

Performance and Musical Perception Analysis

Mondher AYARI*

RÉSUMÉ : Analyse de performance et modélisation musicale. La perception structurelle sous-jacente à l'écoute musicale est un processus cognitif d'une grande complexité qui met en jeu une multitude de stratégies interdépendantes. La compréhension approfondie de cette architecture cognitive, et en parallèle la description détaillée du foisonnement de structures émergentes, nécessitent en conséquence le support de la systématisation informatique, afin d'appuyer la démarche empirique sur une modélisation complexe. Les multiples stratégies concourant à l'écoute musicale structurelle peuvent être scindées en diverses catégories. Une distinction majeure, développée dans cette étude, sera opérée entre, d'une part les mécanismes d'émergence structurelle de bas niveau apparentés à la Gestalt-théorie, et d'autre part les stratégies de plus haut niveau fondées sur des schémas culturels.

Mots clés : processus perceptifs, schéma cognitif, écoute culturelle, pertinence musicale

ABSTRACT: The main objective of this multidisciplinary study is to develop a cognitive model of the mechanisms of musical perception and comprehension. This model aims specifically at exploring the close interaction between the processes of segmentation and pattern recognition in musical listening from different angles including perception, musical analysis, and computer modeling. This question touches upon the domain of complex objects in terms of the representation of knowledge schemas, hierarchical segmentation processes, the interaction between ascending and descending processing, and, especially in regard to music, problems that arise when applying those operations in real-time while listening to music.

Keywords: perceptive processes, cognitive scheme, cultural listening, musical pertinence

1. EXPERIMENTAL STUDY

The principal objective of this study on intercultural perception is to compare the effects of ascending segmentation and those that are influenced by recognition based on cultural schemas. The empiric characterization of the segmentation processes and schema recognition will establish the reference points that will ultimately be simulated within a complex-system computer model.

1.1. The Experimental Hypotheses

One of the study's hypotheses was that in an aurally experienced musical sequence the patterns that correspond to acquired knowledge schemas could activate these same schemas which then affect, in a descending and dynamic mode, the segmentation process. Therefore, there is complex interaction between the analysis of the input data and the influence of cultural knowledge

* Maître de conférences, Université de Strasbourg II Marc-Bloch, Mondher.Ayari@umb.u-strasbg.fr.
Tél. +33 (0) 9 51 21 47 54

in the way a given musical sequence is organized. Hence, we must look at this process from different perspectives including musical analysis, cognitive ethnomusicology and computer modeling of musical pattern identification, in order to understand the materialization of musical comprehension in real-time.

The segmentation indicators can be classified according to the degree of implication of preexisting knowledge and the abstraction of this knowledge, as well as the time span involved. The low-level indicators are not linked to the acoustic properties of the musical surface (pitch, timbre, intensity, duration) whereas the high-level indicators are established entirely according to these properties. One of the main goals of this study is to understand the complex interaction between processing based on sensory data and processing based on preexisting, cultural knowledge.

Both of the proposed hypotheses refer to earlier studies on intercultural perception carried out by the Musical Perception and Cognition team at IRCAM (Ayari and McAdams, 2000-5), notably indicators 3, 4, 5, and 6. Other hypotheses (indicators 1 and 2) refer to important items in the literature on musical psychology, such as Gestalt theory, the works of Lerdahl, Bergman, etc. We therefore defined our principal hypothesis by using at least six perceptive indicators which can stimulate segmentation when listening to music. This list of indicators is not exhaustive.

1.1.1. Discontinuities between auditory attributes

For example: rests and silence; pitch leaps; sudden changes in tempo, register, instrumentation, etc. These discontinuities can be classified into two categories:

- a) *Qualitative Dissemblance*: pitch, timbre, sound level, temporal shape of individual events;
- b) *Temporal Proximity*: tempo, silences... (McAdams, 1989).

The processing of this class of indicators (a - b) is probably universal and the influence of acculturation should therefore be minimal.

1.1.2. Extraction and memorization of repeated patterns

This corresponds to the principle of musical parallelism (Lerdahl and Jackendoff, 1983) and has been modeled by repetition detection algorithms.

1.1.3. Event stability in relation to a functional hierarchy between attributes

Musical phrases tend to conclude on a hierarchically higher scale degree that appears more stable (tonic in the tonal scales of Western music, pivot note or root in the *Maqâm*). Endings on less stable notes induce a sense of incompleteness or musical tension. As shown by the results of Bigand (1993a, b), listeners try to segment following a resolution that ends on a stable note in the melodic and harmonic sequences. Similar effects exist for Arab *Maqâmât* with listeners from that culture (Ayari, 2003). This type of indicator should produce different results depending on the listener's cultural background.

1.1.4. Grouping along the musical 'Iqd-genre constituting Arab Maqâmâts

The reconstruction series of a *Maqâm* (figure 1) is made up of the juxtaposition of musical genres (group of 3 to 5 notes called '*Iqd* or *Jins* in Arabic). Different melodic-rhythmic patterns are developed simultaneously inside each '*Iqd*-genre, but also from a combination – sometimes partial – of two constituent '*Iqd*-genres. Going from one '*Iqd*-genre to another is perceived as a change in tonality or a melodic modal modulation resulting in the perception of a segmentation in the musical grammar. Both European and Arab listeners could perceive this composition process produced in Arabic music, but the feeling of segmentation is stronger with Arab listeners. A rough equivalent (but not identical) of this phenomenon in Western music would be a change in tonality or a melodic modulation.

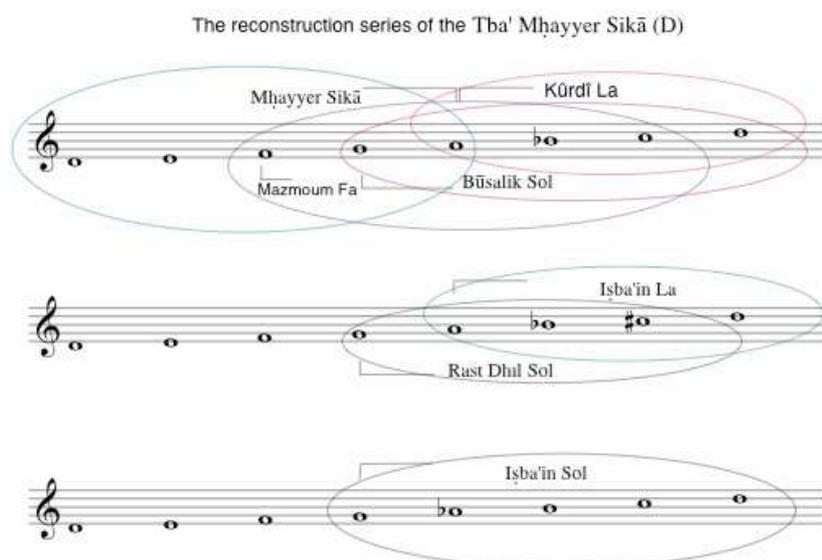


FIG. 1: The Mhayer Sikâ (a Tunisian musical mode) contains several variants which operate principally within the second '*Iqd*. The '*Iqd* musical genres forming the scale, changing roots each time (A, G, and F), are: *Bûsalik* (G), *Mazmoum* (F), *Isba'in* (A), *Râst Dhîl* (G), and *Isba'in* (G).

1.1.5. Specific melodic-rhythmic patterns in the musical 'Iqd-genre

In a given Arab culture, certain melodic-rhythmic patterns are emblematic of a specific '*Iqd*-genre; recognizing them signals a change of '*Iqd*-genre and therefore causes segmentation at a relatively high level of the hierarchy. Such representative patterns cannot be found in classical or contemporary European music, and Arab listeners manifest more segmentation tendencies based on recognition of these patterns than their European counterparts.

1.1.6. Formal and stylistic schemas

The high-level schemas discussed in this last category are linked to musical process and to melodic introduction, overture, exposition, development, recapitulation, and closing gestures specific to a given musical structure such as a *Taqsim*, a sonata, a minuet, etc. These large sections, and parts of these

sections, are often characterized by prominent harmonic or modal modulations that only listeners from that culture are able to hear. When hearing a piece of music within a given cultural context, expert and acculturated listeners' reactions result partly from the organization of the piece's structure. The cognitive schemas that are activated prompt an attentive approach, which anticipates what should happen next. These expectations can be more or less precise depending on the style of the piece, the performer, and the culture in question. In the context of this study, they can create a sectional segmentation linked to the expected sequence within the work heard.

1.2. Methodology

The perceptive organization of the musical structure is defined here by processes of segmentation and identification of the musical sections, processes of reduction of the temporal frames aimed at exteriorizing the melodic-rhythmic pattern implied in the development, and, lastly, the comparison of this pattern with a mental reference or a cultural model, allowing the listener to recognize the modal origin of the sequence heard. In order to address the role played by acquired cultural knowledge in musical structure perception, we will use music from two different cultures, Arab and European. This music obeys more or less the respective prevalent grammar of each culture, i.e. the comparison between "classical" and "contemporary" genres for the two cultures.

