

Opening the Social Gateway: Early Vocal and Social Sensitivities in Brown-Headed Cowbirds (*Molothrus ater*)

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Abstract

The organization of cowbird (*Molothrus ater*) social groups affords individuals living in the groups different opportunities for learning and also structures trajectories of social development. Here, we studied the influence of adults on social organization of very young cowbirds. In three experiments, we housed juvenile birds in large, seminatural environments that either contained or did not contain adult conspecifics. We then observed the social associations and vocalizations of juveniles in each environment. The presence of adults in the social environment influenced the assortment and singing patterns of juveniles, although throughout the three experiments adults rarely interacted physically with juveniles. Juveniles housed with adults interacted with other juveniles more often and sang significantly less often than juveniles housed without adults. Effects of adult presence or absence on social organization and singing patterns emerged extremely rapidly and could be reversed quickly. Taken as a whole, the experiments revealed that very young cowbirds, in the first days of independence from their hosts, were sensitive to, and reacted rapidly to, the composition of their social environment. Specifically, presence of other age classes of individuals within the group increased juvenile associations and delayed production of vocalizations by juvenile males. Self-organization within the social group produced different social environments, which could in turn create different gateways for social learning and vocal development.

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Introduction

In nature, young animals typically learn in social or public settings: environments in which other animals serve as observers, tutors, distracters, or predators (Zentall & Galef 1988; Valone 1989; Heyes & Galef 1996). Studying learning in such social settings requires two steps: (1) describing the affordances of

predators (Zentall & Galef 1988; Valone 1989; Heyes & Galef 1996). Studying learning in such social settings requires two steps: (1) describing the affordances of the environment, that is, determining what is there to be learned, and (2) ascertaining ways in which animals gain access to social stimulation. Features of social organization that alter the potential flow of information among animals represent social gateways, that is, social features that channel opportunities for learning. In songbirds, for example, if adult males do not sing, young cannot copy their songs. But, for the young to learn from them, not only do adults have to sing, they also have to sing in physical locations to which the young have social access. Thus, territorial behavior or dominance interactions can serve as social and physical barriers to information transfer.

This study is part of a series of investigations into how social organization in cowbirds (*Molothrus ater*) affects learning and development. In recent work (discussed below), we have found that the composition of the social environment in which juvenile cowbirds spend their first year of life can alter the development of their courtship and communicative competency (Smith et al., in press; White et al., unpubl. data). We observed large captive groups of cowbirds of mixed age and sex. In every group, cowbirds formed and maintained a structured social organization based on age and sex. This social organization provided birds living in the same social context with different interactions and experiences, leading them down different ontogenetic trajectories. The present study examined the emergence of such social organization and the potential for information transfer in young cowbirds.

We sought to understand the origins of social organization in cowbirds because in nature young receive little if any exposure to adult cowbirds prior to achieving independence from their host. Being brood parasites, young cowbirds must leave one social ecology and enter another to obtain species-typical instruction. We chose to look at the social responsiveness of young birds to adult conspecifics during the period in summer when interactions with other young and adult conspecifics first begin to occur in many populations as young cowbirds begin to join flocks (Friedman 1929; Hahn & Fleischer 1995).

Our interest in the effects of exposure to adults was motivated by previous findings revealing powerful effects of the presence of adult male and female cowbirds on the rate of vocal and social development of juvenile male cowbirds (Freeberg 1998; Smith et al. 2000; Smith et al., in press; White et al., unpubl. data). In these studies we compared social organization, patterns of affiliation, and courtship skills of individuals in different, captive social environments. For example, in studies using highly controlled environments in which young males were housed with pairs of females in sound-attenuating chambers (size: 1.3 m³), we found that differences in female reactions to male singing led to reliable differences in the ontogenetic vocal trajectories of the males. Not only did song structure differ, but so also did the rate of development, that is, the seasonal timing of transitions from subsong to plastic song to stereotyped song (Smith et al. 2000).

