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Study of African Scales: A new experimental approach for cognitive aspects

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I will discuss the untempered scales used in the music of Central Africa and an innovative methodology using interactive experiments with new technologies recently developed and tested in the field with vocal polyphonies in Cameroon. In the oral traditions of Central Africa, such methods seem to be the only way to understand the principles on which the scale system is based [1].

The following points will be covered:

1. Issues related to the nature, behaviour and use of musical scales in Central Africa, the difficulties involved in studying musical scales in oral tradition and why the cultural context in which we work requires such an experimental approach.

2. Previous work done in this area, particularly experiments with xylophones in the Central African Republic, before going into more details regarding the experimental methods and the analytical proceedings that we use today.
3. The initial results from the latest experiments regarding the conception and the nature of the system.

4. I will conclude by discussing the differences – in terms of goals and results – that such a procedure can offer with respect to a more “conventional” ethnomusicological investigation.

1. Issues

While presenting the theoretical and methodological issues that led us to develop the specific investigation protocols, I will focus on examples from the music of the community within which the experiments were carried out, the Bedzan, a Pygmy group living in Cameroon. We have frequently observed these same problematics in other oral tradition communities of Sub-Saharan Africa however, and they probably exist elsewhere in the world. The Bedzan are the northernmost Pygmy group in Central Africa. They live 250 kilometres south of Yaoundé, the capital of Cameroon.

The Bedzan music is mostly vocal —some of the songs may also be played on a zither-harp. It is composed of four-part polyphonic songs accompanied by one or several drums, wicker rattles, and sometimes also hand clapping. The four voices correspond to four different timbres:

\[
\begin{align*}
\text{nkwɔ bùnkà} & \quad \text{(voice of mature men) meaning the oldest,} \\
\text{nkwɔ bɔmbɔbɔ} & \quad \text{(voice of young men),} \\
\text{nkwɔ bëyi} & \quad \text{(voice of mature women), and} \\
\text{nkwɔ bwësɔ} & \quad \text{(voice of little ones, meaning children).}
\end{align*}
\]

The polyphony is reminiscent of that of the Aka Pygmies of the Central African Republic, although the Bedzan do not use yodelling, a striking feature of Aka songs. A soloist, male or female, followed by various voices of the chorus entering by superposition or juxtaposition. This latter technique (juxtaposition, soloist/chorus alternation) is apparently linked to more recent songs. In most cases, only the solo part that begins the song has words. The rest of the song is composed of vocables which allow the singers to freely perform different variations. Like all music in Sub-Saharan Africa, the Bedzan music is cyclical. Each voice is based on the repetition of a musical figure which can be varied at the singer’s will as the song goes on, without the song losing its identity. The participants thus have a degree of flexibility which is further extended by the possibility of switching parts at certain precise moments in the cycle.

The scale used in the Bedzan music is tritonic, tetratonic or pentatonic. The main difficulty which investigators face in trying to understand how pitches are organised is the mobility of the tuning of the scale degrees. We observed several types of situations:

- The same degree may be realised differently within the performance of a given piece (this is often the case in vocal music). In a polyphonic context, this phenomenon occurs in the different parts, leading us to speak in terms of “density” when the same degree is sung or played simultaneously by several parts. Based on the experiments that we carried out with the musicians, I can say that they are really seeking this density. Is it for aesthetic reasons? Or to amplify the impression of the mass of sound coming from the vocal group? These questions are interesting and deserve further investigation, but the main issue that we were focusing on at that time was to really understand why this density was culturally acceptable and what the principles were that made this acceptable within the scale system. This density is not just a margin of realisation due to a performance that is done more or less correctly, it is a part of the possibilities that the system itself offers.
- The scale may also be modified during performance, especially in vocal music in which some intervals may undergo changes (to simplify this phenomenon, we can say that a scale that would be close to C, D, E, G, A would become closer to C, D, F, G, A, for example).

- Furthermore, pieces are almost never played twice with the same scale. This is almost systematic in vocal music but also in instrumental music: If the musicians change the tuning of their instrument between two playings or if they change instruments, the scale becomes noticeably different. Sometimes the changes of scale and the use of melodic and rhythmic variation – principles inherent to these musics of Central Africa – are such that they become really unrecognisable for foreign listeners to the culture [2].

- When the ambitus of the piece covers more than one octave, the pentatonic scale observed in the lower register is not systematically reproduced according the same configuration in the higher register: the degrees are not reproduced as the octave and the succession of intervals inside the lower register is not the same as in the second.