The use of listener groups from both cultures that were made to listen to all of the music allows us to vary the degree of familiarity with the music and therefore the listeners' knowledge of the piece. This manipulation facilitates to some extent the control of the degree of evocation of acquired cultural schemas. In order to study the listeners' variable processes of segmentation and recognition, a series of tasks are used (these tasks were previously adjusted in the context of the studies cited above). Several of them were carried out in real-time when listening to real pieces of music:

Segmentation and recognition in real-time with musical material already heard;

Description in real-time when listening to a work or an excerpt indicated by a segmentation task;

Reduction of the segments to their essential musical elements thereby exposing the structural similarities between produced melodic variations and the original themes or familiar melodic schemas;

Validation linked to the perception of virtual stimuli generated by a computational response model. This model was designed and continually improved on the basis of the results of the initial experiments. Such re-synthesis phases reveal the model's characteristics and downsides and therefore can validate the model as a formalism of our knowledge of the representations and processing involved.

1.2.1. Choosing the piece

The first experimental part of this study, which is concerned with intercultural perception, addresses a particular type of Tunisian music (figure 2) within which the flautist Mohamed Saâda¹ performs in a style perfectly in

¹Mohamed Saâda is one of the greatest artistic masters of Tunisia. He died recently at the age of 70. He

keeping with the prevailing grammar. We presumed that a traditional improvisational style would not create any problems for an acculturated listener in terms of perception and understanding. We hoped that, in this way, we could understand how a listener with no specific knowledge of the improvised musical culture and style perceives the structure of the piece in question. For this experiment, we chose an *Istikhbâr* (a traditional instrumental style) for the *Nay* flute that explicitly explores the fundamental elements of the *Mhayyer Sikâ* D-soundscape (figure 1). The improvised melodies of this *Istikhbâr* are composed of melodic motifs that represent recognition schemas specific to *Tba'Mhayyer Sikâ*. The organization of the musical structure is representative of traditional improvisation with, of course, new transitions between melodic movements.

Partie A

Mhayyer Sikâ

Nāy

Kürdi La ————— Mhayyer Sikâ

Mhayyer Sikâ

Kürdi La ————— Mhayyer Sikâ

was a conductor, composer, and professor at the Institut supérieur de musique de Tunis.

1.2.2. Selection of subjects

Two groups of listeners from European and Arab cultures listened to Mohamed Saâda's *Istikhbâr* improvisation.

Forty professional European musicians took part in the experiment. Some were chosen from IRCAM's network of musicians and others through personal contacts. Twenty of these musicians play classical, contemporary, rock, or electronic music. The others were professional, trained jazz musicians who regularly perform improvised music. Improvisation is therefore an aspect of their musical competence, and we might hypothesize that some musical materials from the context of jazz bear a similarity to mechanisms found in Arabic improvised music. Especially in the jazz model, where improvisation is often based on repetitions and transformations of melodic motifs and/or rhythms, playing with modes, melodic development on degrees that are considered as temporal markers, e.g. starting points, recapitulations, and melodic resolutions. Several European musicians had some general theoretical knowledge about improvised modal music (Indian, Turkish, or Arabic music).

In the second part of this experiment, twenty expert Tunisian listeners from the Institut supérieur de musique de Sousse were made to listen to the piece. The musicians (instrumentalists, singers, and composers) are teachers and students (in the second and third cycles of their musical training) who play both popular and academic Tunisian music as well as general Arabic music on a regular basis. In this article, we will only present the reactions of the Tunisian listeners. For details relating to the reactions of the European listeners, the reader can refer to the essay published in Ayari (2005).

1.2.3. Experimental protocol

This experiment is composed of three stages. Each stage is further decomposed into several tasks:

1. Identification and Melodic Reduction Stages

1.1. Identification:

After a first listening aimed at acquainting the subjects with the piece, they are asked to:

Question 1: Judge the level of familiarity of the piece;

Question 2: Judge the level of familiarity with the musical style;

Question 3: Describe the modal behavior of the *Istikhbâr* (the main *Maqâm* in the piece).

1.2. Melodic reduction

The *Istikhbâr* is composed of a simple melodic pattern and a pre-established melodic development schema. At the end of his improvisation, Mohamed Saâda plays the representative "mother structure" of *Mhayyer Sîkâ*, showing the construction of the improvised melodies in the *Istikhbâr*: the melodies come from a simple melodic schema that forms both the mental reference and the cultural model. The variations do not follow a theme, as we can hear in jazz, they instead embody a model – a *Tba'* type of melodic-rhythmic structure – the equivalent of the minimal expression of a musical utterance.

The melodic reduction step is composed of two tasks and its objective is to prove, on the basis of immanent (i.e. cultural) data the presence and the resonance of this concept in the collective conscience of traditional cultures. Hence, the objective is to explain its *raison d'être* and its function in the processes of perception and understanding of the structure of improvised Arab music modes in general, and of the Tunisian *Tba'* in particular.² It seems that the recognition of the modal origin and the representation of the melodic compositional schema are closely connected to the process of melodic reduction. This is what we intended to demonstrate with the two following reduction tasks:

a) Firstly, we ask the listeners to sing (or describe) the simple melodic schema in order to give an idea of the original *Istikhbâr* mode. The goal of this reduction is to determine the existence, or non-existence, of similarities between the melodies produced by the listeners and the original themes played by the performer.

b) Then, the second step consists in reducing the totality of the improvisation in order to sketch its melodic development (the dynamic macro-structure of the work). In this task the listeners are asked to sing from memory or to explicitly describe the important elements.

2. Segmentation Stages

This phase of the experiment is composed of three "segmentations" (locating the hierarchical sections) of the piece as it is heard in real-time. Like any musical piece, the *Istikhbâr* by Mohamed Saâda is constructed along several different musical organizational levels. When structuring the sound material in real-time, the listeners are free to choose and change at any time the segmentation criteria and the hierarchical levels they consider appropriate, while listening to the first and second segmentations.

2.1. We therefore ask the listeners to segment the *Istikhbâr* into small units that are as musically coherent as possible and to indicate the places where the piece was segmented as well as, in the course of a second listening, the moments where new ideas arise throughout the musical progression. It is important to note that, during these stages in the experiment, the listeners press a key on a keyboard while describing the melodic sequence in order to record their reactions. A program is used to synchronize the audio sequences, the timer display, and the recording of the verbal responses that correspond to a specific moment in the piece.

2.2. The previous pieces could also have contained underlying musical ideas, just like the chapter of a book, which is composed of a group of paragraphs. This stage (second segmentation) consists in segmenting the previous sequences into small musical ideas while specifying the musical function of each.

² Our model of musical cognition is defined by a complex set of perceptive and cognitive processes used to perceive the structure of improvised Arabic modes within a work, particularly in the context of traditional improvisations. The process of melodic reduction involves several levels of perceptive processing. For more details, see the chapter "Proposition pour une représentation globale du schéma cognitive culturel de l'improvisation," in M. Ayari (ed.), *L'écoute des musique arabes improvisées : essai de psychologie cognitive*, Paris, L'Harmattan, 2003, pp. 189-195.

2.3. On the fourth hearing of the piece, the segmentation criterion is precise. We ask the listeners to segment the improvisation in terms of modal variations: this time, the listening is subjective and is based on locating the piece's 'Iqd'-genres throughout the development of the modal melodies. We present the listeners with a series of reconstructions of an Arab music mode, indicating the consecutive 'Iqd'-genres (i.e. groups of three to 5 notes, called *Jins* or 'Iqd in Arab) as illustrated in figure 3.



Fig. 3.

3. Interview and musical analysis

Following this study, interviews³ with our expert listeners were carried out in order to:

- interpret the listeners' reactions;
 - understand the difficulties experienced by the listeners during the identification, reduction, and segmentation stages;
 - contrast the different listening strategies contributing to the real-time perception of a musical work -time;
 - compare different approaches to musical analysis:
1. The work as seen by the performer (poietic aspect);
 2. The perception of the listening experience in real-time by listeners (inductive aesthetic analysis);
 3. The analytic perception of the musicologist from a neutral perspective (the score).

In its tripartite version, our model for analyzing the structure of improvised Arab *Maqâmâts*, which is founded on experimental psychology and musical semiology, is intended to study the multidimensionality of the temporal phenomenon and the perceptive rules implicit to its aural representation. Not only must the intrinsic cross-references – the internal relationships of the music – be taken into account, but the diversity of interpretations and understanding of the work that depend on the aesthetic and affective values of the listeners must also be considered.

