

DISPERSION AND MOVEMENT IN SMALL FLOCKS OF DOMESTIC CHICKS

by

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Abstract

The object of the present set of experiments was to determine the effects of food deprivation and prior experience in the test environment upon the group dispersion and movement of small flocks of domestic chicks in a controlled field situation. One hundred and two White Leghorn cockerels were tested in groups of six subjects, in both two, and three factor, factorial experimental designs. It was found that after five pre-exposure sessions in the test setting, groups undergoing food deprivation were more dispersed and showed a greater amount of movement than groups not deprived of food prior to being tested. Increases in the amount of food deprivation resulted in increases in group dispersion and in the amount of movement. The results substantiated the usefulness of this laboratory model of gregarious open field behavior. The role of social facilitation of the feeding response was considered within the context of social communication.

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INTRODUCTION

Systematic experimentation has repeatedly demonstrated social facilitation of feeding responses in domestic fowl under a variety of experimental conditions (Tolman, 1964; Tolman, 1965 a & b; Tolman, 1967; Tolman and Wellman, 1968; Tolman & Wilson, 1965). It has failed, however, to produce a unified theoretical interpretation that exclusively accounts for the effects of social facilitation (Tolman, 1968). The failure of attempts to determine the stimulus conditions necessary for the occurrence of social facilitation, and how they come to function, may lie in the restricted behavioral context in which these effects have been considered.

A typical set of operations defining social facilitation within this narrow context involves the measurement of an increase in the frequency of the occurrence of a response, or an increase in the vigor of its performance which results from some aspect of the stimulation afforded by a conspecific companion. This conception of social facilitation is particularly amenable to experimental investigation. However, it is possible that in the laboratory the relevance of the social facilitation effects may be obscured or distorted by the experimental situation.

There have been a number of field observations of social facilitation of the feeding response during the course of communal foraging which seem to demand a broader conceptualization of this phenomenon than is provided by the increased frequency definition (birds: Collias, 1955; Crook, 1961; Sparks, 1964), (fishes: Breder & Halpern, 1946). The role of social facilitation in nature seems to be to induce rapid aggregation and to synchronize the activity of the individual group members (birds: Crook, 1964; fishes: Keenleyside, 1955; Keenleyside, 1962). The most readily observed and

unambiguously defining feature of a group of gregarious animals is probably the spatial organization of the group members (birds: Emlen, 1952; Lill, 1969), (fishes: Keenleyside, 1955; Parr, 1927). The most dramatic effect of social facilitation in this situation is the rapid change in the spatial organization of the group. It may be significant that some of the variables which appear to be important determinants of social facilitation in the test situation, previous experience and food deprivation, (Tolman & Wellman, 1968), have also been found to be important determinants of spatial organization (birds: Crook, 1961; Emlen, 1952), (fishes: Breder & Halpern, 1946; Breder & Nigrelli, 1935; Keenleyside, 1955).

It is possible that some of the independent variable manipulations in the laboratory setting may have directly effected the spatial organization of the group, or that fragment of group spatial organization represented in the experimental situation. Thus such manipulations might effect the laboratory measurement of social facilitation only indirectly to the extent that the effects measured varied with changes in spatial organization. In any case, it is hoped that a study of the determinants of spatial organization in small groups of gregarious animals may provide an expanded behavioral and conceptual framework in which a rapprochement of the problems seemingly inherent in the study of social facilitation may be achieved.

A number of studies have been concerned with changes in group structure under a variety of experimental conditions. From these some general trends have emerged. The effect of hunger on the spatial organization of the group is to increase the distance between individual members and to increase the general level of group activity (birds: Crook, 1961; Crook, 1964; Emlen, 1952; Lack, 1954, p. 72; Lill, 1969), (fishes: Breder & Nigrelli, 1935; Keenleyside, 1955). When one individual finds food and

starts feeding a rapid aggregation response by the other group members is precipitated (birds: Collias, 1952; Crook, 1964; Lill, 1969; Sparks, 1964), (fishes: Breder & Halpern, 1946; Keenleyside, 1962). The distribution of group members is less dispersed following feeding than when animals are engaged in communal foraging (birds: Crook, 1961; Crook, 1964; Emlen, 1952; Lill, 1969), (fishes: Keenleyside, 1955). The effect of novel stimulation on a group of gregarious animals is a drawing together such that the distribution of the animals becomes more aggregated (birds: Crook, 1961; Noble & Curtis, 1939), (fishes: Breder & Halpern, 1946; Breder & Nigrelli, 1935; Keenleyside, 1955).

These behavior patterns are of considerable adaptive value, especially when taken in the context of the geographical distribution of the species' characteristic foods (Crook, 1964). An increase in the distance between individual group members results in a wider area of territory being searched at any one time by the group (birds: Lill, 1969), (fishes: Keenleyside, 1955). An increase in the general activity level of the group would result in the group's moving over a larger area than would be the case if the activity level were lower (birds: Crook, 1961; Lill, 1969), (fishes: Breder & Halpern, 1946). Increasing the size of the area searched during communal foraging increases the probability of food finding. The rapid aggregative response of the group members to a feeding individual ensures the synchronization of food finding and feeding (birds: Lill, 1969; Sparks, 1964), (fishes: Breder & Halpern, 1946; Keenleyside, 1955). This results in the most effective consumption of the available food resources (birds: Crook, 1961). The advantage of increased aggregation resulting from fear induced by novel stimulation is primarily one of defense against predators (birds: Emlen, 1952), (fishes: Breder, 1954; Brock & Riffenburg, 1960; Parr, 1927; Shaw, 1965). In addition it results in the reinstatement and maintenance

of the gregarious spatial organization.

