Social stimuli influencing feeding behaviour of Burmese fowl: a video analysis

L. M. MCQUOID & B. G. GALEF, JR*
Department of Psychology, McMaster University, Hamilton, Ontario, L8S 4K1 Canada

Abstract. After adolescent Burmese red junglefowl, *Gallus gallus spadecius*, were exposed to videotapes of conspecifics feeding from visually distinctive food dishes, the viewers exhibited enhanced preferences for food dishes of the type that they had observed conspecifics exploit. Both auditory and visual stimuli associated with feeding fowl played a role in producing these socially enhanced feeding-site preferences, and videotapes of fowl actually feeding from a food dish were more effective in enhancing preference for that type of food dish than were videotapes of fowl either active or immobile near a food dish. Thus, juvenile junglefowl not only responded to video images of conspecifics and generalized from video images of objects to the objects themselves, they also responded differentially to video images of general activity near a food dish and feeding behaviour directed towards a food dish. Whether exposure to a videotape sufficed to influence feeding behaviour during testing depended on: (1) the duration of the subjects' exposure to videotapes, (2) the duration of the delay between videotape viewing and preference testing and (3) the criteria used to detect social influence on feeding behaviour.

Analysis of the stimuli that mediate social learning in animals is an inherently difficult task because, in general, experimenters conducting studies of social learning cannot present stimuli to their subjects directly. Rather, experimenters use trained animal tutors to exhibit behaviour patterns to naive observers. These tutors invariably behave inconsistently from trial to trial, and the resulting lack of stimulus control interferes with analyses of social learning processes.

Use of video technology provides a potential, though largely unexplored, means of markedly increasing experimenter control of the behaviour of tutors seen by observers in studies of social learning. Video images can be selected and edited for presentation to subjects and all subjects can therefore be exposed to identical demonstrations of behaviour. Furthermore, modern electronic techniques for modifying video images and computer-generated video images permit sophisticated analyses of visual stimuli producing socially induced modifications of behaviour that would not otherwise be possible (see Evans & Marler 1991 for further discussion).

*To whom correspondence should be sent.

Of course, such analyses can be carried out only if subjects respond similarly when exposed to video images and to live conspecifics. To date, few cases of response to video images have been described in the literature, and those that have been (see Evans & Marler 1991 for review) are not really suitable for use in studies of social learning.

A major goal of the present studies was to determine whether adolescent Burmese red junglefowl, *Gallus gallus spadecius*, that learn to prefer particular types of feeding sites by watching live conspecifics feed, would also learn such preferences by watching video images of feeding conspecifics.

After directly observing conspecifics feeding from a visually distinctive feeding site, adolescent Burmese red jungle fowl prefer to eat at feeding sites of that type (McQuoid & Galef 1992). For example, when offered a choice between marked and unmarked feeding dishes, fowl that previously had watched conspecifics feed from a marked food dish (and ignore unmarked food dishes) preferred to feed from a marked dish, while those observer fowl that had watched conspecifics feed from an unmarked food dish (and ignore marked dishes) preferred to feed from an unmarked dish (McQuoid & Galef 1992). Fowl that had directly observed conspecifics feeding in an enclosure also exhibited

shorter latencies to begin feeding in that enclosure than did fowl that had not seen conspecifics feeding there (unpublished data).

The studies reported below were undertaken to determine which aspects of the behaviour of demonstrator fowl were responsible for the social influences on both feeding-site preference and latency to initiation of feeding observed by McQuoid & Galef (1992 and unpublished data). Our goals were conceptually similar to those of earlier researchers who used mechanical models to determine which aspects of the total stimulus complex provided by a feeding hen sufficed to release and orient concurrent pecking by newly hatched chicks (Turner 1964; Tolman & Wilson 1965; Tolman 1967, 1968; Suboski 1984; Suboski & Bartashunas 1984). Both our methods and specific interests, however, differ from those of earlier workers.

First, we used edited videotape recordings of behaviour rather than mechanical models as stimuli to determine which of the visual and auditory signals associated with feeding fowl would influence initiation and orientation of pecking by their observers.

Second, we were more interested in the deferred effects of viewing video images of feeding fowl on the behaviour of their conspecifics than in the immediate effects of such experience. Deferred effects of exposure to the behaviour of one animal on the behaviour of another provide evidence of underlying processes both different from and more sophisticated than those supporting concurrent influence of the behaviour of one animal on another (Galef 1988; Speidel & Nelson 1989; McQuoid & Galef 1992). For example, by itself, neither local enhancement (Thorpe 1963) nor social facilitation (Zajonc 1965, 1969) can explain deferred effects of observation of the behaviour of a tutor on the behaviour of its observers.