But do young males have reliable access to such stimulation in the real world? To begin to answer this question, we had looked at an over-wintering roost in the

field, where we found that young males aggregated with adult females in late winter and early spring, the time when song development undergoes major changes. Their stage of vocal development was similar to that of the males housed in the restrictive environments. The roost had disadvantages for observers, however, in that it was not possible to follow a large number of individuals or to locate individuals in the roost of tens of thousands of birds (King & West 1988).

Thus, to gain more control, we chose to look at social learning in birds living in groups in captive environments. In three previous studies, using near-neighbor measures, we found reliable organization by age and sex in flocks of captive cowbirds (Freeberg 1999; Smith et al., in press; White et al., unpubl. data). Smith et al. (in press) studied the largest flock, using 74 birds in a 2511.5-m³ aviary complex. They measured near-neighbor patterns longitudinally, from Aug. until the following May. A striking feature of the pattern of age by sex assortment was the rapidity with which it appeared. These patterns persisted throughout the year. In the breeding season, young males that had associated more with adult males earlier in the year achieved greater courtship success, and males that had associated with adult females earlier in the year developed differences in singing frequency, which may be related to rate of song stereotypy. These correlations suggested that the young learners had to act on their social environment to develop courtship skills.

We next looked at birds in settings in which we manipulated the potential for social organization by manipulating the age and sex classes of birds present within conditions (White et al., unpubl. data). We hypothesized that, if social organization affects options for obtaining experience, the groups should show different developmental outcomes. Compared with young males housed with adults, young males housed without adults showed far less social organization, paid little attention to females, displayed different patterns of courtship and sang in longer bouts of undirected soliloquies. Young males housed with adults assorted by sex and age, directed more songs to males and females, and sang in shorter bouts of undirected song. Data also revealed differences in the rate of vocal development, with the juveniles housed without adult males advancing sooner to stereotyped song. These differences revealed the facultative nature of cowbird social development, that is, social or vocal development is not a fixed program but is constructed from recurring patterns of social interactions during a bird's first year.

The purpose of the present study was to investigate the origins of social organization, where different opportunities for learning and development begin to emerge. The young cowbirds we used in this study were at the age at which in nature they start to aggregate in flocks, and young males begin to produce species-typical plastic song and to direct song to conspecifics (Friedman 1929). Although the aviaries we used were not as large as the range of cowbirds in the wild, they did permit birds to perch in multiple locations, find food easily and shelter in many places. With this degree of freedom, it was possible that no pattern of social organization would develop at all in these young birds. If we found social organization, however, could we perturb it by manipulating the presence of

adults? Moreover, how rapidly would such effects occur? We carried out three interrelated experiments investigating how juveniles behaved when adults were either present in or absent from their social environment. We observed the social organization among the juveniles and the beginnings of their vocal development.

Experiment 1

The purpose of the first experiment was to determine whether juvenile cowbirds showed any behavioral response to the presence of adults in their social group. We housed juveniles in one of two social environments. One environment held only peers, and the other held peers and male and female adults. We left birds in these two environments for 3 wk, during which time we observed their patterns of social assortment.

Methods

Subjects

We used as subjects 12 juvenile male, 12 juvenile female, four adult male and four adult female brown-headed cowbirds, all captured between 23 and 29 Jun. in Monroe County, IN. We determined the sex of juveniles by the mature plumage that was beginning to emerge and we estimated the median age of the juveniles to be between 30 and 40 d using the amount of mature plumage present and also by **6** date of capture. Adults were at least 1 yr old at the beginning of the study. We marked all birds with uniquely colored leg bands to permit individual identification. Prior to experimentation, we housed juveniles and adults in separate large ($9.1 \times 21.4 \times 3.4$ m) outdoor aviaries. We provided all birds daily with vitamin-treated water, white and red millet and canary seed, plus a modified Bronx zoo diet for blackbirds.

