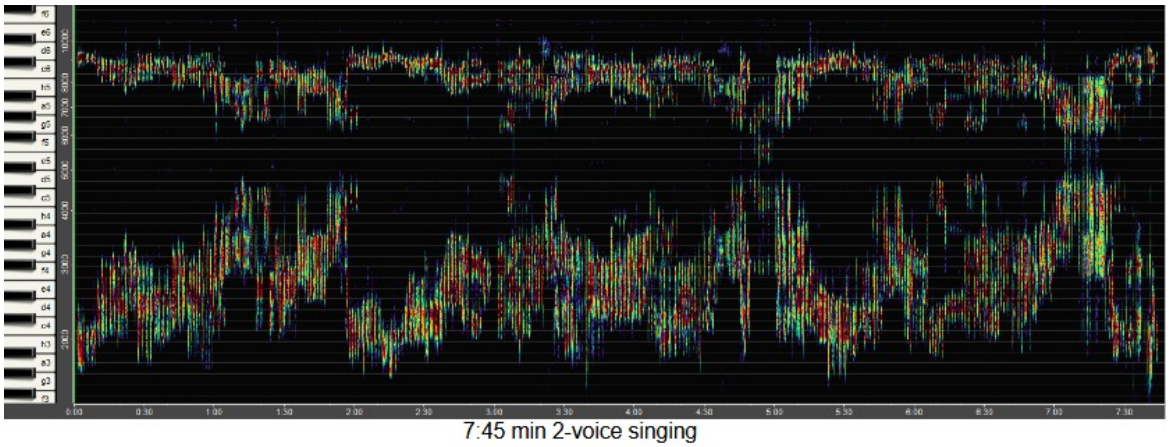
Mockingbird song (3) - a polyphonic 2-voice singing

an art of singing of the highest virtuosity in rhythmic and harmonic counterpoint

7 min of continuous singing with 2 individual voices – 0-2-4-8-16-32x slowdown

See and listen to the original version of the 7 min long singing: https://youtu.be/AUk2fYpwwTM



7:45 min 2-voice singing

Summary

The song of this mockingbird is a genuine chirping song without melodies, without perceptible sound figures and without verses, an incessant succession of short motifs that are often repeated in chains of certain motifs (a total of 850 motifs with 96 individual motifs, 89 of which are different).

The immediate impression of the singing is of noise sounds (= chirping). The singing can be very intense at times or with certain motif chains and can really excite the ear. (The high speed and the sounding together of the two voices can create acoustic interference in the ear). Nothing can be heard of two different voices in the original song (upper voice at 8000 Hz - lower voice at 1500-4500 Hz), everything sounds monophonic, but in the spectrogram the two voices are clearly recognizable (up to 2 octaves between the two voices).
The octave slowdown (2-4-8-16-32-fold) turns the chirping into more and more pure sound, a full and colorful singing, tonally and harmonically well-ordered even for our ears, with tone sequences, intervals, sound figures, rhythm - *a polyphonic two-part singing.*

In this mockingbird it is a quite extraordinary, real 2-part song, perfectly symmetrical, two independent voices (double syrinx of the songbirds) in the most beautiful coordination and correlation, rhythmically synchronized, tonal and harmonical in musical contrapuntal (!) counter-movement - an art of singing of the highest virtuosity in the physical order of the nature of sound (vibration, spectrum, resonance). When slowed down, each voice can be heard as an independent singing with its own intonation (quarter tones in the upper voice, intervals in the lower voice), specific rhythm, differentiated dynamics and musically elegant phrasing. In sounding together both voices form harmonic interval proportions: octave (1:2), fifth (2:3), third (4:5), seventh (4:7), tritone (5:7). Dynamic interactions arise between the two voices when they sound together.
In 2 motifs, even impressive spectral sounds with combination tones are formed from the feedback interactions between the frequencies of a multi-layered spectrum.

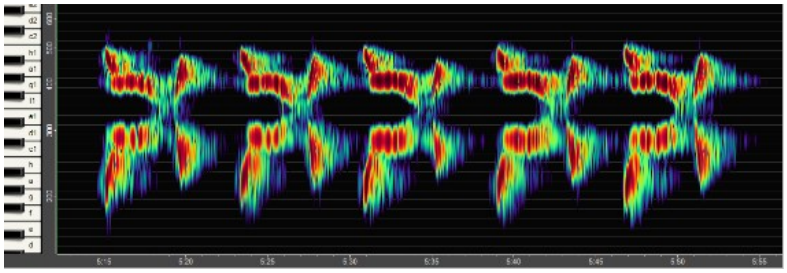
In every motif, in every sound figure, in every pitch change, every interval and every glissando, both voices move in contrapuntal, mirrored counter-movement, even in parallel trills with 48, 96 or 192 pulses per second (!), even in small, fast “ornaments” and even in the noisy calls of the territorial song. In this way, the most beautiful and multifaceted symmetrical sound figures are formed in the sound image of the spectrogram.
(in the spectrogram image as 2-dimensional symmetry in the vertical and horizontal - in the sound process in complex, developing 3-dimensionality).

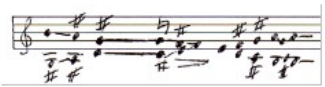
Listening to the 2-voice singing - *one* song *and* polyphonic two-part singing
In the octaving slowdown, we can explore how we perceive the song of the mockingbird differently with our human hearing in each slowdown:
a uniform noisy sound → 2 independent voices in one sound with metallic coloring → pure sound in the process of 2 voices sounding together with their own coloring - slight dominance of the bright intense upper voice to the dark soft lower voice → extended deep dimensions in a sounding space, in light-dark spheres of one sound.

