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Signal Value of Partial Song (Composed of 1 Phrase Unit) in Great Tits, *Parus major*: Evidence from Playback Experiments

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Playback experiments were excecuted with seven Great Tit males inhabited in Gangnae Myeon, Darak Ri, Chungbuk province to investigate the signal value of partial song (one unit phrase composed of two notes) as a species recognition releaser. Territorial males responded strongly to their own natural, synthetic and partial songs played in the field. However, they showed weak or no responses to the playback songs of other species: Coal Tit (*Parus ater*) and Yellow-throated Bunting (*Emberiza elegans*). Great Tits distinguished conspecific partial songs readily from songs of other species. The results demonstrated that one unit phrase which is a basic arrangement of the Great Tit song, containes information on species recognition.

KEY WORDS: Playback Experiments, Partial Song, Great Tit, Territorial Male, Phrase, Notes, Species Recognition

The manifold sounds of birds are characterized by a large number of different combinations of acoustical characteristics such as repertory size, song duration, frequency, intervals between songs, and the variation of song types (Becker, 1982). But only some characteristics of a species's song act as releasers for a distinct function, and these may differ from one species to another. To minimize chances of species' misidentification, songs should be highly stereotyped and unvaring throughout a population (Emlen, 1972). So, signals as species-specific releasers must be stable over time (Marler, 1960; Falls, 1963; Emlen, 1972; Becker, 1982), conspicuous, easily perceived, and not easily confused with other signals (Lorenz, 1935). In several species of birds, individuals are able to discriminate their species out of others using their songs (Krebs, 1971; Brooks and Falls, 1975; Falls, 1982). However, little is known about how the birds discriminate their identities by their songs (Weary and Krebs, 1992).

It was known that birds use features that can be evaluated over a single note rather than features that can be evaluated over the course of several notes. There are at least two functional explanations for the difference in weighing between the song note and whole song feature. One is that Great Tits may categorize songs very quickly and thus use only information contained in the first notes. The second explanation for the importance of the note features may be that a bird's measure of a parameter improves with the number of repetitions it hears or in other words, with the feature's redundancy (Weary, 1991). Whole song features are relatively unimportant in recognition. Western Meadow Lark (*Sturnella neglecta*) can match playback (i.e. respond with a song of the same type as that is being played) using only the first half of the song (Falls *et al.*,

1988).

Some hypotheses relating with conveyance of explaining species-identifying information are as following: The 'releaser' hypothesis is that species identification in the song is localized and information elsewhere in the song is irrelevant to this function, but presumably serves others (Becker, 1982). Another is 'additive' hypothesis; species recognition is achieved by the summing of information from different parts of the song (Shiovitz and Lemon, 1980; King and West, 1983). The final 'syntactical' hypothesis is that information is not only added from different song parts, but that it must occur in a particular sequence to be maximally effective (Ratcliffe and Weisman, 1987). These hypotheses differ in the degree to which information is recognized as discrete or additive. But the application of these hypotheses must be tested by accurate playback experiments, because it has been known that each hypothesis could be applied differently according to what species birds are.

Our study was subjected to obtain the signal value of partial song in Great Tit as species recognition releaser by executing playback experiments. This partial song is a basic composition of song which is a unit larger than one note, but smaller than one strophe. If the tested birds discriminate and respond differently to the partial song and heterospecific song, it will be possible to conclude that one phrase include information for species recognition.

Materials and Methods

Playback works were carried out on seven wild Great Tits (*Parus major*) inhabited in Kangnae Myeon, Chungbuk province in 1994. Experiments were performed during the beginning of the breeding season (March to May).

