

Neighbor-Stranger Discrimination of Yellow-throated Buntings (*Emberiza elegans*) and Gray-headed Buntings (*Emberiza fucata*) to Playback of Song

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Songs of the Yellow-throated Bunting (*Emberiza elegans*) and the Gray-headed Bunting (*Emberiza fucata*) in allopatric populations in Gangnae-meon, Cheongwon-gun, Chungbuk in Korea, were recorded during the breeding season and analyzed in sound spectroraphs. Males of *E. elegans* and *E. fucata* were tested to investigate whether territorial males can discriminate between neighbor and stranger based on playback of natural and artificial song repertoires. In addition, *E. fucata* was stimulated by playback of only the individually specific section as well as of only the posterior portion of the song. Males of *E. elegans* were able to discriminate individually between neighbor and stranger in response to natural song repertoires, but they did not respond to playback of the artificial song repertoires of neighbor and stranger. Males of *E. fucata* were able to discriminate individually between neighbor and stranger in response to natural, artificial song repertoires, and the anterior section of the song, while males did not respond to playback of the posterior section of the song.

KEY WORDS: *Emberiza elegans*, *Emberiza fucata*, Neighbor-Stranger Discrimination, Natural Song Repertoires, Artificial Song Repertoires.

A bird that can discriminate between its neighbors' vocalizations can save time and energy by gauging its territorial response according to the threat posed by a particular individual neighbor. Birds should gain from learning to recognize their neighbors by voice and learn not to respond to conspecifics who are established for the whole breeding season and pose no immediate threat. Strange males should, on the other hand, be recognized as threats and responded accordingly. Differential responses of established birds are adaptive in reducing energy expenditure to stimuli with little significance to them (Falls, 1982). Recognition of individual birds by vocalization

requires adequate identifying information and an ability on the part of receivers to detect and learn individual differences (Falls, 1982, Elfström, 1990).

One possible function of song complexity is to render the singer more readily identifiable to neighboring conspecifics (Beecher and Stoddard 1990), however several authors have suggested that one aspect of song complexity, song repertoires, may adversely affect neighbor recognition (Wiley and Wiley, 1977, Krebs and Kroodsma 1980, Falls 1982). Field experiments have confirmed that males of *E. elegans* could discriminate individually between neighbor and stranger (Sung and Park, 1993).

Emberiza fucata has a single song type. Each

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males has a distinctive section at the anterior part of the song (Kim and Park, 1993). Therefore Kim and Park (1993) predicted that this part was used as an important discriminative factor for individual recognition.

In this study, we conducted four playback experiments. The first, we directly examined if the males of *E. elegans* could discriminate individually between natural song repertoires of neighbor and stranger. The second, we examined if they are able to discriminate individually between artificial song repertoires (loop playback of one song) of neighbor and stranger. The third, we investigated if males of *E. fucata* could discriminate individually between natural song repertoires of each neighbor and stranger. The fourth, we also tested if these males are able to discriminate individually between artificial song repertoires of neighbor and stranger, and if so, whether they were able to discriminate individually between neighbor and stranger using only the individually specific section (fixed part of the song of each male) of the song or only the plastic part of the song of each male.

Materials and Methods

Field work and habit

This study was performed from March to June in 1993 and 1994. Songs of males Yellow-throated Bunting (*E. elegans*) (n=5) and Gray-headed Bunting (*E. fucata*) (n=4) were recorded in Gangnae-meon, Cheongwon-gun, Chungbuk in Korea. Before the playback experiment, each individual's territory and its boundary were determined by observations.

Equipment

Kowa telescope (8 × 42) and BUSHNELL spacemaster II telescope (70mm) were used to observe the bird's behavior. All recordings were made using Uher 4000 tape recorder (tape speed of 19 cm/s) with an AKG C1000S microphone mounted in a 50 cm diameter parabolic reflector. For the playback experiments, we used the Uher reel-to-reel tape recorder and a Sony TCM-5000EV cassette tape recorder with a remote (20 m) JBL proIII loudspeaker. We made the

sonagrams on a Kay Electric Company DSP Sona-graph Model 5500 and computer interface data processing.

