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CONDITIONED SUPPRESSION AS A SENSITIVE BASELINE FOR SOCIAL FACILITATION[1]

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The key pecking of pigeons maintained on a variable-interval schedule of food reinforcement was suppressed during occasional presentations of a warning stimulus paired with electric shock. On alternate sessions, a co-actor pigeon was visible in an adjoining chamber where it emitted the same food-reinforced key peck during the warning stimulus that signalled shock for the subject. With no shock and at low shock intensities, where the subject's responding was not suppressed or suppressed only slightly, the co-actor had little effect. At the higher shock intensities, where the subject's responding was reduced by at least 40%, the response rate during the warning stimulus was consistently higher when the co-actor was present. One explanation of these results assumes a special relationship between social stimuli and aversive stimuli in which the presence of another animal reduces emotional reactions and thereby allows operant responses to increase. This was not the case here because the mere presence of the co-actor did not maintain social facilitation. Rather, the present results, taken in conjunction with previous findings, suggest that changes in social and non-social variables which affect the rate of food-reinforced responding may produce proportionately larger changes in responding when that responding is suppressed by aversive stimulation than when it is not.

Social facilitation refers to an increase in an already learned behavior that occurs in the presence of another animal. The term includes increases in behavior that occur in the presence of another animal engaged in the same behavior, a "co-action effect", as well as increases in behavior that occur in the mere presence of another animal, an "audience effect" (Zajonc, 1965). Feeding, the behavior most frequently studied, has been socially facilitated in many species under conditions of food satiation as well as food deprivation (see reviews by Crawford, 1939; Smith and Ross, 1952; Zajonc, 1965; Tolman, 1968). A recent study showed that behavior suppressed by electric shock can also be socially facilitated (Hake and Laws, 1967). That study employed a conditioned suppression procedure (Estes and Skinner, 1941) in which the key pecking of pigeons maintained on a variable-interval schedule of food reinforcement was suppressed during the occasional presentation of a warning stimulus paired with electric shock. The presence of a co-actor emitting the same food-reinforced key peck reduced the suppression that otherwise occurred during the warning stimulus when the co-actor was absent.

There are two lines of evidence that predict a larger social facilitation effect when responding is suppressed by aversive stimulation than when it is not. The first concerns the sensitivity of a baseline that is suppressed by aversive stimulation. Previous studies of conditioned suppression and punishment indicate that changes in non-social variables such as food deprivation (Dinsmoor, 1952; Azrin, 1960; Azrin, Holz, and Hake, 1963) and frequency of reinforcement (Lyon, 1963; Church and Raymond, 1967) produce proportionately larger changes in responding when the responding is suppressed by electric shock than when it is not. Such findings raise the possibility that responding that is suppressed by aversive stimulation may be an unusually sensitive baseline for a number of variables, including social stimuli. The sizable and durable social effect observed by Hake and Laws (1967) may have been due in part to the fact that responding was suppressed by electric shock. Experiment I evaluated this possibility by following the procedure of Hake and Laws (1967) and by comparing social facilitation ef-

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fects before introduction of shock and at different shock intensities.

The second line of evidence that predicts a larger social facilitation effect when responding is suppressed by aversive stimulation concerns a special relationship between social stimuli and aversive stimuli. Several studies have shown that the presence of another animal can reduce emotional behaviors (Liddell, 1964; Harlow and Zimmerman, 1959; Hoffman, Searle, Toffey, and Kozma, 1966). Liddell (1964) found that the presence of a mother goat prevented experimental neurosis in kids subjected to respondent conditioning. Harlow and Zimmerman (1959) found that the presence of a cloth surrogate mother reduced indicators of emotionality in infant monkeys during the presentation of novel stimuli. Hoffman *et al.* (1966) found that the distress calls of ducklings were reduced in the presence of an imprinting object. It follows that the potential for reducing emotional behaviors should be greater during aversive stimulation than in the absence of aversive stimulation. To the extent that emotional responses interfere with ongoing operants, a reduction in emotional responses should allow ongoing operants to increase. The special history of experience with the social stimulus and the age of the subjects may have been critical to the above mentioned social effects, but it is also possible that such effects may generalize to other members of the same species and endure over time. Experiment II attempted to determine whether the social facilitation effect obtained during the conditioned suppression procedure using adult pigeons with no prior relationship could be attributed to the mere presence of the co-actor.