This highly virtuosic polyphonic song of the mockingbird reveals with the greatest clarity and sonorous beauty what and how birds really hear and sing. The French composer Olivier Messiaen rightly described songbirds as “probably the greatest musicians that inhabit our planet”. However, he was not yet able to grasp the complexity and diversity that is hidden to our ears in the sound cosmos of birdsong and only becomes comprehensible to our ears in the octaving slowdown in the spectrogram, because he was only able to notate the songs of birds by ear, but with great skill.

The mockingbird gets its name from the fact that even in early times people had the impression that this type of thrush would imitate other birds in its song and incorporate their songs into its song. In the myths of the Hopi, it was the mockingbird that taught the various human tribes all the languages. Thus the scientific name for this bird species is Mimus (to imitate), and the garden mockingbird bears the Latin-Greek name Mimus polyglottos (imitating many languages). In bird song research, it is said that “the” mockingbird sings over 200 verses (?) and imitates up to 400 songs (?) of other birds.
I have a few very big question marks “???” about these assertions. Anyone who has heard and seen just one of the complex contrapuntal and symmetrical motifs of the “mocking” thrush in the 16-fold slowdown in the spectrogram and immediately afterwards “hears” the fine, ultra-short chirping sound in the original register at 3-8000 Hz (6.4 s → 0.4 s) will hopefully be gripped by great amazement and will certainly no longer be able to say what and how this thrush sings and which other bird it imitates.
How can a bird song researcher know which peculiar, very special sound figures this or that bird actually sings, which the mockingbird supposedly imitates with its song, if he only knows the chirping song in the high register and at tremendous speed?
Why should a bird that can create these polyphonic 2-part songs in such a virtuoso way imitate any other bird song on a completely different level?
The 7-minute long continuous song is divided into 4 phases and develops in a wave-like dynamic. The song is integrated into a spectral matrix. The bird combines certain motifs in chains of varying duration. Only very few, very specific, complex motifs are repeated at long intervals.
How and why should a bird that sings at this high level in the organization of sounds, with this balanced flexibility, this rhythmic and tonal fine-tuning, how and why should it insert other types and forms of song into its own highly developed singing, which are probably also “composed” (“compose” = put together) in a certain, very own sound order.

The “mocking” thrush should be given another name:
Turdus polyphonos - the polyphonic throat (= *turdus*) - the thrush with the many sounds tuned in harmonic polyphony.





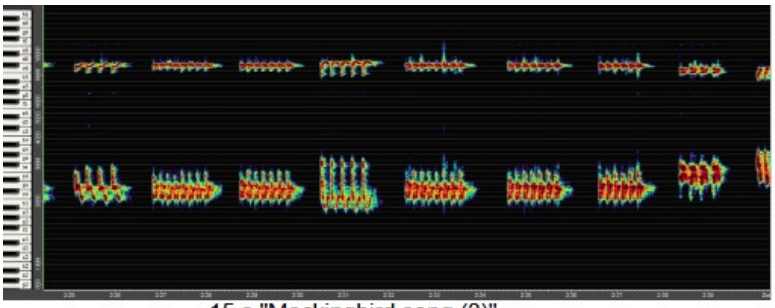
Overview of this special 2-voice singing:

- 7 minutes of continuous singing with 2 individual voices
- syrinx 1 at 1600-4500 Hz and syrinx 2 at 6000-9500 Hz
- main sound spectrum: syrinx 1 at 2-3000 Hz and syrinx 2 at 8-9000 Hz
- parallel and correlating in the motif sequences
- rhythmically synchronized and coordinated in each motif
- all sound figures and pitch movements in each motif in mirroring and counter-movement
  also for parallel trills with 48, 96 or 192 pulses per second and also for small ornaments
- Each voice can be heard as an independent singing when slowed down.
- a total of 850 motifs in shorter or longer motif chains (usually 2-8 motifs in a chain) and in different combinations and repetitions
- 96 motifs, 89 of which are different, 7 at large intervals twice

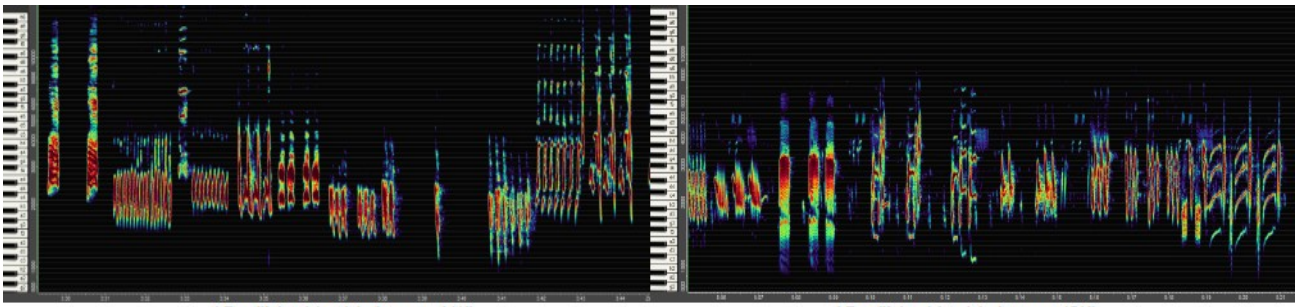
Themes of the text:

Introduction

The song has a clear structure. It begins and ends with the same short motif in a wide position (2 octaves). In each phase there is a wave-like dynamic development in the ambitus of the 2-voice singing, in the intensity of the sound and in the complexity and quality of the motif figures with a high point towards the end of the phase. And there is an increase in the musical sonorities and vocal virtuosity towards the high point of phase 3 and phase 4. The motif with the most beautiful symmetrical shape (in octave position = narrow position) is heard directly before the chorus, and finally, after the chorus, two very virtuoso polyphonic motifs from the end of phase 1 are repeated before the chorus ends with contact calls and a final trill motif in a wide position.