Stimuli tape preparation

We made every attempt to place the microphone close to the bird, ie. less than 10 m to minimize attenuation and degradation of the sound quality. Our playback tapes were of three kinds: 1) the natural song sequence of neighbor and stranger (both *E. elegans* and *E. fucata*), each cassette tape being 3 mins long; 2) the artificial song sequence of neighbor and stranger (both *E. elegans* and *E. fucata*), each stimulus songs was presented for 3mins (loop playback of one song). One song type of the natural song repertoires was chosen and digitized on a computer disk using computer interface. This information was then sent to a DSP Sona-graph. This stimulus song was rescaled to approximate the song intervals of each male, by repeating one song of each male continuously; 3) anterior and posterior portions of the song of neighbor and stranger (*E. fucata* only) with each cassette tape of 3 mins.

Playback experiments: design and procedure

All trials were conducted in semiopen coniferous and mixed forests. Each territorial male (*E. elegans* and *E. fucata*) was exposed to playback of songs of conspecific neighbors and strangers. For playback a loudspeaker was placed in a tree 1.5 to 2 m above ground. The loudspeaker was oriented toward the territorial center of each test bird. The experimenter monitored the playback experiments from about 20 m away. The volume of playback was adjusted to 90dB at 1 m from the speaker using a precision integrating sound level meter.

Different trials with the same bird were at least 2 days apart and no adjacent area was visited every other day. The order in which birds were tested each day and the order in which test songs and speaker locations were used with each bird on different days were randomized for disturbing song habituation. Because the birds sang most actively near sunrise and sunset, playback experiments were generally conducted within 3 hours (06:30-

09:30) after sunrise and within 2 hours (16:30–18:30) before sunset with light to moderate winds. If the weather deteriorated or if no response occurred, the experiment was abandoned but repeated on another day. When subject individuals for playback experiment were chosen, one male of *E. fucata* was excluded because it occurred in a territory too far from others.

Measures of response

The measures of response were of three kinds: 1) Latency time from the start of playback to the first response, either by vocalizations or by approach within 15 m radius circle of the loudspeaker. 2) The closest distance of a bird to the loudspeaker, estimated in centimeters. 3) Staying time measured as the time that a bird spent within 15 m of the loudspeaker.

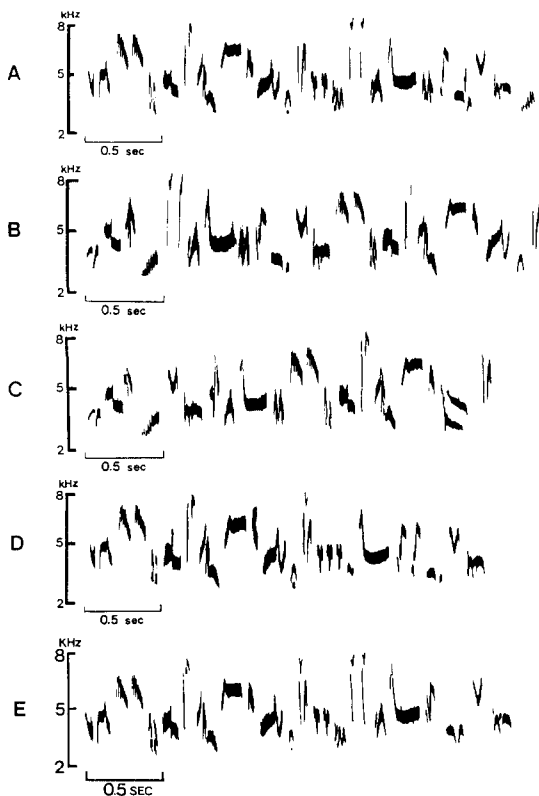


Fig. 1. Serial song sequences of a male Yellow-throated Bunting (*Emberiza elegans*). The order of alphabet indicates the order of continual song.

