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CAN WE ACCEPT THE SOUNDS MADE BY ANIMALS TO BE PERFECT IN THEIR FORMATION ILLUSTRATED IN SOUNDGRAMS

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Abstract

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In representatives of two animal species - an African gray parrot (*Psittaccus erithacus timneh*) and a Wolf (*Canis lupus*) are registrated soundgrams (graffical records of sounds). In the first case the parrot is accurately reproducing the well learned phrase „Obicham te“ (I love you), imitating human speech. In the second case is represented an extraordinary record of a human male (researcher), who imitates in a sophisticated and exact way the wolf howl. Those record are compered to the same kind of vocalization in human and accordingly a wolf and then analysed by amplitude, frequency and other modulations, thereafter presented as a graphical registration.

Key words: soundgrams, African gray parrot, wolf, sound, glottis, sound formation

Introduction

The larynx was originally developed as a device to protect the lower airways against the entrance of food and liquid, which is its main purpose. The other function of the larynx is in phonation – the production of voice, which developed later in the evolutionary history to achieve its perfection with humans.

The sounds of human speech are more complex than those produced by other species, although no greater complexity of laryngeal structure is present. Indeed the complex laryngeal mechanism is not indispensable to this task.

The larynx in birds is placed below the pharynx and consists of two structures - larynx cranialis and larynx caudalis. Larynx cranialis is what we know as larynx in mammals and represets a horizontaly possitioned mucosal fissure behind the tongue’s root. When swallowing it closes, and opens when breathing. Larynx caudalis (also know as Syrinx) has a strictly vocal function and can be reffered as the main soundformational organ of the birds. (Kent and Carr, 2001).

Dyce (2010) described the syrinx as formed by the terminal part of the trachea and first parts of the primary bronchi. The tracheal cartilages of the syrinx are sturdy, but the bronchial cartilages are commonly missing, although a short vertical bar (pessulus) separates the bronchial openings. The lateral and medial walls of the initial segments of the bronchi are membranous and produce the voice when caused to flutter (the characteristics of sound – pitch, frequency, etc. depends on the vibration of the membrana tympaniformis interna). Depending on their stretchability they control the pitch and the frequency of the emmited sounds. Membranes can vibrate independently from each other with different fundamental frequencies and modes). This gives birds the ability to simultaneously produce various sounds.

A small paired muscle, the sternotrachealis, pulls the trachea toward the syrinx and aids in vocalization. An elaborate set of five pairs of syringeal muscles is present in Passeriformes (songbirds), which according to their stretchability control the loudness and frequency of vocalization. The surrounding interclavicular air sac gives the voice resonance and increases the sound by resisting the membranes. In the throat and the air pipes the sounds are modulated and amplified again. The abillities of the syrinx are impressive. It can play tones from 6 to 8 octaves with a duration of 15 minutes.

The same authors described the following anatomical features in the voice box of psittacines - a median pessulus is missing and despite their great speaking ability, parrots have a relatively simple syringeal apparatus with only three pairs of syringeal muscles.

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According to everything said, a conclusion can be drawn that sound is generated when (Gill, 1995):

- contractions of muscles (thoracic & abdominal) force air from air sacs through the bronchi & syrinx
- the air molecules vibrate as they pass through the narrow passageways between the external labia & the internal tympaniform membranes (or, as in the diagram above, tympanic membrane).

Like humans, songbirds learn their vocalizations by imitation. The syrinx is unique to birds and performs the same function as vocal cords in humans. Birds can have such a complete control over the syrinx, with sub-millisecond precision, that in some cases they are even able to mimic human speech. (Glover, 2013)

In this sophisticated and complex process we must not forget the tongue, the beak, especially the opening of the beak, for shaping the sound that birds make. Similarly, people move their tongues and change the shape of their upper vocal tract and mouth when singing, laughing, talking and whistling. “Vocal tract of the bird, same as the human vocal tract in speech, acts as a resonance filter that can control the sound coming from the mouth.” Beak movements during a song also contribute to this filter, but they are not as important as the changes in the size of the internal vocal tract.

