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SOCIAL ENHANCEMENT AND IMPAIRMENT OF PERFORMANCE IN THE COCKROACH [1]

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Maze and runway performance of cockroaches was observed under solitary and social conditions in an attempt to test the drive theory of social facilitation. In Experiment I cockroaches were observed under two types of social treatments, coaction and audience. In both treatments maze performance was impaired while runway performance was facilitated when compared to performance of subjects in solitary conditions. In Experiment II the effects of reduced presence of conspecifics were investigated. Experiment I generated results that were in support of the hypothesis that the mere presence of conspecifics is a source of general arousal that enhances the emission of dominant responses. The results of Experiment II suggested that partial presence of conspecifics may have distracting effects.

About 35 years ago Gates and Allee (1933) reported a study on the maze learning of isolated and grouped cockroaches in which they observed a clear inferiority of performance of the grouped subjects. Gates and Allee attributed these effects to distraction, saying that cockroaches learning in groups were responding not only to the physical topography of the maze but to the social situation as well, and that the "chemical traces introduced by one of the other roaches simultaneously occupying the maze may have acted to interfere with orientation [Gates & Allee, 1933, p. 357]." Other studies using animal or human subjects also found a deterioration of performance under social conditions (Allee & Masure, 1936; Klopfer, 1958; Pessin & Husband, 1933). In agreement with Gates and Allee, Jones and Gerard (1967) have recently ascribed all these effects to distraction.

However, equally prevalent are data showing improvement in performance as a function of social stimuli. These socially facilitated increments in performance are usually found for behaviors that are either very well learned or instinctive. Thus, for instance, in experiments using human subjects, skilled performance on pursuit rotor (Travis, 1925), accuracy in a vigilance task (Bergum & Lehr, 1963), scores on chain-association, vowel cancellation, and multiplication tasks (Allport, 1924; Dashiell, 1930), and latency of word associations (Matlin & Zajonc, 1968) have all been shown to improve under social conditions. Studies using animal subjects found social increments in eating (Bayer, 1929; Fischel, 1927; Harlow, 1932; Tolman & Wilson, 1965), drinking (Bruce, 1941), bar pressing (Stamm, 1961), copulating (Larsson, 1956), exploring (Simmel, 1962), nest building (Chen, 1937), and running (Scott & McCray, 1967).

It has recently been suggested (Zajonc, 1965) that these seemingly conflicting results can be reconciled if it is assumed that the presence of others is a source of general drive (D). While the presence of others can certainly be a source of specific cues, of reinforcement, and of rather specific excitation (as in mating or aggression, for example), and it can therefore *direct* behavior, it is also a source of nonspecific arousal, and hence acts as a general *energizer* of all responses that are likely to be emitted in the given situation. The degree of such an arousal need not be intense, of course. Nevertheless, it is assumed that its effects would be those that are predicted by the Spence-Hull drive theory (Spence, 1956). If the animal's dominant

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responses are appropriate from the point of view of the experimental situation, the presence of others will enhance them; and the resulting performance will appear as being improved. If these dominant responses are largely inappropriate, however, performance in the presence of others will appear as being impaired. Thus, for instance, if the given stimulus situation elicits in the animal dominant responses that are connected with eating, while the experiment "requires" the animal to delay or suppress instrumental responses leading to eating—as is the case in DRL (differential reinforcement of low rates) training—the presence of conspecifics will work against the experimental requirements, and "performance" will appear to suffer. Such an effect has indeed been obtained (Wheeler & Davis, 1967). On the other hand, if the experimenter is interested in establishing high response rates using continuous reinforcement, and if the total experimental situation also elicits dominant responses that are connected with eating, the presence of others will appear to have beneficial consequences. Hence, it is not performance but the emission of dominant responses, whatever they are, that is "facilitated" by the social stimulus.