Third, we were interested in social influences on foraging efficiency in birds that, like Burmese red jungle fowl, forage in flocks (Collias et al. 1966; McBride et al. 1969), rather than in the foraging behaviour of hens specialized to elicit and orient pecking by their newly hatched chicks. Therefore, rather than use recently hatched chicks and tidbitting hens in our experiments, we used adolescent fowl as subjects. Our immediate goal was to describe those aspects of the stimulus complex provided by a feeding conspecific that would influence future feeding behaviour of mature fowl.

EXPERIMENT 1

The first experiment was undertaken to determine the sufficiency both of television images and of recorded feeding sounds to initiate and orient later feeding by Burmese fowl. Each subject was randomly assigned to one of four experimental groups that differed in the visual and auditory content of the videotapes to which group members were exposed during training. After training, subjects were tested to determine both their latencies to begin feeding and their preferences when choosing between the type of food dish from which they had seen and heard conspecifics feed during training and an unfamiliar type of food dish.

Methods

Subjects and maintenance

One-hundred and fifty-six, 21- to 28-day-old, experimentally naive Burmese red jungle fowl served as observers and eight similar fowl served as demonstrators. All were descendants of a flock maintained in the Department of Psychology at the University of Toronto and all were offspring of birds born in the vivarium of the McMaster University Psychology Department.

At McMaster, eggs were collected daily and were then maintained for as long as one week at 7–12°C before being incubated at 37·7°C in batches of 20–60 eggs.

From the time of hatching until the start of experimental procedures, chicks were maintained in groups of 10–20 on ad libitum chick starter (Purina Startina, B & W Feed, New Hamburg, Ontario) and water to which a vitamin supplement (Vitadol, Tuco Products, Orangeville, Ontario) had been added.

Apparatus

Rearing enclosures. For 3–4 weeks after hatching, we housed each group of young fowl in a rearing cage constructed of angle iron and hardware cloth, measuring $1 \times 1 \times 0.3$ m. Each enclosure had a floor of galvanized sheet metal which was covered to a depth of 2–3 cm with woodchip bedding. A 250-W brooder lamp suspended over one corner of each rearing enclosure provided supplementary heat. Food and water were available to chicks in 1-liter, Mason-jar chick feeders and chick waterers (Berry Hill Ltd, St Thomas, Ontario).

Sliding partition

0·3 m
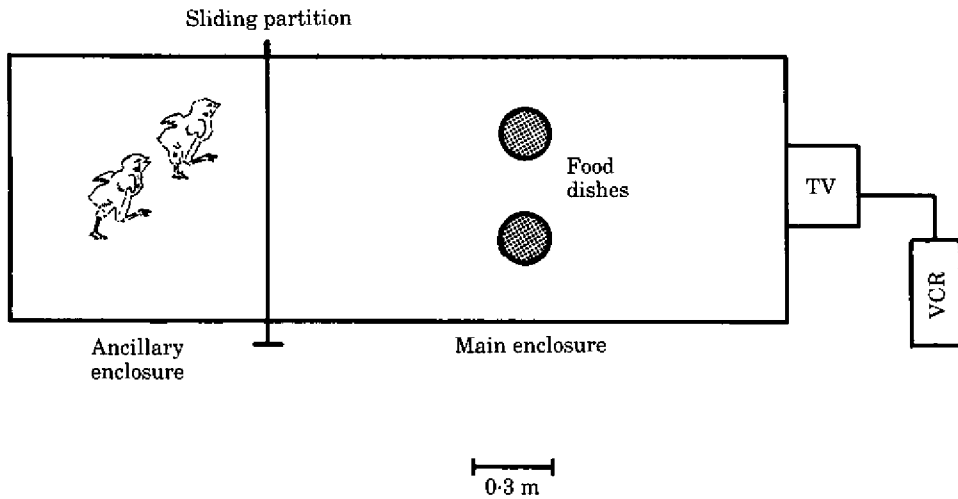
Figure 1. Overhead schematic of the experimental enclosure used in all experiments. The enclosure is shown in the configuration used during the interval between training and testing in experiments 1 and 2.

Experimental enclosure. We trained and tested chicks in an experimental enclosure (Fig. 1), constructed of the same materials as the rearing enclosures described above. We divided the experimental enclosure into an ancillary ($1 \times 1 \times 0.3$ m) and main enclosure ($1.5 \times 1 \times 0.3$ m) separated by an opaque sliding door, and we placed a 33-cm colour video-monitor (Panasonic LT 1331YC) in the centre of the side of the main enclosure opposite the sliding partition.

