

**INDIVIDUAL RECOGNITION OF NESTLING DISTRESS
SCREAMS BY EUROPEAN STARLINGS (STURNUS VULGARIS)**

by

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(With 1 Figure)
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Introduction

Many species of bird give loud distress screams when seized by a predator. It has been hypothesized that these calls function as a call for aid (DARWIN, 1872; ROHWER *et al.*, 1976; GREIG-SMITH, 1982) or as a warning (ROHWER *et al.*, 1976; GREIG-SMITH, 1982; INGLIS *et al.*, 1982; HILL, 1986). Screams may also serve interspecific functions, such as startling a predator into loosening its grip (ANDREW, 1961; DRIVER & HUMPHRIES, 1969) or attracting secondary predators, which might allow the caller to escape in the ensuing scuffle (PERRONE, 1980; HÖGSTEDT, 1983).

Playbacks of screams give mixed results, either attracting or repelling conspecifics. For example, scream playbacks elicit harassment behaviour and distraction displays from song, swamp, and white-throated sparrows with young, thus supporting the call-for-aid hypothesis (STEFANSKI & FALLS, 1972a). At the same time, playbacks of screams are used to repel pest species, particularly starlings, from orchards, airfields, and undesirable roosts (FRINGS & JUMBER, 1954; BUSNEL & GIBAN, 1968; BROUGH, 1969), suggesting that screams also function as a warning.

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In general, attempts to rescue the caller have been observed most often during the breeding season, while playback studies conducted at other times have not reliably elicited mobbing or distraction responses (PERRONE, 1980; CONOVER & PERITO, 1981; HÖGSTEDT, 1983; HILL, 1986). A possible explanation is that birds risk intervening on behalf of the caller only when their own young or other kin appear to be threatened, in accordance with the general predictions of kin selection theory. If this were the case, it would be advantageous for parents to distinguish the screams of their own young from those of neighbouring birds. Individual recognition by voice between parents and offspring is the norm among species in which intermingling of dependent young makes possible the misdirection of parental care (BEER, 1970; FALLS, 1982; BEECHER *et al.*, 1986; BEECHER, 1990). Parent-offspring recognition among birds has generally been demonstrated for begging or contact calls rather than for distress screams. It is not known whether screams afford a suitable acoustic basis for individual recognition, although an acoustic basis for individual recognition of analogous distress screams has been demonstrated in primates (GOUZOULES & GOUZOULES, 1990).

The present study examines the specificity of responses to screams by comparing the responses of European starlings (*Sturnus vulgaris*) to playbacks of screams recorded from their own young or from neighbouring chicks. Acoustic variation among chick screams is analysed to assess whether these vocalizations are sufficiently distinctive to afford a basis for individual recognition.

As semi-colonial breeders, starlings are good subjects to test the possibility of individual recognition of screams (see FEARE, 1984, for review of breeding biology). Parent-offspring recognition has been demonstrated for the contact calls exchanged between parents and nestlings in the week before fledging (VAN ELSACKER *et al.*, 1986), the same period in which screams first develop (CHAIKEN, 1986).

Methods

1. Study site.

The research was conducted during the summers of 1981 through 1983 at two breeding sites approximately one mile apart on the grounds of the Stroud Water Research Center near London Grove in southeastern Pennsylvania (see RICKLEFS & PETERS, 1979). The main colony consisted of about 100 pairs of starlings and the smaller colony of about 10 pairs nesting in plywood boxes. The nest boxes were mounted about 2 m off the ground and were placed at least 9 m apart at the edges of pastures or cultivated fields.

2. Playbacks.

Twenty-eight color-banded male and female starlings were tested with playbacks of nestling screams. All subjects had two to five nestlings between 15 and 17 days posthatch at the time of testing. Fourteen parents heard screams that had been recorded from one of their own chicks on the day before testing, and fourteen heard screams of an alien chick recorded at an age which matched that of their own chicks at the time of testing. The same set of recordings used to represent the subjects' own chicks in the first group were used to represent the alien chicks in the second. Male and female starlings both participate in caring for young. Since no statistically significant sex differences were detected in responses to playbacks, data from males and females were combined.

Screams to be recorded were elicited from nestlings by gently grasping them and lifting them out of the nest box; no attempt was made to induce screams by rougher handling. Recordings were made on a Uher 4200 Report Stereo or a 4000 Report-L at 19.05 cm/s with a Uher M516 directional microphone. Approximately 7 s of screaming were used in a repeating tape loop, with about half a second between repetitions. The playback lasted for one minute (approximately 8 repetitions of the loop).

