# Syntagms and paradigms in Zoomusicology

The organization of animal signals, and particularly of birdsong, offers a strong convergence with human speech and music. The importance of this fact has only been fully revealed thanks to the recording and analytical devices which are now available. The quickness of the tempo in most birdsong is such that a detailed analysis by ear alone is impossible, and their complexity is also such that only a transcription allows precise comparisons. As most researchers are only interested in physiology, acoustics and behaviour, study of the syntax of animal signals has been comparatively neglected, and remains widely unrecognized and disregarded.

When the methods of structural analysis have developed in the American context, where the point was to interpret the vanishing Indian languages, the ideal of a phonemic analysis carried out with purely formal criteria - without refering to meaning - had sometimes been claimed as a critical case where a rigorous structural analysis could make up for the want of informants. A language could be understood from the mere analysis of the "neutral level" of the stocks of recorded documents. It has been realized since that such a view is broadly utopian, as practically no definition of discrete units is possible without a ratification by semantic criteria. At this point, transformational grammars and cognitive psychology came to the forefront.

The domain of animal signals offers the peculiar case of a set of sound phenomena which are sometimes highly organized, but whose analysis is apparently doomed to keep to the neutral level. Sure enough, on coming out of the pre-scientific era when one imagined that the language of birds could be translated, and was even understood by a few initiates, any attempt to relate sound features to significations has been limited to the study of behaviour ; and as the diversity of this was much smaller than that of the more elaborate songs, the ethologists have soon decided that the few hundreds of species, offering songs both varied and individual, were characterized merely by a phenomenon of redundancy. This word designates what makes very different signals induce similar behaviours, and consequently leads one to consider them as roughly equivalent. In that respect, the ethologic point of view constitutes a pure denial of the kinship of animal signals either to speech or to music, or to both.

Now, the species which have individual songs can create sound structures which are phonetically and syntactically coherent : how can one bring out the laws of such a coherence, and compare them to those which prevail in speech and in music ?

Distributional analysis seems the best possible basis for the study of that everlasting "neutral level" to which animal signals apparently belong. With the simple criteria of pauses, associated elements, recurrences, combinations of the same and the other, a description of the relevant units and their groupings is made possible.

When a song uses evolutions : going up and down the scale, transforming smoothly an element into another, crescendo or decrescendo, the distributional analysis is more complicated, while still possible. But that sort of transformation is on the whole rare enough among animal signals. In the song of the skylark alauda arvensis, which I shall take as an example throughout this lecture, the steadiness of most of the sounds is such that it is possible to undertake an exhaustive list of them. Such a catalogue is likely to contain several hundreds of entries.

The skylark has a song which can be likened to a moto perpetuo : for one or several minutes uninterruptedly, it will utter sounds which either occur only once, or are repeated more or less often, and which present a very large diversity, including occasional imitations of other species. Figure 1 shows, in sonographic transcription, an example of a series of sounds which appear identical throughout their numerous recurrences. Later on, we shall see the complete song from which it has been extracted. Following each other, the original signal ( duration : 444msec ), then a downward transposition by one octave, then by two , and three octaves, with durations of 888msec, 1".8, and 3".5 :

Figure 1

One sees that the changes in scale gradually bring forward to human ear some sound phenomena that were imperceptible before. The problem which is set by this fact, concerning segmenting, may seem difficult : for example, in a sound unit as 8 e do we stand at "phonetical" or "lexical" level ? Or more precisely, must we distinguish levels, considering the great difference of time apprehension in bird and man ? What seems to us a somewhat complex note might be a motive or a phrase for the animal ?