Starting on Jul. 4, we moved birds to two new aviaries of identical dimensions to the home aviaries. The social composition of the two test aviaries differed only in the age classes of birds present. In the juveniles-only aviary (J), we placed eight juvenile males and eight juvenile females. In the juveniles-and-adults aviary (JA), we placed four juvenile males, four juvenile females and the eight adults. The two aviaries were adjacent to one another and separated by wire mesh; thus, birds in the two aviaries were able to see and hear each other. Ecological conditions within the aviaries were similar with each containing trees, perches, feeding stations, a grass covered ground surface, and shelters. Birds were exposed to ambient climatic conditions, wild local cowbirds, and the sight and attention of predators.

Procedure

For 20 consecutive days, an observer recorded social assortment of birds in each aviary for approximately 1 h each day starting between 07:00 and 08:00 h.

To measure social assortment, we recorded near-neighbor associations in each of the two aviaries. The procedure for measuring near-neighbor associations generally followed that of Smith et al. (in press) whose near-neighbor association measures proved to be sensitive to functionally important aspects of social organization. Briefly, for six 10-min blocks each day, we sampled each bird (referred to as a ‘target’) in an aviary and noted any other bird (referred to as a ‘near neighbor’) that was within 30 cm. To avoid counting one association as two data points, we recorded each association for the target bird only. Once we recorded a pair as near neighbors, they could not be recounted as another near-neighbor association within the block. Birds had to move apart and re-associate in order for us to score a new near-neighbor association. To obtain a measure of rate of associations, we allowed individuals to serve as targets or near neighbors multiple times within a block. We recorded near-neighbor associations continuously and as quickly as possible until the end of the block.

Data analysis

Owing to low sample sizes and heterogeneity of variance, we used non-parametric statistics throughout (using two-tailed p-values). We report means and standard errors for descriptive purposes. There was no significant difference in the number of associations by juvenile males and females in either group throughout the experiment; we therefore combined across sexes to report rates of near-neighbor associations for juveniles.

Results

JA juveniles (housed with adults) displayed different patterns of social assortment than J juveniles (housed without adults). J juveniles had significantly fewer near-neighbor associations per bird with other juveniles than did JA juveniles (Mann–Whitney U-test; $U = 9.5$, $n_1 = 16$, $n_2 = 8$, $p < 0.001$, Fig. 1a). There was assortment by age class in the JA conditions. JA juveniles allocated a significantly greater proportion (\pm SE) of their near-neighbor associations to juveniles (0.68 ± 0.02) than did adults (0.31 ± 0.02 ; $U = 0$, $n_1 = 8$, $n_2 = 8$, $p < 0.001$). Of the associations that juveniles did have with adults, they did not preferentially associate with one sex (mean juvenile–adult female associations: 7.34 ± 1.39 , mean juvenile–adult male associations: 7.17 ± 1.18 ; Wilcoxon T, $T = 13$, $n = 8$, $p > 0.48$).

Experiment 2

Our primary purpose in Experiment 2 was to replicate the effect of the presence of adults on juvenile social assortment with a new group of birds. Because the patterns emerged so quickly in Experiment 1 (they were present within the first 4 d of the experiment), here we observed birds only for the 4 d immediately following group assignment. We also investigated vocalization