Some parrot species are born with the ability to develop the talent of speech. These birds do not have vocal cords, and produce sounds through the trachea and syrinx, and some also use their tongue. The best speaking birds include: Monk Parakeet (*Myiopsitta monachus*), Budgerigar (*Melopsittacus undulatus*), Eclectus Parrot (*Eclectus roratus*), Rose-ringed Parakeet (*Psittacula krameri*), Amazon parrot, African Grey Parrot (Grey parrot) – it is defined as one of the most intelligent birds in the world and the most babbling parrot. Alex the parrot was as intelligent as a 5-year-old child and had the abillity to communicate as a two year old.

The formation of sounds is a complex nervoreflectory act. It involves organs and systems, such as respiratory, digestive, muscle, bone, etc.. The adjustment of the type and volume of the sounds, songs, etc., is performed by the central nervous system. (Kostov and Alexandrova, 2004)

According to Wild (1997), in birds, as in humans, vocal control involves the intricate coordination of three major groups of muscles, namely, those of the vocal organ, the respiratory apparatus, and the vocal tract, including the jaw and tongue. The pathway in songbirds that controls the syrinx, the bird’s vocal organ, originates in the telencephalon and projects via the occipito-mesencephalic tract directly upon vocal motoneurons in the medulla. This pathway appears to be primarily involved with the control of the temporal pattern of song, but is also highly involved in the control of vocal intensity, mediated via air sac pressure. The dilation of this pathway may reflect the imperfect correlation of jaw movements with the dynamic and acoustic features of song. The brainstem pathways mediating control of vocalization and respiration in songbirds have distinct similarities to those in non-oscine birds and in mammals such as cats and monkeys. However, songbirds and parrots, like humans, but unlike other non-songbirds, have developed a special telencephalic vocal control system for the production of learned vocalizations.

Anatomically examined, the larynx of the wolf shows no significant differences compared to humans - ventriculus laryngis is well developed in both species. The human larynx is located lower in the neck, and is extended in the pharynx and thus the two organs are placed at a relative angle to one another, which is important for rezonation and amplification. In the wolf due to the proximity of these organs, the larynx is located in the same plane with the pharynx, and they ressemble a straight pipe. Perhaps in these anatomical features and changes in the configuration of the structures lies the fact that when howling, the animal stretches its neck. When the head is in a lower position howling is not efficient. This is what allows them to get those high tones that can be heard from miles away.

Wolves make four types of sounds: howl, bark, whimper, and growl. Howling is the most familiar wolf vocalization to everyone. When wolves howl together they harmonize, rather than howl the same note, creating an impression of more animals howling than there actually are.

Auditory discrimination was studied by Theberge and Falls (1967), by stimulus-response experimentation involving simulated wolf howls by humans. By either howling in response or remaining silent, one wolf demonstrated an ability to detect the slight difference between live howls and recorded, played-back ones. This ability enhances the possibility that individual recognition and conveyance of information may take place by means of differences in howls.

Italian wolves’ howl in eastern Tuscany is observed and described by Passilongo et al. (2010). 37 solo and 128 choral howling were recorded and elected and the analysis, made of this data indicates, that the sound frequency is between 274 and 908 Hz. The analysis also shows the maximum frequency and scope of the fundamental frequency as the most important features of the sounds, emitted by the 7 packs.

According to Fitch (2000), the evolution of speech can be studied independently of the evolution of language, with the advantage that most aspects of speech acoustics, physiology and neural control are shared with animals, and thus open to empirical investigation. At least two changes were necessary prerequisites for modern human speech abilities: (1) modification of vocal tract morphology, and (2) development of vocal imitative ability.

Materials and Methods

To decode the language of these three representatives of different species (human, African gray parrot and grey wolf), in their comparative presentation we used complex equipment, consisting of recorders, digital voice recorder, oscillograph, frequency measuring device that makes it possible to read the sound by amplitude, frequency, coding and modulation of the signal. Readings were taken on paper with a speed of movement of 100 mm/s.