15 s "Mockingbird song (3)"



15 s "Mockingbird song (1)" 15 s "Mockingbird song (2)"

After I had thoroughly analyzed the singing of “Mockingbird 1” and then also the singing of “Mockingbird 2” for comparison, I listened to various mockingbird songs on “xeno-canto” and on YouTube out of interest and came across a recording of 1 hour duration:
https://youtu.be/Q4oTqHg-eu4?si=sxKVmy88cG4UnaYq
To check whether this is the song of a single mockingbird or a loop, I re-recorded the song and looked at it in the spectrogram on the overtone analyzer. In fact, it was recordings of different mockingbirds that were played repeatedly.

The first of these recordings lasted 7 minutes, but did not sound as interesting and varied as the singing of “Mockingbird 1”, even though it contained very intense sounds that had an immediate and strong effect on the eardrum. What astonished me, however, was what could be seen but not heard in the spectrogram. These were clearly 2 individual voices, which were produced simultaneously by the mockingbird in the most beautiful parallelism and correlation, in the same rhythm and in the same motif sequence, apparently each with 1 membrane of its double syrinx. It was a true 2-voice singing and this continuously for over 7 minutes. The lower voice was mainly in the range of 2-4000 Hz and the upper voice 2 octaves higher at 8-9000 Hz. Only at the very end is there a 21 second sequence of chorus sounds.

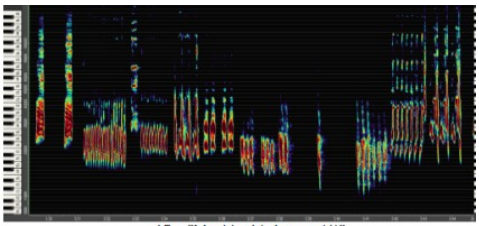
"Mockingbird song (3.0)" : https://youtu.be/AUk2fYpwwTM

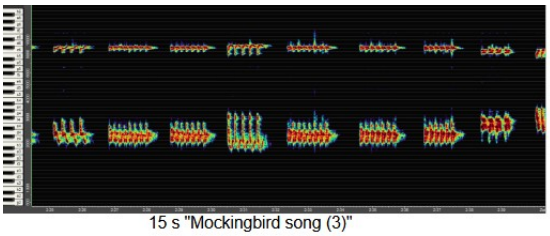
I had never seen anything like it, neither in the 10 recordings of mockingbird songs that I had listened to and looked at in the spectrogram, nor in any other of the 20 or so songbirds that I knew from the analysis, not even in blackbird songs, in which I had found very special, very complex 2-voice motifs.
I knew from other bird songs that males and females exchange contact sounds in the range of 8-9000 Hz (e.g. blackbirds, robins, nightingales), which we cannot hear, although they are just as loud as other sounds in the lower frequency ranges. However, they are clearly recognizable in the spectrogram on the overtone analyzer. In blackbird songs I have found 2-voice singing motifs in which the male blackbird produces an independent complex sound figure in its normal register at 1500-3000 Hz and at the same time another sound figure in the high register of the female at 7-9000 Hz. And it happens that the female blackbird coordinates and synchronizes with the male's song with her own sound figures in this high register.

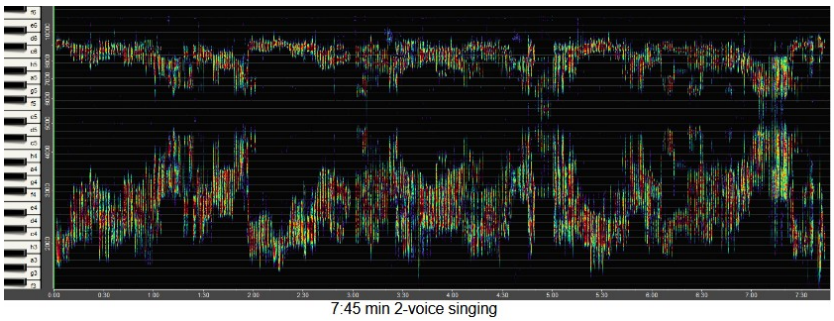
As can be seen below in the comparison of the overall spectrum of “Mockingbird 1” (9 min) and “Mockingbird 3” (7 min), the 2-voice singing is also a real chirping song without melodies and without verses, an incessant stringing together of short motifs that are often repeated in chains of specific motifs. The immediate impression is of noise sounds. At times or with certain chains of motifs, the singing can be very intense and downright arouse the ear. When heard, it does