Two arguments allow us to roughly solve that question. First the difference of time perception, which enables many animal species to discriminate two sounds distant of only 1/1000 sec, whereas man needs 1/25 or at the best 1/100 sec, does not seem to be linearily proportional. I mean that it does not suffice to multiply by a constant factor, - say 40 -, the scale of the durations as perceived by man to be able to imagine the ones the animal perceives. The capacity of some animals ( dolphins, mynahs etc.) to imitate human signals , as well as some

composers' use of animal sound materials do show that there is no complete incompatibility between both time worlds. Moreover, the primary aim of distributional analysis implies that one does not care basically about human or animal perception, but solely about the internal organization of the sound "message". So, at least at a starting point, any question of perceptive relevancy has to be dismissed.
In order to allow those among you who have no very precise idea of what is a birdsong of some somplex organization, I think it may help to give an example in sound and score. Here is a complete song of a skylark, transposed downward by an octave ( and consequently with durations doubled ). The visual representation uses the usual sonographic transcription, obtained on a MacIntosh II with Signalyse software :

Example 2

The rigorous applying of distributional analysis implies that one makes basically no distinction in level or duration, and that one takes into account only the relationships, along the syntagmatic axis, between the categories of the same and the other. The criteria of pauses and shifts in frequencies are sufficient. As the song of the skylark is characterized by a low variability of the sound units, it is easy to identify them. The song we have just heard can schematically be analysed this way, designating by a single symbol any sound or set of sounds which can be segmented according to its recurrences in different contexts :

Example 3

You can see that the bird proceeds by putting together different subsets inside which it juggles more or less dissymetrically with a particular stock of sound elements. Sometimes, it comes back to one of those subsets for a novel variation. For example, the subset C could be designated as A' , and the subset L as I'. It is to be noticed that the end of the song presents a rate of recurrences much smaller than the three first quarters.
Obviously, the provisory terminology I have just been using has some practical drawbacks. But is it possible, at this point of the analysis, to define syntagmatic categories which do not risk to be called again in question by further analysis ? As it happens in phonemic analysis, the conclusions can only be confirmed at the end of an exhaustive checking, because such and such grouping which is apparently indivisible may be later dissociated, in another song, and compel us to redistribute the symbols. Such an exhaustivity being unachievable in our field, how must we do ? Until XXth century, the efforts bore on typology, not on

criteria for segmentation. Since the times of Father Kircher, and his Musurgia universalis published in 1650, several terminologies have been proposed by musicologists, and more recently by biologists. They have nearly never been justified by very elaborate arguments ; but, as the musicologists themselves did not yet agree upon their own terminology, they could not reproach it to their scientific collegues.

Kircher would distinguish three sound types among birds : glazismus, pigolismus, and teretismus. Of these three terms, only the last one exists in ancient Greek, meaning warbling. The two others seem either to be invented, or perhaps borrowed from some Byzantine writers, and mean probably utterance and compactness. Whatever their exact meaning, glazismus , according to the examples given, refers to the close repetition of the same sound ; pigolismus to a fast oscillation between two pitches ; and teretismus to a fast group of sundry elements including a noticeable amount of repetitions .

According to Bondesen, in his work North American Bird Songs , published in 1977, 5 types of notes or syllables can be recognized : the staccato, or quick repetition of a constant tone with rather pure timbre ; the glissando, or quick shift in frequency upward, downward, up and down, or down and up ; modulated warbling , a note composed of elements differing in timbres and frequencies ; and the stroke, a very fast simple or double glissando lasting less than 50msec.

If some precise duration criteria were sufficient to define a typology of that sort, most of difficulties would be over. Problems arise from the fact that the length of the elements separated by pauses is extremely variable, and that some continuous elements last much more than some complex successions of numerous units. Is the main relevancy duration or morphology ? In other words, can a purely distributional analysis be carried out ? Before answering, let us show two instances of that fact, represented at the same time-scale, and both borrowed from the same song. Each series of sounds is figurated by an oscillogram above and a spectrogram below :

Example 4

So, at this scale of about half a second, one single symbol designates now a unique sound, and now a rather important series of different sounds. It is the more necessary for the terminology to try to bring some precision, in order to avoid confusions. Trying to take into account criteria both quantitative and qualitative, I tentatively propose these terms, of which several are already commonly used :

