FRANZ FÖDERMAYR &
WERNER A. DEUTSCH

EXAMPLES OF VIRTUAL MULTI-PART MUSIC AND THEIR PSYCHOACOUSTIC FOUNDATION

The general definition of multi-part music (polyphony) is based on what musicians or singers actually perform – “music in more than one part” (N. Grove, ²2001, vol. 19:74), “music in multiple parts” (ibidem:75), “music in more than one voice” (Oesterr. Musiklexikon, 2004, Bd. 3:1406). Nevertheless in Western as well as in non-Western music phases of compositions exist in which what is performed as distinctive parts does not correspond to what a listener can hear as melodic or rhythmic lines. The played or sung image is different from the heard image. Even in strictly one-voice pieces or sequences, the impression of several different parts can occur. As they are not played or sung explicitly, these parts should be called “virtual”. Consequently, psychoacoustics is challenged to give appropriate explanations of such “virtual multi-part music”.

I

Virtual multi-part music can be found in Western music, particularly in compositions of the Baroque period. W. Jay Dowling (1973) has provided a list of twenty recordings of Baroque music where virtual multi-part passages occur, such as the *Preludio* from *Partita number III* for violin solo by Johann Sebastian Bach (BWV 1006). With the exception of three chords towards the end of the prelude the whole movement is strictly in a one-voice texture. But in several sequences the auditory impression of two or even three voices is prominent. As an example, measures 12 to 29 are analysed (Fig 1). The upper system of Fig. 1 displays the part to be played; the lower system shows what is heard.

The psychoacoustic phenomena underlying these effects are called “auditory stream segregation” when high and low registers alternate, and “fission” when the temporal coherence of sequential auditory elements is lost. Temporal coherence exists, when an observer has the impression that a sequence forms a whole which is ordered in time (van Noorden, 1975: glossary). If, as in the current example, the tones of a sequence have the same timbre, temporal coherence depends mainly on the mutual relation of two factors: the tempo of the sequence and the width of the intervals between successive tones. “Small tone intervals (1 to 3 semitones) give strong melodic coherence, while larger intervals give more “tension”. (van Noorden, 1975:1).

The tempo of the sound excerpt analysed is seven tones per second, and the intervals between successive tones vary between 4 and 10 semitones, so that in combination with the relatively high tempo, the temporal coherence is broken and the tone sequence is divided into two simultaneous auditory streams: an upper and a lower one The upper melodic stream in measures 12 to 17 is characterised by an isorhythmic figure repeated once (measures 12 and 13, measures 14 and 15), introduced by an upbeat (measure 14) or an upbeat figure respectively (measure 12). The lower accompanying stream in these measures has syncopating character. Stream segregation is continued even in measures 13 and 15 because g/sharp, d/sharp and f/sharp stand out of the one-voice passage by accentuation and they are perceived as part of the upper melodic stream.

Beginning with measure 17 the regular groups of sixteenths are again split into two auditory streams. Here, the upper stream has accompanying character and is formed by the high tones of each group of sixteenths. First it forms a regular chain of quavers and is then (beginning with measure 24) changed into a regular anapaest figure consisting of the first three tones of each group of sixteenths. The melodic information of this section (measures 17 to 29) is given by the low auditory stream consisting of the fourth tone of each group of sixteenths, which forms a low voice starting with /e^5/ in measure 17 and continually descends down to /e^4/ in measure 29. The reason for this splitting is given by the size of the intervals between successive tones of each group exceeding the so-called temporal coherence boundary beginning at 4 semitones in measure 17 and reaching the size of 10 semitones in the last measures of the sound example. From measure 17 to 29 two conflicting metres occur: both streams move in three-four time, but beat one of the lower stream is shifted against the upper voice by three sixteenths.

II

Many examples of virtual multipart music can be found in African instrumental music South of the Sahara, particularly in the music for lamellophones, zithers, harps, lyres, and xylophones (Kubik, 1962:33). The Austrian ethnomusicologist and cultural anthropologist Gerhard Kubik seems to have been the first to describe virtual multipart music in Africa (Kubik, 1960;1962). He became aware of the phenomenon during his first fieldwork in Africa in 1959/60, when he was learning to play the xylophone music of Buganda. “Our playing when recorded sounded much more complicated than it actually was”, he wrote. “I heard a number of rhythm patterns which I was sure that none of us has played, while on the other hand the rhythms which we had actually played were inaudible on the tape” (Kubik, 1962:34).