The repeated demonstrations of social facilitation effects in domestic chicks (Tolman, 1965 a & b; Tolman, 1967; Tolman & Wellman, 1968) and the numerous considerations of their being a gregarious species (Allee, 1931; Breed, 1911; Collias, 1952; Emlen, 1952; Lill, 1969) make them especially suitable as subjects in the present set of experiments. The present set of experiments will attempt to establish a broader and perhaps more relevant behavioral framework for the investigation of the determinants of social facilitation of the feeding response in domestic chicks.

EXPERIMENT I: The effects of hunger and of prior exposure to a test environment upon the spatial organization of small flocks of domestic chicks.

Dispersion phenomena have been described as occurring in different avian species observed in their natural habitat (Crook, 1964; Emlen, 1952). Similar phenomena observed in the laboratory have been reported for fishes (Breder, 1954; Kennleyside, 1955). Extreme hunger in a small flock of domestic chicks tended to produce an increase in the distance between individuals when foraging in a controlled field situation (Tolman, personal communication, 1968).¹

The general task of this experiment was the laboratory demonstration of similar dispersion phenomena occurring in domestic chicks. The specific concern was to determine what effects hunger and prior experience in the test environment would have on the spatial organization of small flocks of domestic chicks communally foraging in a controlled field situation.

Because of the lack of pertinent experimental evidence upon which to make predictions only two general expectations were entertained. It was expected that the lack of prior experience in the test apparatus would result in a greater density in group spatial organization when compared to the spatial organization of groups which had had prior experience in the apparatus. It was also expected that the effect of hunger on the group spatial organization would be an increase in the distance between individual group members and an increase in the group's activity level as compared with groups that were not under food deprivation when tested.

Method

Subjects and Apparatus

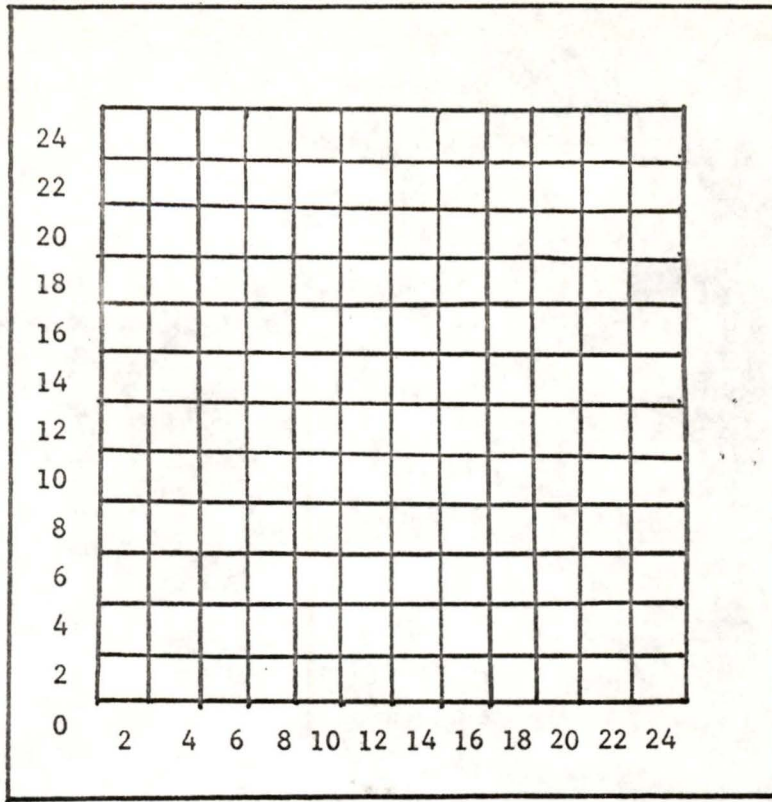
Forty-eight white Leghorn cockerels, obtained when one day old from a local commercial hatchery, were tested when six days of age.

The simulated open-field situation was achieved through the use of a large wooden box with a floor area 4 feet x 4 feet. The walls of the box

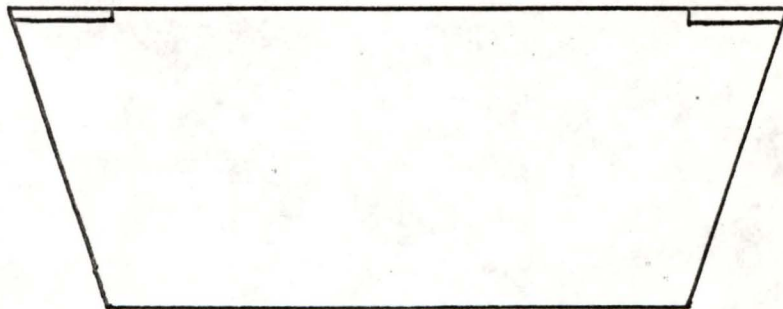
were 2 feet high. The floor area was covered with heavy-weight brown paper and the walls were finished in a gray enamel paint. The surface area of the open top of the box was 52 inches x 52 inches, giving the walls a trapezoidal form. There was a 4 inch wide grid frame on the top of the test box which gave it an open surface area, 4 feet x 4 feet. Fine black electrician's wire was used to mark the grid off into squares, two inches by two inches. Four 40 watt fluorescent lamps were each placed on the upper edge of an inside wall of the box. A GraLab Universal Timer was arranged face up beside the grid frame such that the exact time each observation was made would be recorded. In a similar manner the experimental conditions of the group being tested were recorded by placing a piece of paper clearly marked with the appropriate titling next to the test box on a level with the grid frame.