The phonatom is the most simple and indisputable unit. It can be defined as the

smallest continuous sound element.
The note is much more controversial, and includes many forms. It can be defined as one or several ( maybe up to 10 ) phonatoms associated by a relationship of extreme closeness in time ( ranging from about 3 to 30 msec), and/or of identity in register or timbre. The staccato is a note consisting of a repeated phonatom, similar to the glazismus of Father Kircher. When the repetitions deal with elements which range from 1 to 10 msec, the sound is perceived by human ear as granulated and continuous. Beyond, rebounds appear gradually. The trill is a staccato playing with two different, discontinuous phonatoms , similar with Kircher's pigolismus. The vibrato is a trill whose both elements are linked continuously. The sustained note comprises a single long phonatom ( ranging from 100msec to several seconds ). The group is a succession of different phonatoms associated only by proximity in time. It is Kircher's teretismus or Bondesen's modulated warbling. One will consider a neum if they follow each other continuously. At last, the cycle, a note verging on the higher level unit, is a group which is reiterated at least twice at a time.
The motive is an association of several notes. If the same notes are repeated, it can be named iterance.
The figure is an association of several motives. If the same motive is repeated, it can be said an ostinato.
The theme is an association of several figures. If the same figure is repeated, one shall describe it as a strophe.
The sequence is a free medley of notes, motives, figures, etc.
At last, the song is whatever the bird has uttered ( or whatever the recorder could get of it ). It is separated of another song by pauses ranging from a few seconds to longer durations.
Here are some illustrations for most of those terms :

Example 5

which reads this way :
5 : a motive containing two notes staccato associated by tempo and differentiated by register and by the slight pause between both notes ( time between the phonatoms : 26msec ; between the notes : 39msec ; between motive and the following note : 47msec. ).
6 : a note consisting of an appoggiatura of a single phonatom, and, after 23msec., of a sustained note of 12 phonatoms in staccato giving a granulated note ( distance : 7msec.).
7 : granulated sustained note of 21 phonatoms ( distant by 13msec.).
8 : a figure containing 5 motives and notes :

a = motive 1 = 4 notes, i.e. 1 staccato and 3 phonatoms
b = note 2 = staccato of 3 phonatoms
c = note 3 = 3 phonatoms
d = note 4 : vibrato.
e = motive 5 = iterance of 2 notes.
The series 5-6-7-8 is a theme, which recurs several times in the song.

The preceding definitions call for some difficult questions. I am quite aware that such a tentative to define 7 levels of increasing complexity from the phonatom to the song can face some objections.
For example, the second note of figure 8, which I first analysed as a staccato note with 3 phonatoms could also ,( if we dissociate those 3 phonatoms into 3 x 2, as an extreme slowering of the recording suggests, ) be viewed as a motive, an iterance of 3 notes with 2 phonatoms each ; one could even think of a cycle consisting of 3 very short groups. However, such extremely detailed analysis are based on morphology without reference to time scale. They point out the quasi-fractal structure of that birdsong. But we must not neglect the fact that motive 5, at the beginning of the theme, and particularly its second staccato note, is similar to note 2 in figure 8. The segmentation has to make a choice between a priority given to the time-scale of the elements or to their morphology. I personnally prefer the latter, which has the advantage of dealing better with the rythmic aspects. But we must confess that our tentative typology leads us to submit the syntagmatic axis to a more risky paradigmatic axis.
On which conditions are we allowed to speak of paradigms in animal syntagms ? The term always refer, in linguistics, to a proof given by semiotics, or at least by grammaticality. Nothing such is available, here. The formal parallel between phonatoms and phonems , between notes and syllables, motives and lexems, figures and clauses, themes and sentences or periods, is certainly a permanent temptation ; but, still more than in human musics, the hypothetic melems remain undiscovered, and confusion between the levels is too common. At first sight, it seems that the song of the skylark is an everlasting chatter combining all the components of a speech, from the ultimate element to the most complex structures. But the same principles of repetition and dissymmetry are apparently operative at all the levels of organization, as if we were dealing with a musical play on speech elements, a kind of animal counterpart to the so-called sound poetry or lettrisme.
One can also think of the rakish use of speech which is commonly encountered in human songs. It is rather funny to remark that the surrealist French poet André Breton, a sworn enemy of any music, has occasionnally played that game himself in this Pièce fausse from his book Clair de terre in 1923 :

Example 6

The scheme of such a poem is practically similar to that of the words of many songs, and to many skylark songs as well. If it is submitted to a purely distributional analysis, the result is such, with figures corresponding to the segmented units :

