4 Pied Butcherbirds singing in choir - 11 verses with spectrogram and notation

4-part singing - synchronized and coordinated, correlating and corresponding in intonation, harmony, tempo, rhythm, phrasing, gestures

Analysis with the "Overtone Analyzer" software and by octaving slowdown

Summary: In choral singing, the Pied Butcherbirds (PBBs) sing alternately, simultaneously and sometimes in two or more voices. There is a bass voice, middle voices and an upper voice in all verses. Each voice is sung by different PBBs; exactly the same motif can be sung in different verses by other PBBs, they are then exactly identical in pitch, rhythm and length. Between the verses, the PBBs usually sit quietly, then one bird makes an initial sound and the others start immediately. Certain sound figures are associated with a certain physical movement. There is a rhythmic pulse in all verses, even through the pauses, which all birds follow, even when two voices start the 2-part singing. Certain pitches within a verse and in different verses are identical in frequency. Intervals between the tones and sounds of different PBBs mostly correspond to each other in terms of frequency in the harmonic spectrum (fifth 2:3, third 4:5, seventh 4:7).
In the singing of PBBs there are beautiful sound figures, the highest level of skill in the variation, flexible ornamentation, musical imagination, differentiated intonation, precise coordination as well as harmonic order and variability in sound and rhythm. All this not only with 1 bird like with the blackbird, but in the alternating 4-part singing of 4 birds.
The slowing down in octaves makes it obvious that the same *harmonic order of the nature of the sounds* is at work in the sound cosmos of bird song as they are by Pythagoras discovered and how it underlies the most diverse forms and cultures of music in the same way, which was discovered, found, invented by humans in this natural harmonic order and was and is practiced and performed according to this "beautiful order", in singing and making music together with other human beings. Millions of years before the dawn of human musical culture, songbirds developed beyond biological functionality the ability to listen to one another and to sing together, in the same pulse, in the one varied and multidimensional harmonic spectrum of sounds. So today we can still hear how each genus and each species of songbirds has found its specific *way of singing lively and creatively, that is shaping sounds and music creatively and thus bringing the cosmos of sound to life, letting it come alive in swinging and vibrating singing*.
The 4 Pied Butcherbirds document this with their choir singing.

This analysis was published in German on https://www.entfaltungderstimme.de/Klangkosmos.html in 2020.

Introduction, overview and notation for the video:

"Pied Butcherbirds singing in choir (1) - 11 verses with spectrogram - slowed down 2-4-8-16x"
https://youtu.be/xvK64lTmjNg

This video with the spectrograms from the "Overtone-Analyzer" is based on my own recording of the YouTube video https://youtu.be/Wr46I3568Hk "A group of four pied butcherbirds sings a morning concert in Cape Range National Park, Western Australia." In the video you first see and hear a single PBB, from 2:25 the choral singing begins. In the first two verses, 3 PBBs sing, then a fourth one joins them.

The above video is special because it features the singing in choir of the PBBs in a real and accurate spectrogram, both to hear and to seen. It's also the first time the PBB's vocals have been released in octaving transpose and slowdown (as of 2020).

Status 2022: see https://www.entfaltungderstimme.de/Klangkosmos.html with many videos and texts on the subject of bird songs. This text was slightly revised and expanded in 2022.

overview

When I listened to and looked at the PBBs' choral singing on the "Overtone Analyzer" for the first time, I was amazed at the variety of sounds and the rhythmic coordination with which these 4 PBBs sing together. And I was even more overwhelmed when I heard 2 octaves lower - in the familiar range of human hearing - what amazing sounds and sound figures can be heard in her singing when we can follow it in our human time scale. There were very unique timbres and shapes, rhythms and tone sequences that I had never heard before, and yet they touched me immediately and deeply when I first heard them. At the same time, there were familiar sound sensations in the surprising variety and my musical sense of sound was also able to orientate itself in these sound dimensions. Above all, what moved me deeply was the experience that I am the first human being that is allowed to hear and experience this singing in this way, a music that was already being sung when evolution did not yet "know" anything about a *homo sapiens*.

Hollis Taylor (http://www.hollistaylor.com/), an Australian composer with whom I am in exchange, has studied the singing of the PBBs thoroughly, but she was only able to analyze what a sonagram depicts and, more importantly, what she could notate by ear how it the French composer Olivier Messiaen also practiced. This also applies to the Hungarian musicologist and bioacoustician Peter Szöke with his "The Unknown Music of Birds", who was only able to research with an analogue tape recorder and the sonagram.
Also Emily Doolittle and David Rothenberg did not have the software of the "Overtone-Analyzer" and the possibility of slowing down in octaves in the spectrogram. These bird song researchers are all musicians (apart from Peter Szöke) who also compose and improvise themselves.

I am the first bird song researcher to use these tools, opening a new chapter in the study of bird songs. On the one hand, my competence consists in the fact that I, as a singer, singing teacher and choir director, can immediately understand *what* and *how* the birds sing, based on my experience and my practice. And on the other hand in the fact that my own learning process in the development of my voice and my singing was oriented towards the functional and physiological conditions of the breathing-larynx-hearing system, a learning process that I pass on as a "voice-sound-teacher", not as a singing technique, but rather through stimulation and experiential learning.
This means "*breathing and singing in the parasympathetic mode*" (as one of my basic texts is called), and this means at the same time listening and vocalizing based on the harmonic spectral order of the sounds, in the same way as the birds do and practice it. ("How can blackbirds and humans hear and sing fifths without having learned it?" - is another text I wrote about blackbird song.) In my teaching, when someone relies entirely on their inner spectral hearing to find a sound and its relationship to other sounds, I say, *"Now you hear and sing like the birds."*

The functional organization of the nervous system in vertebrates - the feedback functional circuit of hearing (= cochlea) - larynx/syrinx - vagus nerve - brainstem - cerebellum - limbic system (all below the cerebral cortex) has "fortunately" not changed significantly since the evolution of bird song, so that we can spontaneously whistle after a bird song, let ourselves be vegetatively aroused by birdsong and even perceive their sounds and songs and "understand" their tonal language (*homo "sapiens"*). Yes, it seems that we *recognize* these sounds when we can hear them at the rate of vibrations we are familiar with and at the pace appropriate to us in the sequence of tones. If I slow down a bird's chirping 16x and then recognize and hear the melody in the chirping, I can spontaneously and immediately imitate these melodic phrases in my vocal register without knowing and defining what and how I'm singing. And if I speed up my song 16x again, it's indistinguishable from the bird's singing or chirping.

Choral singing

In choral or ensemble singing, the Pied Butcherbirds (PBBs) sing alternately, simultaneously and sometimes in two or more voices. There is a bass voice, middle voices and a main voice in all verses. Each pitch is sung by different PBBs; exactly the same motif can be sung in different verses by other PBBs, they are then exactly identical in pitch, rhythm and length. Between the verses, the PBBs usually sit quietly, then one bird makes an initial sound and the others start immediately. There is a rhythmic pulse in all verses, even through the pauses, which all birds follow, even when the voices enter the two-part ensemble. Certain pitches within a verse and in different verses are identical in frequency. Intervals between the tones and sounds of different PBBs mostly correspond to each other in terms of frequency in the harmonic spectrum (fifth 2:3, third 4:5).
There is even a 2-part 7th (D6/C7 = 4:7) in verses 6 and 7, i.e. if a PBB joins the C7 of another PBB with the minor 7th D6, the 7th partial of D6 is identical to the 4th partial of C7. You can hear this "natural seventh" in the video at 07:00 and 07:24. Also for the blackbird the seventh is a very popular interval. It can sing a pure natural seventh in two voices with both parts of the syrinx.
The second time, 2 PBBs sing the C7 in unison, whereupon a third then joins in with the seventh (D6). The C7 has a very subtle interference between the two frequencies from the 2 PBBs, giving an interesting timbre.

As a singer, I too find it extremely pleasurable to sing a triad plus seventh (f - a - c - e-flat) to another voice that sings a sonorous fundamental in such a way that my seventh coincides exactly with the 5th, 6th and the 7th partial in the spectrum of the other voice resonates.

Tone sequences: A very special motif that appears 11x in different verses is a downward Phrygian tone sequence with the characteristic semitone at the end, best heard in verses 9 and 11: b-g-e-d-c--b-- (20:00 and 22:40). (Phrygian scale on the piano: e-d-c-b-a-g-f-e).
In verse 1 there is an E flat major scale several times, downwards with diminuendo and chromatic ending.

Variations: After the intro, verse 4 is identical in structure and type of motive to verse 5, but there are variations in the two-part voices and in the distribution of voices.
The Phrygian motif is introduced right away in verse 1 in a somewhat abbreviated form of PBB 3 and immediately slightly varied by PBB 2. In again changed form it is sung in verse 2 by PBB 1 and 2, in verse 3 varied again by PBB 1 and 2. And then in verse 9 it is presented in the most musically coherent form of PBB 2 and 3, which is repeated in verse 11 all by one PBB as well.
In all verses this musically exceptional motif sounds with a different, appropriate harmonic and rhythmic accompaniment from the other PBBs.

Two-part singing: In all verses there are different types of genuine two-part singing, rhythmically and harmonically: upper voice over a sustained tone, minor third, fifth, seventh, second, and also as a tritone, a very popular interval in bird circles of Old Europe, very euphonious in the exact ratio of 5:7, the third and seventh in the partial tone spectrum.

Sound gestures: As can be seen in the video, the birds repeatedly make certain movements when they sing: lightly flapping their wings, pointing their open beak towards the sky, or first raising their heads and then bending their whole body deeply. The PBB, raising his wide-open beak to the sky, is the one singing "out of the full throat" (as we say in German) the intensely pulsing sound at C#7 in verses 4 and 5 (each a different bird). And the PBB, singing the Phrygian tone sequence downwards, first raises its beak and then bends its body deeply forward. In verse 9, first PBB 2 sings this motive to the bass voice of PBB 3 an octave higher (duration 0.18 s) and 1.2 s later PBB 3 sings the same motive with a small embellishment to the bass of PBB 1, a fifth higher.
In the combination of vocalization and body gestures, this is an interesting early form of linguistic and social communication, as practiced by our direct ancestors in evolution, in rhythmic coordination and in a musically harmonious order.
(See the images from the video of verse 9 in the appendix p. 39)

Incidentally, these are all body movements that I practice myself in my voice exercises and that have a positive effect on singing. See the exercises on my website:
"Unroll and Roll Up the Spine", "Let Rising the Arms"" (arms = wings).

By slowing down the video several times, I was largely able to find out which phrase is being sung by which bird, who is singing with whom in 2 parts and when there is ensemble singing, i.e. two, three or four birds singing a phrase at the same time - all without a conductor and without eye contact, only by ear with unbelievable precision and at the highest speed.

The assignments of the phrases to the respective PBBs can be found in the notations (p. 9 ff), as far as I was able to find out after the video, which was not so easy because the birds unfortunately do not always point their beaks to the camera.

For octaving transposition and slowing down

The original singing has been slowed down in tempo and pitch by an octave (50%), e.g. transposed from E6 to E5, E4, E3 and E2. Due to the octaving (1:2), the pitches, the intervals, the partial spectrum, the sequence of movements, the volume and the dynamic and proportional sound structure remain completely the same. But in the lower frequency ranges that are appropriate and familiar to our ability to hear, we hear *more*, especially more *sound*, and we hear differently. And we hear something different and divers in every register and in every sound range. Melodies and tone sequences come to our ears, sound forms and sound figures emerge, and what in the high frequency ranges of the birdsong and in this tremendous speed of the sound movements is sometimes more noise than sound for our ears - stimulating and exciting, but beyond our ability to perceive slowed down, it becomes an astonishing and impressive sound, an "unheard of" music ("eine unerhörte Musik").

In German "unheard of" ("unerhört") has the double meaning of "never heard" / "not answered" / "unknown" and "incredible" / "outrageous" / "enourmes".

The analysis was carried out using the *"Overtone-Analyzer"* (https://www.sygyt.com/de/), with which the spectrogram of an audio file can be displayed in progress. The pitch and volume of each partial tone or each frequency of a sound spectrum can be read, the frequency ± 50 cents and the volume up to tenths of a decibel. The spectrum can be read up to the 128th partial (!), which is 7 octaves above the fundamental (at G2 = 100 Hz it is at 12.8 kHz). I have actually found such extraordinarily high frequency spectra in the singing of Pied Butcherbirds and blackbird.
At 5000 Hz, a semitone is around 290 Hz (at A4 around 25 Hz). In this wide range, the birds sing octaves, fifths, natural sevenths with a difference of sometimes only 5 Hz, if the proportion is sometimes not frequency-precise. But this is usually the case, even in two-part singing.
For the analysis it is helpful that on the Overtone-Analyzer you can zoom into a sound in the vertical of the spectrum and in the horizontal time axis like with a sound microscope.
A pitch marker shows the loudest sound in a spectrum, which is not always the fundamental tone. This marker also precisely depicts the vibrato movement in the lower register, which can amount to 600 pulses per second in the case of the blackbird, for example. The vibrato can speed up or slow down in a sound, and the amplitude can increase or decrease in dynamics (usually the amplitude it's a semitone). In 2-part interval sounds or in spectral sounds, the marker shows the harmonic fundamental, i.e. the virtual fundamental, usually one octave below the 2nd partial.
The octave transposition (tempo/pitch 50%) was done with "Audacity".

In bird song research, *sonograms* are mainly used, which, compared to the Overtone Analyzer only reproduce the sound spectrum very diffusely and imprecisely and with which one cannot look *into* the spectrum and hear the sound and the complete frequency spectrum with its "overtones" (partials). One sees only gray bands with no frequency-accurate pitch information, and the exact frequency spectrum of the high vibrations in a sound is hard to discern, even though these high frequencies are crucial for analyzing and identifying the sounds.
In addition, the pitch scale in the sonagrams is linear, which does not correspond to the actual, i.e. integer logarithmic ratios in the frequency spectrum (1:2:3:4:5...), which means that an incorrect "sound image" ("sonagram") is displayed. The noise in the chirping sound of the birds is created precisely by the compression of the frequency spectrum in these high registers, which means that our ears cannot distinguish pitches. Then there is the speed in the sequence of tones, which we cannot hear at this rate, which is of course displayed linearly on the time scale.
Since these sonagrams only indicate the dynamic level for the overall sound and do not provide any precise information about the volume of each partial tone, one cannot make any statements

about the character and structure of a sound (2-part singing of 1 bird? spectral sound? sound color? trill? vibrato? pulsation?).

Above all, the slowing down in octaves and its representation on the Overtone Analyzer offers a previously unknown and practiced method for analyzing and comprehensively researching all the elements of bird song. This applies not only to the components of the singing, which are to some extent recognizable as sequences of tones, but also to the overwhelming majority, which in the original is only perceived as a diffuse noise and cannot be represented concretely and differentiated in the sonagram at all. With conventional methods, this proportion can only be described by the sound/noise surface or by the structural elements in the course of the singing, which are then statistically examined in scientific studies without knowledge of the *actual sounds* (!).
This means that one can only make sufficient statements about *what* and *how* the birds *sing* and *hear* using real spectrograms, such as those provided by the Overtone Analyzer.

(In the case of blackbird song, this noisy chirping component (3-9000 Hz) accounts for up to 80% of a verse. With the PBBs it is significantly less because they do not sing in the frequency range above 3000 Hz. The song of female blackbirds that I discovered can only be recognized and heard with the help of the overtone analyzer and with octave slowdown: https://youtu.be/6FMif9wnLKA)

Dimensions of space and time - between noise, sound impulse, tone sequence and melody

The PBBs sing in the original register in these verses in the range of 2 octaves between D5 and E7 (600 - 2600 Hz). This is the area in which we can still distinguish individual tones, sequences of tones and intervals at an appropriate speed. In a similar range (1500-3000 Hz) the blackbird also sings its melodic phrases, which we can sometimes whistle by ear because we can produce whistling sounds in the same frequency range. In contrast to the PBBs, however, blackbirds also sing in the range of 3000-9000 Hz, a range in which our ears can no longer distinguish pitches, but only hear a song at this speed as chirping or noise. In the case of the PBBs, there are also several extremely short chirping noises in a relatively low range between B5 and B6 (1-2000 Hz). In order to find out what they are singing, I had to slow down this short sound 2 octaves lower at this pitch 4 times in tempo, i.e. 16 times in total.

And then, when I first heard the PBBs singing in 16x slowdown - I couldn't believe my ears:
I actually heard a beautiful, touching sequence of notes, which was also very musical in terms of rhythm and dynamics, B-G-E-D-C---B----, a Phrygian sequence of notes with the characteristic downward movement and the semitone towards the final tone. Since then, I just can't get this impressive sequence of tones out of my head.

(The Phrygian mode is one of the old "church keys", it was common in the Middle Ages. Jazz musicians still improvise in this scale today. Example: e-d-c-b-a-g-f-e)

On my video with the spectrograms, I recorded all verses in a 4x slowdown again in a 4x slowdown, in order to make these and other sound phenomena and tone sequences sufficiently audible that we cannot perceive at all, on the one hand because of the great tempo and on the other hand because of the complexity of the sound. Complexity means that it seems noisy to us.

Since I created the audio file from a video with poor sound quality, there are slight distortions in the sound in the slowdown, but this does not hinder the perception of the sequences of sounds and the harmonies.

Another example of what sound phenomena can be concealed in an "animal" sound that sounds more like a rough frog croaking than a bird song is found in verse 1 at the beginning of parts b) and c). They are indeed strong, steady, large amplitude vibrato sounds that swell on and down, dynamics and pitch, but all 5 sounds are perfectly precise in pitch and rhythm. In the 8x and 16x slowdowns you can see and hear that they are perfectly evenly vibrations. We do not call everything that we perceive as chirping in bird song and often describe as "beautiful" as a noise, although it is actually at least a sound noise in its indefinable acoustic complexity, and some of what we perceive in the 4-fold slowdown perhaps describe as "strange sounds" or as somewhat noisy, turns out to be pure sound with spectral order in the slowdown appropriate for our hearing ability.

In acoustics, noisy sounds are called "complex sounds" in contrast to the sounds/"tones" with a simple harmonic frequency spectrum (1:2:3:4....). Noises are called colored noise, they have an unspecific frequency spectrum.

Only in this 16-fold slowdown was it possible for me to create a sufficiently precise notation in lengthy analysis work. From verse to verse I was more and more astonished that in fact the same pulse prevails throughout all verses, even with grace notes, with long trills, with the use of a second voice, even through pauses. In verse 8 there is a long initial sound on the low 'B---B♭---' at the beginning, then there is actually a 16-beat pause and another PBB starts exactly with a rhythmically complex short figure, followed by another PBB with a long F#-----F---- in the exact fifth. Even in the pauses between verses, I can keep a steady count.
The rhythmic spectrum ranges from 1/16 tones to tone durations of 22 quarter beats, from 1/16 pauses to pauses lasting 16 beats, with an even quarter pulse.

As the basic pulse for the notation, I heard quarters = 88 in the 16-fold slowdown.
In the video there is a cut between verses 5 and 6 and between 9 and 10. All other pauses are in real time.

On the duration and the proportions of time

The verses last between 2.5 and 5.3 seconds, the pauses between the verses 3.2 - 5.3 s. The pause in verse 8 between the initial sound and the following phrase lasts 0.7 seconds. The entire Phrygian sequence of tones, phrased melodically and dynamically, lasts 0.18 seconds in all verses in which it is heard. The shortest single note that I discovered in all the verses and that I can just recognize and identify in the original register lasts 0.05 seconds.
The temporal dimensions and proportions involved become clear between the 8th and 9th verse. The 8th verse lasts a little less than 4 s, the break between 8th and 9th verse 5.2 s.
During the break, the tone sequence F-A♭-G--- can be heard from afar, which can also be heard at the beginning of the complete video from a single PBB before the choral singing. This touching little melody lasts 2.5 s, the breaks between the three tones last 1.5 s. The first time you hear it, it catches your ear and I can spontaneously whistle or sing after it. And then in the 9th verse, a PBB sings the Phrygian tone sequence B6-G-E-D-C--B-- right at the beginning after the initial sound B5, which, however, lasts only 0.18 s. It is only heard as a very short chirp in the original and when I play it by itself I hear virtually nothing and see nothing in the spectrogram that I can identify in any way except downward movement.
But if I then stretch the time by a factor of 16, the Phrygian tone sequence lasts 4 seconds.
It was only in this extension of the temporal course that I was not only able to recognize the exact tone sequence in terms of pitch and rhythm, but also to understand the musical character and the beauty of the phrasing by listening. Notated in this time dimension, the sequence lasts 5 beats. But in relation to this, the F3 minor melody 'F-A♭-G---', which can be heard from afar before the 9th verse, now lasts a total of 44 beats in the temporal extension, so that we our ability to perceive time is no longer able to establish a melodic relationship or a harmonic connection between these three tones.

4x slowdown - our familiar listening range

The 4x slowdown corresponds most closely to our familiar listening and singing habits, the 2 octaves between E3 and E5 (160-640 Hz), the range in which men and women sing. The tempo is sometimes still too fast for our ears to hear, distinguish and understand everything. But we hear clear pitches in the intense, somewhat longer sounds because they have a distinctive, large harmonic frequency spectrum (many high "overtones").
And we hear relationships between these sounds because one sound still resonates in our inner ear when a following sound with its specific spectrum also stimulates the sensory hair cells in the cochlea (cilia) and both sound spectra resonate with each other, complement each other, reinforce each other or also partially rub against each other, e.g. if at the beginning of the 4th verse a long F#4 can be heard, then after a pause an E4 and a G#4 and then after 2 short sounds an intensive long D4 (F#-E-G#-D : E major/D -major ?). The following intensive sound pulses at C#5 and the strong F/F#4 trill at the end then really nestle in the already excited vibrations in the inner ear and thus act as increased stimulation, even if I don’t recognize the C#5 and the F/F#4 as pitch or can identify because of their very noisy vibrating intensity. But an octave lower, i.e. slowed down

8 times, I then hear the C#4 as individual pulse sounds with a pitch that I can sing after, and I can also hear the pitch of the last semitone trill F#/G.