The most important point in here is what the researcher may analyse as two different scales is considered equivalent by the people within the culture. In some cases, we can obtain as many different scales as there are versions of a piece. All of the versions given by the musicians are thus among the “possible versions” because it is inconceivable that a musician could sing or play outside of the system defined by the culture to which he belongs without the other musicians or villagers intervening. It is clear that the musical system that the ethnomusicologist is dealing with gives the musicians a wide virtual range of expression in terms of scale. The ethnomusicologist is thus seeking a collective norm that is expressed differently through the performance of each individual: why are several possibilities considered equivalent and what is the model that allows these various realisation possibilities?

To achieve his aim, the ethnomusicologist also faces another methodological problem related to the context of the research itself. In Central Africa, the research takes place in cultures of oral tradition in which musical theories are not explicit and where verbalisation is usually limited to a meta-language, which we must interpret. With an ethnographic inquiry, researchers can sometimes get musicians to provide explanations, which they would not have given spontaneously. With regard to musical scales however, we must ask whether it is even possible to verbalize the data, which researchers would need, as there is no term for “scale degree”, nor “interval”, or even for the “distance between scale degrees”. The scale is not an element, which can be isolated within the musical system. For the musicians it only exists through its manifestation in music. It is not conceptualized and therefore cannot be considered as an abstraction. The investigator must therefore avoid the pitfall of verbalisation by working with facts rather than statements, finding a way to focus on a subject that, for the members of the community, does not exist as such in isolation, outside of practice.

The mere measurement of facts, i.e. the intervals that separate each degree as well as their margins of production, is not satisfactory for musical scales as this way of doing enables us to determine the limits of the system. The various measurements that can be made merely reflect possible actualisations, but do not give us access to the model of the scale system. In other words, measuring intervals and classifying them in different size categories gives some information but doesn’t allow us to explain how the system works nor its indigenous conception.

Since the vocabulary that would allow us to communicate with the musicians in direct terms is almost non-existent and the very object that we seek to study cannot be isolated from its performance context, the only remaining possibility is experimentation. We must imagine a tool that would allow us to culturally validate researchers’ theoretical hypotheses and to test the limits of the system based on the repertoire. Testing the limits of the system does not just mean questioning the musicians about what they do but also implies having the means to test the various possibilities that the system can generate.
2. Interactive experimental approach in the field

A) The first experiments

Musical scale experiments began in 1989 under the direction of Simha Arom at LACITO-CNRS. At the time, the goal was to understand the modalities of tuning the xylophones used by various ethnic groups in Central Africa. The researchers used a DX77 II F synthesizer, which was intended to simulate the xylophones. To do this, wood strips were glued on to the keyboard to simulate a xylophone keyboard so that the musicians would be at ease as much as possible and find their natural playing reflexes. A palette of 12 synthesized timbres had been pre-programmed, along with a certain number of scale models. Using a cursor, the musicians could choose from among various timbres and modify the pitch of the scales so that they would correspond to their usage. A computer connected to the synthesizer provided an automatic transcription of what the musicians played, allowing for direct analysis of their reactions.

With this interactive method, convincing results were obtained by demonstrating firstly that the conception of the anhemitonic pentatonic system in use in this region was based on three interval sizes of 200, 240 and 285 cents. The interval of 240 cents seems to have a special status however in that the musicians accept that the scale could be based only on this interval size, i.e. it would be equipentatonic. However – and this is curious – the musicians never actually use such a scale. Furthermore, results show that the three interval sizes identified are subject to significantly different realization margins depending on the community. This means that at this stage in the research we can make a hypothesis that these three interval sizes constitute interval models that are fully acceptable for describing the scale systems of several different communities, while keeping in mind that each of them maintains its cultural specificity in the form of variation from the defined model. The flexibility of the system does not mean that these three interval sizes are freely interchangeable figures. The musicians refused some scale configurations that were offered to them, leading the researchers to assume the existence of different modal possibilities.

Despite the unquestionable progress that these experiments represent, several questions remain. One of them is the notion of the field of dispersion of the degrees with respect to an ideal interval model. Why should we continue to view the system in terms of a realisation or deviation margin with respect to an ideal, non-realised mental model instead of really considering the possibilities of dispersion of a degree as inherent to the system? This latter hypothesis implies a definition of the system as a dynamic one.