EXPERIMENT I

Subjects and Apparatus

Twenty adult male White Carneaux pigeons were maintained at about 80% of free-feeding body weight; 10 served as subjects and 10 as co-actors. Two subjects (2 and 3) had previously served in a conditioned suppression experiment in which responding had been socially facilitated at a single shock intensity. All subjects and co-actors had a separate living cage but there was no attempt to control visual or auditory observation of other pigeons.

The experimental space, which was inside a sound-attenuating and light-proof box, consisted of two 18-cm wide by 36-cm long compartments separated by a transparent partition. The partition allowed the subject continuous visual and auditory observation of the co-actor's compartment but prevented physical competition over food. Both compartments had a key, a 1.9-cm diameter illuminated disc, and a feeding mechanism located on the same front wall so that the two separated animals worked alongside each other. In both compartments, a peck of 10 g or more on the response key defined a response; reinforcement was a 3-sec presentation of a grain mixture that could be reached when the bird put its head into a wall aperture. During reinforcement an overhead light and the key light were extinguished and the aperture was illuminated by 2-w lights. The warning stimulus was a change from white to red or green illumination of both response keys and the electric shock delivered at the end of the warning stimulus was a 100-msec ac shock. The ac shock, specified as the voltage at the secondary of a step-up transformer, was delivered through a 10K series resistor to electrodes in the tail region of the subject (Azrin, 1959). Since the resistance of the subject was approximately 1000 ohms, each 10 v was equivalent to about 1 ma of current flow through the subject. The co-actor did not receive shock.

Procedure

For the subjects, food reinforcements were scheduled according to a 1-min variable-interval (VI 1-min) schedule. A 2-min warning stimulus (1.5 min for Subjects 2 and 3) was presented four times per session (three times for Subjects 2 and 3) at irregular intervals of time averaging 15 min apart. One VI 1-min reinforcement tape operated during the warning stimulus and another identical tape operated during the safe stimulus so that reinforcements which became available during the warning stimulus but were not obtained were available upon the next presentation of the warning stimulus. This minimized any possible difference in reinforcement frequency between the two components that might result from suppression during the warning stimulus.

The subjects were exposed to this procedure without shock in daily 1-hr sessions (45 min for Subjects 2 and 3) for at least a month. Then, the co-actor was introduced during alternate sessions. For the co-actor, each key