And we hear in the 4x slowdown something like melodies or motifs that combine into a melody as the verse progresses, despite other intermediate sounds that we can't hear in this area.
The following melody with its own rhythm can be heard in the first and second verse:
C#-E---E-D-C#-D---. The fact that we can hear this sequence of melodies so well is also due to their characteristic timbre. In this position it is another element of our familiar listening experience. It is created by the type of vibration and the way it is created, but above all by the specific composition and structure of the frequency spectrum (which and how many "overtones" / partial tones vibrate in this sound and with what intensity). Especially the main note E4 in the first three verses has such a characteristic coloring. It is a rhythmically pulsating sound that transitions into a tenuto sound (a "straight" sound). A color and expression very touching sound for our ears and our mind, which reminds me of the sound and atmosphere of a Duduk, an instrument from Armenia that is similar to an oboe, only much darker.

8- and 16-fold - in the depths and at the limits of our hearing

The recordings in these registers should definitely be listened to with good headphones or external speakers. The sounds are actually no louder than in the higher registers (-30 to -40dB), but their vibrations are so intense that the bass cone on my speakers sometimes begins to buzz.
The sounds appear strangely diffuse and scattered, as if without contour and without a center, as if they had unlimited inner depth and breadth and as if they were surrounded by an infinitely wide space into which their vibrations expand and lose themselves. At the same time, these sounds can have a density and intensity that can be felt and experienced not only on the eardrum, but also in the skull, in bones and tissue, as well as from the outside through the skin.

These sounds have a very special atmosphere and can lead you into an extraordinary listening experience that touches the limits of what is audible, especially in the 16x slowdown - an experience like out of time in a wide, deep space.
So it may be that a pitch, a sound or a sound figure is not only perceived from outside here or there, but that we (especially with headphones) are with our ears inside these sound spaces and the sounds themselves, as in large ones cavities, corridors and tubes from whose invisible walls the sound echoes.

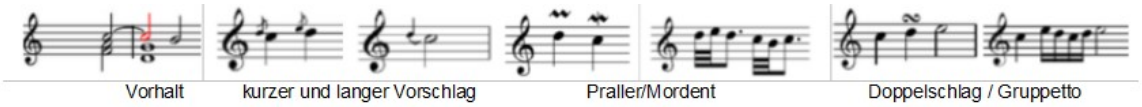
In this stretched time and in these wide, deep spaces we can even watch and listen to the sounds in their creation process, when a slow rhythmic pulsation accelerates and condenses into a continuous band of sound (. . . . -----).
We can see, hear and feel the precise regularity and speed with which a sound can pulsate and vibrate, so that our perception almost forms a continuum, a sound that we perceived 4 and 8 times faster only as a diffuse noise . And we can also experience a vibrato of 7 Hz in real time, in its rhythmically even pulsing, the vibratopulse, which also stimulate the human voice as vibrato in singing and which balances and orders all the different forces that are involved in this process of self-organization in the voice-breath-hearing system.

The dynamic bandwidth of these oscillations is very large, which can be seen from the wide stripes in the spectrogram. Depending on the position, it covers 50-70 Hz, which is a fourth or fifth in the lower octave range. If sounds have a vibrato, the vibrato pulse in this position can be around 30-40 Hz (pulses per second), with a full sound the vibrato can have an amplitude of around 16 Hz, which corresponds to a semitone with C4. At C6, a semitone is 64 Hz. (For comparison: With my singing, fully sung sounds in the lower octave can have a dynamic range of 90 Hz, the vibrato also has a pitch amplitude of one semitone with a pulse of 6 Hz.)
In the slow versions, of course, I shortened the pauses between the verses. Unfortunately, an irregular pulsing noise can be heard in these positions at 2600/1300 Hz, which probably originates from the video recorder with which the video was recorded. In the original it is around 21 kHz and then of course it cannot be heard. To keep it from being too distracting, you might classify it as a high-pitched noise of insects accompanying the low-pitched song of the birds.

The "singing technique" of the PBBs

In addition to the complexity of timbres, in addition to the abundance of different forms of articulation from violent pulsations to the smooth tenuto sound, in addition to the harmonic intonation that fills the ears, I was particularly fascinated as a singer by the way in which the PBBs produce and shape their sounds. Here are some examples:

Embellishment: Each tone is "started from above", as singers say and as choir directors preach, i.e. it oscillates from a slightly higher frequency or from the overtone spectrum. Sometimes a proper "*Appoggiatura*" (a note before the main tone - "Vorschlag") is also prefixed, or a suspension ("Vorhalt") is sung, as written in the notes of composed music or given as ornamentation. This also applies to a "Praller" (D-E-D) or a "Mordent" (C-B-C) at the beginning of the tone, sometimes also during the course and at the end of a tone. Sometimes a PBB will just start a note very briefly, as if checking pitch or tuning in, and then sing the note to the fullest. Then there is also a so-called "*Gruppetto / Doppelschlag*" at the beginning of a note (E-D-C-D), in which a note is played around, an embellishment technique that is found in many singing styles and musical genres, as well as the slight gliding into another note, this is called "*Portamento"* in classical singing. And sometimes, towards the end of a longer tone, a small rhythmic impulse or a swerve is added.



In verses 1 and 2 you can hear very nicely at the main note E4 that the PBBs like to sing with a pulsating vibrato (E---F-E---F-E---F-E---), i.e. with a slightly longer main note and an impulsively short secondary note.
(This stimulation can be used in singing to develop an even vibrato in the voice.)

There are different types of trills, mostly semitone trills, mostly very even, also in triplet rhythm (e.g. verse 6). They begin either from above or from below, i.e. with F#/G either with G or with F#. (Blackbirds, robins, great tits and others, in their "traditional European style" with their completely even semitone trills, always start from above. In classical singing, trills are also sung from the higher note, because in singing it's easier to perform.)

There is a kind of trill in the "singing technique" of the PBBs, which is also used in Renaissance music as "fioritura" (ornament) or to increase emotional expression, in that a tone is only sung with more vibration after several short impulse tones (il trillo . . . . ----------). And the "technique" of starting a note "straight" and then letting it swell in vibrato can also be heard in the PBBs, a phrasing technique that is also used in baroque music, among other things. Even the particularly striking rapid sound pulses in verses 4, 5 and 10 are also found in Monteverdi, for example, as amplification of special sounds through more intensive rhythmic pulsing of the voice.

Even the core element of the Bellcanto can be found in the PBBs, the "messa di voce", which is the art of letting a sound or even a trill swelling and ebbing. (For me a "messa di voce" is the most pleasurable and lively way to sing and experience a tone/sound.)

All these types of phrasing, embellishment, "fioritura" in singing can be found in other songbirds *and* in many musical cultures, especially in improvised singing, but also in composed music for singing from the Middle Ages to the Baroque. For it was common practice that the musical text was designed and phrased, even in choral singing as in medieval polyphony, all according to the diverse possibilities of expression and design inherent in the richness of the human voice. Instead of "singing and embellishment technique" I could also say that it is a specific *way of singing lively and creatively, that is shaping sounds and music creatively and thus bringing the cosmos of sound to life, letting it come alive in swinging and vibrating singing.*

The interesting thing about the way PBBs shape and modulate their singing with their voice is this: In the same and similar way, I have learned in my vocal development to train and stimulate my voice for greater flexibility, mobility and modulation ability. I also practice the same kind of stimulation in my lessons, so no exercises and no training in singing "technique".

The same type of flexibility that I experience with the PBBs is also what stimulates my arousal in singing and can also express higher vocal and inner excitement in singing.

Interaction of stimulation and excitement of ears and throat, not only in itself, but in the joint song of "males and females", listening to each other, singing together, in the same pulse, in the one varied and multidimensional harmonic spectrum of sounds and all their frequencies, without stress and beyond biological functionality, rather communication and strengthening of togetherness - is there a nicer way to sing and sound, to create music from voice and sound?

When the dimensions and spheres of bird song, as practiced by the PBBs in a very special and exquisite way, become audible and tangible for our ears, it becomes obvious that the same ***harmonic order*** *of the nature of the sounds* is at work in the sound cosmos of bird song as they are by Pythagoras discovered and how it underlies the most diverse forms and cultures of music in the same way, which was discovered, found, invented by humans in this natural harmonic order and was and is practiced and performed according to this "beautiful order", in singing and making music together with other human beings.

harmonic order = sound cosmos = beautiful and comprehensive order in nature

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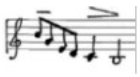
On the following pages there is the spectrum picture for each of the 11 stanzas in the original position and in the 4-fold slowdown, plus the notation in the 2 octaves lower position. The tempo of the notation corresponds to the 16-fold slowdown, i.e. if the 1st verse lasts 7.5 seconds in the original, it has a duration of 2 minutes at this tempo. The notated tempo for the quarter note is 88 beats per minute (Andante). In addition, I wrote in notation for each verse what I can hear in the original register and speed with the help of the Overtone-Analyzer.
The up and down arrows on individual notes refer to the intonation relative to the exact pitch on the keyboard. Sometimes I have given the deviations in cents (-12 or +6). A semitone is divided into 100 ct. The intonation can be read so exactly in the spectrogram! If a fifth is exact in the PBBs, which is the case in the vast majority of 2-part sounds or subsequent intervals, it means that both sounds have a fundamental frequency ratio of 200 Hz to 300 Hz and not 204:297.



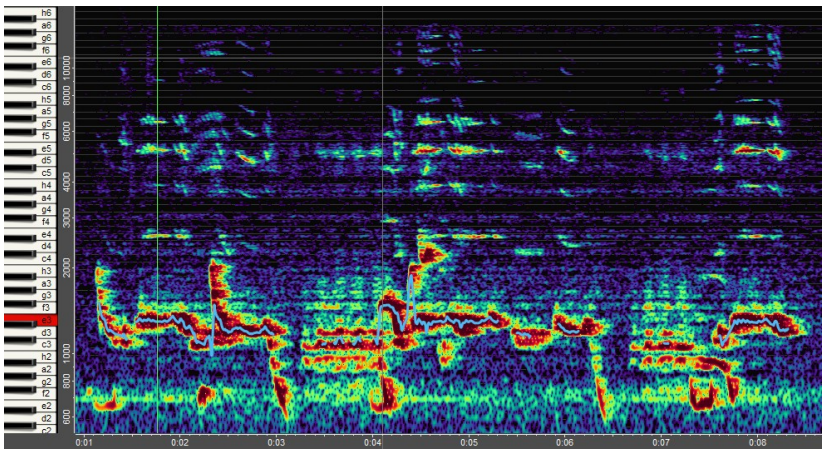
For example, in the Phrygian motif, if the B4 in the 4x slowdown is 486 Hz, the E4 has a frequency of 324 Hz, and if I divide the 486 by 3 and the 324 by 2, the quotient is 81 both times. This is the exact fifth in this sequence of eighth notes with a motif duration of 0.18 s.

The additional spectrum images for the notation in the description are without a partial spectrum.
Each verse is accompanied by a brief description of the main motifs. In the small spectrogram images, the note designations are in German. (e = E3 - e1 = E4 - h1 = B4 - b = B♭3 - es2 = E flat5)
Since this is a video recording, only the spectrum up to 16 kHz (H9) is displayed. In this range you can read a spectrum of 4.5 octaves in the singing of the PBBs, from E5 to B9. Some sounds have an intense full spectrum up to the 10th partial (third), which is then at 14.5 kHz (A9). From verse 8 I re-recorded an F6 sound 8 times slower with a wave recorder. The spectrogram then shows a complete spectrum up to the 64th partial, which is almost 3 octaves more than in the mp4 recording. The 64th partial is originally at 90.24 kHz.

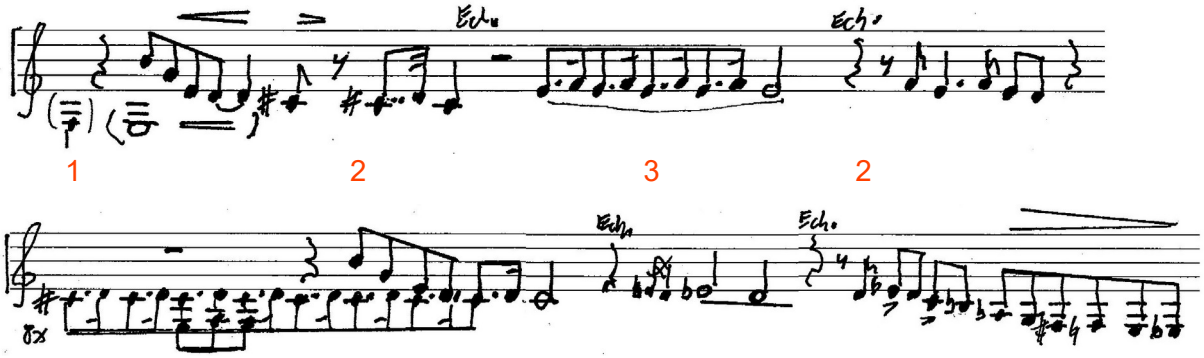
Regarding the notation, I have to say that this was by no means the case, that I could simply write it down using the spectrogram in the 16-fold slowdown and with the help of the pitch marker. I had to keep listening, listening, listening, zooming into the phrase, comparing it with the other octaves, finding out the pulse, checking the partial spectrum and calculating for the exact proportions between the frequencies and for the relationship between the sounds, 2:3 - 4:5 - 5:7 ..., 4th partial = 3rd partial etc.etc. Some passages took me a long time to decipher. Overall, none of this would have been possible without my musical and vocal skills and especially my knowledge of the harmonical order of sounds.

In the first two verses, 3 PBBs sing, then a fourth one joins them. In verses 10 and 11, only one PBB is seen, with which the others nearby sing together.

1st verse - 3 PBBs with 2 Phrygian motifs

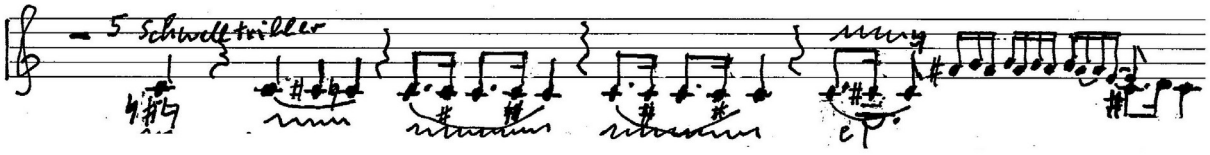


a) 1 3 1 1 2

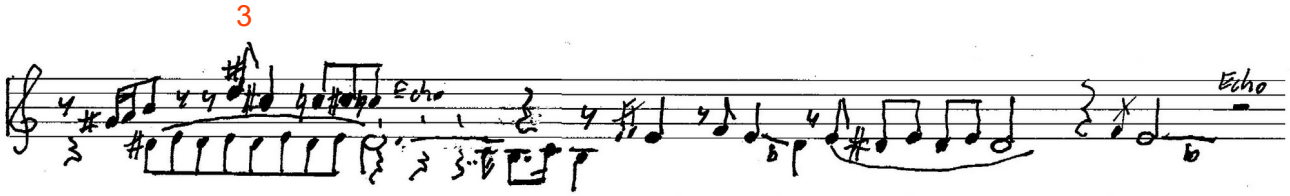


1 2 3 2

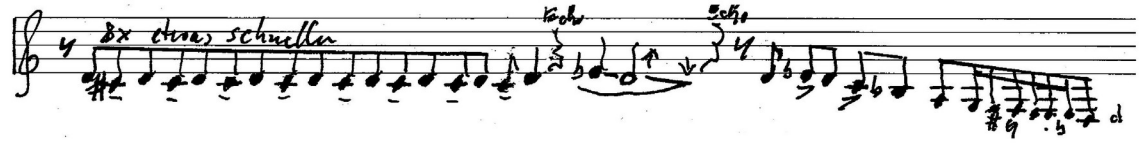
b) 3 1



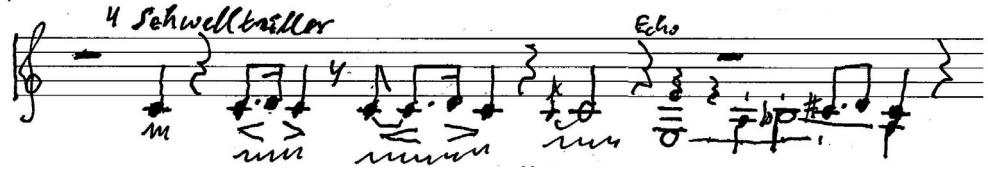
3



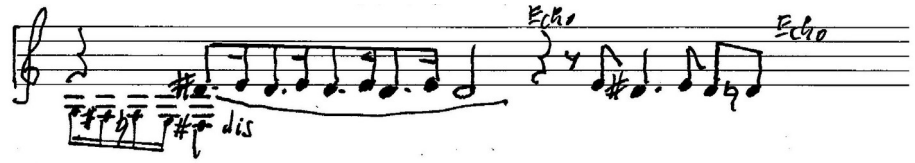
3 2



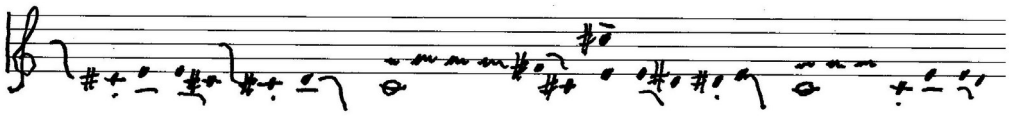
c) 1 3 2 1

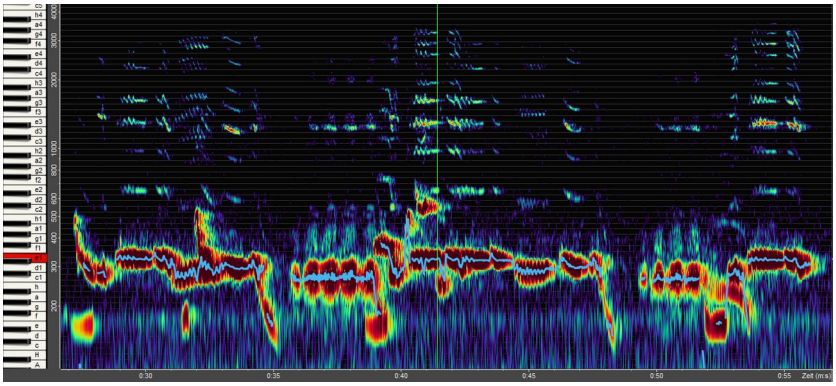


1



1st verse to be heard in the original position:



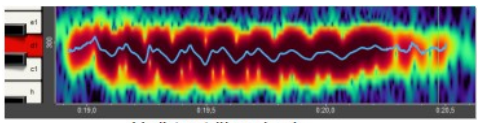


1a)
- **Beginning 2-part**: to the bass part E3 - Phrygian motif (PBB 3) - B4-G-E-D---C#---
- **Main note E4**
- **Semitone trill C#/D** - plus 2-st. Bass part E-F-E and Phrygian motif (PBB 2)
- **E flat major scale** with chromatic at the end

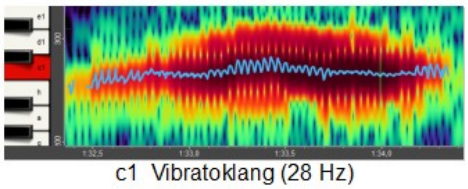
1b)
- **5 "Swelling Trills"**
- **3 voices:** middle voice D#-E4, upper voice C5-C#-C, lower voice B-C4-B
- **Semitone trills** D#/E and intensive upper voice C#5-C-C#-C
- **Semitone trill** D-D#-D
- **E flat major scale**

1c)
- **4 "swelling trills"**, then 3-part: bass part E3, middle part A-Bb----A, upper part plump C#-D-C#
- **semitone trill** D#/E pulsating

Hauptnote e1 pulsierendes Vibrato

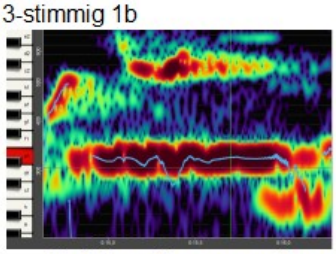


Halbtontriller cis-d



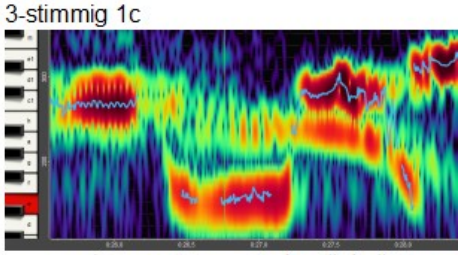
c1 Vibratoklang (28 Hz)

3-stimmig 1b



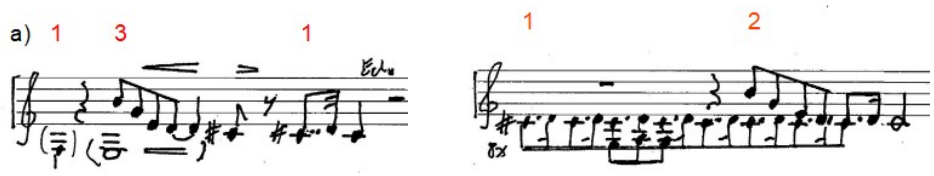
g# d#/e c2 c1-h

3-stimmig 1c



c1 e b c#-d-c#

1st verse with 2 Phrygian motifs



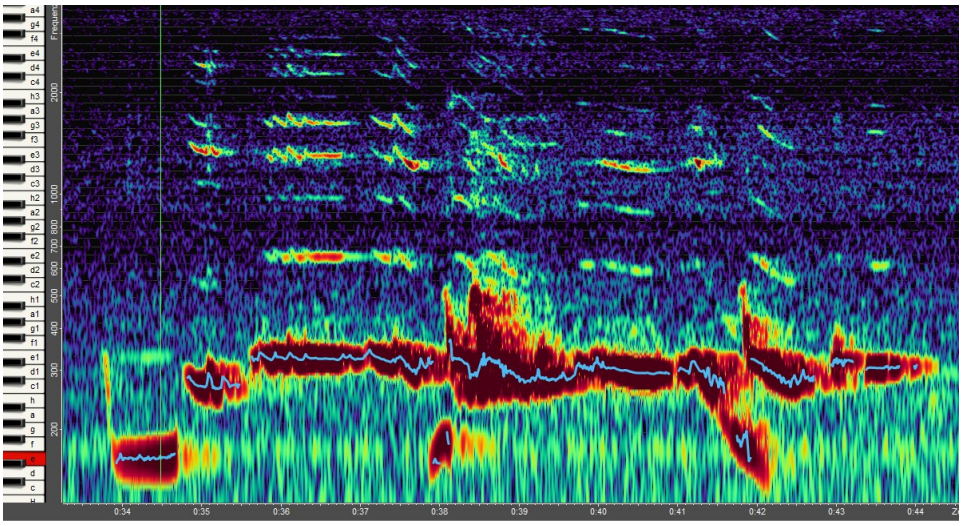
The first verse is divided into 3 parts. On the video you can see 3 PBBs sitting on a bare tree when PBB1 begins the choral singing with a deep, soft F - E----, to which PBB 3 immediately begins exactly a fifth higher in the upper voice with a shortened form of the Phrygian motif (the full form is in verses 9 and 11).
This motif always begins on the B4 and ends with a semitone, the so-called Phrygian second, the characteristic final interval of this scale or in this modal key. It is striking that the first time the phrasing increases dynamically towards D4, into the seventh to the low E, which then fades away in a major sixth, a seventh suspension, while the motif in the complete and authentic version becomes quieter towards the final sound and fades away.
Significantly, after several semitone trills (E4-F4), first from PBB 1 then PBB 2, PBB 1 begins with a dotted semitone trill on C#4 (8x), the final sound of the Phrygian motif, and on the 6th trill PBB 2 now repeats the motif. He begins with the seventh C#/B and now emphasizes the final note C# by picking up the dotting of PBB 1 and letting the C# sound for a half note. I couldn't tell which bird the bass figure G-A-G was singing in the video.