A 16 millimeter motion picture camera, the Bolex H 16 Reflex, was used to record the chicks' behavior in the test box. The camera was mounted in a central position in the ceiling of the experimental room, directly above the experimental equipment. The distance from the film plane to the floor of the box was 100 inches. The distance from the film plane to the grid surface was 76 inches. One G.E. Mardi Gras Movie Lamp was mounted in a central position adjacent to the camera, 92 inches above the floor of the test box. Two Hunter Interval Timers controlled a solenoid-driven cable release such that a single frame of film was exposed every 15 seconds. In this manner 60 frames were exposed at equal intervals over the 15 minute test period.

The wide-angle lens, a Switar 1:1.6 $f = 10$ millimeters, had a diaphragm setting of $f/5.6$, with a filming speed of 24 frames per second, or an equivalent shutter speed of $1/65$ seconds for the single frame exposures. The reflex mechanism in the camera was closed during filming.



top (camera view) of test chamber
(1 unit = 1 inch)



side view

Fig. 1 Schematic drawing of the controlled field situation test chamber.

Procedure

Equal numbers of subjects were maintained in each of four identical brooder compartments. A locally prepared chick starter mash was continuously available in the brooder with the exceptions of the stated periods of food deprivation. A fluorescent lamp in each brooder compartment provided 16 hour periods of continuous illumination followed by 8 hour periods of darkness, approximating the natural diel cycle. The temperature in the brooder for the first five days was 94° F. From the sixth day onward the brooder temperature was the same as that in the test apparatus, about 88° F. The experiment took place between 12 noon and 4:30 p.m. on two consecutive days. All food deprived chicks were 24 hours hungry before testing took place.

On the first day half the 48 subjects were deprived of food 12 hours prior to the exposure sessions. Of these 24 food-deprived subjects 2 groups of six subjects were each placed in the test environment for 15 minute exposure sessions while 2 identical groups of 6 subjects each remained in the brooder. Similarly 24 non-deprived subjects were divided into 2 groups of 6 subjects that were each given a 15 minute exposure session in the test environment while 2 identical groups of 6 subjects each remained in the brooder.

On the second day each of the eight groups was given a 15 minute test session identical to the exposure sessions given on the previous day. The exposure- and the test-sessions were recorded on film. The eight experimental conditions were achieved by placing one member-group from each of the pairs of groups established on the first day, on 24 hours deprivation prior to testing on the second day. The remaining member-group of each pair was not food deprived prior to being tested.

On both days food deprivation occurred in two shifts, half the deprived chicks undergoing deprivation 2 hours before the other half. There was no food or water available in the test environment. Water was continuously available in the brooder through out the experiment. A session began with the simultaneous activation of the 15 minute timer and the occurrence of the first film exposure, just as a group of chicks was first placed together onto the center of the floor in the test box.

Measures and Analysis

There were two response measures; a measure of group dispersion, and a measure of the movement of individuals from frame to frame. These two response measures were recorded for each of the 60 film frames and then the average was taken of these 60 measurements to compute the score for each subject that was used in the statistical analysis.

The measure of the group dispersion was achieved by determining the bivariate mean of the six coordinate points on the grid, each representing the position of a chick. From this point the distance back to a chick's coordinate point was computed. The distance of the chick from the point representing the joint mean was the dispersion measurement indicating the extent to which a subject contributed to the dispersion of the group.

The amount of movement by individual chicks from frame to frame was determined by computing the linear distance between a chick's grid point position on a particular frame and its grid point position on the subsequent frame.²

The statistical analysis used in this experiment was an analysis of variance for a factorial design having three factors with two levels of each factor.

RESULTS

Dispersion

Food deprivation during the pre-exposure period resulted in a

decrease in group dispersion during testing ($F = 7.46$, $df = 1/40$, $p < .01$). Pre-exposure hunger interacted with exposure, ($F = 9.25$, $df = 1/40$, $p < .005$), and with food deprivation during testing and exposure ($F = 5.60$, $df = 1/40$, $p = .025$). Subjects that were hungry during the pre-exposure period and that were not given prior exposure in the test apparatus before being tested showed less dispersion during the test session than did similar subjects that did undergo pre-exposure in the test apparatus. These same subjects were also less dispersed than subjects that were not hungry during the pre-exposure period, regardless of whether or not they were given the pre-exposure session.

Movement

Food deprivation during the pre-exposure period, in and of itself, resulted in an increase in subjects average movement during the test session ($F = 14.64$, $df = 1/40$, $p < .001$). Food deprivation during testing ($F = 66.37$, $df = 1/40$, $p < .001$), and exposure ($F = 150.46$, $df = 1/40$, $p = .001$), although significantly effecting increases in movement, were interactive ($F = 18.16$, $df = 1/40$, $p < .001$). Subjects that were hungry during the test session were more active than subjects that were not hungry when tested. This effect was most marked in subjects that had not had pre-exposure in the test apparatus. Subjects that had been exposed in the test apparatus prior to being tested showed greater movement than subjects that had not had this experience. This effect was most marked in subjects that were not hungry during the test session.