Another question is related to the fact that many different scale configurations are considered equivalent by the musicians and that the reasons for which some scale configurations are accepted, but not others, remain obscure. This question implies more work on the framework intervals that might or might not virtually delimit the wider intervals within which the smaller intervals are expressed.

Lastly, while the experiments seem to support the thesis according to which the mental representation of the Central African scale system is based on an equidistant division of the octave, we must ask why the musicians would prefer a model that is never actually realised. To this question, Jean Molino is said to have given the following answer at a round table devoted to pentatonism: the equipentatonic scale is probably part “of the sphere of the possible”, which basically means that it does not violate the norms that govern the system.

B) New experimental attempts

Since then, new experiments have been carried out among Bedzan Pygmies by Simha Arom, Fabrice Marandola and I. The experiments are also based on a similar interactive method based on the principles of induction and deduction. We now have more technologically sophisticated
tools however. For example, we can use the recordings of the musicians’ own voices and change their pitches without modifying the timbre and also the technique of multi-track recording which facilitates analysis of the data in terms of consonance, particularly when we estimate the phenomenon of thickness that systematically appears within the four voices of the polyphony. The principle of the methods is to make the musicians actors in the experiment, able to react immediately to the proposals of the investigators and to provide modifications of them, directly or indirectly. The goal is to progressively arrive at a model of the scale system used by the community, in other words, to reveal the collective mental representation that the holders of a tradition have of their musical scale.

The experimental system that we developed uses a combination of a multi-track digital audio recording system, a program for analysis of the sound spectrum and a computer composition program (OpenMusic). Fabrice Marandola developed a specific application in OpenMusic, named Scala, for analysis and transformation of the pitches of the songs used in the experiments. It involves a sequence of operations:

- Recording the four parts of the polyphony in real performance conditions and in multi-track recording with software named Pro-tools.

- The analysis of the performance: analysis of each voice part in order to visualize and measure the fundamental frequencies of the various notes with Audio Sculpt and the specific application Scala (this application includes several curves and graphs allowing us to visualize the behaviour of each voice in its temporal continuity, to determine the number of degrees and to evaluate their fields of dispersion. These diagrams can be displayed in both monodic and polyphonic form).

- The formulation of hypotheses concerning the size of the intervals, their distribution and the determination of classes of intervals in the musical scale in form of prototype scales which can be considered as possible models for the realisation. - The modification of each part of the polyphony according to these different models (each of them was implicated to the entire polyphony).

- Proposal of various models to the singers for validation. If they refuse, we try to identify the place on the melodic curve that is problematic by having them listen to the excerpts again (the multi-track recording in Protools software allows segmenting of the melodic contour in order to locate the error and to check with the musicians regarding the reason of refusal). If the hypothesis is accepted, we keep one or several of the voices and re-record the missing voices by superimposing to check whether the musicians really manage to adapt to the proposal made to them.

For the multi-track recording, each singer wears a head-worn microphone that records only his or her voice. In order to facilitate the analysis work done with the computers, the singers are asked to sing simple versions, particularly to eliminate the problem of accumulation of melodic variations – the only variations that interest us in this context are the interval variations between the same degrees of a scale. It is also really important that the tools used allow the reproduction of the same polyphony with modification of the pitches – without changes to the other parameters of the piece or the voices of the singers because their timbre remains unchanged. Also, the interactive conditions of experimentation allow the musicians to accept or reject each of the models one by one, thereby guiding the investigator in the development of new proposals.
3. The conception and way of working of the scale system according Bedzan polyphonies

Whether the scales are tritonic, tetratonic or pentatonic, their way of working is the same. The conception of the scales is based on structuring intervals of less than an octave. The scale system is composed of a large framework interval, and a smaller one. For tetratonic and pentatonic scales, these framework-intervals are trichords or tetrachords.

The scales are governed by interval relationships subject to reciprocal constraints, the trichords and tetrachords playing a leading role in the conception of the system. There can be relatively wide margins of realisation for each of these framework-intervals, as for the intervals that make them up. Each of these framework-intervals can be subdivided into two (for trichords) or three (for tetrachords) smaller intervals. Each smaller single interval may be realised with substantial differences from one version to another, but also from the lower octave to the higher, and for the same degree, from one voice Petitjean wearing a head-worn microphone (Mbondé, Cameroon). [Photo N. Fernando] to another – that is what we call “density”. These single intervals change considerably, but the framework intervals are more stable.