In order to explain what happened we refer to a short composition for *amadinda* xylophone, *Olutalo olw’e Nsinsi* (The Battle of Nsinsi). The *amadinda* xylophone (Fig. 2) has twelve keys covering two octaves with five keys each, and two additional keys at the top of the pitch range. The keys are roughly tuned to a tempered pentatonic scale (Kubik, 1991:29, 46). The instrument is played by three players. For the sake of simplicity let’s call them A, B, and C. The parts of the players A and B are played strictly in parallel octaves, therefore whatever is played on the keyboard, the performers preserve a fixed striking distance of their two beaters. The notation at the bottom of Fig. 2 shows the transcription of *Olutalo olw’e Nsinsi* provided by Gerhard Kubik (1991: 146/7). Since the early 1960’s ciphers are used for xylophone notations (see Kubik, 1991:45-52).

The part of player A represents the general basis of *amadinda* compositions and starts the performance with “a strict isorhythmic pattern, consisting of a series of notes of equal length" (Kubik, 1960:11). The part is repeated throughout the whole piece. At a certain point (marked by the upward arrow in the transcription of fig. 2) player B starts with a contrasting part, also consisting of a series of notes of equal length. The B-part occurs exactly interlocking between the strikes of the A-part, and consequently the tempo of the performance is doubled. Because of the high tempo the human ear is not able to follow the rapid sequence of alternating large intervals. Independently of the part that plays the tones, the ear groups the tones into different auditory streams according to their pitch levels. The auditory "Gestalt" process is based on virtual patterns, which have been named by Kubik (1960:12f.) "inherent rhythms" or "inherent patterns". According to the comments of African musicians, the most important variant of inherent patterns of *amadinda* compositions consists of the tones of the instrument's keys number 1 and 2. Player C is responsible for the delicate task of following the pitches 1 and 2 of the interlocking parts A and B accurately and adequately playing his own two keys situated in the high octave (tuned to 1 and 2). The entry of his part is given by an asterisk in the transcription of Fig. 2. Each *amadinda* composition has five "transpositions", so-called *miko*, such that the inherent rhythms built by the keys number 1 and 2 are different according to each miko. Evaristo Muyinda, the teacher of Gerhard Kubik, demonstrated this fact in 1962 (Kubik, 1994:312, Ex. 113).

III

Similar virtual multipart music phenomena can be recognised in many musical styles, not restricted to Africa and Europe, when one has become familiar with inherent patterns. Fig. 3 shows the cipher transcription of a short composition of two *gender wayang* metallophones from Bali. The composition for two players consists of three parts: a low melody played in unison by the left hands and two higher voices played by the right hands figurating the lowest voice. In the figuration, tone number 5 of the low octave and tone number 3 of the higher octave sound together, resulting in a so-called *saih gender* fifth with 724 Cents interval size. Due to the different timbre and the higher volume, the chord is accentuated in the figuration and creates a repeated pattern of the form of 3+2+3 beats within an octovalent section. The distance of 273 Cents between the slabs number 2 and 3 of the upper octave in combination with the rapid sequence of strikes and the highest position of slab number 3 in the polyphonic texture provide an additional profiling factor for the pattern generation (Födermayr & Deutsch, 1992:386).

The current example was played by two young European musicians who learned to play compositions for gender wayang metallophones. The next example was played by a professional gender wayang quartet from Bali. The piece was originally recorded and analysed by Mantle Hood (1971: The Recordings, II:1). Although Mantle Hood did not mention the perception of inherent patterns, on careful listening they can be found.

The excerpt from the composition entitled *Selasah* can be divided into four sections with eight metrical units each. Fig. 4 shows the spectrogram of the first section. The lowest line of the cipher transcription, provided by Mantel Hood (1971:239), displays the so-called fixed melody played in unison by the left hands. The lines above show the figuration parts played by the right hands. If one listens carefully to each of the sections, several inherent melo-rhythmic patterns can be perceived which are marked in the transcription. One pattern can be heard prominently in section number 3 (Fig. 5). The middle part consists of a continuos sequence of tones number 6 and 5. As number 6 of the middle part is close in pitch to number 1 of the upper part, auditory perception integrates number 6 in the upper part to a distinct pattern.

