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Influence of External Stimuli on the Quality of the Song of the Zebra Finch (*Taeniopygia guttata castanotis* Gould)

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With 2 figures

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Abstract

The effect of models differing in releasing quality is tested with respect to acoustical features of the directed song, and is compared to song not induced by releasers (so called "undirected song"). A gradual change of several parameters (for example number of introductory elements, number of motifs per strophe, speed of performance of the first motif) was found, indicating a gliding increase of intensity from song not releaser-provoked, via song released by models poor in releasing stimuli to song induced by living females.

Introduction

Males of the Zebra Finch (*Taeniopygia guttata castanotis* Gould) sing in two different behavioural contexts: 1. During courtship display (MORRIS 1954; IMMELMANN 1962), and 2. in situations not clearly associated with a definite function but rather characterized by low general locomotor activity. As in the courtship sequence the male directs all its movements and the song towards the female, this type of song has been defined as "directed" (MORRIS 1954; IMMELMANN 1962), whereas song independent of the presence of a female and thus without an orientating component is referred to as "undirected" song (IMMELMANN 1968). SOSSINKA and BÖHNER (1980) have demonstrated that the song phrases of both types consist of the same basic structure (Fig. 1), but are clearly distinguishable by certain criteria: the number of introductory elements as well as the number of motifs per strophe are significantly larger in directed song compared to undirected song. Furthermore the overall speed of song, measured by the length of the first motif of a strophe, is also higher in courtship song.

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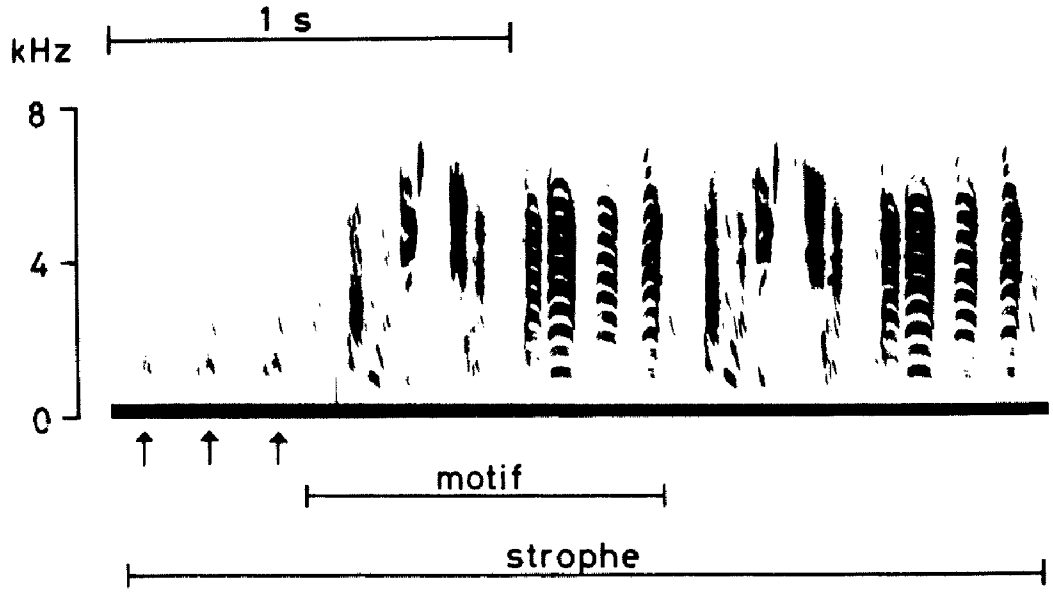

Fig. 1: Structure of the Zebra Finch song.
Introductory elements are indicated by arrows

Moreover, the directed song is more regular with respect to the sequence of elements than is the undirected song. These results confirm presumptions by Immelmann (1968) and Kalberlah (1980). Sossinka and Böhner (1980) guess that the two types consist of a common basic song pattern and that the differences between them are the result of different intensity levels. They suggest that these intensity differences are caused by changes of motivation, which — besides other factors — might be dependent on the level of male sexual hormone (c.f. Pröve 1974). The presence of a female, together with high testosterone level, modifies or switches the undirected to the directed song type.

This assumption and the hypothesis first published by Morris (1954) and confirmed by Pröve (1974) that undirected song can be considered as sexual behaviour pattern with the lowest threshold, makes it likely that song intensity may be influenced by endogenous as well as by exogenous factors. Thus, changes in the song intensity should result from artificial increase of the hormone level as well as from manipulation of the quality of the releasing stimuli.

In this study the influence of external stimuli on the acoustical features of the Zebra Finch song is tested. As it is hardly possible to attach different releasing qualities to living female birds, we elicited song by presenting either a living female or one of two dummies of different quality and compared the song uttered under these conditions to undirected song.

Material and Methods

Domesticated Zebra Finches from the institute's stock with a singing activity not below average were kept singly in a small cage for a minimum of 2 weeks. Before the experiment the birds were transferred to a cage in a sound-isolated room and allowed to get familiar with the new surrounding for one day. They then were observed in the morning for ½ h after introduction of a test object. Songs were recorded with a tape recorder (Uher Report 4400 Stereo, 9.5 cm/s) and a microphone (Uher 815). The birds were tested several times in random order in the four different test situations:

I. with a live female bird,
II. with a stuffed female in natural posture,
III. with a painted plaster image of a female,
IV. without an additional stimulus.

