Using body vibrations for teaching, visualization and analysis of traditional Georgian singing

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1. INTRODUCTION

The generation of body vibrations (BV) during speaking and singing has recently become an area of interest in a number of different fields. We believe that they are also crucial for a full understanding of Georgian traditional singing. This paper consists of two parts. In the first part Frank Kane demonstrates how BVs and BV recordings can be used in a teaching context and in the second part Frank Scherbaum illustrates their use for the documentation and analysis of Georgian vocal polyphonic music. **[Authors' note. The first person singular "I" in section 2. is Frank Kane and the "I" in section 3. is Frank Scherbaum].**

2. THE USE OF BODY VIBRATIONS IN A TEACHING CONTEXT

In September 1982, I heard Georgian songs for the first time as sung by the Yale Russian Chorus and on the Melodiya LPs that I found in the library of this chorus when I became a member shortly thereafter. I was immediately struck by the energy of the songs. It was like nothing I had ever heard before. I quickly became something of an addict, listening to the songs for hours and hours! The attraction to this unique sound pushed me forward to learn more about this music: I started a vocal ensemble dedicated to Georgian folk music, studied the language, traveled to Georgia, and invited many Georgian singers to France to teach people there.

When I ask Georgian singers to explain what makes their group sound so powerful, they invariably say: friendship, love, trust, and confidence between people who sing together. I have no doubt that they are right, but I was curious to know *how* this love and friendship were expressed. I wanted a *technical* answer. In July 1997 I was in a room in Dmanisi surrounded by 28 Svan singers. As they sang together, the strongest impression for me was not the sound I heard, but rather the vibration I *felt*. I had never had such a strong experience of *feeling* other people's vibrations. Even after they had stopped singing, my body still seemed to be trembling, and the feeling persisted long after.

Little by little a hypothesis developed: perhaps the remarkable power of Georgian singing was partly due to the quality and the intensity of the body vibration generated by Georgian singers? Using the tools I had learned from studying the Alexander Technique, among other practices, and with Georgian singers who were willing to let me touch them as they sang, it quickly became clear to me - using my hands as the measuring tools - that there was a significant difference in the body vibration of Georgian and Western European singers.

I decided to apply this principle in my voice teaching. Doing experiments on my own and with my "laboratory" group in Paris, I found ways to increase the intensity of vibration in different parts of the body, to focus on this element while singing, and to become aware of other people's physical vibration. The results were very positive. My initial idea was to come closer to the sound that Georgian village singers have when they sing. In my opinion, confirmed by Georgians and other people familiar with Georgian songs, this approach brought my pupils closer to this way of singing. With this experience, they traveled to Georgia and found it easy to sing and learn with Georgian singers.

As my teaching work continued, the focus changed. While people initially came to my workshops to learn the Georgian repertoire, more and more people started to come particularly for my way of working with the voice and the focus on vibration. Today, I lead workshops and vocal coaching sessions for individuals and vocal ensembles that sing Corsican, Balkan, Ukrainian and Romantic Era Classical polyphony, among other repertoires. They all find that this principle of focusing on body vibration, which I have developed from observing Georgian singers, enhances their enjoyment of singing these different repertoires. On a regular basis, it brings them a feeling of intense connection which was formerly an exceptional event. They also say that it builds a feeling of trust and confidence within their groups. Observing them over time, it seems to me that their group cohesion is indeed developing. When they sing in this way, they are sharing something which reminds me of the Georgian singers I have been listening to for 34 years. "Sharing" is one of the words that best describes this phenomenon. It is possible to listen to someone with concentration and to then try to precisely sing a unison or some other interval with them. But with Georgian singers and the people I teach, it seems like a different phenomenon, so I use the term "vibrational sharing" to describe an action which includes listening and, on a sub-conscious or semi-conscious level, attunement to the physical vibration of one or several singers.

As the empirical results of this approach have been fully satisfying for me as a teacher and for the great majority of my pupils, I might never have undertaken a more scientific investigation of the phenomenon of body vibration and its role in singing if not for my meeting in 2011 with a person for whom the study of vibration, in a different context, has been a life's work: Frank Scherbaum.

