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THE SINGING OF PRIMATES

The study of the melodic expressions of other animals arises questions and as many lines of research that help us to understand better, through different (but not necessarily complementary) perspectives of investigation, the origins of the musical ability of our kind. To avoid confusions it is necessary to distinguish the matters inherent in the basic mechanisms involved in the musical ability (evolutionary change, neurophysiological substratum), from those of evolutionary function (adaptive significance) and history (phylogenesis). One of the matters on which the research efforts are assembled is to understand if birds, whales, gibbons and human beings uses same neural network and comparable neurochemical balance when they sing, and in particular if this ability may influence their reproductive performances (fitness) and therefore the propagation of the genes in the generations to follow. Probably, the understanding and the resolution of these issues could lead to a better overall view for the evaluation of the characteristics of the evolutionary history of music systems (Hauser 2001).

A first step in this direction that could provide interesting insights regarding the evolution of music, may be the examination of the vocal repertoire of non-human primates in order to measure both the referential and affective components of the emitted signal. Since the end of 1970, studies in monkeys have revealed the existence of conceptual tools producing the idea of the presence, in those animals, of a system of referential communication (Premack 1986). In 1980 he made a crucial experiment (Seyfarth et alii 1980) that brought to reconsider the idea that animal vocalizations reflect changes in emotional state, and emotional reasons. The meaning emerging from a study conducted by Struhsaker (1967) is that the vervet monkey (*Cercopithecus aethiops*) produces three different types of alarm in response to three types of predators: the big cats (leopards), raptors (martial eagle) and snakes (pythons, mambas). Exactly the close association between the type of call and the response that follows, suggests that such signals may function as a label for each different type of predation: the animal will climb the highest branches of trees at the presence of leopards or hide under a bush or branches if it is warned of the presence of an eagle, or more if the signal indicates, instead, the proximity of a snake's the response will be to stand bipedally and scan the ground nearby.

Each of the answers is of course the result of the presence of an acoustic division that allows different sounds for each type of predator behavior and then generates a result, the run or the patrol, a general alarm, in fact, would be a failure because it would require the detection of the real nature of the hazard resulting then in a vulnerability (Hauser 2001). Based on these results, Cheney and Seyfarth (1990) gave a more sophisticated function and meaning to the monkey vocalizations. It is clear that some of these are functionally referential vocalizations (Marler, Evans, Hauser 1992), that are salient within the environment, similar kinds of references were also tested in other species (ring-tailed lemur, macaque rhesus macaque toque), and in the domestic chicken (Zuberbühler et alii 1997). What emerged from these studies is that signals are often associated with food. According to a recent hypothesis supported by Ouattara, Lemasson and Zuberbühler (2009), the signals delivered by a monkey to indicate specific external events show their ability to change sound during the production of the call that is functionally equivalent to the suffixation in human language. This hypothesis is supported by the theory that human language has evolved on a biological substrate that has deep roots in the phylogenetic lineage of primates (Hauser, Chomsky, Fitch 2002). Certainly, fundamental for this thesis has been the study on Campbell's vervet (small arboreal monkey of West Africa) that made possible the identification of form of "words" in the sounds of alarm calls. The three words uttered were: BOOM! To tell the group about the falling branches or the moving into a new corner of the forest; HOK! To indicate the presence of prey eagles; KRAK! To warn of the presence of a leopard. the extraordinary ability of vervets to create different expressions from the three major, by adding a suffix, which resembles the construction of the adverb in our language (which is obtained by adding "mind" at the end of the adjective) is surprising. The suffix in question is "oo", with this trick the monkeys have created several variations: for example, "hok-oo" has the meaning of "Attention! There is something in the trees". Furthermore, the vervets are able to develop even a "sentence" with 25 vocalizations that, combined in different ways from time to time, provide information on the nature of the risk (Ouattara et alii 2009).

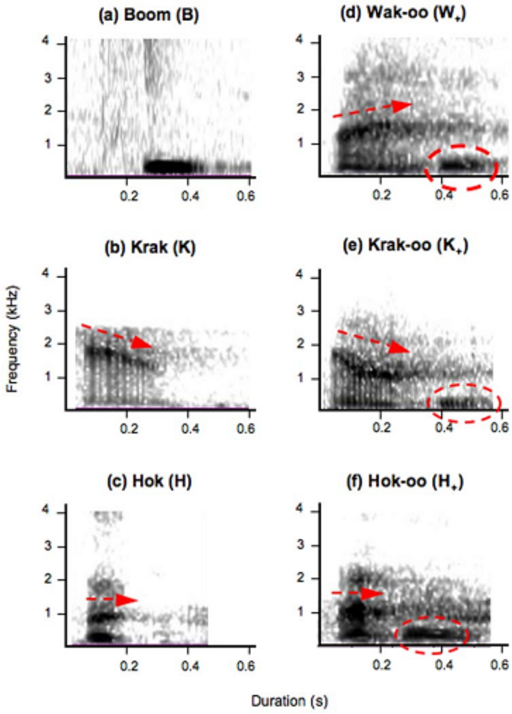

Figure 1: Spectrographic illustrations of the different loud call types produced by Campbell's vervets in different contexts. From Ouattara et alii (2009).