The margins of single intervals are limited by a triple constraints related to:

1. The upper and lower limits accepted for the trichords and Tetrachords

2. The upper and lower limits of the “octave” formed by the juxtaposition of the framework-intervals, and

3. By the minimum and maximum values that the intervals that make up these framework-intervals can take.

The Bedzan’s conceptual model of scale system is dynamic. Based on a limited number of rules, it involves a set of reciprocal constraints that ensure the equilibrium of the whole. In such a system, all of the degrees are potentially mobile and no interval size is fixed: the size of each interval depends on the size of the others.

It would seem that the properties of such scale systems resemble those that underlie the phonological systems of all languages and through which a given phoneme can be realized in different ways without us needing to reconsider its identity. The development of intervals allows the degrees that establish their momentary limits to distinguish themselves – to be in contrast with each other – in the same plane as that formed by the sound continuum. Each interval has flexible
borders with the adjoining one, which sometimes, when they are overstepped, creates an ambiguity regarding the identification of the degrees, leading to incomprehension of the “message” and thus cultural non-validity. It is thus possible to “disfigure” an interval to the point where its dimension leads to confusion of the degrees that constitute the boundaries with those immediately above and/or below.

The model chosen here is thus a dynamic system within which the musicians seem to refer more to prototypical realisations than to a predimensioned scalar configuration. The margins of realisation thus result more from the nature of the mental references than from a deviation with respect to a fixed system. This probably explains why multiple actualisations of the pitch system are all considered as culturally equivalent. Furthermore, this leads us to reconsider the idea that the scale can correspond to a single archetype representative of an ideal model for the organisation of pitches. This could in fact cover multiple formal realities for which an analysis of the traits would not necessarily reveal common points or lead to a representation for which it would be possible to tangibly predict the multiple variations. Each musician can realise different forms which we may see as resulting from equally dissimilar mental references, although these would still follow a collective norm that can only be modelled in terms of dynamics – and thus of process. This model must necessarily cover the potentialities of the system and include the possibility of the system’s including and creating random events.

4. What does the application of such an experimental method offer within the framework of ethnomusicology with an anthropological outlook?

We can point to four important factors:

1) The experimental method used to gain access to the non-verbalised rules certainly generated more information that we would have had solely from questioning compared with analysis of data. The experiment initially avoids the pitfalls of verbalisation. Both parties are more at ease because they know at all times what they are talking about and exactly what the experiment involves due to the possibility of separating the parameters within the experiment (for example, with the timbre parameter neutralised, the attention of the musicians is focused on pitch). The experiment involves work that is based on facts and musical gestures drawn from a concrete body of material, the community’s own repertoire.

2) This procedure operates in conditions which are totally neutral because it does not involve questioning but rather making proposals. The indigenous informants are no longer led to make projections regarding a thought or words which do not belong to their culture, because the object presented to them is taken directly from their own community. Although the researcher retains the cognitive categories of his own culture, he is not tempted to use them because the experiment forces him to work directly with the musical material of the “other” and to build with formal units which are foreign to him.

3) The interaction holds an essential share during the experimentation. The musicians play a decisive role in the work and are involved in each step. The researcher develops hypotheses that he must then test with the members of the community. The advantage of this new tool is that it can be used to test all sorts of hypotheses, good or bad. The researcher offers theoretical models, and the musicians can test them, and guide the researcher to modify them and their input lets the work move forward. It is above all the negative responses of the informants that help the researcher to gradually determine the limits of the system.

4) Lastly, by seeking the objective conditions for the production of certain phenomena, the experiments allow us to deal with problematics involving cognitive processes that are not verbalisable and of which the musicians themselves are probably not always conscious. The most important point is probably that this experimental method and the principles that it covers can be
transposed to studying scale systems in use in music among other populations, in Central Africa and elsewhere in the world. Studies with a comparative approach are thereby possible.

Notes

[1] The research that I will be presenting was carried out within the framework of a programme of the French Ministry of Research: Cognitique 2000, Art and Cognition. The research team included ethnomusicologists from the Laboratory of Languages, Music and Societies of the French National Research Centre CNRS (Simha Arom – Project Director –, Nathalie Fernando, Fabrice Marandola), acousticians (René Caussé, Claire Ségoufin, Christophe Vergez) and a psycho-acoustician (Daniel Pressnitzer) who works at IRCAM.


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