3. THE USE OF BODY VIBRATIONS FOR DOCUMENTATION AND ANALYSIS

When I first participated in one of Frank Kane´s workshops in 2011, I did not foresee the impact this would have on my life. I immediately became infected (and still am) by the beauty of Georgian vocal polyphonic music, but as a seismologist I was particularly intrigued by Frank´s way of using vibrations in his voice work and his concept of singing as “vibrational sharing.” I have worked with waves and vibrations for most of my professional life, so I immediately started to wonder about the physical aspects of body vibrations. Soon after our first meeting, we jointly undertook some “seismologically inspired” experiments to quantitatively investigate the generation of body vibrations during singing. The questions which motivated us were (among others): Is the phenomenon of body vibration real, measurable and reproducible? How does vibration move through the body? Can we test whether people who are singing together react to the physical vibration of the singers around them? How are body vibrations related to the audible sound? It soon became obvious that with modern high fidelity sensors (e. g. bone and larynx microphones) body vibrations during singing can be recorded all over the body. Based on travel time measurements, we were also able to identify bone conduction as a particularly effective transport mechanism (Scherbaum et al., 2015). What was surprising to us in this context was the high fidelity of the recordings in terms of frequency bandwidth and dynamic range. For example, one can clearly identify not only the melody but also the singer’s voice quality from recordings picked up from the ankle or the toe of a singer.

Further tests and comparison with conventional audio recordings (Scherbaum et al.,

2015) led to the realization that recordings of body vibrations contain all the essential information from a singer's voice in terms of pitch, intonation, and voice intensity found on conventional audio recordings, but offer the additional advantage that they are practically unaffected by the voices of other singers. This allows for the quantitative and reproducible analysis of the contribution of each singer while they are singing together. We eventually realized that this opens new ways to document, visualize and investigate the melodic and harmonic inventory of polyphonic vocal music.

It is worth mentioning that the use of body vibration sensors for pitch analysis was pioneered almost 40 years ago (on the technical level available at that time) in a laboratory study of barbershop singing by Hagerman and Sundberg (1980). To the best of my knowledge, however, it has never before been systematically applied to ethnomusicological fieldwork. In order to explore their potential in such a context, I performed a pilot field study in Georgia in the summer of 2015 using a combination of body vibration sensors, regular audio and video recording devices. I will present some of the results of this study based on recordings of two different trios in Lakhushdi and Ushguli in Svaneti, Georgia. Additional data and details of the analysis are given in Scherbaum (2016).

3.1 Documentation of microtonality

One of the most obvious uses of body vibration recordings is in the context of documentation. In contrast to conventional audio field recordings, larynx-microphone recordings capture the contribution of each singer separately and in a way which allows for automatic pitch recognition and note estimation with high precision. Fig. 1 shows an example of the individual pitch and note tracks for the song Elia Lrde, recorded by three larynx microphones. The pitch and note estimation was done with the TONY software (Mauch et al., 2015). The lyrics were manually added to the output file.

Several advantages of documenting oral tradition music this way come to mind. First, the process captures all microtonal details of the music and does not force it into a possibly inappropriate (tempered) notation system. It is completely transparent and reproducible. Furthermore, it documents the music in digital form which allows subsequent processing in a multitude of new ways. To illustrate this further, Fig. 2 shows the beginning of the song Elia Lrde displayed in a way which allows us to see both the complete melodic and harmonic content including all the microtonal details in a single plot.

3.2 Intonation and communication between singers

One of the most fascinating aspects of the intonation process in polyphonic a-cappella music is how the individual singers find and maintain their pitches and timbres and how their perception of their own and the other voices influences them in this process (e.g. Mauch et al., 2014). Larynx-microphone recordings in combination with regular microphones can help in monitoring the intonation process in an interesting way. Fig. 3 shows again the song Elia Lrde, but only for the beginning of the polyphonic part and only for the top voice. The dense dotted line at the bottom part of Fig. 3 shows the sequence of pitches (determined by the TONY pitch tracking algorithm) for the first few seconds. The horizontal blue lines show the pitches of the determined notes with the red error bars indicating their corresponding standard deviation. The blue and red traces in the top part of the figure show the sensory roughness values (Vassilakis, 2007) for the top voice and the mix of all voices, respectively, which before the onset of the polyphonic part is determined solely from the contribution of the middle voice.