For almost sixty years, research has been conducted on a population of monkeys that live in the *rhesus island* of Cayo Santiago (Puerto Rico). What impressed the researchers was that, when rhesus find food, they give one or more distinct vocal signals: warble, grunts, harmonic vocals. Even if they were fed daily with forage products available in nature such as leaves, fruits, insects, grass, however, they raised the calls. The research carried out in recent years have focused on some interesting questions:

- How does motivational state affect the production of food-associated calls?
- Does each call type refer to something like the kind of food or its relative quality?
- When rhesus monkeys hear the calls, how do they classify them?

Based on a large sample of adult males and females, we examined the change in the production of the recall as a function of food consumption and time available depending on the level of hungry, the food was placed in the dispenser in the morning and then again in the noon the next day was added from 4.00 PM to 8.00 PM. From this evidence it was assumed that they were more hungry in the early morning and late afternoon were full. You can see that the males produced less food-calls than females and that, as in most mammals, males left the group to reach their sexual maturity while females remained in herds. In addition to differences of a sexual nature, it was discovered that the rate of production of food-calls would rise before the peak of food consumption and then fall rapidly after food consumption, suggesting that the percentage of appeals is correlated positively with the level of hunger. To further investigate the relationship between the level of hunger and vocal production, it has also been considered the relationship between the frequency of call signs and the time of an individual to reach the food placed in the dispenser, while the food was placed in the dispenser, one or more groups would sit next to the fence waiting to eat.

From the graphic below we can see the relationship between speed (call / min) of Food-Calls of rhesus monkeys and the latency time (in minutes) to get the dispenser of food (Scherer and Kappas 1988).

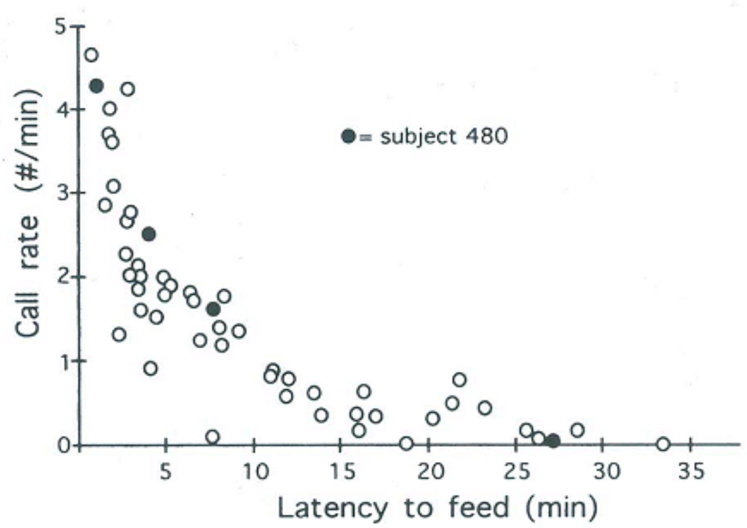

Figure 2: The relationship between rate (number of calls/minute) of food – associated calls and latency (minutes) to arrive and feed at the chow dispensers. From Scherer and Kappas (1988).

To contribute to eventual comparisons with new studies the changes in the acoustic structure of rhesus monkeys during recall at the time of the meal have also been examined, as we see from the chart below there are two common situations reported. Early in the morning the monkey starts moving toward the distributor of food when the staff arrives the monkeys begin to coo (COO) waiting for the food, but everything is done with minimal vocal effort, it is relatively low and its frequency is flat. When food is placed in the machine a morphological change happens and individuals put more effort into the call. Examining spectrographic analysis this changement in the production seems to cause greater vocal turbulence at the top of the chart, you can analyze the sound made while waiting in front of the machine who is, in fact, without any alteration harmonic.