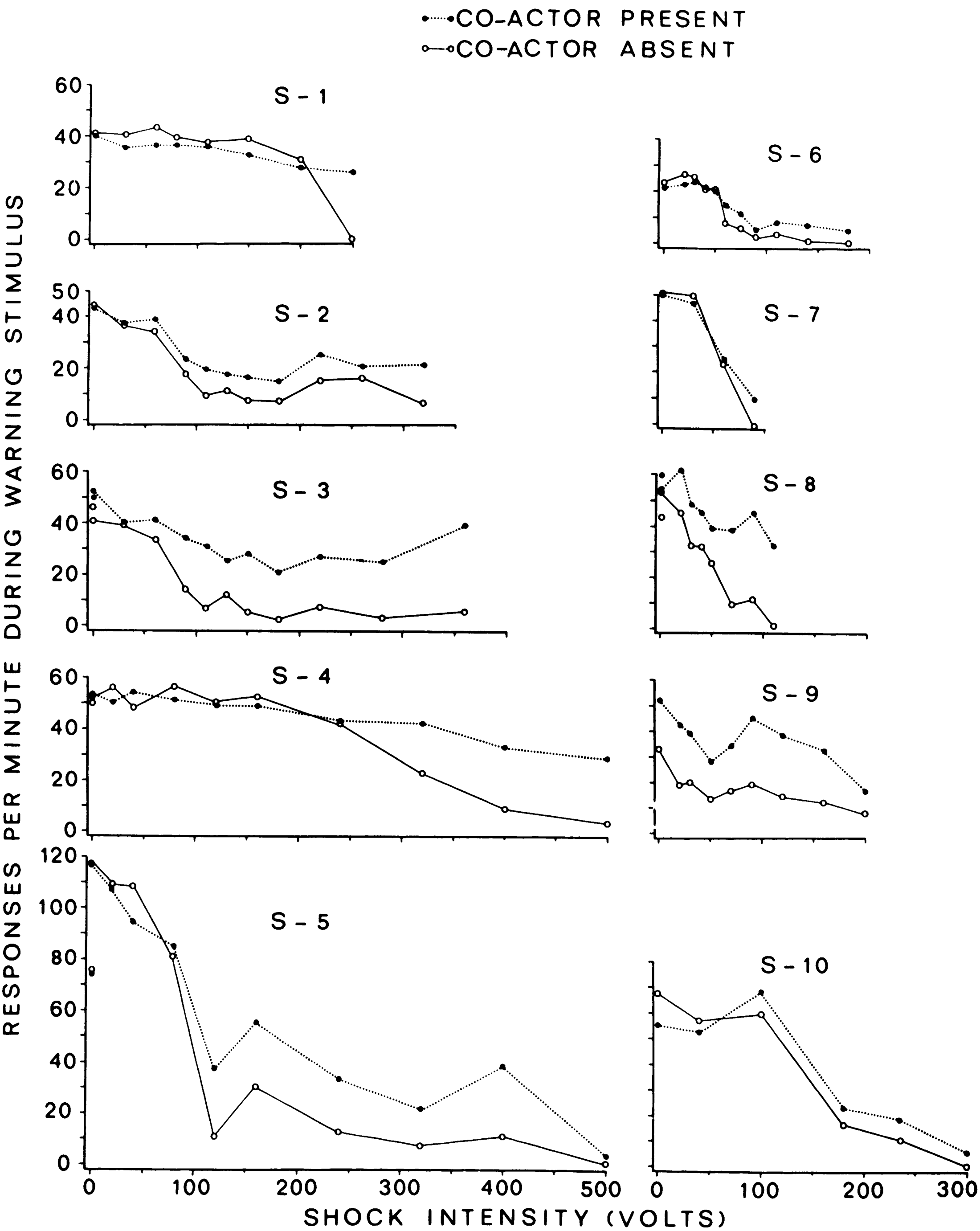

Fig. 1. Social facilitation as a function of shock intensity. Responses per minute during the warning stimulus are given separately for sessions when the co-actor was present (solid circles) and for sessions when the co-actor was absent (open circles). Each point represents the mean of the last four sessions that the co-actor was present or absent at a given shock intensity. The unconnected points at 0 v for Subjects 3, 4, 5, and 8 are redeterminations obtained after the highest shock intensity.

peck during the warning stimulus was followed by food reinforcement; responses during the safe stimulus (absence of warning stimulus) were not reinforced. The shock was then introduced at the end of the warning stimulus and gradually increased in intensity over sessions so each subject was given several different levels of suppression, including nearly complete suppression. A given shock intensity was in effect until there was no consistent change in the response rate during the warning stimulus but a minimum of eight sessions, four with the co-actor present and four with the co-actor absent, was provided at each intensity. More sessions were provided at the highest shock intensity in order to assess the consistency and durability of the social facilitation effect. After the highest shock intensity, four subjects (3, 4, 5, and 8) were returned to 0 v for 30 sessions.

RESULTS

Figure 1 shows the response rate during the warning stimulus as a function of shock intensity. Sessions with the co-actor present are indicated by the solid circles and sessions with the co-actor absent are indicated by the open circles. It can be seen that: (1) response rates decreased as a function of shock intensity whether the co-actor was present or absent; but, (2) at the highest shock intensities there was less suppression when the co-actor was present. With the exception of Subjects 3 and 9, there was little or no social facilitation before shock was introduced. This was also the case at some of the lower shock intensities. However, all subjects showed a social facilitation effect at the highest shock intensity and most subjects had a consistent social facilitation effect at several of the higher shock intensities. The consistency of the social facilitation effect at the highest shock intensity is indicated by the finding that in 179 of the 185 sessions, with the co-actor present at the highest shock intensity, the response rate was higher than during both the preceding or subsequent sessions with the co-actor absent. The larger social facilitation effect at the higher shock intensities cannot be attributed to the fact that the animals had been tested together for a longer period of time, since the effect was either greatly reduced or eliminated for the four subjects that were returned to 0 v (Subjects 3, 4, 5, and 8).

It should be pointed out that for two subjects (4 and 5) social facilitation did not result during the first intensity function (not shown). However, when a second intensity function was run with a different co-actor, a social facilitation effect was observed. The results of these two subjects suggest that some as-yet-unspecified aspect of the individual co-actor is an important variable in social facilitation.