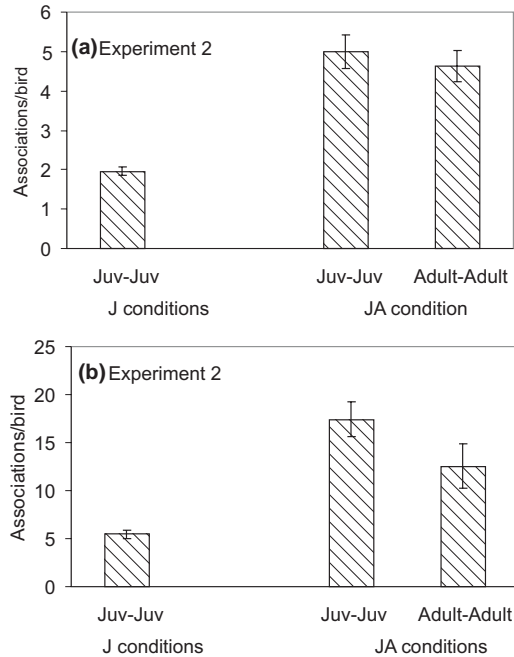


Fig. 1: Mean (\pm SE) near-neighbor associations per bird for juvenile–juvenile associations in the J and JA conditions and adult–adult associations in the JA conditions over the entire observation session in (a) Experiment 1 and (b) Experiment 2

patterns of juvenile males in the two conditions. Our interest in vocalizations was influenced by apparent differences in vocalization in Experiment 1. At the beginning of Experiment 1, no juvenile males were vocalizing. By the end of the experiment, however, only J juvenile males had begun to vocalize.

Methods

Subjects

We used all new birds for this experiment. We estimated median age of juveniles to be between 40 and 50 d. They had been captured between 29 Jun. and 10 Jul. Prior to commencement of the experiment (24 Jul.), the new birds had been treated exactly as birds in Experiment 1 had been treated prior to their participation in Experiment 1. We used the same number of birds as in Experiment 1, counterbalancing locations of the two conditions. For the JA adults, we used four females that had been caught at the same time as juveniles and four males that had been caught the previous year and had served in an aviary experiment throughout the year.

Procedure

To obtain enough data for statistical inference within a 4-d sample, we used two observers, working concurrently, and voice recognition technology to measure social assortment and singing data. For both near-neighbor and song blocks, observers spoke bird band acronyms into a wireless microphone (Telex WT 150; Telex Communications Ltd). We used IBM ViaVoice Millennium Pro Edition voice recognition software operating on a Pentium III, 500-MHz IBM-compatible computer (Compaq Deskpro EP), running Microsoft Windows 98 and Microsoft Word 2000 to receive the voice signal and transcribe speech into text. We then exported text into a database (4th Dimension vs. 6.5.1; ACI Inc.) that we programmed to match incoming text to a list of possible codes to detect and correct errors automatically. To determine whether birds were behaving differently later in the day, an additional observer recorded data in the late afternoon (starting at *c.* 17:00 h). There were, however, no time of day effects.

To measure social assortment, we collected 17 h of near-neighbor associations using the same rules as in Experiment 1. To measure vocalization patterns, we conducted 17 h of song censuses. Song censuses consisted of 15-min blocks in which observers scan-sampled aviaries noting any male that vocalized. While, for simplicity, we regard these vocalizations as songs, they were actually primitive sounds consisting of a variety of unformatted notes. For each vocalization, we recorded whether it was directed at another bird or was undirected. To be scored as a directed song, the bird had to vocalize toward a recipient, oriented on an axis between approximately 0° and 45°. The distance between vocalizing bird and recipient could not exceed 60 cm. We considered vocalizations that were not oriented to another bird as undirected song.

Interobserver reliability was high using voice recognition for measures of near-neighbor associations per bird ($r = 0.87$, $p < 0.005$) and song production per bird ($r = 0.98$, $p < 0.001$).

Results

Similarly to Experiment 1, J juveniles had significantly fewer near-neighbor associations per bird with other juveniles than did JA juveniles ($U = 0$, $n_1 = 16$, $n_2 = 8$, $p < 0.001$; Fig. 1b). Also similarly to Experiment 1, both classes of birds in JA conditions assorted by age, with juveniles allocating a significantly greater proportion of their near-neighbor associations to other juveniles (0.71 ± 0.04) than did adults (0.34 ± 0.06 ; $U = 0$, $n_1 = 8$, $n_2 = 8$, $p < 0.001$).

