

paired $t=3.162$, $df=5$, $P=0.025$). The magnitude of this difference was not great and was due to the loss of one song type each by four birds. There were no differences apparent in the amount of within song type variation observed between the photorefractory and the photosensitive birds (2.8 ± 0.26 versus 2.7 ± 0.28 , paired $t=0.529$, $P=0.069$), or in the production of incomplete songs (29 ± 9.5 versus 27 ± 9.8 , paired $t=-0.794$, $P=0.463$, data arcsin transformed).

Although numbers of songs elicited by testosterone did not vary in photorefractory and photosensitive song sparrows (Nowicki & Ball 1989), our analyses of song structure reveal one difference. Photorefractory birds tend to use fewer song types, but the magnitude of this difference is slight. Other measures of structure do not reveal differences, indicating a lack of major differences in the quality of song produced by photorefractory and photosensitive birds. Although not quantified here, we also did not find any differences in the structure of the acoustic elements, or 'notes', that comprised the songs, based on visual inspection of sonagrams.

These data suggest that any seasonal differences occurring in the central nervous system of song sparrows do not involve major changes in the ability of the song control nuclei to produce species-typical song. Nor do they involve a substantial change in the sensitivity of these nuclei to testosterone. Subtle differences in the functional organization of song behaviour may occur.

We thank S. Lang, T. Rudnický and M. L. Sotanski for assistance, P. Marler and S. Peters for providing the subjects, and W. A. Searcy for comments on the manuscript. This work was supported by USPHS grant DC 00402 to S.N., and awards from the Cary Trust, Hirschl Trust and Revson Foundation.

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References

- Baker, M. C., Bottjer, S. W. & Arnold, A. P. 1984. Sexual dimorphism and lack of seasonal changes in vocal control areas of the white-crowned sparrow brain. *Brain Res.*, **295**, 85–89.
- Hinde, R. A. & Steele, E. 1978. The influence of daylength and male vocalizations on the estrogen-dependent

behavior of female canaries and budgerigars, with discussion of data from other species. *Adv. Stud. Behav.*, **8**, 159–200.

Nottebohm, F. 1981. A brain for all seasons: cyclical anatomical changes in song-control nuclei of the canary brain. *Science*, **214**, 1368–1370.

Nowicki, S. & Ball, G. F. 1989. Testosterone induction of song in photosensitive and photorefractory male sparrows. *Horm. Behav.*, **23**, 514–525.

Searcy, W. A. & Andersson, M. 1986. Sexual selection and the evolution of song. *A. Rev. Ecol. Syst.*, **17**, 507–533.

Stoddard, P. K., Beecher, M. D. & Willis, M. S. 1988. Response of territorial male song sparrows to song types and variations. *Behav. Ecol. Sociobiol.*, **22**, 125–130.

Wingfield, J. C. 1984. Environmental and endocrine control of reproduction in the song sparrows, *Melospiza melodia* I. Temporal organization of the breeding cycle. *Gen. comp. Endocrinol.*, **56**, 406–416.

(Received 5 March 1990; initial acceptance
20 March 1990; final acceptance 5 June 1990;
MS. number: AS-669)

Social Learning Without Imitation: More About Milk Bottle Opening by Birds

Fisher & Hinde (1949) suggested that the opening of milk bottles by British tits (*Paridae*) may have been initiated independently by a few birds and then acquired by the majority following observation of those birds that opened bottles. However, as Fisher & Hinde (1949, page 347) recognized, analysing social influences on acquisition of milk bottle opening requires 'controlled experiments'.

We reported previously (Sherry & Galef 1984) results of a laboratory experiment indicating that either of two types of experience increased the probability that black-capped chickadees, *Parus atricapillus*, would learn to open sealed milk bottles. Both chickadees that fed from previously opened milk bottles and chickadees that observed trained tutors open and drink from milk bottles were more likely to learn to open sealed milk bottles than were naive chickadees. In our earlier discussion (Sherry & Galef 1984), we emphasized the role of drinking from opened milk bottles in promoting acquisition of milk bottle opening. However, our results showed that observation of tutors also facilitated acquisition of milk bottle opening by naive birds. Here we examine how direct observation of behaviour of conspecifics might facilitate learning by naive chickadees.