A GM Reflex HS-8 speaker, wrapped in camouflage net, was placed on the ground, 1.5 to 2 m from the nest box, in the nearest patch of dense vegetation. This reproduced the natural situation in which chicks that fledge prematurely head for the nearest cover. The speaker was set in place at least an hour before the playbacks began, and the tape-recorder was operated from a hide. The hide and the observer had been present in the colony from the initiation of nest-building, and the starlings were habituated to their presence. Behavioural observations began with the subject's second visit to the nest after the observer had entered the blind. The playback began as soon as the parent was sighted returning for the third time. During the first 3 s of the playback the volume was increased gradually to a predetermined level, as indicated on the volume unit meter. The level had been judged previously by ear to approximate that of a bird screaming from the same distance as the speaker, and was kept constant for both own-chick and alien-chick playbacks. The subject's behaviour and location were indicated on a data sheet for as long as the bird remained visible during the pretest (undisturbed visit to the nest) and the playback.

3. Acoustic analysis.

Ninety-eight screams recorded from 33 chicks during two breeding seasons were used in the analysis of acoustic variation. Recordings were obtained as above, once or twice a day, on a rotating basis. To control for the possibility that screams performed in the same bout might be more similar than screams given on separate occasions, only one scream from each bird was selected for analysis from each recording session, using a table of random numbers.

Recordings were analysed on a Kay Elemetrics 7029A Sona-Graph using the wide-band filter and a frequency range setting of 160-16000 Hz. Sonagrams were overlaid with a 1/16 inch transparent grid to obtain the measurements described in Fig. 1 and Table 1. All measurements were made without knowledge of the identity of the chick from whom the scream had been recorded.

Measurements of 9 acoustic parameters were included in a multivariate analysis of variance (MANOVA). The approximate F-statistic associated with Wilks' Lambda, a multivariate ratio of variance within groups to total variance, was employed to test the null hypothesis that no classification of screams by individual chick was possible. MANOVA assumes equality of individual variance-covariance matrices; Box's test statistic was used as a check that the data met this assumption. Where MANOVA detected a significant difference among means, univariate F-tests were employed to com-

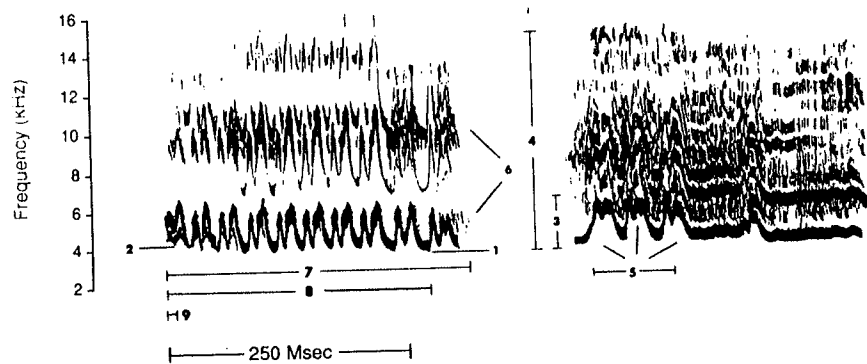


Fig. 1. Spectrograms of two screams recorded from different starling chicks. Numbers indicate parameters listed in Table 1.

pare the contributions of the individual acoustic parameters (see BRAY & MAXWELL, 1990, on the use of MANOVA and *post-hoc* F-tests). The tests were performed using BMDP statistical software (1988).

Results

1. Responses of starling parents to playbacks.

The behaviour of parents arriving near their nests fell into three distinct categories: They either flew to the nestbox and fed their chicks, flew away without approaching the nest or the speaker, or dived and snarled at the speaker, approaching it within a few feet. The number of birds displaying each response is shown in Table 2.

Parents who heard recordings of their own chicks' screams were much more likely to dive at the speaker than parents who heard the screams of a neighboring chick (Fisher's exact test, two-tailed, $p < .01$). Nine out of 14 parents gave "diving attacks" during playbacks of their own chick's screams, while only 1 out of 14 parents showed this response to playbacks of a neighbouring chick. No parents gave diving attacks and all parents fed their chicks during the undisturbed pretests. The difference between playback and pretest was significant for parents hearing their own chick's screams (McNemar test with Yate's correction: $\chi^2 = 7.11$, $df = 1$, $p < .01$). The number of parents (one) behaving differentially with respect to diving attacks during pre-tests and playback of a neighboring chick scream was too small for statistical testing.