From Fig. 3 it can be noted that the voice slides to the target pitch from below. Interestingly, this "sliding phase" is so soft that it is not really audible on the acoustical microphone but is clearly detected on the larynx microphone. It coincides with a short time of increase of sensory roughness (blue trace) which is also observed on the mix of all voices (red trace). Sensory roughness measures the amount of beating generated from combinations of overtones in a sound and is therefore related to its sound color (timbre). As a consequence, a change of sensory roughness will be perceived as a change of timbre. Fig. 3 can therefore be interpreted as showing that while tuning in to the other singers, the singer of the top voice adjusts both pitch and timbre at the same time. Interestingly, the other singers do the same, which points to a strong mutual interaction. This feature was consistently observed for all voices during intonation.

3.3 Tuning of traditional Georgian vocal music

Part of the distinctiveness of authentic Georgian vocal polyphonic music comes from the fact that the underlying musical scale(s) are not tuned to the 12 tone equal temperament scale (12-TET scale). While this observation has found a consensus amongst musicologists, the particular nature of the Georgian sound scale(s) is a topic of ongoing debate (e. g. Erkvanidze, 2002,Tsereteli and Veshapidze, 2014). Since synchronized pitch information from all voices can be derived unambiguously, the analysis of larynx-microphone recordings can be used to determine both the interval sizes in a melody (horizontal perspective) and the harmonic interval sizes in a chord (vertical perspective) and hence contribute to the determination of the sound scale(s) from two complementary perspectives.

The harmonic interval set, in other words the set of concomitantly perceived intervals, was determined only from those pitch samples from the complete pitch tracks of notes (as determined by TONY) which have a minimum duration of 1 second and for which the first 0.4 and the final 0.25 sec were discarded for the analysis so that the focus is on intervals which could be called "stably established" by all three singers. The resulting frequency distribution is shown in Fig. 4. The most prominent harmonic intervals appear at 209, 366, 498, 706, 873, 1061, and 1214 cents. This corresponds to a slightly sharp major second, a "neutral" third, a pretty close to perfectly tuned fourth and fifth, a "neutral" sixth and seventh, and a slightly sharp octave.

In contrast to the harmonic interval set, the determination of the melodic interval set requires the estimation of the pitch step sizes of successive notes in each of the voices. In this context, all note durations (not only the long ones) where considered. The resulting statistical frequency distribution is shown in Fig. 5. The dominant melodic interval for all voices and all songs is on the order of 150 - 170 cents. In addition, one can see that the pitch steps downward are systematically smaller than the upward steps in all songs.

Based on the preliminary analysis of a subset of the recordings of the Svaneti 2015 field experiment, it seems already justified to say that field recordings of body vibrations can provide new and very valuable information for the documentation and analysis of vocal polyphonic music which would be difficult to obtain solely from conventional audio recording setups. If the difference between the melodic and the harmonic intervals turns out to be a real and robust feature of traditional Georgian vocal polyphony in general (which needs to be tested), it may be that the various proposals regarding the "Georgian sound scale" are not in contradiction but rather that they capture different aspects of the sound scale, namely the melodic and harmonic aspects, respectively. For the moment, this is only speculation based on a very limited data set, but the hypothesis seems worthy of further investigation.