If information about the subject's response hierarchy were available prior to the tests of social effects, the drive theory of social facilitation could be given a critical test. Such methods have been used with humans (Cottrell, Rittle, & Wack, 1967; Zajonc & Sales, 1966), and the evidence obtained was in substantial agreement with the drive theory of social facilitation. But procedures of this sort have not been employed with animal subjects.

Gates and Allee's (1933) experiment lends itself to some modifications which should generate useful information for the drive theory of social facilitation. In their experiment Gates and Allee (1933) used an E-shaped maze suspended over water. Light served as a noxious stimulus, while an opaque bottle located in the central portion of the maze provided the subjects with the only means of escape. The procedure entailed placing the cockroach (or cockroaches) at one of the terminals of the maze and observing the time required to reach the goal bottle. Because of the many spatial alternatives available—at first all equally inviting—many response tendencies were elicited that were not correct. In fact, of the many ways in which the cockroach could proceed in the E-maze, only one led to escape, and hence to what the experimenter would consider as "appropriate behavior." To the extent that the presence of conspecifics did act as a source of general drive (D), these many "inappropriate" response tendencies were energized, delaying the emission of the appropriate one.

If one could contrive a situation in which the cockroach's response tendencies would be largely "correct" or "appropriate," an increment rather than a decrement in performance should be obtained under social conditions. In comparison with maze performance, this situation would provide a rather stringent test of the drive theory of social facilitation. The straight runway with the noxious stimulus at the start and the means of escape at the goal can serve this purpose rather well. Such a straight runway, properly constructed, does not prompt the cockroach to turn, for if it turns it must only face the noxious light. The entire stimulus situation is so contrived that the dominant tendencies that are elicited consist of running away from the start box and directly toward the goal box. The present paper reports two experiments in which the performance of cockroaches in a maze and in a runway was compared under various social conditions. In all these experiments socially mediated performance decrements in the maze and socially mediated increments in the straight runway were expected.

EXPERIMENT I

This experiment had two major purposes. The first was to test the drive theory of social facilitation. To accomplish this purpose paired and isolated cockroaches were observed as they performed in a maze and as they performed in a straight runway. As in the experiment carried out by Gates and Allee (1933), the social variable was manipulated by having the subjects traverse the

maze or the runway alone or in pairs, that is, in coaction. However, this experimental manipulation, which has been used in nearly all experiments on social facilitation with animals, may lead to a confounding of two possible effects of others' presence: its energizing effects and its directive (or cue) effects. Two animals using the same maze or runway may affect each other's behavior because they act as a source of arousal for each other, *or* be-