PBB 3 and 2 end the first part of the verse with an "E flat major" tone sequence, introduced by PBB 3 with mordent E flat 4 -------d and executed by PBB 2 in differentiated phrasing (leading tone D4 as upbeat, accents on octave and sixth, diminuendo and chromatic at the end).

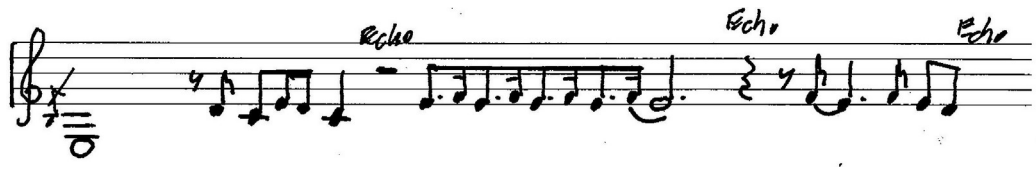
The 2nd part begins with 5 "swelling trills", 5 vibrato sounds, which originally have a vibrato pulse of 448 Hz at C6, rising as a result and each rising and falling with a pulsating oscillation C---C# and large dynamic amplitude, which is why they sound noisy in the high registers. On the final C4, PBB 1 joins in with a long low E, to which another PBB sings a trill of F#/G to E4.

Then it becomes 3-part: middle voice semitone trill D#-E4, upper voice C5-C#-C PBB 3, lower voice B-C4-B. PBB 3 is recognizable because all the PBBs singing the loud trill on the C5 are pointing their heads skyward and beak wide open making this intense sound. Then 2 PBBs again circle the main sound E4 with different short motifs, then PBB 3 with a trill D-C# (triplet D-C#-D-C#-D-C#... thus acting faster) leading to E♭4-D and PBB 2 also ends the 2nd Part with a variation of the downwards "E flat major" tone sequence.
The 3rd part begins with 4 "swelling trills". PBB 3 now sings the low E, to which 3-part PBB 2 and 1 form the middle voice A-Bb----A and the upper voice the "Praller" C#-D-C#. The verse ends with a pulsating trill D#-E4 and a short echophrase.

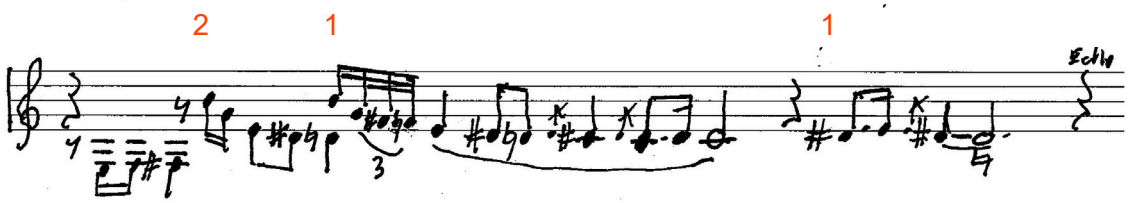
2nd verse - 3 PBBs with 3 Phrygian motifs



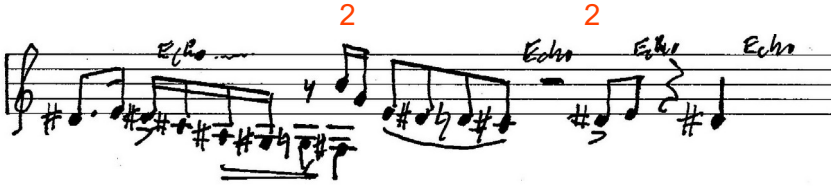
3 2 1/2/3 1



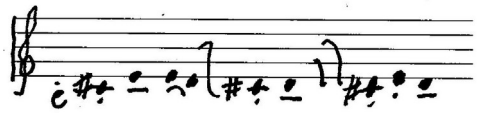
2 1 1

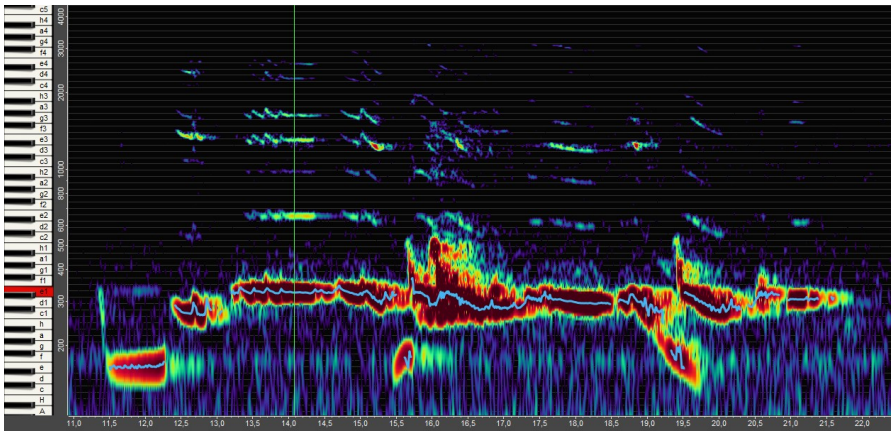


2 2

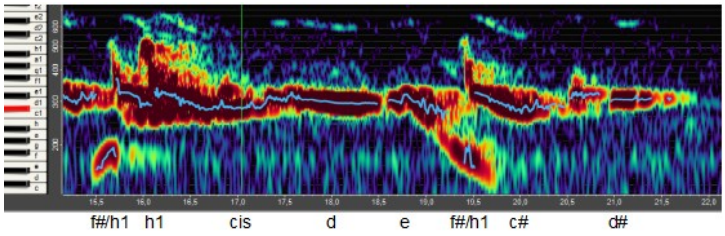


2nd verse to be heard in the original position:

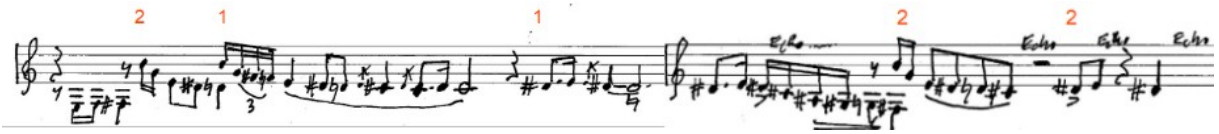




- Initial sound E3 in bass voice (= 1st verse)
- Main note E4
- "B major" scale: downwards with diminuendo
- 3x Phrygian motif



2nd verse with 3 Phrygian motifs

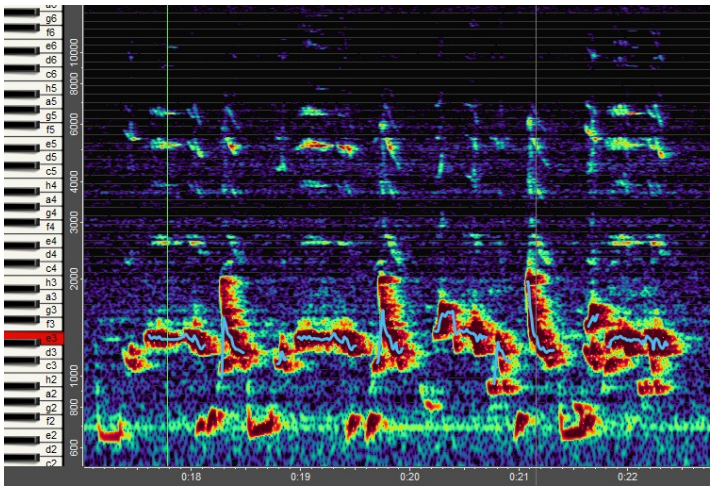


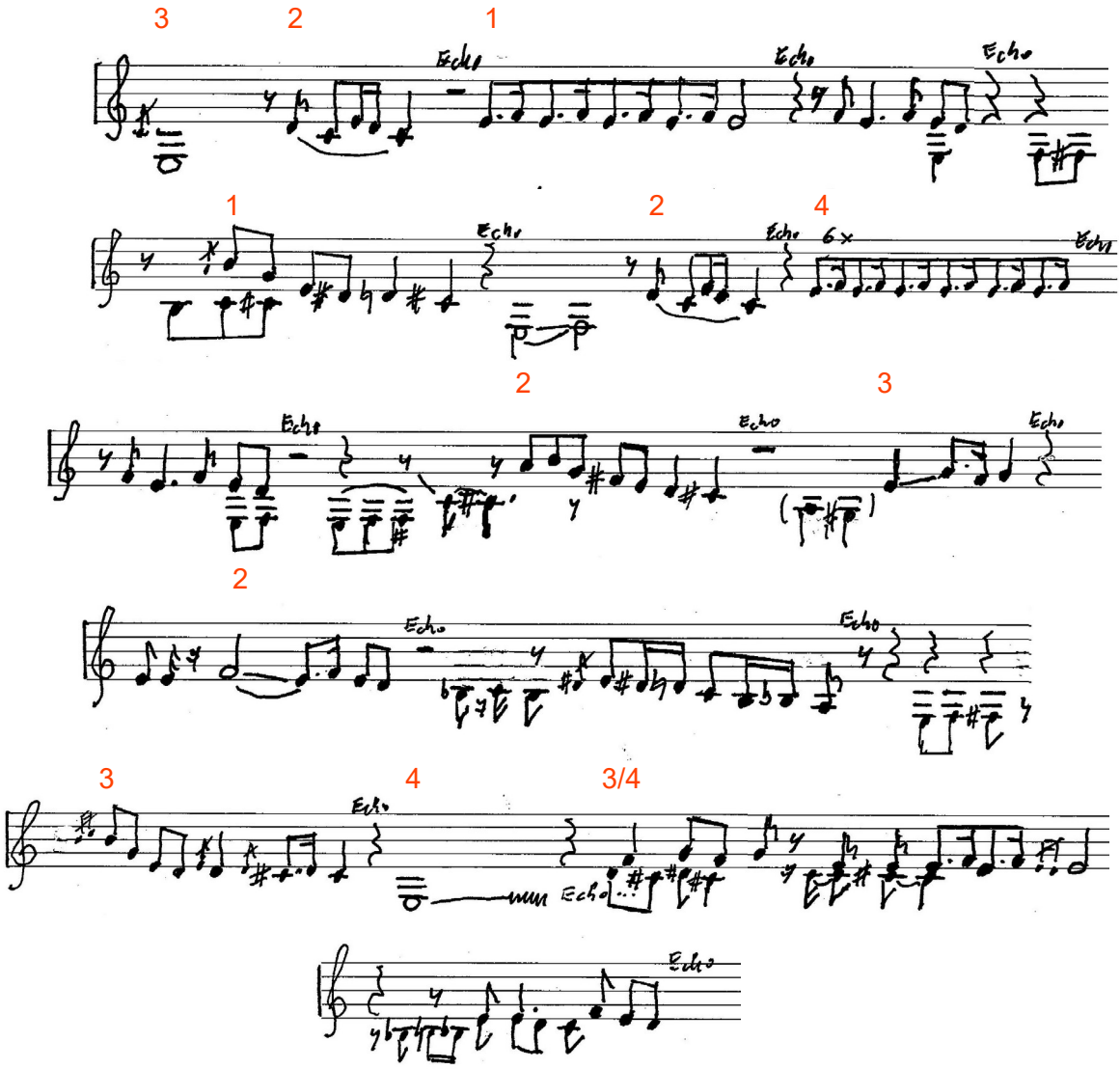
(I was only able to match the phrases to individual PBBs where it was recognizable in the video.)

Verse 2, PBB 3 begins with a long low E, then 3 PBBs simultaneously sing several semitone trills (E4---F-E---F-E---). As can be seen above, the bass begins with a small phrase (E-F-F#) and PBB 2 immediately follows with a rhythmic and chromatic variant of the Phrygian motif. PBB1 doesn't let him sing to the end, starts on the sixth with another rhythmic and chromatic variation, which he continues with short "Vorschlagnoten" (notes before the beat) up to C#. And that's not all, he spins on the figure chromatically from D#4 to D4 and then from D#1 down a "B major" scale in the diminuendo (from the third down to the fifth F#). The part after the treble clef will probably be sung by another PBB.
Exactly to the low F#, PBB 2 comes into play again on the fourth B4 and can now sing his figure from beginning to end at C#4, but after a break ends the verse with an amazing, rhythmically ordered ritardando: after the chromatic completely surprisingly 2 beats pause - accent on the three - 1 quarter pause - D# on the one - finish.
If I take the dotted D# after the treble clef as the upbeat and the accent on the first semiquaver as the one, I can count down the 4/4 bar from the semiquaver figure with the next one on the half rest to the final note.

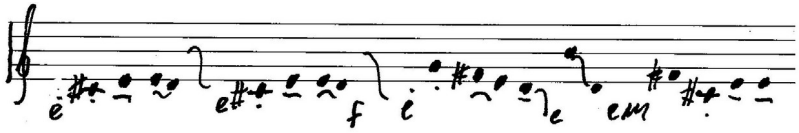
When I took a closer look at this verse for the first time after completing the notation and understood it with my inner ears, I was completely overwhelmed by what I saw and heard there: beautiful sound figures, the highest level of skill in the variations, flexible ornamentation, musical imagination, differentiated intonation, precise coordination as well as harmonic order and variability in sound and rhythm. All this not only with 1 bird, but in the alternating 4-part singing of 4 birds. (For the song of the blackbird, this solitary and musical master singer among songbirds, all these descriptions would apply at least as well.) Such a highly developed music and singing art in birds that have only lived in Australia for millions of years, who would have thought it.
This art of variation, modulation, embellishment, embellishment, ornamentation has always existed in music in all cultures and styles, and it continues to be performed, improvised and composed with it ("motivic work" is what it's called).

3rd verse - 4 PBBs with 3 Phrygian motifs

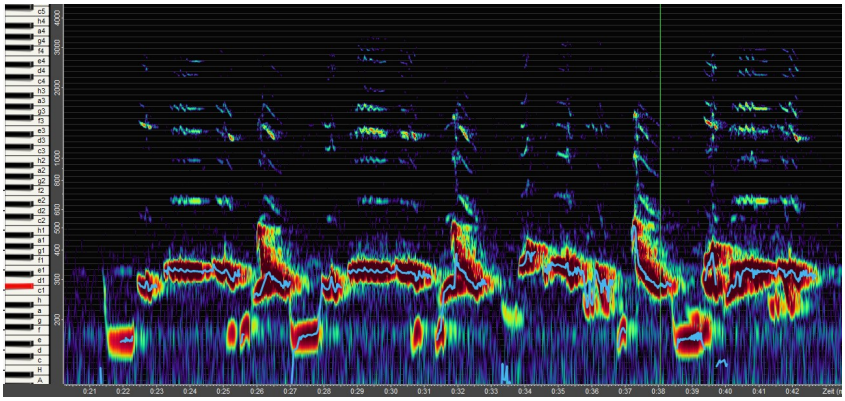




3rd verse to be heard in the original position:



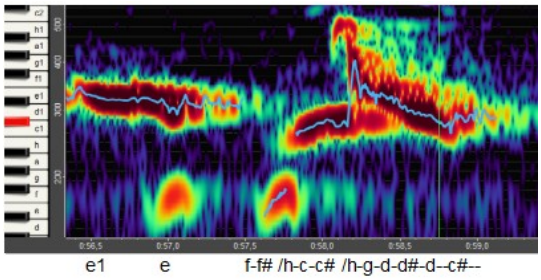
3rd verse

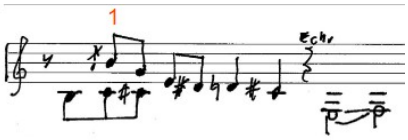


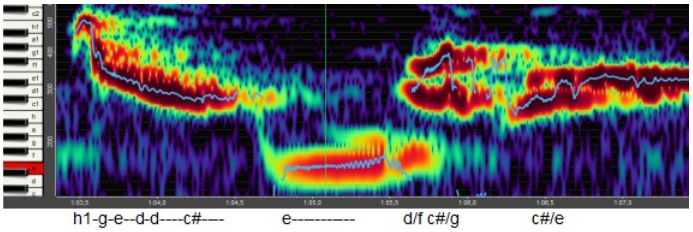
In the spectrogram of the 3rd verse the triple Phrygian motif can be seen beautifully and strikingly, plus the bass voice and the middle voices.

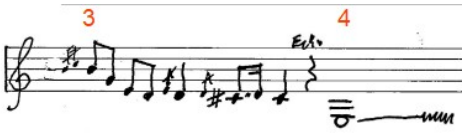
Bass: E3, E-F, E-F, E-F-F#, E-F-F#, E------- (rising vibrato sound)
Main note E4: 3x exactly the same length and pitch
1) from pulsating oscillation in tenuto sound (line 1)
2) pulsating oscillation with 6 impulses (line 2)
3) to C#4 of the middle voice (minor third) first 2 eighths, then 2 pulsating sounds and then from a mordent (e-d-e) into a tenuto sound (5th line end)
3 x Phrygian motif: A4-B-G-E-D#-D--C#--, A-B-G-F#-E-D--C#--, B-C/B-G-E-D-E/D--D/C#--D/C#--
Chromatic: before 3rd Phrygian motif D#4-E-D#-D-C-B-B♭-A
2-part: an iridescent, touching sound, each part makes a wave movement (F4-G-F-G and D4-C#-D#-C#), slightly shifted in parallel fourths, from the minor third (d-f) through 3 diminished fourths into the tritone C#4/gG4 (diminished fifth or augmented fourth)

first Phrygian motif

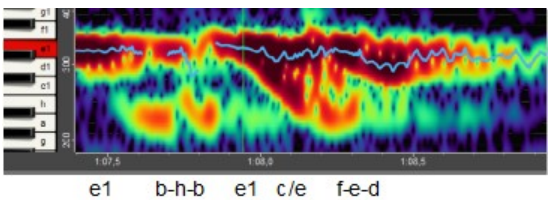




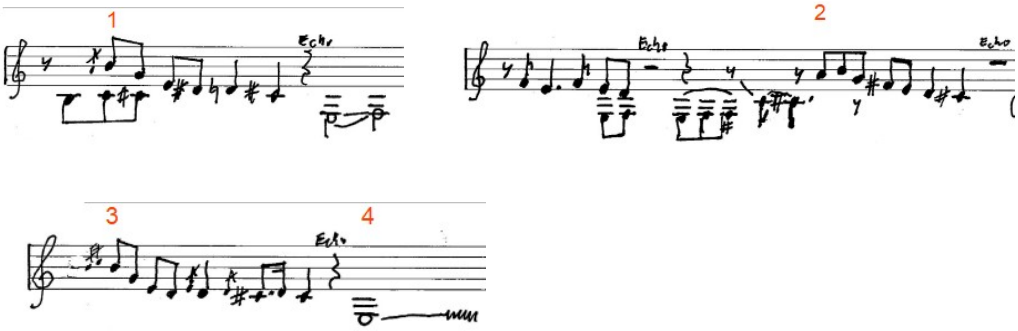




at the end: from the unison E4 into a small imitation (alternating note b♭-b-b♭ is bass voice)