The data of Fig. 1 have been replotted in Fig. 2 which shows social facilitation as a function of the amount of response suppression obtained at each shock intensity. Response suppression was expressed as the per cent reduction in the pre-shock (0 v) response rate and was calculated as follows:

$$\text{per cent suppression} = 100\left(1 - \frac{\text{resp/min during the warning stimulus at a given shock intensity, co-actor absent}}{\text{resp/min during the warning stimulus at 0 v, co-actor absent}}\right)$$

Hence, each point in Fig. 2 represents the degree of response suppression for a given subject for the sessions that the co-actor was absent at a given shock intensity. Social facilitation has been expressed as the sign difference in response rates between the sessions at a given shock intensity when the co-actor was present and when the co-actor was absent. Thus, points above zero indicate social facilitation while points below zero indicate a higher response rate when the co-actor was absent. Figure 2 shows that social facilitation occurred only part of the time at shock levels that produced less than 30% suppression but that it occurred consistently when shock produced over 40% suppression.

Figure 3 shows the response rate during the safe stimulus as a function of shock intensity. The safe stimulus response rates represent the response rate for the entire session time in the absence of the warning stimulus. First, consider Subjects 1 through 7. For these subjects, increasing the shock intensity had only a slight suppressive effect and the social facilitation effect, if any, for a given subject was never as large as the largest effect obtained during the warning stimulus. For Subjects 8, 9, and 10,

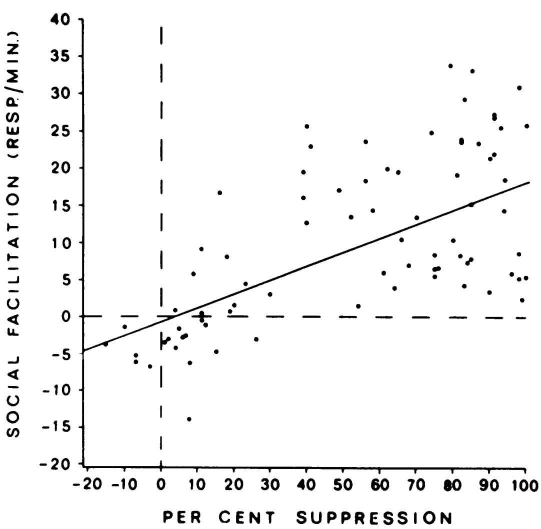

Fig. 2. Social facilitation as a function of the amount of response suppression obtained at each shock intensity. Social facilitation is expressed as the sign difference in responses per minute when the average response rate for the sessions at a given shock intensity with the co-actor absent was subtracted from the response rate for the sessions with the co-actor present. Social facilitation has been plotted as a function of the per cent response suppression obtained at each shock intensity (see text for method of calculation). Positive percentages indicate suppression during the warning stimulus and negative percentages indicate that response rate during the warning stimulus was higher than it had been without shock. The line through the points is the line of best fit based on least squares.

however, the safe stimulus response rate with the co-actor absent was reduced by 40% of the pre-shock rate at at least one shock intensity. It can be seen that there was also a sizable social facilitation effect at these intensities. In fact, for these three subjects the largest social faciliation effect during the safe stimulus (110 v for S-8; 120 v for S-9; 300 v for S-10) was comparable to the largest social facilitation effect seen during the warning stimulus.

EXPERIMENT II

Subjects and Apparatus

Ten adult male White Carneaux pigeons were maintained at about 80% of free-feeding body weight; five served as subjects and five as co-actors. The five subjects had implanted electrodes for the delivery of shock (Azrin, 1959). The apparatus was the same as that used in Exp. I except that for Subjects 11, 12, 13, and 14 a metal plate covered the co-actor's response key.

Procedure

Subjects 11, 12, 13, and 14 were tested under a conditioned suppression procedure in which a 2-min warning stimulus (green illumination of the response key) which ended with a 100-msec ac shock was presented at irregular intervals of time averaging 15 min. The warning stimulus was presented a total of three times in daily 1-hr sessions. Food reinforcements were scheduled according to a VI 1-min schedule. During the warning stimulus, the co-actor's food tray was presented automatically for 3 sec with 1 sec between presentations. As a control for the effects of the co-actor's food tray *per se*, it was also presented in this manner during the alternate sessions when the co-actor was absent. The shock intensity was gradually increased over sessions from 0 v to a shock intensity at which response rates during the warning stimulus were reduced by at least 75% and until there was a sizable and consistent social facilitation effect for 20 sessions (10 with the co-actor present and 10 with the co-actor absent). A consistent social facilitation effect was obtained at shock intensities of 70 v for S-11, 180 v for S-12, 150 v for S-13, and 50 v for S-14. Then, in order to evaluate the effects of the mere presence of the co-actor, the automatic presentations of the co-actor's food tray were discontinued for a minimum of 16 sessions and then reinstated for 20 sessions.

