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Scales Beyond Major and Minor

Musicology meets seismology – and opens up new possibilities for computer-assisted recording and analysis of polyphonic singing. Researchers use throat microphones to study traditional Georgian vocal music, which is included in the UNESCO World Heritage list.

Located in the South Caucasus on the border between Europe and Asia, Georgia has a remarkably diverse and highly respected musical tradition. In particular, this includes a type of polyphonic singing that presumably dates back to pre-Christian times. The songs do not remain the same, however: passed down from generation to generation, they constantly change. In 2001, this traditional Georgian singing was included in the UNESCO list of “Human Masterpieces of Oral and Intangible Heritage”.

Another point of interest is that documentation and research into the songs of Georgia can be traced back more than a hundred years in Germany and Austria. For example, phonographic recordings of Georgian songs in German and Austrian prisoner-of-war camps during the First World War formed the basis for a series of seminal articles on Georgian vocal music.

To Western ears, the music often sounds unfamiliar, as the scales used do not fit into the familiar major and minor scheme. In particular,

the similarity of traditional Georgian singing to the late medieval music of Western Europe gave rise to speculation as to potential links between the two musical traditions.

The songs are usually for three voices, and these are combined differently depending on region and context. It is still predominantly the men who perform the songs in public, although this is just beginning to change. Traditional singers tend to match their intonation to each other during the course of a song so as to produce certain harmonic intervals with particular purity, for example, or achieve certain timbres within the ensemble, while often performing in close physical contact. In the past, this caused an unsolvable technical dilemma for ethnomusicological field recordings. Clean acoustic separation of the individual voices – a prerequisite for a precise acoustic analysis of the singers’ interaction – was not possible using conventional microphones due to the virtually unavoidable acoustic cross-talk. When the singers sang their parts individually in a (portable) studio, they could no longer relate to each other, so a characteristic feature

Ethnomusicological fieldwork in Ajara, Western Georgia.





In order to record throat muscle vibrations that occur during traditional Georgian singing, the singers are equipped with throat microphones. Frank Scherbaum (left) fits them on site.

of singing, namely the interaction between the singers, disappeared completely. The authentic sound was lost.

In order to record individual voices while maintaining interaction between the singers at the same time, however, there is an amazingly simple solution if the problem is approached from a “seismological perspective”, i.e. focusing on the body vibrations generated during singing. In concrete terms, this means recording not just the airborne sound signal of a voice, but also the elastic muscle vibrations of the throat muscle near the larynx using throat microphones. These signals contain the essential information about a singer’s voice in terms of pitch, intonation and vocal intensity, but they

are virtually unaffected by neighbouring singers, even when the latter are in close physical contact.

Using throat microphones, it is possible to extract the time-dependent frequency information contained in the recorded signals for each singer on a more or less automated basis. This information then provides the basis for the likewise largely automated determination of the pitch trajectories (melodies) and the pitch inventory of the individual singers. This gives rise to a whole new approach of using computer-assisted methods for the documentation and analysis of orally transmitted vocal music.

The DFG research project “Computational Analysis of Traditional Georgian Vocal Music GVM” was preceded by a three-month ethno-

musicological field expedition in summer 2016. The objective was to record and document traditional Georgian chants, prayers and laments. The regional focus of the expedition was on the high-altitude mountain villages of Upper Svaneti where very old (presumably pre-Christian) traditions and songs are still maintained as part of daily life, as these villages were previously difficult to access.

Every performance was recorded in the form of multi-channel multimedia recordings, combining a high-definition (4K) video channel with one conventional headset microphone and one throat microphone per voice group, as well as a conventional stereo recording. In addition, each recording session was accompanied by extensive in-