Playback Experiments:

The note numbers most frequently found in 45 song types from 38 individuals were two (Cheon and Park, 1993), and songs of these features were selected as control. The song used in the work of playback was recorded in Bucheon, Kyeonggi-Do

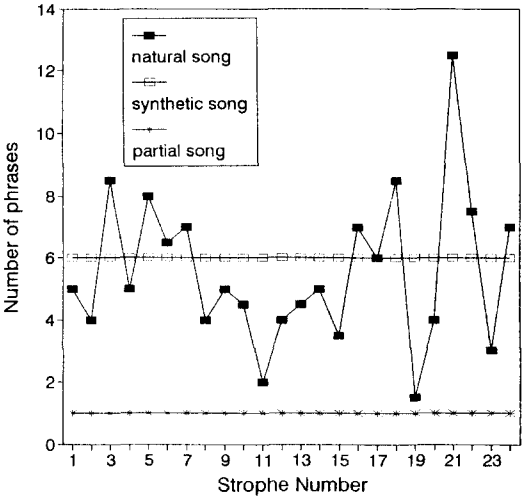

Fig. 1. Comparison between natural and artificial playback stimuli (synthetic song, partial song).

Table 1. The average values of frequencies and temporal features of songs used in playback experiments.

	Frequency (Hz)		Duration (sec)		INP (sec)	IPP (sec)	ISP (sec)	Number of phrases
	1st note	2nd note	1st note	2nd note				
natural	3760	4920	0.1437	0.1156	0.0781	0.0969	1.512 ± 0.651	5.7 ± 0.2
synthetic	3760	4920	0.1437	0.1156	0.0781	0.0969	1.356	6
partial	3760	4920	0.1437	0.1156	0.0781	–	1.641	–
YTB	–	–	–	–	–	–	1.550	–
CT	3860	6100	0.1875	0.1094	0.0625	0.0875	1.491	6

INP; inter-note pause, IPP; inter-phrase pause, ISP; inter-strophe pause: mean ± SD, YTB; Yellow-throated Bunting, CT; Coal Tit

province about 100 km distant from the experimental area, because the effects of 'neighbor-stranger' discrimination factors must be excluded (Becker, 1982). The artificial songs generated were as following: Two kinds of artificial songs of Great Tits were made from formal natural songs. One (synthetic song) has a strophe composed of six phrases that is similar to the average phrase number of natural songs (5.7 ± 0.2) but there is no fluctuation in that song, and