During the stage of the experiment when the feeding behaviour of observers was tested, we placed two round Pyrex dishes (10×5 cm) painted white into the main enclosure (Fig. 1). We decorated the exterior of one of these dishes with eight, 1·9-cm diameter, red, adhesive labels evenly spaced 1 cm below the rim of the dish; the other dish was similarly decorated with blue adhesive labels.

Preparing videotapes. Four, different 32-min training videotapes were prepared by editing several hours of videotape of feeding fowl recorded on industrial grade, closed-circuit television equipment (Panasonic WV CL110 colour video-camera, Panasonic AG 1240 video-cassette recorder and Panasonic LT 1331YC 33-cm, colour video-monitor with a horizontal resolution of 420 lines). Sound was recorded using a dynamic omni-directional microphone (Model 635A, Electrovoice Inc., Buchanan, Michigan).

Each training videotape began with a 2-min presentation of a life-size image of either a red- or blue-marked food dish. This was followed by a series of 15, 1-min scenes in which the same type of food dish played a central role. The 15, 1-min scenes were separated by 1-min intervals during which a videotape was blank.

Each of the 15 scenes in any one of the four 32-min videotapes was similar. When viewed on a 33-cm video-monitor, each showed an 80% of life-size image recorded from fowl's-eye height of either: (1) a red-marked food dish, (2) a blue-marked food dish, (3) a pair of 21- to 28-day-old Burmese fowl feeding continuously from a red-marked food dish or (4) a pair of 21- to 28-day-old Burmese fowl feeding continuously from a blue-marked food dish. In recording scenes for all four tapes, camera placement was such that, although a food dish or a food dish and fowl were clearly visible in each scene, any food present in a food dish was not visible.

Tapes were played to subjects through the monitor in one of two versions: either silent or containing audio recordings of the sound of Burmese fowl pecking vigorously in a food dish (90–110 pecks/min) and uttering twitter calls (Kruijt 1964) at a rate of 35–45 calls/min.

Training subjects. We had found during our earlier work on social influences on feeding-site

Table I. Behaviour during testing of subjects in experiment 1

Behaviour	Training condition			
	Sound/bowl	No sound/bowl	Sound/fowl	No sound/fowl
Number of pairs trained	18	15	23	22
Percentage of pairs feeding during testing	67[a]	73[a]	83[a]	73[a]
Latency to first peck:mean ($\pm$SE) min	7·1$\pm$0·5[b]	6·2$\pm$0·9[b]	3·5$\pm$0·7[c]	3·9$\pm$0·8[c]
Percentage of pairs first peck to training dish	50·0[d]	54·5[d]	89·5[e]	43·8[d]
Percentage of pairs feeding more from training dish	50·0[f]	54·5[f]	89·5[g]	43·8[f]

Cells in the same row containing different superscripts were significantly different.

preferences in Burmese fowl (McQuoid & Galef 1992), that it was necessary to keep subjects in pairs throughout experiments; isolated fowl engaged in prolonged periods of distress vocalization and remained immobile. Consequently, to begin training, we removed a pair of 21- to 28-day-old fowl from their rearing enclosure and placed them together in the ancillary portion of the experimental enclosure. Here, they were, first, fed their standard rations for 24 h from an unmarked 10-cm diameter Pyrex dish painted white, then, deprived of food for 24 h.

At the end of the 24-h period of food deprivation, we opened the sliding partition separating the ancillary enclosure from the main enclosure and played a training videotape through the monitor.

Each pair of subjects had been assigned to one of four groups, which differed in the type of training videotape that group members observed: 15 pairs of subjects saw a food dish and heard no sound (group no sound/bowl); 18 pairs of subjects saw a food dish and heard the sound of fowl feeding (group sound/bowl); 22 pairs of subjects watched a pair of fowl feeding from a food dish and heard no sound (group no sound/fowl), and 23 pairs of subjects both saw a pair of fowl feeding from a food dish and heard the sounds of fowl feeding (sound/fowl). Within each group, we exposed as close to half of the subject pairs as possible to a red-marked food dish in each 1-min scene and the remainder of subject pairs in that group to a blue-marked food dish in each 1-min scene.

When a training videotape ended, we returned the pair of fowl to the ancillary enclosure, closed the sliding partition and turned off the monitor.

Testing subjects. Pairs of subjects were held in the ancillary enclosure for 10 min between training and testing. During this 10-min interval, we placed two food dishes, one marked with red labels and one marked with blue labels, in the main enclosure in the positions indicated in Fig. 1. Each of the two marked food dishes contained 5 g of the birds' standard rations covered with sufficient strips of torn newsprint to conceal completely the food in the bottom of the dish. The positions of the red- and blue-labelled dishes were counterbalanced across subjects within training conditions.