2. RESULTS AND ANALYSIS

2.1. Identification stage

Using the experimental process described above, the listeners with Tunisian musical background reported the following characteristics after the first listening:

- a) The musical discourse of the performer does not conceal any ambiguity with regard to the perceptive analysis of the structure and the recognition of its modal origins. Mohamed Saâda improvises in a traditional style in which the melodies are constructed using stable invariants and universal qualities of Tunisian music. He does not try in his playing to create surprises and

³For details concerning the questions posed during these interviews, see the appendix.

unexpected changes, or to confuse his audience with unpredictable elements. In fact, the listener who is familiar with improvised modal music can easily imagine the systematic development schema of the melodies by anticipating the continuation and the eventual end of the musical time of the *Istikhbâr*.

b) The Tunisian listeners identified different methods of melodic arrangement specific to the *Tba' Mhayyer Sîkâ* in the form of melodic enunciations and phrase contours frequently used in Tunisian classical music, particularly in the *Mâlouf*. These melodic arrangements are significantly different, but they both belong to the same *'Iqd* musical genre.

c) Because they already knew all the possible variants of the *Mhayyer Sîkâ* (the secondary *'Iqd*-genre), the listeners recognized the most obvious modal modulations in Mohamed Saâda's *Istikhbâr*, particularly in the second part of his improvisation.

2.2. Reduction stage

The improvisation is based on the representation and exploration of a melodic pattern typical of the *Mhayyer Sîkâ*, featuring many rhythmic and melodic variations (ornamentations). The Tunisian listeners were able to memorize and reproduce long sequences of the *Istikhbâr* after listening to it once, and were able to optimize the complexity of the musical surface in order to recognize the melodic prototypes and underlying modal origins. The melodic reductions realized by the Tunisian listeners can be classified into two categories of reactions:

a) The first group of listeners sang the "mother structure" exactly as played by the performer after his improvisation. These listeners highlighted the fact that the compositional process was based essentially on the exploration of this melodic pattern and that the performer presented it deliberately at the end of his improvisation in order to remind the listener of the modal origins of the *Istikhbâr*.

b) The second group of Tunisian listeners sang various melodies bearing a manifest resemblance to the melodic pattern (the "mother structure"). The melodies sung were derived from a cultural reference schema preserved in the collective memory that makes it possible for listeners to recognize the *Tba' Mhayyer Sîkâ* on which Mohamed Saâda improvised. Previous experimental results addressing other, more complex improvisation styles (Ayari and McAdams 2000, 2004) support the psychological data that leads to the hypothesis which states that auditory reduction is an important component in the general processes of perceiving Arab music and, more specifically, in recognizing the modal origins of improvised music.

2.3. Segmentation stages

1. The first segmentation

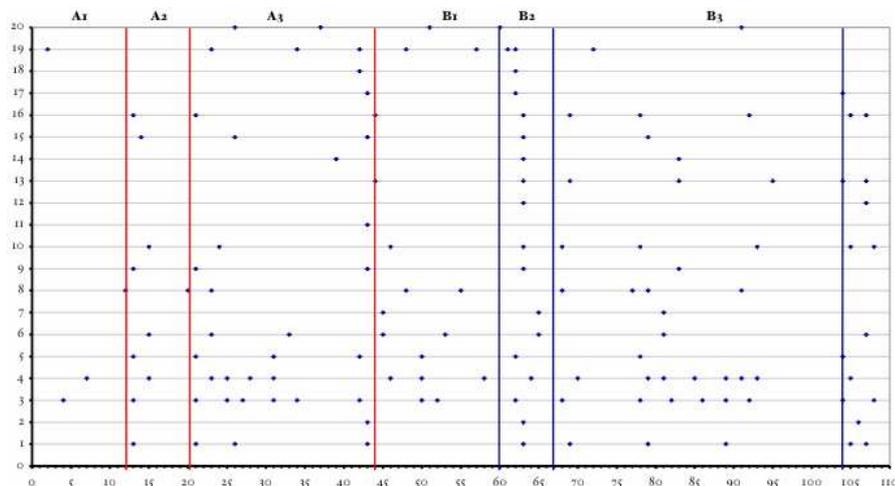


FIG. 4: Segmentation Results (1), Tunisian Subjects. The X-axis represents the time of the piece in seconds and the Y-axis the subject ID number. The blue points correspond to the segmentations decided by each subject while listening to each piece in real-time. The red and blue segments are formal marks that we indicated on the score in order to delimit (according to our analysis) the major sections of the two parts (A and B) of the improvisation (A1, A2, A3, and B1, B2, B3).

The results (figure 4) show the reactions (and the number of reactions) of each subject compared to the others. For example, subject No. 11 segmented the piece into two parts (what we will call on the score: parts A and B), while subject No. 3 segmented it into 19 sections. This signifies that the Tunisian listeners did not all use the same criteria when segmenting the piece.

1. One category of musicians (subjects Nos 2, 7, 11, 12, 14, 15, 16, 17, and 18) perceived broad hierarchical forms in the improvisation and were easily able to describe them.

2. Others (subjects Nos 1, 3, 4, 8, and 19) turned their attention hastily to a local level within the internal organization of the improvisation's structure during this listening. Consequently, these listeners had difficulty carrying out a precise division at a given moment. The reactions and descriptions for most of the sequences were recorded relatively late compared to the normal progression of the piece.

3. Finally, a minority of listeners (notably subjects Nos 7 and 13) segmented more in the second part of the improvisation than in the first. Those listeners did not maintain the same segmentation criteria throughout the sessions. They explained (during the interviews that followed the study) that the performer's playing changed considerably in the second part and that the way of organizing the structure was, according to them, more complex and indeterminate.

In order to interpret the subjects' responses during this first segmentation better and to see how they organized (or, more precisely, began to organize) the dynamic structure of the improvisation, a second representation of the data was necessary. The goal of this second representation was to show the major

trends in the listeners' divisions and to evaluate the number of reactions made at precise moments during the improvisation.

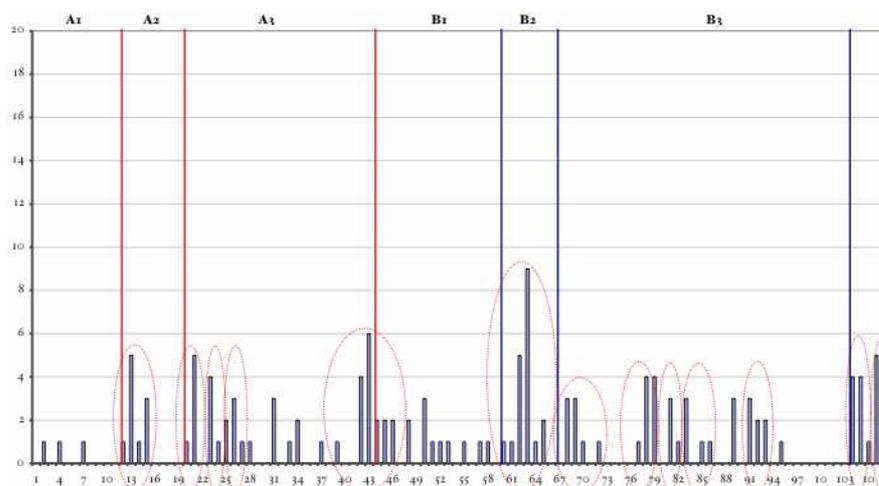


FIG. 5: Segmentation Results (1), Tunisian Subjects. The X-axis represents the time of the piece in seconds and the Y-axis the subjects ID number. The red circles group together reactions corresponding, according to the descriptions provided by the Tunisian listeners, to similar musical percepts, for example: “the end of the melodic movement”, “the end of the section,” etc.

The reactions of the subjects occasionally appeared before the ticks we had inserted on the score (figures 5), but most of them after these ticks. Certain Tunisian subjects were able to recognize the improvisation style by identifying a remarkable dynamism in the development of melodies, which allowed them to anticipate the continuation and the eventual end of the musical process. On the other hand, a large number of subjects reacted late because they waited for the beginning of the following melodic movement before finally signaling the end of the sequences. They were thus in a state of uncertainty about what was coming next in the music, and the resolution or the completion on a more or less stable note in the hierarchy of degrees. Using a real-time perceptive analysis, the temporal difference between the responses on the time axis is therefore of a moderate size (from 2 to 7 seconds), related to the organizational complexity of the melodic movements.

For the reasons stated above, it seemed important to regroup the reactions corresponding – according to our Tunisian listeners – to the same perceptual signification of the “object” heard into one segment, which we repositioned precisely at the end of each movement on the score.

Grouping of responses as a function of the subjects' descriptions

- The ten reactions located between 12 and 25 seconds (one reaction at 12”, 5 reactions at 13”, one reaction at 14 s, and 3 reactions at 15 s, see figures 5 et 6), corresponding, according to certain Tunisian subjects, to “the end of the first section,” were regrouped into one segment at $t=12''$ (which we will call on the score section A1);

129

Une réaction à 12 s • 5 réactions à 13 s •

Les 10 réactions sont replacées à la fin de cette section à 12 s •

Une réaction à 14 s • 3 réactions à 15 s •

Fig. 6.