4. REFERENCES

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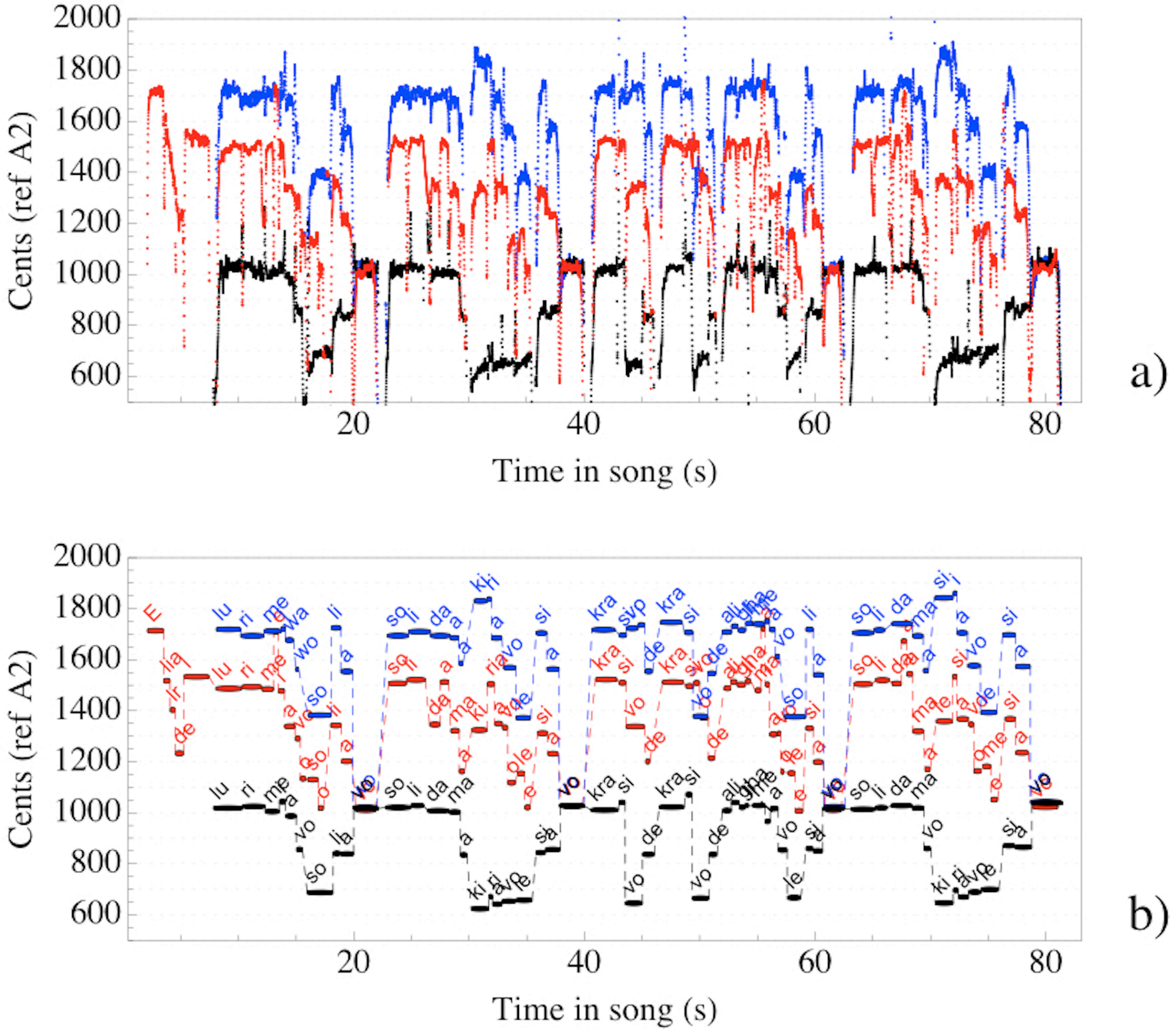

Figure 1. Pitch tracks (a) and annotated note tracks (b) for the song Elia Lrde (singers: Islam Pilpani (red), Gigo Chamgeliani (blue), Murad Pirtskhelani (black)). Pitches are given in cents relative to A2 (110 Hz).