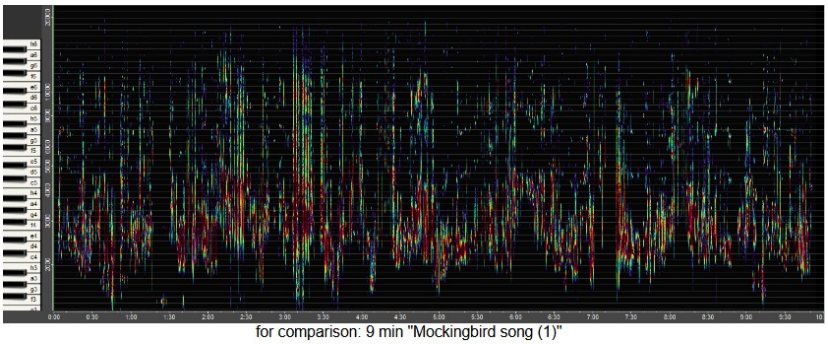
not differ in any way from the usual song of a mockingbird. Even when I hear the song with the spectrogram, I cannot acoustically recognize that the song is 2-voice singing.
When comparing the 15-s excerpts above, you can clearly see that the singing of M1 and M2 is more varied with rather more complex motifs that have a wider sound spectrum, while the singing of M3 seems to be somewhat simpler.

When comparing the overall spectrum of M1 and M3, it is immediately apparent that both songs have roughly the same range in the spectrum (2-10 kHz), but in M1 the frequencies of the partials are distributed over the entire spectrum, while in M1 there is this seemingly empty space between the two voices, predominantly a distance of 2-1½ octaves. However, M1 also has a very intense spectrum range at 2-5 kHz and dynamic intensities in the range of 8-10 kHz.

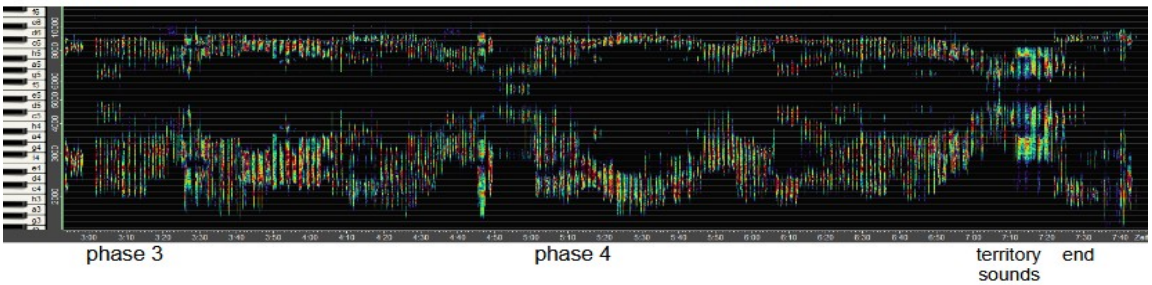

15 s "Mockingbird song (1)"


15 s "Mockingbird song (3)"


7:45 min 2-voice singing

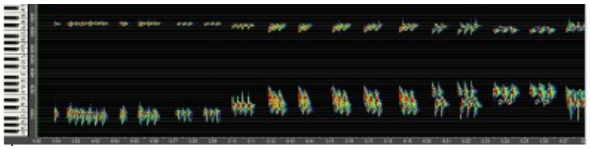

for comparison: 9 min "Mockingbird song (1)"

Overview of the 4 phases in the 2-voice singing

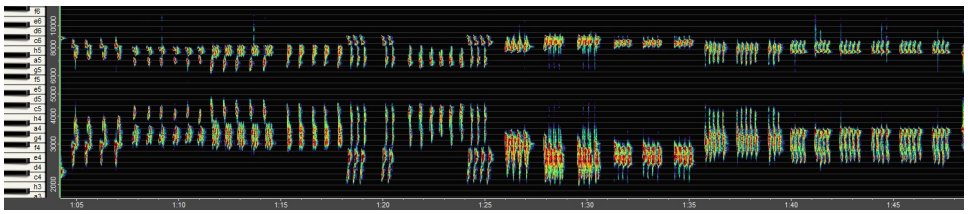


The song has a clear structure. It begins and ends with the same short motif in a wide position (2 octaves). In each phase there is a wave-like dynamic development in the ambitus of the 2-voice singing, in the intensity of the sound and in the complexity and quality of the motif figures with a climax towards the end of the phase. And there is an increase in the musical sound shapes and vocal virtuosity towards the climax of phase 3 and phase 4. The motif with the most beautiful symmetrical shape (in octave position) is heard directly before the territorial sounds, and finally, after the territorial sounds, two very virtuoso polyphonic motifs from the end of phase 1 are repeated before the song ends with contact calls and a final trill motif in a wide position.

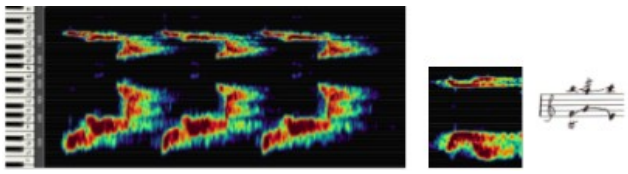
Phase 1



The 7-minute continuous 2-voice singing of the mockingbird is divided into 4 phases, as can be seen in the sound image of the spectrogram above. It begins in a very wide position with a short sound with C#9 (9000 Hz) in the upper voice and B6 (2000 Hz) in the lower voice, i.e. with a good 2 octaves difference, and then a series of simple motifs. In the dynamics, the tonal figures and the spatial relationship between the two voices, there is then an increase and concentration (1½ octaves - F#7/B8). The lower voice moves back into a lower spectrum and after a chain of short, striking sounds, the first more complex polyphonic motif (M 10) appears with a strong stimulus for the ears and a recognizable pitch movement.
In a larger undulating movement, which the upper voice follows in smaller arcs in counter-movement, both voices approach each other down to a fifth (C#8/G#8 - 4400/6700 Hz).