Pronounced differences in singing also emerged. J juvenile males sang significantly more undirected and directed song than did JA juveniles (both $U = 2$, $n_1 = 8$, $n_2 = 4$, $p < 0.02$; Fig. 2). JA juvenile males sang rarely; we only recorded one male ever to sing under these conditions (who sang three undirected songs). We recorded singing from all J juvenile males.

There was pronounced variability in the amount of song produced by adult males. We observed $0.32 (\pm 0.21)$ undirected songs per adult male per song

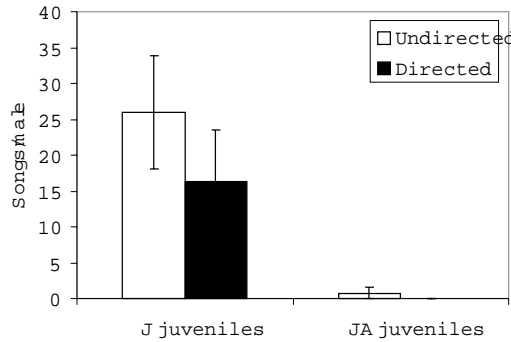


Fig. 2: Mean (\pm SE) directed (■) and undirected (□) songs sung per male for juveniles in the J and JA conditions over the entire observation session in Experiment 2

census block and $1.19 (\pm 0.88)$ directed songs per adult male per block. Most of the directed songs sung by adult males were directed to other adults ($99.2\% \pm 0.7$).

Experiment 3

The purpose of Experiment 3 was to examine the duration of effects of adults on juvenile social organization and singing. It is possible that brief exposure to adults can have long-term effects on juveniles, launching them down different developmental trajectories. It is also possible, however, that effects on assortment and singing are transitory, lasting only as long as adults are present. To distinguish between these possibilities, we conducted another experiment, exposing two more groups of juveniles to social environments either containing or not containing adults. In this experiment, however, after the two groups of juveniles had been exposed to either adults or just peers for 2 wk, we reversed their conditions. Thus, we removed adults from the JA conditions and added adults to the J conditions. We then observed the social assortment and singing patterns of the juveniles for another 4 d following the reversal of conditions.

Methods

Procedure

This experiment followed the procedure described for Experiment 2, again with a new group of birds. We estimated median age of the juveniles participating in this experiment to be between 60 and 70 d. They had been captured between 6 and 10 Jul. and entered the experiment on 29 Jul. We assigned birds to groups exactly as we had with the birds in Experiments 1 and 2, except in this experiment we used nine juvenile males and seven juvenile females in the J conditions and six juvenile males and two juvenile females in the JA conditions. We captured four

adult females and two adult males for this experiment during the time we captured juveniles. In addition, we used two adult males that had been in our laboratory for a year. We left the birds in their initial conditions for 16 days. We observed the birds, measuring social assortment and singing for the 4 d immediately following group assignment and again for 2 d commencing on the 14th day after group assignment. After this second observation period, we began the reversal phase, wherein we removed the adults from the JA conditions, replacing them with 11 new juveniles, and removed four juveniles and added eight adults to the J conditions. All eight of these adults were captured at the same time as juveniles. We manipulated the number of birds in conditions in this way to increase numbers of subjects while ensuring that density and sex ratios remained the same between conditions. We then observed both conditions for another 9 days. One juvenile male in the JA conditions died before the reversal phase.

Results

Near-neighbor organization

During the time when adults were present in the JA conditions and absent in the J conditions, J juveniles had fewer near-neighbor associations with other juveniles than did JA juveniles after the 4-d observation session ($U = 6$, $n_1 = 16$, $n_2 = 8$, $p < 0.01$) and after 16 d ($U = 0$, $n_1 = 16$, $n_2 = 8$, $p < 0.001$; Fig. 3), again replicating the patterns from the previous experiments. When the conditions were reversed (i.e. after the introduction of adults to the J conditions and the removal of adults from the JA conditions), the patterns of near-neighbor associations also reversed. Juveniles who initially were housed with adults (JA) significantly decreased their amount of near-neighbor associations after adults were removed (Friedman test, $\chi^2 = 12.25$, $df = 2$, $p < 0.005$). Juveniles who were housed initially without adults (J) significantly increased near-neighbor associa-