In view of the fact that the transcription of Mantle Hood does not mention inherent patterns, and moreover no further reference to this phenomenon could be found in the literature on the music of Bali, Andràs Varsányi, a prominent expert on Indonesian and particularly Balinese music, was asked to comment on whether inherent patterns really do exist, at least in gender wayang music. His answer was: “You are right, musicians/composers in Bali partly apply this effect.” But he further commented that inherent patterns are mostly not a prerequisite, but a result of the interlocking playing technique *kotekan* (Varsányi’s letter of 24th July 2003). But in any case inherent patterns (whether deliberately created or not) enhance the perceptual ambiguity, which according to Mantle Hood (1980:1-14) is a fundamental trait of Javanese as well as Balinese music, in common with the duality of the society, both reflecting a governing principle in Javanese culture. Perhaps experts on Balinese music have not paid enough attention to this phenomenon so far?

IV

In addition to virtual multi-part effects in instrumental compositions the phenomenon can also be found in vocal music. The following example, recorded in May 1966 by Maurice Djenda and Gerhard Kubik, in addition to other aspects — tone to tone change of voice register: chest-falsetto; no isoparametric sequences with register change; unison with different register: upper voice chest, lower voice falsetto; tone to tone vowel quality change (Deutsch & Födermayr, 1997:61ff.) - is of specific interest due to the appearance of inherent patterns.

The song consists of a solo introduction and a duet section. The structural core of the duet section (see fig. 6) is given by the slightly varied reiteration of a unit which in voice A is divided into two symmetrical halves, the second one representing the tonal downward transcription of the first half. Voice B delivers four short phrases of yodel, each consisting of six elementary pulses. Their characteristic style seems to be derived from the first three-tone motif of voice A and their sequence in the single lines is always the same. The solo introduction (Fig. 7) consists of six phrases separated by short rests. Only phrase number 4 is directly connected with the next phrase (number 5). This yodel can be seen as an example of the coherence/fission phenomenon, in which in addition to the tempo and interval width, the importance of the observer’s attentional set as a decisive factor can be observed. Investigating the coherence/fission phenomenon, van Noorden (1975:10) presented configurations where “inevitable fission” occurred and others where “inevitable temporal coherence” appeared. But he discovered an “intermediate range where a choice is possible” depending on the attentional set of the observer, and he distinguished between (1) comprehensive listing, where the observer perceives all tones of a sequence together as a coherent whole, and (2) selective listening, where the observer tries to split off the sequence into several auditory streams (v. Noorden, 1975:9ff.). We think the solo introduction of our Pygmy yodel is relevant in this regard. On unbiased listening to the solo part, all phrases are perceived as coherent units. But under selective listening several phrases can be split off. While in phrases number 1 and 2 the falsetto tones are perceived as distinct strings, from phrase number 4 on, the tones sung in chest voice come to the fore, anticipating the constituent tones of voice A of the duet section as an inherent pattern.

V

The examples described in this paper give evidence that the general definitions of multi-part music mentioned at the beginning are not conclusive as long as they are based solely on what musicians or singers actually perform as distinct parts. They do not really include all manifestations of music which create the impression of multiple streams. As an example we would like only to recall the styles of overtone singing, most highly developed by Mongolian and Turkic peoples, where only a single complex tone 2is sung but by means of special formant techniques the singer brings out a high melody which is accompanied by the first harmonic of the complex tone as a drone. Those and other examples induced Rudolf M. Brandl to break up the common synonym of "part" and "voice" and henceforward to use the term "voice" for what is heard as a musical pattern independently of what is actually performed as a "part", and which a competent listener does not necessarily perceive (Brandl, 2005:12). In any case the terms "virtual polyphony" (Bregman, 1990:464) or "virtual multi-part music" have to be classified as belonging to the usual categories of multi-part music such as drone, heterophony, parallelism etc.

References

Brandl, Rudolf M. (2005). Universale Basis-Definitionen vom *Mehrstimmgkeit*, *Polyphonie* und *Heterophonie* (= multiple Abläufe) aus Sicht der Vergleichenden Musikwissenschaft. *Vergleichende Musikwissenschaft*,4:9-35.

Bregman, Albert S. (1990). *Auditory Scene Analysis: Perceptual Organisation of Sound*. Cambridge, Mass.: MIT Press.

Deutsch, Werner & Franz Födermayr. (1997). Visualization of Multi-Part Music (Acoustics and Perception). *Systematische Musikwissenschaft,* 5/1:49-68.