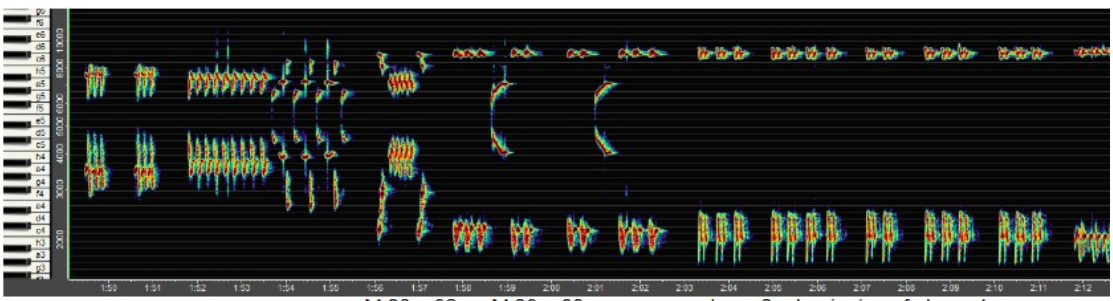


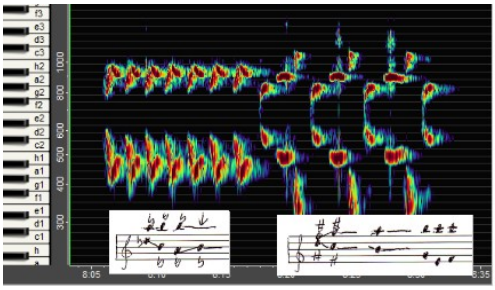
In the picture above, the end of the wave movement can be seen on the left. The motif repetitions now do not form dense chains, but individual motifs, more complex in their two-part structure, sound in series in their repetitions. Motif 17 (=19 - see below) has a total range of 2 octaves (C#7/C#9), the lower voice alone 1 octave and the upper voice also moves through a third.



In the middle of the large picture above you can see how the mockingbird sets to a renewed intensification, now by repeating intensive chains of motifs (M 24 with 6 repetitions).
It should be noted that even in the seemingly extremely short motifs, as in M24 with up to 6 motifs in a chain, there are pronounced tonal figures that have a tonal dynamic in them-selves, forming a tonal shape that generates a high acoustically stimulating energy in its repetition (fourth F#/B → dissonant compression in minor ninth → resolution in sixth E/C).

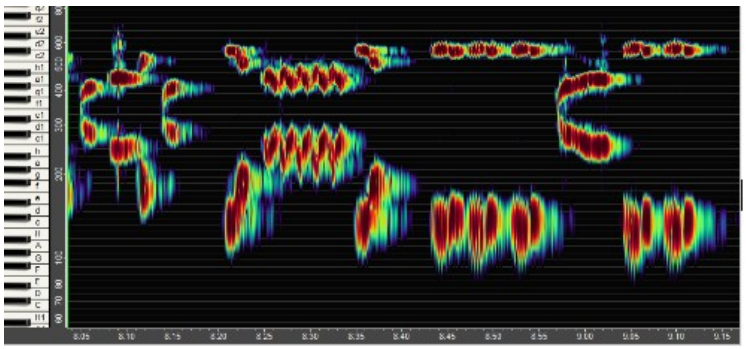
The other motifs in the dense chains of motifs are of a similar quality in the sound figures - *repetition in the function of progressive acoustic stimulation and dynamic vegetative arousal.*

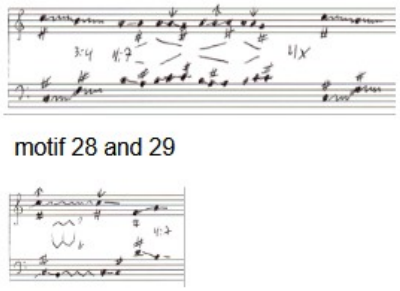




Then we reach the climax of phase 1.
Motif 26 - a rhythmically concise and harmonically well-ordered figure (fifth-octave-ninth-octave) - is repeated 9 times, and the mockingbird immediately shifts to an extraordinary motif sequence that is not only completely symmetrical, has a special rhythm, is contrapuntally ordered, has good phrasing, but also sounds very attractive (in the 16-fold slowdown - third-quint-seventh-----third-sixth-fifth), especially the “pure” seventh.
(B/A = 4: 7 - *one* sound, no dissonance !)