DISCUSSION

The results expected for the dispersion measure were not obtained. The only significant main effect, pre-exposure hunger, worked in an opposite direction than was expected. Food deprivation during the pre-exposure

Table 1
Group Means for Experiment I

Food Deprivation Prior To Being Tested	Exposure Conditions			
	Exposed		Not Exposed	
	Hungry	Not Hungry	Hungry	Not Hungry
	Dispersion Measurement			
24 Hours Deprived	1.267	1.332	1.150	1.343
Not Food Deprived	1.173	1.049	0.955	1.855
	Movement Measurement			
24 Hours Deprived	1.669	1.597	1.186	0.974
Not Food Deprived	1.639	1.090	0.336	0.110

(1 unit = 1 inch)

Table 2

Analysis of Variance Experiment I: Dispersion Measurement

Source	df	M S	F
Test Hunger (A)	1	0.003	
Pre-exposure Hunger (B)	1	0.802	7.461**
Pre-exposure (C)	1	0.174	
A X B	1	0.202	
A X C	1	0.363	
B X C	1	0.995	9.251***
A X B X C	1	0.602	5.599*
Within	40	0.108	

Analysis of Variance Experiment I: Movement Measurement

Source	df	M S	F
Test Hunger (A)	1	3.800	66.369*****
Pre-exposure Hunger (B)	1	0.838	14.645*****
Pre-exposure (C)	1	8.613	150.456*****
A X B	1	0.181	
A X C	1	1.040	18.161*****
B X C	1	0.025	
A X B X C	1	0.161	
Within	40	0.057	

*p < .05; **p < .01; ***p < .005; ****p < .001.

period resulted in a decrease, rather than an increase in group dispersion. It was impossible to interpret this result. The primary consideration in including this independent variable manipulation was as a precautionary measure in the event that only borderline results were obtained from the food deprivation undergone while groups were being tested. Should this have been the case it was anticipated that the additional food deprivation experience would have enhanced the effectiveness of the food deprivation undergone by some groups for 24 hours prior to testing. The interpretation of the first and second order interactions is equally impossible. The original expectations tended to be counter-indicated by the results.

It was expected that hunger during testing would increase the amount of movement shown by a group. Food deprivation prior to testing had this effect, as did food deprivation during pre-exposure, and also pre-exposure itself. It was generally expected that there would be a much greater correspondence between the dispersion and the movement measures. Such an expectation failed to take into consideration that a group may be widely dispersed but show little individual or group movement, or that a densely bound group may show a lot of movement while group members maintain their relative positions.

EXPERIMENT II: Spatial organization of small flocks of domestic chicks as a function of degree of hunger, and of familiarity with the experimental situation.

A typical response of gregarious animals to fear inducing stimuli is an increase in aggregation or intra-group density. Almost any sudden change in the environment results in this effect (birds: Crook, 1961), (fishes: Breder & Halpern, 1946; Breder & Nizerelli, 1935; Keenleyside, 1955). In the natural setting, changes in the quality and the intensity of impinging stimulation are probably much less marked than when chicks are placed in a test situation of which they have had only brief, if any, prior experience. The latter situation may result in a masking of the effects of hunger on the spatial organization of the group. The same reports also suggest that an increase in familiarity with the novel sources of stimulation results in the habituation (Glaser, 1966; Lynn, 1966; Thorpe, 1952) of the fear responses with a subsequent increase in the distance between individual group members.

The present experiment involved the manipulation of three levels of food deprivation across three levels of prior exposure in the test apparatus. The object of this was to assess the effect of hunger upon the spatial organization of small flocks of communally foraging chicks in the absence of any masking effects that fear responses to the test situation might induce. Attempts to achieve familiarity for some groups in this experiment through repeated exposures to the test situation resulted in subjects being tested when they were five days older than subjects were when tested in Experiment I. The control for the possibility of the dependent variable measurements being age dependent there was a partial replication of Experiment I within Experiment II, Experiment IIb.

It was difficult to make explicit predictions about the results

in the absence of an established literature. However, it was expected that the distance between individual group members, and also the groups activity levels, would be an increasing function of the hours of food deprivation undergone by a group. It was also expected that the differential effects of hunger would to a large extent be lost in groups that had not had prior experience in the test apparatus. Further, it was expected that there would be greater dispersion in the multi-exposure condition as compared with the single exposure condition.

There was no a priori basis for making predictions concerning the age dependency of the dependent variable measurements in Experiment IIb. However, it would seem essential that the effects of age be independent of the effects of prior exposure and of hunger if use of the chick as a model of the gregarious organism is to be substantiated.

Method

Subjects

Fifty-four subjects from the same batch of white Leghorn cockerels used in Experiment I were tested when 14 days of age. Maintenance conditions were essentially the same as those in the first experiment.

Apparatus

The environment and the experimental equipment were the same as that used in Experiment I.

Procedure

The experiment was arranged in a 3 x 3 factorial design. There were three levels of hunger (none; moderate; extreme) and three levels of prior exposure in the test apparatus (non; one - 15 minute exposure session on the day before testing occurred; five - 15 minutes exposure sessions, one each

day for five days prior to the test sessions on the 14th day). Other than the hours of food deprivation outlined below, food was continuously available in the brooder, as was water throughout the entire experiment. The order of occurrence of testing for the groups was randomly determined prior to the onset of testing.

When subjects were nine days old three groups of six subjects were each given a 15 minute exposure session in the test apparatus and this procedure was repeated for these groups each day through subjects' 13th day of age. On the 13th day another three groups of six subjects were each given one 15 minute exposure session in test apparatus prior to testing on the following day. The remaining three groups of six subjects each were not exposed in the test apparatus before being tested.

The three groups in each of the exposure conditions were randomly assigned to one of the three hunger conditions when subjects were 13 days old. It was assumed that the amount of food eaten by subjects during the nightly eight-hour period of darkness would be negligible. Subjects under moderate hunger were food deprived just before the onset of darkness, at 8:45 p.m. on the eve of the test day. Subjects in the extreme hunger condition underwent food deprivation at 2:00 p.m. on the day immediately preceding the test day. Subjects were not given access to food or water while in the test environment either during exposure, or test sessions.

