EXPERIMENTAL EVIDENCE FOR SIBLING RECOGNITION IN COMMON TERNS (*STERNA HIRUNDO*)

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ABSTRACT.—Young Common Terns (*Sterna hirundo*) did not respond preferentially to calls of siblings at 8 and 9 days of age, but did so by 12 days of age. In experiments with and without visual isolation, and with use of playback, we demonstrated a tendency to approach sibling begging calls. This differential response indicated sibling-recognition occurred, was based on experience, and involved vocal cues. *Received 26 May 1987, accepted 14 October 1987.*

THE ability to discriminate among individuals or categories of conspecifics, to recognize mates, parents, offspring, kin, neighbors, or strangers, is fundamental to social organization. Individual recognition in birds refers to the ability of one bird to discriminate correctly among selected individuals of the same species by some combination of sensory cues, which in birds are usually visual or vocal or both. Such recognition can be observed in the field or can be demonstrated by controlled playback experiments in the field or laboratory (Falls 1982, Kroodsma 1986).

Theoretically, recognition should evolve in situations where it is essential to distinguish among individuals and to respond differentially, assuming that such differentiation is not possible solely on the basis of location. Individual recognition has been demonstrated between mates (Penney 1968; Beer 1969, 1970; White 1971; Brooke 1978), between parents and young (Tinbergen 1953; Hutchison et al. 1968; Penney 1968; Tschantz 1968; Beer 1969, 1970, 1979; Evans 1970a, b; Stevenson et al. 1970; Ingold 1973; Burger 1974; Busse and Busse 1977; Shugart 1977), and between territorial neighbors vs. strangers in a variety of species (Beecher 1981, Falls 1982).

Parent-offspring recognition might be expected to develop early in nidifugous species where parents are required to attend mobile chicks, and where the possibility exists that young of different parents could intermingle. Such recognition could include parental recognition of young, young recognition of parents, or both. Parent recognition of young ensures that parents care for their own reproductive units, rather than caring for unrelated offspring. Young recognition of parents ensures that young seek out and beg from their own parents, increasing their chances of being fed and avoiding attacks by unrelated adults, as Evans (1980) showed in gulls. The age of recognition varies and is related to age of chick mobility (Evans 1970a).

In many gulls and terns, brood size is two or three, allowing for the possibility of sibling recognition. When chicks first become mobile they could be separated from siblings, and sibling recognition by visual or vocal means would be adaptive in maintaining contact. Spatial proximity of offspring might ensure chicks are near the nest and within their parents' territory, and together the enhanced vocal stimuli might attract parents, stimulating them to provide protection and adequate food. Circumstantial evidence for sibling recognition, such as chicks attacking foreign chicks, has been described for several seabirds (Cullen and Ashmole 1963; Snow 1963; Warham 1963; Schaller 1964; Nelson 1966, 1969; Dinsmore 1972; Spurr 1975; Howell 1978). There is evidence that recognition of siblings occurs in gulls with broods of two or more young (Evans 1970a, Noseworthy and Lien 1976). When tested in the confines of a runway, colony-reared, young Ring-billed Gulls (*Larus delawarensis*) responded selectively to their siblings at 4 but not 3 days of age, and laboratory-reared chicks did so at 4.5 days of age (Evans 1970a). Similary, evidence for sibling recognition in nonseabirds exists (Beecher and Beecher 1983). Nonetheless, experiments with seabirds have not determined if sibling recognition is visual or vocal, or which particular calls of siblings are recognized.

We examined sibling recognition in Common

Terns (*Sterna hirundo*) to determine whether chicks can recognize their siblings when they can see and hear them or only hear them. Further, we tested whether chicks recognized the contact or begging call. It is important to recognize that failure to respond does not necessarily indicate lack of recognition.

Common Tern young can move from their nests by 3 or 4 h of age; during the first week of life, however, they usually remain in or close to the nest, huddled in nearby shelter. Thereafter they range more widely around the territory while waiting for their parents to return with food. We predicted that sibling recognition would be present at the time chicks begin to wander away from the nest (Evans 1970a), which in Common Terns occurs at the end of the first week.