Sonogram interpretation and data treatment

All comparisons were made between responses to each stimulus song presentations (neighbor and stranger song, natural and artificial song, anterior and posterior song and so on). Quantitative statistics of song of each species were used for ONE-WAY ANOVA test and mean test. Wilcoxon matched pairs signed rank test and Mann-Whitney U test (Siegel 1956) were used to determine

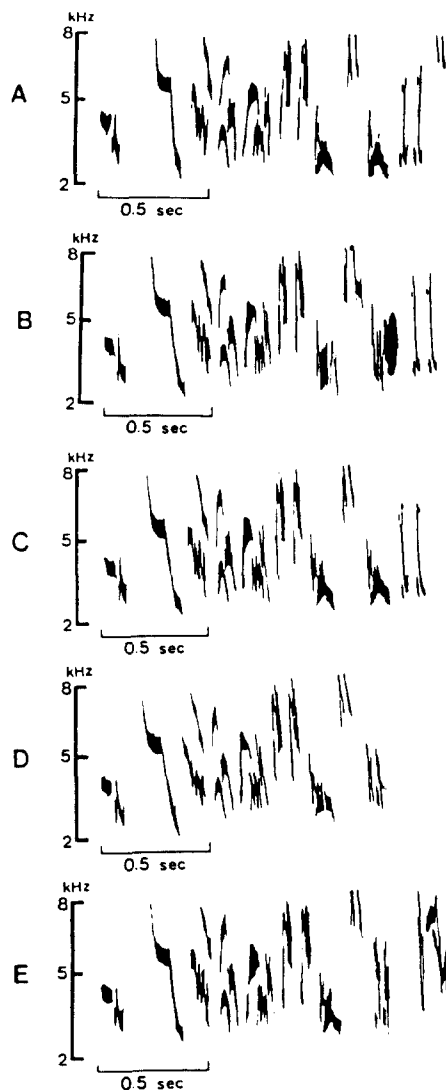


Fig. 2. Serial song sequences of a male Gray-headed Bunting (*Emberiza fucata*). The order of alphabet indicates the order of continual song.

Table 1. Comparison of the response to playback of neighbor's and stranger's natural and artificial song repertoires of Yellow-throated Bunting (*Emberiza elegans*).

	Natural song repertoires of Neighbor			Natural song repertoires of Stranger			Artificial song repertoires of Neighbor	Artificial song repertoires of Stranger
	latency time (sec)	closest distance to speaker (cm)	staying time within 15 m radius circle (sec)	latency time (sec)	closest distance to speaker (cm)	staying time within 15 m radius circle (sec)		
A	83	1330	205	54	810	391	no response	no response
B	57	1730	159	37	515	270		
C	115	910	298	96	780	453		
D	34	1310	132	18	300	737		
E	89	1160	41	78	515	127		

All test birds could discriminate individually between neighbor and stranger to playback of natural song repertoires. On the other hand, they didn't respond to playback of artificial song repertoires of neighbor and stranger.

Table 2. Comparison of mean values of the three response measurements from playback experiments with male Grey-headed Bunting (*Emberiza fucata*).