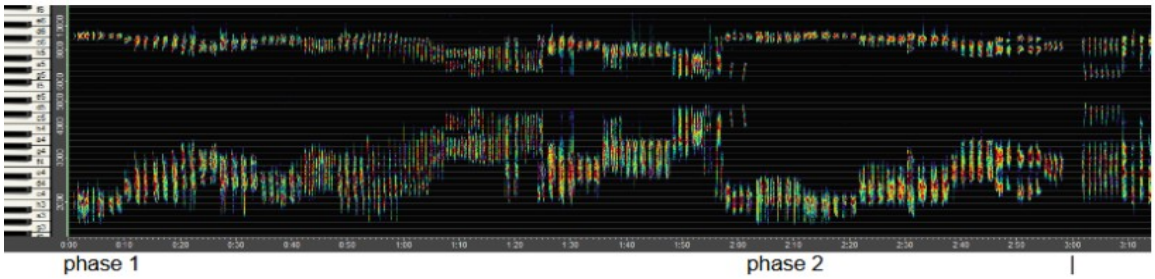
Motif 26, however, only seems to be the ear-opener for motif 28, which follows after a pause and is the most visually beautiful motif of the entire song: trills from the double octave into a wide fourth (C#/C#→F#/B=3:8) at the beginning and at the end and in the middle a precisely contrapuntal counter-movement from the seventh (4:7) into the fifth (2:3). And motif 28 opens up even more space for motif 29: trills in counter-movement in both voices (whole-tone trills in the bass and half-tone trills in the soprano) and then a quiet glissando from the minor third (D#/F#) back to the seventh B/A. (Motifs 28-29 are repeated as the climax of the whole song at the end of phase 4 (M 92-93), motif 28 then even twice.



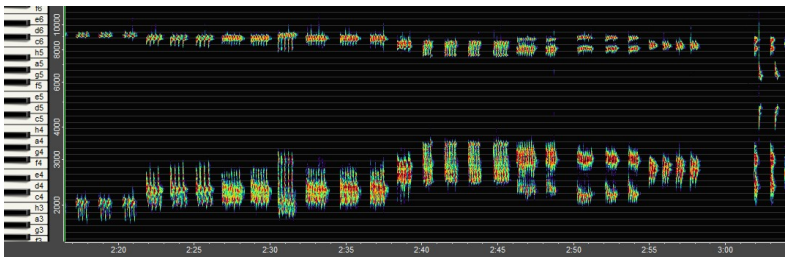


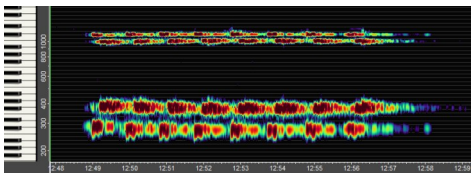
I can highly recommend listening to this entire passage from motif 26 to motif 29 in the 16-fold slowdown - a magical soundscape!

"Mockingbird 3.4" (04:40) https://youtu.be/d623E2e92oU?si=nJyADqw69ueooMqc
Comparison in the original: "Mockingbird 3.0" (01:56) https://youtu.be/AUk2fYpwwTM?si=st8E5JrVo33p9CzJ



Phase 2





Immediately after motif 29, phase 2 (60 s) begins without any particular pause, surprisingly with the same simple motifs as phase 1 (2:03 min). Now the smaller wave movements move directly into a larger dynamic increase in intensity, as can be seen from the stronger red coloration (= volume) in the spectrogram.

The spectrogram above shows this dynamic increase from motif 32 to motif 41:
The volume doubles!

What looks like two voices in both parts at the end (M39-40) are repeated intervals, M39 lower part F#-C# / upper part B-C# and M40 lower part C#-F# / upper part C#-B - a rhythmic and harmonic counterpoint in and between both motifs.

video: “Mockingbird 3.8.5 - 2 motifs in rhythmic and harmonic counterpoint” - https://youtu.be/vgBr8gk9wbk)
However, the dynamic increase in this passage is not only due to the volume. These are sounds which, at this pitch and tempo, make our ears ring with their metallic overtones, because there is so much inner movement and variety in the different motifs in the two-part texture and in the sound figures in each voice that our hearing is simply overwhelmed and can only react with pure excitement, which has a factual effect. In the octave slowdowns it sounds quite different, especially in the 16-fold slowdown 4 octaves lower and 4 time octaves slower: mysterious, full soundiung, harmonic sounds in a wide atmospheric space.

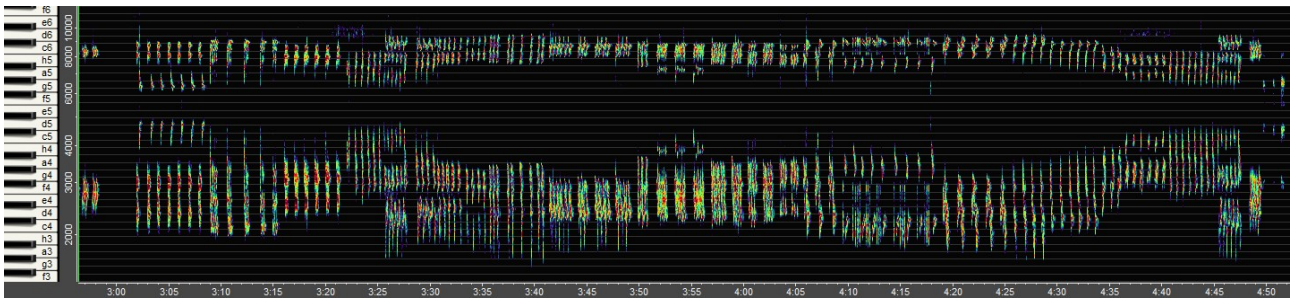
Because this phase so impressively expresses the special character and high quality of this bird song, qualities that no one can imagine who only knows the song of the mockingbird in its original position, I have published several videos on this motif sequence (“Mockingbird 3.8.1-5”), under the theme:

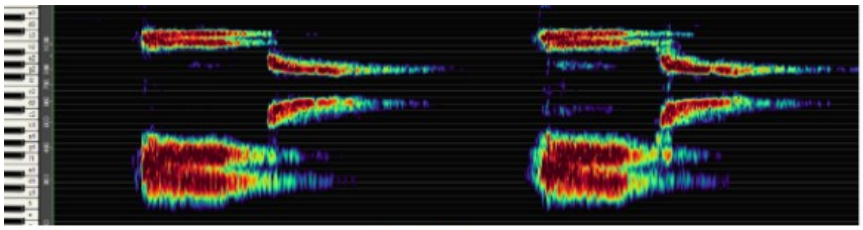
“Listening experiences in different dimensions of time and space”

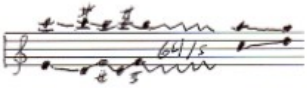
The above passage with the 9 motifs can be found in the video “Mockingbird 3.8.1 - nine 2-voice motifs in a row” : https://youtu.be/yp2u_6pLpMQ?si=nPWbt7LTsAAEAuOs

The song breaks off after motif 41, followed by a very long pause of 3.5 s, just as long as the 3 motif chains of M40 with the pauses.

Phase 3

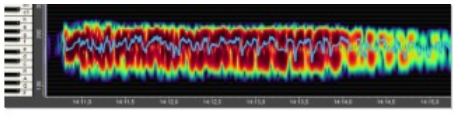






Motiv 42

Phase 3 (1:50 min) begins immediately with a spectacular motif (M 42), which “sounds” like an intense rubbing noise in the original and which turns out to be a highly complex sound structure in the 8-fold slowdown. What it actually is, however, I was only able to read in the spectrogram at 16x and 32x slowdown and with a filter for each voice.



It is a third trill (D-F#-D) in the lower voice and a whole-tone trill (C#-H-C#) in the upper voice, both trills with 64 pulses per second in contrary motion, both trills very loud and in vehement vital (!) motion, then, into the echo of the trills, followed by a rather soft and smooth-sounding glissando from the sixth C/A into the fourth D/G, and this 7 times in exact repetition. I can play a D-major-7$^{\#}$ chord (D/F#/A/C#) on the piano in complete harmony with the two trills. And we hear this complex, well-organized sound structure in the original in 0.5 s as a pure chirping noise!

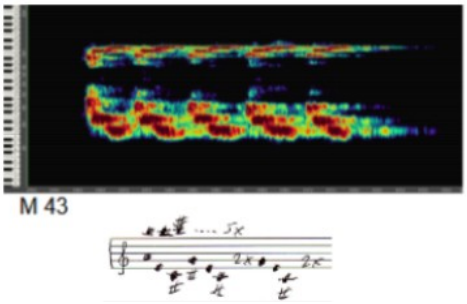
The sound figure in the 16- and 32-fold slowdown is particularly impressive. I don't hear two voices with their trills, it is an incomprehensible sound in which the whole atmosphere seems to quake and vibrate as if some gongs or large drums were being made to vibrate very softly somewhere. And the 2-voice glissando also forms a slightly pulsating but very calm stream of sound with a long reverberation.
This sound sequence could therefore be heard as a modulation D-7$^{\#}$→a minor→G major.
What composer would not be grateful if he could come up with such a beautifully contrasting sound figure and make it resound with the appropriate instruments.
But with which instruments? How should he notate it? Who could realize it and repeat it 7 times? - a sound experience full of quivering and at the same time calm liveliness.

In addition, the mockingbird sings this special sound figure a second time as motif 83, again with 7 repetitions and in combination with the “A7” sound of motif 43.

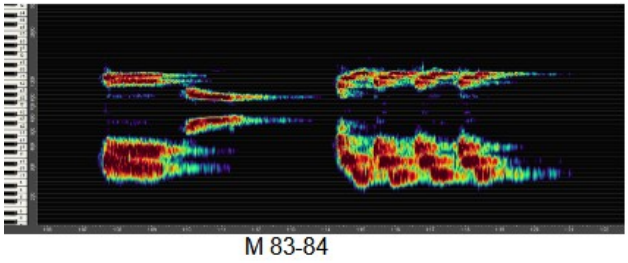
Video for motif 42-43 : "Mockingbird (3.8.8) - a 2-voice D-major-7$^{\#}$ trill and an A-major-7 sound"
https://youtu.be/X3-aUjtHsbk

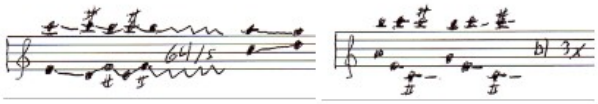
Motif 42 and motif 43 = motif 83 and motif 84

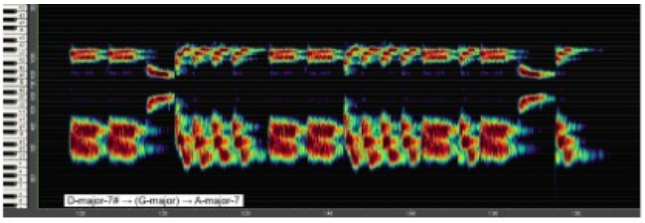
M42 (7x) / M43 (5 motif chains) = M83 (7x) / M84 (6 motif chains)



Motif 43: In the 8-fold slowdown, a semitone sequence can clearly be heard in the upper voice and a triadic break in the lower voice, which ends in the octave to the upper voice. Rhythmically, the sixth E/C is emphasized, followed by the octave C#/C#. The whole figure can be heard as an A major seventh chord, with the diminished triad G-E-C# clearly audible in the slowdown in the lower voice. (I have often encountered such diminished triads in various songbirds.)