To begin testing, the experimenter opened the sliding partition separating the ancillary enclosure from the main enclosure. During the subsequent 10-min test period, the birds were allowed to feed ad libitum in the main enclosure. The experimenter recorded: (1) the latency of each pair of fowl to begin pecking, (2) the food dish in which each pair of subjects first pecked, and (3) the location and duration of each pecking bout exhibited by each pair of fowl. A bout of pecking was defined as a series of pecks directed inside a feeding dish by a bird; a bout of pecking was considered to have ended when 2 s passed without further pecking.

Results

The main results of experiment 1 are presented in Table I which provides an overview of the behaviour exhibited during testing by subjects in each of the four training conditions.

Percentage of pairs feeding during testing

As we have reported previously (McQuoid & Galef 1992), in our test situation, not all pairs of

adolescent fowl deprived of food for 24 h before testing will feed during a 10-min test period. In the present experiment, of the 78 pairs of subjects, neither member of 20 pairs (26%) ate during the 10-min test. In our previous studies (McQuoid & Galef 1992), in which pairs of adolescent fowl watched live, rather than videotaped, conspecifics feed during training, neither member of 13 of the 44 pairs of subjects (29%) ate during testing sessions. Exposure to video-recordings seems to have been as effective in eliciting feeding in the test situation as was exposure to live conspecifics in our earlier experiments. Although, in the present experiment, a greater percentage of the pairs of subjects in the sound/fowl condition fed during testing than did pairs of subjects in other conditions; this difference was not statistically significant ($\chi^2 = 2\cdot12$, $df = 3$, NS).

Latency to first peck

A 2×2 ANOVA revealed significant effects of training conditions on the latency to first peck in the 58 pairs of fowl that did peck during testing. As can be seen in Table I, presence of a demonstrator during training ($F_{1,54} = 14\cdot60$, $P < 0\cdot003$), but not presence of sounds of feeding during training ($F_{1,54} = 3\cdot67$, NS), significantly affected latency to first peck during testing. Neuman–Keuls tests revealed that subjects in both sound/fowl and no sound/fowl groups exhibited significantly shorter latencies to first peck than did subjects in either sound/bowl or no sound/bowl groups (all $Ps < 0\cdot05$).

Percentage of pairs delivering first peck to the training dish

A chi-squared test revealed a significant effect of training condition on the probability that during testing the members of a pair of subjects would direct their first peck into the type of food dish from which they had seen demonstrators feed during training ($\chi^2 = 9\cdot34$, $df = 3$, $P < 0\cdot05$). Post-hoc Fisher's exact probability tests revealed that subject pairs in the sound/fowl group were significantly more likely to direct their first pecking bout towards the bowl that they had observed during training than were subject pairs in each of the other three training conditions (all $Ps < 0\cdot05$).

Percentage of pairs preferring to peck in the training dish

Examination of the percentage of the total time that pairs of subjects spent pecking in the type of bowl that they had observed conspecifics exploit during training revealed again that only subjects in the sound/fowl group exhibited a consistent bias in the orientation of their pecking. There was a significant effect of training condition on frequency of preference for the type of food dish viewed during training, where 'preference' is defined by a subject pair pecking for a greater number of seconds in one type of food dish than in the other ($\chi^2 = 9\cdot34$, $df = 3$, $P < 0\cdot05$). During testing, subjects in the sound/fowl group were more likely to prefer the type of food dish that they had observed during training than were subjects in each of the other three groups (Fisher's exact probability tests, all $Ps < 0\cdot05$).

In summary, under the conditions of the present experiment, latency to first peck was reduced by seeing conspecifics peck during training (regardless of whether auditory cues were present or absent), while orientation of pecking was biased only by both seeing and hearing conspecifics peck during training.

Discussion

The results of experiment 1 clearly show that observation of the videotaped sight and sound of conspecifics feeding, like observation of the sight and sound of live conspecifics feeding (McQuoid & Galef 1992), can influence subsequent feeding behaviour of observer fowl. Observing videotapes of conspecifics feeding both decreased the feeding latencies of observer fowl and oriented their feeding behaviour towards the type of feeding site that they had watched conspecifics exploit during training.

While the results of the present experiment provide convincing evidence of the usefulness of videotapes as sources of stimuli to be employed in analyses of social stimuli influencing behaviour in fowl, the results provide no simple answer to the question of which aspects of the feeding behaviour of one bird influenced the feeding behaviour of its observers. In the present experiment, latency to begin feeding during testing was affected by exposure to visual cues alone; orientation of pecking was influenced only by experience in concert with both visual and auditory cues.