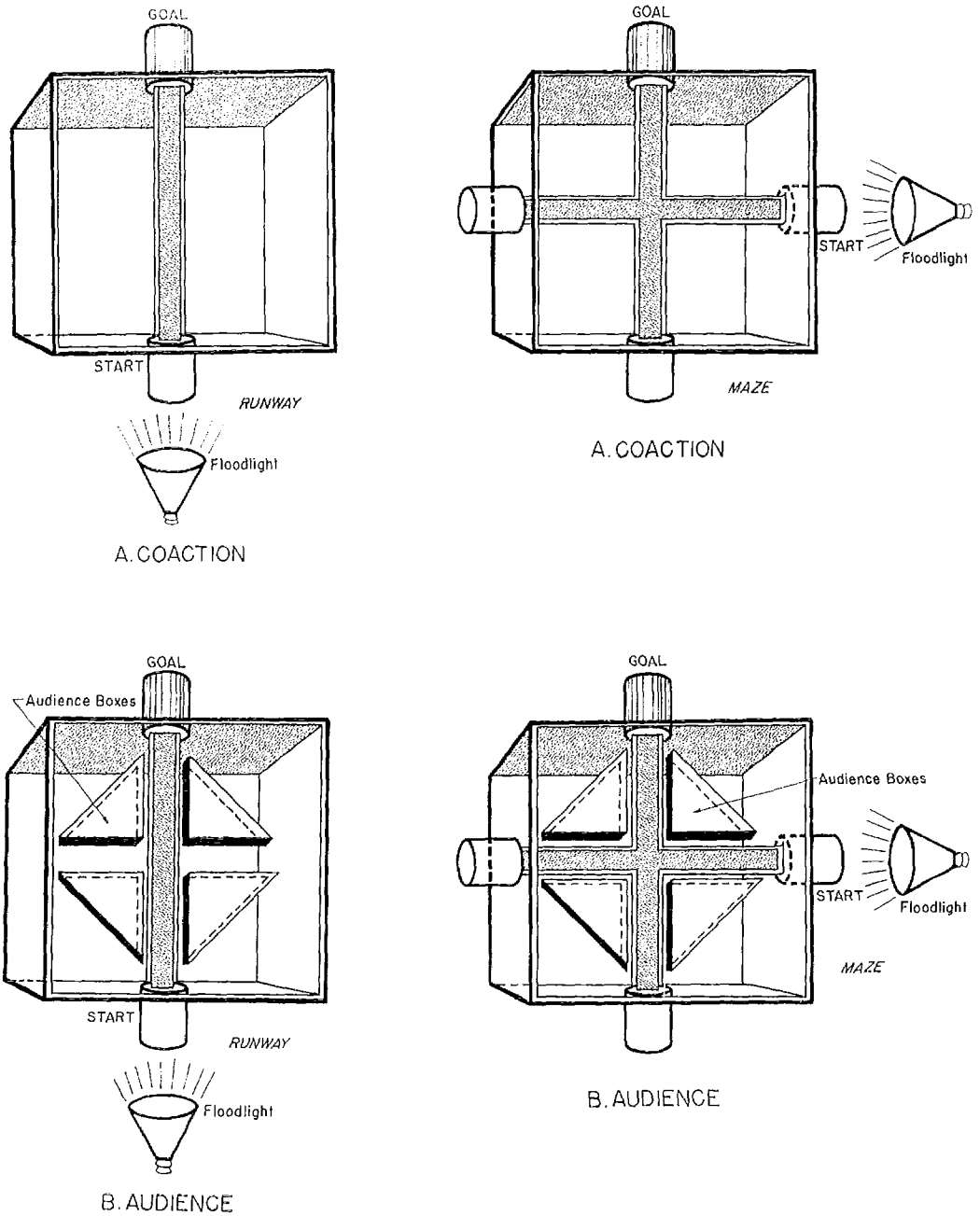


FIG. 1. Diagrams of runways and mazes used in the coaction and in the audience treatments of **Experiment I.**

TABLE 1

RUNNING TIME AND STARTING LATENCY IN SECONDS FOR SUBJECTS TESTED ALONE, IN COACTION, AND IN THE PRESENCE OF AN AUDIENCE

Treatment	Task			
	Runway		Maze	
	Alone	Social	Alone	Social
Coaction				
Starting latency	8.25 (8)	6.88 (8)	10.56 (8)	11.19 (8)
Running time	40.58 (8)	32.96 (8)	110.45 (8)	129.46 (8)
Audience				
Starting latency	14.80 (10)	9.35 (10)	37.55 (10)	22.75 (10)
Running time	62.65 (10)	39.30 (10)	221.35 (10)	296.64 (10)
Both treatments				
Starting latency	11.89 (18)	8.25 (18)	25.56 (18)	17.61 (18)
Running time	52.84 (18)	36.48 (18)	172.06 (18)	222.34 (18)

Note.—Averages of medians. Figures in parentheses indicate the number of roaches in each cell.

cause they emit responses that may be imitated. The second purpose of the present experiment, therefore, was to determine if socially mediated effects obtained in cockroaches when the subjects could not profit from directive cues provided by companions. Hence, while the social variable in one group of subjects was manipulated by means of coaction, in the other group it was manipulated by providing an audience, in order to eliminate all cues connected with the presence of conspecifics that may have been task relevant and may have influenced the subjects' behavioral choices rather than his response vigor. If similar socially mediated effects were obtained with an audience as with coaction, the drive theory of social facilitation would receive more unequivocal support than had these effects been obtained under the conditions of coaction alone.