The two major call types of tern chicks are a begging call (directed at parents to initiate feeding) and a contact or low-intensity distress call given when isolated (Fig. 1). We hypothesized that young should be able to recognize both types of calls, because when they are separated they should find their siblings (contact-call recognition), and if their siblings are begging and being fed by their parents, chicks should go to that place to be fed as well (begging-call recognition).

METHODS

We collected newly hatched Common Tern chicks (±5 h old) from widely separated nests at several colonies in Barnegat Bay, New Jersey, in 1984 ($n = 23$) and 1986 ($n = 15$). We took only 1 chick from each nest. In the laboratory chicks were weighed, legringed, and placed in rearing cages in groups of 3 chicks to simulate natural sib groups. Thus, the sib groups shared rearing cages from the day of hatching, but did not share parentage. Each rearing cage (30 × 50 cm) had a 5-cm-deep layer of sand and was placed in a larger box that provided visual but not acoustic isolation from adjacent sib groups. The boxes were randomly rearranged every day to ensure the same sib groups were not always adjacent to one another. Before testing, each chick could hear every other chick but could see and interact only with the members of its sib group. Chicks were fed 3-4 times a day with fish species (*Menidia, Ammodytes, Fundulus*) normally fed to tern chicks in the wild. Chicks were hand fed and quickly became habituated to the observers. During tests observers were shielded from the chicks' view.

In 1984, 23 chicks were given a choice test of their siblings vs. nonsiblings at 8 and again at 9 days of age. Each chick was tested in a straight run (100 × 23 cm). The midpoint of the run was marked 0, and the end of each arm was marked 4. Each arm was divided into 4 equal sections, used for scoring the position of the test chick. The subject's siblings were placed in a clear plastic box (17 × 28 × 12 cm high, open at the top) at a randomly chosen end of the maze, and an equal number of chicks from a randomly chosen sib group was placed at the other end of the run. The sibling end was position +4; the nonsibling end was −4. The test was conducted 30-120 min after a feeding. The chicks called frequently, giving both low-intensity begging and contact calls.

The test chick was placed under an inverted cup at the midpoint and was allowed to acclimate for 30 s. The cup was lifted remotely, and we watched the chick for 2 min from a hide, recording its latency (time until it first moved more than 5 cm), each position change, how closely it approached either end, and how long it remained at either the +4 or −4 position. By adding the position changes we calculated the total distance moved by each test chick. Some chicks moved toward one stimulus and remained there (score of 0.5 m), and others walked back and forth several times (scores of up to 5 m).

We divided the responses of chicks into 4 categories: no response (remained in −2 to +2 range), approached siblings (reached +3 or +4 and did not at any time reach −3 or −4), approached nonsiblings (reached −3 or −4 and did not at any time reach +3 or +4), and ambivalent (moved back and forth from −3 or −4 to +3 or +4 at least once).

In view of the mixed results obtained in the 8- and 9-day tests (1984), we performed additional experiments with a new group of chicks in 1986. We performed four tests in the following order: (1) visual and acoustic exposure at 12 days of age (live chicks in clear plastic box), similar to 1984 test; (2) acoustic only at 12.5 days of age (live chicks in opaque box); (3) playback of sibling and nonsibling begging calls at 13 days of age; and (4) playback of sibling and nonsibling contact calls at 13.5 days. The protocol was similar in all cases. The test chick was placed in the test run with the sibling stimulus at one end and the nonsibling stimulus at the other. One observer set up the location of the sibling and nonsibling stimuli (chick tested was randomly selected), and the second observer, blind to the sibling location, recorded the behavior of the test chick for 2 min. The chick was then removed for 1 min; the location of the sibling and nonsibling stimuli was reversed, and the test chick was then returned to the run for a second trial. During each 2-min test the observer recorded the latency for the test chick to move, the location of the chick at the end of each 30-s interval, and the distance it moved every time it moved.