Dowling, W. Jay. (1973).The Perception of Interleaved Melodies. *Cognitive Psychology*, 5:322-337.

Födermayr, Franz & Werner A. Deutsch. (1992). Musik als Geistes- und Naturwissenschaftliches Problem. In: *De Editiones Musices. Fs. Gerhard Croll zum 65. Geburtstag*, hrsg. v. Wolfgang Gratzer und Andrea Lindmayr. (pp.377-389). Laaber: Laaber-Verlag.

Hood, Mantle. (1971).*The Ethnomusicologist*. Los Angeles: Inst. of Ethnomusicology.

Hood, Mantle. (1980). *The Evolution of Japanese Gamelan: Book I Music of the Roaring Sea*, New York: C. F. Peters Corporation.

Kubik, Gerhard. (1960). The Structure of Kiganda Xylophone Music. *African Music* 2/3 :6-30. Corrigenda, (1970), 4/4 :136.

Kubik, Gerhard. (1962). The Phenomenon of Inherent Rhythms in East and Central African Instrumental Music. *African Music* 3/1: 33-42. Corrigenda, (1970), 4/4 :136.

Kubik, Gerhard. (1991). Theorie, Aufführungspraxis und Kompositionstechniken der Hofmusik von Buganda: Ein Leitfaden zur Komposition in einer ostafrikanischen Musikkultur. *Hamburger Jahrbuch für Musikwissenschaft*, vol. 2 : 23-162.

Kubik, Gerhard. (1994). *Theory of African Music*., vol. 1. Wilhelmshaven: Florian Noetzel Verlag.

Kubik, Gerhard. (2005). Multipart Singing in Sub-Saharan Africa: Remote and Recent Histories Unravelled. *Vergleichende Musikwissenschaft*, 4: 181-209.

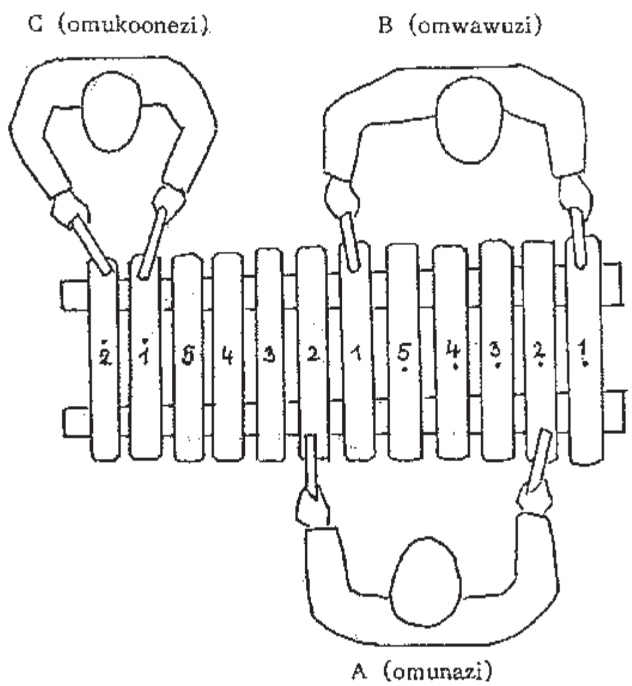
Noorden, van Leo Paul. (1975) *Temporal Coherence in the Perception of Tone Sequences*. Eindhoven.

სურათი 1. ი. ს. ბახი, *პარტიტა* (BWV 1006), პრელიუდია, ტაქტი 12-29 ასრულებს 18 წლის იეჰუდი მენუჰინი (პარიზი, 25 მაისი, 1934). ჰეიესი, მიდლსექსი, EMI, 1989, კდ 7630352, ბილიკი10. გაშიფრულია ფ. ფოიდერმაირის მიერ

Figure 1. J.S. Bach, *Partita III* (BWV 1006), Preludio, measures 12-29 played by 18 year old Yehudi Menuhin (Paris 25. Mai 1934). Heyes, Middlesex: EMI Rec. 1989, CDS 7630352, track 10). Played image: after *Neue Bach Gesamtausgabe*, Serie VI, Bd. 1, S. 54. Heard image: transcr.: F. Foedermayr.

სურათი 2. “Olutalo olw’e Nsinsi” (“ნსინსიების ბრძოლა”) ამადინდა ქსილოფონის ვერსია. * აღნიშნავს C-ს შესვლის მომენტს; ↑ – B-ს შესვლის მომენტს (Kubik,1994:60; 1931:312).