Subject 15 was tested under a discriminated punishment procedure in which daily 30-min sessions included one 5-min punishment period after 10 min of the session had elapsed and another after 25 min. The warning stimulus for the punishment period was a change from white to green illumination of the response key. Responding was maintained on a VI 30-sec schedule of food reinforcement and, during the warning stimulus, every tenth response was followed by a 100-msec electric shock. For the co-actor, present during alternate sessions, every seventh response during the warning stimulus was followed by a 3-sec presentation of the food tray; responses in the absence of the warning stimulus were not reinforced. The shock intensity was increased gradually over sessions from 0 v until responding during the warning stimulus was suppressed by 75% and until there was a sizable and consistent social facilitation effect for 20 sessions (10 with the co-actor present and 10

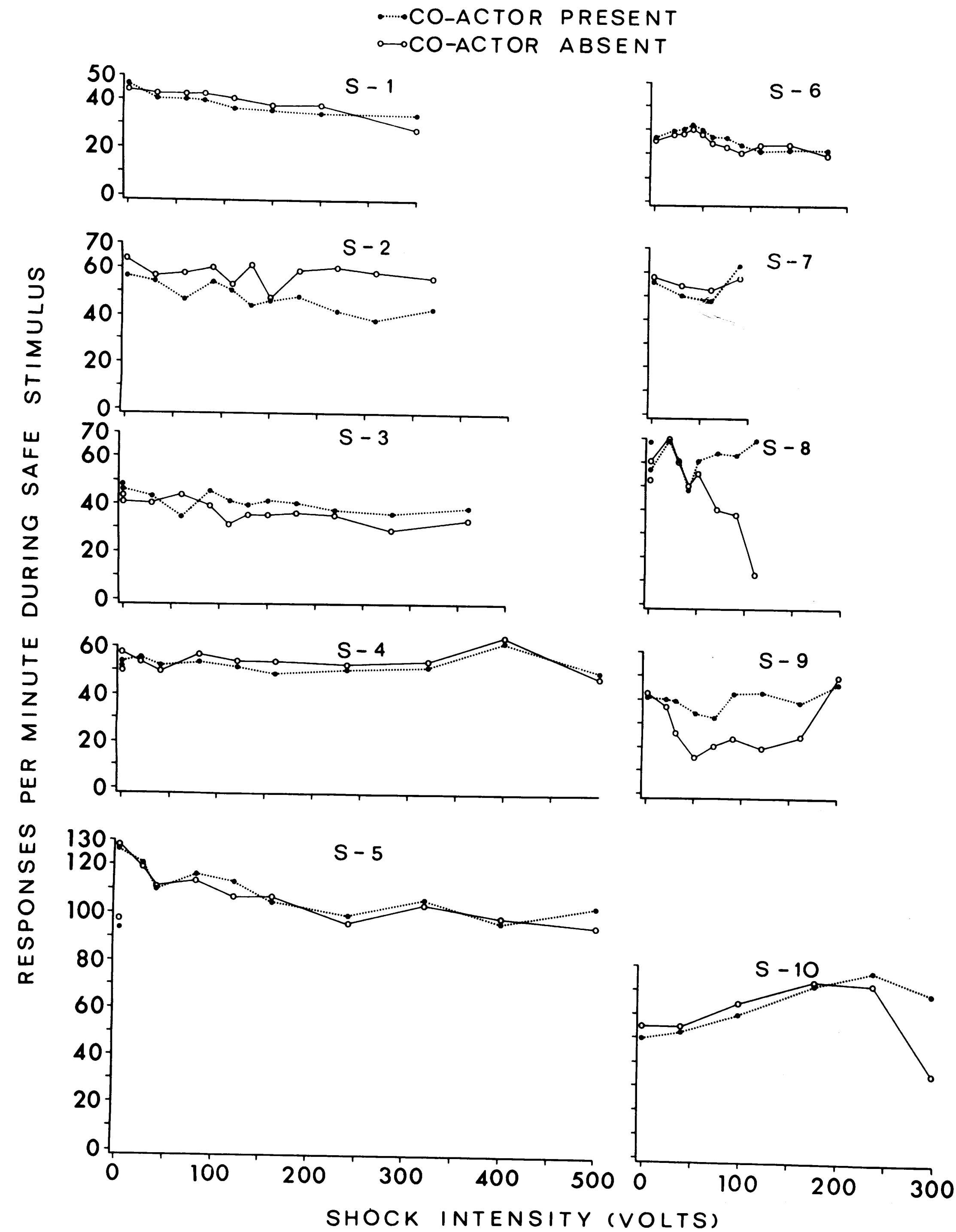

Fig. 3. Response rate during the safe stimulus as a function of shock intensity. Responses per minute during the safe stimulus are given separately for sessions when the co-actor was present (solid circles) and for sessions when the co-actor was absent (open circles). Each point represents the mean of the last four sessions that the co-actor was present or absent at a given shock intensity. The unconnected points at 0 v for Subjects 3, 4, 5, and 8 are redeterminations obtained after the highest shock intensity.

with the co-actor absent). A consistent social facilitation effect was obtained at a shock intensity of 70 v. Two other animals were tried under the punishment procedure but sizable and consistent social facilitation effects were not obtained and these two animals were discontinued. To evaluate the effects of the mere presence of the co-actor, the co-actor's response key was covered so that it could not respond and produce the food tray. This lasted 54 sessions and then the co-actor's response key was again uncovered for 20 sessions.

Results

Figure 4 shows a session-by-session plot of the response rate during the warning stimulus at the shock intensity where a consistent social facilitation effect was obtained and the effects of the mere presence of the co-actor were evaluated. The first panel of Fig. 4 shows the social facilitation effect obtained when the co-actor was eating (Subjects 11, 12, 13, and 14) or pecking and eating (S-15). This first panel also shows that the effect was not the result of the presentations of the co-actor's food tray alone, since for four of the subjects (11, 12, 13, 14) the co-actor's food tray was