	Natural song repertoires					
	latency time (sec)		closest distance to speaker(cm)		staying time within 15 m radius circle (sec)	
	neighbor	stranger	neighbor	stranger	neighbor	stranger
A	80.3±15.5*	49.6±10.4	1206.6±261.0	340.0±206.6	500.6±245.7	683.6±361.4
B	83.6±38.4	49.3±26.5	931.7±307.5	118.6±64.4	496.3±30.6	787.0±247.3
C	114.0±62.5	30.3±23.3	856.6±332.7	360.0±98.4	252.3±56.3	599.6±241.0
D	103.6±27.2	34.0±11.7	1211.6±443.9	276.6±136.9	208.3±91.4	261.3±145.7
	ANOVA test; P<0.05		P<0.01		P<0.01	
	Artificial song repertoires					
	latency time (sec)		closest distance to speaker (cm)		staying time within 15 m radius circle (sec)	
	neighbor	stranger	neighbor	stranger	neighbor	stranger
A	95.3±64.0	75.0±31.3	1180.0±407.0	270.0±193.1	211.0±122.7	280.6±35.5
B	66.7±12.6	44.6±8.9	1016.6±253.8	240.0±195.1	212.6±40.1	338.0±45.9
C	80.6±38.1	33.6±19.0	728.3±207.5	316.6±20.8	127.6±26.2	318.3±107.1
D	54.3±12.5	31.0±1.7	850.0±157.1	265.0±108.9	208.3±91.4	261.3±35.7
	P<0.05		P<0.01		P<0.01	

*; Standard deviation (S.D.)

All test birds could individually discriminate between neighbor and stranger to playback of natural and artificial song repertoires of *Emberiza fucata*.

relative differences in response among the treatments when each measure of response was treated separately.

Results

Males of Yellow-throated Buntings sing 15-65 songs per bout and a bout usually consists of 3-8 song types. Each song types was repeated 2-20 times before switching to a different song type.

Table 3. Comparison with P values of Mann-Whitney U test between the response of natural and artificial song repertoires in Gray-headed Bunting (*Emberiza fucata*).

measured factors	stimulus song	neighbor	stranger
latency time		0.1060 n.s.	0.8852 n.s.
closest distance to speaker		0.4354 n.s.	0.7948 n.s.
staying time within 15 m radius circle		0.0004*	0.0001*

Note; n.s. (not significant), *; significant $P < 0.001$

The individual response of natural and artificial song repertoires was not significantly different with latency time and closest distance to speaker in measured factors, but the difference of staying time within 15 m radius circle was significantly different in context to each case.