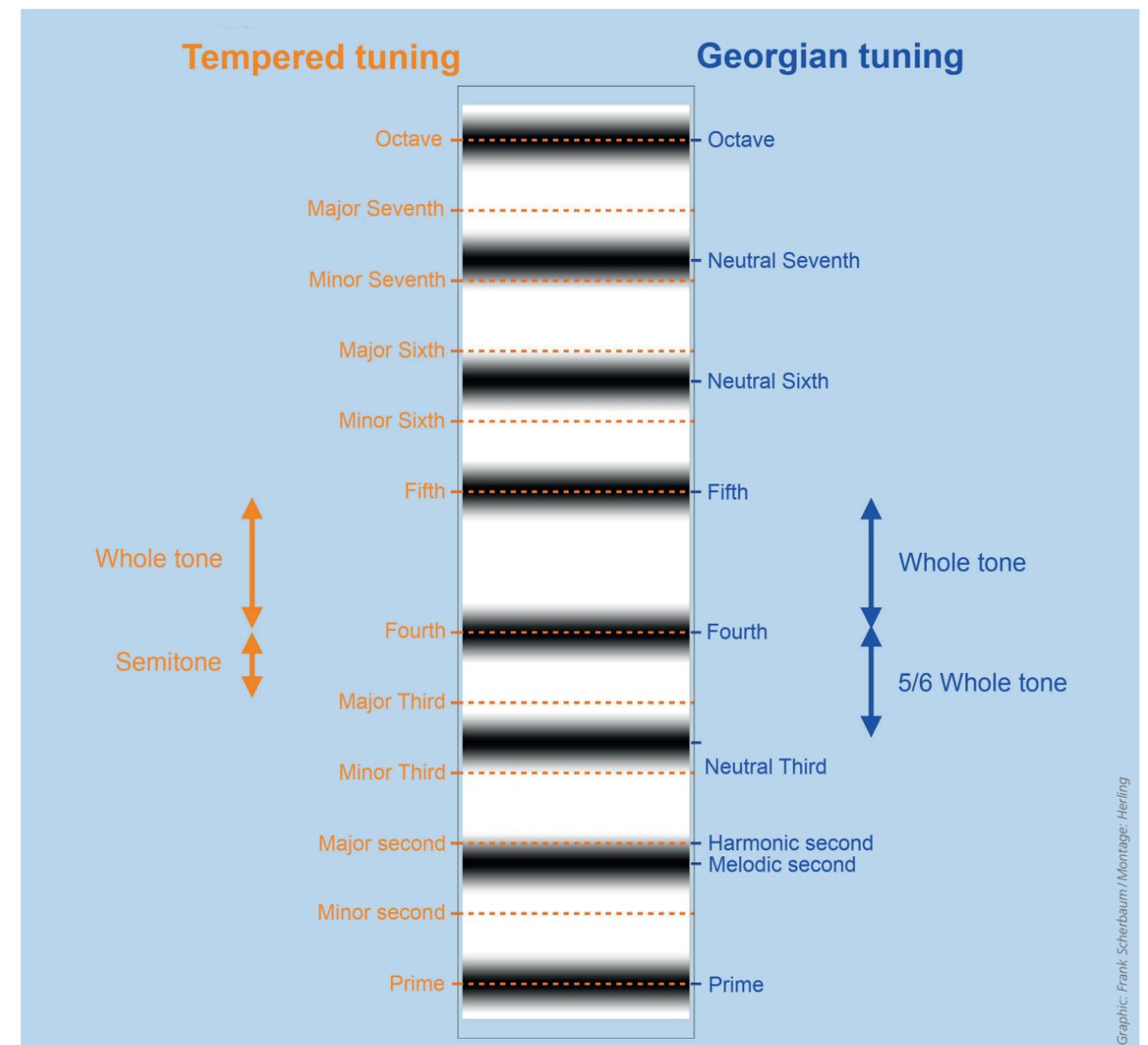
terviews with the musicians. This so-called GVM dataset, consisting of approximately 250 new recordings, together with the newly prepared approximately 100 historical recordings by the master singer Artem Erkomaishvili (1887–1967) dating from 1966 in which he sang all three parts separately, provides

an excellent data basis for computer-assisted analyses of traditional Georgian vocal music.

The new and elaborately created datasets are to be used to gain a better understanding of Georgian tonal systems. For decades now, there has been much controversy

over the question of whether there is or was a characteristic traditional Georgian tonal system, and if so, how it is structured. This is not just of academic interest: among other things, the answer to these questions will determine in what form this music will be considered authentic, performed and passed on in the future.

Schematic representation of the pitch inventory for comparison purposes: in terms of pitch, the intervals used in Georgian tuning (blue) are mostly in between the small and large intervals used in Western tuning (orange). This explains why traditional Georgian songs do not fit into the major and minor scheme of Western music.



In order to conduct this discourse in an evidence-based manner based on a large dataset of objectively verifiable pitch measurements, the interdisciplinary research project involved carrying out a computer-assisted analysis of the entire pitch and interval inventory of both datasets. In concrete terms, this meant evaluating something like more than one million pitch and interval samples. The result so far: the melodic scales used are significantly different from those that occur in music that is based on the major and minor systems, in which the melodic scales are made up of intervals the size of half or whole steps.