1 = Du vase  2 = en  3 = cris  4 = tal  5 = de  6 = Bo  7 = hême  8 = oui

In the lower part of the page, the same presentation has been used for this poem and for the song of a skylark. It is clear that, whenever a poet deliberately splits the words, he rejoins, consciously or not, the sound structures of animal signals. This has been practised since the beginnings of mankind. At least since 2200 years. One of the few verses by Ennius still preserved uses this process in an expressive way. It tries, by a naïve imitation of the alleged Homeric tmeses and apocopes, to describe the violence of war through the violence he imposes to the lexic : saxo cere comminuit brum  instead of saxo comminuit cerebrum. ( "With a stone he made the brains explode" ). The same process is working in the kind of recitation known in Vedic chant as vikŕtis , or even in our schools, when the pupils have to recite some Latin or German declensions. But it is only when the language loses its specificity that it shows all its potential analogies with animal musics. On the contrary, the latter are so close to human musics that we can no longer  think of a metaphoric similarity, but to a plain identity, in spite of their obvious limitations. If the most elaborate animal signals have ever  been felt like pre-linguistic phenomena, it may be because human music itself is a pre-linguistic phenomenon.

When we observe the different types of organization  of birdsongs, we find that, for a given species, the diversity of the proposed solutions to the balance between identity and alteration, the key to all musical variations, is comparable with the inventions of the composers. Whereas the skylarks from Western France, recorded by Jean Roché, which I have used as a material for analysis, already show a great diversity of sound constructions, while keeping a certain amount of phonetic and syntactic features particular to that region,  the comparison with individuals from far-away countries show some marked differences.

Most of the songs which I have analysed from French individuals seem to illustrate three great types of organization : in one, enumerations of different notes are interspersed with iterances of other notes, creating a stair-like scheme ; in another one , some themes  use up successive stocks of sonic units submitted to a more or less dissymmetrical juggling ; and their is an enumerative type where the amount of recurrency is small. Here are 3 examples of these

organizations coexisting in the same song :

Example 7

But when we analyse a Russian skylark recorded by Veprintsev in 1960, we meet a very different organization, a strophic one. Here are 2 among the 10 strophes appearing on the record, and perceptible in spite of the spoken commentary and quail songs which are mingled with it ( even after my fltering out ) :

Example 8

The strophes which could be recorded schematize this way, in a presentation which underlines the steadiness of the beginnings and ends of the strophes, contrasting with the different treatments of the middle :

Example 9

or, in the common presentation which also allows the strophic regularity to be perceived :
Example 10

It is clear that with analog sonic materials the Russian skylark organizes variations quite different from those which are common in Western France. The disproportion between the 37 notes or motives of A and the other units is striking. The principle of distributional analysis creates here a meta-language which, although giving a coherent description of the recurring units, tends to conceal their respective time proportions. In that song, the balance between identity and variation is obtained in a special manner. I should very much like to learn from ornithologists if in their opinion it exists elsewhere as well. Everything occurs as if the strophic regularity ( the duration of each strophe ranging, however, from 10 to 19sec. ) came to make for the extreme diversity of the components of the strophe.
When analysing another skylark song, which has been recorded in Hungary by P.Szöke, I find this :

Example 11

The scheme seems closer to the French skylarks. It shows that the three main themes are organized in an introduction followed by ostinati, then by an abbreviated coda.

Example 12

It happens so, frequently enough, that the same structural schemes seem to work in different themes and different stocks of sonic units. It is apparently the case in this succession too :

Example 12

When one pays attention to the "paradigmatic" relationships in the syntax of skylarks songs, one encounters processes the analogy of which with human musical forms is remarkable. We have just seen the phenomenon of the abbreviated coda. The recapitulative abbreviation can take a shape which reminds of the eliminating development typical of Beethoven. For example in this passage where every recurrence of the strophe ABCD is accompanied by a regular diminishing of motive A, along with the adjunction of an infix E and a suffix F :

Example 13

Sometimes the coda consists of the sudden retrogradation of two elements so far coupled in an invariant order, as in the two following examples :