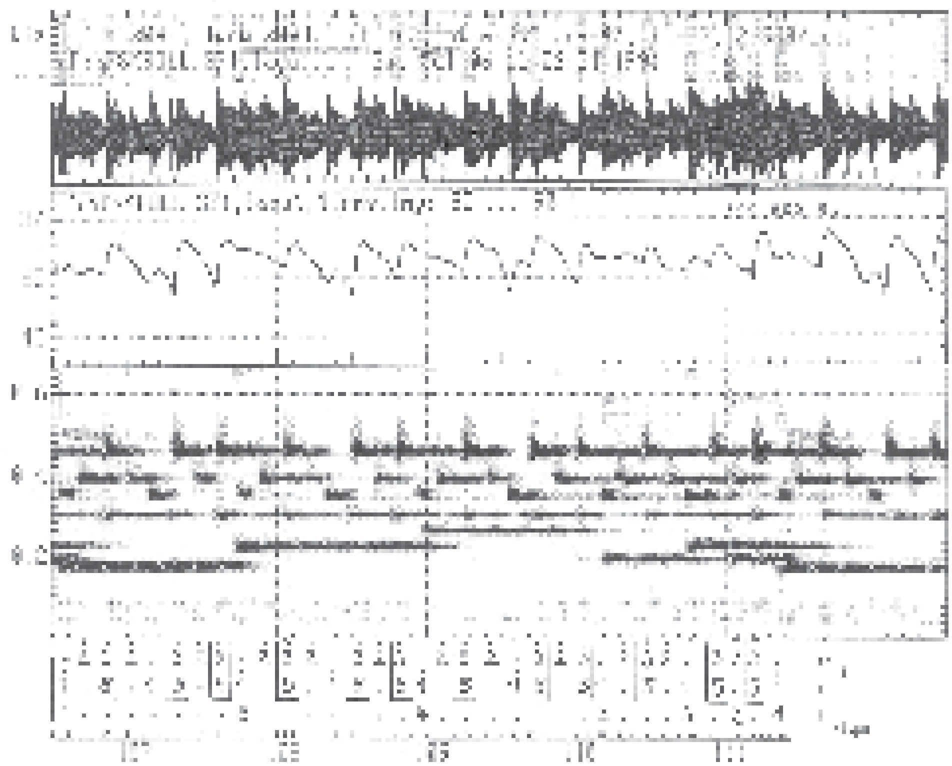
Figure 2. The amadinda version of “Olutalo olw’e Nsinsi”. * point of entrance of C. ↑ point of entrance of B. After Kubik (1994:60; 1931:312).



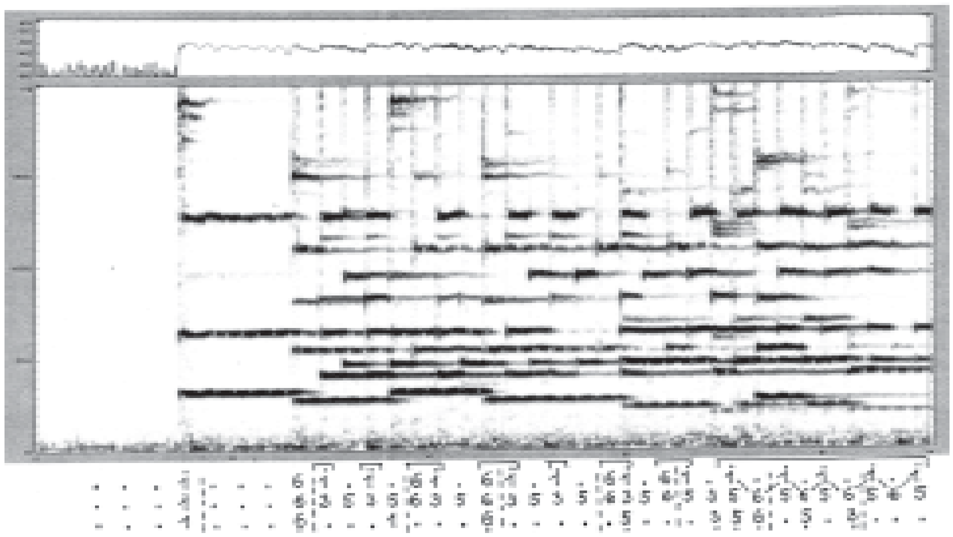
Olutalo olw'e Nsinsi:

```
            *
C: . 1 . . . 2 . 1 . . . 2 . 1 . . . 2 . 1 2 . 2 2
A: 4 . 3 . 4 . 3 . 3 . 3 . 4 . 3 . 4 . 4 . 2 . 2 .
B: . 1 . 5 . 2 . 1 . 5 . 2 . 1 . 5 . 2 . 1 . 5 . 2
                                             ↑
```