Method

Subjects. Seventy-two adult female cockroaches (*Blatta orientalis*) were used,[4] and for at least 1 week prior to the first experimental trial they were housed in individual mason jars supplied with screened lids. They were maintained in dark quarters with a relatively constant temperature of about 75 degrees Fahrenheit. The insects were fed an ad libitum diet of peeled and sliced apples.

[4] The authors are grateful to Louis M. Roth of the United States Army Natick Laboratory who was kind enough to supply the subjects for the audience treatment. The subjects in the coaction treatment were obtained from the Carolina Biological Supply Company.

Apparatus. The basic apparatus is shown in Figure 1. It consisted of a 20 × 20 × 20-inch clear plexiglass cube outfitted so as to house either a maze or a runway. A 150-watt floodlight served as a source of noxious stimulation. In the center of each vertical wall of the plexiglass housing, 8¼ inches from the top, was a rectangular 1¾ × ¾-inch opening, which could be closed by means of a guillotine gate made out of sheet metal. A set of tracks on the exterior of each opening served as a shoe for a goal box or a starting box, clamping it firmly in place against the wall opening. Both the goal box and the starting box were made of 4-inch clear plexiglass tubing. A square flange that could slide into the shoe on the vertical wall of the housing was affixed to the opening of the boxes, while the other end of the tubing was sealed with ¼-inch clear plexiglass.

The maze and the runway could be suspended in the housing flush with the goal boxes and the starting boxes. Both the runway and the maze were made of black bakelite floor 2 inches wide, with walls made of clear plexiglass, 1 inch high. The runway and the maze were provided with clear plexiglass tops ⅛-inch thick. The runway consisted of a straight track running between two opposite vertical walls, and was 20 inches long. The maze was made of two runways, placed in the same plane and perpendicular to each other, thus forming a cross with the walls of the intersection removed. The lengths of the paths in the runway and in the maze, namely those leading from the starting box to the goal box or to a cul-de-sac, were 20 inches.

The guillotine gates that separated the starting and goal boxes from the runway or maze were made of galvanized sheet metal. To attract the roach to the goal box an opaque cover, painted flat black on the inside, was placed over the box making its interior dark. A flat black posterboard, covering the entire 20 × 20-inch area, was hung on the wall which held the goal box.

For the groups in which the social variable was manipulated by means of a passive audience four 9 × 9 × 1-inch boxes with plexiglass sides and tops and bakelite floors were used. These boxes were placed inside the plexiglass cube housing in such a manner that their floors were flush with the floors of the runway or the maze and their sides directly contiguous with the walls of the runway or the maze. When these boxes were in position almost the entire extent of walls of the runway or maze were in direct contact with the sides of the audience boxes. Air holes in the sides of the boxes lined up with air holes in the walls of the runway and the maze to allow transmission of olfactory cues.

Procedure. Before each trial the runway (or the maze) was swabbed with alcohol which was allowed to evaporate thoroughly. The starting box and the goal box were swabbed in the same manner before each set of 10 trials. The roach was transferred from its home jar to the starting box which had been covered with an opaque container similar to that which also covered the goal box. Each trial began by removing the cover, turning on the floodlight, and removing the guillotine door separating the opening in the starting box from the runway or the maze. The floodlight was always in line with the runway or the maze and 10 inches directly behind it. No light other than that provided by the floodlight was present in the experimental room. The trial was terminated when the cockroach (or the pair of cockroaches) entered the goal box and the guillotine gate was lowered behind it (or them), or in 5 minutes—whichever was earlier. The guillotine gate was always lowered immediately after the roach's last leg crossed the entrance of the goal box. In the coaction treatment the starting latencies and the running times were scored for each subject individually, although the gate was not lowered until the last member of the pair entered the goal box.