In between, they got isolated for 7 days. Tests were continued until we got a minimum of 10 bouts of song (consisting of one to several strophes) from each bird in each test situation.

The terminology concerning the song parameters was taken from Sossinka and Böhner (1980, Fig. 1). Quantification of certain acoustical parameters, such as number of introductory elements and motifs, and duration of the first motif of a strophe, was obtained by the methods described in the same paper.

Differences between song parameters elicited by the test stimuli were tested by Student's t-test for matched pairs for each single bird, and by the Wilcoxon-signed rank test for all males tested.

Results

a) Variability of Song Parameters

As Immelmann (1968) stated, the inter-individual variability of the Zebra Finch song is very large. This variability manifests itself by the difference in the character form of song elements between the birds, but also in differences in the basic song-activity, which can be measured by the number of introductory elements and motifs per strophe in a defined test situation (Fig. 2a).

The individual bird in contrast sings a very stereotype song in terms of the form of the elements and their sequence. In a given experimental situation, the number of motifs and introductory elements is relatively constant too.

These factors had the following implications for our experiments: In statistical analysis the differences between the distinct experimental situations were significant in most cases for a single bird, but not significant for the whole sample, if we used the t-test. Therefore we applied the Wilcoxon signed rank test, which ignores most of the interindividual differences and considers mainly the deviations evoked by the distinct test situations.

b) Introductory Elements (Figs. 2 a, b)

The results the most evident were obtained by measurement of the number of introductory elements. The birds sing the largest amount when faced with the living female ($\overline{m}$=5.4/strophe). The number of introductory elements decreases in all but one bird in the sequence living female, stuffed female ($\overline{m}$ = 4.4), painted plaster image ($\overline{m}$ = 3.8), no dummy ($\overline{m}$ = 2.6). The differences are significant between all situations at the 5 %-level with the Wilcoxon-test, for each single bird with the t-test at the 5 % level (in most males even at the 1 % level).

c) Motifs per Strophe (Fig. 2 c)

The same trend demonstrated above for introductory elements was obtained by measurements of the motifs per strophe except for undirected song (i.e. with no model present). The amount of motifs per strophe decreases from the test with the living female ($\overline{m} = 6.4$) via stuffed female ($\overline{m} = 5.2$) to painted plaster image ($\overline{m} = 3.2$). Without external stimuli, however, the mean (4.7) is higher than with the plaster image (Fig. 2c). Comparison of the values of single birds reveals that 3 of 7 birds express song amounts according to the sequence expressed by these means. In each of the other 4 birds, however, in one of the four situations the amount of motifs per strophe does not follow this trend. That is why only the difference between the painted plaster image and the undirected song proves to be significant at the 5 % level by the Wilcoxon test.

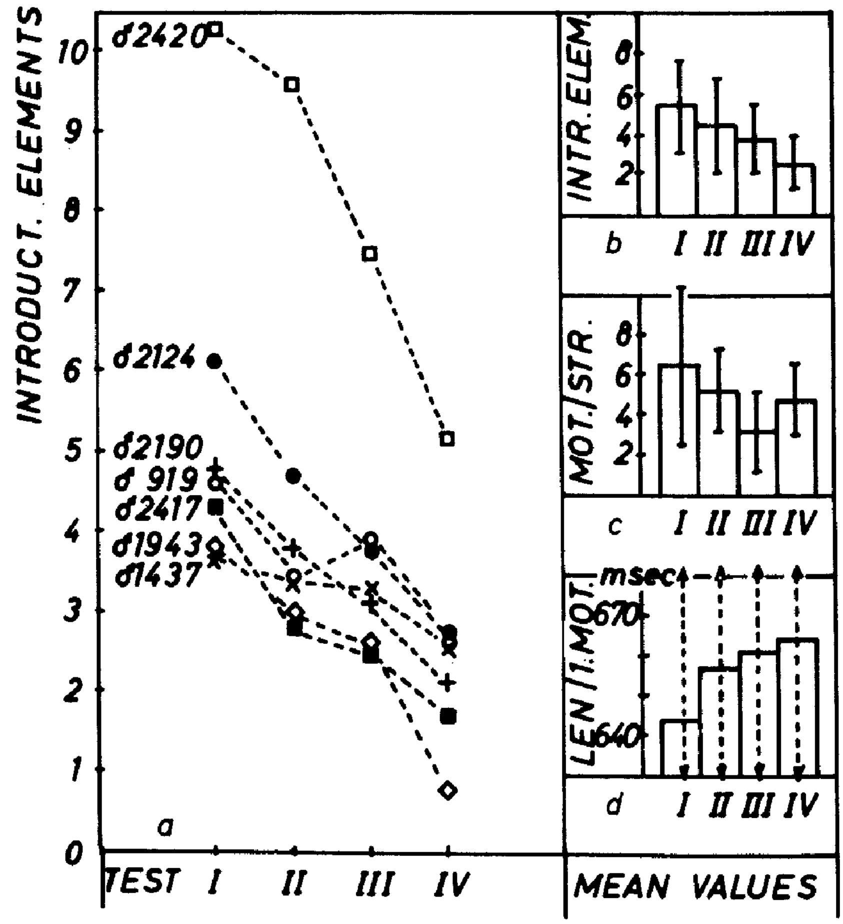

Fig. 2: a) Number of introductory elements elicited by each single bird in the four test situations. The individual birds are indicated by different symbols. b)—d) Mean values of song parameters over all birds in the four test situations: b. number of introductory elements, c. number of motifs per strophe, d. length of the first motif of a strophe

d) Length of the First Motif of a Strophe (Fig. 2 d)