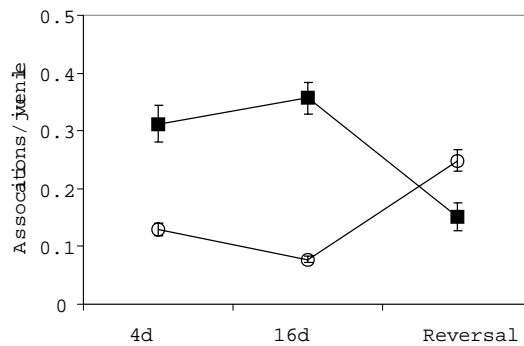


Fig. 3: Mean (\pm SE) near-neighbor associations per juvenile per 15- min block for juvenile–juvenile associations in the J (○) and JA (■) conditions after the 4- and 16-d observation session and after the reversal in Experiment 3

tions with other juveniles after adults were introduced ($\chi^2 = 22$, $df = 2$, $p < 0.001$).

Song

J juveniles produced more undirected song than did JA juveniles after 4 and 16 d (both $U = 10$, $n_1 = 9$, $n_2 = 6$, $p < 0.04$; Fig. 4a), replicating the patterns from Experiment 2. After the conditions were reversed, juveniles housed initially without adults decreased undirected singing after adults were introduced ($\chi^2 = 9.48$, $df = 2$, $p < 0.01$). Juveniles housed initially with adults did not increase singing undirected song after the removal of adults ($\chi^2 = 3.26$, $df = 2$, $p > 0.15$).

Similarly to undirected song, J juveniles produced significantly more directed song than JA juveniles after 4 and 16 d (both $U < 2.5$, $n_1 = 9$, $n_2 = 6$, both $p < 0.01$). When the conditions were reversed, the patterns of directed song singing reversed. Juveniles initially housed without adults significantly reduced directed singing when adults were added ($\chi^2 = 13$, $df = 2$, $p < 0.005$). Juveniles

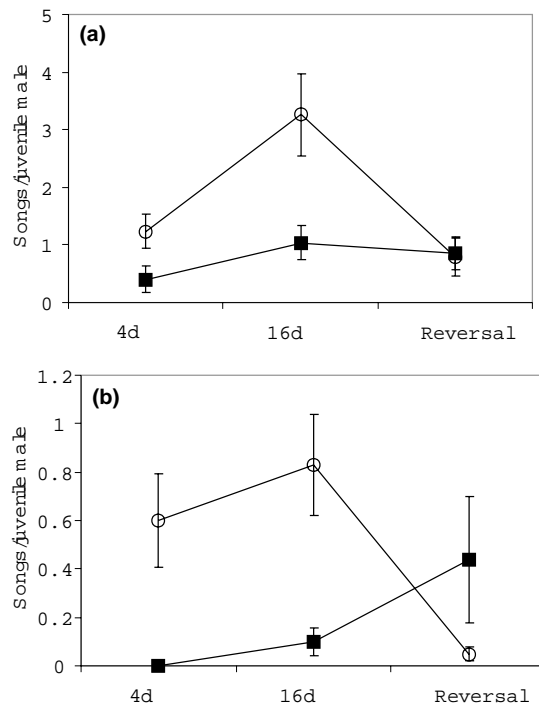


Fig. 4: (a) Mean (\pm SE) undirected songs and (b) mean (\pm SE) directed songs sung per juvenile male per 15-min block in the J (○) and JA (■) conditions after the 4- and 16-d observation session and after the reversal in Experiment 3

initially housed with adults significantly increased directed song singing after adults were removed ($\chi^2 = 9.33$, $df = 2$, $p < 0.01$; Fig. 4b).