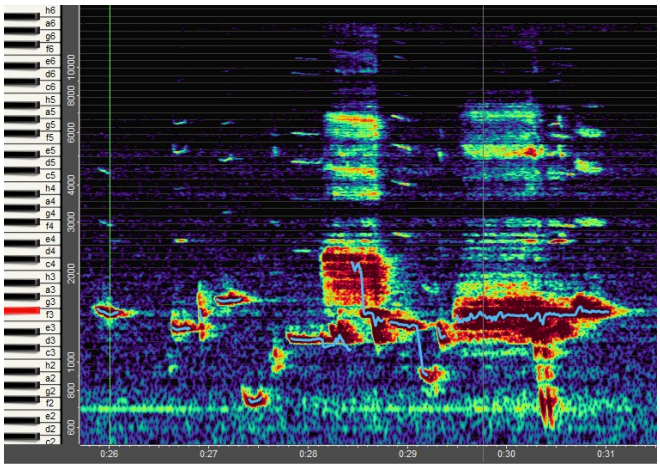
3rd verse with 3 Phrygian motifs

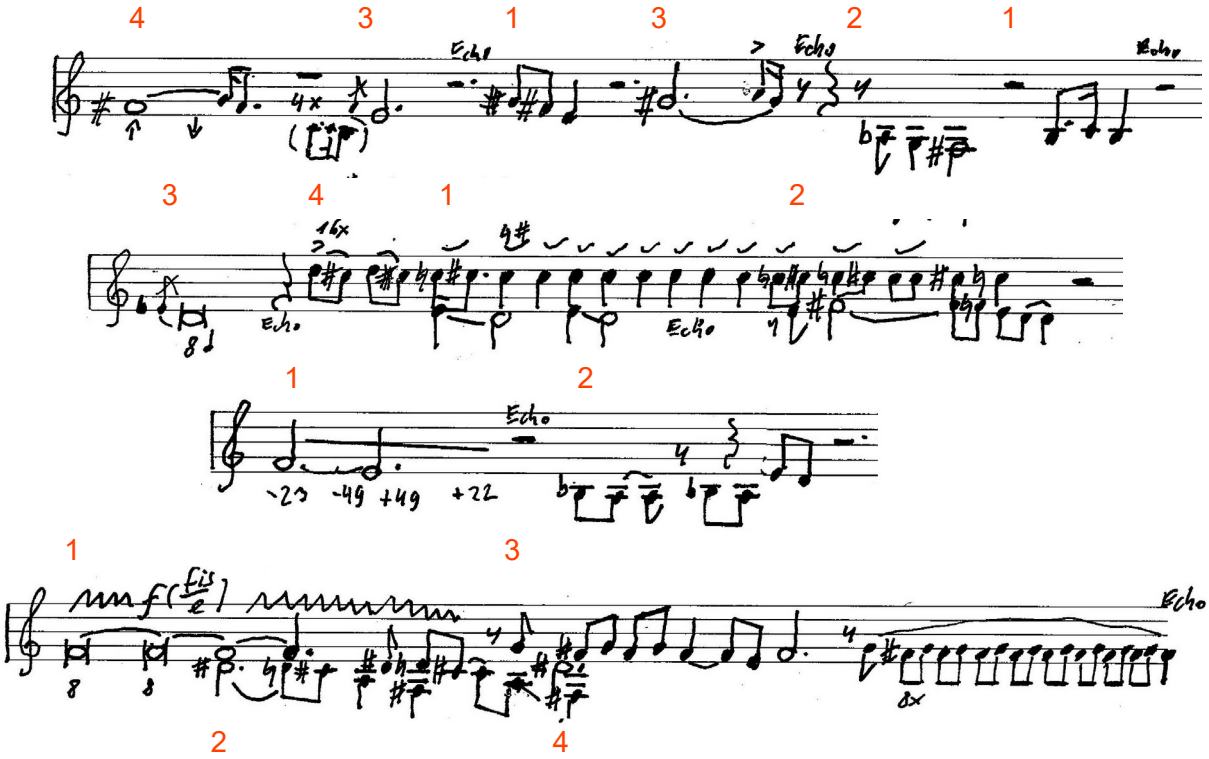


After the 2nd verse, a 4th PBB settles on the tree, the birds regroup on the various branches and then the 4-part choir begins.

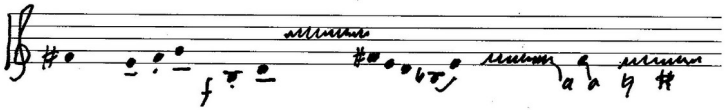
The verse begins exactly like the 2nd verse with the low E and the semitone trill e---f-e---f-e---f ...
To the last sound figure in the first line (f-e--f-e-d) continues now the bass voice again with the deep E and continues her voice over eighth notes to C#. After the B, PBB 1 immediately begins with the Phrygian motif, this time with a short "Vorschlag" from A4 and then, as before, in a chromatic sequence of notes from E to C#, now evenly in eighths and quarters, whereupon the bass responds from the deep with a long E-F.
Now PBB 2 reacts with the same motive as at the beginning of the verse (d-c-e-d-c), whereupon PBB 4 intones the semitone trill of PBB1 at the beginning (6x instead of 4x) and also continues with the phrase f-e--f-e-d. The bass again makes its intro to C#4, and now PBB 2 sings the Phrygian motif, now quite evenly with an upbeat from A4 and a very distinctive sounding tone sequence to C#4: a-b-g-f#-e-d-c#. (It is worth playing this episode on the piano.)
But that's not all: After several short phrases from different PBBs around F4 and a chromatic progression down through the fifth e/a, it is PBB 3 who sings the Phrygian motif for the 3rd time in this verse, now with a "Praller" (b-c-b) as an introduction and 2 short "Vorschlagnoten" before the main notes D and C#. Now PBB 4 adds the bass part with a low E ending with a trill.
A dense 2-part duet of PBB 3 and 4 follows, an iridescent, touching sound, each part makes a wave movement (f-g-f-g and d-c#-d#-c#), slightly offset in parallel fourths, from the minor third (d-f) through 3 diminished fourths into the tritone c#-g (diminished fifth or augmented fourth).
The verse ends with a figure at E4, which has been heard several times in this verse and in verse 1 and 2.

4th verse - 4 PBBs

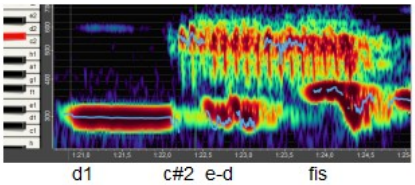


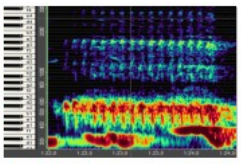


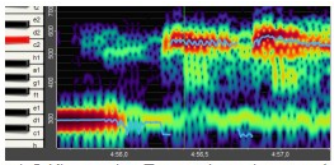
4. verse to be heard in the original position:

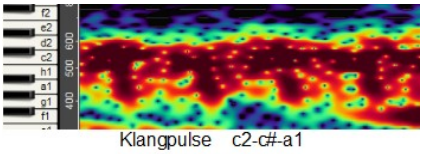


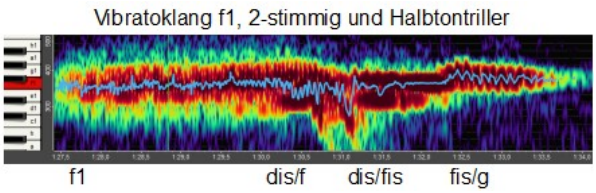
- Initiation sound F#4
- pulsating sound C#5 (32/s) with lower voice
- Vibrato sound F4 (80 pulses per second), 2-part and semitone trill g-f# (32/s)

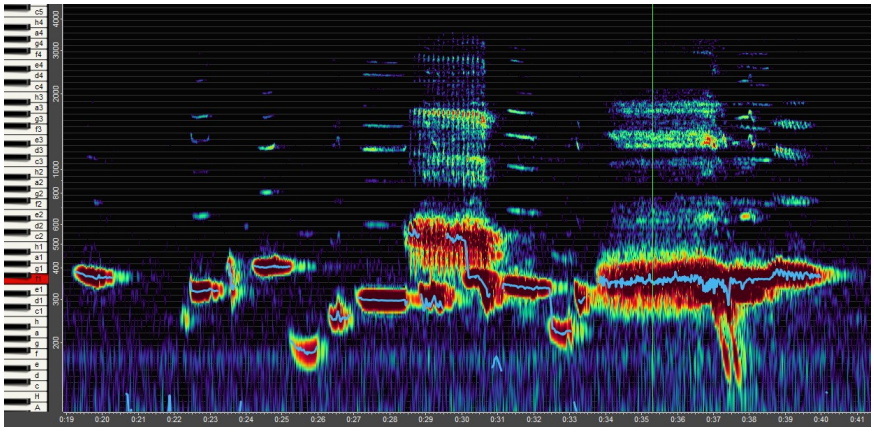

d1 c#2 e-d fis


16 Pulse bei 3. Teilton gis3


cis2-Klangpulse Tempo 4x verlangsamt


Klangpulse c2-c#-a1

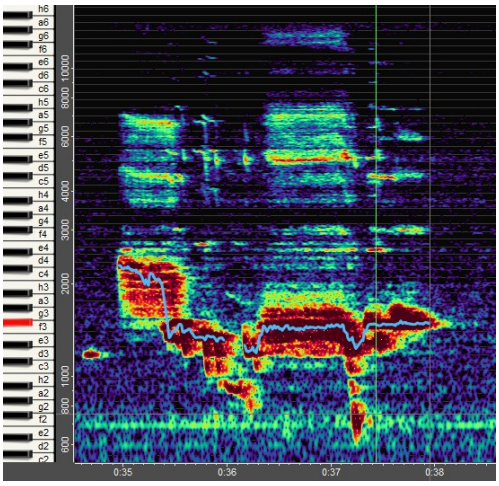


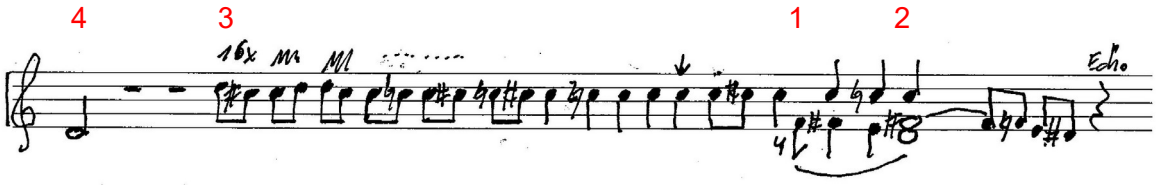


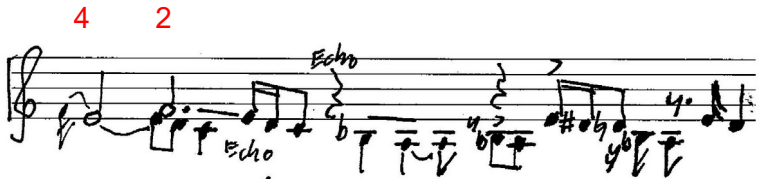
4th verse

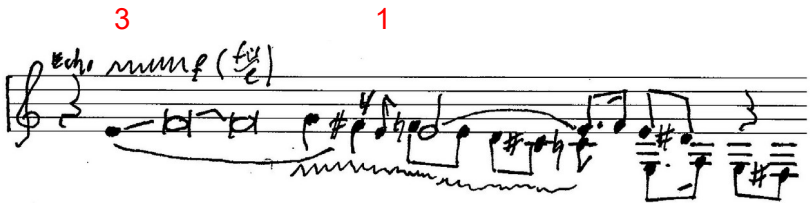
As can be seen at first glance in the spectrogram, there is a completely different verse model in the 4th verse than in the previous 3 verses. After several isolated sounds, a very intense, higher sound appears and then an even longer, deeper and very moving one. In the video it can be seen that the PBB sings the high intense sound, stretching his head to the sky and opening his beak wide.
The initial sound of the verse is an F#4. Only after a break of 8 beats do other PBBs follow with E4, G#4, a low F# and then PBB 3 with a very long D4. All input sounds are harmonically related to each other: the two F# sounds form an exact octave, the 5th partial of E4 (G#6) corresponds to the 4th partial of G#4 and the 8th partial of E4 to the 9th partial from D4 (E7).
The D4 appears to be the stimulus for PBB1 to trigger an octave up from the D5 on C#5, a long intense pulsing sound that lasts a full 16 beats (at 32 pulses per second). These pulses with vibrato gradually develop from d-c# and c-c# to the figure C5-C#-A4.
Exactly on the 3rd beat, PBB 1 an octave lower accompanies the trill with 2x E4-D---, a major seventh, which increases the intensity of the pulsating sound. At the 13th pulse, PBB 2 adds the lower fifth F#4 to the C#, which ends on D4.
While the individual sounds E4 and G#4 already had a spectrum up to the 8th partial (3rd octave) and the long D4 even up to the 9th partial (E7), the C# is also characterized by a strong partial tone spectrum (up to the 6th partial G#7), with a particularly loud fifth partial at G#6.
In resonate with the long D4 and the lower voices, a D7# sound can actually be heard here, a D major sound with a major seventh, which can be played on the piano in 4 times slowing down suitable to this sound
Then PBB 1 takes over the leading voice. First he lowers the intonation via F4 to a high E4 and then begins a very long, intense vibrato sound, more than twice as loud as the C#5, with a duration of 20 beats, large amplitude (3 whole tones), vibrato pulse of 96/s and with strong formants in the 2nd octave and in the third (4th and 5th partial). At the end of the F4 comes a lower voice (PBB 2) with D#4, which phrases down via C#4 and A to the F#, whereupon the upper voice imitates this downward phrase. Then PBB 3 begins a longer play around (g-f#--e-f#) with an F#4, to which PBB 4 sings a D#4 at the beginning (sounds like B major). The verse ends with an even semitone trill f#-g of PBB 3 (fifth of B major).

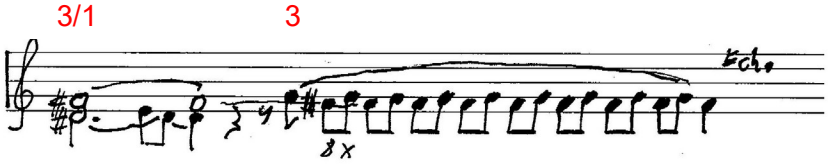
5th verse - 4 PBBs



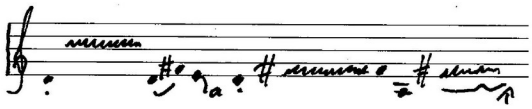


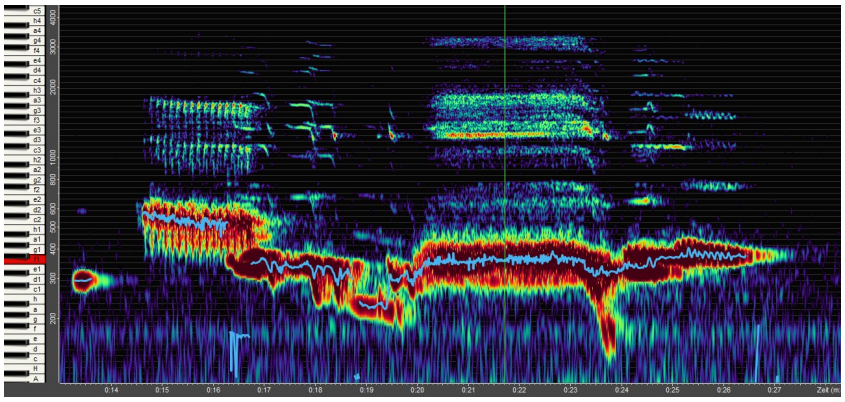




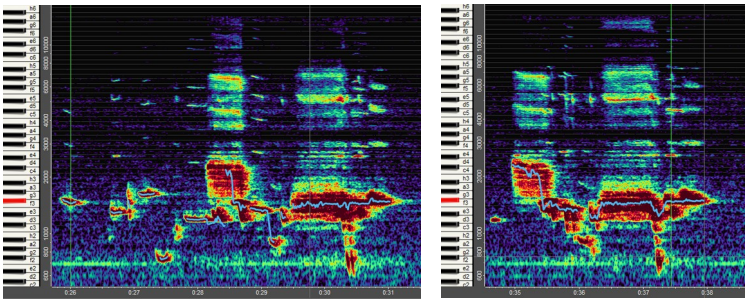


5th verse to be heard in the original position:

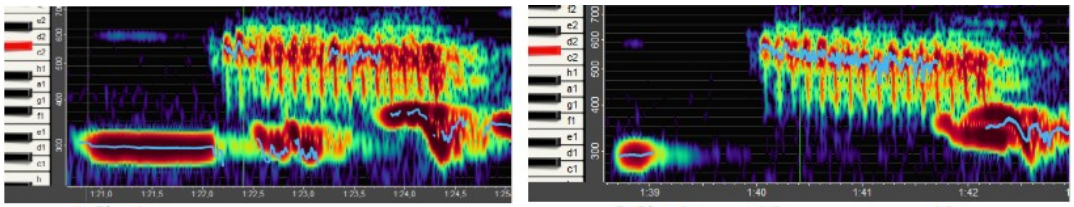


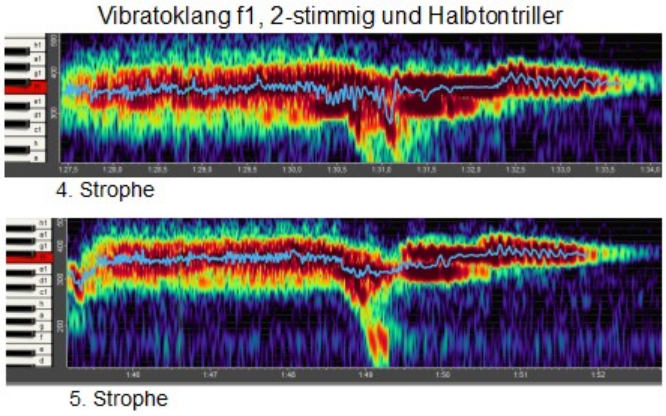


- Initiation sound D4
- Sound pulses c#-c
- 3-part
- Vibrato sound F4, 2-part and semitone trill g-f#

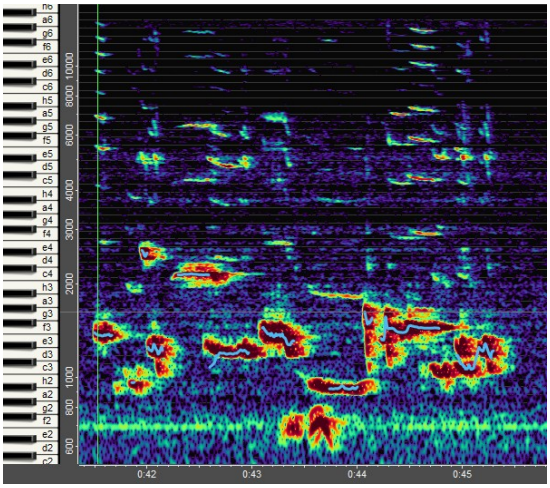


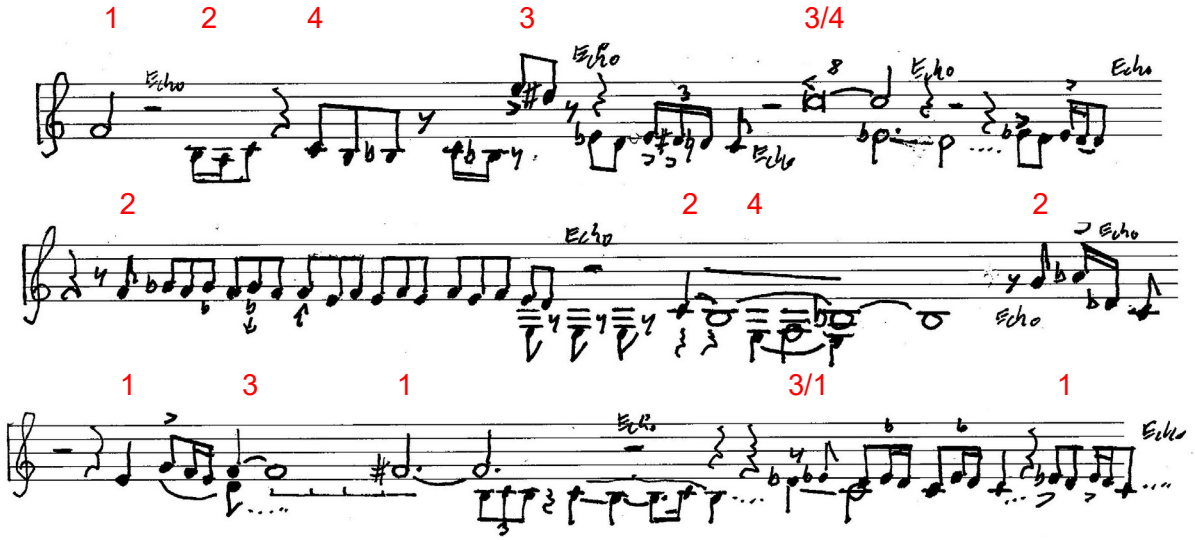
The 5th verse repeats the 4th verse without the opening sounds. The D4 is only 2 beats long, then there is a longer pause (8 beats) and, as in the 4th verse, the sound pulses begin, this time with a D5 suspension in the exact octave of D4. In verse 4, PBB 3 sang the tenuto sound D4 and PBB 4 the sound pulses, in the 5th verse it is the other way around, but the C#5 is not as loud as in verse 4. There are again exactly 16 sound pulses with the same character, only that towards the 8th sound they detonate a little from C#5 to C5.
Exactly on the 13th sound pulse, a lower voice starts again, first PBB 1 with f#-e-d---- and then on the 16th sound pulse PBB 2 with an imitation f#------f-e-d#.
PBB 3 now sings the vibrato sound F4 (in the 4th verse PBB 1). F4 continues into a descending sequence into which PBB 1 sings a upper voice with an E4. At the end of PBB 3 and 1 the pure minor third d#/f# can be heard and again PBB 3 ends the 5th verse with exactly the same semitone trill as in the 4th.



