

K.O.Uplisova
**ACOUSTICAL CHARACTERISTICS OF VOWEL-LIKE SOUNDS OF THE GREY
PARROT**

Saint-Petersburg State University
Russia, 199034, Saint-Petersburg, University emb., 7/9
Tel.: (812) 328-9706 e-mail: sehmet@fromru.com

In connection with studying of acoustic characteristics of vowel sounds under different conditions of generation and attempt to reveal the attributes, allowing to divide various categories of vowel sounds, the analysis of vowel-like sounds of talking birds was realized. The auditor analysis four hundred the vowel-like sounds picked out from imitations of human speech by a grey parrot was carried out. The most part of these sounds had no harmonious structure, and was amplitude modulated more often. In such sounds determination of the fundamental frequency was impossible. Earlier it has been shown [1], that vowel-like sounds of talking birds cannot be divided into categories on the basis of frequencies of formants (spectral maxima), but dependence of relations of amplitudes on frequencies of spectral maxima has various character for various categories of vowel sounds. It has allowed to divide categories of vowels "a", "o", "i" for one grey parrot and a starling, for the second grey parrot the distinction have appeared less expressed. Results of the given work have shown, that the vowel-like sounds of a grey parrot authentically identified by independent auditors, have no more stable values of frequency and amplitude of spectral components than for the sounds allocated only on the basis of sounding in structure of a word, and character of distribution of dependence of amplitude considerably differs from frequency of spectral components from received for the previous birds. It allows to assume, that each bird has features in the decision of a problem of imitation not native sounds for it.

INTRODUCTION Studying of imitating signals of talking birds represents special interest in connection with basic differences in a structure of the voice device and nervous maintenance of sound production at birds and the human. But, despite of it, birds distinguish categories of speech signals of the humans [2] and simulate words despite of acoustic differences of voices of humans surrounding them. Imitating sounds, in turn, are distinguished by the humans though they cannot have the same acoustic characteristics, as speech of the humans. At present there are some works in which imitations of human speech by various talking birds were analyzed.

One of the first works was comparison of acoustic characteristics of imitations of a starling-mynah and a voice of the man trained a bird [3]. It has been shown, that though the mynah as well as all sparrow family has two independent sources of vibration, on one in each bronchial tube, it can copy precisely enough frequency of the fundamental frequency and the formants of the owner.

In detailed research of acoustic structure of imitations of two grey parrots [4], obtained data were agreed by that parrots possess only one pair vocal folds, and thus their way of sound production is closer to human than at the mynah. But nevertheless, though authors could determine and frequency of the fundamental frequency and frequency of formants of vowel-like sounds of parrots, values coincided with values of frequencies of formants of vowel sounds of human speech far not for all categories (values for 10 categories of vowels of English language were investigated). Thus, the basic attribute on which various categories of vowel sounds of human speech were traditionally divided, namely values of frequencies of the first and second formant has appeared is inapplicable for imitating sounds of parrots.

Several years ago acoustic structure of imitations of human speech by budgerigars had been analysed [5]. This bird is smallest of talking birds, but it has a typical syrinx parrot family. On the basis of detailed studying acoustic characteristics as specific signals and imitating sounds, the author has put forward the assumption, that despite of presence only one source of vibration, the way of sound production for these birds is amplitude modulation, result of nonlinear interaction of two sources of vibration – carrying and modulating. Sources are formed because the folds connected among themselves vibrate with different frequency. As a result of this in a spectrum of such signal there are the frequencies which are not present at an initial signal. To the sounds formed in a similar way, according to classical representations the concepts of fundamental frequency, formants and harmonics are not applicable.

In our country the work on studying imitating speech of various birds was carried out. The vowel "i" from a word "ptichka" said by the budgerigar [8] has been investigated. Researches have shown that the waveform of pronouncing consists of the periods of very small duration, subdivided on impulses. In case of precise pronouncing these impulses have the correct form, at bad - are not distinct. Frequency of the fundamental frequency and frequency of formants were on 2 kHz above than human,

and amount of formants were same as at the human. Duration of the vowel in a word at a budgerigar makes 19 %, at the person of 26 % from duration of all pronouncing a word. On the basis of spectral data authors have drawn a conclusion that between a sound "i" in pronouncing the human and a parrot there is a basic similarity, in case of precise pronouncing, spectral characteristics correspond human.