Forty-eight chickadees captured as adults served as subjects. Each was housed individually in a wire-mesh cage measuring $80 \times 80 \times 100$ cm, except during the training phase of the procedure

Table 1. Cream tub opening by black-capped chickadees

Condition	N	Number of observers opening cream tubs*		
		Pretraining	Training†	Testing
Tutor demonstration	14	0	7	7
Tutor present	16	0	6	5
Tutor absent	10	0	2	0

*Data from five trials in each experimental phase. Subjects include 32 birds from the present experiment and eight from Sherry & Galef (1984).

†Twelve of the 13 subjects in tutor-demonstration and tutor-present conditions that opened a cream tub during training also opened one or more cream tubs during testing.

described below, when each subject was placed in a training cage measuring $80 \times 80 \times 100$ cm divided by a screen partition into compartments of equal size for tutor and subject.

During each trial of the experiment, we presented subjects with a small sealed plastic tub measuring 3.2×4 cm containing table cream. Each tub was secured in the neck of a 500-ml flask placed on a retort stand. A retort ring provided a perch at tub height.

The experiment consisted of three phases: pretraining, training and testing. Five, 25-min trials were run in each phase, two trials per day for 2 days and one trial on the third day. Five trials were run in each phase to allow the milk-bottle-opening abilities of birds to be expressed in pretraining and testing, and for learning to occur during training. Both subjects and tutors were deprived of food for 1 h before each trial and, except for cream in sealed tubs, no food was available to subjects during trials.

A pretraining trial consisted of a 25-min presentation to each of the 48 subjects alone in its home cage of a cream tub in a flask on a retort stand. Only those 32 birds that did not open any cream tubs during the five pretraining trials participated in training and testing.

At the start of training, each subject was assigned to one of three conditions differing only in the contents of the tutor's compartment on each training trial. On training trials of subjects in the tutor-demonstration condition ($N=10$), a tutor was present in the tutor's compartment as was a cream tub in a flask on a retort stand. Each tutor punctured the lid of the tub and ingested cream during each training trial.

For subjects in the tutor-present condition ($N=16$), the tutor's compartment contained a conspecific tutor, retort stand and ring, but no cream tub or flask. For subjects in the tutor-absent condition ($N=6$), the tutor's compartment was empty, except for a retort stand. After training, each sub-

ject was returned to its home cage and given five testing trials identical to pretraining trials.

Two of the training conditions in the present experiment duplicated conditions in our earlier experiment (Sherry & Galef 1984) except that a trial lasted 15 min in the previous experiment and 25 min here. For statistical analyses, we pooled data from the four birds in each of the tutor-demonstration and tutor-absent conditions of the previous experiment with data from subjects in the corresponding groups in the present experiment.

Subjects in the tutor-demonstration and tutor-present conditions were significantly more likely to open cream tubs during testing than were subjects in the tutor-absent condition ($\chi^2=6.78$, $df=2$, $P<0.05$; Table 1). However, opportunity to observe a tutor both open and take cream from tubs during training was no more effective in eliciting opening of tubs by subjects during testing than was the opportunity simply to observe a bird in the tutor's compartment during training ($\chi^2=1.09$, $df=1$, NS). Although results of pretraining indicated that many chickadees opened cream tubs spontaneously, it is unlikely that spontaneous opening was responsible for cream tub opening by subjects in the tutor-demonstration and tutor-present conditions because no subject in the tutor-absent condition opened cream tubs during testing.

These results demonstrate, as did those of Sherry & Galef (1984), that observation of a tutor opening cream tubs significantly increases the probability that a naive chickadee will learn to open tubs ($\chi^2=7.05$, $df=1$, $P<0.01$). The results indicate further that cream tub opening can result from simple exposure to tutors in an environment where subjects can learn for themselves to open cream tubs. Simple exposure to tutors during training may also account for the learning exhibited by subjects in the tutor-demonstration condition during testing.

Although our data do not indicate why subjects were more likely to learn to open cream tubs when

in the presence of a tutor than when alone, presence of a conspecific during training may have reduced fear (Clayton 1978) or vigilance (Elgar 1989), and thus increased the subjects' opportunities to find food for themselves during training trials. Alternatively, the presence of tutors may have elicited foraging by subjects and thus facilitated food discovery (Ficken 1981).