- Similarly, the 6 responses situated between 19 and 21 s, signaling “the end of the section (2)” (the section A2 according to our divisions on the score) were regrouped into one segment at 20”;
- The reactions (recorded between 23 and 25”) were repositioned at t=23”;
- The responses situated between 25 and 27” that announce, according to certain subjects, “the end of the melodic movement” were repositioned at t=26”;
- 14 reactions appear within an interval of 7” (between 39 and 46”) and designate, according to certain Tunisian listeners, “a section end.” This division coincides with the end of the first part of the improvisation (A3), which finishes on a held note (the tonic D of the *Mhayyer Sîkâ*) followed by a rest of approximately 4”. We grouped these responses together into one segment that we situated after the rest at t=44”;
- 19 subjects reacted at different times (between 59 and 65”) by signaling the “beginning of a melodic modulation” (this corresponds to section B1). We repositioned the 18 similar responses⁴ into one segment situated at 60” on the time axis ;
- The reactions that appear between 68 and 72” – corresponding for some to “the end of the section (6)” (for our musicological analysis, this marks the end of section B2 and the beginning of section B3) were repositioned to t=67”;
- 8 reactions situated between 76 and 79” designate, for certain musicians, “the end of the section (7).” These responses were repositioned at t=76” on the time axis;
- 5 responses situated between 79 and 82” corresponding to the “beginning of the second modulation” were grouped together at t=79”;

⁴One of the subjects reacted two times at t=61” and 62” by signaling the “end of the first part.” However, we only kept one of these two reactions, which gives us a total of 18 responses.

- The reactions between 84 and 87 s announcing a "modulation" were repositioned into one segment at t=84";
- The reactions between 90 and 93" were repositioned at t=91";
- The reactions between 103 and 106" signaling the end of the improvisation (the end of section B3) have been grouped together into one segment at t=104";
- Finally, the reactions situated between 106 and 108" announcing "the exposition of the mother structure" after the improvisation were repositioned to the end of the piece between 106 and 107";

The results graphic (figure 7) presents the Tunisian subjects' responses, some of which have been grouped together on the time axis depending on their significations. This graph makes it possible to look at listeners' perception of the major forms during the second listening. The major sections and the most relevant anchor points that characterize this improvisation were perceived (with a variable reaction time of 2 to 3" on average) by a considerable number of subjects (see figure 8).

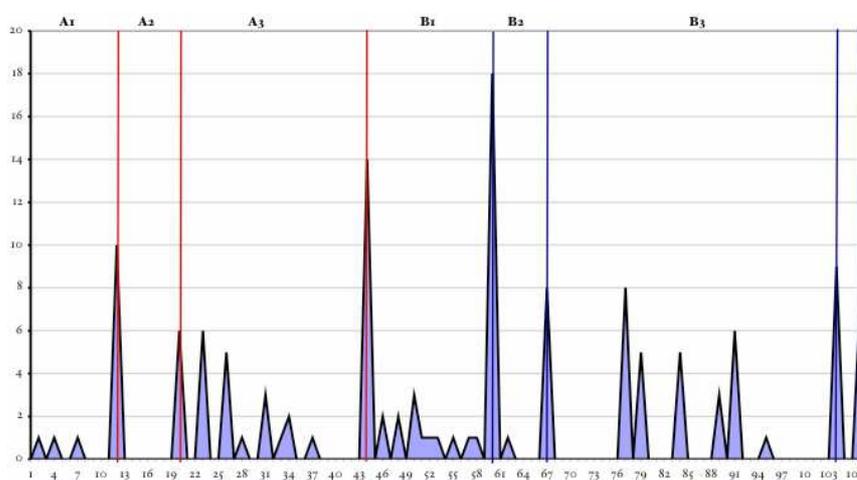


FIG. 7: Segmentation Results (1), Tunisian Subjects.

Location of the major sections	Time in Seconds	Number of Subjects
Section 1 (A1)	From 00 to 12 s	10 subjects / 20
Section 2 (A2)	From 12 to 20 s	06 subjects / 20
Section 3 (A3)	From 20 to 44 s	14 subjects / 20
Section 4 (B1)	From 44 to 60 s	18 subjects / 20
Section 5 (B2)	From 60 to 67 s	08 subjects / 20
Section 6 (B3)	From 67 to 104 s	09 subjects / 20
The "mother structure" played at the end of the improvisation	From 104 to 107 s	07 subjects / 20

FIG. 8.

However, it is important to note that, at this stage of the experiment where the subjects had to segment the piece into sections that were as musically coherent as possible and to indicate the cuts that seemed the most suitable, certain Tunisian listeners did not carry out the task exactly as it had been planned. Not having any previous knowledge of Mohamed Saâda's *Istikhbâr*,

these listeners tried from the very beginning to approximate the smaller musical organizational elements (the melismas, the small melodic gestures, etc.) by reacting after each pause or rest that delineated a phrase or a section. Without taking into account the progression of the musical phrases that punctuated the performer's discourse, these listeners looked deeper into the work's composition in order to identify certain surface details or certain gestures in the performance such as a change in register, a pause, a change in timbre (6 subjects segmented between 22 and 24", 5 subjects between 25 and 27", see figure 7).

We will address other problems related to the perceptive organization of this improvisation's internal structure in the following stages of the experiment (the second and third segmentations).

2. The second segmentation

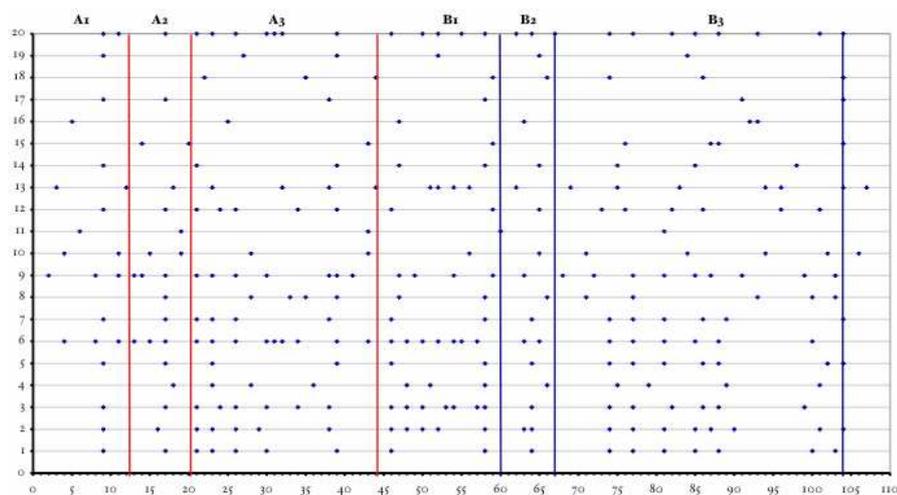


FIG. 9: Segmentation Results (2), Tunisian Subjects. This graphic presents the reactions of Tunisian subjects during the second segmentation. In this stage (the third listening session), the subjects had to mark, within the previously identified large sequences, the smaller underlying musical ideas by specifying their respective musical function. As it involved real-time auditory analysis, we recorded the responses with variable delays ranging from 1 to 3 s, in general.

The divisions realized by the subjects during this stage of the experiment (figure 9) reveal at least three categories of listeners perceiving the piece on three different hierarchical levels:

- Category 1:

7 Tunisian subjects focused on approximately the same level of the piece's hierarchy by identifying a similar number of sequences (figures 9, 10).

Subjects	Number of Sections
Subject No. 11	06 sections
No. 16	07
No. 17	07
No. 19	07
No. 18	09
No. 15	09
No. 15	10

FIG. 10.

- *Category 2:*

Focusing on a relatively high level in the piece's hierarchy, 8 subjects fragmented the piece into several sequences (figures 9, 11).

Subjects	Number of Sections
Subject No. 08	14 sections
No. 10	14
No. 05	15
No. 07	16
No. 12	18
No. 01	20
No. 04	13

FIG. 11.

- *Category 3:*

Among the 20 Tunisian listeners, 5 focused on the microformal level, identifying a remarkably high number of sequences (figures: 9, 12).

Subjects	Number of Sections
Subject No. 02	23 sections
No. 03	23
No. 20	27
No. 09	28
No. 06	31

FIG. 12.

A second representation of the data (figure 13) enables a visualization of the general trends in the Tunisian subjects' responses, and thus an evaluation of the number of reactions corresponding to similar musical percepts at precise moments during the improvisation.

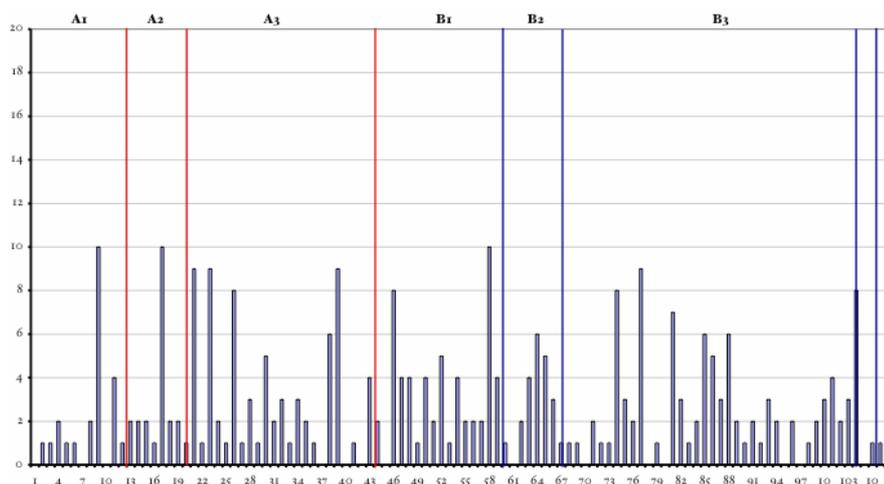


FIG. 13: Segmentation Results (2), Tunisian Subjects.