Thirty-two animals served in the experimental treatment involving coaction [5] and 40 in the treatment involving audience. In each treatment half of the roaches worked in the runway and half in the maze. In addition, within each combination of treatment and task, half of the animals were run in the alone condition and half in the social condition. In the coaction treatment the subjects were placed into starting boxes in pairs. For purposes of identification they were marked with airplane dope, one white and one blue. In the audience treatment 10 adult female *Blatta orientalis,* which were previously housed in common quarters of the laboratory colony, were placed in each of the four audience boxes. The control group of 20 roaches, which was not to be exposed to a passive audience, worked with audience boxes in position, but empty and clean. All roaches run in the audience treatment and in their proper control conditions were run individually. Starting latencies to the nearest second and total running times to the nearest tenth of a second were recorded. Starting latency consisted of the interval beginning with the opening of the guillotine gate of the starting box and ending at the time the last part of the roach's body left the starting box. In all treatments and conditions the subjects were given 10 consecutive trials, all separated by 1-minute intertrial intervals.

[5] This treatment constitutes a partial replication of a previous experiment, reported elsewhere (Zajonc, 1968).

Results

Because starting latencies and running times are generally skewed, the scores subjected to the analysis of variance consisted of median times computed over the 10 trials performed by each subject. The averages reported throughout this paper are averages of these median times. Table 1 shows the entire results of the experiment, and Table 2 shows the analysis of variance of these data. Above all, it is clear that with respect to starting latencies all effects fail to reach acceptable levels of significance. It was considered that leaving the starting box, which, it will be recalled, was the nearest to the floodlight, was a relatively simple task for the roach, comparable to traversing a straight runway. Therefore, under the coaction treatment, starting latencies should be shorter in the social condition than in the alone condition, regardless of whether the subjects are entering the maze or the runway. Under the audience treatment, however, there are no social cues in the starting box in the social as well as in the alone condition and we would, therefore, not expect strong effects associated with either treatments or conditions. While the results are not significant, we note from Table 1 that the task may have affected starting latencies, with the relevant F ratio nearly reaching an acceptable level of significance.

The total running times show patterns that are quite consistent with the drive theory of social facilitation. Relevant here is the significant interaction between the conditions and tasks ($F = 7.57$, $df = 1/64$, $p < .01$). Roaches running the maze in coaction required longer times than roaches running in isolation. This result replicates the findings of Gates and Allee (1933). However, the effects of coaction are reversed for the runway. Here the coacting roaches perform more quickly than the solitary subjects. And the

TABLE 2

SUMMARY OF ANALYSES OF VARIANCE FOR DATA IN TABLE 1

Source	*df*	Starting latency		Running time	
		MS	*F*	*MS*	*F*
Alone vs. social (A)	1	603.78	<1	5180.48	1.962
Runway vs. maze	1	2386.25	2.650	418826.03	158.639
Coaction vs. audience (C)	1	2514.87	2.793	104373.47	39.533**
A × B	1	83.42	<1	19977.75	7.567*
A × C	1	422.50	<1	1823.85	<1.000
B × C	1	968.58	1.076	69258.45	26.233**
A × B × C	1	143.14	<1	5764.66	2.183
Error	64	900.36		2640.11	

* $p < .01$.
** $p < .001$.

same pattern of results prevails for the audience treatment. Hence the three-way interaction was not significant.

The analysis of the above results also shows that the running times and the latencies are substantially shorter in the coaction animals than in the audience groups. Unfortunately, because these subjects came from different colonies, we are unable to determine from the data alone whether these differencs are due to the diverse origins of the two groups of animals, or whether they have something to do with the experimental treatments. It is a rather plausible conjecture that the differences are attributable to the former factor because of the consistently longer running times of roaches in the control groups of the audience as compared to the coaction treatment.