The present results, like those of Sherry & Galef (1984), provide no evidence that imitation learning played a role in acquisition of cream tub opening. Our data are thus quite different from those of Palameta & Lefebvre (1985) who found that naive pigeons, *Columba livia*, observing tutors both open and feed from food bins were more likely to learn to open food bins than were naive pigeons that observed tutors only open bins or only consume food. The behaviour of Palameta & Lefebvre's pigeons was consistent with the hypothesis that their pigeons learned by imitation; the behaviour of our chickadees did not suggest learning by imitation.

Taken together, our present and previous results indicate that two socially mediated processes, neither of which involves learning by imitation, can increase the frequency with which free-living British tits learn to open milk bottles. First, feeding from milk bottles opened by others can increase the probability that naive birds will learn to open milk bottles (Sherry & Galef 1984). Second, simple presence of conspecifics near a milk bottle can increase the probability that naive birds will discover for themselves the rewards of milk bottle opening.

We thank Victoria Esses, Luc-Alain Giraldeau, Louis Lefebvre, Boris Palameta and Susan Smith for comments and John Arrowood, Michael Clinchy, Nalini Mohan and Liana Zanette for assistance. This research was supported by Natural Sciences and Engineering Research Council of Canada grants to both authors. Chickadees were observed under a CWS Scientific Capture Permit.

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References

- Clayton, D. A. 1978. Socially facilitated behavior. *Q. Rev. Biol.*, **53**, 373–392.
- Elgar, M. A. 1989. Predator vigilance and group size in mammals and birds: a critical review of the empirical evidence. *Biol. Rev.*, **64**, 13–33.
- Ficken, M. S. 1981. Food finding in black-capped chickadees: altruistic communication? *Wilson Bull.*, **93**, 393–394.
- Fisher, J. & Hinde, R. A. 1949. The opening of milk bottles by birds. *Br. Birds*, **42**, 347–357.
- Palameta, B. & Lefebvre, L. 1985. The social transmission of a food-finding technique in pigeons: what is learned? *Anim. Behav.*, **33**, 892–896.
- Sherry, D. F. & Galef, B. G., Jr. 1984. Cultural transmission without imitation: milk bottle opening by birds. *Anim. Behav.*, **32**, 937–938.

(Received 20 February 1990; initial acceptance
13 April 1990; final acceptance 19 June 1990;
MS. number: AS-696)

Relations Between Sleep Duration, Body Weight and Metabolic Rate in Mammals

Elgar et al. (1988) drew a number of conclusions about interspecific differences in patterns of sleep among mammals. Their conclusions are based upon correlations between sleep variables, body weight and basal metabolic rate (BMR). They drew values of these variables for individual species from published literature and performed correlations on family means calculated from constituent generic means. However, since there are a substantial number of instances in which they make use of erroneous data, their conclusions may well be invalid. Listed below are mistakes I discovered during a spot check on a relatively small number of the values in their tables.

In the opening paragraph, it is stated that the daily total duration of sleep in the pocket mouse, *Perognathus longimembris*, exceeds 20 h (Walker et al. 1983). Elgar et al. (1988) claim that the values of sleep variables for all species included in their data set were collected from EEG recordings, 'each recorded as total time per 24 h'. In the case of pocket mice, '8-h polygraphic recordings beginning at noon' were taken during their major sleep period (Walker et al. 1983). Other articles cited in Table I of Elgar et al. (1988) as sources for sleep variables were also not based on 24-h recordings, e.g. 4-h recordings from kangaroo rat, *Dipodomys heermanni* (Sakaguchi et al. 1979), and 14-h recordings from grey seal, *Halichoerus grypus* (Ridgeway et al. 1975). Simple extrapolations from recordings of less than 24 h to obtain 24 h totals of sleep result in such absurdly high values as 20 h for the pocket mouse. A similar extrapolation from the value of 7.92 h of human sleep (Meddis 1983), which was based on nocturnal EEG recordings, would generate a daily sleep total of more than 23 h. Although