Of course, it is possible that increasing either the number or duration of training trials experienced by observers might cause stimuli that were ineffective in altering the behaviour of observer fowl during testing to become effective. Consequently, the results of experiment 1 indicate only that, for example, the

Table II. Behaviour during testing of subjects in experiment 2

	Training condition		
Behaviour	Sound/feeding*	Sound/active	Sound/still
Number of pairs trained	23	20	15
Percentage of pairs feeding during testing	83·3[a]	75·0[a]	80·0[a]
Latency to first peck:mean ($\pm$ SE) min	3·5 $\pm$ 0·7[b]	6·1 $\pm$ 0·8[c]	5·7 $\pm$ 0·9[c]
Percentage of pairs first peck to training dish	89·5[d]	80·0[d]	41·7[e]
Percentage of pairs feeding more from training dish	89·5[f]	80·0[f]	41·7[g]

*Data from experiment I.
Cells in the same row containing different superscripts were significantly different.

orientation of pecking by fowl is more readily influenced by experience of the combination of the sight and sound of conspecifics feeding than by experience of either only the visual or only the auditory stimuli displayed by conspecifics.

EXPERIMENT 2

In experiment 1: (1) exposure to the sight and sound of conspecifics feeding at a particular type of foraging site increased the probability that an observing fowl would direct its subsequent feeding behaviour towards sites of that type and (2) exposure to the sight of conspecifics feeding reduced observers' latencies to begin feeding in the test situation. In experiment 2, we examined in greater detail those features of the visual signal provided by feeding fowl that influenced the feeding-site preferences and feeding latencies of conspecifics that observed them.

Methods

Subjects

Seventy 21- to 28-day-old, experimentally naive Burmese red jungle fowl from the McMaster colony served as subjects.

Apparatus

The apparatus used in the present experiment was that used in experiment 1.

Procedure

Training and testing procedures used in experiment 2 were identical to those used in experiment 1,

except with respect to the materials videorecorded for the 15, 1-min scenes viewed by each pair of subjects during training. In the present experiment, both of the videotapes that we used provided the sound of fowl feeding vigorously in a food dish. One training videotape contained 15, 1-min scenes, each of which showed a pair of demonstrator fowl active in the vicinity of either a red- or blue-marked food bowl, but not feeding from it. The other training videotape showed a series of 15, 1-min freeze-frames taken from the first videotape. These freeze-frames each showed pairs of fowl standing close to food bowls in natural postures.

As in experiment 1, subject pairs were tested for their food-dish preferences 10 min after viewing a 32-min training videotape.

Results and Discussion

The main results of experiment 2 are presented in Table II which provides an overview of the behaviour exhibited during testing by subject pairs in each of the two training conditions. Data from subjects in the sound/fowl condition of experiment 1 (labelled sound/feeding in Table II) are provided for comparison. As can be seen in Table II, in comparison with subjects in group sound/feeding, subjects in groups sound/active and sound/still exhibited relatively long latencies to initiation of pecking in the test situation ($F_{2,43} = 4 \cdot 22$, $P < 0 \cdot 02$). Exposure to videotapes of conspecifics near a food dish, either active or immobile, but not feeding from it and to audio recordings of feeding sounds, failed to shorten observers' latencies to initiate

pecking during testing relative to subjects that saw and heard conspecifics feeding (Neuman–Keuls tests, both $Ps < 0.04$).

In contrast, fowl that had viewed videotapes of active fowl and heard sounds of feeding during training were more likely to: (1) peck for the first time in the type of food dish that they had observed on training videotapes ($\chi^2 = 4.20$, $df = 1$, $P < 0.05$), and (2) prefer to feed from the type of dish that they had observed on training videotapes ($\chi^2 = 4.20$, $df = 1$, $P < 0.05$) than were fowl that had been exposed to videotapes of immobile fowl and heard feeding sounds during training.

These data indicate that the sight of moving conspecifics in combination with sounds of feeding is more effective in enhancing preference for a particular type of feeding site than is the sight of immobile conspecifics in combination with the sounds of feeding. Once again, the stimuli that facilitated initiation of pecking differed from the stimuli biasing the orientation of pecking.