The second sound of the harmonic structure shows instead a break for a short period of time, while the final part of the harmonic structure is almost completely stopped. These changes are perceptible by the ear. In the second part of the graph we have the representation of a male adult who sees a coconut from a distance and then get closer to it. The first three calls made before and during the sighting of the coconut can be classified as a sort of grunt, but in the phase in which the male grabbed and ate the coconut he produced two harmonics sounds. In contrast with the first box so here we see a change in call type voice generated by the capacity of the structure to implement the changes. The hypothesis at this point would be that the rhesus monkeys implement changes in emotional state when approaching the food, which can lead to more important morphological changes as the switching from one type of calls to another. This would be corroborated by observations of free individuals in nature that showed systematic differences in different contexts producing different types of calls, especially trills and chirps were produced by some individuals when food as rare as a coconut was found. These forms of grunts were sometimes accompanied by other types of calls that were primarily generated as a response to the search of less refined food. The morphological and spectral characteristics of the types of calls refer then to the found of a rare food by an individual or the type of the food (Hauser 2001).

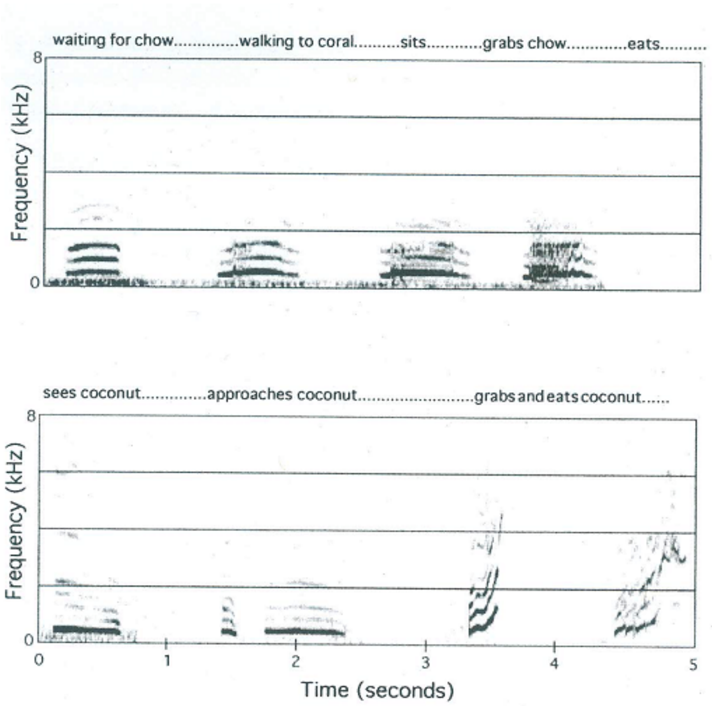

Figure 3: The upper panel shows changes in acoustic morphology of the rhesus coo vocalization as a function of proximity to chow. From Hauser (2001)

Given the understanding of the contexts and functions associated with food recalls, an experiment was set up to determine how these recalls can be classified. A technique employed in the understanding of the developmental processes underlying the development of vocal prelinguistic infants has been borrowed for this purpose, that is a process of habituation and discrimination used to determine if the acoustic morphology was the driving factor in the classification of the calls of rhesus monkeys for his food. This procedure was performed on field upon a group of vervets monkeys (Cheney and Seyfarth 1990), the experiment focused on three types of calls: warble, harmonic sound, grunt. These sounds are acoustically different but the warble and harmonic sounds are produced in the same context and therefore may have a different meaning from the grunt, although a change in perceived noise level has been observed, the same is not necessarily accompanied by a semantic change. Tested Individuals participated in a session Within-Referent (used to warble and sound harmonic) and Between-Referent (used to warble and grunt and vice versa), the caller's identity was kept constantly hidden during the session. Several specimens with various types of call were used until the tested individual was unable to look in the direction from which the sounds were coming, once used to this environmental context a signal of a specimen with a different type of call has been reproduced. If the individual showed some interest the test session was considered over, if any answer was given instead, the session was repeated but with a new type of call, the second condition could occur either because the animal grouped stimuli in one category by its perception, or because he was accustomed to all the sounds coming from that area. The session Within - Referent individuals showed a greater response in the case of harmonic sounds among trills made them heard, all the participants failed the test in two consecutive trials as evidence in the trial were not able to respond suggesting that trills and harmonic sounds were grouped in one category, even if they were acoustically different (Figure 4). Coherent responses have been obtained whithin a session of Between – Referent even if the answer has been subordinated by the presence of pre-stimulus during the habituation phase, especially when the subjects were accustomed to the grunts they showed a significant response to trills and harmonic sound. When they were accustomed to warble their responses to the growl were instead low.