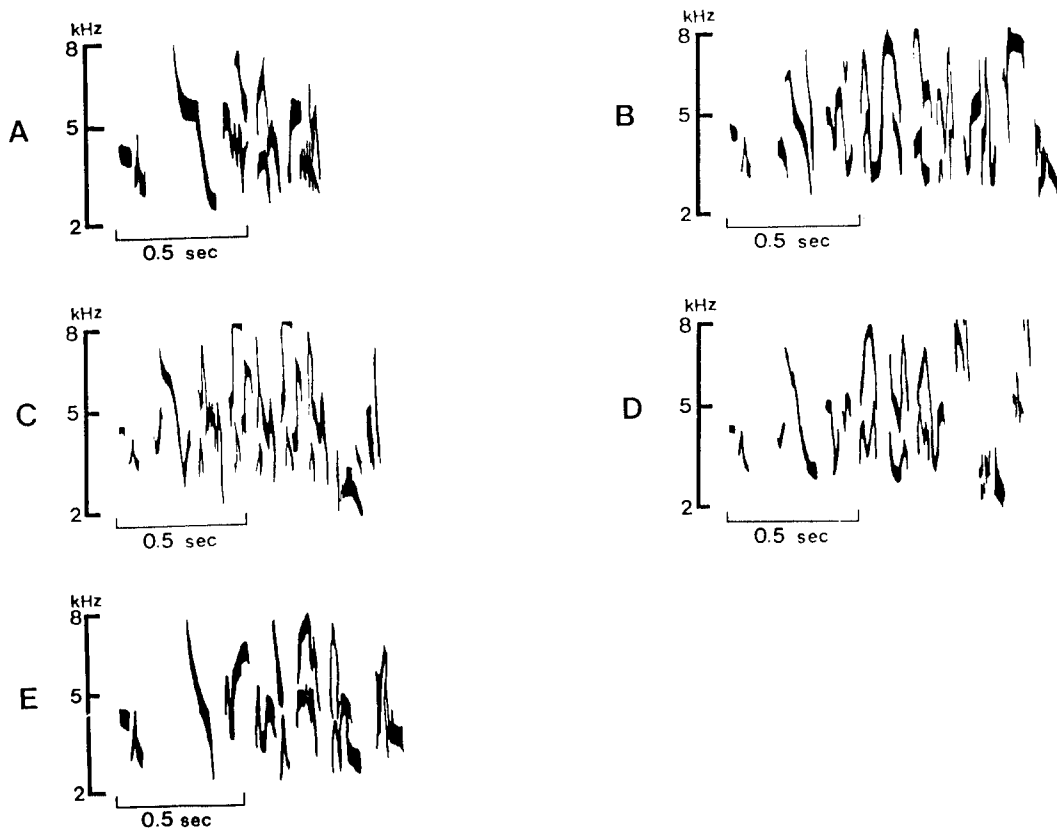


Fig. 3. Individual specific sections (anterior section) of song in the five males' Gray-headed Bunting (*Emberiza fucata*).

Sonagrams of serial song sequence in *E. elegans* are shown in Fig. 1. Males of Gray-headed Buntings sing 30-80 songs per bout and a bout usually consists of one song type. Sonagrams of serial song sequences in *E. fucata* are shown in Fig. 2.

Experiment 1.

Neighbor-stranger discrimination to playback of natural and artificial song repertoires in Yellow-throated Bunting and Gray-headed Bunting.

Emberiza elegans exhibited significantly different responses to the natural songs of neighbors and strangers for each measurement (Wilcoxon matched pairs signed rank test ($n=5$); latency time $P<0.0431$, closest distance $P<0.0431$, staying time within 15 m $P<0.0431$). *Emberiza elegans* was also exposed artificial song

repertoires of neighbor and stranger. But none of the subjects responded to the stimulus songs (Table 1).

Emberiza fucata exhibited significantly different responses to the natural songs of neighbors and strangers for each measurement (Wilcoxon matched pairs signed rank test ($n=4$); latency time $P<0.0022$, closest distance $P<0.0022$, staying time within 15 m $P<0.0022$). *Emberiza fucata* was also exposed artificial song repertoires of neighbor and stranger. *Emberiza fucata* discriminated individually between neighbor and stranger for each measurement (Wilcoxon matched pairs signed rank test ($n=4$); latency time $P<0.0022$, closest distance $P<0.0022$, staying time within 15 m $P<0.0022$) (Table 2).

Comparing results with natural song repertoires and those with artificial song repertoires, the staying time within 15 m radius circle was