Based on an initial approximation, the melodic scales of traditional Georgian music are constructed from more or less equally spaced intervals of the size of 5/6 of a whole tone, though the distance between the fourth and fifth steps above the last bass note of a song often corresponds to a whole tone step. The size of the melodic second as the most frequent tone step of the songs varies significantly around a mean value of 5/6 of a whole tone step, whereas the harmonic second is

The team developed a broadband recording device specifically designed for singing that is able to record vibrations of the lateral neck muscle from the heartbeat frequency up to frequencies of several kilohertz. Created using a 3D printer, the neck brackets are individually adapted.

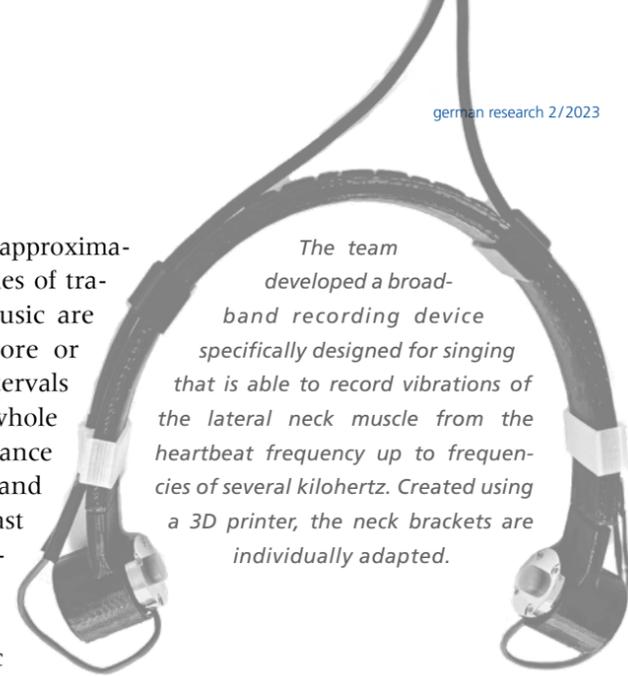
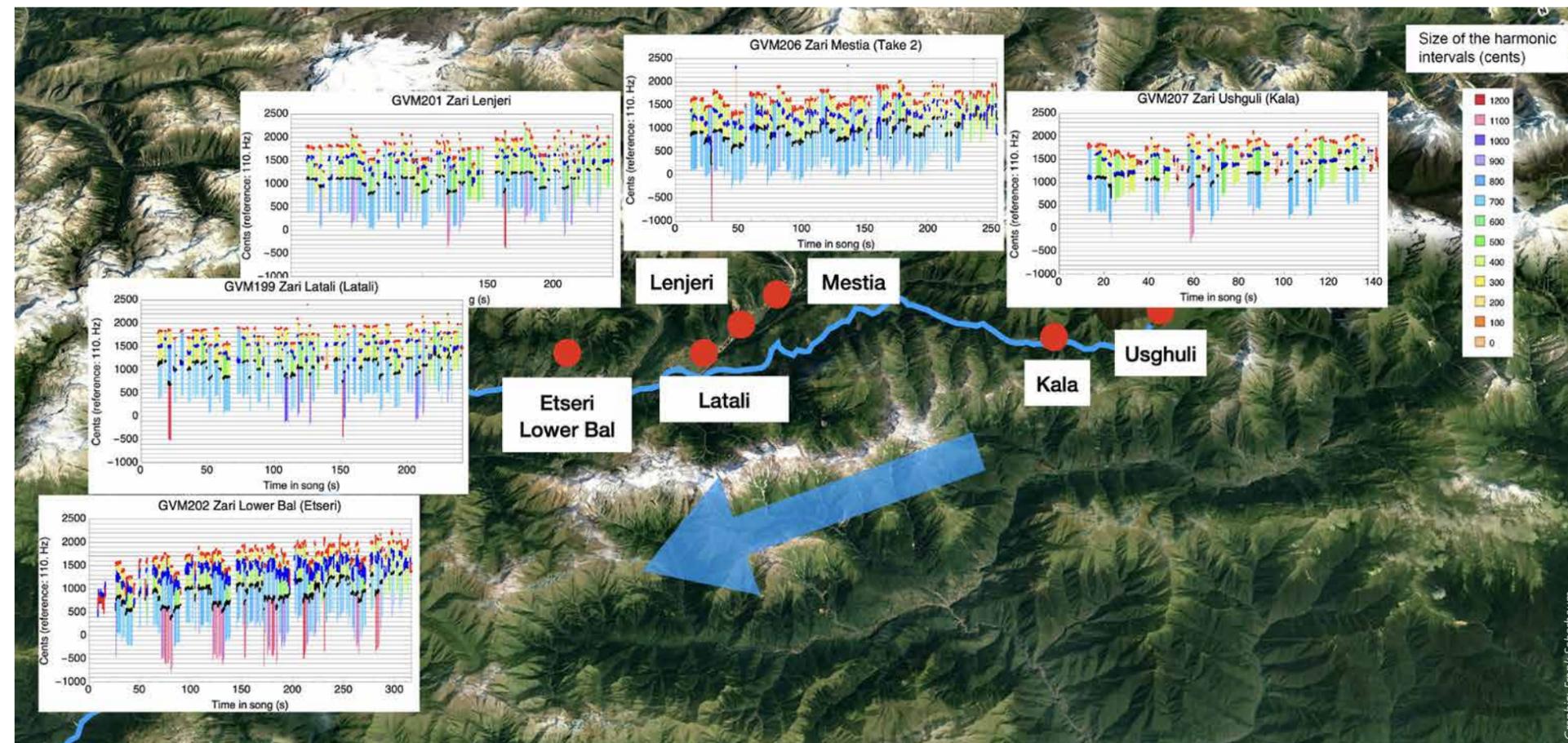