EXPERIMENT II

In the first experiment it was shown that the presence of an audience of conspecifics is a sufficient condition for the enhancement of dominant responses, such that the performance of the subject in a one-alternative task is improved and the performance of the subject in a multialternative task is impaired. But the variable, "presence of conspecifics," is certainly not precise either from a theoretical or methodological point of view. What are the essential and critical features of "presence of conspecifics" that produce these effects? What is the nature of the social stimulus that elicits these effects and has the capacity of increasing general arousal? Complete answers to these questions must await a great deal of research not only on the nature of the social stimulation involved in social facilitation effects but also on the nature of the arousal that is brought about by the social stimuli. But as a first step we may inquire about the minimal conditions which are sufficient for producing social facilitation effects. Tolman (1965) found that feeding behavior of young chicks was facilitated by the presence of a companion separated from the subject by a plexiglass partition, and also by feeding the subject in front of a mirror. These increments, however, were not as impressive as those obtained with a coacting companion. Tolman (1968) regarded such socially mediated effects primarily in directive (cue) terms. Hence he accepted as more likely the hypothesis that it is the behavior of the companion rather than its mere presence which produces increments and decrements in performance. Animal research, especially on feeding behavior, supports his contention. However, results of Experiment I with audience show that even when the conspecific companion does not emit behavior which can be used by the subject to guide the course of his action, effects which are consistent with the drive theory of social facilitation are obtained.

Experiment II attempted to determine if socially mediated effects such as those obtained in Experiment I would be produced if the immediate presence of conspecifics were somehow curtailed or reduced. Two treatments were employed. In both treatments

there were no other roaches besides the subject. Both dealt with some components of the presence of conspecifics, one emphasizing its cue effects, the other emphasizing its energizing (general arousal) effects. Thus, in the former the insects ran in mazes and runways which were outfitted with mirrors alongside their vertical walls. In the second treatment regular runways and mazes were utilized, but the animals were stimulated by the presence of olfactory cues associated with their conspecifics. These treatments were compared with one in which the insects were observed under solitary and socially neutral conditions.

Method

Subjects. One hundred and eighty female *Blatta orientalis* obtained from the Carolina Biological Supply Company were employed in the present experiment. All insects were housed in individual mason jars for 4 days prior to the experiment. One third of the subjects were assigned to the mirror treatment (Mi), one-third to the odor treatment (Od), and one-third to the alone treatment (Al). In each treatment, half of the subjects (30) were given tests in the straight runway and half in the maze.

Apparatus. The apparatus from Experiment I, in which modifications were made to allow tests under the requirements of the experimental treatments, was employed. In the Mi treatment a runway and a maze were used which were equipped with reflecting half-aluminized film affixed to the entire extent of the walls. Otherwise the apparatus was the same as in the alone treatment of Experiment I. In the Od treatment the regular runway and maze from the audience treatment of Experiment I were used which, it will be recalled, had holes drilled in their walls. An olfactory social stimulus was provided by placing an egg carton impregnated with the odor of conspecifics inside the housing of the apparatus and 4 inches directly beneath the maze or the runway. The egg carton was thoroughly impregnated with the odors of conspecifics by having it in the quarters of the colony for several days prior to the tests. Several cartons were kept in the quarters of the cockroach colony during the course of the experiment, and during each testing session a freshly impregnated carton was always used. The Al treatment was the same as the Od treatment except that a fresh clean egg carton, not impregnated with cockroach odor, was placed 4 inches beneath the runway or the maze. The same procedure was used for scoring latencies and running times as in Experiment I.