To create the playback tapes, we elicited begging calls when chicks were moderately hungry and contact calls shortly after feeding by separating chicks

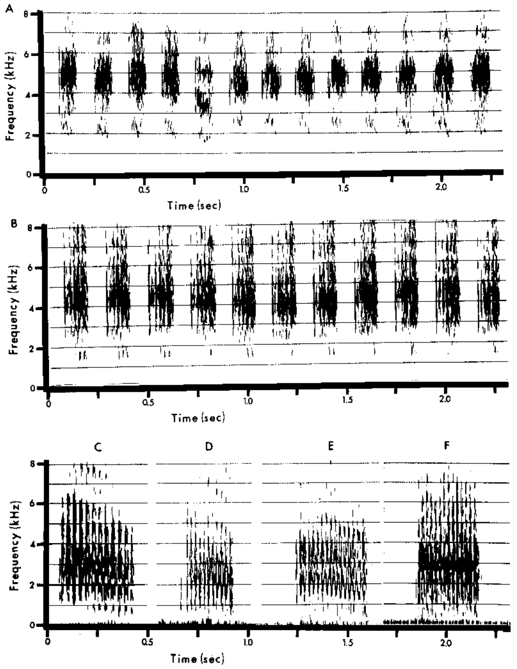

Fig. 1. Spectrograms of test tapes showing begging calls of 2 different chicks (A and B) and contact calls from 2 chicks (C–F). C and D represent variation in calls of one chick, E and F represent variation in calls of another chick.

from their siblings. These were recorded on a Uher 4000 Report IC through a Sennheiser MKH 416 directional microphone. During the recording session a chick was isolated from all others. We prepared 2-min test tapes for each call for each chick by combining calls to mimic the constancy of begging calls and the intermittent character of contact calls (10-s intervals; Fig. 1). Playback employed two Uher 4000 Report IC tape recorders and Realistic Minimus 7 speakers. The sound volume from the two speakers was balanced at the midpoint.

In nature chicks give contact calls when separated from parents or siblings. At 14 days of age we conducted an additional experiment, exposing chicks sequentially to sibling and nonsibling contact calls. Chicks were placed in a 17 × 28 × 12-cm-high test box open at the top and were exposed to 1 min of silence, 1 min of taped contact calls (of either the sibling or nonsibling calls selected at random), and then 1 min of silence. After all chicks were tested with one type of call, they were exposed to the other type of call with the same 3-min design. During each 3-min test a second observer, blind to which calls were sibling and nonsibling, recorded the number of contact calls given by the test chick during the 1-min playback, the latency to call from the initiation of the playback, and whether the test chick responded to (or "answered") each stimulus contact call.

TABLE 1. Visual and vocal recognition tests for Common Tern chicks tested at 8 and 9 days of age (1984 sample, $n = 23$) and 12 days of age (1986 sample, $n = 15$).

	Chick age (days)		
	8	9	12
No. of chicks tested	23	23	15
No. of chicks responding			
No response	1	0	1
Approach siblings	10	7	12
Approach nonsiblings	8	11	1
Ambivalent response	4	5	1

RESULTS

The 23 chicks tested at 8 and 9 days of age were able to both see and hear the chicks in the boxes at either end of the test device, and showed no preference for siblings (binomial sign test, $P > 0.05$; Table 1). They approached siblings and nonsiblings with essentially equal likelihood. The 15 chicks tested at 12 days of age approached siblings significantly more often than nonsiblings (binomial sign test, $P < 0.05$; Table 1, Fig. 2).

When the 12-day-old chicks were visually isolated at the ends of the maze, the test chicks responded preferentially to siblings (binomial sign test, $P < 0.01$; Fig. 2), and moved to them more quickly ($\bar{x}$ latency = 18.7 ± 7 s) than when they were not visually isolated ($\bar{x} = 31.8 \pm 7$ s, Wilcoxon matched pair test, $P < 0.05$). Visually isolated chicks frequently attempted to climb over the partition separating them from their siblings.

When tested with a simultaneous choice of sibling and nonsibling contact calls, chicks showed no clear indication of sibling preference (binomial sign test; Fig. 2). They did not move toward their siblings more frequently than toward nonsiblings in either the first or second test (shown for all chicks in Fig. 3). Chicks that responded to sibling contact calls (and not to nonsiblings) did so significantly faster on the second compared with the first test (Wilcoxon matched pair signed rank test, $P = 0.025$). Similarly, test chicks moved farther during the second test, indicating ambivalence concerning