Grouping of responses as a function of the subjects' descriptions

- The reactions situated between 5'' and 9'' on the time axis appear before and after what the subjects called "the exposition of the *Mhayyer Sîkâ*'s tonic" or "the presentation of the fifth of the *Tba*." The 14 recorded responses (one reaction at 5'', one reaction at 6'', 2 reactions at 8'', and 10 reactions at 9'') were repositioned at t=6'' after the playing of an A held for approximately 3'' (figure 14). We will call this first sequence A1a;

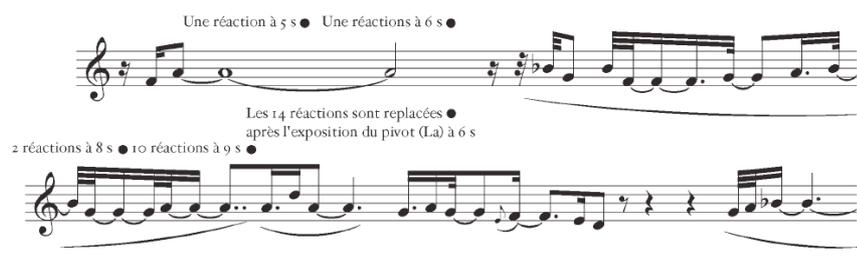


FIG. 14.

- Similarly, the reactions situated between 11 and 13'', corresponding – according to certain Tunisian musicians – to "the end of the exposition of the first *'Iqd*-genre *Mhayyer Sîkâ*" were grouped together at t=12'' (A1c) ;
- The responses situated between 19'' and 22'', corresponding for some to "the end of the second musical idea" or "the beginning of the third" were repositioned on the time axis at 20''. We will call this sequence A2c⁵ ;

⁵The sequences not cited here, such as A1b, A2a, A2b, etc., will be addressed later in the section on musical analysis.

- The two segments (the first situated at 23'' and the second at 25'') marking, according to certain listeners, "the end of a small melodic movement" were repositioned on the time axis at 24'' (A3a).
- The set of responses from the second segmentation, regrouped according to the descriptions provided by the Tunisian listeners, are presented in the table on figure 15.

Reactions	Musical descriptions of the sequences	Grouping of responses
Reactions between 5 and 9 s	"Exposition of the root of the Mhayyer Sikâ", "presentation of the fifth of Tba'."	6 s (A1a).
From 11 to 13 s	"End of the exposition of the first 'Iqd-genre of the Mhayyer Sikâ."	12 s (A1c).
From 19 to 22 s	"End of the second musical idea and beginning of the third."	20s (A2c).
From 23 to 25 s	"End of a small melodic movement."	24 s (A3a).
From 25 to 28 s	"Affirmation of the Mhayyer Sikâ."	26 s (A3b).
From 29 to 31 s	"Return to the principal 'Iqd-genre," "recapitulation of the first 'Iqd-genre of the mode."	29 s (A3c).
From 40 to 47 s	"End of the first part," "completion of the first musical idea," "end of the presentation of the first 'Iqd-genre of the mode"	44 s (A3g).
From 49 to 50 s	"Beginning of a new musical idea," "after the establishment of the principal 'Iqd-genre, a new project is taken up."	49 s (B1a).
From 51 to 52 s	"Transposition of the melodic motif into different notes."	51 s (B1b).
From 53 to 54 s	"Symmetrical development of the same musical idea."	53 s (B1c).
From 60 to 62 s	"End of the presentation of the mode and beginning of the melodic modulation," "a modal transition," "presentation of one of the variants of the Mhayyer Sikâ."	60 s (B1e).
From 65 to 68 s	"End of the first modulation and return to the principal 'Iqd-genre."	67 s (B2b).
From 76 to 78 s	"Melodic descent," "return to the root of the Mhayyer Sikâ," "return to the principal 'Iqd-genre."	76 s (B3a).
From 79 to 82 s	"Second modulation," "return to the previous modulation," "second Isba'in 'Iqd-genre."	79 s (B3b).
From 83 to 86 seconds	"Exploration of the Isba'in 'Iqd-genre in the upper register," "register change," "continued development of the same musical idea (modulation)."	84 s (B3c).
From 88 to 90 s	"Return," "Recalling of the principal 'Iqd-genre," "Return to ré (D)."	88 s (B3d).
From 90 to 92 s	"End of the modulation," "return to the principal mode," "intent to complete the melodies."	90 s (B3e).
From 100 to 105 s	"Melodic descent," "Return to the departure point," "release of the discourse," "preparation for the conclusion."	104 s (B3f).
Finally from 106 to 108 s	"Conclusion," "presentation of the principal motif," "representative structure of the Mhayyer Sikâ."	107 s (mother structure)

FIG. 15.

Finally, the divisions carried out by the Tunisian subjects during the second segmentation are presented in the following graph (figure 16). Note that certain responses are regrouped and repositioned according to the musical descriptions they contain. This analysis shows the organization of the improvisation's internal structure as it was described by the 20 Tunisian musicians. The most relevant articulation points in the improvisation and the subsections that organize its structure were perceived at the same time by a variable number of subjects (3 to 17 subjects).

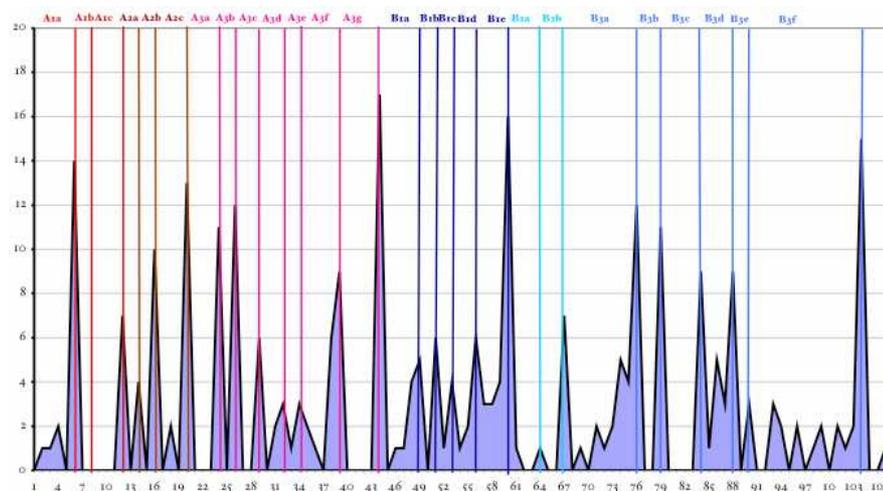


FIG. 16: Segmentation Results (2), Tunisian Subjects. This table outlines certain general tendencies (the number of reactions at a given time) in the way the musical time of the piece was organized.

The next schema (figure 17) reveals the improvisation's overall form as it was perceived by the Tunisian listeners in real-time. Using the program Cubase SE, we assembled, on a first AUDIO track, the sections (A1, A2, and A3, and B1, B2, and B3) that make up the entire improvisation. We then superimposed the subsections (A1a, A1b, A1c, etc.) forming, according to most of our listeners, the previously mentioned major sections on separate AUDIO tracks. This form diagram serves multiple objectives:

a) to represent the dynamic behavior of the improvisation as a function of time;

b) to describe the structural constitution of each major section and to take into account the transformation of the musical sound material as a function of time (the sections presented in separate tracks on the Y-axis). For example, section A3 is both longer and more complex than sections A1 and A2. The performer, after having introduced and established the principal mode on which he intended to improvise, composed different melodic motifs in this section (A3). The musical technique that characterizes this exploratory phase of the *Tba'* features melodic excursions, permutations, and connections – sometimes direct – that make it difficult to identify the subsections while listening. Such was the case at the beginning of the closing phrase situated in the middle of section B3. The performer continuously chained together the elements of his improvisation and concluded without any perceptible cadence that would separate the two movements of the *Istikhbâr*. This melodic transition, between the development and the final conclusion, caused segmentation problems for both the European and the Arab listeners.



FIG. 17.

3. The third segmentation

During the fourth listening, we asked the listeners to segment the improvisation only according to the 'Iqd musical genres. We reminded the listeners that the reconstruction series of a *Maqâm* (or of a *Tba'*) is constructed by the juxtaposition of genres (a series of 3 to 5 notes called *Jins* or 'Iqd in Arabic). For example, they were presented with a scale of the *Maqâm Râst* (figure 18) in order to give them an idea about the hierarchical organizational method of the pivot degrees and of their 'Iqd-genre (*râst* G, *râst* D, and *jaharkâ* G, for example).