Adult behavior

Adult males sang very little throughout the experiment. For the first two observation sessions, males produced a mean of 0.02 (± 0.007) undirected songs per male per song block and 0.03 (± 0.01) directed songs per male per song block, respectively. In the reversal phase, adult males produced 0.005 (± 0.005) undirected songs per song block and 0.21 (± 0.194) directed songs per song block. All directed songs sung by adult males were sung to adult recipients.

Behavior of new juveniles

The juveniles that we introduced into the JA conditions for the reversal assorted and sang in patterns not significantly different from the juveniles with whom they were housed during the experiment (mean near-neighbor associations per bird per block = 0.10 ± 0.02 ; mean undirected songs per male per block = 0.97 ± 0.48 ; mean directed songs per male per block = 0.71 ± 0.37).

Discussion

Taken as a whole, the results of the three experiments revealed that very young cowbirds were sensitive to, and reacted to, the presence of adults as opposed to peers. Juveniles interacted with one another more frequently when adults were present than when adults were absent. Juveniles housed without adults spread out through the aviary and sang significantly more than juveniles housed with adults. These effects occurred rapidly, remained stable while the conditions remained unchanged, and for the most part reversed themselves as soon as the social compositions of the conditions were reversed. Both the presence of social organization and the rapidity with which it could change suggest that these effects did not emerge as a result of juveniles learning from long-term social interactions, and complement previous work with older cowbirds in the same 8 kinds of physical environments (Smith et al., in press; White et al., unpubl. data). Differences were pronounced and persistent across three replicates of juveniles tested across a 2-mo period; a time characterized by dramatic changes in growth, molt, and song production in juveniles. Throughout these changes, their sensitivities to the social group were consistent.

Different patterns of associations and singing among juveniles reveal the beginnings of interactions important for establishing social order within a group. Directed song in particular is critical for social life as males establish dominance hierarchies with song (Dufty 1986), as well as using it in the breeding season to acquire mates (Friedman 1929). Near-neighbor associations provide a measure of opportunities for interacting with others, and thus opportunities for social learning. Early differences in producing and using song along with differences in

interacting with others can lead individuals down diverging developmental trajectories.

While in this study we have not shown the outcome of these differences, past work in our laboratory has revealed that differences in social organization within cowbird groups can have important long-term developmental consequences (Freeberg 1999; Smith et al., in press; White et al., unpubl. data). Freeberg (1998, 1999) showed that patterns of social assortment predicted mate choice: Smith et al. (in press) showed that differences in individual assortment patterns were correlated with differences in courtship competency, and White et al. (unpubl. data) showed that different age or sex classes precipitate different degrees of assortment and different patterns of vocal use that lead to differences in communicative and courtship competencies. Taken with the data from the present study, these findings indicate that cowbirds construct and reconstruct patterns of aggregation in response to social cues. These dynamic social assemblies are robust phenomena across seasons of the year, across cohorts/replicates of birds, and across physical contexts.

These results also begin to help us generate hypotheses about how patterns of social organization emerge and change over time. The present data show strong dispositions of cowbirds to respond to the presence of individuals within their immediate social environment. The juveniles in the J and JA conditions resided in adjacent aviaries, with the view between them only partially blocked by wood partitions and trees. The birds in both aviaries could position themselves to see and hear what was happening 'next door', at times as easily as they could see and hear what was happening in other parts of their own aviary. Despite the ability to see and hear one another, the two aviaries developed different social profiles. The birds behaved in a way to suggest that the possibility of recurring physical access is a social cue that exerts strong perceptual constraints, in effect creating a control parameter of the social gateway.