Results

Table 3 shows the data from Experiment II. It may at first be noted that under the present experimental treatments the latencies do not differ across tasks ($F < 1$, $df = 1/174$). Such a tendency was present in Experiment I, although it also did not attain an acceptable level of significance. The latencies are also fairly uniform across treatments. The relevant F ratio did not reach an acceptable level of significance ($F = 2.681$, $df = 2/174$). Similarly, the interaction between treatments and tasks did not attain significance. However, with respect to total running times both main effects and the interaction are significant ($F = 4.197$, $df = 2/174$, $p < .05$ for treatments; $F = 167.925$, $df = 1/174$, $p < .001$ for tasks; and $F = 7.117$, $df = 2/174$, $p < .001$ for the interaction between them). These effects, it seems, are due primarily to the relatively fast maze running time among the Mi subjects. In contrast to the previous experiment, running times in the straight runway are not improved in the two social treatments. Both the Mi and the Od subjects took longer times to traverse the runway than the Al subjects. Maze running seems to show a relative facilitation for the Mi treatment and an impairment for the Od treatment.

TABLE 3

RUNNING TIME AND STARTING LATENCY IN SECONDS FOR SUBJECTS TESTED ALONE, WITH MIRROR, AND IN THE PRESENCE OF CONSPECIFIC ODOR

Treatment	Task	
	Runway	Maze
Mirror		
Starting latency	27.38	28.88
Running time	77.21	160.71
Odor		
Starting latency	20.00	24.97
Running time	69.53	245.72
Alone		
Starting latency	22.67	18.33
Running time	55.67	219.63

Note.—Averages of medians. These means are based on 30 independent observations in each cell.

DISCUSSION

The results of Experiment I support the hypothesis that the presence of conspecifics acts as an energizer of dominant responses in the cockroach. There were rather clear indications that enhancement as well as impairment of performance could be obtained with

these insects, depending on whether a simple or a complex task was used, and therefore depending on whether the situation was more likely to recruit appropriate or inappropriate response tendencies. While results on starting latencies failed to generate useful information, data on running times unequivocally favored the drive theory of social facilitation.

The fact that performance in the runway was enhanced by the presence of conspecifics does damage to the distraction hypothesis proposed by Gates and Allee (1933) and reintroduced by Jones and Gerard (1967). It must be noted that the runway and the maze differed only in the number of alternative turns available to the subject at the choice point, that is, 9 inches from the starting box. The runway had only one alternative, while the maze had three. In all other respects the two tasks and the two stimulus situations were nearly identical.[6] It would not be parsimonious, therefore, to maintain that the distraction hypothesis applies to maze performance alone, for we would have to invoke a new psychological process to account for the improvement of running times in the runway.

The results of Experiment I also eliminated the possibility that social facilitation effects depend on the specific behavioral output of the companion. In nearly all previous experiments on social facilitation with animal subjects the coaction paradigm was employed. Data from these studies could therefore be interpreted by assuming that the companion emits behavior which the subject can imitate. The fact that the results in the audience treatment show the same pattern as those in the coaction treatment indicates that specific directive cues need not be involved in socially mediated performance effects. In fact, the effects obtained in the coaction treatment were less pronounced than those found in the audience treatment. Simple effects tests on running time data from Experiment I show a strong interaction between conditions (social versus alone) and tasks (runway versus maze) for the audience treatment ($F = 9.19$, $df = 1/64$, $p < .01$), while the same interaction is only of borderline significance in the coaction treatment ($F = 2.80$, $df = 1/64$, $p < .10$). It should be noted, at the same time, however, that in a previous experiment on coaction in cockroaches (Zajonc, 1968), using subjects as their own controls, this interaction was reliable.

Subjects in the coaction treatment did not show tendencies to crowd or to form traffic jams in the runway and in the maze. While they usually did not leave starting boxes or enter goal boxes at the same time, the openings were sufficiently wide to allow them to do so. The fact that maze performance was observed to deteriorate in the audience treatment would lead us to expect that this deterioration was socially mediated in the coaction treatment as well, rather than having been brought about by crowding or traffic jams.

Qualitative observations of the roaches did not reveal specific behaviors by virtue of which such social effects might be produced. Perhaps the only consistent pattern found was that the behavior of the subjects in the coaction treatment was devoid of tendencies to follow or to imitate. The roaches seemed to traverse the alleys of the maze and of the runway in an apparent ignorance of each other. In the audience treatment, too, there was nothing detectable in the subjects' behavior to indicate that they oriented toward the spectator roaches. But, of course, there is today only scanty information on the social significance of the various responses of the cockroach.