In the graphic registration of the language of these species, we were looking for a technical solution that takes into account not only the amplitude of the biphasic period sound vibrations as in computer analysis, but also that the graphs should be close to the zone of the frequency fluctuations.

With the available equipment we achieved a reading of the dynamics of the sound vibrations in the spectrum band, as well as gave a visual representation of the modulated syllable in the coded signal.

Results and Discussion

The African Grey Parrot (*Psittaccus erithacus timneh*) is one of the best representatives of the 'talkies' birds. For a short period of time they can "learn" phrases and sentences from the human language and remember and pronounce them for different periods of time. When listening to the monologue of their "speech" of imitated words, it seems to us that they are truly and accurately reproduced.

In the soundgrams made of the words "Obicham te" (which means „I love you" in Bulgarian) spoken by the parrot Thea and a man, a big difference in the phonoformation and the syllabicformation is seen (Figure 1).

In the soundgram of the parrot, the field of spoken words is clearly outlined, but it is in the general contours of the module "a". The profile of the module gradually rises and remains at one level for a short time, and then more gradually returns to the center line. It is imposed all along with low-frequency and low-amplitude waves.

The human soundgram reflects each syllable of the phrase - "o", "bi", "cham", "te" saved as separate submodules "a". Each submodule has its distinctive shape, its amplitude and frequency response, separated from one another by varying lengths of pause. These features correspond to sound-submodules, the coherent and intonational ability of the human in formation and recognition of speech and language as a method of communication controlled by specific neural structures (areas, fields) in the cerebral cortex.

In addition to integrating all types of sensory information and coordinating voluntary movement, all cognitive functions (speech, math, learning, memory) are located there as well. Frequency of sound – 500 - 2500 Hz.

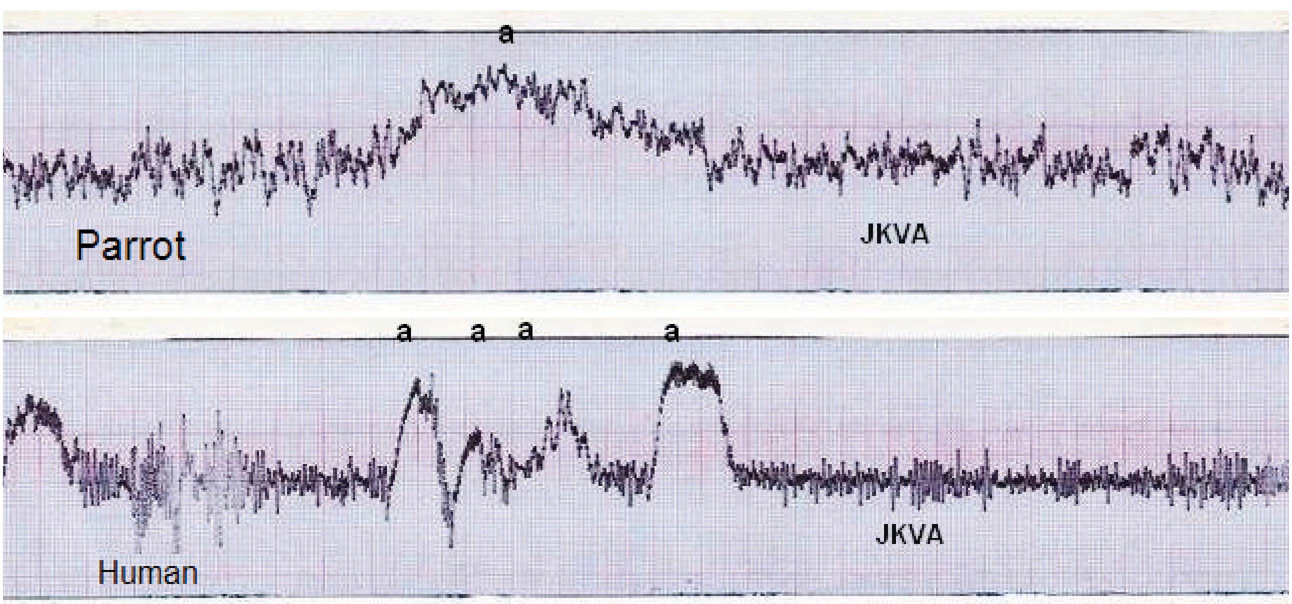

Fig. 1. Soundgram of the phrase „Obicham te", pronounced by the parrot Thia and the human

