sec 1000-Hz tones were presented. Throughout the final 9 sec of each tone, a 2-mA pulsating electrical shock occurred. Shock pulses were 0.25 sec duration and were presented at a rate of two per second. A given tone-shock session began with the subject placed in the chamber with all lights off for at least 30 sec. The tone-shock procedure began with the onset of lights. After 10 min in this condition, the first tone was presented and tones subsequently occurred at intervals of approximately 10 min. Before the first, and after every five of these sessions, subjects were exposed to a shorter (approximately 20 min) session incorporating a single tone shock trial. During each of these "observation" trials, subjects were monitored via television and, using the procedures described above, their overt movements were recorded.

Finally, all subjects were again placed on a restricted feeding regimen until their body weights had once more dropped to 80% of their free-feeding levels. When the new weight levels were attained (after approximately 21 days), the subjects were returned to the apparatus and again using a variable-interval 60-sec schedule of reinforcement, baseline key pecks were reestablished. When base rates were stable (after five 1-hr sessions), tests for conditioned suppression were begun. In each of seven sessions, two or more 69-sec tones were presented at intervals of about 10 min (without an accompanying shock), while the birds pecked the key for food. In the first session, two tones were presented and, using the procedures described above, behavior during each was monitored. On the next session, seven tones were presented but, except for the automatically recorded key peck, overt behavior was not monitored. The next session again contained only two tones and again overt behavior was monitored. Subsequent observation sessions (two tones) alternated with longer sessions (seven tones) until a total of 29 tones had been presented.

RESULTS

Figure 2 portrays the frequency of key pecks and of other head movements (averaged across birds) throughout the several stages of the

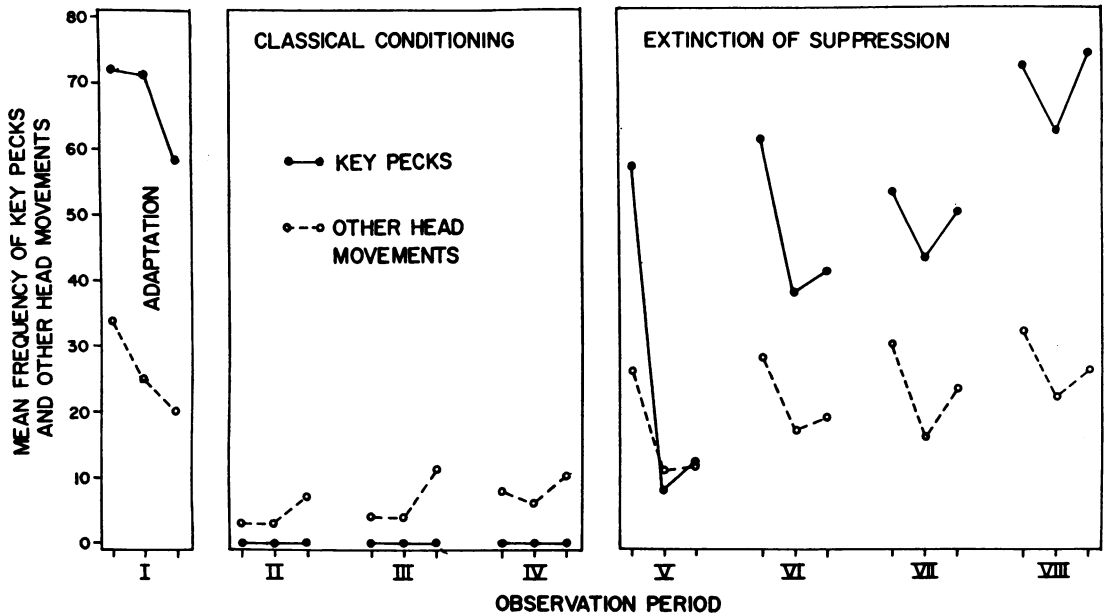


Fig. 2. Mean frequency of key-peck responses and of other head movements during each phase of the experiment. Observation period I refers to the final two trials in which tone was presented before tone and shock were paired. Observation periods II, III, and IV refer to successive pairs of observation trials during which tones ending with shock were presented while the birds were satiated and hence did not peck the key. Observation periods V to VIII refer to successive pairs of observed trials during which tones, but not shocks, were subsequently presented while the birds again pecked the key. In each observation period, the first point refers to the 60-sec pre-tone period that ended with tone onset, the second point refers to the initial 60-sec (shock-free) period of tone, and the third point refers to the 60-sec post-tone period that began when the tone was terminated.

Table 1

Key Pecks and Other Movements

Frequency of key pecks (P) and other movements (O) for the individual birds at each stage of the experiment. In a given observation period, the entry at the left refers to the 60-sec pre-tone period that ended with tone onset, the entry in the middle refers to the initial 60-sec (shock-free) period of tone, and the entry to the right refers to the 60-sec post-tone period that began when the tone was terminated.