Another hypothesis offered to account for the effects associated with the presence of conspecifics assumes that they are not due to an increased arousal but to calming. For instance, Davitz and Mason (1955) have found that rats in an open field test reduce their fear responses when a previously habituated rat is also present. And Liddell (1950) has shown that neurotic symptoms produced in a young goat by means of a continuous noxious stimulation are attenuated when the mother goat is also present. Bovard (1959) proposed that social stimuli elicit a competing response "which inhibits, masks, or

[6] It is true, however, as the reviewer of this manuscript correctly observed, that the maze did require a right (or a left) turn of the subject, while the runway did not.

screens the stress stimulus, such that the latter has a minimal effect [p. 269]." Because the response of the posterior hypothalamus initiates pituitary-adrenal cortical and sympathetic-adrenal medullar activity associated with stress reactions, Bovard argued that the presence of another member of the same species must dampen the activity of the posterior hypothalamus, and thereby dampen the stress reactions of the adrenal system. It has been suggested elsewhere (Zajonc, 1965) that the reduced stress reactions may be due simply to the availability for imitation of coping responses. Hence, the experimental data associated with reduction of fear which occurs with the presence of conspecifics might be best accounted for by focusing upon the directive (cue) effects which are provided by the conspecifics. The situation in Experiment I can certainly be considered a stressful one, for the species of the cockroach used in the experiment is rather photophobic. The effects observed in the coaction and in the audience treatment are not consistent with the hypothesis that companions have a calming effect. If this were the case we would expect an increase in the running time in the runway and a decrease in the running time in the maze—results which would be diametrically opposite to those found in Experiment I. But such an effect was found in Experiment II in the Mi treatment. In comparison with the Al treatment, these subjects took longer in the runway and were faster in the maze. The Mi treatment, it will be recalled, stresses the directive (cue) properties associated with the presence of conspecifics. But in Experiment I there also was a treatment (coaction) in which cues were available for imitation but in which an actual companion was present. Yet this experimental situation did not produce a calming effect.

The results of Experiment II are ambiguous. One conclusion to be drawn from these results is that in order for drive effects to take place the presence of conspecifics must be actual. Partial presence, such as the presence of olfactory traces, was not sufficient to produce effects consistent with the drive theory of social facilitation. It seemed, on the contrary, that the Od treatment generated results most consistent with the distraction hypothesis. In comparison with the Al treatment, the subjects running in the presence of the odor of conspecifics had longer times in the maze as well as in the straight runway. The question immediately arises whether social facilitation effects consistent with the drive theory of social facilitation would be obtained in the presence of an immobile audience. For instance, one could observe the runway and maze behavior of cockroaches in the presence of a dead or anaesthetized companion. The danger of such an experiment is that a dead or an immobile cockroach, while leading to an increase in the general arousal level of the subject, might also elicit specific alarm or stress responses that may interfere with task performance. The problem of what are the minimal features of the presence of conspecifics which are sufficient for social facilitation effects which the drive theory predicts is quite difficult from a methodological point of view.

Another problem associated with social facilitation effects is that concerning the nature of the arousal or drive that increases in the presence of others. Social facilitation effects obtained with human subjects can be readily interpreted as caused by a motivation to succeed, a desire to be praised and avoid blame, or in general, by assuming that the presence of others creates in the individual the anticipation of socially positive or negative consequences and thus increases the general arousal level (Cottrell, 1968; Cottrell, Wack, Sekerak, & Rittle, 1968). Had the present been experiments using human subjects one could easily raise questions about self-disclosure, evaluation apprehension, the approval motive, etc. But one finds it rather awkward to attribute this sort of motivation to the cockroach, even though we have no idea if these seemingly spiritless creatures aren't vulnerable to some of the very same passions and weaknesses which beset our sophomore population of subjects.

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