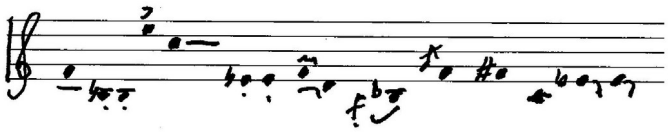


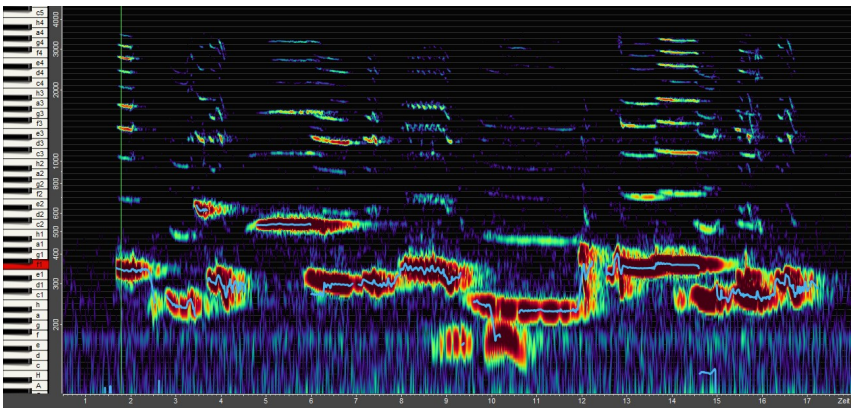
6th verse - 4 PBBs





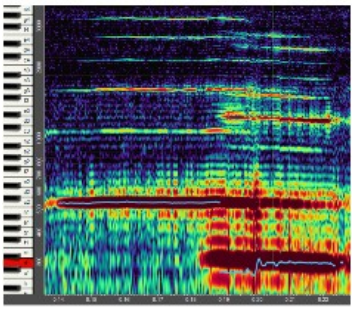
6. verse to be heard in the original position:



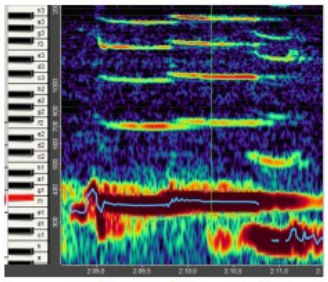


- seventh C5/D4
- semitone trill F3/G♭
- 2-part F3/B♭ and C3/E♭
- quarter tone shift F3/F# and 2-voice with bass part

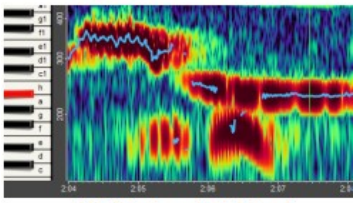
c2 plus Naturseptime d1



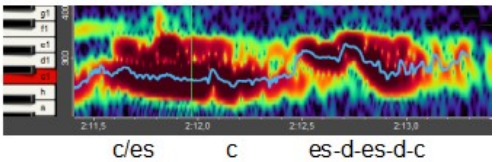
Viertelton-Rückung f/fis



2-stimmig



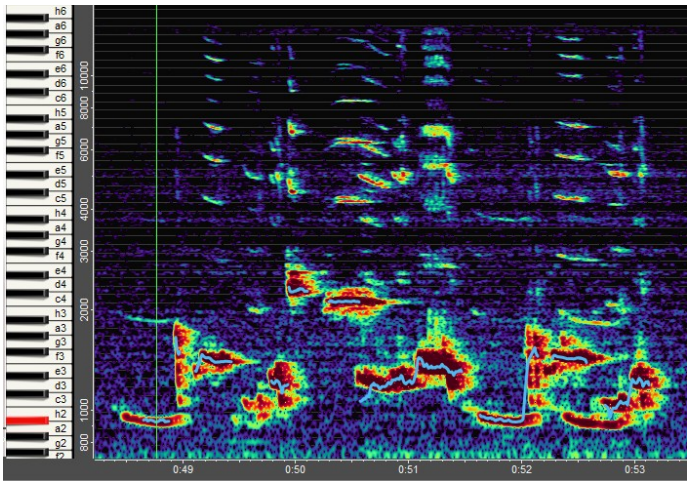
2-stimmig

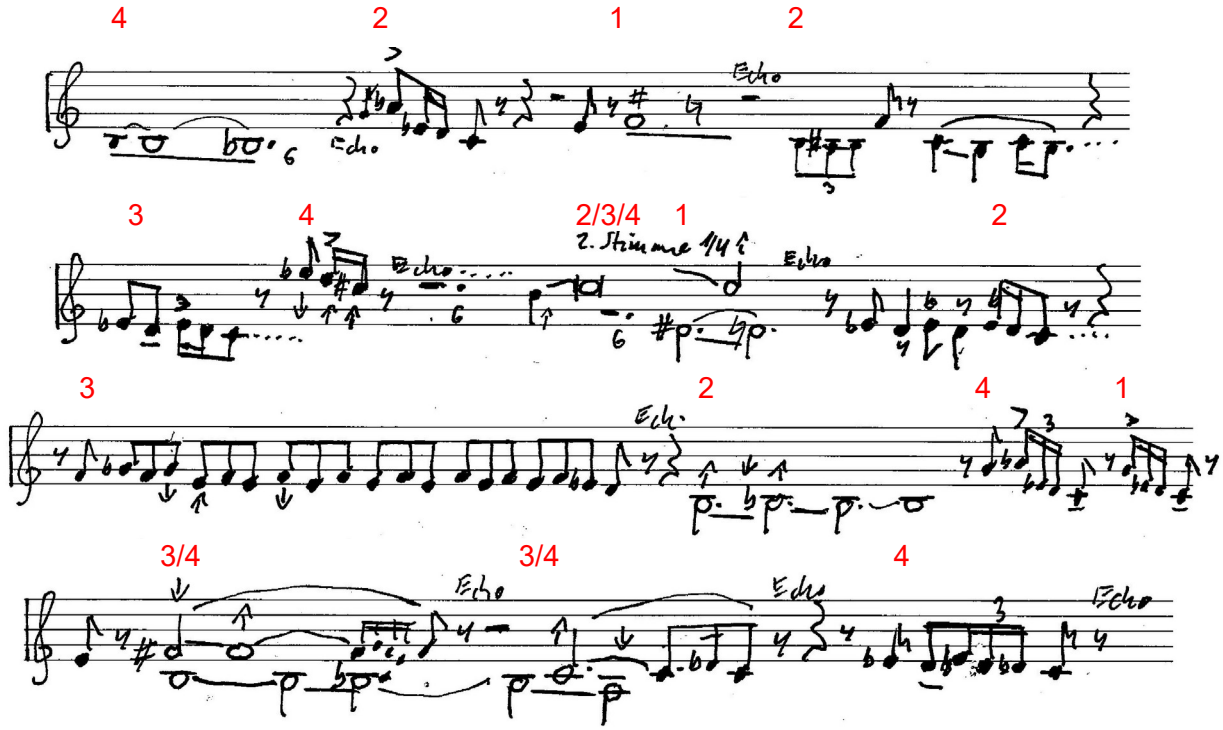


The 6th verse again has a different model. It begins with a short but very sonorous F4 from PBB 1, whose intense high spectrum extends to the 10th partial (A7). After very short motives from PBB 2, 4 and 3, a special sound occurs when PBB 3 sings a long and loud C5 and then PBB 4 intones a D4 a seventh lower, while the C5 continues to sound (spectrum C5 up to 6th partial G7 and spectrum D4 to the 9th partial E7). As can be seen in the spectrum image, a denser sound is created by the resonate of the sevenths. The 7th partial (C7) of D4 corresponds exactly to the 4th partial of c2 and the third partial of d2 (F#6) comes from the strong fifth partial (G6) of C5 (cf. the same sound in verse 7).

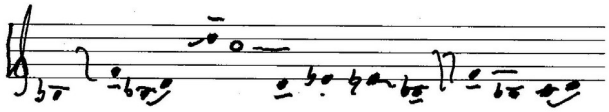
A trill follows from F4/Gb to F/E gradually detonating in a triplet rhythm e-f-e-f-e-f and then PBB 4 begins with a bass voice (e - e - e e-f--e) over PBB2 a long sustained note C-B--Bb-- aa a plain, even glissando sings, so that the alternation fifth-tritone-fourth can be heard.
Another interesting sound combination follows - a quarter-tone shift: PBB1 starts with E4 and an accented descending sequence (g--f-e-d), into which PBB 3 intones a long F4, followed by PBB1 again a quarter-tone higher with a long F#. In the overlap, a vibrating sound emerges briefly between the two tenuto tones. At the end, a bass voice sings B-C4-B / C-B--C-B to the F#4. Both sounds are very loud, but the F#4 is half as loud. And both sounds have a full spectrum up to the 9th partial (G7/G#7), the F#4 even a strikingly intense one, so that it can be assumed that it reaches far beyond that and is only limited because of the video recording (mp4).
At the end of the verse, the upper part Eb-D-C sounds in 2 voices to the sustained tone C4.

7th verse - 4 PBB

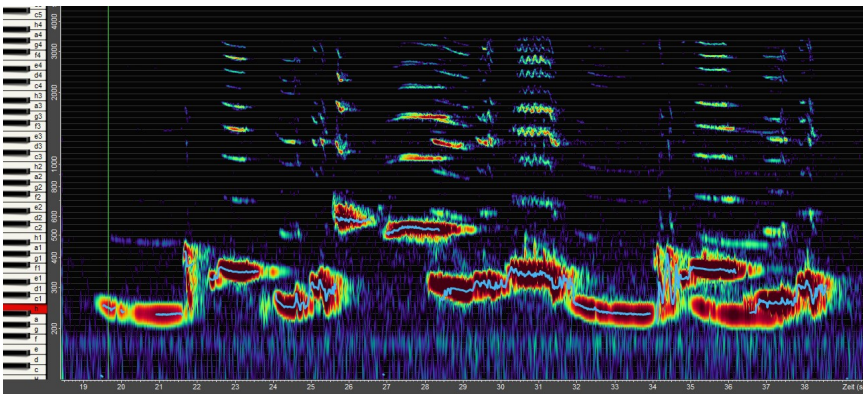




7th verse to be heard in the original position:



Initial sound: glissando B3--B♭--- (PBB 4), PBB 1 responds with glissando F#4--F--
bass part: 3x B3--B♭----
unison C5 with slight interference plus 7th D4: 2 PBB sing C5, 1 PBB sings the 7th D4
Semitone trill: gradually detonating from F4/G♭ to F/E - triplet rhythm e-f-e-f-e-f2-part: fifth B3/F#4--B slides on to B♭ and A, on the B♭ upper part comes with C4.

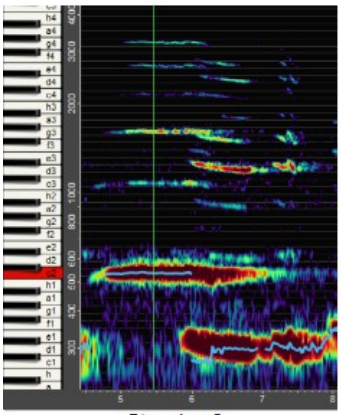


7th verse

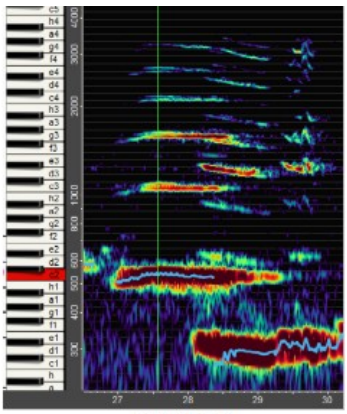
PBB 4 begins with a long glissando in the bass register (B--B♭----), to which PBB1 responds a fifth higher with a glissando F#--F--. The bass sound B--B♭---- is heard 3 times in this verse, from PBB 4, 2 and 3.

Similar to verse 6, there is a series of short motifs at the beginning and then, amazingly, the seventh C5/D4 reappears. Now 2 PBBs sing the C5 in unison, although I couldn't tell which two they are. And they sing it with a fine quarter-tone interference, one sings a tenuto sound, the other a slight bow. While the C5 continues to sound, PBB 1 starts from D#4 with a D4, so that a 2-part 7th can be heard again (D4/C5 = 4:7), i.e. the 7th partial of D4 is identical to that 4th partial of C5. This is followed by the semitone trill on F4 (as in verse 6), the long bass sound B-B♭ (13 beats), 2 very short fast motives from PBB 4 and 1 and then a long 2-part fifth from PBB 3 and 4, in which the lower fifth B3 slides on to the F#4 to B♭ and A. On the B♭ the upper part comes with C4, so that the second becomes the minor third A/C with a small "Praller" (C-C#-C) at the end, which is continued to the end still within an echo sound.

Unison c2 plus natural 7th with 3 PBBs in verse 7

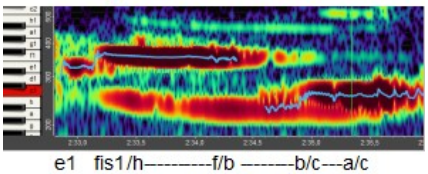


Strophe 6

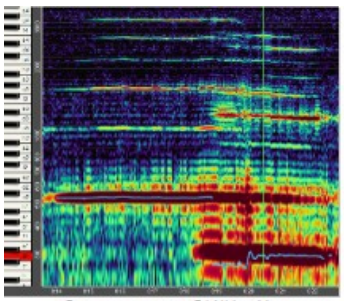


Strophe 7

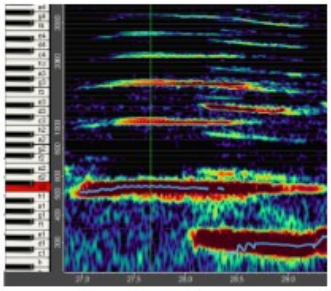
2-stimmig h/fis und h-a/c1



e1 fis1/h---------f/b -------b/c---a/c



c2----------c2/d#1--d1--------

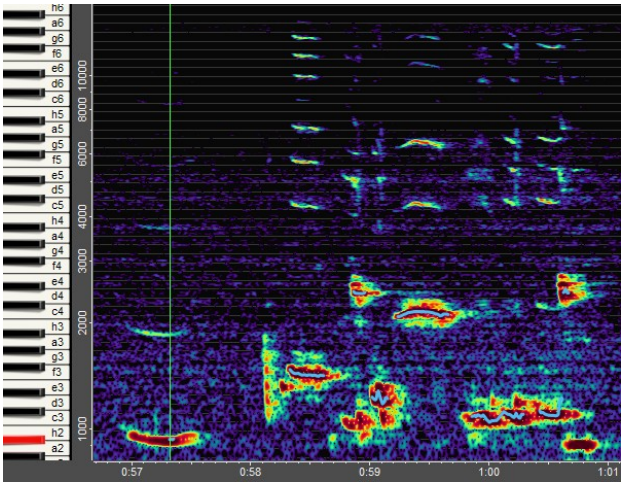


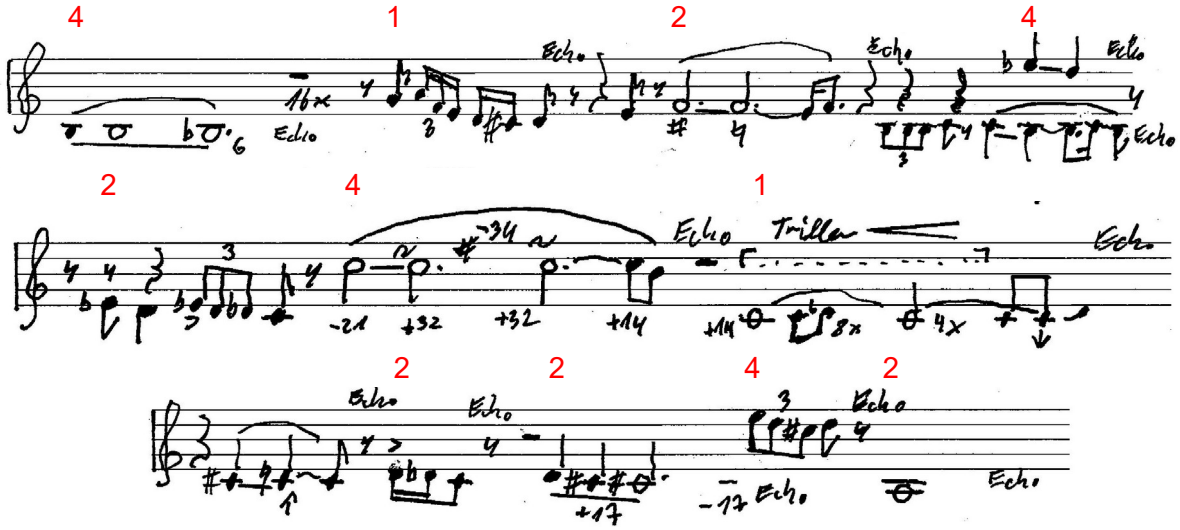
c2 "Vibrato"

In verse 6 there is friction between the two sounds before the frequencies match in a ratio of 4:7, while in verse 7 the two sounds tend to match.

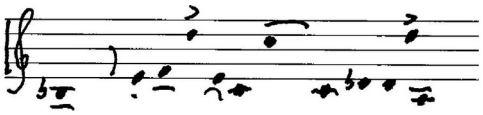
The vibrato in the pitch marker in verse 7 is explained by the interference of the 2 voices

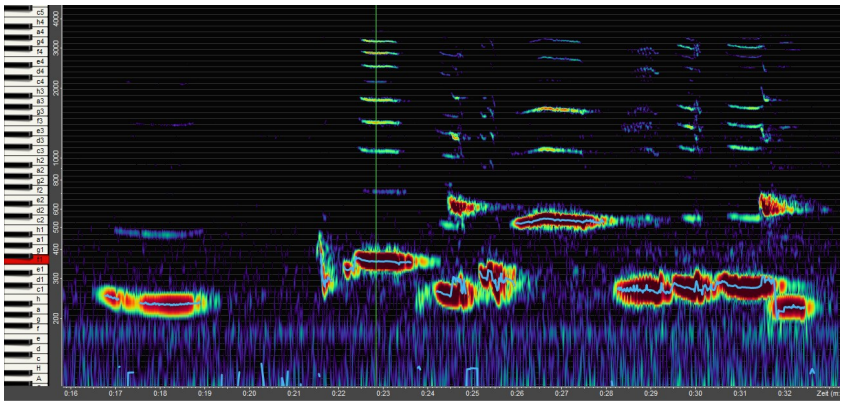
8th verse - 4 PBB





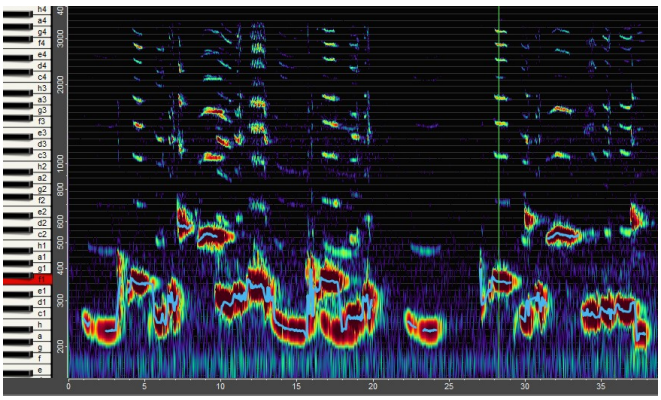
8th verse to be heard in the original position:





Initial sound: B3---B♭--- (PBB 4), as in the 7th verse answer F#4--F-- (here PBB 2)
C5: After verses 6 and 7, in the 8th verse PBB 4 alone sings the C5 as a large arc of sound.
Semitone trill C4/D♭ - third C#4 / A

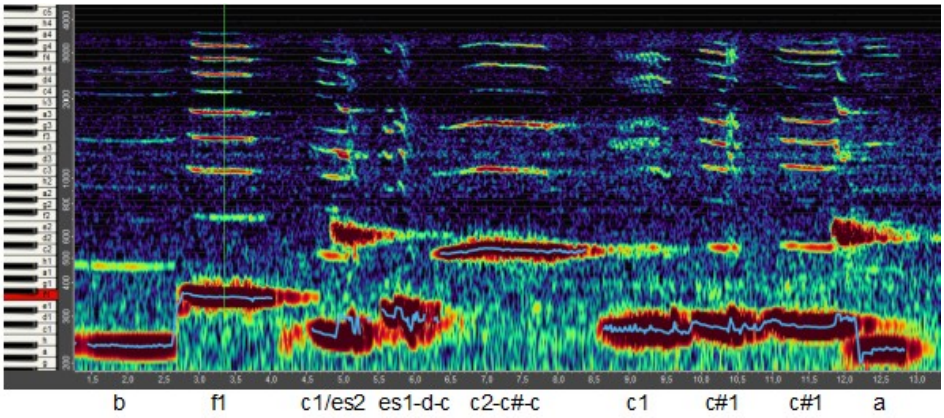
Strophe 7 Strophe 8

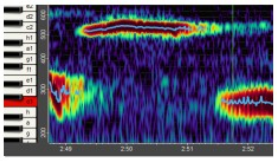


8th verse
PBB 4 sings in verse 8 as in verse 7 the soft, quiet initial sound B-B♭----- with a little weak spectrum. After 10 beats B-B♭ there is a pause of 16 beats, before PBB 1 starts with a short "D major" sequence (g-a-f-e-d-c#-d) as in verse 7 and then PBB2 intones F#4-F, the fifth to the initial sound B-B♭, a little quieter than PBB 1, but with a different tone coloration (sound structure) and a little more intense spectrum up to the 10th partial (third A7). Then PBB 2 takes over the same bass voice as in verse 7 (loudest sound C4 - C-B-E♭-D-C), to which PBB 4 first throws in a loud E♭5 and then sings the C5 all alone, which can already be heard in verse 6 and 7. PBB 4 also designs the C5 as a large arc of sound C5---C#---C---- only without the seventh. Instead, PBB 1 sings a big swelling trill at C4 an octave down, followed by another swelling sound half a tone higher (C#4), whereupon PBB 2 picks up the modulation: D-C#-C and D-C#-----. As at the beginning, PBB 4 adds an upper voice E5-D-C#-D ("D major") and then PBB 2 ends the verse with a low A ("A major").

Except for a short 2-part passage, it is a pure monophonic antiphon, completely different from the previous verses, so again a new verse model. In the spectrogram below, I've noted the melody progression (without the long pause between B♭ and F4):
B♭ -F4-C4-E♭5-E♭4-D-C-C5-C#5-C5-C4-C#4-C#4-A.