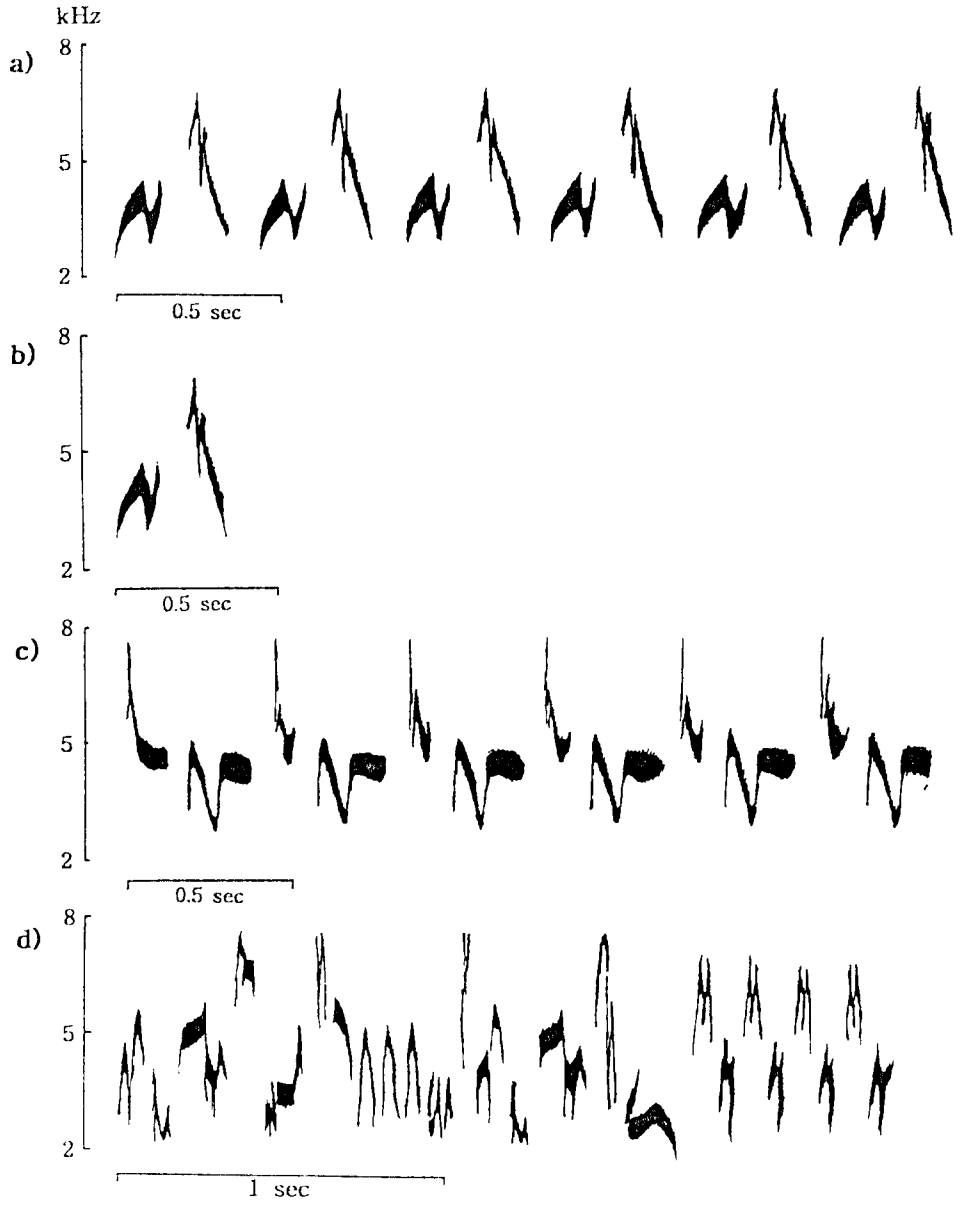

Fig. 2. The sonagram patterns used in playback experiments for species discrimination: a) synthetic song, b) partial song, c) Coal Tit's song, d) Yellow-throated Bunting's song.

thus it is very monotonous. The other (partial song) has a strophe composed of only one phrase and also has very monotonous song patterns (Fig. 1). Both of these artificial songs have a quite similar frequency features as the natural song but are different from natural song in the duration. The controls of heterospecific song were prepared using Yellow-throated Bunting (*Emberiza elegans*) and Coal Tit (*Parus ater*) to test functions of Great Tit phrase and of phonology (acoustic morphology of the elements) in species recognition respectively. These two selected species were sympatric with Great Tits in the experimental area.

All the artificial songs for playback were prepared to have same inter-strophe pause intervals (Table 1). These song manipulation was made by using DSP Sonagraph and computer interface. Song intervals were adjusted by manipulating Sonagram buffer sizes. Fig. 2 shows the sonagram pattern used in playback experiments. Each test song was played for 90 seconds and the volume was adjusted at 1m distance to have the sound level (90 dB) similar to the natural song.

Categories of response

Responses of males were recorded during and after 90 seconds of each playback presentation. Four categories of responses were established based on observed territorial males' behaviour in the field. These response categories are as following:

1) Latency to song (sec): period from the start of the experiment to the first vocalization of the bird.

2) Latency to close (sec): time of the bird's approach to 5m distance

3) Staying time (sec): time of the bird's stay within 5m radius area

4) Closest approach (cm): nearest distance from the bird to the playback speaker

Results

Comparison between responses to natural and conspecific synthesized songs

Most of phrases in the Great Tit songs were found to be composed of two or three different notes arrangements (42/45, 93.4%; Cheon and Park 1993). We determined first whether the synthesized songs evoke a strong response as well as natural songs. As Fig. 3 shows, responses of test birds to playback stimuli of synthetic and partial songs were nearly same as those of natural song. In Comparison to natural song, synthetic and partial songs induced similar reactions for three response criteria (i.e., no significant difference, $P>0.05$, one-way analysis of variance); latency to song ($F_{2,21}=0.8266$, $P>0.05$), latency close time ($F_{2,18}=5.0666$, $P<0.05$), staying time ($F_{2,17}=0.4092$, $P>0.05$) and Closest approach ($F_{2,17}=0.3518$, $P>0.05$). Although there was a significant difference in latency close time, as it will be discussed later, great tits still responded appreciably to the synthetic and partial song as to natural song (Table 2).