also presented during the sessions that the co-actor was absent. In the second panel of Fig. 4, the effects of the mere presence of the co-actor were evaluated by eliminating all presentations of the co-actor's food tray. It can be seen that the social facilitation effect disappeared over sessions until the response rate during the warning stimulus was about the same regardless of whether the co-actor was present or absent. For two subjects (13 and 14), response rate initially increased. For these two subjects, the presentations of the food tray may have become part of the warning stimulus that signalled shock. After a few sessions without the presentations of the co-actor's food tray, however, the response rate during the stimulus decreased to about the level seen in the first panel for the sessions when the co-actor was absent. Reinstatement of the conditions under which the co-actor could eat during the warning stimulus (panel 3) was effective in reinstating a social facilitation effect for four of the five subjects. For these four subjects, the response rate with the co-actor present increased while the response rate with the co-actor absent remained about the same. It may be noteworthy that for the one subject for which social facilitation was not recovered, responding during the warning stimulus had dropped to a near-zero level.

DISCUSSION

Previous research has indicated that the key-pecking response of pigeons maintained by a variable-interval schedule of food reinforcement, but suppressed during a stimulus paired with electric shock, may be socially facilitated by the presence of a co-actor emitting the same food-reinforced response (Hake and Laws, 1967). The present experiment extended these results by showing that the social facilitation effect obtained under these conditions was larger than that obtained when responding was not suppressed by electric shock and that the social facilitation effect increased as a function of shock intensity. It will be interesting to determine the extent to which these results extend to other species, to other procedures of aversive control, and to other schedules of reinforcement. There was some evidence in the present research that social stimuli may not have as large or as consistent an effect during a punishment procedure as they do during conditioned suppression. Only one of the three subjects tested under a punishment procedure in Exp. II showed a consistent and sizable social facilitation effect for 20 consecutive sessions. However, a definitive answer to this question, as well as the other questions concerning the generality of the present results, must await additional research.