Observation Period	Adaptation				Classical Conditioning								Extinction of Suppression												
	I				II			III			IV		V			VI			VII			VIII			
Bird #17	P	84	77	85	—	—	—	—	—	—	—	—	—	41	4	4	43	7	22	56	3	28	73	20	53
	O	23	19	15	15	5	11	4	1	24	18	14	14	24	8	7	26	16	19	24	15	23	23	26	23
Bird #16	P	72	80	37	—	—	—	—	—	—	—	—	—	68	6	9	38	6	6	46	29	32	55	28	48
	O	29	21	23	1	3	9	3	8	8	6	5	14	31	25	20	34	30	22	35	22	30	38	26	39
Bird #13	P	70	83	62	—	—	—	—	—	—	—	—	—	32	—	—	33	3	5	26	3	23	62	27	58
	O	31	23	19	1	1	2	6	5	7	4	3	8	21	5	2	21	4	12	19	4	17	31	24	27
Bird #12	P	78	65	44	—	—	—	—	—	—	—	—	—	76	4	8	86	66	77	54	50	47	72	103	75
	O	39	34	16	6	5	9	2	4	5	1	6	5	29	4	11	20	24	20	33	26	34	36	25	27
Bird #23	P	51	47	40	—	—	—	—	—	—	—	—	—	27	8	10	54	23	38	50	32	42	72	58	80
	O	30	25	20	3	4	5	4	5	8	6	5	13	20	8	14	34	21	24	23	22	27	21	27	23
Bird #24	P	80	73	82	—	—	—	—	—	—	—	—	—	98	23	40	114	125	97	90	150	128	99	139	131
	O	32	25	22	1	1	11	5	2	15	5	2	11	35	15	19	34	16	19	49	9	14	41	4	19

experiment. Table 1 shows these frequencies for individual birds.

In preparing Fig. 2 and Table 1, the procedures described in Stein, *et al.* (1971) were used to provide a strip-chart record of each bird's head movements throughout each observation period. Frequencies of key pecks and of other head movements were tabulated from these strip charts. Frequencies of key pecks were counted on the charts and verified against counter readings that had been obtained previously. Frequencies of other head movements were obtained from the strip charts by counting the number of times the bird's head had moved into each of the eight regions of the chamber (see Fig. 1) and summing across regions. Although no counter readings were available to check the head-movement data, an indication of their reliability is given by the fact that of the approximately 5000 movements (over and above key pecks) recorded in the present experiment, in only 154 cases were the observers in disagreement. Moreover, of these disagreements, 117 cases represented differences in the identification of adjacent regions into which a bird's head had moved. The remaining 37 instances were the only cases in which the observers disagreed as to whether, at a given moment in time, the bird's head had or had not moved into one or another region. In this respect, it is relevant to note that, while this method of recording the bird's behavior overlooks head movements within a region, because of the small size of the separate regions, movements initiated within one region almost invariably ended outside of it and, hence, were recorded.

The data summarized in Fig. 2 and Table 1 reveal that during the final two trials of tone adaptation (observation period I), while tone presentation produced no overall disruption of key pecking, all of the birds exhibited a small, but consistent, reduction in the number of other head movements. There also appears to be some reduction in key pecking and other head movements during the post-tone period of these trials, but as seen in Table 1, most of this effect can be attributed to the performance of a single bird (No. 12). During the classical conditioning phase of the experiment (observation periods II, III, and IV), no key pecks occurred and the largest number of other head movements appeared in the post-shock period. In general, however, there were few move-

ments throughout and there is no evidence of either a systematic increase or decrease in movements with tone presentation.

The low frequency of recorded movements during tone-shock pairings suggests that inadvertent punishment of movements was unlikely. Examination of the individual strip-chart records provided further support for this suggestion. On only seven of the 36 observed tone-shock trials (six trials for each of six birds) did shock onset occur within 5 sec of a recorded movement and in no case was the response-shock interval shorter than 2 sec. On the remaining 29 trials, shock onset followed the previous recorded movement by at least 8 sec. Clearly the data on observation trials provide no indication that movement *per se* was ever contiguous with shock. Of course, not all tone-shock trials were monitored, and shock may have occurred contiguous with movement during unmonitored tone-shock trials. However, considering the overall low incidence of recorded movement during tone-shock pairing, even this possibility seems remote.

As revealed in Fig. 2 and Table 1, when tones were first presented during the reestablished baseline of reinforced key pecks (observation period V), both key pecks and other head movements exhibited much more suppression than was observed before tone and shock were paired (observation period I). Initially, key pecking was suppressed more than other head movements but as trials progressed, and tone continued to be presented without an accompanying shock, suppression of key pecks recovered more rapidly than suppression of other head movements (observation periods V, VI, VII, and VIII). This latter effect was not, however, synchronized across birds. As seen in Table 1, for some birds, tone suppressed key pecks throughout the final procedure, whereas for other birds (Numbers 12 and 24), during the later sessions, tone presentation led to increased rates of key pecking. Finally, it is noteworthy that at no point in these data is there a strong indication that tone presentation led to reliable increases in other head movements.

DISCUSSION

Both in general features and finer details (as for example, the post-suppression acceleration noted above), the present results are in

close accord with the data from previous experiments in which only the reinforced operant was measured (Hoffman, 1969; Hoffman, Fleshler, and Jensen, 1963). While the present findings augment these earlier studies by documenting the course of movements other than the reinforced operant, the principal focus of this research concerned the role of punishment in conditioned suppression. To that end, the experiment was designed to minimize the possibility that during conditioning, movements would be contiguous with the noxious event and hence punished. As indicated above, this effort was largely successful. Since under these circumstances, suppression still was obtained, the study provides the sought-for evidence that punishment of movement *per se* is not a necessary precursor to conditioned suppression. Moreover, since in the present study, as in the earlier study by Stein, *et al.* (1971), the overall effect of the conditioned stimulus was a reduction in all movements, both studies provide evidence against the proposition that during conditioned suppression the rate of the baseline response is reduced because the subject is engaging in other, presumably incompatible, activities.

Brady and Hunt (1955) characterized conditioned suppression as reflecting a conditioned emotional reaction that exerts a direct inhibitory effect on the subject's overt behavior. More recently, Estes (1969) suggested that the effect may be mediated by stimulus-induced reductions in the motivational state that supports overt behavior, rather than by direct inhibition of the behavior itself. While the present data cannot discriminate between these possibilities, it is clear that they support the major premise of both of them, namely, that by virtue of its pairings with an aversive event, an initially neutral stimulus can acquire the capacity to inhibit ongoing overt activity.

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