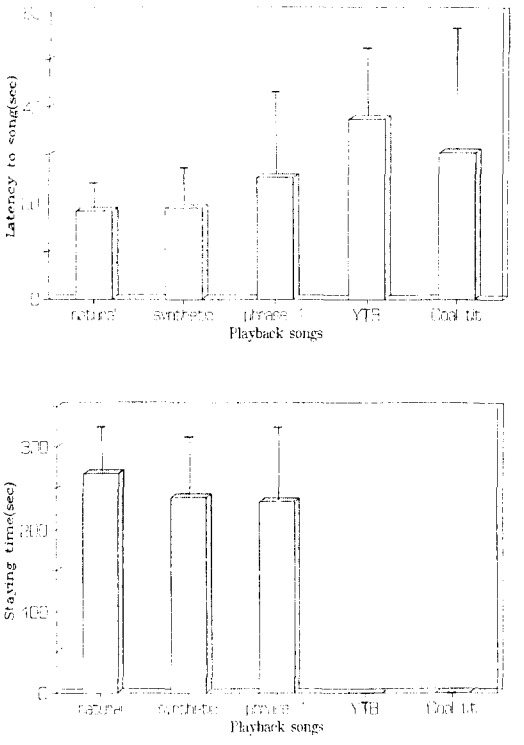

Fig. 3. Comparison of Great Tit's response to various playback stimuli: YTB; Yellow-throated Bunting, CT; Coal tit.

Comparison between responses to partial song and heterospecific song

Table 3 and Fig. 3 show that there were significant differences in reponses between conspecific partial song and heterospecific songs (Mann-Whitney U test, one tailed). The partial song elicited territorial responses significantly stronger than heterospecific song did in the three response criteria except the latency to close time. Therefore, we can conclude that the whole song repertoires is not necessary to induce territorial reactions in Great Tit. Partial song that is composed of one phrase alone are able to ensure some level of species recognition. But the phrase must be conspecific, as demonstrated by the responses to the heterospecific playback songs, which was unable to induce strong reactions.

Discussion

One of the central focuses in the study of bird communication concerns the encordment of information in different types of signals. Several researchers have used operant techniques to study discrimination of natural sounds in birds (Park *et al.*, 1985; Park and Dooling, 1985). Weary (1991) also performed operant techniques and showed that some birds used features that could be evaluated over a single note rather than features that could be evaluated over the course of several notes. Evidence from other studies also suggests that whole-song features are relatively unimportant in recognition. Other studies also have demonstrated that certain features of acoustic song units are important for song recognition for the following species: White-throated Sparrow (*Zonotrichia albicollis*) (Falls, 1969), Woodlark (*Lullala arborea*) (Tretzel, 1965), Golden-winged Warbler (*Vermivora chrysoptera*) (Ficken and Ficken, 1973), Willow Tit (*Parus montanus*) (Romanowski, 1979), Chiffchaff (*Phylloscopus collybita*) (Becker *et al.*, 1980).

From our playback experiment results, we reached a conclusion that a full repertoires in Great Tit is not necessarily designed to induce normal responses. One phrase also could induce strong reactions as the natural song does. As shown in Table 2, three out of four responses categories led us to the conclusion. Only the

Table 2. Strength of response to playback of natural, synthetic and partial song to 7 males.