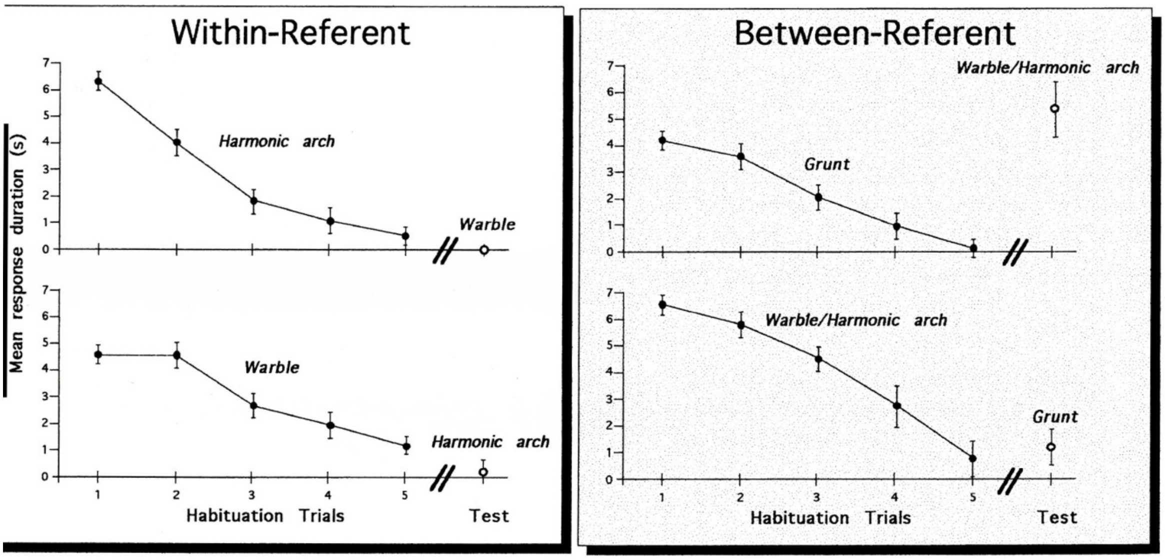

Figure 4: Results from Within- and Between-Referent sessions. From Hauser (2001)

What remains then to understand is why three different sounds are used to refer to the food. data suggest that in some animals the morphology of the acoustic repertoire consists of several components that question the status of calls and other emotional components that relate to objects and events in the external environment. The most radical idea about this matter is if the animal vocalizations can't approach the referential power of our words, both in objective terms than instates of mind, it may nevertheless be sufficiently advanced to justify the classification as a precursor. Before to deal with these issues it would be appropriate to strengthen our understanding of other animals, because if it is believed that the vocalizations of primates represent a form of proto-language, then this implies a more precise conceptualization of the morphogenetic instruments of human primates as well as the type of selection pressures that occurred during the evolutionary history of humans and nonhuman primates.

An interesting example of vocalization (and maybe the most complete) is produced by gibbons, whose main specialization are, in fact, the vocalizations emitted especially in the morning, gibbons produce long and high sound that differs by species and environment it has a duration ranging from 10 to 30 minutes, although there was a continuous sound emitted by a male Hylobates lasting 86 minutes. The songs are preferably articulated early in the morning while there are others produced in specific times of day, these are stereotyped and species - specific. The species can be identified through their songs and their vocal characterizations used to establish systematic relations among Hylobatids and reconstruct their phylogeny. Another, further specialization is the accuracy of all the singing duet with the exception of gibbons Hylobatids Kloss and Hylobatids Moloch. The duets are sang by a couple of mates, they usually combine their music with a certain rigidity in order to arrive at clear voice interaction to produce a good duet. The males of many species of gibbons produce one ore different types of phrases that often become progressively more complex (by the number of notes, number of distinct types of notes, modulation frequency), as a song procedees. During the execution of the song the contribution of the male sex in the exhibition shows a form of gradual development that goes from the expression of simple phrases to most complex ones; the contribution of females is given with a strong call of stereotyped type and shows a form of locomotion to the apex of the call. In many species instead, the male contributes with a "tail" in order to follow the call of the female and can also participate in his show (Geissman 1993).

For more or less regular intervals, we can have specific phrases usually produced by female exemplary that may affect the degree of relationship, in many species the call of relational degree consists in a particular series of rhythms made of from long notes with an increment of duration in peak frequency. Males usually stop when vocalization began a recall of kinship and reproduce a sound response (tail) to the relational degree call, before starting to sing their "common phrase". In addition, one or both partners may exhibit movements as violently shaking the branches of trees, the call of kinship by the female and the subsequent tail of the male will be repeated many times during a single short-singing. This is obviously a simplified description of the duet of the gibbon, but we must also consider the fact that the species of gibbons also produce other singing sequences, the females of many species in fact help with sentences as the duet of the call of kinship is considered stereotyped. In Siamangs (Hylobatids syndactylus) and Hoolock (hoolock Hylobatids), interactions whithin duets are much more complex and even the recall of sequences in the degree of relationship and the corresponding tail, includes several phrases and vocal interactions between males and females. At present time, the duet of siamangs is probably the most complex musical singing made by a terrestrial vertebrate further the human (Hauser 2001).

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