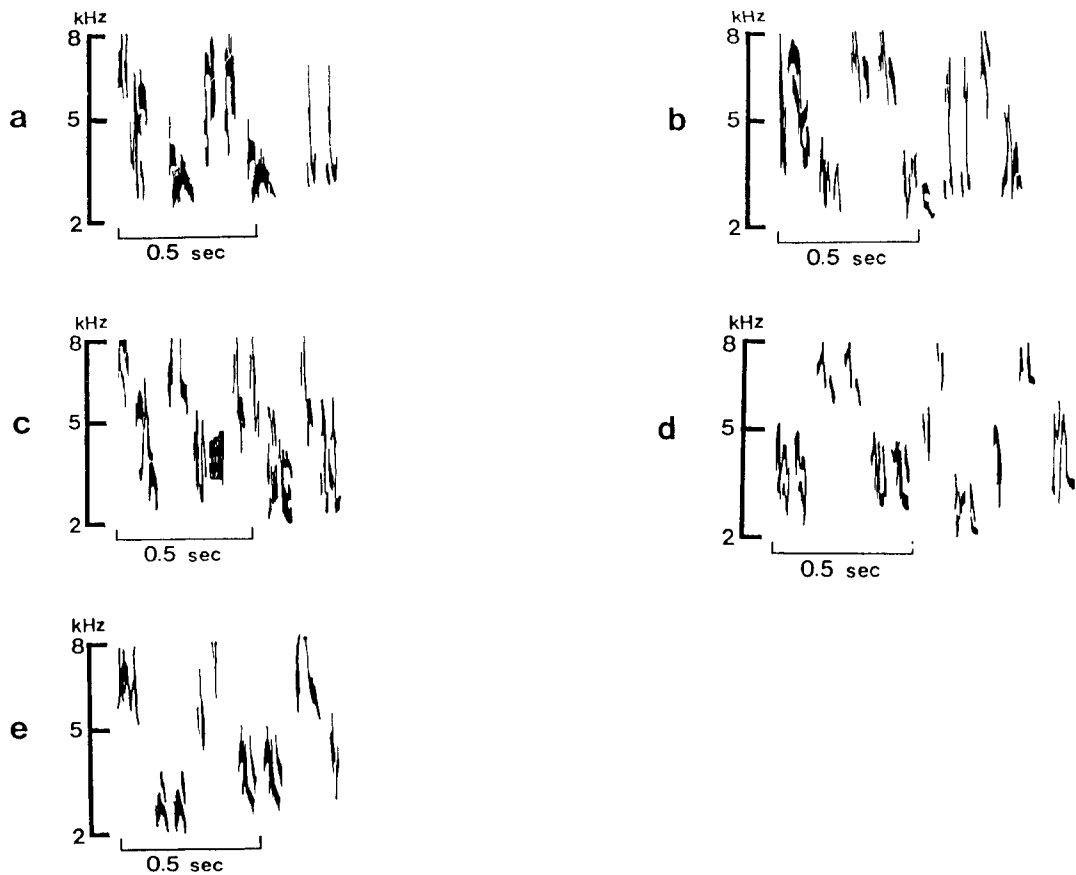


Fig. 4. Plastic sections (posterior section) of song in the five males' Gray-headed Bunting (*Emberiza fucata*).

significantly different (Table 3).

Experiment 2.

Neighbor-stranger discrimination to playback of anterior and posterior sections of the song in Gray-headed Bunting.

The individually specific sections of the song of five males of *E. fucata* are shown in Fig. 3 and the other sections of the song in Fig. 4.

When *E. fucata* males were exposed to the anterior section of the songs of neighbors and strangers, they exhibited significantly different responses of neighbors and strangers for each measurement (Wilcoxon matched pairs signed rank test (n=4); latency time $P < 0.0117$, closest distance $P < 0.0117$, staying time within 15 m $P < 0.0117$). *Emberiza fucata* was also exposed to the posterior section of the songs of neighbors and strangers. But none of the subjects responded to the stimulus songs (Table 4).

Discussion

The results of our experiments are consistent with the hypothesis that territorial male Yellow-throated Buntings and Gray-headed Buntings

discriminate between songs of neighbor and stranger. As in the studies of neighbor-stranger discrimination in other species (Weeden and Falls, 1959; Emlen, 1971; Krebs, 1971; Goldman, 1973; Brooks and Falls, 1975; Kroodsma, 1976; Harris and Lemon, 1976; Wiley and Wiley 1977, Wunderle 1978, Searcy *et al.*, 1981, Slater, 1981; Sung and Park, 1993), playback of stranger songs elicited stronger responses than did playback of songs of neighbors.

The most direct way to demonstrate individual recognition by sound is to compare responses of birds to recordings of different individuals (Falls, 1982). We showed that *E. elegans* and *E. fucata* could in fact discriminate neighbor from strangers on the basis of song. In this study, these two species were clearly different in their ability to make individual discrimination. *Emberiza elegans* could discriminate individually between the natural song repertoires of neighbor and stranger. Although the song repertoires of this species ranged from three to eight discrete song types, when we executed to loop playback of a randomly chosen song from a male, none of the males responded to the stimulus song. We thought that *E. elegans* did not recognize the individual's information with just one song type. These

Table 4. Comparison between the response of neighbor-stranger discrimination to playback of only the anterior and posterior section of the song in Gray-headed Bunting (*Emberiza fucata*).