Measures and Analysis

The response measures, a measure of group dispersion, and a measure of the movement of individual group members from frame to frame, were the same as those used in Experiment I. The statistical analysis used in Experiment II (a) was an analysis of variance for a factorial design having two factors with three levels of each factor. The statistical analysis in Experiment II (b) was the same used in Experiment I, an analysis of variance

Table 3

Group Means for Experiment II

Number of Pre-exposures	Deprivation Prior to Being Tested		
	0 Hours	12 Hours	24 Hours
	Dispersion Measurement		
0 Pre-exposures	1.286	1.652	1.531
1 Pre-exposure	1.432	2.698	1.703
5 Pre-exposures	2.282	3.998	5.402
	Movement Measurement		
0 Pre-exposures	1.571	1.337	1.219
1 Pre-exposure	1.451	2.767	1.517
5 Pre-exposures	3.260	4.793	8.169

(1 unit = 1 inch)

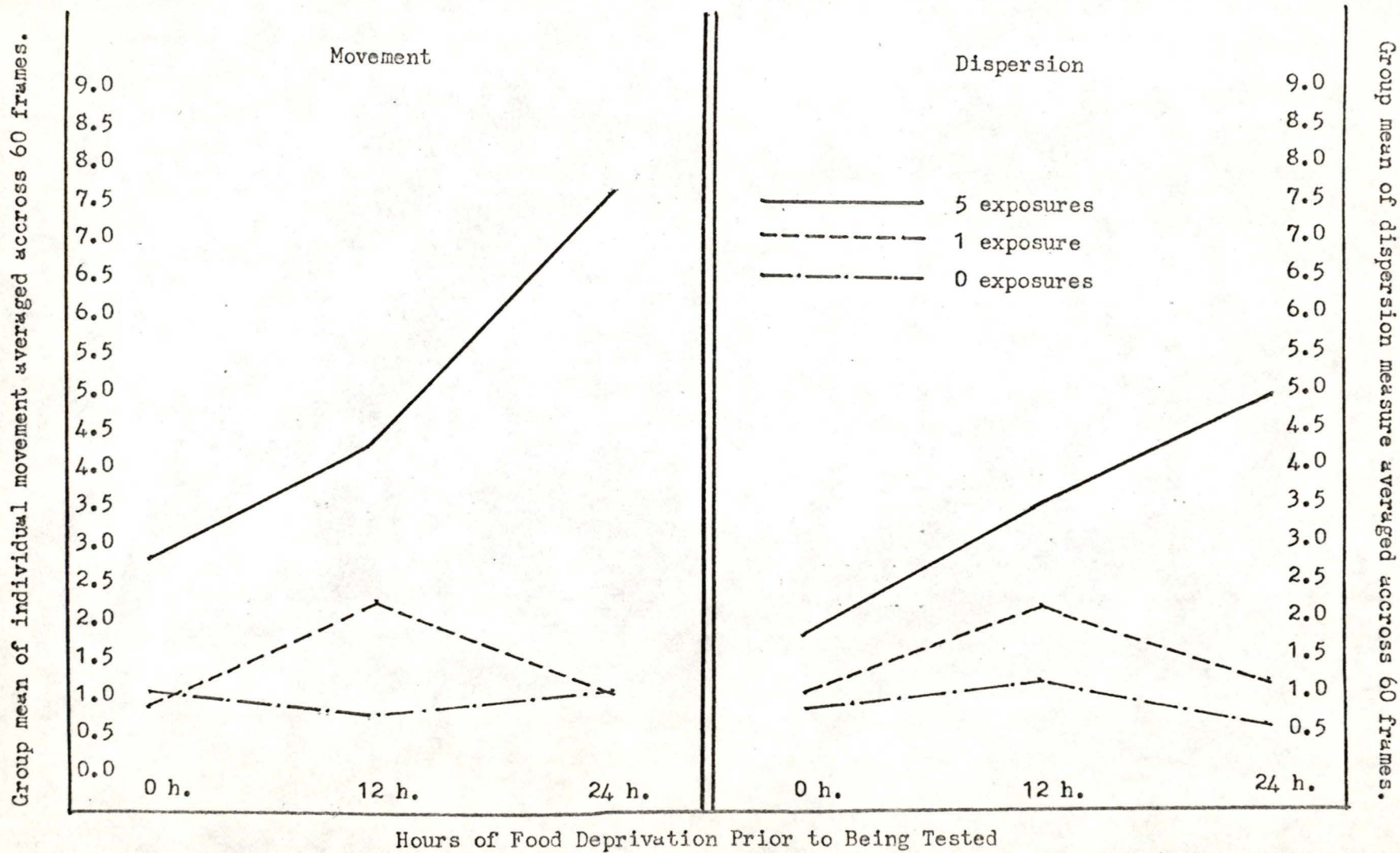


Fig. 2. Movement and dispersion as a function of food deprivation and prior exposure.

Table 4

Analysis of Variance Experiment II(a): Dispersion Measurement

Source	df	M S	F
Hours of Deprivation (A)	2	8.172	77.646**
Number of Pre-exposures(B)	2	29.369	279.048**
A X B	4	4.675	44.418**
Within	45	0.105	

Analysis of Variance Experiment II(a): Movement Measurement

Source	df	M S	F
Hours of Deprivation (A)	2	10.752	9.025*
Number of Pre-exposures(B)	2	86.284	72.426**
A X B	4	15.293	12.837**
Within	45	1.191	

for a factorial design having three factors with two levels of each factor.

RESULTS

Dispersion

Food deprivation resulted in an increase in the distance between individual group members ($F = 77.65$, $df = 1/45$, $p < .001$). The effect of prior exposure to the test apparatus was also an increase in the distance between individual group members ($F = 279.05$, $df = 1/45$, $p < .001$). These results can be seen in Figure I. There was an interaction between food deprivation effects and prior exposure ($F = 44.42$, $df = 1/45$, $p < .001$). The expected effects of prior exposure in the test apparatus were most clearly demonstrated under the moderate hunger condition. The expected effects of test hunger were seen most clearly in the multiple exposure condition.