There was no significant difference between groups in the number of parents who flew away without approaching the speaker or the nest

TABLE 1. Parameters measured from spectrograms of nestling screams, with mean (\pm SD) values

Acoustic parameter*	Measurement technique	Mean	SD
1. Minimum freq., Hz	Frequency of lowest discernible trace	1253	259
2. Max. fund. freq., Hz	Frequency of highest trace of first frequency band	1604	292
3. Max. freq. sweep, Hz	Maximum frequency change from peak to trough of a single frequency modulation	946	372
4. Bandwidth, Hz	Frequency of highest discernible trace minus frequency of lowest discernible trace	5779	1107
5. Period of freq. mod.	Maximum number of frequency peaks in any 100 ms of call	4.08	1.56
6. No. freq. bands	Number of distinct frequency bands	4.43	2
7. Duration, ms	Time from first to last discernible trace	439	135
8. Time to min. freq., ms	Time from start of call to lowest frequency in first frequency band	339	151
9. Time to max. freq., ms	Time from start of call to highest frequency in first frequency band	88	79

* Numbers of acoustic parameters correspond to numbers in Fig. 1.

(Fisher's exact test, two-tailed, $p > .05$). This occurred only during playbacks, but not significantly more often than in pretests for either group ($\chi^2 = 1.33$, $df = 1$, for own chick playbacks; $\chi^2 = 2.25$, $df = 1$, for alien chick playbacks, $p > .05$ in both cases).

Vocalizations given by the parents consisted of snarls (an aggressive call) and chips (an alarm call), both of which are associated with the presence of potential predators (HARTBY, 1969; CHAIKEN, 1986). Long series of snarls (more than six) occurred on 5 occasions, in every case associated with diving at the speaker during playback of the bird's own chick. Starlings often give a few snarls when visiting their nestlings under undisturbed conditions. Only two birds, one in each group, gave alarm chips, both during playbacks.

2. Responses of other birds.

On three occasions, a parent was joined in its attack on the speaker by its mate, who arrived after the playback began. On six occasions other

TABLE 2. Response of starlings to playbacks of screams recorded from their own or from alien young

	Feed chicks	Fly away	Dive at speaker
Own chick	2	3	9
Alien chick	9	4	1

starlings, blue jays (*Cyanocitta cristata*), redwing blackbirds (*Agelaius phoeniceus*), and/or common grackles (*Quiscalus quiscula*) gathered in a nearby tree as the parent dived and snarled. These birds vocalized, the starlings giving occasional snarls, but did not approach the speaker. During one of the playbacks, the chicks in the nestbox nearest the speaker abandoned the nest.

3. Acoustic analysis.

Multivariate analysis of variance revealed highly significant differences among groups of screams recorded from different chicks (Wilks' Lambda = 0.0017; $p < 0.01$; Lambda approaches 0 when groups are well separated and 1 when group centroids are nearly identical). The results of the *post-hoc* F-tests for the individual acoustic parameters are shown in Table 3. Of the individual parameters, the period of frequency modulation and the maximum frequency sweep showed the highest ratios of among-chick to within-chick variation. Maximum fundamental frequency and bandwidth also showed significant F-ratios.

Discussion

1. Screams as a call for aid.

A significant number of parents responded to playbacks of chick screams by diving and snarling at the speaker. The response seems a clear attempt to rescue the chick and corresponds to the behaviour elicited by real predators near the nest. Diving attacks on predators are associated specifically with parental defense in starlings (HARTBY, 1969; DE BRUYN & VERHEYEN, 1985). The incidence of snarling rises sharply at hatching

TABLE 3. Univariate F-tests comparing among- and within-individual variation in 9 acoustic parameters of screams recorded from nestling starlings

Acoustic parameter	Mean square	F-ratio	Prob F = 0
Minimum freq.			
Among	5.14	1.49	0.09
Within	3.45		
Maximum fund. freq.			
Among	7.32	1.98	0.01
Within	3.70		
Max. freq. sweep			
Among	14.05	3.07	0.01
Within	4.57		
Bandwidth			
Among	97.82	1.67	0.04
Within	58.69		
Period of freq. mod.			
Among	5.37	2.81	0.01
Within	1.91		
No. freq. bands			
Among	7.48	1.37	0.15
Within	5.47		
Duration			
Among	626.61	1.58	0.06
Within	397.84		
Time to min. freq.			
Among	628.55	1.08	0.38
Within	580.31		
Time to max. freq.			
Among	190.78	1.05	0.43
Within	182.36		

df = 31, 64.

and increases until fledging (CHAIKEN, 1986), a pattern typical for parental defense in other altricial birds (STEFANSKI & FALLS, 1972a; ANDERSSON *et al.*, 1980; GREIG-SMITH, 1980). Thus chick screams appear to function as a call for aid from adults.