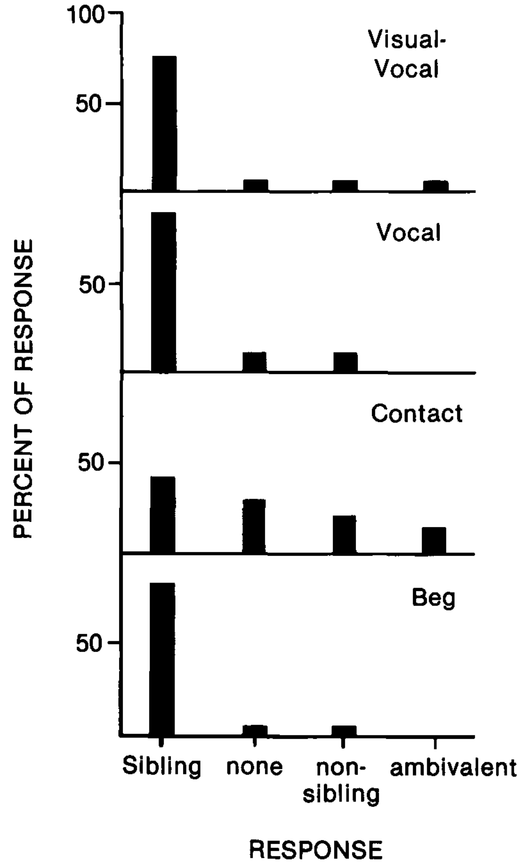

Fig. 2. Responses of 12- and 13-day-old Common Tern chicks to 4 test situations. Shown are percentage of chicks approaching siblings or nonsiblings, giving no response, or responding ambivalently. Visual-vocal represents live chicks in clear container; vocal represents live chicks in opaque container (visually isolated); contact and beg represent playbacks.

their choice of the location of the call (Wilcoxon test, $P < 0.01$; Fig. 3).

When chicks were tested successively with contact calls, they did not respond differentially (Table 2). Ten of the 15 chicks responded to calls by calling, but their response did not differ between sibling and nonsibling playbacks with respect to latency or number of response calls.

When tested with simultaneous presentation of begging calls, 13 of 15 chicks approached their sibling calls (binomial sign test, $P < 0.01$; Fig. 2), moving during the first test directly to the speaker ($\bar{x} = 13.5 \pm 21$ s). During the second test of the begging calls immediately following the first test, chicks showed signs of confusion related to the switching positions of the stimuli. Although mean latency to respond was less (Wilcoxon test, $P < 0.05$), chicks moved about the run significantly more than during the first test (Fig. 3), some approaching both speakers before they stayed at the end with the sibling stimulus.

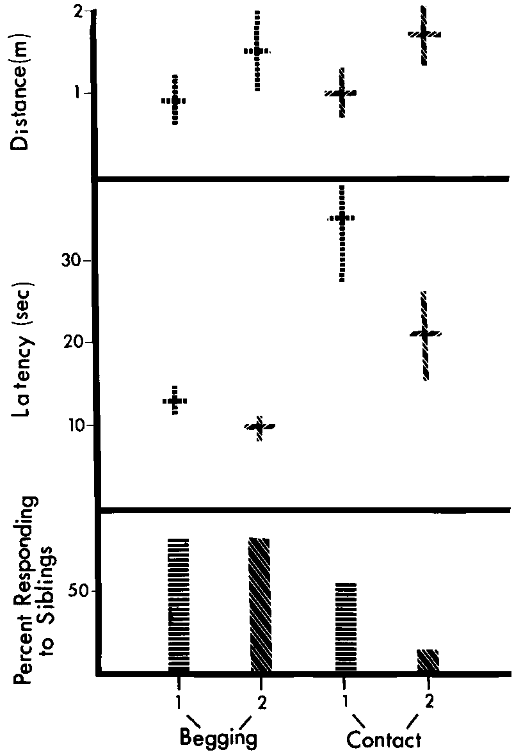

Fig. 3. Responses of all Common Tern chicks tested to begging calls and contact calls on first and second trials of playback tests after reversal of stimulus direction.

DISCUSSION

Eight-day-old Common Tern chicks did not recognize or preferentially respond to the vocalizations or sight of their siblings, but this behavior was apparent in chicks first tested at 12 days. The onset of this response was later than we had predicted on the basis of chick mobility. Moreover, Common Tern chicks recognize their parents at an earlier age (Stevenson et al. 1970), and this assures their remaining near the nest site. It is possible that separation of chicks over large distances within the territory does not occur until the chicks are over 12

TABLE 2. Responses of 15 Common Tern chicks to successive playback of sibling and nonsibling contact calls.