Movement

The results concerning the average movement of subjects from frame to frame were similar to those for the dispersion measure. Food deprivation resulted in an increase in the amount of movement ($F = 9.03$, $df = 1/45$, $p < .005$). The effect of the number of prior exposures was to increase the amount of movement ($F = 72.43$, $df = 1/45$, $p < .001$). There was an interaction between food deprivation effects and prior exposure in the test environment ($F = 12.84$, $df = 1.45$, $p < .001$). The expected effects of test hunger were seen most clearly in the multiple exposure group, and the expected effects of prior exposure were seen most clearly under the moderate hunger condition.

Discussion (a)

A major conclusion arising from this experiment concerns the inadequacy of the single pre-exposure condition, both here and in Experiment I, to effect sufficient habituation of fear responses to allow elaboration

Table 5

Group Means for Experiment II(b)

		Exposure Conditions			
Food Deprivation		Exposed		Not Exposed	
Prior					
To Being Tested		9 Days Old	16 Days Old	9 Days Old	16 Days Old
Dispersion Measurement					
24 Hours Deprived	1.332	1.703		1.343	1.531
Not Food Deprived	1.049	1.432		1.855	1.286
Movement Measurement					
24 Hours Deprived	1.597	1.517		0.974	1.571
Not Food Deprived	1.090	1.451		0.110	1.571
(1 unit = 1 inch)					

Table 6

Analysis of Variance Experiment II (b): Dispersion Measurement

Source	df	M S	F
Test Hunger (A)	1	0.062	
Pre-exposure (B)	1	0.187	
Age (C)	1	0.104	
A X B	1	0.507	4.621*
A X C	1	0.417	
B X C	1	0.968	8.827***
A X B X C	1	0.443	
Within	40	0.110	

Analysis of Variance Experiment II (b): Movement Measurement

Source	df	M S	F
Test Hunger (A)	1	0.884	7.954**
Pre-exposure (B)	1	2.377	21.380*****
Age (C)	1	2.959	26.611*****
A X B	1	0.003	
A X C	1	2.058	18.507*****
B X C	1	1.523	13.696*****
Within	40	0.111	

*p < .05; **p < .01; ***p < .005; ****p < .001

of the group's tendency to disperse in response to food deprivation. Intense hunger interacted with the strangeness of the test environment to induce a dense aggregation. It is possible that a high state of arousal resulting from the extreme hunger condition sensitized the chicks to the fear inducing stimuli in the test environment. This is not a surprising finding when the magnitude of the stimulus change that occurred during testing is considered. The naive chicks were removed from the only environment with which they had had experience, the brooder, and placed in a totally new setting, the test environment. Given sufficient prior exposure in the test apparatus to ensure habituation of the fear responses to it, the effect of an increase in food deprivation was an increase in dispersion and in the general activity level of the group. The performance of the groups that did not undergo food deprivation prior to being tested indicates that the distribution of a group is less dispersed following feeding than when chicks engaged in communal foraging.

Results (b)

Dispersion

In and of themselves, food deprivation, prior exposure, or age did not differ in the effects they had on group dispersion. There was an interaction between food deprivation and exposure ($F = 4.62$, $df = 1/40$, $p < .05$), and between prior exposure and age ($F = 8.83$, $df = 1/40$, $p < .005$). Hungry subjects that were given prior exposure in the test environment showed greater dispersion than similar subjects that were not food deprived when tested. This relationship tended to be reversed in subjects that had not undergone prior exposure in the test apparatus. Nine day-old subjects that had had no prior exposure were less dispersed than similar subjects that had had exposure in the test apparatus prior to being tested. This relationship tended to be reversed in the older subjects.

Movement

Food deprivation resulted in an increase in subject's movement during testing ($F = 7.95$, $df = 1/40$, $p < .01$). Prior exposure in the test environment also resulted in increased movement ($F = 21.38$, $df = 1/40$, $p < .001$), as did age ($F = 26.61$, $df = 1/40$, $p < .001$). There was an interaction between prior exposure and age such that groups of 9 day-old subjects which had not undergone prior exposure in the test environment did not show as much movement as subjects of the same age in groups that had undergone prior exposure. Age and food deprivation interacted ($F = 13.70$, $df = 1/40$, $p < .001$), 16 day-old subjects that were not food deprived when tested showing more movement than similar groups of 9 day-old subjects. Nine day-old subjects that were not food deprived when tested showed less movement than groups of similar subjects that were under food deprivation when tested. This relationship tended to be reversed in groups of 16 day-old subjects.

Discussion (b)

The single pre-exposure conditions in both Experiment I and II were not sufficiently effective to counteract the effects of fear-inducing novel stimulation in the test situation. The movement variable seems clearly age dependent, but it would be premature to come to this conclusion about either the movement of the dispersion variable on the basis of these results. The kind of movement expected was the type concomitant with the patterns of dispersion expected from the independent variable manipulations. The expectations about movement were generally confirmed, but this kind of movement may not be relevant to dispersion phenomena in particular because of the failure to demonstrate dispersion in these conditions. To assess fairly the age dependency of dispersion and movement within the present context, different-aged groups of chicks must be given an equal number of repeated pre-exposures in the test apparatus prior to being tested. The

testing of the age dependency of both variables should only be done in circumstances that allow the full elaboration of the dispersion response.