Illustration: Frank Scherbaum

significantly larger. This can be accounted for among other things as a consequence of the 1-4-5 chord that is very popular in Georgian music:

The range, duration and complexity of the melodic and harmonic structures of the so-called zār dirges increase systematically in the direction of the flow of the Enguri river (arrow). This correlates with the fact that the non-Svan influence from the Samegrelo lowlands increases, the further the settlements are located from the high-altitude mountain areas.



Graphic: Frank Scherbaum

this involves a fourth and a fifth being sounded simultaneously as pure intervals above a root.

Of particular importance in terms of both research and the cultural history of Georgia are eleven recordings of dirges from Svaneti in the north of the country. Known as zār in Svan language and zari in Georgian, this chant for three voices consists solely of vowel-rich sounds and is sung by men on the day of the funeral before the body of the deceased is placed in the grave. This musical expression of collectively expressed pain provides a glimpse into one of the oldest layers of Georgian vocal polyphony. The eleven recordings included in our dataset represent five out of a total of eleven still known variants of zār, all

of whose origins can be attributed to localities in the Enguri Valley in Upper Svaneti.

The pitch and harmonic interval analyses show remarkable results. For the most part, the bass and top voice of the zār chants move in parallel fifths: acoustically, this results in a very marked overlapping of their overtone spectra, resulting in an intense “merging”, i.e. fusion, of the two outer voices. In addition, the average pitch of the singing is continuously raised in the course of the song, giving rise to the impression of a permanent increase in the intensity of the sound.

This requires the singers to have an extremely well developed sense of harmony and engage in a very high level of vocal coordination. The intensity of the acoustic impression is further enhanced by the fact that, as phonetic analysis shows, some of the singers “detune” certain resonance frequencies of their vocal tract (formants) in such a way that the fundamental frequency appears amplified. This technique, known in Western singing styles as “formant tuning”, is apparently used unconsciously by the zār singers and results in penetrating tones that spread far into the landscape. Given the fact that after the death of a village member, zār is the only song that may be sung for 40 days, one can appreciate how much the mourning for a deceased person imprints itself onto the day-to-day soundscape of a village over a certain period of time, thereby blending everyday life and singing in a distinctive manner.

Furthermore, the acoustic analysis of the zār recordings shows that both the range and the complexity of the songs’ melodic and har-

monic structures increase systematically from the upper reaches of the Enguri River in Ushguli – the highest permanently populated place in Georgia – in the direction of the river. This correlates with the increasing exposure of settlements to non-Svan influences from the lowlands. Based on the example of Georgian vocal music, these and other analysis results clearly show the enormous and as yet unexploited potential inherent in the measurement of muscle vibrations. This will benefit the recording and detailed analysis of polyphonic singing in the future, too.



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