2. Specificity of response.

In the present study, diving attacks were elicited almost exclusively by screams recorded from the parent's own young. In other species, such responses are not necessarily so selective. For example, STEFANSKI &

FALLS (1972b) elicited "diving attacks" from nesting song, swamp, and white-throated sparrows with playbacks of adult screams. In fact, distress screams, which show striking acoustic convergence among many avian and even mammalian species (COLLIAS & JOOS, 1953; MARLER, 1956), often elicit heterospecific responses (BUSNEL & GIBAN, 1968; STEFANSKI & FALLS, 1972b; CURIO, 1978). In the present study, playbacks of nestling screams attracted both conspecific and heterospecific "onlookers".

3. Are screams attractive or repellent?

Scream playbacks are used routinely to drive starlings from undesirable roosts or feeding grounds. In the present study, however, scream playbacks were primarily attractive. Parents either approached the speaker or ignored the playbacks and continued to feed their chicks. Only an insignificant number of parents were discouraged from approaching their nests.

What accounts for these seemingly contradictory results? First, differences may arise from the use of nestling rather than adult screams. Starlings may more readily come to the aid of a nestling than an adult. They may have more to gain by aiding a nestling, in that the caller could be their own chick, or less to lose in that the main predators on nestlings, such as rodents or snakes, pose little danger to alerted adults.

It is not necessary, however, to assume that juvenile and adult screams function as different signal types. Birds of other species respond differently to the same adult screams at different times of year (STEFANSKI & FALLS, 1972a). It is not uncommon for responses to the same signal type to vary with circumstances or with the age, sex, or breeding status of the sender or recipient (MARLER, 1961; SMITH, 1963, 1965; BEER, 1982). Responses to predators vary in the same ways (*e.g.* ALATALO & HELLE, 1990) and may depend, in particular, upon whether young or adults are threatened (KRUUK, 1964; CURIO, 1975). Thus the starlings' responses to screams probably depend upon such factors as their breeding status, their vulnerability to predators, and the specific nature of the disturbance. Accordingly, some of the starlings (*e.g.* the "onlookers") may have been seeking further information in the absence of a visible predator during playbacks. Even during playbacks designed to disperse a roosting or feeding flock, starlings generally approach the sound source before dispersing (*e.g.* AUBIN, 1987).

While nestling screams appear to function as calls for aid, there is little doubt that they can also serve as warnings. Playbacks of nestling screams

silence chicks in the nest, as do chip alarm calls from adults, in contrast with other conspecific and heterospecific vocalizations (CHAIKEN, 1986). In the present study one brood abandoned the nest during the playbacks, suggesting that screams can induce premature fledging, a common response to predators at the nest.

4. Individual distinctiveness of screams.

Multivariate analysis of variance employing 9 acoustic parameters of chick screams indicated that screams could afford a suitable acoustic basis for individual recognition. The two acoustic features that would appear to provide the best cues for individual identity are the period and the extent of the rapid frequency modulations. A study by LOESCHE *et al.* (1991) suggests that starlings can use features of a periodic frequency modulation to discriminate among cliff swallow calls in an operant procedure. Interestingly, playback experiments of synthesized screams in which acoustic parameters were systematically varied found these modulations irrelevant for the starlings' perception of screams as distress calls (AUBIN, 1987). This suggests that different acoustic parameters of the scream encode different types of information (see MARLER, 1960). Playback studies are necessary to test this hypothesis.

5. Development of recognition.

Although parents responded selectively to the screams of their own chicks, and screams appear to provide a suitable acoustic basis for individual recognition, it is not clear how individual recognition of chick screams develops. Parents have few opportunities to hear their young producing these vocalizations, since chicks scream only in the event that a predator or other intruder enters the nest. One possibility is that parents recognize their chicks' screams through extrapolation from another call type. This could occur if individually distinctive acoustic features remained invariant across call types. Several call types in the chicks' repertoire contain the same kind of rapid frequency modulations that varied significantly among screams recorded from different chicks. Starling parents have ample opportunity to hear these call types during frequent vocal exchanges at the nest (CHAIKEN, 1990). Furthermore, recognition of contact calls develops at the same age at which chicks begin to produce screams (VAN ELSACKER *et al.*, 1988). Thus the possibility of "recognition by extrapolation" warrants further study.