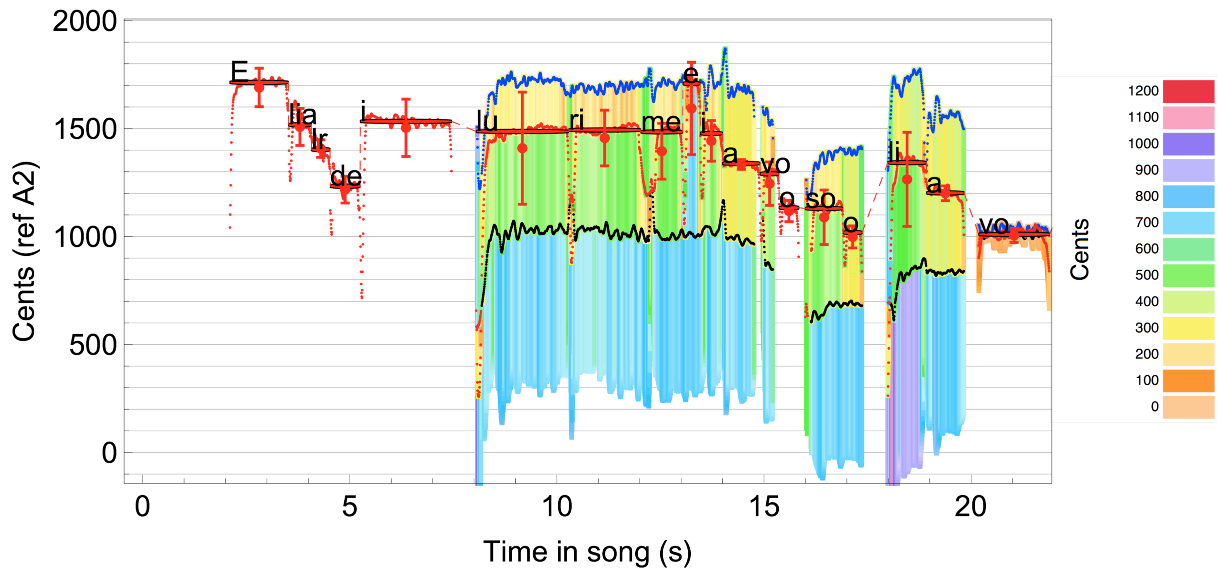

Figure 2. Melodic and harmonic content of the beginning of the song Elia Lrde. The black, red and blue dotted lines show the pitch tracks for the bass, middle and top voice respectively. The spaces between the middle and top voice and the bass and middle voice are color coded according to the corresponding interval size between the voices. The space below the bass voice is shaped and color coded according to the interval between bass and top voice.

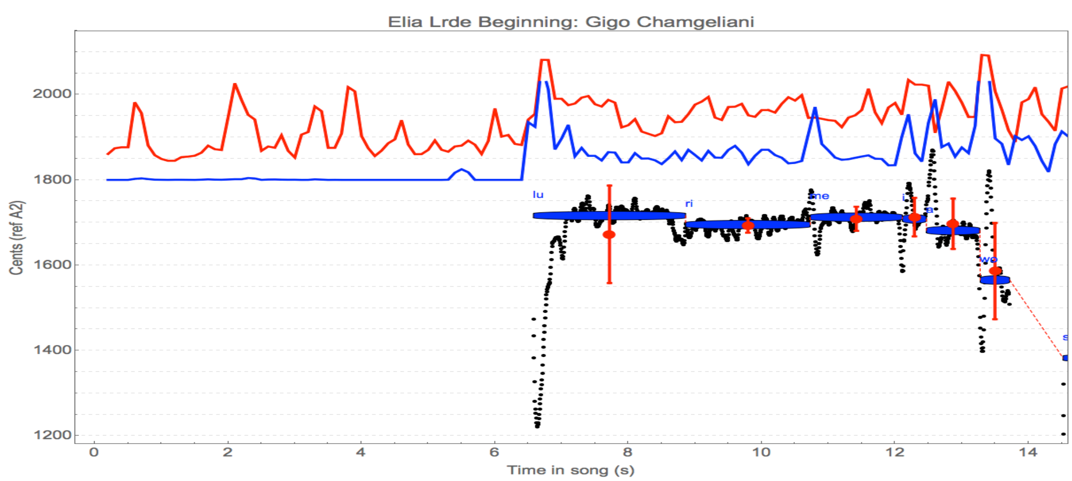

Figure 1. Voice track of the top voice onset together with sensory roughness track for top voice and mix of all voices.