The cortex in birds is less developed and there is no direct connection to the spinal cord. Singing and speech functions in some members of the feathered are determined by the brain. In parrots it is eight times greater than that of chicken. In parrots, complex mental capabilities are observed as well. Immediately after the nervous system, hormones play a particularly important role in the communication and management of the body.

Different sounds of a wolf (*Canis lupus*) are recorded, especially during the breeding season. In grouping of individuals in a pack, wolves emitte long sounds, which are deffined as howling.

Figure 2 shows such a record. Module "a" begins with a few short fluctuations, with varying amplitude, that return to the baseline level. Rapid rise of the curve in another band and holding it long plateau with superimposed low-amplitude waves follows. The module ends with some brief downward fluctuations. Frequency - 1130 Hz.

Large Brain Capacity - Skull capacity allows adequate space for an advanced cerebral cortex (brain) necessary for coordinating group social activity.

The soundgram in row 2 of the figure spikes a great deal of interest, showing an amazing record of a person (researcher) who imitates a wolf howl in a wonderful way. In the record, the performance and the accuracy of imitation is so perfect that it corresponds to the supplied pack howl. This is confirmed by the soundgram, where the registered curve is very similar in characteristics of the recorded unit and resembles that described in the wolf (first row in the Figure 2).

Kardong (2008) describes that human words are build up from carefully formed sounds calles phonemes. Animal communication with sounds is mainly an emotional response to immediate circumstances, but in humans phonemas carry ideas and thoughts about past events or future actions. The combination of sounds, the relationships between them build words, which placed in order form sentences. Our speech apparatus has changed anatomicly to serve speech by lengthening the pharynx, which was accomplished by the separation of the soft palate and epiglottis. By such lengthening, air can be effortlessly channeled on a sustained basis through the mouth, where it is shaped into sounds. Wolves can sustain a howl by lifting their heads, stretching their throats, and thereby temporarily lengthening their pharynx. As opposed to nonhuman animals, where the larynx sits high in the neck and fits into the nasopharynx at the back of the nasal passage, in humans the larynx has dropped further down**.**

Kostov and Alexandrova (2010, 2011) accept that in animals with well developed audio system (vocalization) probably synthesis (pulse modulation) is used to modulate the waves. They are located in the zone of the bandwidth. They define them as "modules". A module can contain a different number of "submodules" and to be dotted with or imposed with more oscillations of varying frequency and amplitude.