FIG. 18.

Mohamed Saâda's *Istikhbâr* is in *Mhayyer Sîka* (D). This Tunisian musical mode corresponds to the 'Iqd-genre previously described in figure 1.

On the score (figure 2), we indicated the modulations and the 'Iqd-genre contained within the *Istikhbâr* in order to obtain the following sequences (figure 19):

Section numbers	Time in Seconds	'Iqd-genres
Section (1)	From 00 to 12 seconds	Mhayyer Sikâ Ré (D)
Section (2)	From 12 to 18 s	Kürdî La (A)
Section (3)	From 18 to 32.5 s	Mhayyer Sikâ Ré (D)
Section (4)	From 32.5 to 34.5 s	Kürdî La (A)
Section (5)	From 34.5 to 44 s	Mhayyer Sikâ Ré (D)
Section (6)	From 44 to 51 s	Bûsalik sol (G)
Section (7)	From 51 to 53 s	Mazmoum Fa (F)
Section (8)	From 53 to 55 s	Mhayyer Sikâ
Section (9)	From 55 to 56.5 s	Bûsalik sol (G)
Section (10)	From 56.5 to 57.5 s	Mazmoum Fa (F)
Section (11)	From 57.5 to 61 s	Mhayyer Sikâ
Section (12)	From 61 to 67 s	Isba'in Sol (G)
Section (13)	From 67 to 75 s	Kürdî La (A)
Section (14)	From 75 to 79 s	Mhayyer Sikâ
Section (15)	From 79 to 84 s	Isba'in Sol (G) and Mhayyer Sikâ Ré (D)
Section (16)	From 84 to 86.5 s	Isba'in Sol (G)
Section (17)	From 86.5 to 104 s	Mhayyer Sikâ Ré (D)
Section (18)	From 104 to 107 s	Mhayyer Sikâ

FIG. 19.

The subsequent formal diagram (figure 20) describes the modal behavior of the improvisation as a function of the underlying 'Iqd-genre changes. It makes it possible to discern the complexity of the arrangement of modes in the two parts of the improvisation: the first part (from 00'' to 44'') contains 4 melodic modulations that alternate between *Mhayyer Sikâ* (D) and *Kürdî* (A). The second part, the more complex of the two, contains 12 modal modulations with a recall of the principal 'Iqd-genre (the *Mhayyer Sikâ* D) each time. Finally, the blue section (at the end of the second track) corresponds to the mother structure of the *Mhayyer Sikâ* played by the performer after his improvisation.

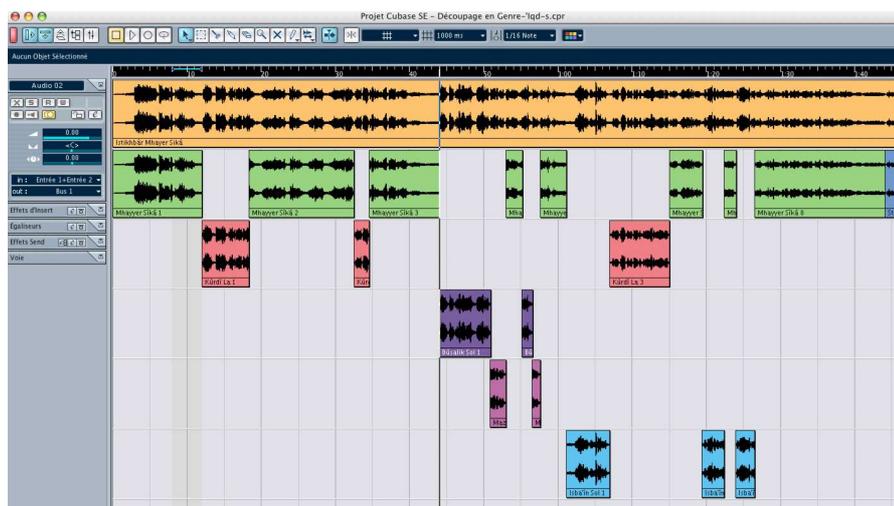


FIG. 20: The X-axis represents the time of the piece in seconds and the 18 melodic sections corresponding to different successive 'Iqd-genres. The Y-axis shows the organization of the musical material on the different AUDIO tracks. The first yellow track contains the entire piece (*Istikhbâr* by Mohamed Saâda); the green track exposes only the melodic passages composed in *Mhayyer Sikâ* (D) in the piece; Track 3 presents the three melodic sections in *Kürdî* (A); Track 4: the 2 small melodic movements in *Bûsalik* (G); Track 5: the two brief pauses in *Mazmoum* (F); and, finally, Track 6: the 3 sections in *Isba'in* (G).

During that phase of the experiment, the subjects were asked to focus their listening exclusively on the 'Iqd-genre changes, independently from the dynamics that give rhythm to the musical ideas and the relatively long rests that delineate the phrases in Mohamed Saâda's playing. In order to indicate their reactions and to designate the modal modulations throughout the melodic development of the work, they had to press on a MIDI keyboard while describing the 'Iqd-genre on which the performer was improvising.

It is important to highlight that, in this *Istikhbâr*, the transition from one 'Iqd-genre to another is sometimes very smooth, making it difficult to identify the beginning or the end of the development of the 'Iqd-genre in question. This is the founding principle of an elaborate improvisation: the most beautiful music is that which does not strictly follow the theory. Mohamed Saâda constructs his musical discourse and composes his melodic ideas sometimes without including a pause between certain movements, or stopping on the tonic of the 'Iqd-genre in which he is improvising.

Before proceeding to the data analysis of the modal-based listening session, it is important to distinguish two analytic approaches resting on different perception strategies: on the one hand, real-time listening in an experimental context with recommendations indicated by the instructions, and, on the other hand, a musicological analysis of the piece based on the score. The musicologist possesses a remarkable freedom when approaching the reality and the complexity of the work by listening to the piece over and over again to verify and measure certain parameters, etc. The two stages of perceptive processing, carried out in real-time by the listeners (identification of mode changes in the improvisation, location of the beginning and the end of each melodic modulation), are two dependent and complex tasks that cause distinct difficulties.

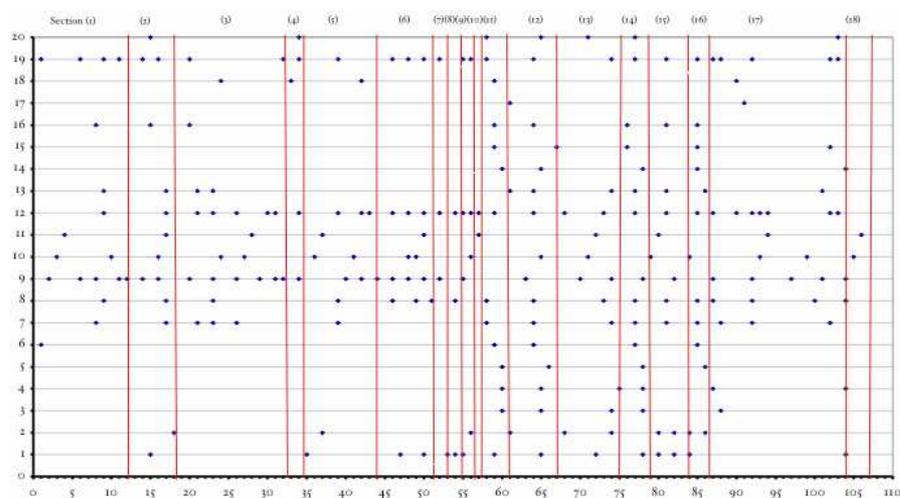


FIG. 21: Segmentation Results (3), Tunisian Subjects. The X-axis represents the time of the piece in seconds, and the Y-axis the number of the subject. The red segments correspond to the divisions we made on the piece's score according to the musical 'Iqd-genre to mark the boundaries between the melodic sections (sections: 1, 2, ..., and 18).

The vertical segments in figure 21 and the 18 melodic sections that were designated after listening to the improvisation several times and also from the

analysis of the score, do not correspond entirely with the divisions made by the listeners (Tunisian and European) in real-time for the following reasons:

1. *Problems linked to the complexity of the organization of the improvised melodies*

We identified at least three kinds of complex melodic arrangements in this improvisation:

a) A melody based on a particular *'Iqd*-genre of which the beginning and the end of the modulation are relatively intelligible when listening or looking at the score. This type of melody concludes clearly on the tonic of the chosen *Tba'* or of the *'Iqd*-genre, through a relatively long ending (rest) (figure 22).



FIG. 22.

b) A melodic arrangement that develops two related *'Iqd*-genres, but without emphasizing the pivot notes articulating one with each other. Conversely to what can be easily gathered from the score, the determination of the segmentation relative to the *'Iqd*-genre transition is difficult to accomplish with precision at any given moment during a listening session in real-time (figure 23).



FIG. 23.

c) Finally, a complex melody composed by a succession of *'Iqd*-genres, whose melodic modulations over time are not consensually identified by the experts. The transient modal variations are not particularly discerned by the listeners because they appear in rather brief melodic extensions that do not completely explore the modal scale of the *'Iqd*-genre in question (figure 24).