It was pointed out in the introduction that at least two lines of evidence would predict a larger social facilitation effect when responding is suppressed by aversive stimulation than when it is not. One involved a special relationship between social stimuli and aversive stimuli in which the mere presence of another animal reduces emotional responses and thereby allows operant responses to increase. Several studies have shown that the presence of another animal can reduce emotional behaviors during aversive stimulation (Liddell, 1964; Harlow and Zimmerman, 1959; Hoffman *et al.*, 1966). In these experiments the subjects were young, had a special history with respect to their companion, *e.g.*, mother, imprinting stimulus, and, in two of the experiments, were allowed tactual contact with the companion (Liddell, 1964; Harlow and Zim-

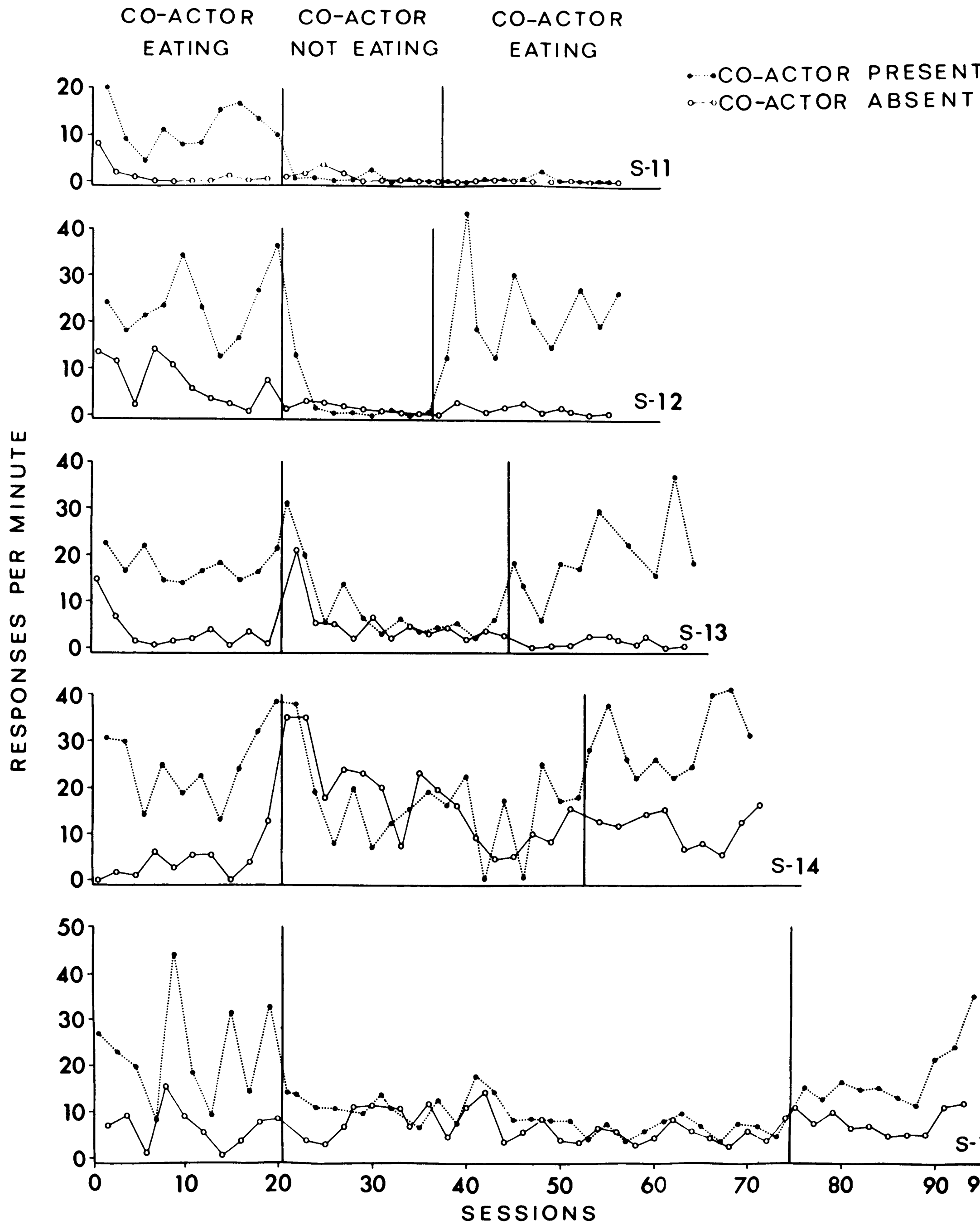

Fig. 4. The effects of the mere presence of the co-actor. Responses per minute during the warning stimulus are given separately for sessions when the co-actor was present (solid circles) and for sessions when the co-actor was absent (open circles). The first and last panels show response rate during the warning stimulus when the co-actor was eating (Subjects 11, 12, 13, 14) or pecking the response key and eating (S-15). The middle panel shows the response rate during the warning stimulus when the co-actor was present but not eating. The shock intensity was 70 v for S-11, 180 v for S-12, 150 v for S-13, 50 v for S-14, and 70 v for S-15.