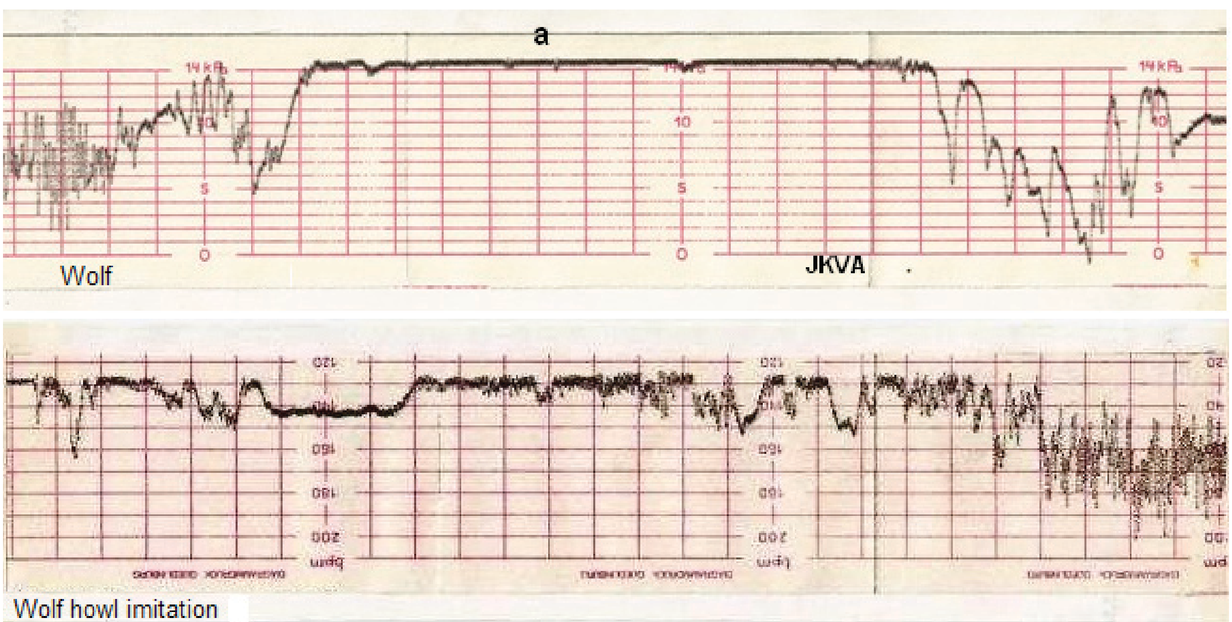

Fig. 2. Soundgrams of wolf and the imitation of the wolf howl

In this case, in the concept characteristic of human speech, the modules can be assimilated with syllables and phonemes with submodules.

The codes of language are built on the duration of modules and their combination on similarity or difference in shape and their spatial location in the band. So by the combination of modules in the process of encoding the signal phrases (of identical or different modules) and topics (same or different by construction phrases put together) are formed in the language of animals.

All this allows us to offer and use the term "soundgram" which gives a better picture and idea for the graphic recording of the sounds, emitted by animals. (Kostov and Alexandrova, 2009)

Unlike our choice of method for recording and modulation, the widely used method is to record spectra. It gives an idea and only shows the spectral density of the signal variation over time (It presents the spectra of the sounds of speech in a graphic way). Spectrogram is used to identify phonetic sounds, to analyze animal sounds, or in other areas such as music, learning spoken language, seismology and more. Devices for playing spectrograms are called spectrographs or sonographs.

The smallest unit of the recorded spectrogram is the note, or more precisely leitmotif called theoretical syllables. Repeated syllables are called tours. The different stages form "stanzas".

Conclusion

After all the facts, observations, and research results, described above, we should make several conclusions:

- Animals have their own language for comunication, which is strictly coded and modulates depending on their physiological condition and the impact of the environment. The different species have a certain plate of sounds for intraspecies comunication, which is inherited and gained through the ontogenic development of the individual.
- For the presented species (human, African gray parrot and wolf) the identifying characteristic and the anatomical features in the structure of the "voice box" are clearly seen, splet apart in the process of evolution, making these representatives (as well as most species in nature) unique in the formation of their language and communication.
- The ability of some talking birds (most noticeably Timnehs), although only mechanically, to resemble to some extent human speech, lies in the synchronization of the work of the brain centers, responsible for voice-forming (a special telencephalic vocal control system) and those that control motor activity of the muscles involved in vocalization, and especially those responsible for the movement (opening and closing) of the jaw (beak) and tongue.
- In both species - human and parrot, learning of syllables and phrases unnatural to them is due to accustomation, imitation and experience.
- Man was the only representative, who could imitate the sounds of wildlife in such a manner that fully complies with both auditory (mechanical) and with the way of coding (modulation) of syllables and phrases in sound, expressed with soundgrams.
- This unique ability of humans is the result of evolutionary development of his second messenger system - thought and speech (language), as thought preceds speech, due to the complex associative links and centers in the neocortex - the highest level of control.

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