FIG. 24.

2. Criteria for segmentation and recognition of modes during real-time listening

a) The listener could perceive, by ear, a modal variation without identifying the *'Iqd*-genre at work in the melodic development. In this experiment, we recorded the MIDI reactions of certain subjects (Tunisian and European) who did not describe the mode in which the performer was improvising. These listeners explained during the interviews that followed the experiment that they effectively perceived a change in color, but that they were unable to describe the modal origins of some of the sequences.

b) Certain subjects made a cut after each pause, rest, or continuous playing of the *Mhayyer Sikâ* tonic. Even if the performer did not actually change modes, these listeners subdivided all the musical ideas composed on the same *'Iqd*-genre (subjects 7, 8, 9, 10, 12, and 19, see figure 21).

c) 8 Tunisian listeners adopted segmentation criteria that changed according to the performer's playing (subjects 2, 3, 4, 5, 6, 14, 15, and 17). They did not react during the first part of the improvisation because Mohamed Saâda did not try to play outside the *Mhayyer Sikâ* framework, highlighting this scale and emphasizing the pivot note (A) and the 6th (B-flat) in such a way as to lightly draw attention to a second center of tension around the pivot note G. According to these listeners, the improvisation in this first part conforms to and evolves mostly around the first *Mhayyer Sikâ* *'Iqd*-genre (D, E, F, G, A). On the other hand, from 44 s until the end of the improvisation, the 8 listeners focused their listening more on modal modulations, particularly on the brief melodic transitions that emerge from the variations of the *Mhayyer Sikâ* (the secondary *'Iqd*-genre, figure 20). Indeed, starting at the obvious modulation that marks the beginning of the second part (at 61'') and the incursions into different modal universes via secondary *'Iqd*-genres (often played virtuosically), these listeners were able to distinctly perceive the mode changes and to describe the same underlying *'Iqd*-genre.

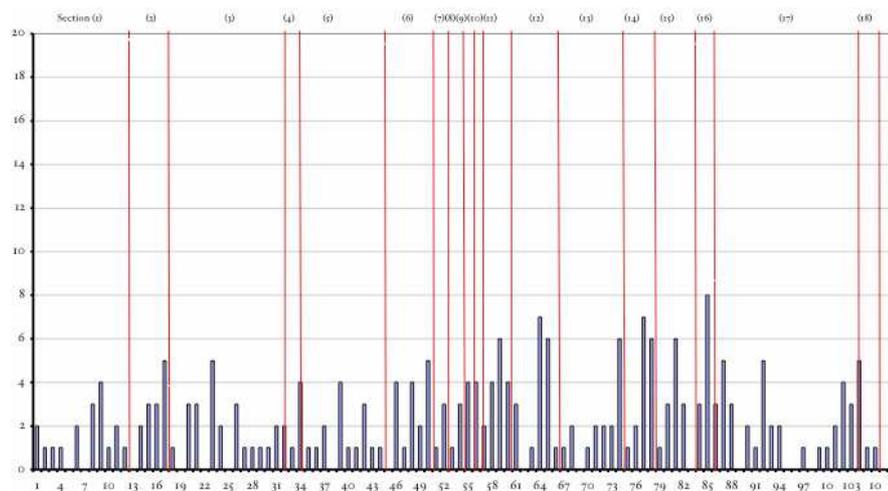


FIG. 25: Segmentation Results (3), Tunisian Subjects. The graph reveals the number of reactions of the Tunisian subjects at different points on the time axis. Certain MIDI reactions agree with the divisions we made on the score, while others describe the same *'Iqd-genre*, but with a slight delay, from 1 to 3''.

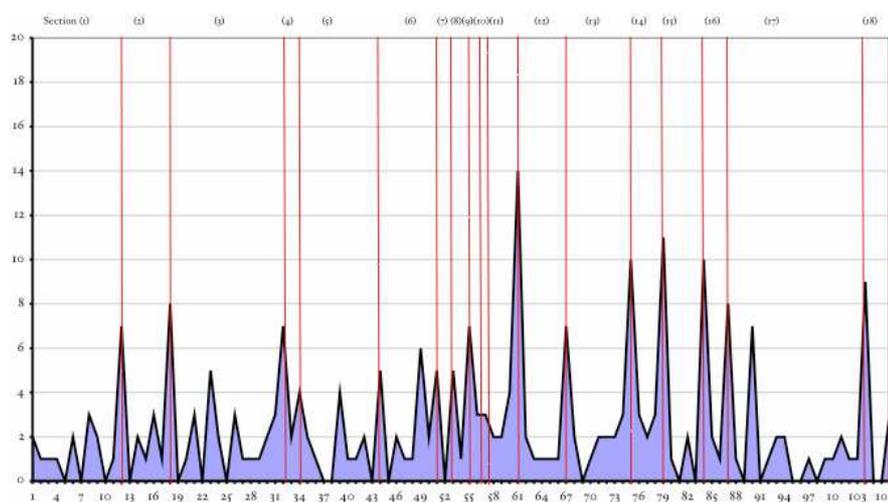


FIG. 26: In this figure, we regroup similar reactions related to the same *'Iqd-genre* on the time axis. It should be noted, however, that the repositioning of responses carried out in specific places on the score do not include reactions associated with divergent musical percepts.

3. INTERCULTURAL COMPARISON

The objective of this experimental study⁶ was to test the influence of diverse cultural background on the perception and comprehension of a musical work (not familiar to the group of European listeners), namely a traditional Tunisian improvisation. We assumed that the European musicians did not

⁶The experiments were carried out in France and in Tunisia with 80 listeners from different musical cultures.

possess any knowledge of this musical grammar. However, this position was revised slightly by choosing European subjects that play jazz.⁷

The results show that both groups (jazz musicians and non-jazz musicians) had difficulty anticipating the progression of the melodic development. The different modulations were perceived by many listeners, particularly the jazz musicians, but not having the cultural and cognitive background relative to this musical grammar, it was quite difficult for them to be able to anticipate the musical gestures. These musicians were often surprised by the arrival of musical events such as a change in tonality, a modal variation, a recapitulation of the theme, a partial resolution, etc.

One of the problems that we experienced with the two groups concerned the choice of criteria that had to be established in real-time, which led to a lack of coherence between the reactions of the European subjects. Certain subjects had difficulty perceiving the overall structure, but not in perceiving the underlying musical ideas, while others, on the contrary, were more at ease segmenting at a more general level than at a specific level.

Another difficulty was due to the absence of a regular pulse that disturbed some of the non-jazz musicians' listening, as well as the fact that the phrases were not of the same magnitude. Among the 40 European subjects, 3 preferred to listen to the whole piece without having to analyze it.

1. During the identification stage, the non-jazz-musician listeners encountered difficulties when trying to detect the scales corresponding to the *'Iqd*-genre on which the improvisation was constructed. Although other musicians perceived a development of motifs that did not relate, according to them, to the definition of the mode, none of them were able to identify the melodic-rhythmic schemas of the *Tba'* or the exploration of the different variations of the mother structure throughout the *Istikhbâr*. The unfolding of the musical structure is, in some passages, unpredictable and there is no temporal continuity. This is because there is no agreement between the structural schema and the implicit cultural reference used by the listeners in order to analyze the piece.

2. The objective of the melodic reduction stage was to test – based on inherent, therefore cultural, data – the presence and the pregnancy of this concept in the collective consciousness of those acculturated in this tradition. From thereon, this stage aimed to clarify its *raison d'être* and its functions within the process of perception and comprehension of the structure of improvised Arab modes in general and, more specifically, of the Tunisian *Tba'*. It therefore seems that the recognition of the modal origins and the representation of the melodic composition schema are closely related to the process of melodic reduction. The fact that listeners can recognize that a melody is an elaborate variation of another is proof of the psychological reality of such hierarchical representations.⁸

⁷For details concerning the reactions of the listeners from western musical cultures, the reader can refer to the article published in the book *De la théorie à l'art de l'improvisation*. (Ayari, 2005).

⁸Previous research has shown that western musicians possess an implicit knowledge of tonal relationships in the long-term memory (Bigand, 1993). As a result of this knowledge, the listener is able to spot the places where the musical sequence is modulated.

The experiments showed that the Tunisian listeners succeeded after only one listening at memorizing and reproducing long melodic sequences, and were able to optimize the complexity of the musical surface and to then recognize the melodic prototypes and the underlying modal origins. The reductions of these listeners that prefigure the melodic-rhythmic characteristics of the *Tba'* were remarkably similar. This coherence in reduction suggests that the essential melodic form is part of the hierarchical representation of the music and that it plays a fundamental role in segmentation, considered as knowledge acquired from the musical system. This hypothesis is supported not only by the convergence of reductions made by acculturated listeners, but also by the large divergence of reductions made by European listeners that did not perceive the improvisation's construction according to this process. Some listeners did not feel capable of reducing the piece to a melodic schema because it did not seem to have any relevance. In fact, the act of reducing the piece to a simple melodic structure did not for them reflect the entire improvisation. Not having any knowledge of how the improvisation was built, they did not perceive that it was constructed on the development of a particular musical *Tba'*.