General Discussion

The presence of all but one of the general characteristics reported in the introduction as typical of gregarious animals has been demonstrated as occurring in small groups of chicks within this set of experiments. The effect of hunger on the spatial organization of the group was an increase in the distance between group members and also an increase in the groups' general activity level. Groups that were not food deprived prior to being tested were less dispersed than groups that were hungry when tested. The occurrence of these effects depended to a large extent upon the groups' familiarity with the test environment. This strangeness effect was somewhat stronger than had been originally anticipated. These experiments were not designed to determine the effects of social facilitation of the feeding response in this controlled field situation. Rather, it was hoped that a broader and more relevant behavioral framework for the investigation of the determinants of social facilitation would be established by the laboratory demonstration of these other functions. Having substantiated these relationships and the usefulness of this laboratory model of gregarious open field behavior, the way is left open for the future demonstration of the effects of social facilitation within this context. It should be expected that social facilitation of the feeding response in the controlled field situation will result in a rapid aggregation response, and synchronization of the feeding behavior of group members.

In gregarious species selective pressures have favoured the evolution of social as opposed to individually independent modes of behavior through which an animal achieves the most advantageous adaptation to its environment. The mechanisms of social interaction are not necessarily

different in kind from those involved in interaction with non-social environments, the point being that pressures related to social factors have been involved in their evolution. Specializations in social modes of adaptation occur widely in which specific actions or perhaps simply a sensory attribute of the body appears to function in the evocation of regular changes in the behavior of conspecifics. Specifically, this can result in particularly systematic, regularized episodes of social interaction. Selective pressures favour the conventionalization of such behavioral specializations in much the same way that a particular anatomical structure may be favoured. This tendency is particularly marked in behavior episodes that are biologically critical or that contribute to the integrity of the species. Thus, with the exploitation of social modes of adaptation an additional range of environmental information becomes available to an animal, that arising out of the social environment. It is just such an information exchange that defines social communication in animals, and within this context it can be seen that social communication and social behavior in animals are identical concepts.

Social facilitation is a social signal and as such is of no greater relevance to the study of animal behavior than any other social behavior. That social facilitation should be singled out among social behaviors as especially deserving of attention is to subscribe to the pursuit of an exceedingly insular kind of science. The essential consequence of any readily identifiable social behavior is a redistribution of the spatial organization of the group. It is difficult to specify the name, function, or species' relevance of a particular behavior pattern in the absence of a knowledge of the animal's spatial relationship with other group members.

The scientific value of the use of experimental methods to further

understanding of the significance of social behavior in animals is in direct proportion to their degree of congruence with information known about the nature of ecological adaptations of animal populations. The procedure used in the present set of experiments is not meant to be a panacea for the methodological weaknesses in the study of animal behavior. It does however, provide a direct measure of an essential characteristic of all social behavior, the spatial proximity of the possibly relevant conspecifics. This method is flexible enough to allow measurement of the effect of the occurrence of a particular social behavior on the ambient spatial organization, and also its subsequent consequences.

The present results for the most part affirm the adaptive rationale suggested in the introduction. However, it must be left largely to comparative studies to determine the precise adaptive significance of the spatial organization of groups of gregarious animals. An important clue to the direction such studies should take may be a consideration of the characteristic geographical distribution of a species' typical foods, which may vary greatly between species. The selective pressures resulting from such differences may provide a basis for making differential predictions concerning the relative strengths and importance of the various aspects of an open field behavior considered in this paper.

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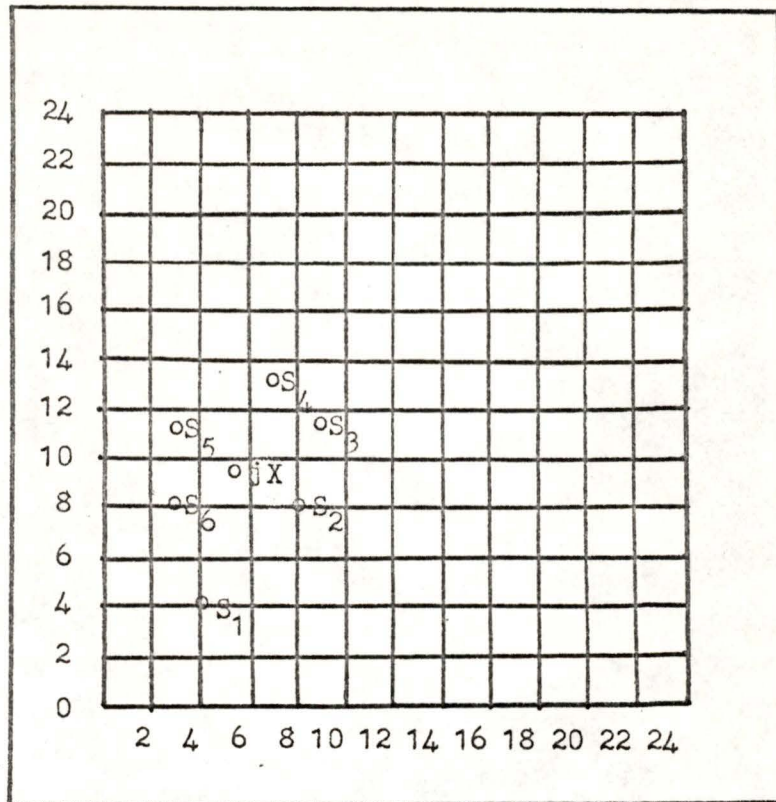
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Footnotes

1. This was an unpublished experiment on the spatial organization of small flocks of domestic chicks performed by Dr. Tolman in the summer of 1968. The dependent variable measurements in the present experiment were derived directly from this study.
2. Sample calculations of the dependent variable measurements can be found in the appendix.