In the given work imitations of human speech by species of sparrow and parrot family have been investigated. Imitations of speech of two grey parrots and a starling-mynah contain a lot of noise components, in most cases had no harmonious structure, and at vowel-like sounds it was impossible to determine frequency of the fundamental frequency. But, nevertheless sounds with strictly harmonious structure took place at the mynah, in rare cases at two grey parrots, and is frequent enough at the third grey parrot which research has been begun recently. Imitations of words at all birds were precise enough, but with smaller than for the human duration and, definition of a category of a vowel sound, after its allocation from a word, has often been connect with greater difficulties.

For all three birds it has been shown [1], that on the basis of values of two most expressed spectral maxima, it is impossible to divide various categories of vowel-like sounds, in connection with a wide scatter of values. Therefore the measure gained earlier for vowel-like vocalizations of babies, which sounds has been used as were not divided on the basis of values of formants, in connection with high frequency of a fundamental frequency [9]. Character of allocation of dependence of peak values from frequencies of spectral maxima has allowed to part precisely categories "a", "o" "i" for the mynah and one of grey parrots. But for the second grey parrot the distinction have appeared not so obvious.

The given work it is carried out research of vowel-like sounds of the second grey parrot, subjected to the auditor analysis.

MATERIALS AND METHODS Record the grey parrot Kuzia belonging A.A.Tikhomirov, has been lead on tape recorder SONY TC-D5 Pro II (non-uniformity ± 3 дБ in a frequency range 40 - 17000 Hz), in house conditions. Numeralization of records was carried out with use of 16-digit sound card Creative Labs AVE 64, with frequency of digitization of 44100 Hz.

From whole vocal repertoire of a bird imitations of words of human speech were found. Besides them, in record there were specific signals of a bird and imitation of mechanical sounds. The tool analysis of the vowel sounds isolated from precisely said words of human speech was carried out. Vowel-like sounds were allocated on uniformity of sounding, on uniformity of the dynamic spectrogram and the waveform of representation of a signal.

The spectral analysis of sound signals was carried out on the basis of fast Furrier transformation, data were weighed by means of Hamming window with 1024 filters.

As imitating vowels, in most cases, were not harmonious, the spectral maxima necessary for definition of a contour of spectrum envelope of a signal were analyzed all. It was whenever possible to define carrying and modulating frequencies of an analyzed sound.

The auditor analysis four hundred vowel-like sounds has been lead. The series of sounds intended for listening by auditors, consisted of fifty pronouncings, each of which repeated on three times with an interval 400 ms, various sounds have been divided by an interval in two a second. Series were demonstrated to the various groups of students which are not heard these sounds earlier. Before auditors the task was put to designate they hear what vowel sound (any), or to put a crossed out section if the shown sound cannot be distinguished as vowel-like. It has been received twelve variants of the answer (Cyrillic «а», «о», «и», «у», «ы», «е», «ю», «я», «э», «ё», a non-uniform sound, not a vowel-like sound). Reliability of reference of a sound to one of categories was determined by binomial criterion.

On the basis of the received values of amplitudes and frequencies of spectral maxima for sounds authentically identified by auditors with one of categories of vowels (a, o, i, u) a database was formed. Relations of amplitudes of spectral maxima to the first for each sound have been determine. Further the received values in each category, on the basis of frequency have been distributed on groups to corresponding critical bands of hearing of the human [10]. Medians of relations of amplitudes have been calculated and the amendment on audiogram for a median in each critical band is entered. Distributions of dependence of relations of amplitudes of spectral maxima from their frequency for each category of vowel-like sounds as a result were constructed. Reliability of distinctions of distributions was determined by Kolmogorov-Smirnov criterion in each critical band.

RESULTS From 400 sounds 78 sounds as concerning to a category "a", 24 sounds - "o", 108 sounds - "i", and 34 sounds - have been authentically determine "u". The others or have not received enough of identical estimations, or have been authentically determine as concerning to two and more categories of vowel sounds. The assumption that categories of authentically identified sounds will possess more obvious differences was not justified. Sounds met harmonious structure seldom, and all the others had attributes of amplitude modulation. Distributions of values of frequencies of two most expressed spectral maxima on two formants space, in the same way as well as for all weight of sounds, were overlaped.

Construction of distributions of dependence of relations of peak values of spectral components on frequency for the identified vowel-like sounds of a grey parrot has shown (Fig. 1), that distributions for categories "u" and "i" keep various character. The sound "i" has one maximum of a spectrum in high-frequency area, the maximum of a spectrum of a sound "u" is in the same frequency range, as for "o", but values of relations of amplitudes at "u" it is much less.