This study is part of our comprehensive attempt to expand the study of social and vocal learning from highly restricted lab environments to the public contexts containing more of the features that young learners face in nature (Freeberg 1999; Smith et al., in press; White et al., unpubl. data). We believe that two processes must be considered when investigating social learning: (1) the effects of providing different kinds of social stimulation, and also (2) how social stimulation becomes distributed over individuals. Our studies thus far indicate that individual animals do not always have direct access to potential stimulation that provides basic conditions for learning, nor do they have direct access to proximate reinforcement systems that consolidate and shape attention and response. In the present study and those preceding it, we have found that young males residing with adult males or adult females are not automatically afforded close contact or exposure to conspecific vocalizations or social responses. If there is a 'transfer' of information from one generation to the other, as is customarily discussed in theoretical accounts of social learning (Boyd & Richerson 1985), it is neither a passive nor automatic process. Although we saw strong assortment by age, the age classes did not completely segregate themselves from one another. Across the experiments in

the JA conditions, approximately 30–40% of the near-neighbor associations of juveniles were with adults. These associations may represent active attempts to facilitate information transfer.

Our efforts to describe the origins of social organization stem from an interest in expanding the study of learning via actual ecological pathways. We propose that much species-typical knowledge is transmitted via social gateways, social systems in which older organisms or peers facilitate or constrain sensory exposure, its timing and duration. The idea or effect of social gateways has been bypassed in most laboratory research on social learning (but see Terkel 1996; Carlier & Lefebvre 1997; Galef & Whiskin 1997; Reader & Laland 2000 for examples of its operation in the laboratory). For the most part, animals are simply exposed to social stimulation delivered without species-typical meaning. New studies must start by describing the rules by which such social learning opportunities arise. Next, such investigations must consider how organisms may use (or not use) such opportunities. Finally, functional validation is needed to show that differences in socially acquired information influence the behavior and fitness of individuals. Here, juveniles in the two conditions may have been exposed to similar social contexts: the presence of other juveniles, but the two groups of juveniles interacted with their peers in different ways. These different patterns of interactions have the potential to lead the two groups of juveniles through different social gateways.

At this point, we need to do more work to explain the potency of adult presence on aggregations of juvenile cowbirds. Juveniles were not actively avoiding adults; they did engage in many associations with them. Nor did juveniles behave as if they were stressed by the presence of the adults. It is furthermore unclear whether the presence of adult cowbirds per se was responsible for the effect on the social assortment of the juveniles. Possibly, juveniles were reacting to the presence of individuals that were different from themselves. It may be that the difference in size and details of plumage are sufficient to indicate to juveniles that a new social category is present (see Hauber & Sherman 2000; Shusterman et al. 2000). As it may be a novel category, it elicits avoidance, which in turn facilitates rapid aggregation and inhibition of vocalizations among the juveniles as they share the common perception of the adult class as novel. The phenomenon at work may be similar to that documented in the dynamics of human group formation, first articulated by Campbell (1958). He identified three control parameters modulating group cohesiveness, a phenomenon he called 'entitativity'. These principles are common fate, similarity, and proximity.

With respect to the present study, JA juveniles experienced the novel group at the same time (common fate); juveniles displayed the same reaction either individually or by social facilitation or matching (similarity), and they were in close enough quarters to observe fully the adult cowbirds (proximity). As they spend more time as a group or entity, they also may learn more characteristics that define their group and differentiate it from the adult class. These principles would also apply to the J birds and explain their vocal behavior and maintenance of greater social distances as these behaviors obey principles of similarity and

common fate. The strength of the young birds' tendencies to match each other's behavior would then only serve to strengthen their ability to perceive a change in their social setting when adults appeared, but would also bring new sights and sounds to the social setting.

Further study using heterospecifics as controls, as well as giving juveniles opportunities to choose the composition of the social group to join, will begin to produce insight into the mechanisms controlling social organization. But, whatever the mechanism, the emergence of the different social organizations in the two groups stresses the need to look at learning as a function of social structures or gateways. The major implication may be that different contexts facilitate or inhibit different modes of learning, that is, trial-and-error or operant shaping vs. observational learning. In previous work, we have suggested that social shaping, in addition to imitation, plays a role in vocal learning (West & King 1988). The present data suggest that reliance on one mode or another may be too narrow a view of how animals learn in an actual ecology.

Acknowledgements

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