3. Conversely to what we could discern amongst Tunisian listeners who perceived the structure of the improvisation in a relatively homogenous way, the responses of the European musicians during these segmentation stages were less significant, and imprecise. The performer's discourse seemed to be unfamiliar and unpredictable to these listeners who remained in a state of uncertainty and were not able to develop perceptive expectations about the melody's evolution. Nevertheless, the group of non-jazz musicians appeared to be more sensitive than the group of jazz musicians in the sense that their responses were more distinctive and less heterogeneous. However, the absence of verbal description in real-time for most of the musicians did not allow us to create a classification based on the reactions' significance at a given moment. One of the most important indicators for these musicians remained the pauses, which enable them to delineate phrases and sections. This does not involve any preexisting knowledge and corresponds to the lowest level of segmentation indicators (*indicator level 1*).

4. During the third segmentation (with the listening focused on modal changes), the European musicians (figures 27 and 29) were able to recognize the most striking melodic modulations in the improvisation. Despite the divergences revealed in the subjects' reactions, we noticed a fairly general trend in the jazz musicians who acknowledged the importance of the different modes used and their materializations in the improvisation. An expertise in modal scales – acquired through the practice of modal jazz, in particular – and of improvisatory mechanisms, although various in several regards, allowed them to better understand the improvisation and to better analyze the melodic construction schemas in particular. Most of the jazz musicians perceived the major modal changes from the start and were more precise in their descriptions. The induced segmentations, particularly in the second part of the piece, were relatively close to the ones made by the group of Tunisian musicians. This shows that jazz musicians are more sensitive to improvised modal music and many of them are less concerned with the musical categories that can be perceived when listening to classical European music (ABA parts, reprise of the theme, bridge, etc.). In fact, one of the important structural elements that informs the listening method of these listeners is the performer's

playing and musical style, and the metaphorical possibilities as well as the musical figuration techniques that determine them (highlighting of certain polarized intervals, playing a series of modulations from a “grid,” etc.) Certain listeners were nevertheless aware of the existence of rules within this *Istikhbâr*, but without knowing the details, they could not structure their listening around them.

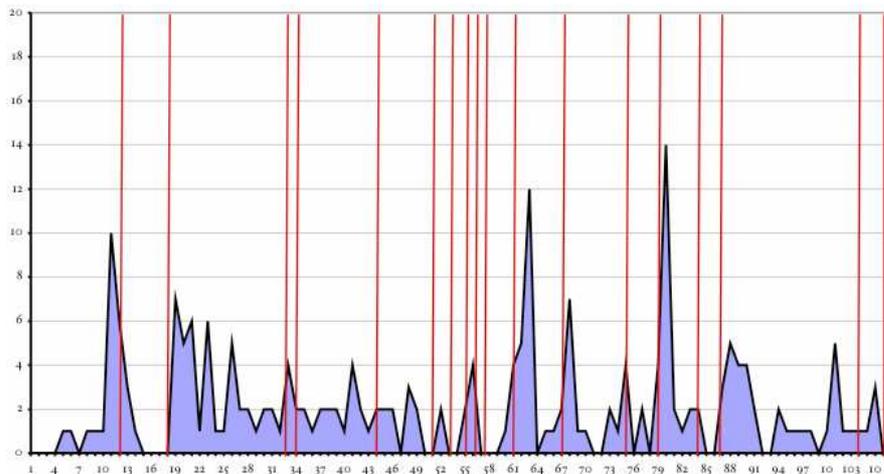


FIG. 27: The responses of the jazz musicians, during the third segmentation, are slightly closer to the structure of the work than those of non-jazz musicians.

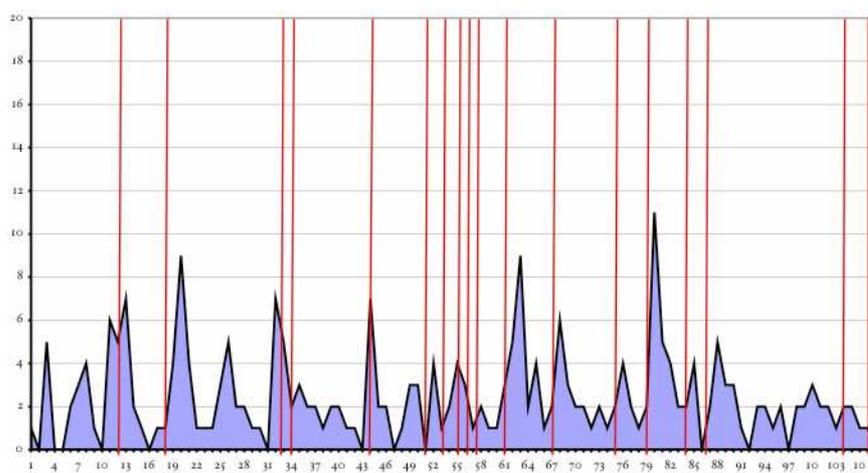


FIG. 29: The responses of non-jazz musician subjects during the third segmentation.

*

**

Finally, we would like to continue the experimentation with modal jazz, composed for the study according to a schema that should make it possible to bring together the two types of music at the level of their structural complexity. The same experimental paradigms will be applied in such a way as to cross the

musical genres with the cultural origins of the listeners.⁹ The use of two groups coming from two different cultures allows us to vary the degree of familiarity with a musical style and, thus, the knowledge that the listener possesses in relation to the music that is heard. The goal of these experiments is to uncover differences in modal processing in relation to acquired cultural schemas, and to contribute to the successive modifications of computational modelings.

APPENDIX

INTERVIEWS WITH THE MUSICIANS

This experimental study and the interviews with listeners from different musical cultures make it possible to establish the decisive factors of our approach to musical analysis. This analysis takes into account the listening strategies and the individual practical experience of the listeners, emphasizing the role of acculturation and the implications of cultural categories and filters on the work during the listening period of each listener and his manner of structuring the musical phenomenon in real-time.

The interviews with the musicians were guided by the following questions:

1. *Questions on the dynamic structure of the piece:*

- 1.1. How did you analyze the structure of the piece?
- 1.2. What are the important articulations and markers in the development of the melodies?
- 1.3. What are the playing mechanisms used by the performer to produce his improvisation?
- 1.4. Did you notice the reoccurring motifs, the general invariants?

2. *Questions on the general form and the melodic modulations of the piece:*

You were asked to describe the general form of the piece:

- 2.1. Did you experience any difficulty?
- 2.2. At which point did you detect this form?
- 2.3. Using what clues?
- 2.4. How did you perceive the modal modulations, breaks, or transitions?

3. *Questions on the segmentations:*

3.1. Free segmentations

- 3.1.1. What difficulties were you confronted with while segmenting the piece?
- 3.1.2. What were your segmentation criteria?
- 3.1.3. Did you always use the same criteria?
- 3.1.4. How were you able to define these sequences?
- 3.1.5. You segmented the piece into two hierarchical levels: How did you define these hierarchical levels?

3.2. Guided segmentation

You were asked to segment the piece according to the *'Iqd-genres*:

⁹I would like to thank all of the Arab and Western musicologists and musicians who agreed to offer their support to assure the successful completion of these experiments.

- 3.2.1. What difficulties were you confronted with while segmenting the piece?
 - 3.2.2. Did you always use the same criteria?
 - 3.2.3. How were you able to define these sequences?
 - 3.2.4. Do you think that you recognized these 'Iqd-genres'?
 - 3.2.5. What clues helped you to distinguish these 'Iqd-genres'?
 - 3.2.6. Was the passage from one musical 'Iqd-genre to another clear to you?
 - 3.2.7. According to you, are there melodic-rhythmic patterns proper to these 'Iqd-genres'?
4. Questions on the melodic reduction:
 - 4.1. Do you think that there are several ways to reduce this piece?
 - 4.2. Do you think that these melodic patterns reflect all of the movements of the piece?
 - 4.3. What are the elements that allowed you to reduce the piece in this way?

REFERENCES

- Ayari, M. (2003). *L'écoute des musiques arabes improvisées : essai de psychologie cognitive*. Collection « Univers musical », Paris : l'Harmattan.
- Ayari, M. (2005). *De la théorie à l'art de l'improvisation : analyse de performance et modélisation musicale*. Collection « Culture et Cognition Musicales », Paris : Delatour-France.
- Bigand, E. (1993a). Contributions of Music to Research on Human Auditory Cognition. In S. McAdams et E. Bigand (éd.), *Thinking in Sound: The Cognitive Psychology of Human Audition*. Oxford: Oxford University Press, pp. 231-277.
- Bigand, E. (1993b). L'organisation perceptive d'œuvres musicales tonales. *Série Recherche, Musique et Danse, n° 10*, Paris : Editions de la Maison des Sciences de l'Homme.
- Lerdahl, F. & Jackendoff, R. (1983). *The Generative Theory of Tonal Music*. Cambridge, MA: MIT Press.