EXPERIMENT 3

The results of experiments 1 and 2 indicated that both visual and auditory components of the behaviour of conspecifics can play an important role in enhancing the short-term attractiveness of particular types of feeding sites to adolescent fowl. Experiment 3 was undertaken to determine whether videotapes of the same social stimuli that enhanced the relatively short-term attractiveness of feeding sites to observer fowl would also enhance their longer-term attractiveness. We have reported previously that direct observation of conspecifics feeding from a visually distinctive food dish can effect observers' food-site preferences during testing 48 h later (McQuoid & Galef 1992). The present experiment was undertaken to determine whether exposure to videotaped sounds and images, like direct observation of feeding conspecifics, can have long-lasting effects on the feeding-site preferences of observers.

The methods used in experiment 3 were similar to those of the sound/fowl group of experiment 1, except that the delay we employed between training and testing observers was 48 h, rather than 10 min, in length.

A 48-h delay was chosen for a combination of practical and ethical reasons. Such a delay was the shortest one that enabled us both to expose our fowl

to videotapes and to test them after they had been without food for 24 h, and at the same time, did not require 48 h of food deprivation in less than 72 h.

Methods

Subjects

Thirty-six 21- to 28-day-old experimentally naive Burmese red jungle fowl from the McMaster colony served as subjects.

Apparatus

The apparatus used in the present experiment was that used in experiment 1.

Procedure

The procedure used in experiment 3 was the same as that used with the sound/fowl group of experiment 1 (i.e. each pair of subject fowl viewed 15 1-min scenes of demonstrators pecking in marked food bowls and heard the sound of fowl pecking throughout each scene), except that the interval between the end of training and the beginning of testing was 48 h rather than 10 min in length. During the first 24 h of this 48-h interval, observers were left in the ancillary portion of the test enclosure with ad libitum access to chick starter in a Mason-bottle chick feeder. During the second 24 h of the 48-h interval, observers remained in the ancillary portion of the apparatus and were deprived of food.

Results and Discussion

Thirteen of the 18 pairs of subjects that participated in experiment 3 (72%) fed during the testing phase of the procedure. The mean ($\pm$ SE) latency to first peck by these 13 pairs of subjects was 3.54 ± 0.96 min and seven of the 13 pairs of subjects directed their first bout of pecking during testing toward the type of food dish which they had observed on videotape during training (sign test, $x = 6$, $P = 0.50$). Eight of the 13 pairs of subjects directed more than half of their pecking toward food dish (sign test, $x = 5$, $P = 0.24$).

In summary, although the relatively short mean latency to initiation of pecking suggested that the feeding behaviour of observers may have been influenced by hearing and seeing videotapes of feeding conspecifics during training, when testing was delayed by 48 h, there was no sign of an effect of

Table III. Behaviour during testing of subjects in experiment 4

	Training condition		
Behaviour	Sound/feeding	Sound/active	Sound/still
Number of pairs trained	18	15	15
Percentage of pairs feeding during testing	83[a]	87[a]	93[a]
Latency to first peck:mean ($\pm$ SE) min	$3\cdot2\pm0\cdot7$[b]	$5\cdot6\pm1\cdot3$[b]	$5\cdot0\pm1\cdot0$[b]
Percentage of pairs first peck to training dish	93·3[c]	46·2[d]	50·0[d]
Percentage of pairs feeding more from training dish	86·6[e]	46·2[f]	50·0[f]

Cells in the same row containing different superscripts were significantly different.

training on observers' preferences for a particular type of food dish.

EXPERIMENT 4

Our failure in experiment 3 to find effects of viewing videotapes on the food-dish preferences of observing fowl after a 48-h delay, led us to undertake a series of pilot studies in which we gradually increased the duration of the exposure of fowl to videotapes during training. In the course of this series of informal studies, we found that doubling the number of 1-min scenes to which pairs of demonstrators were exposed during training resulted in reliable alterations in food-dish preferences during testing 48 h later. In experiment 4, we determined those aspects of video scenes sufficient to affect feeding-site preference and feeding latencies during a test session undertaken 48 h after training.

Methods

Subjects

Ninety-six 21- to 28-day-old, experimentally naive, Burmese red jungle fowl from the McMaster colony served as subjects. Each subject was randomly assigned to one of three groups that varied in the visual content of the videotape that group members viewed during training.

Apparatus

The apparatus used in the present experiment was that used in preceding experiments.

Procedure

The procedure of experiment 4 was similar to that of experiment 3 with the following exceptions. (1) Each pair of observer fowl was exposed to a 32-min videotape composed of a 2-min view of a marked food bowl followed by 30 consecutive 1-min scenes, each showing both a demonstrator fowl and a food bowl (there were no inter-scene intervals in the tapes). (2) Observers in each of the three groups viewed scenes that contained recorded sounds of fowl feeding and showed either fowl feeding (group sound/feeding), fowl active but not feeding (group sound/active) or freeze-frames of fowl in natural postures taken from the videotape showing fowl active near a food dish but not feeding (group sound/still). As in experiment 3, there was a 48-h delay between training and testing.