Response measure	Playback stimuli			F-ratio	P
	Natural	Synthetic	Partial		
Latency to song (sec)	18.4 ± 5.8	18.9 ± 8.3	25.3 ± 17.0	0.8266($F_{2,21}$)	0.4513
Latency close (sec)	19.9 ± 6.2	25.4 ± 8.3	5.3 ± 12.1	5.0666($F_{2,18}$)	0.0180
Staying time (sec)<5m	267.9 ± 56.4	239.6 ± 73.1	234.2 ± 89.8	0.4092($F_{2,17}$)	0.6706
Closest approach (cm)	129.3 ± 76.9	160.0 ± 98.0	165.0 ± 75.8	0.3518($F_{2,17}$)	0.7084

Values are means ± SD (N=7). F-ratio and P-value refer to a repeated measures one-way analysis of variance.

Table 3. Comparison* of responses of Great Tits to heterospecific playback songs.

	Comparison of responses		
	control:partial	partial:YTB	partial:CT
Latency to song (sec)	NS	NS	NS
Latency close (sec)	<0.05	<0.001	<0.001
Staying time (sec)<5m	NS	<0.001	<0.001
Closest approach (cm)	NS	<0.001	<0.001

*Mann-Whitney U test, one tailed; NS: not significant, P>0.05 (YTB: Yellow-throated Bunting, CT: Coal Tit)

category of latency to close did not give affirmative evidence to our conclusion. However we could explain the result as following. It was due to a varied location of test bird at the beginning of each experimental trial. In other words, the distance between test bird and the playback speaker could not be controlled to make it constant in the field situation, as a result, the distance was varied great deal for each trial. Therefore it is possible to predict that a bird situated close to the speaker could approach more rapidly than the one distant from, though the strength of responses could be similar to each other. We believe that it would be more affirmative to use the categories of staying time and closest approach when we compare the bird responses.

Now we also conclude that the fluctuation of song affect little to the recognition of species. Natural song is so variable in view of the number of phrases, inter-strophe interval and strophe length that Great Tit can refrain from monotonousness. As a contrast, the artificial songs had no fluctuation in their song. They were synthesized to show the constant song duration and interval, and the experimental results showed that there were no differeces in responses between natural and the artificial songs. Our conclusion is that the rhythmical fluctuation in full repertoires have little effect to species recognition. But the fluctuation in whole-song may still convey certain information, such as the motivational state (Weary *et al.*, 1988) or quality (Lambrechts and Dhondt, 1988) of the singer. It also seems to be related to the hypothesis of anti-exhaustion (Lambrechts and Dhondt, 1988). In addition, there have been reports that the variation of songs showed individual differences and gave information of individual identities (Weary and Krebs, 1992). Table 3 also shows that test birds had tendencies to sing at the heterospecific song stimuli anyway, though not responded actively in behaviour. We think this particular feature of responses may be in some degree involved with a alarming call function among populations, but it must be further investigated for better understanding.

Conspecific elements were important for the identification of a song in Great Tits that would use the structure and shape of a multiful note and a phrase in full repertoires as an important cue for the species recognition processes. Finally, our experimental results have some limits in explaining species isolation. Interspecific discrimination of sounds minimizes unnecessary expenditure of energy, interspecific conflicts, and hybridization and generally it makes intraspecific acoustical communication more efficient. Especially, we believe that isolation mechanism (Nicolai, 1968) must be most important of all in vocal communication. But the effectiveness of song as a species isolating mechanism could not be expressed here, because we discovered so little about ultimately decisive reactions of females. We think it is necessary to test female behaviours and also to decide the categories of responses for revealing the species isolation mechanism.

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박새(*Parus major*)의 Partial Song(1 phrase)의 신호적 가치

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세력권을 형성한 박새(*Parus major*) 7개체를 대상으로 song인식에 관련한 playback 실험을 실시하였다. 박새는 진박새(*Parus ater*)와 노랑턱멧새(*Emberiza elegans*)의 자극 song에 대해서는 반응을 하지 않은 반면에, 합성 song과 partial song(one unit phrase composed of 2 notes)의 자극에 대해서는 모두 자연 상태와 유사한 공격 반응 정도를 나타내었다. 이는 박새가 song을 통해 동종과 타종을 구분할 수 있으며 또한 song의 기본 조합인 1개의 phrase내에도 종 인식을 가능하게 하는 정보가 내재되어 있음을 시사해 준다.