merman, 1959). The present results suggest that such variables may be critical to reducing emotional behaviors, since in the present experiment none of these conditions existed and the presence of another animal did not maintain the social facilitation effect. One other special relationship between social stimuli and aversive stimulation would predict a larger social facilitation effect during aversive stimulation than in its absence. The activity of a companion that has never been exposed to aversive stimulation could serve as a stimulus to the subject that the situation no longer contained aversive stimulation. In the present experiment, the sight of the co-actor responding could have served as a stimulus to the subject that shock was no longer forthcoming. Such vicarious learning does not appear likely in the present experiment, however, because shock continued to be delivered when the co-actor was present and the social facilitation effect endured for many sessions.

The second possible reason for a larger social facilitation effect when responding is suppressed by aversive stimulation than when it is not, concerned the sensitivity of a baseline suppressed by aversive stimulation relative to a baseline that is not suppressed by aversive stimulation. Previous studies of conditioned suppression and punishment indicate that changes in non-social variables such as food deprivation (Dinsmoor, 1952; Azrin, 1960; Azrin *et al.*, 1963) and frequency of reinforcement (Lyon, 1963; Church and Raymond, 1967) may produce proportionately larger changes in response rate when the responding is suppressed by electric shock than when it is not. The present results appear to provide another variable that produces a proportionately larger effect when responding is suppressed by aversive stimulation. All of the variables which have produced larger changes when responding has been suppressed by aversive stimulation affect the rate of responding for food reinforcement. The mechanism by which a co-actor increases response rate is not clear, but there are several possibilities. For example, the sight of the co-actor eating could: (1) elicit respondents which increase response rate, (2) produce a competitive situation, or (3) be a stimulus for a high frequency of reinforcement due to a history of group feedings. At any rate, the present results, taken in conjunction with previous findings, suggest an interaction between variables that affect the rate of food-reinforced responding and behavior which is maintained by food but suppressed by aversive stimulation such that a change in one of these variables produces a proportionately larger change in response rate when responding is suppressed by aversive stimulation than when it is not.

If this is the case, the question arises concerning what it is about responding under aversive stimulation that makes that responding more sensitive to social facilitation. Is it the aversive stimulation *per se*, the suppression, or the low response rate which in this case necessarily accompanied the suppression? Unfortunately the present research did not experimentally isolate which of these were critical. The relationship between social facilitation and response suppression, however, appeared particularly promising, since a consistent social facilitation effect usually did not emerge until responding was suppressed regardless of whether the shock intensity was 40 v or 200 v. This was also true during the safe stimulus: responding was suppressed whenever a sizable social facilitation effect was observed to spread to the safe stimulus. The present results also provide some data which argue against response rate as the critical variable. An explanation in terms of response rate alone would be that low rates of responding have more room to increase than high rates do. In the present study, the response rates before shock and at the lower shock intensities ranged from 20 to 120 responses per min with most subjects responding at rates of 40 to 60 responses/min. These response rates are far below the maximum capabilities of the pigeon and leave a wide range for response rate to increase. Yet, Fig. 1 revealed that only two of the 10 subjects showed a consistent social facilitation effect before shock was introduced and at the lower shock intensities. Consider Subject 6, which responded at a low rate throughout the experiment. Before introduction of shock and at the lower shock intensities, the response rates of this subject were about 20 responses/min, a rate at which social facilitation always occurred with the other subjects when their responding was suppressed. Yet for this subject, a social facilitation effect was not observed until responding was suppressed. If low response rate alone had been the critical variable, it seems that social facilitation should have occurred more consistently before shock and at the lower shock intensities where rates were considerably below the maximum capabilities of the pigeon. The social facilitation effect occurred consistently only when responding was suppressed.

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