8. Strophe (ohne Pause zwischen b und f1)





c1 c2---c#--c------ c1-Triller

The spectrum of the partials clearly shows that it is not an arbitrary sequence of tones, but that all sounds in the spectrum are related to one another.
Right at the beginning it is the fifth B♭/F (2:3 - F6 - 6th partial of B♭ = - 4th partial of and C7 - 9th partial B♭ = C7 - 6th partial F4).

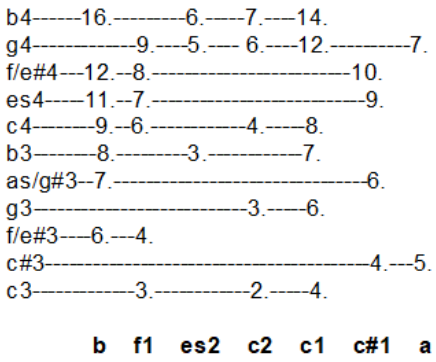
E♭5 corresponds in the spectrum to the 7th partial of F4 (E♭7 - 7th partial F4 = 4th partial E♭5) as well as related to C4 in the lower voice (G7 - 9th partial C4 = 5th partial E♭5).

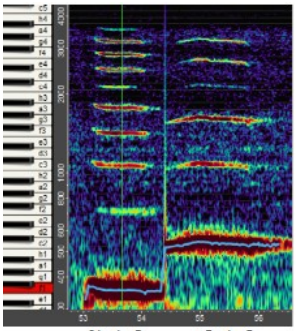
Then comes the upper fifth C5 to the F4 (2:3 : C6/C7 - 3rd/6th partial F4 = 2nd/4th partial C4 and G7 - 9th partial F4 = 6th partial C5). The corresponding relationship naturally exists with the following C4 trill, even if it is sung in a very "fundamental" way with a less pronounced spectrum. However, the "C major triad" can still be seen in the spectrogram: C6 / E6 / G6, which resonates in the fundamental tone.
Although C#4 is in an octave relationship to C#5 from the sound arc C5-C#-C, there seems to be no agreement in the spectrum of partials in the increase to C#4, but of course from the third C#4 to the fundamental A3 (5:4 - C#6 - 4th partial C#4 = 5th partial A3), but if you take a closer look at the spectrum and consider the enharmonic confusion (F = E# - A♭ = G# - E♭ = D#), there are connections in the network and the structure of the whole spectrum:

A♭6/G#6 - 7th partial of B♭3 = 6th partial (fifth) of C#4 / E♭7/D#7 - 11th/7th Partial B♭3/F4 = 9th partial C#4 / F7/E#7 - 12th/8th Partial B♭3/F4 = 10. Partial (third) C#4.
The low A agrees in its 7th partial (G7) as 9th-5th-6th-12th. partial with F4-E♭5-C5-C4

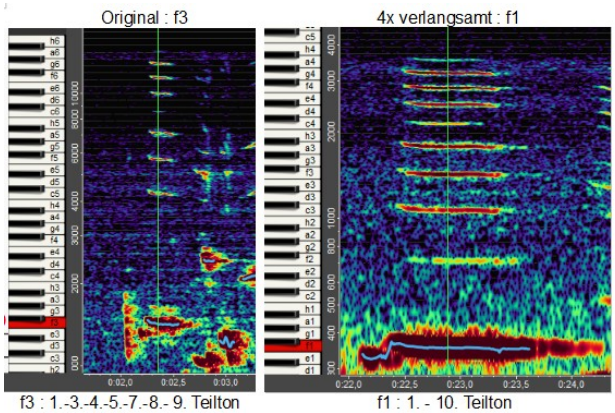
At the beginning of the "melody" an F7 sound can clearly be heard (f/a/c/e-flat) and so one could hear the harmony sequence or modulation in the verse: B flat major - F7 - C major and from C sharp major to the sub-mediant A major (affinity of thirds).

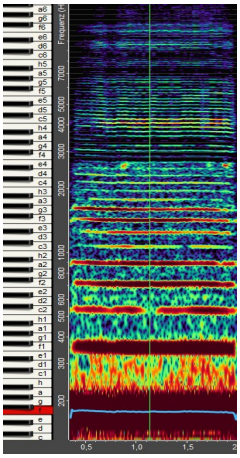
The weave or network of partials in the "melody" of verse 8:





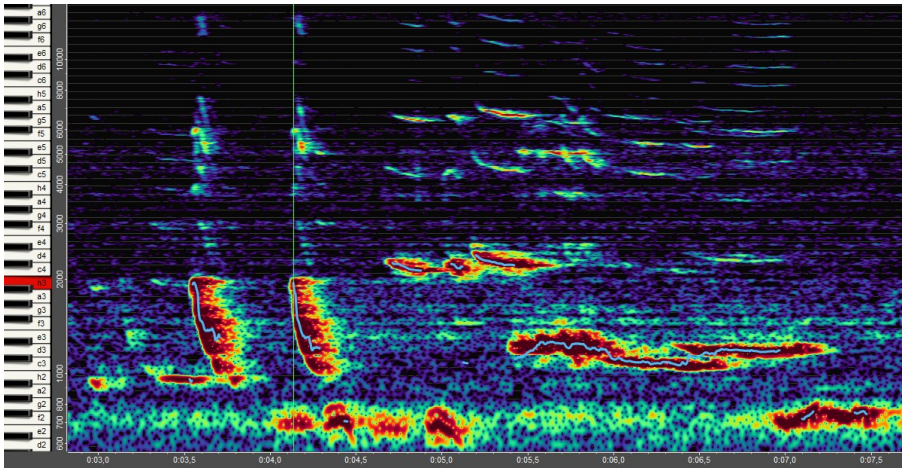
Spektrum von F6 und F4:

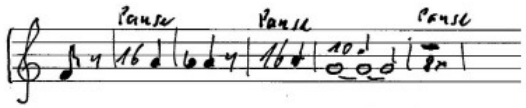




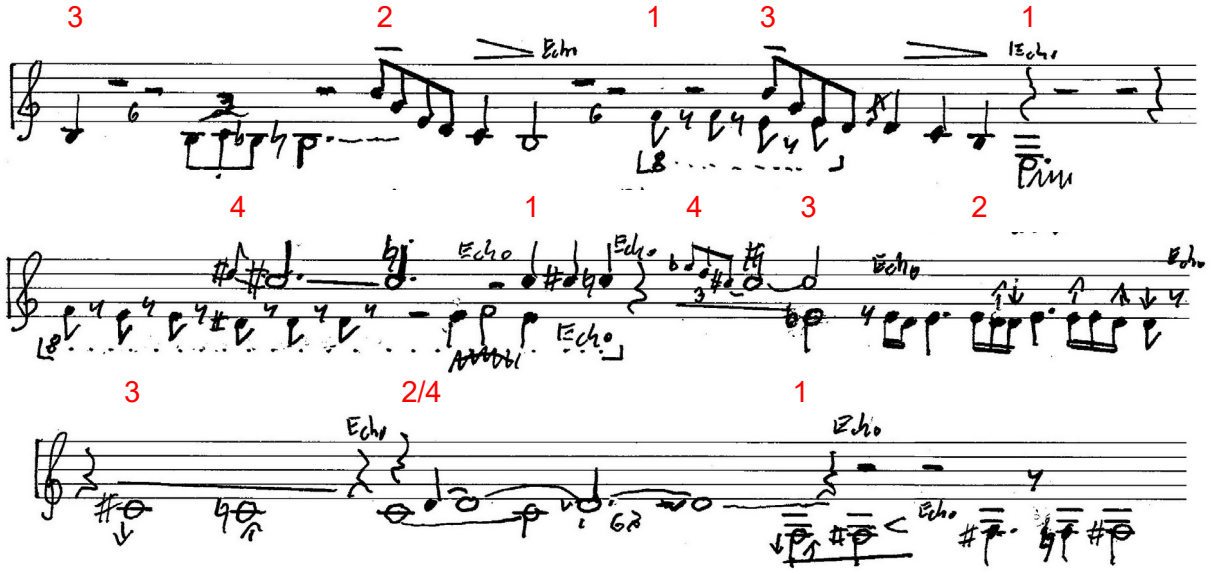
right image slowed down 8x Spectrum of F3 re-recorded with a wave recorder: The video recording only goes up to 16 kHz (B9 left image F6) and 2 octaves lower correspondingly to B7 (4000 Hz). As the new recording demonstrates to eyes and ears, the sound of the F3 (178 Hz) has a full and complete spectrum up to the 64th partial (F9 - 11.392 kHz).
(Explanations with spectrograms in appendix p. 35)

9th verse - 4 PBBs with 2 Phrygian motifs

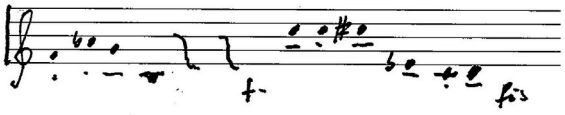


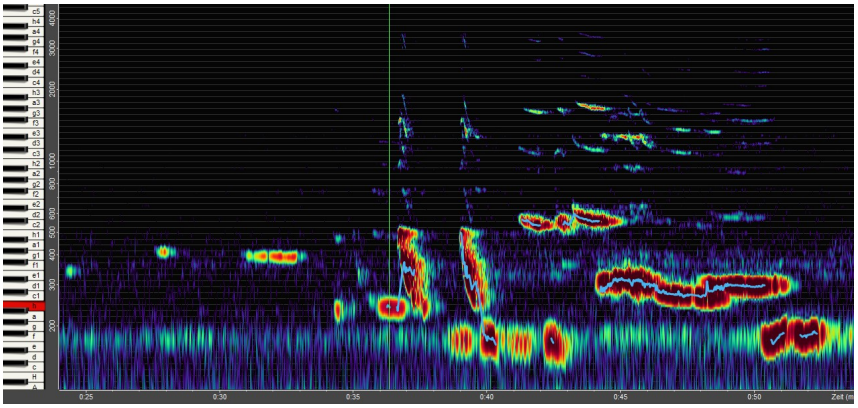


da lontano - from far



9th verse to be heard in the original position:





9th verse with 2 complete Phrygian motifs

(Before the 9th verse, the motif F4-A♭-G--- of a single PBB can be heard from afar. The pauses between the tones are very long in this slowdown, twice 16 beats, then 10 beats.)

Phrygian motif: after bass tone B3--- 2x B4-G-E-D-C--B3----, with the second in the bass pulse tones F3-E3 and trill E3---. First PBB 2 sings the motif in the octave to the bass voice B3 of PBB 3, then PBB3 repeats the motif 1,2 s later with a small embellishment in the fifth to the bass (E3) of PBB1. (As a reminder: in the original register, these are only chirping sounds lasting 0.18 s.)
Seventh C#5/D#5 (cf. verses 6 and 7): As in the previous verses, a lower voice plays around the E4, first with short eighth notes E4 - D#4, then with a trill E4-F--E-. In addition, the upper voice (PBB 4) sings the 7th C#5 from the octave D#5, which resolves towards C5. PBB 1 continues the E4-F--E of the lower voice a sixth higher with C5-C#-C, whereupon PBB 4 (C#5) and PBB 3 (D#4) follow the next seventh. From the D#4 and E♭4, an alternating semitone motif develops around E♭4-D, which PBB 3 lengthens into a long C#4-C.
2-part: Whole tone C4/D4---- (PBB 2 and 4), in unison 12 beats long. At the end of D4, the bass voice (PBB 1) sings a low F, which leads to F#, which is confirmed again as a major third to D4 with F#-F-F#.

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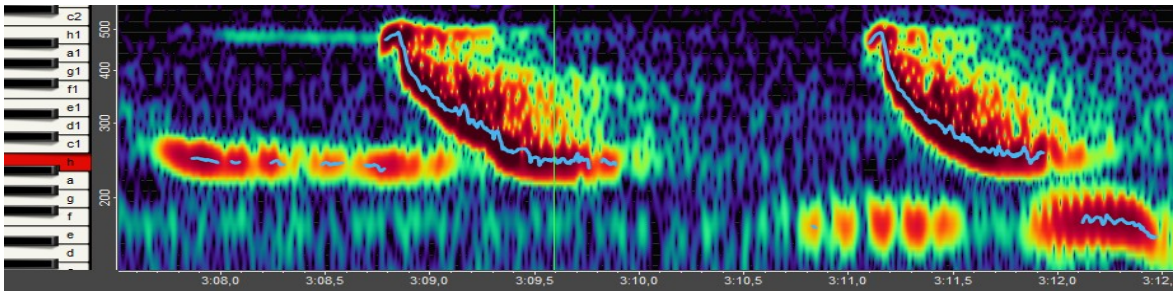
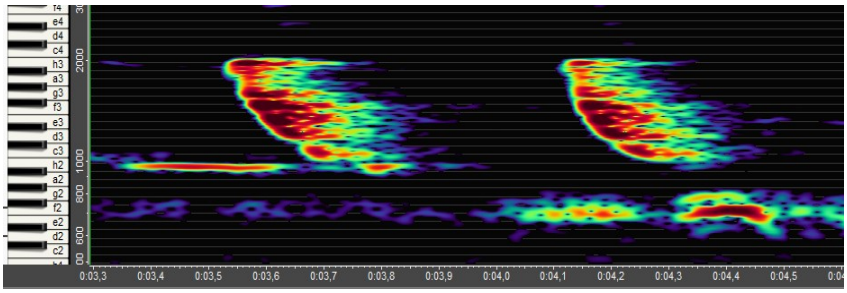
2 phrygische Motive (4x)

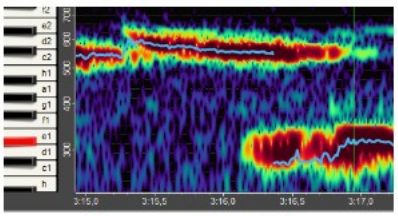


h h-g-e-d-c--h--- f e



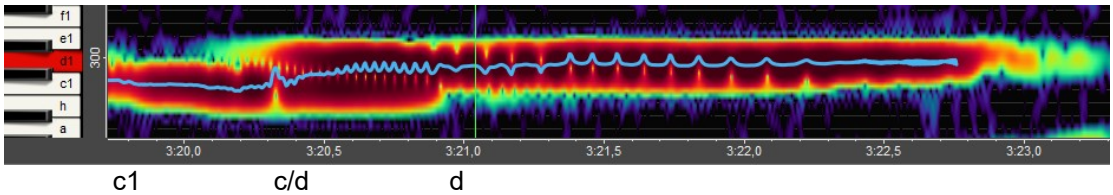
Original h2 / h3: 2 Motive in 0,8 s

Septime cis2/dis1



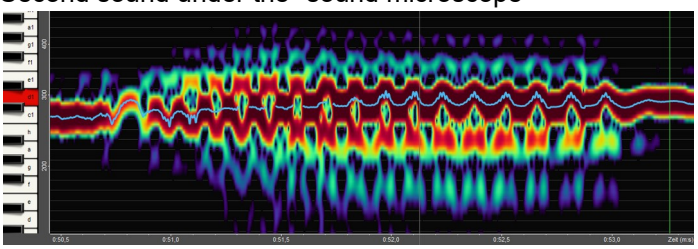
c2 cis2 dis1

2-part second c1/d1

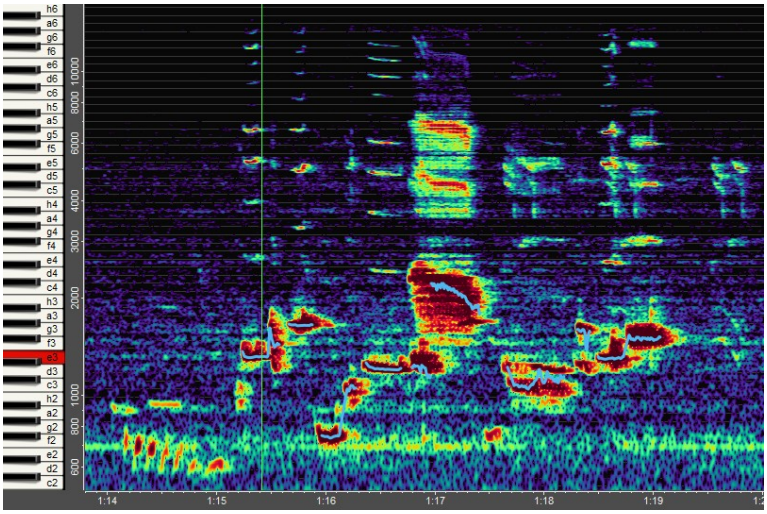


c1 c/d d

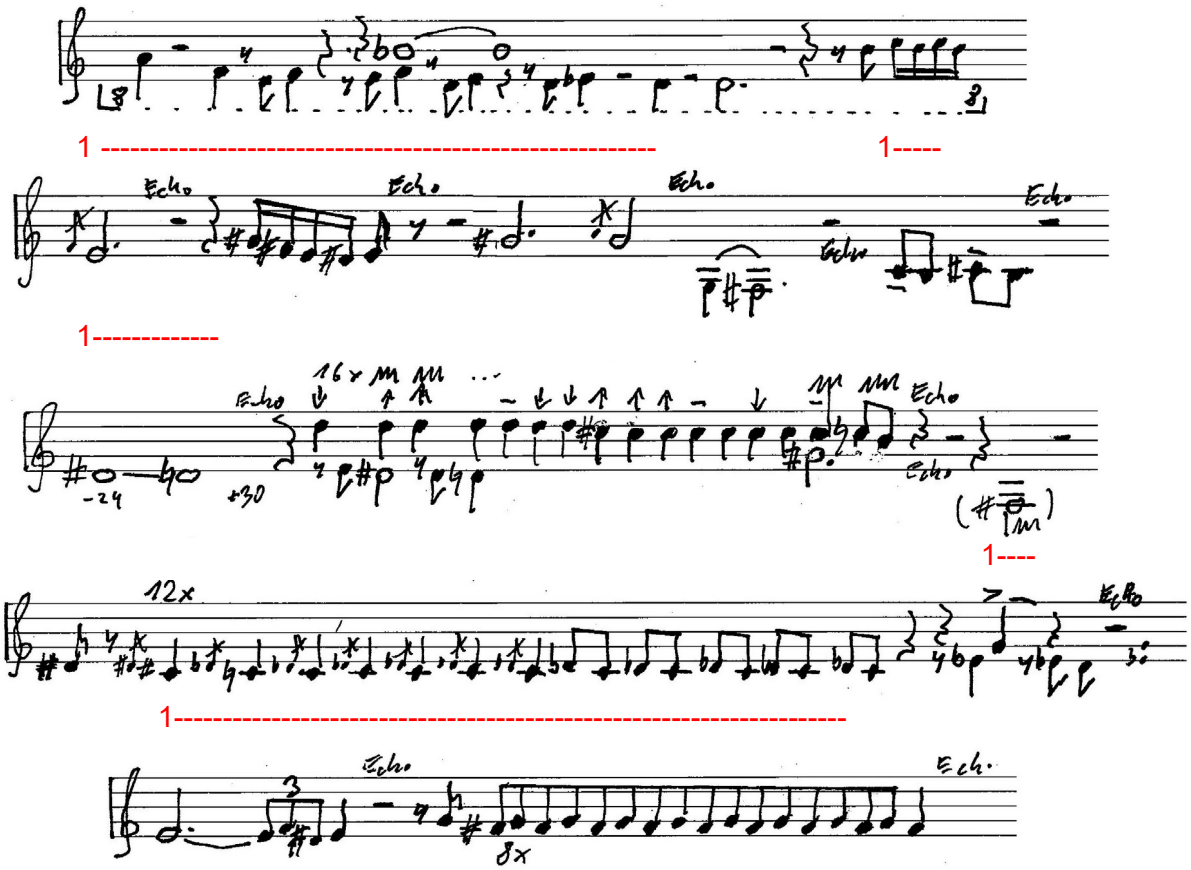
Second sound under the "sound microscope"



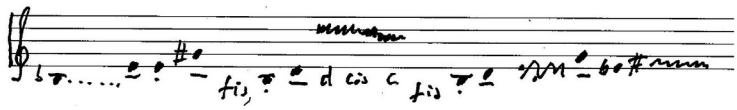
10th verse - 1 + (3) PBBs

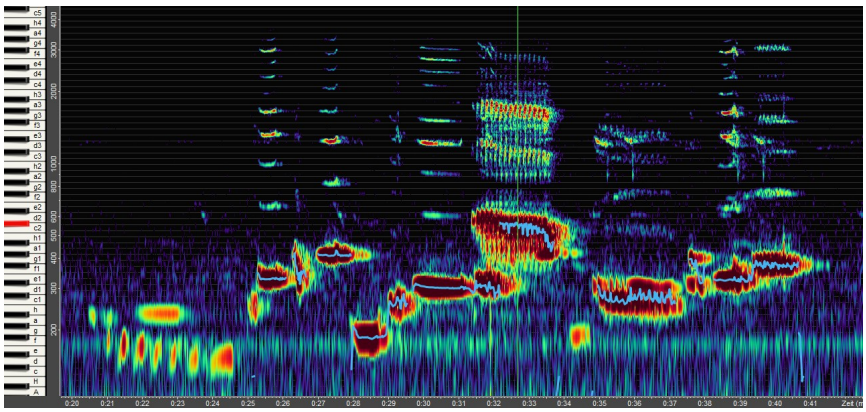


Only one PBB (1) is visible in verse 10, singing in choir with other nearby PBBs.