Example 14

The objection which some might be tempted to make, observing that it is unlikely that the bird has deliberately organized its song in such a manner, and that segmenting any continuous flow may bring out structures which are pure artefacts, arouses three preventive remarks. The first one is that I chose as a basic hypothesis the discarding of any question of perceptive psychology, for the sake of an analysis of the neutral level. Nevertheless, we verify that the fiction of a neutral level cannot, as in linguistics, be thoroughly maintained throughout the analysis. Every apprehension of the units in the syntagmatic chain implies an observation post which can by no means be neutral. Whenever I use the terms "coda" or "elimination", I switch from an ideally pure observation to an attempt of interpretation, obviously marked by my experience and my projects of a composer. Here too we have probably, like J-J.Nattiez, to admit that the neutral level is just a pense-bête, both a pocket-book and a check-list. One cannot speak of artefacts which would be opposed to a reality in itself, because in analysis only the relation between the observer and the observed phenomenon is relevant, provided it comes up to principles and goals clearly defined.

Second remark : there exist, anyway, many evidences for an ability of the animal not only to memorize sequences sometimes exceeding one minute, and to repeat them either as such or with variations, but also to transpose them, especially in the case of the imitation of other species. This fact alone would suffice to prove an ability to manipulate a long and complex sonic image, existing in the animal's psyche at least as a Gestalt.

Third remark, at last : just as the use of language and the practice of music imply very seldom in man a linguistic or musicologic consciousness ( thanks to God ! ), the animal can develop sonic manipulations that are complex and inventive without exceeding for that the probable limits of its conceptual capacities. For the little child, the grammaticality of his discourse is not checked by some experts, but by the communication with, - and irony from -, his surroundings ; and for the bird, to some extent, by the reactogenic property of its song.

All the examples I have dealt with today belong to the skylark. The steadiness of the flow in moto perpetuo is a general, specific feature which eludes the regional or individual variations. But some other analysed features are supra-specific. The strophic structure is met in many other species. The same for the impredictable juggling with 2,3 or more sonic elements. The same for catch songs and ostinati ; changes in tempi or on the contrary sustained steadiness of the pulse ; borrowings or quotations submitted to a re-elaboration ; the insisting use of some motive which has been so far furtively employed, so to speak ; then reminiscence of that same motive in another context : all these are syntactic procedures that are familiar both to animals and man, whatever the different meanings these phenomena can take here and there.

That great analogy of the sonic syntax of some animal species and speech or music could possibly be rated as a case of convergence, a term meaning that completely different series of causes bring very similar consequences. But it seems rather that we encounter a much deeper identity, which assigns music a primary biological function. The questions brought by the analysis of birdsongs are precisely those which musicology could not yet clarify, including first the very purpose of analytical practise. The musicologist is far from claiming for sole task the understanding of the composer's thought. In many occasions he proves to be tempted to show himself more perspicacious than the author he is studying. It is probably unfair to conclude, as some do, that the analyst is a frustrated creator : on the contrary, every analysis is some form of creation, which creates the very phenomenon it is engaged in describing. If I acknowledge that the analysis of birdsongs is for me a help in my reflexion as a composer, I will soon be suspected of being more imaginative than a scientist must be. Where I think I encounter refrains, anticipations, reminiscences etc., the biologist is satisfied with classifying equivalent signals. At the most , he will sometimes

condescend to try and interpret the riot of individual sonic inventions by looking for some utilitarian aspects for the benefit of the species, as if the gratuity of musical play was a human privilege, and the animal had no kind of freedom to imagine.
Some scholars as eminent as Thorpe had eventually admitted that the utilitarian interpretation is so far unable to account for all the phenomena in birdsongs, and that the aesthetic hypothesis has not yet been definitely dismissed as anthropocentric. Nevertheless, such a position is still rare among biologists. They probably would have to reconsider too many notions they take for granted about music and man. Meanwhile, the musicians attempting to analyse the animal signals will find there a matter of amazement and of reflexion , and it will be long before it is exhausted. That is why, instead of being criticized as an anthropocentric biologist, I hope to be accepted as a zoocentric musicologist.

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