Appendix A

Sample Calculations of the Dispersion and Movement Measurements



- $S_1(4,4)$
- $S_2(8,8)$
- $S_3(11,9)$
- $S_4(13,7)$
- $S_5(11,3)$
- $S_6(8,3)$

joint $\bar{X} = (9.2, 5.7)$

Calculation of the joint mean, $(\bar{X}, \bar{Y}) = \left(\frac{\sum X}{n}, \frac{\sum Y}{n}\right) = \left(\frac{55}{6}, \frac{34}{6}\right) = (9.2, 5.7)$

Calculation of the dispersion measure: $= (X_{\bar{X}} - X_{s_1})^2 + (Y_{\bar{X}} - Y_{s_1})^2$
 $= \sqrt{(9.2 - 4)^2 + (5.7 - 4)^2} = \sqrt{29.5} = \underline{\underline{5.43}}$

Calculation of the movement measure in the instance where S_3 is the position of a chick on a particular film frame and S_6 is the same chick's position on the subsequent frame:

$$= \sqrt{(X_{s_3} - X_{s_6})^2 + (Y_{s_3} - Y_{s_6})^2} = \sqrt{(11 - 8)^2 + (9 - 3)^2}$$

$$= \sqrt{45} = \underline{\underline{6.7}}$$

Appendix B

Raw Data Used in the Statistical Analyses

Dispersion Raw Data for Experiment I

Exposed; food deprived during pre-exposure period; not food deprived during testing.

1.0416 1.0826 1.2519 1.3164 1.2671 1.0772

Exposed; food deprived during pre-exposure period; food deprived during testing.

1.2478 1.2635 1.0039 1.1881 1.0744 1.8248

Exposed; not food deprived during pre-exposure period; not food deprived during testing.

1.1071 1.0505 1.0959 1.0046 0.9717 1.0647

Exposed; not food deprived during pre-exposure period; food deprived during testing.

1.2883 1.0791 1.5395 1.1908 1.3603 1.5345

Not exposed; food deprived during pre-exposure period; not food deprived during testing.

1.1663 1.1546 0.8708 0.8819 0.7150 0.9427

Not exposed; food deprived during pre-exposure period; food deprived during testing.

1.0184 0.9854 1.0557 1.2138 1.5382 1.0869

Not exposed; not food deprived during pre-exposure period; not food deprived during testing.

1.8583 2.0359 1.6841 3.0718 0.6834 1.7989

Not exposed; not food deprived during pre-exposure; food deprived during testing.

1.5224 1.2469 1.1056 1.0159 1.4858 1.6789

Movement Raw Data for Experiment I

Exposed; food deprived during pre-exposure period; not food deprived during testing.

1.3479 1.5668 1.6692 1.5735 1.7299 1.9457

Exposed; food deprived during pre-exposure period; food deprived during testing.

1.9262 1.8472 1.5340 1.4408 1.6360 1.6272

Exposed; not food deprived during pre-exposure period; not food deprived during testing.

0.8510 1.5119 1.1330 1.2124 0.7913 1.0403

Exposed; not food deprived during pre-exposure period; food deprived during testing.

1.3900 1.3310 1.7600 1.1585 2.1839 1.7584

Not exposed; food deprived during pre-exposure period; not food deprived during testing.

0.4751 0.1865 0.4034 0.2211 0.2639 0.4638

Not exposed; food deprived during pre-exposure period, food deprived during testing.

1.3366 1.4973 0.8446 1.0223 0.7929 1.6194

Not exposed; not food deprived during pre-exposure period; not food deprived during testing.

0.0800 0.0521 0.0843 0.0233 0.1217 0.2989

Not exposed; not food deprived during pre-exposure period; food deprived during testing.

1.0998 0.9702 1.0472 1.0643 0.6441 1.0199

Dispersion Raw Data for Experiment II

Not exposed; tested 0 hours food deprived.

1.4497 1.3462 1.2008 1.0941 1.3148 1.3094

Not exposed; tested 12 hours food deprived.

1.5259 1.6428 1.8129 1.6797 1.6204 1.6318

Not exposed; tested 24 hours food deprived.

1.4271 1.5851 1.5241 1.4590 1.5643 1.6234

One prior exposure; tested 0 hours food deprived.

1.5446 1.4692 1.1963 1.5227 1.4169 1.4408

One prior exposure; tested 12 hours food deprived.

2.6663 2.5281 3.5720 2.1319 2.9302 2.3601

One prior exposure; tested 24 hours food deprived.

2.4370 1.4627 1.8654 1.4932 1.4775 1.4838

Five prior exposures; tested 0 hours food deprived.

1.8493 2.4293 2.2047 2.5295 2.2790 2.4010

Five prior exposures; tested 12 hours food deprived.

4.6814 3.3694 3.8594 3.5241 3.9779 4.5779

Five prior exposures; tested 24 hours food deprived.

5.7717 5.4628 4.9407 5.9046 5.2346 5.0952

Movement Raw Data for Experiment II

Not exposed; tested 0 hours food deprived.

1.5573 1.7021 1.7369 1.4942 1.2644 1.6692

Not exposed; tested 12 hours food deprived.

1.9106 1.0658 0.5697 1.2597 1.7946 1.4210

Not exposed; tested 24 hours food deprived.

1.0233 1.5418 1.6804 0.9021 1.3669 0.8008

One prior exposure; tested 0 hours food deprived.

0.9683 1.3512 1.1775 1.9834 0.8583 2.3654

One prior exposure; tested 12 hours food deprived.

3.1387 3.4929 0.8284 3.1629 4.2200 1.7616

One prior exposure; tested 24 hours food deprived.

2.1503 1.5077 1.4925 1.5673 1.2168 1.1671

Five prior exposures; tested 0 hours food deprived.

3.3141 3.0971 3.3973 3.3586 3.1150 3.2763

Five prior exposures; tested 12 hours food deprived.

4.2239 5.1632 3.8127 5.5377 5.0466 4.9762

Five prior exposures; tested 24 hours food deprived.

4.9106 9.5664 10.0653 4.2439 10.4253 9.8031

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