Results and Discussion

The main results of experiment 4 are presented in Table III which provides a summary of the behaviour exhibited during testing by subject pairs in each of the three training conditions. As can be seen in Table III, there was a significant effect of training condition on two of the behavioural indices. First, the orientation of initial pecking by pair members varied significantly as a function of training condition ($\chi^2 = 7\cdot53$, $df = 2$, $P < 0\cdot05$). A greater percentage of subjects in group sound/feeding pecked first in the bowl observed 48 h earlier during training than did subjects in either groups sound/active or sound/still (Fisher's exact probability tests both $Ps < 0\cdot02$).

Second, and similarly, the percentage of subjects preferring to peck in the type of food dish they had

viewed during training varied significantly as a function of training condition ($\chi^2 = 6.17$, $df = 2$, $P < 0.05$). A greater percentage of subjects in group sound/feeding preferred to peck in the type of food dish they had observed during training than did subjects in either group sound/active or group sound/still (Fisher's exact probability tests, both $Ps < 0.04$).

The mean latency to first peck was not significantly affected by training condition ($F_{2,39} = 2.18$, $P = 0.13$).

The results of experiment 4 indicate that social influence on feeding-site preference resulted from exposure to videotapes that provided both the sight and sound of fowl feeding, but not from exposure to videotapes providing views of either active or immobile fowl near a food bowl together with the sounds of fowl feeding. This result contrasts with the results of experiment 2 (where testing for the effects of exposure to videotapes occurred 10 min, rather than 48 h, after completion of training). In experiment 2, exposure to videotapes that provided both the sounds of feeding fowl and the sight of conspecific demonstrators active in the vicinity of a food dish, but not feeding, did bias the orientation of feeding by observer fowl during testing.

GENERAL DISCUSSION

Our results support and extend Evans & Marler's (1991) demonstration of the possibility of using video-recordings to analyse social stimuli-eliciting behaviour in fowl. In the present case, video-recordings were found not only to elicit behaviour in fowl, but also to orient their behaviour in specific directions. Adolescent fowl were able to use information they acquired by observing videotaped conspecifics in the same way that they used information acquired by observing live conspecifics (McQuoid & Galef 1992) to orient their own future feeding behaviour in potentially profitable directions.

Taken together, the results of the present series of studies indicate that, although video technology can be used to analyse visual social stimuli in fowl, determination of the social stimuli eliciting and orienting future feeding in Burmese fowl is a fairly complex matter. Different aspects of the feeding behaviour of observer fowl were influenced by different aspects of video-recordings of the behaviour of conspecific demonstrators. For example: (1) latency to initiation of pecking was reduced by exposure to the sight of conspecifics feeding, while orientation of pecking was influenced only by exposure to both visual and auditory stimuli associated with feeding conspecifics (experiment 1); and (2) general activity in the vicinity of a food dish (in combination with feeding sounds) oriented pecking towards that food dish, but did not shorten latency to begin feeding at food dishes (experiment 2). The effectiveness of particular audio-video stimuli in modifying the subsequent feeding behaviour of observer fowl depended not only on the nature of the stimuli the fowl were exposed to, but also on: (1) the duration of exposure to those stimuli (experiments 3 and 4), (2) the delays experienced between stimulus exposure and testing (experiments 2 and 4), and (3) the criteria used to identify social influences on behaviour.

Thus, although the present results clearly demonstrate both: (1) the adequacy of video images as sources of stimuli sufficient to support social learning about foraging sites in fowl and (2) the sensitivity of fowl to both the quantity and nature of the video images that they experience, the present results do not provide a simple answer to the question of the sufficiency of various aspects of social stimuli to support social influences on feeding-site preference in fowl. Indeed, the results of the present experiment suggest that there may be no simple answer to the question of which aspects of the behaviour of feeding fowl affect the subsequent feeding behaviour of their observers. Feeding behaviour of fowl can be influenced both by auditory and by visual stimuli received from fellow flock members, but the particular social stimuli causing modifications of foraging behaviour will depend both on the details of the situation in which both foraging and social learning occur and on the aspects of feeding behaviour selected for study.