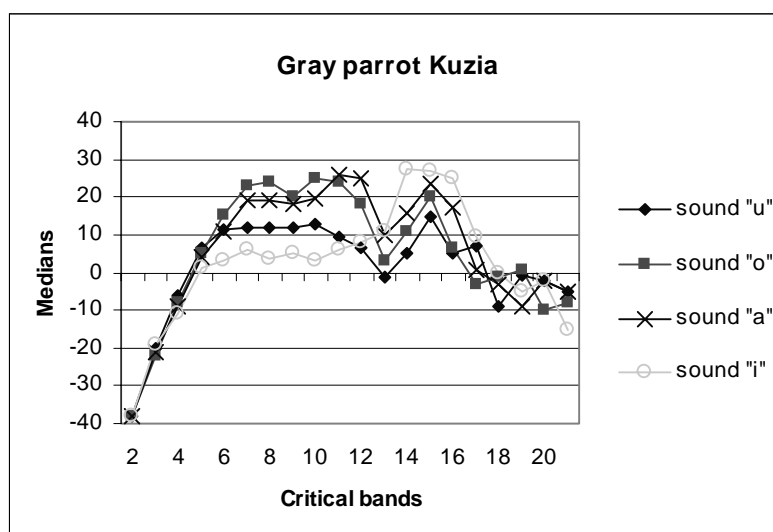


Fig. 1. Dependence of relations of amplitudes on frequency of spectral maxima for categories of vowel-like sounds "a", "o", "u", "i" imitated by grey parrot Kuzia.

On an axis abscise - number of a critical band, on an axis of ordinate - relations of amplitudes, dB.

For sounds "a" and "o" distinctions have appeared are less obvious, both categories had maxima of a spectrum practically in identical critical bands though

for a sound "a" it had hardly great values of frequency than for "o". Thus if for sounds "a" and "o" mynah and a grey parrot Roma distribution of dependence had similar character, for parrot Kuzia the relation of amplitudes of spectral components have appeared much more (Fig.2).

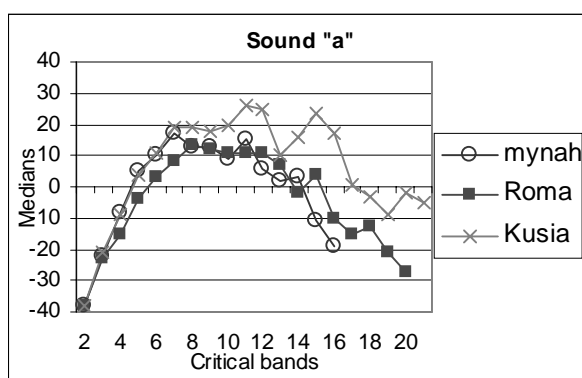
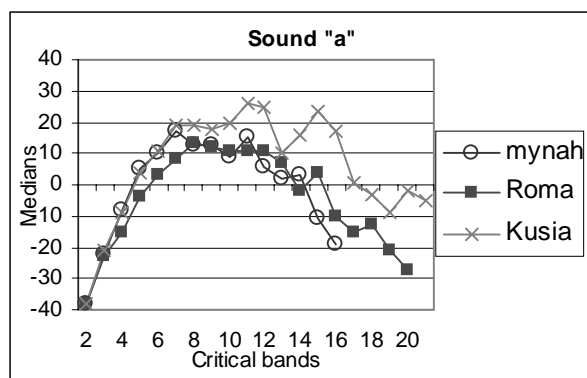


Fig. 2. Dependence of relations of amplitudes on frequency of spectral maxima for categories of vowel-like sounds "o", "a" imitating by gray parrot Kusia, Roma and mynah Chika.

DISCUSSION Results of this work have shown, that spectral characteristics of the vowel sounds imitated by speaking birds, differ a significant variety which does not interfere with an opportunity of identification of a category of a sound various humans.

Sounds "o" and "u" were identified by auditors much worse than sounds "a" and "i" that can be result of greater value for these categories of contextual influences. As it is possible to assume, that in case of the vowel sounds simulated by grey parrots, a category "a", "o", "i" have one significant spectral maximum which is in different frequency ranges for each category, but value of these ranges are various for each bird, and due to it more exact definition of a category is possible only in comparison of sounds with each other.

Acoustic characteristics for two kinds of the investigated birds approached as under criteria harmonious, and amplitude-modulated, for different individuals in a different degree. In view of data for mynah [4] and grey parrots [5] it is possible to assume, that flexibility the syrinx of these birds, and imitation not specific signals can conduct to that each individual can use various mechanisms in a different degree.

Thus, results of the given work have shown, that the vowel-like sounds of talking birds authentically identified by independent auditors, have no values of frequency and amplitude of spectral components of more stable than for the sounds allocated only on the basis of sounding in structure of a word.

Work is executed at support of departmental scientific program «Development of scientific potential of the higher school », №4727.

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