	Sibling	Nonsibling
Total no. tested	15	15
No. increasing call rate[a]	7	7
No. not increasing call rate[a]	8	8
Mean no. of calls (all tests)	39 ± 33	49 ± 28
Mean latency (s)	8 ± 19	7 ± 16
No. responding with latency <3 s	5	7

[a] Eight chicks responded to calls of both siblings and nonsiblings, and 5 responded to neither.

days of age. Chicks may recognize their siblings at an earlier age but not respond differentially. The observed responses indicate discrimination among familiar calls, rather than recognition of familiar vs. unfamiliar calls, because during rearing they were all in vocal contact (Kroodsma 1986). Under natural conditions the proximity of Common Tern nests varies from about 40 cm (highest density) to about 2 m (the density in the colony from which these chicks were obtained). Thus, Common Tern chicks might be in vocal contact with chicks from 2 or 3 neighboring nests under typical conditions, or with those from 6 or more neighboring nests at high density.

In the recognition tests with live chicks it was impossible to control the vocal behavior of the stimulus and test chicks. Thus, if siblings responded more than nonsiblings to the test chick, the stimulus values of the two ends of the maze would differ, confounding the results. The playback experiments ameliorated this problem.

The experiments with the contact call indicated a lack of recognition, or at least lack of a differential response. Most chicks that responded did so to both siblings and nonsiblings, suggesting that the calls elicited approach but not preferential approach. We expected the chicks to discriminate contact calls, because this is the call they give when isolated and that could be used to locate siblings. The results of our tests, however, did not indicate differential response to siblings on the basis of this call. There are several possible interpretations. Chicks may not actually locate siblings by the contact call at this age. Alternatively, although the contact call of an isolated chick may convey distress, our recorded calls may have conveyed more distress and discouraged approach. Most likely, however, because the chicks in our experiments were always in close visual contact with siblings, they were never "lost" and may not have had adequate opportunity to use or learn contact calls. These alternatives (inability to discriminate contact calls vs. lack of experience and learning opportunity) can be tested.

The begging-call tests elicited clearer responses. Thirteen of 15 chicks responded to the begging calls of their siblings. These are the calls they would have experienced most strongly in their cages before testing. The response was more complex on the second trial, indicating that they responded not only to the stimulus but to the siblings' previous position.

We postulate that it is adaptive for chicks to recognize the begging calls of their siblings, because if their siblings are begging, their parents are usually about to feed them, and a separated chick that rapidly approaches a begging sibling may compete for the food. This is particularly critical as chicks get older because chicks typically beg when they see an approaching parent. Thus, a separated chick has a few seconds to run to its siblings before food is dispensed. These results suggest that it would be beneficial for chicks to recognize the call given by a parent approaching with a fish (the fish call). The fish call is given when parents are circling, however, and does not indicate where the parent will land. The position of begging siblings indicates where parents will land.

During the tests most chicks gave begging calls in concert with their begging siblings, suggesting they were expecting food. Chicks responded most strongly when separated visually from siblings; they tried to jump, climb, or push over the barrier separating them from the siblings. When visual contact existed, the chicks tended to remain next to the siblings and join in the begging calls. This difference suggests an active tendency to join one's begging siblings. In nature, chicks that approach a nonsibling chick awaiting food on an adjacent territory are likely to be vigorously and sometimes fatally attacked by the adults, a strong selective factor favoring both sibling and parental recognition.

The confusion (rapid ambivalent movement) chicks showed in the second begging test suggests that chicks quickly learned where their siblings were and expected to find them there during the second test period. Typically, a chick approached the sibling begging calls, moved back to its original position, discovered nonsibling calls, and again moved toward its siblings' calls.

We believe that sibling recognition, or at least preferential response, in Common Terns is not well developed at 8-9 days of age but is present at 12 days of age. Recognition of sibling begging calls was the result of postnatal experience because the sib groups were artificial and the siblings did not share common parents or incubation. Recognition of siblings allows chicks to maintain contact with siblings, increasing the likelihood of being fed and cared for by their parents. Unlike many other seabirds, larids often have siblings throughout their brood period and therefore must compete actively with them for food, maintain contact, and distinguish siblings from nonsiblings.

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