The results of the present study do not provide new insights into the particular processes supporting the social learning exhibited by our observer fowl. Because the effects on food-dish preferences of fowl observing videotapes lasted for many hours, its unlikely that they were the result either of social facilitation (Zajonc 1965, 1969) or of local enhancement (Thorpe 1963), both of which exert only relatively short-term effects on behaviour (Galef 1988; McQuoid & Galef 1992). Longer-term processes, like stimulus enhancement (Spence 1937) or

'releaser-induced recognition learning' (Suboski 1990) would seem to be needed to account for the longer-term effects of demonstrator fowl on the behaviour of their observers. However, that conclusion could be reached by considering the results of our earlier studies of social learning by naive junglefowl that directly watched demonstrator conspecifics feeding from visually distinctive feeding sites (McQuoid & Galef 1992) as from studies of fowl exposed to video images.

We also did not make much progress, in the present experiments, in determining which aspects of the auditory and visual stimuli provided by feeding demonstrator fowl were important in influencing observers' subsequent feeding-site preferences. Perhaps any sound experienced by naive fowl in conjunction with a potential feeding site would be as effective as were twitter calls and pecking noises in biasing subsequent feeding orientation; perhaps any vertical movement in the vicinity of a food dish would be as effective as was the sight of a feeding conspecific in biasing later choice of a food dish.

Although the results of the present experiments do not provide data allowing us to evaluate such possibilities, they do provide the first evidence that such possibilities can be tested experimentally. In at least one social-learning situation, adolescent Burmese junglefowl respond in much the same way to two-dimensional video images as to direct observation of the behaviour of conspecifics. Modern digital methods for modifying video images, in combination with computer-generated video graphics, should permit compelling analyses of the visual and auditory stimuli supporting such social learning by Burmese junglefowl.

ACKNOWLEDGMENTS

REFERENCES

Collias, N. E., Collias, E. C., Hunsaker, D. & Minning, L. 1966. Locality fixation, mobility and social organization within an unconfined population of red jungle fowl. *Anim. Behav.*, **14**, 550–559.

Evans, C. S. & Marler, P. 1991. On the use of video images as social stimuli in birds: audience effects on alarm calling. *Anim. Behav.*, **41**, 17–26.

Galef, B. G., Jr. 1988. Imitation in animals: history, definition and interpretation of data from the psychological laboratory. In: *Social Learning: Psychological and Biological Perspectives* (Ed. by T. R. Zentall & B. G. Galef, Jr), pp. 3–28. Hillsdale, New Jersey: Lawrence Earlbaum.

Kruijt, J. P. 1964. Ontogeny of social behaviour in Burmese red junglefowl (*Gallus gallus spadecius*) Bonnaterre. *Behav. Suppl.*, **XII**, 1–195.

McBride, G., Parer, I. P. & Foenander, F. 1969. The social organization and behaviour of the feral domestic fowl. *Anim. Behav. Monogr.*, **2**, 126–181.

McQuoid, L. M. & Galef, B. G. Jr. 1992. Social influences on feeding site selection by Burmese fowl (*Gallus gallus*). *J. comp. Psychol.*, **106**, 137–141.

Speidel, G. E. & Nelson, K. E. 1989. A fresh look at imitation in language learning. In: *The Many Faces of Imitation in Language Learning* (Ed. by G. E. Speidel & K. E. Nelson), pp. 1–19. New York: Springer-Verlag.

Spence, K. W. 1937. Experimental studies of learning and higher mental processes in intra human primates. *Psychol. Bull.*, **34**, 806–850.

Suboski, M. D. 1984. Stimulus configuration and valence-enhanced pecking by neonatal chicks. *Learn. Motiv.*, **15**, 118–126.

Suboski, M. D. 1990. Releaser-induced recognition learning. *Psychol. Rev.*, **97**, 271–284.

Suboski, M. D. & Bartashunas, C. 1984. Mechanisms for social transmission of pecking preferences to neonatal chicks. *J. exp. Psychol. Anim. Behav. Proc.*, **10**, 182–194.

Thorpe, W. H. 1963. *Learning and Instinct in Animals.* London: Methuen.

Tolman, C. W. 1967. The effects of tapping sounds on feeding behaviour of domestic chicks. *Anim. Behav.*, **15**, 145–148.

Tolman, C. W. 1968. The varieties of social stimulation in the feeding behaviour of domestic chicks. *Behaviour*, **30**, 275–286.

Tolman, C. W. & Wilson, G. F. 1965. Social feeding in domestic chicks. *Anim. Behav.*, **13**, 134–142.

Turner, R. A. 1964. Social feeding in birds. *Behaviour*, **24**, 1–46.

Zajonc, R. B. 1965. Social facilitation. *Science*, **149**, 269–274.

Zajonc, R. B. 1969. Coaction. In: *Animal Social Psychology* (Ed. by R. B. Zajonc), pp. 9–12. New York: John Wiley.