No significant differences between the test situations could be revealed by measurements of the length of the first motif of a strophe. The means demonstrate a trend like that obtained by measurements of the amount of introductory elements. The length increases in the sequence living female — stuffed female — painted plaster image — undirected song, but individual birds do vary. (The exact length of the motif had been measured in 5 out of 7 birds only, because of uncertainties in the definition of start and end in the two other ones.)

Discussion

The results demonstrate that the quality of a certain releaser influences the *quality* of behavioural output. In case of courtship display in male Zebra Finches, GARSON et al. (1980) and BISCHOF (1980) have shown that the *quantity* of courtship behaviour patterns is also affected by the quality of the releaser.

In this study, acoustical features of song have been proven to vary according to the releasing value. This is most evident in the number of introductory elements, is probably true in the speed of performance, and can as well be seen in the number of motifs per strophe. In the latter parameter, however, the situation 'no model' deviates, producing longer strophes than do plaster images. This indicates that a dummy, which could not react in the way a living female normally does, may influence the actual courtship sequence (c.f. CARYL 1976), for example inhibits the continuation.

The interesting fact about the acoustical features is their continuous variation of intensity, as indicated by the gliding alteration of the number of introductory elements, of the speed of performance and — with some restrictions — of the number of motifs per strophe. That means, the intensity of song with no external releaser fits in an extrapolated point of the sequence good, medium, weak releaser, standing for a releasing situation with a very low value. In contrast the courtship display posture and the accompanying dance are switched off completely in the 'no model' situation. (There is evidence, however, that these parameters also vary according to the quality of the releasers, when present; cf. REINHERZ, in prep.) These findings support the hypothesis by MORRIS (1954), that undirected song is sexually motivated as is courtship song, but has the lowest threshold. A corresponding difference in dependence on testosterone-titers was demonstrated by PRÖVE (1974). Whether or not the intensity of this 'basic-level' undirected song can be influenced by manipulation of plasma testosterone levels is the object of another study in progress.

Under natural conditions, however, the differences in releasing value of different females will be much smaller than between a living female and a plaster model. Thus, only the very ends of the possible scale of input are available and the output proves to be well separated in two distinct types of song, as shown by SOSSINKA and BÖHNER (1980).

Summary

The influence of different external stimuli on acoustical features of the song is tested in the Zebra Finch. Songs originating from four situations were compared:

I. directed song induced by a living female,
II. directed song induced by a stuffed dummy female,
III. directed song induced by a painted plaster model female,
IV. undirected song (i.e. with no model).

The songs differ with respect to the number of introductory elements, the number of motifs and the speed of performance. Certain quantitative parameters of song produced in situations II. and III. exhibit values between those of situations I. and IV. It is supposed that undirected song represents a basic intensity level, which is raised by specific releasers and results in directed song, varying in intensity according to the values of the releaser. A living female as a releaser lifts the intensity level of song high enough to induce a "new" type of song, clearly distinguishable from the undirected song type.

Zusammenfassung

In der vorliegenden Arbeit wird der Einfluß verschiedener Außenreize auf akustische Parameter des Zebrafinkengesanges untersucht. Hierzu wurden Gesänge, die in vier verschiedenen Situationen vorgetragen worden waren, miteinander verglichen:

I. Balzgesang, ausgelöst durch ein lebendes Weibchen,
II. Balzgesang, ausgelöst durch ein ausgestopftes Weibchen,
III. Balzgesang, ausgelöst durch eine Weibchen-Gipsattrappe,
IV. ungerichteter Gesang (i.e. ohne Attrappe).

Zwischen den einzelnen Gesangsformen lassen sich Unterschiede in der Anzahl Einleitungselemente, der Anzahl Motive pro Strophe und der Gesangsgeschwindigkeit feststellen. Hierbei liegen die beiden durch Attrappen ausgelösten Gesänge in ihrer Ausprägung zwischen den Gesangsformen ungerichteter Gesang und durch ein lebendes Weibchen ausgelöster Balzgesang. Es wird angenommen, daß der ungerichtete Gesang eine Art Grundpegel darstellt, der durch spezifische Außenreize erhöht und dann als auslöseabhängiger Balzgesang vorgetragen wird. Ein lebendes Weibchen als Auslöser hebt den Intensitätspegel soweit an, daß aus dem ungerichteten Gesang eine bioakustisch deutlich unterscheidbare Gesangsausprägung resultiert.

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