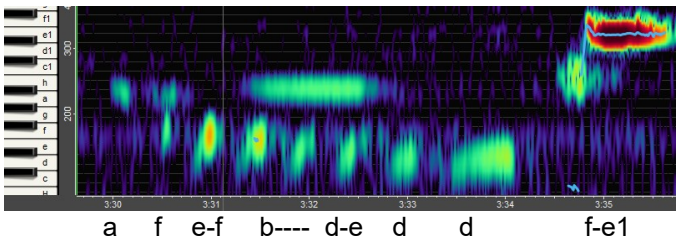
10th verse to be heard in the original position:





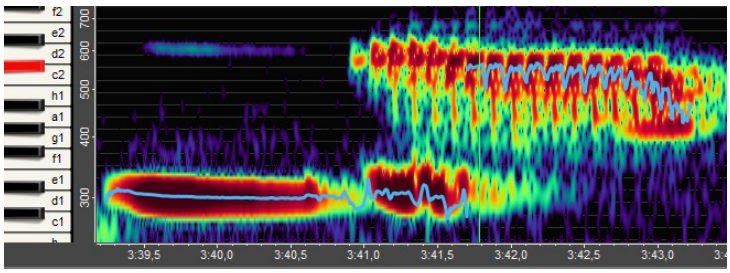
Intro: 2-part bass voices sound a little further away - rhythmic impulse sounds downwards from A3 to D3 (lowest tone in all verses) and vibrato sustained tone B♭3---
"Solo" sounds: start in E major (E4--- / G#-F#-E-D#-D / G#), then the initiation sound D4 for the sound pulses and finally E4 and **semitone trill** F#/G (exactly the same trill also in the duration as at the end of the 4th and 5th verse)
Sound pulses: as in verses 4 and 5, 16 intense, loud sound pulses sung again by a nearby PBB, this time starting exactly in the octave to D4 of PBB 1 and gradually detonating from D5 to C#5
2-part: As in verse 4, another PBB starts immediately after the first sound pulse with a rhythmic lower voice (suitable for the upper voice E-D#--D#-D-) and at the end another PBB probably joins in on the 15th sound pulse a G#4---.
pulsating sound: a pulsating C4 with short grace notes (D♭-C--) becomes an evenly oscillating semitone trill (D♭-C)
2-part C minor: After the long, pulsating C4, a non-visible PBB sings the phrase E♭--E♭-D and PBB1 begins immediately with the exact fifth G4. With E4, PBB1 returns to the beginning of the verse and closes the verse with the well-known F#/G trill.

2-part bass voices (da lontano)



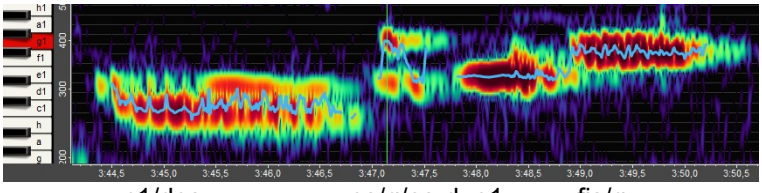
a f e-f b---- d-e d d f-e1

sound pulses



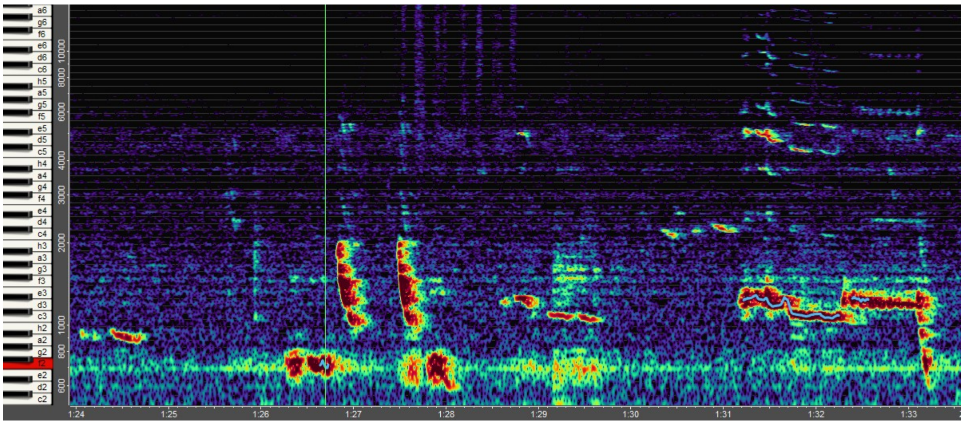
dis1 d d2/dis1-d cis2/gis1

2-part c-moll

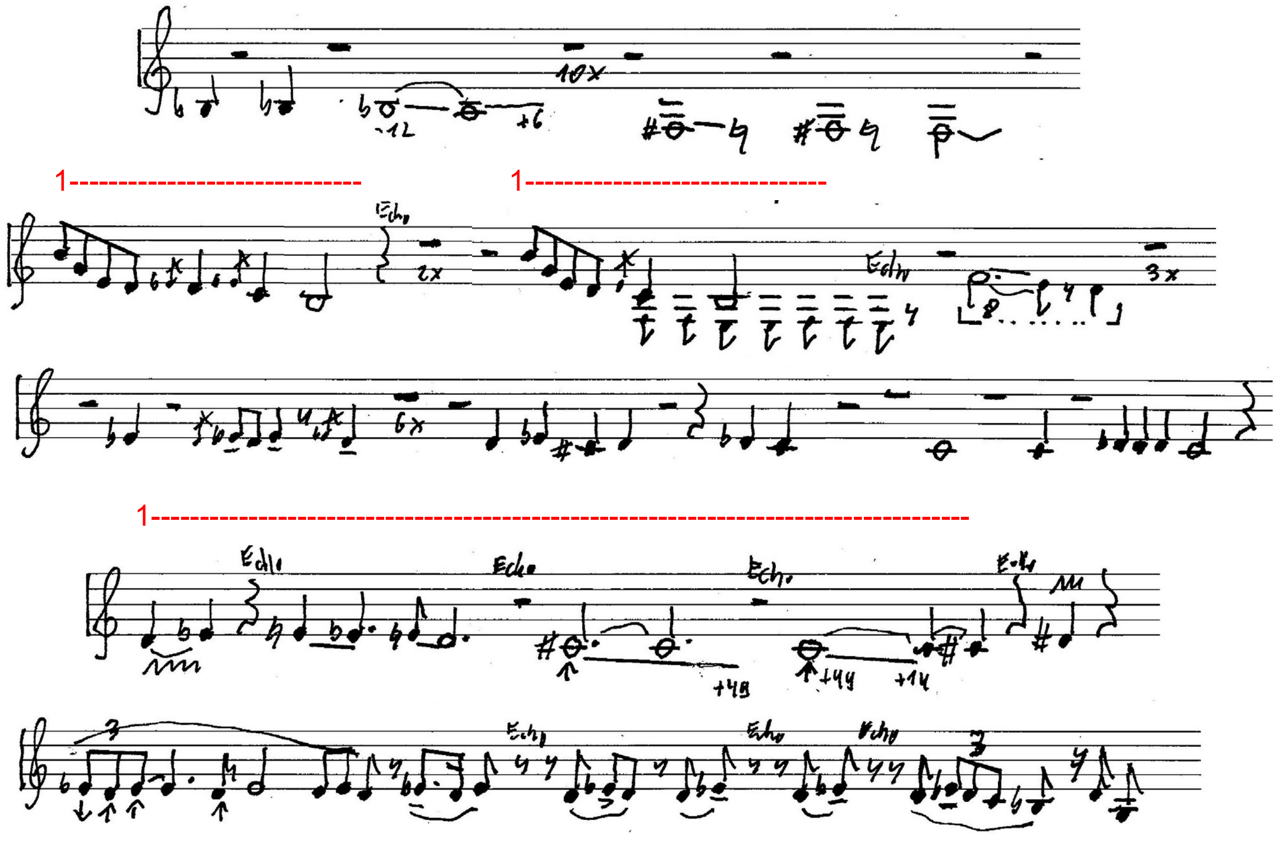


c1/des es/g/es-d e1 fis/g

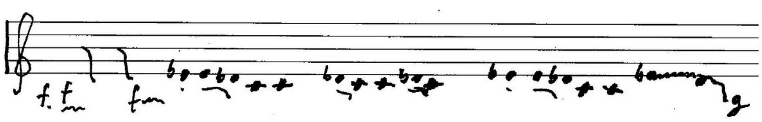
11th verse - 1 + (3) PBBs - 2x Phrygian motif

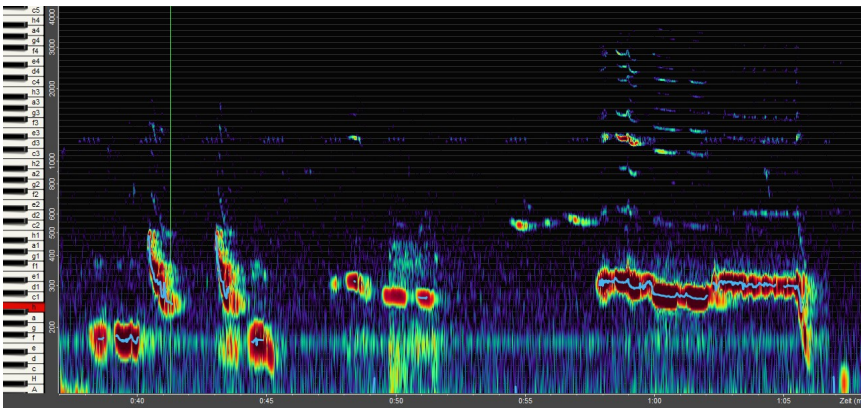


Also in the 11th verse only one PBB (1) can be seen and the others can only be heard nearby.



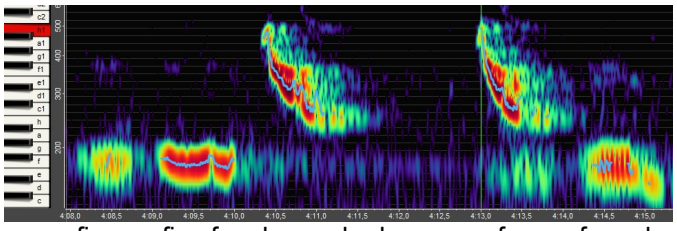
11. verse to be heard in the original position:





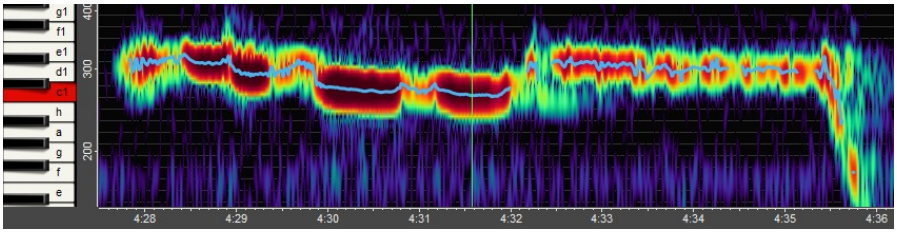
Bass voices: nearby, soft bass voices sing B♭3--A--- and after a longer pause F#3-F-F#
Phrygian motif: PBB 1 sings 2x the most beautiful version of the Phrygian motif B-G-E-D-C--B---, D4 and C4 with small suggestions. The second time, a bass voice with fine F3-E-F sound pulses is added.
alternating motives: nearby choir encircles E♭3-D-C, the second "solo" of PBB 1 glides through the same tonal space with longer sounds and the choir in turn reacts to this with many small alternating motives, from E♭ and D in a rhythmically oscillating band of sound, to finish and die out with D-E♭-D-C-B♭-D-G (E flat major as in the 1st verse).

Phrygian motives



fis fis f h-g-e-d-c-h f f---e-d

alternating motives



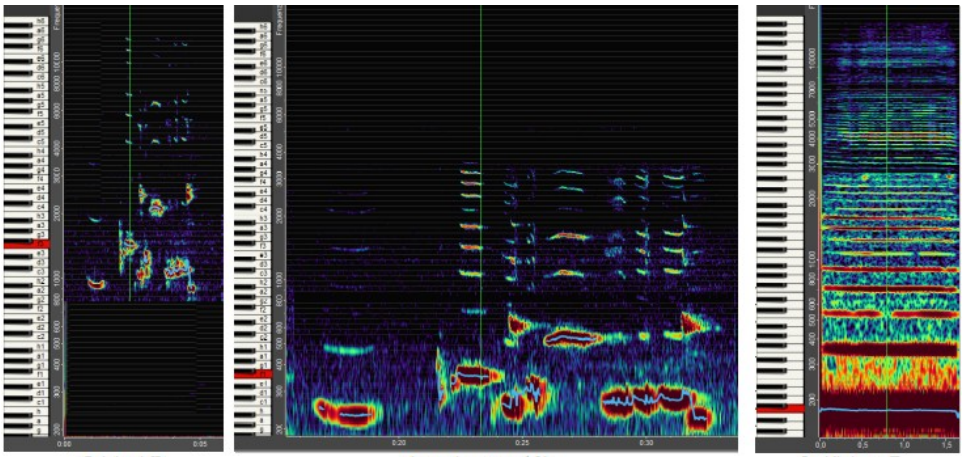
d-es e-es d cis--c c d/es d-g

Appendix

1) the full spectrum in the singing of the PBBs: F6 = 1424 Hz - F12 = 91.136 kHz (64th partial)
2) spectrograms of all 11 verses (37) - 3) all 12 Phrygian motifs (38) - 4) verse 9: images from the video (39) - 5) Comparison: choral singing of the 4 PBBs and solo singing of a blackbird -
6) 4 Pied Butcherbirds singing in choir (2) - a sound-listening-time-experience (42)

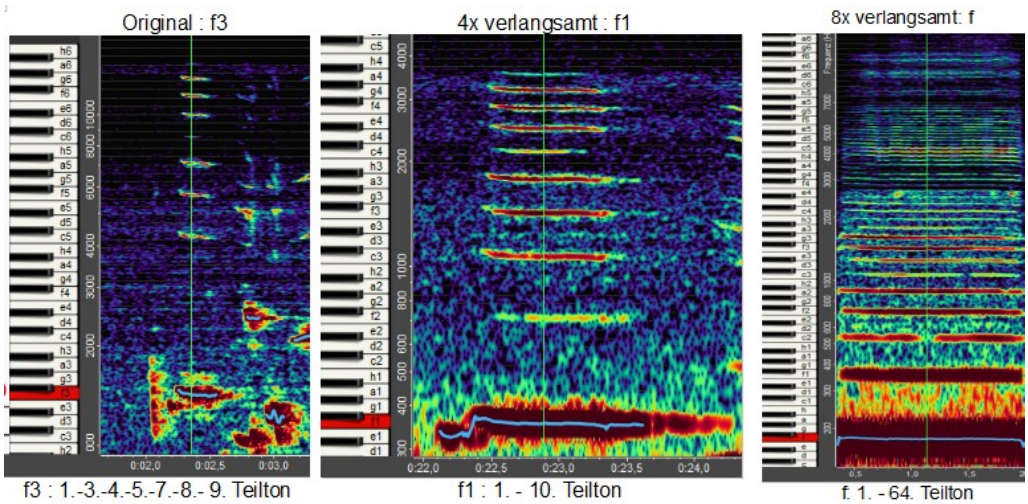
1) the full spectrum of sounds in the singing of the PBBs : the example of an F6 sound

The spectrum of the video recording only reaches up to 16 kHz, as with all mp4 formats (B9 left image below) and correspondingly 2 octaves lower to B7 (4000 Hz - middle image).
To find out the actual spectrum of this sound, I slowed down the sound 8x to the F3 and then I newly recorded it with a wave recorder that can capture the spectrum up to 22kHz.
As the new recording (picture on the right) shows, the sound of the F3 has a full and complete spectrum up to the 64th partial (F9 - 11.392 kHz), i.e. I can count every partial from the 1st to the 64th and read the exact frequency.

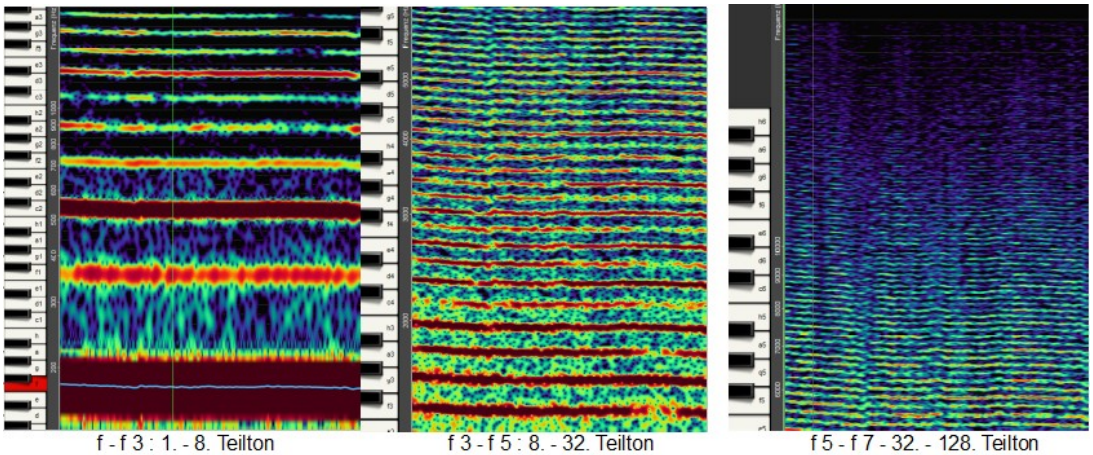


In the original position, the spectrum ranges from F6 (1424 Hz) to G9 (9th partial - 12.816 kHz), in the 4-fold slowdown at F4 from 356 Hz to 3560 Hz (10th partial - A7)
and in the 8-fold slow down at F3 from 178 Hz to 11.392 Hz (64th partial - F9).
In addition, the spectrum is further compressed and also becomes even quieter.

The entire spectrum is displayed in the spectrogram up to the 128th partial: F10 at 22.784 kHz. This spectrum is contained in the sounding F3. Since the slowing down in octaves does not change anything in the sound and its inner spectrum, this means for the spectrum of the original sound F6:
F6 = 1424 Hz (1st partial) - F12 = 91.136 kHz (6 octaves higher = 64th partial) -
total spectrum up to F13 = 182.272 kHz (128th partial)

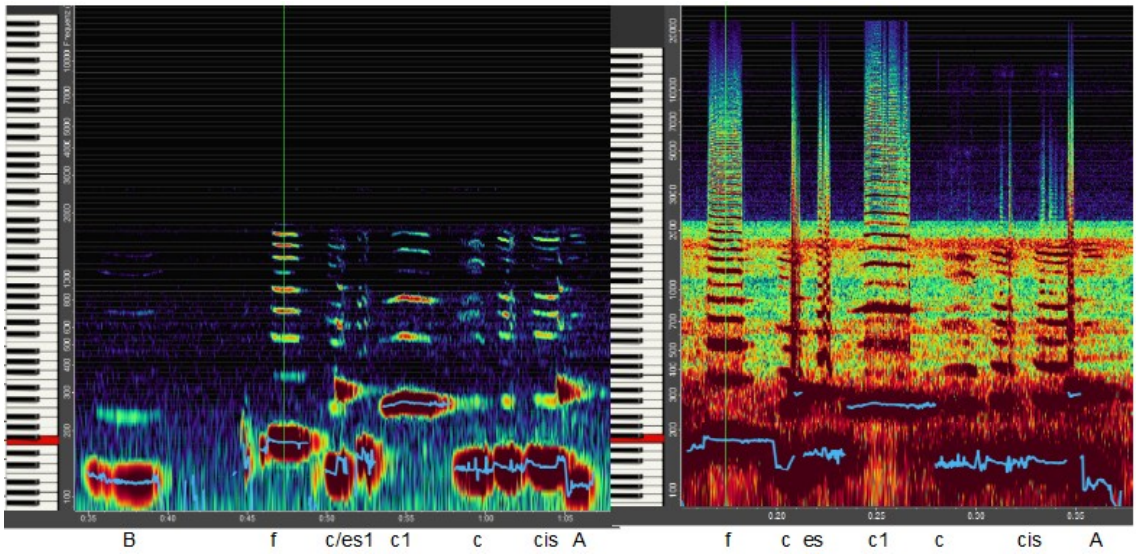


the complete sound spectrum of F3



3 octaves F3 - F6: partials - F3(1.)-F4(2.)-C5(3.)-F5(4.)-A5(5.)-C6(6.)-~(7.)-F6(8.)
1 octave F6 - F7: F6(8.)-G6(9.)-A6(10.)- ~B6(11.)-C7(12.)-~D7(13.)-~E♭7(14.)-E7(15.)-F7(16.)
2 octaves (F4 - F6 = 7 partials) - F7 - F8 = 24 partials - F8 - F10 = 96 partials

the spectrogram of verse 8 - 8x slowed down
on the left the recording of the video - on the right newly recorded (the dynamics were set to the highest level for the image reproduction in the spectrogram on the right, -50dB.)

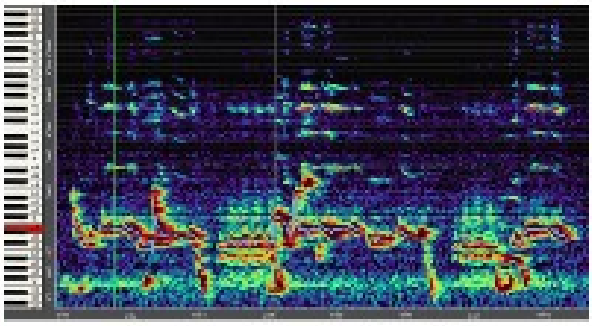


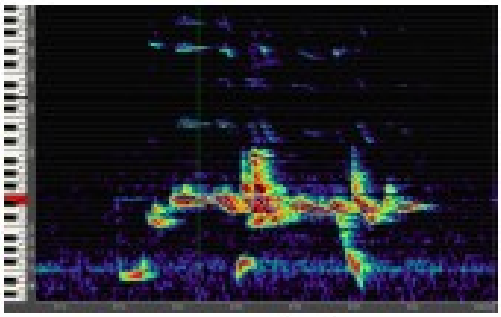
The weave or network of partials in the "melody" of verse 8:

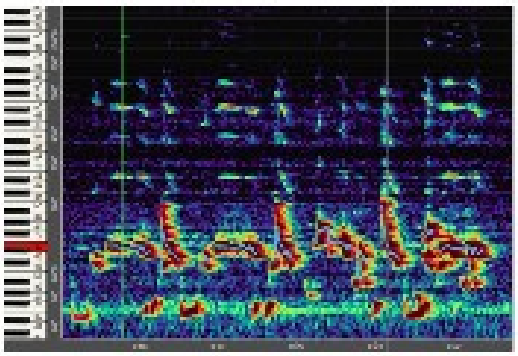
b4------16.---------6.-----7.----14.
g4----------9.----5.---- 6.----12.----------7.
f/e#4---12.--8.-----------------------10.
es4-----11.--7.-----------------------9.
c4-------9.--6.-----------4.-----8.
b3--------8.---------3.-----------7.
as/g#3--7.-------------------------------6.
g3-------------------------3.-----6.
f/e#3----6.---4.
c#3-----------------------------------4.---5.
c3-----------3.-----------2.-----4.