	Anterior section of neighbor's song			Anterior section of stranger's song			Posterior section of neighbor's song	Posterior section of stranger's song
	latency time (sec)	closest distance to speaker (cm)	staying time within 15 m radius circle (sec)	latency time (sec)	closest distance to speaker (cm)	staying time within 15 m radius circle (sec)		
A	96.0± 12.72*	1155.0± 205.06	308.0± 90.51	45.0± 22.63	377.5± 392.44	312.5± 142.13	no response	no response
B	60.5± 4.95	912.5± 144.96	233.5± 30.41	45.0± 5.66	422.5± 152.03	486.5± 16.26		
C	87.0± 56.67	1020.0± 438.41	454.5± 381.13	29.5± 30.41	84.0± 65.05	542.5± 324.56		
D	103.5± 53.03	1187.5± 371.23	288.0± 121.62	16.5± 6.36	310.0± 127.28	414.0± 106.07		

*; Standard deviation (S.D.) Note: testing was used to ANOVA test.

findings indicate that males of *E. elegans* must attain familiarity with most or all of the song types in their neighbors' repertoires. Thus, *E. elegans* need to hear multiple song types in order to make this discrimination, as some have suggested (e.g., Falls 1982, Weary *et al.*, 1987).

Emberiza fucata could discriminate between neighbors and strangers to playback of natural and artificial song repertoires. In contrast with *E. elegans*, these results might be due to continuously repeated song sequence in *E. fucata*. In fact, natural and artificial song repertoires of *E. fucata* are different in only the posterior section of the continuous song sequence. Therefore, although they listen to the only one song, males may be able to acquire needed information for individual recognition.

Searching for discriminant elements within a single song type for neighbor-stranger discrimination, we also performed a playback experiment using the individually specific section and the other section, individually common section. *Emberiza fucata* could discriminate between neighbor and stranger to playback of only the anterior section of the song, while none of the males responded to only the posterior section of the song. This result proposes that anterior section of the song play, an important role for individual recognition.

We think that our experiment of neighbor recognition in *E. fucata* supports the 'releasing' hypothesis in the context of four hypotheses of how species-specific information is conveyed in birds. The 'releasing' hypothesis states that only certain acoustic components of the song are used for species identification (Date *et al.*, 1991).

Conclusionally, our experiments propose that the ability of song recognition between two species, *E. fucata* and *E. elegans* is different, and such a difference might be due to song repertoire size and song variation in a bout.

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노랑턱멧새(*Emberiza elegans*)와 붉은뺨멧새(*Emberiza fucata*)에서 Song의
Playback을 통한 이웃-낯선 개체의 인식
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번식시기동안 상호 이소종인 노랑턱멧새와 붉은뺨멧새의 song을 충청북도 청원군 강내면에서 녹음하여 분석하였다. 두종의 수컷들을 대상으로 playback실험을 실시하였다. 노랑턱멧새와 붉은뺨멧새가 각각 자연적 그리고 인공적인 song repertoires로 playback을 하였을 때 이웃-낯선개체를 인식하는지의 여부를 조사하였다. 또한 붉은뺨멧새에 대해 전반부의 song과 후반부의 song을 playback하여 이웃-낯선개체의 인식 여부도 조사하였다. 노랑턱멧새는 자연적인 song repertoires로 이웃-낯선개체를 인식하였으나, 인공적인 song에 대해서는 반응하지 않았다. 붉은뺨멧새는 자연적, 인공적, 그리고 song의 전반부를 playback하였을 때 이웃-낯선개체를 구별하였다. 반면에 song의 후반부를 playback하였을 때는 반응하지 않았다.