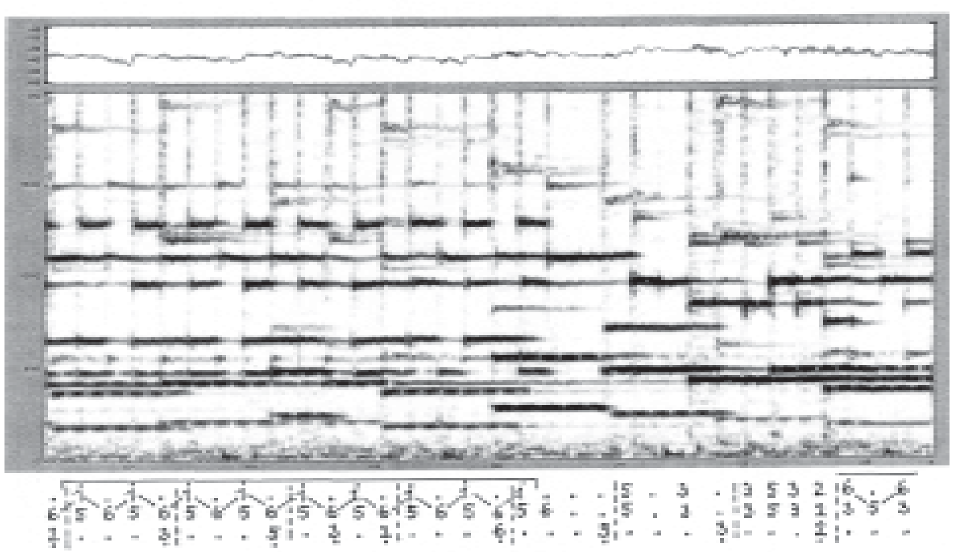
სურათი 3. *Lagu delem*, ფიგურა 1, ასრულებს უ. ჰაიდლი და ა. ვარსანი, მიუნჰენი, 3 აპრილი, 1985. სპექტროგრამა 0.6 კჰც-მდე რმს ამპლიდუტა 300-600 ჰც და დროის ფუნქცია. გაშიფრულია ფ. ფოიდერმაირის მიერ.
Figure 3. *Lagu delem*, figuration 1, played by U. Haydl and A. Varsànyi, München, April 3, 1985. Spectrogram up to 0,6 kHz with RMS amplitude 300-600 Hz and time function. Ciphertranscr.: F. Foedermayr.



სურათი 4. *Selasah*, ნაწილი 1. სპექტროგრამა და ტრანსკრიპცია მ. ჰუდისა (1971:239, ჩანაწერი II, 1).
Figure 4. *Selasah*, section 1. Spectrogram and transcription after M. Hood (1971:239, recording II, 1).



სურათი 5. *Selasah*, ნაწილი 3. სპექტროგრამა და ტრანსკრიპცია მ ჰუდისა (1971:239, ჩანაწერი II, 1).
Figure 5. *Selasah*, section 3. Spectrogram and transcription after M. Hood (1971:239, recording II, 1).



სურათი 6. *Yeli*, დუეტი, სტრიქონი 7. კუბიკი, მრავალხმიანი სიმღერა სუბ-საჰარულ აფრიკაში. *Vergleichende Musikwissenschaft* 4 (2005), კდ, ბილიკი 3. გაშიფრულია ფ. ფოიდერმაირის მიერ.
Figure 6. *Yeli*, duet section, line 7. From G. Kubik, Multipart Singing in Sub-Saharan Africa. *Vergleichende Musikwissenschaft* 4 (2005), CD, track 3. Transcr.: F. Foedermayr.

სურათი 7. *Yeli*, სოლო: კუბიკი (2005): სპექტროგრამა და ტრანსკრიპცია: ფ. ფოიდერმაირი.
Figure 7. *Yeli*, solo introduction. From Kubik (2005). Spectrogram and transcri ption: F. Foedermayr.