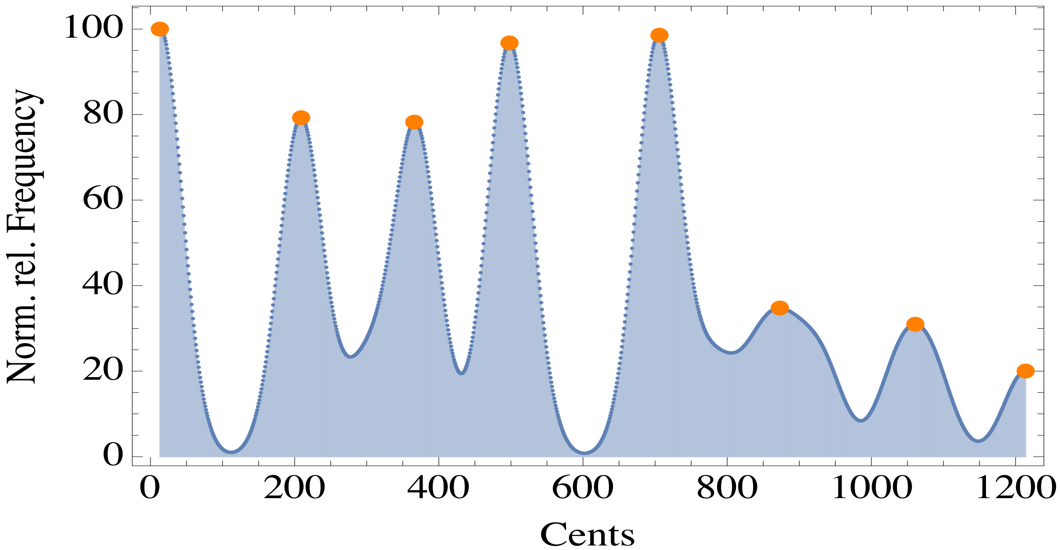

Figure 4. Frequency distribution of all harmonic intervals obtained by analysis of all voices in the songs Elia Lrde, Jgragish, Kviria, Lile and Riho sung by Islam Pilpani, Gigo Chamgeliani, and Murad Pirtskhelani. The peaks (orange disks) occur at values of 13, 209, 366, 498, 706, 873, 1061, and 1214 cents.

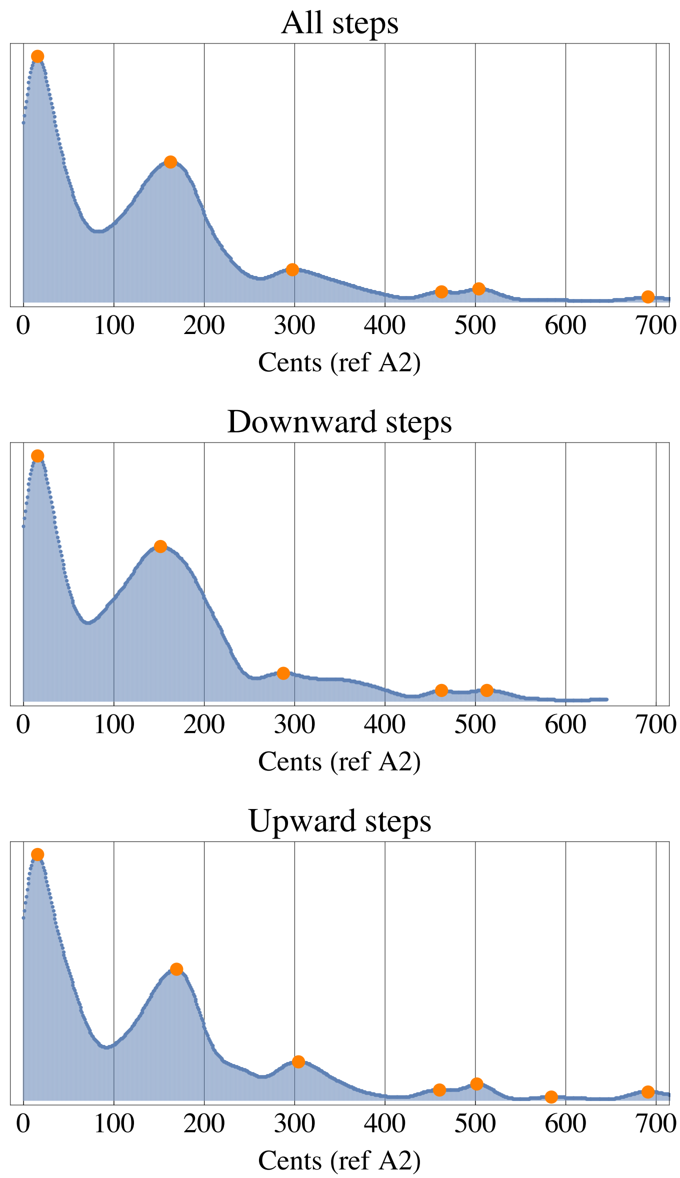

Figure 5. Frequency distribution of all melodic intervals obtained by analysis of all voices in the songs Elia Lrde, Jgragish, Kviria, Lile and Riho sung by Islam Pilpani, Gigo Chamgeliani, and Murad Pirtskhelani. The peaks, marked by the orange discs, of the overall step size distribution (top panel) appear at 15, 163, 298, 462, 504, and 691, cents. The peaks in the distribution of the downward steps (middle panel) appear at 16, 152, 287, 463, and 513 cents. The peaks in the distribution of the upward steps (bottom panel) appear at 15, 169, 304, 460, 502, 584, 691 cents.