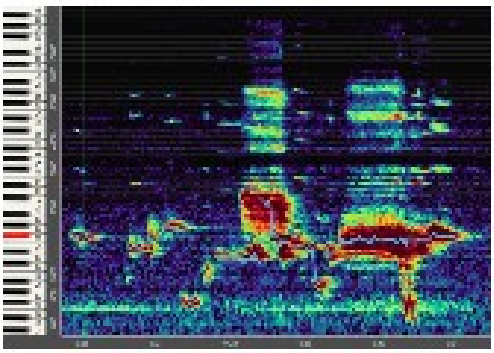
b f1 es2 c2 c1 c#1 a

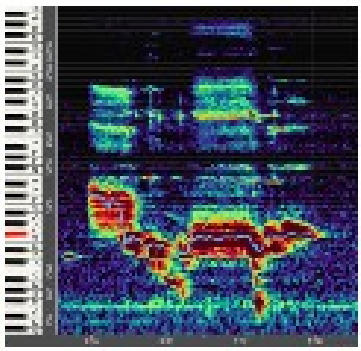
2) spectrograms of all 11 verses

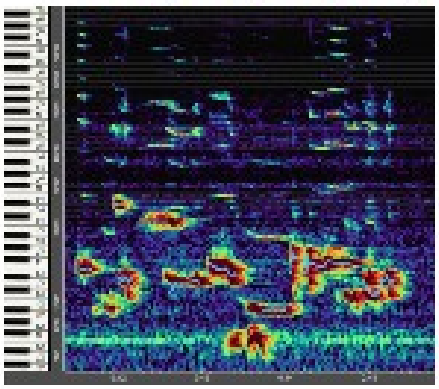


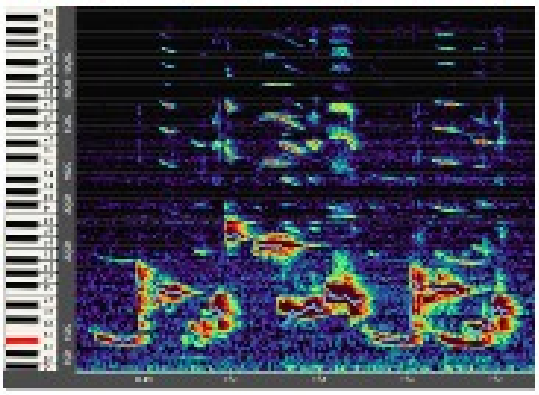


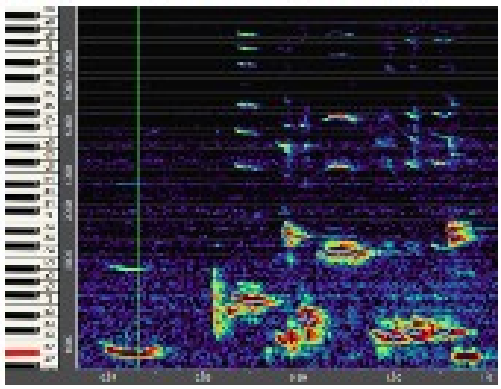


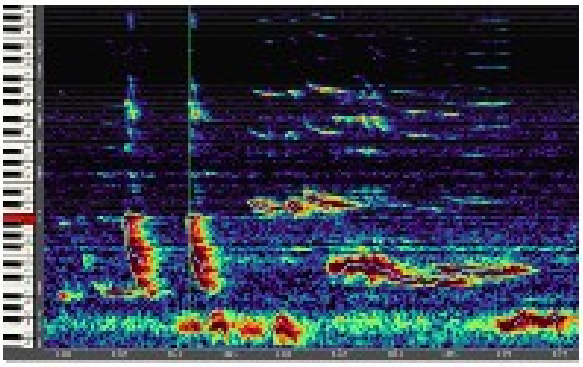


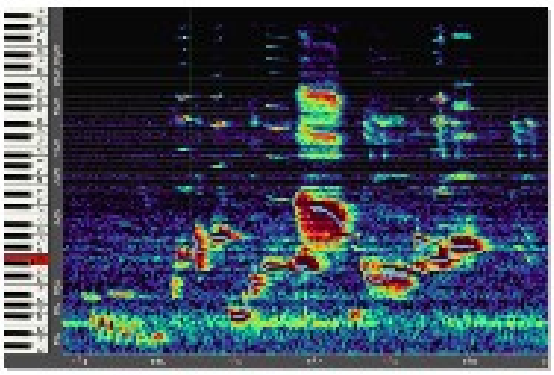


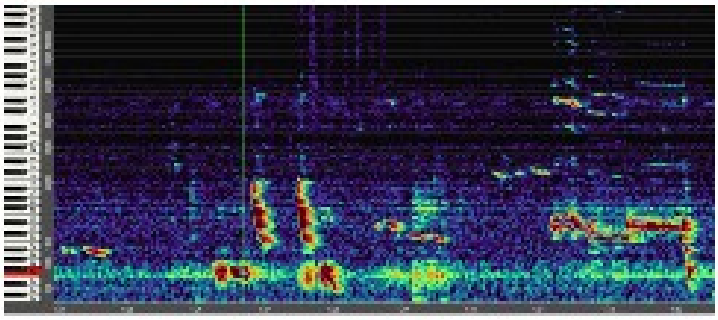






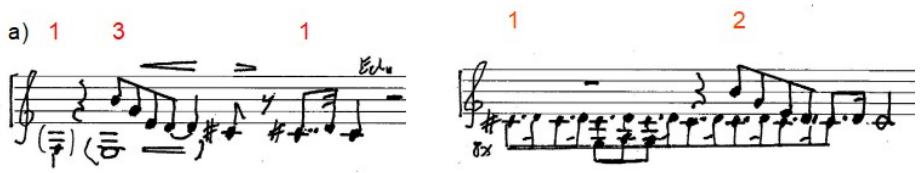




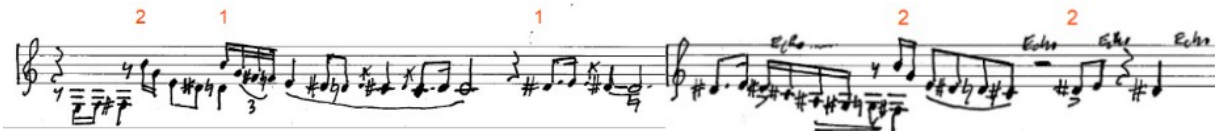


3) all 12 Phrygian motifs

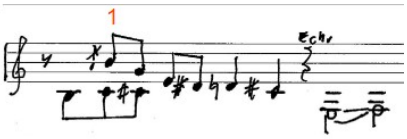
1st verse with 2 Phrygian motifs

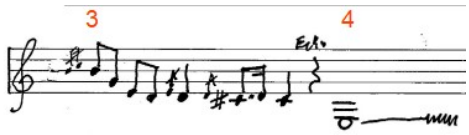


2nd verse with 3 Phrygian motifs

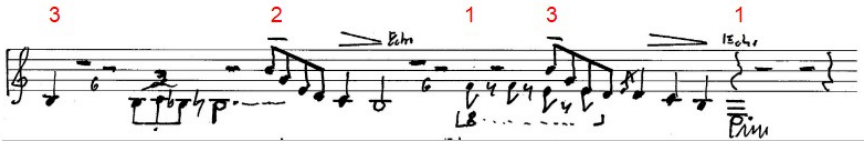


3rd verse with 3 Phrygian motifs

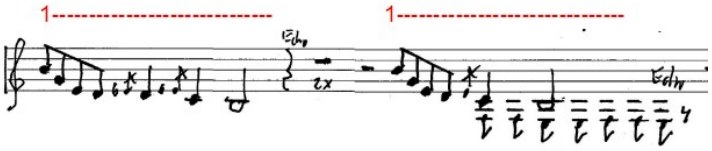




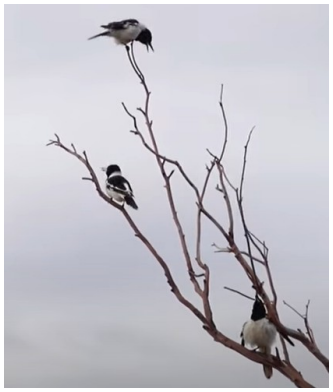
9th verse with 2 complete Phrygian motifs



11th verse with 2 complete Phrygian motifs



4) images from the video (verse 9)



verse 1 : 3 PBBs singing

4 PBBs: rest between 2 verses

4 PBBs sing at the same time

verse 10 and 11

PBB 2: beginning of Phrygian motif head up, wings spread

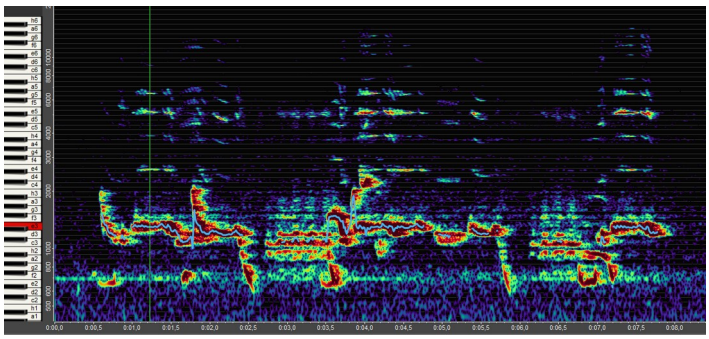
PBB 3: beginning of Phrygian motif and bowing during the motif

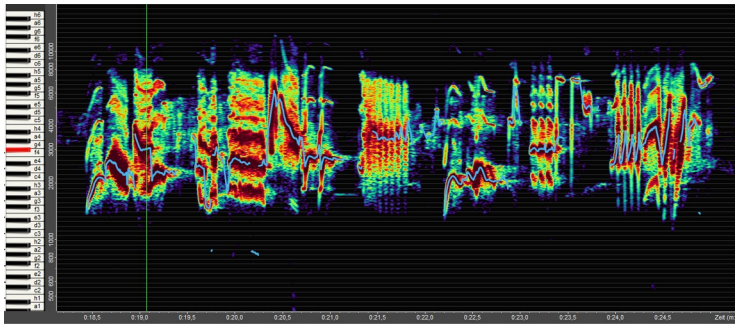
PBB 4 sings high loud C#

PBB 3 then with a lower D#

ending: all PBBs C-C/D-F#

5) Comparison: choral singing of the 4 PBBs and solo singing of a blackbird

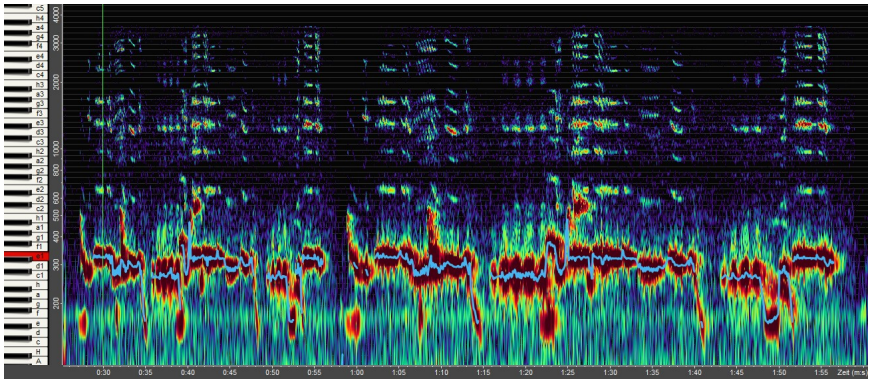




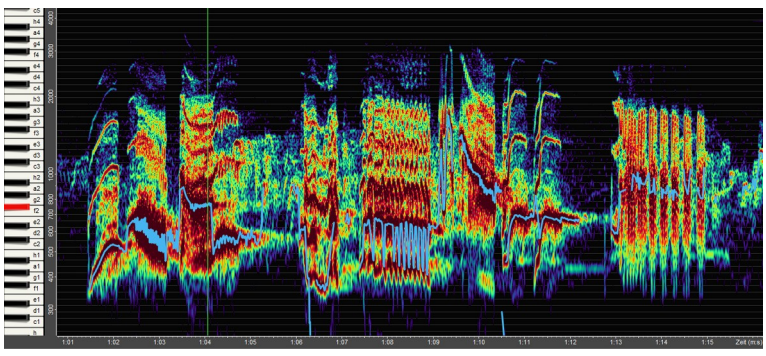
Both spectrograms with the same frequency range and the same dynamic level in the image reproduction, only the recording quality is different: the singing of the PBBs was re-recorded from the video and the recording of the blackbird song comes directly from a CD.

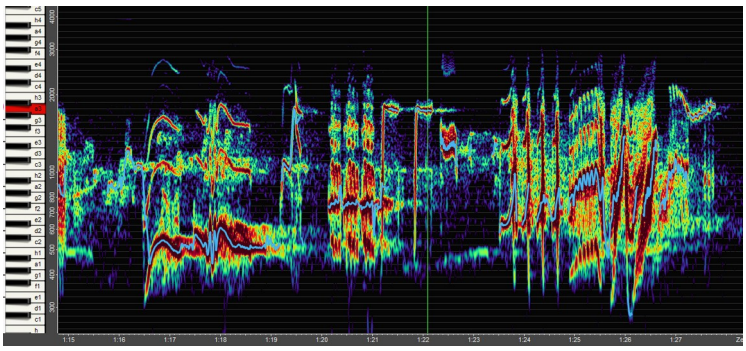
4 PBBs (1st verse: 4-part singing with 12 motifs spread over 4 PBBs)
Range of song E5 - B6 (650 - 2000 Hz), spectrum up to B8 (7700 Hz), duration 7.3 s

1 blackbird (double verse with 20 motifs)
Range of song E5 - B8 (1300 - 7200 Hz), spectrum up to F#9 (12,000 Hz), duration 6.7 s



PBBs slowed down 4x





blackbird double verse slowed down 4x

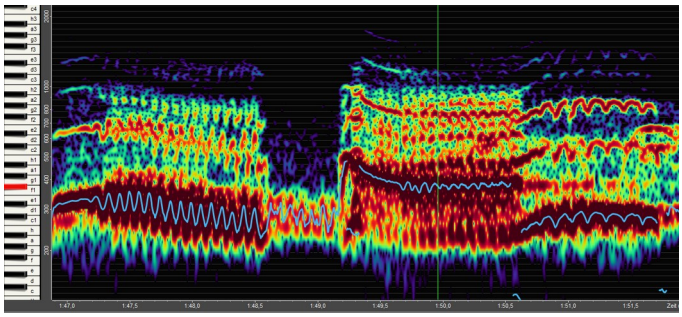
In the original, 80% of the PBBs' vocals are perceived as melodic with pitch, but we cannot tell by listening that it is polyphonic, how many birds are involved and whether the singing is synchronized and coordinated in intonation, harmony, tempo, rhythm.

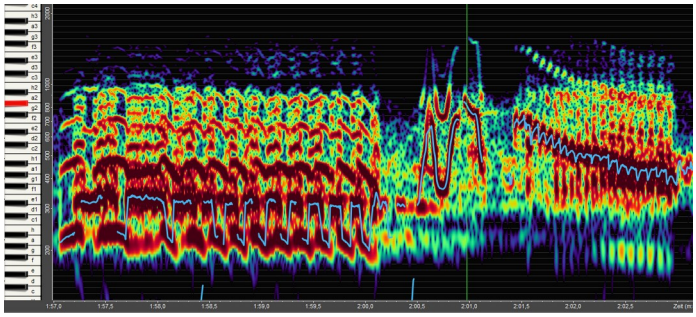
The blackbird song, on the other hand, can only be recognized as pure intensive chirping without specific pitches, except for the beginning of the 2nd part. Only about 8 motifs can be distinguished.

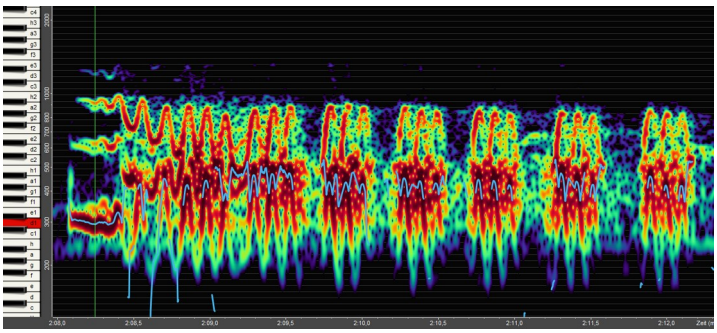
In the 4-fold slowing down, all sound figures can be perceived, also approximately the course of the melody, except for the Phrygian motifs. In 3 short passages one can assume that 2 birds are singing at the same time.

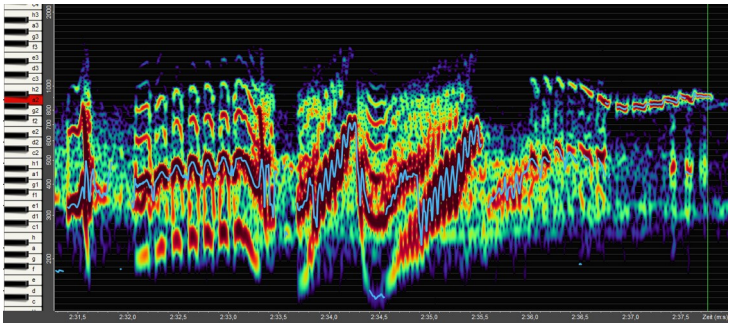
In the case of blackbird song, this slowing down can to some degree recognize about 20% of the song in the course of movement or as a pitch movement. From the precise analysis of the verse, I know that it is only possible to hear and see in the spectrogram at a 16-fold slowdown how complex the sounds really are in these 20%, not to mention the extremely varied and complex sound figures in the remaining 80 % of this verse.

individual motifs from the blackbird song slowed down 8x









Listen and watch the video:

"Blackbird Song (2) - 1 verse with 18 motifs - 0-2-4-8-16x slowed down"

https://youtu.be/ABUx2uUEXGA

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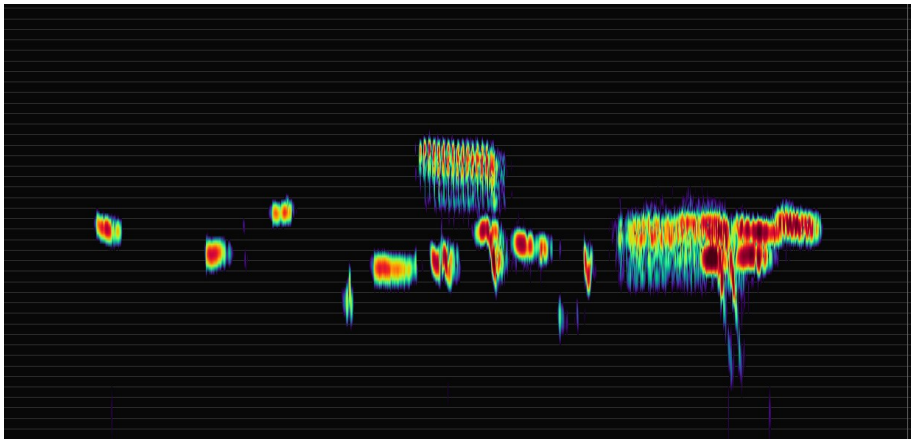
next page: another video of the choral singing of the 4 PBBs



6) Pied Butcherbirds singing in choir (2) - https://youtu.be/S1Xhfp2cDmg

- a sound-listening-time-experience
- a sound journey for ears and eyes through dimensions of space and time
- singing by Pied Butcherbirds with sound spectrum and sound images through 3 octaves in a time stretched several times

Contents:
- Solo and choir singing of the Pied Butcherbirds in the original position at 700 - 2000 Hz
- 2-4-8 times slowdown
- from the 8-fold slowing down at 70 - 250 Hz in the same tempo (!) 1 and 2 octaves higher transposed, without the solo intro (140 - 500 Hz / 280 - 1000 Hz)

The sound spectrum from the Overtone Analyzer in this video is without information on pitch and time. On the one hand, the sound of the original video was recorded a little quieter, on the other hand, the dynamic level was reduced in the image reproduction so that only the pure sounds with their pitches can be seen without the complete sound spectrum of the partials.

The octaving in the lower registers creates interesting changes in the timbre of the singing for our ears and the slowing down makes many elements of the sound audible for our perceptual abilities: melodic phrasing, rhythmic articulation, harmonic relationships, harmony in polyphony - perceptible and experienceable in this video without definition of pitch, spectrum and time course - pure sound shapes in space and time.

A special experience can be had in the 8-fold slowing down. It is recommended to use good external loudspeakers or headphones in this low register in order to be able to absorb the special character of these deep, soft and delicate sound structures. Let yourself be enchanted by these touching, mysterious sound phenomena - expand your hearing into the wide space from which these sounds penetrate your ears - immerse yourself in the interiors and the atmosphere of these sounding phenomena -tune in to the deep silence and tranquility that can be "heard" and felt in the extensive, dark spaces between the verses and also in and behind the sounds.