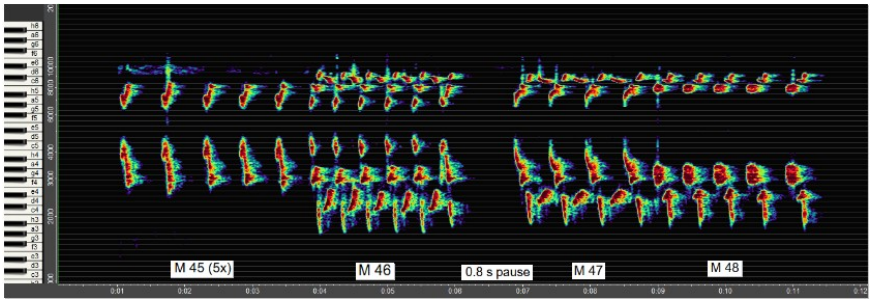




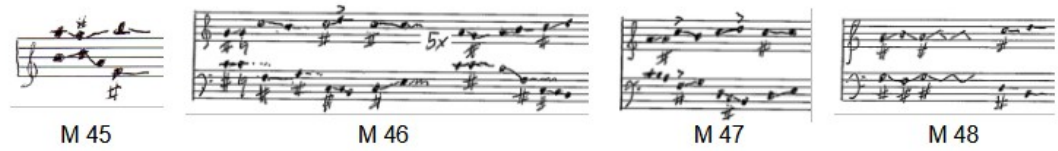
In the video “Mockingbird 3.8.8” I have combined motif 83 and 84, resulting in the very harmonious modulating sound sequence: D major-7$^{\#}$ → (G major) → A major-7.

In the further course of phase 3, even more impressive motifs follow, some of which are repeated several times as chains of motifs, motifs with a distinct tonal shape, special tonal figures, harmonic turns and tone sequences. Here are a few examples:

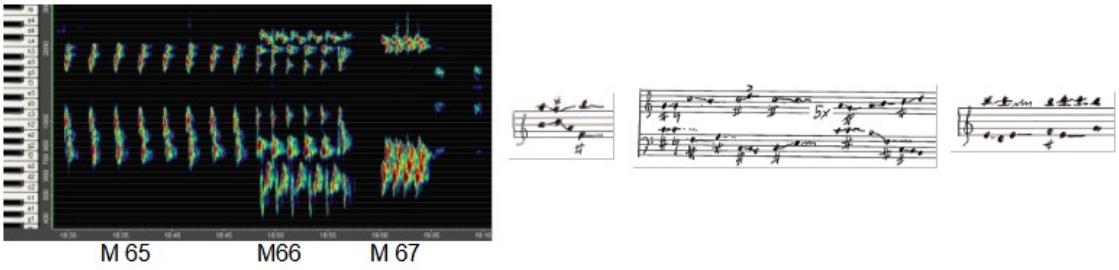
Motif 45-48 - rhythmic and tonal variation of a motif (46/47)



An interesting sequence of motif chains :



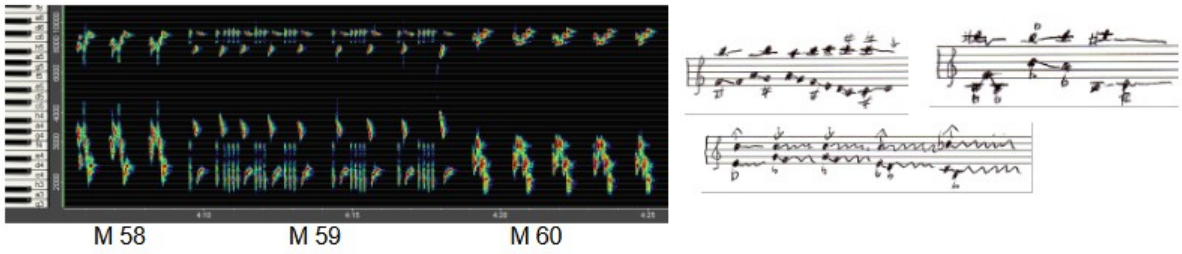
Even in the original position, after 5 very short sounds, one hears 2 chains of motifs with a concise but different rhythm in a kind of tone sequence and, immediately following M47, another 5 short, somewhat rough sounds. There is a longer pause between motif 46 and 47, almost twice as long as between the other motif chains. But the refined vocal artistry that is then revealed in the slow-downs is once again hard to believe. (I only discovered it while writing this overview.)
In the notation, I could neither grasp the special rhythm of motif 46 and 47 exactly nor the respective fine phrasing in the tone sequences. (You can roughly understand it in the 8 and 16-fold slowdown in the video).
Motif 46 is not completed in the 5th repeat, it ends in an open phrase, the bird makes a long pause and then begins again with the same sound figure, but in a varied rhythm and slight changes in the intonation. The 4th repetition is also not fully executed, instead motif 48 follows immediately, an intensely sounding 5-fold trill figure followed by the same wide interval (B6/D9) as in motif 46, but now not via a diverging glissando, but in a clear interval sequence, from the seventh into the Decime. The trill in motif 48 is a whole-tone trill (G#-F#-G#) in the lower voice and a fine half-tone trill (A#-B-A#) in the upper voice. Both trills move in contrary motion as usual. In the harmony of the trills and with the high D at the end, the motif sounds like a G major triad.
In all the songs of the mockingbird that I have analyzed (M1-M2-M3), this is the only case in which the bird varies (improves?) a motif immediately afterwards and then continues with another motif. And what is even more astonishing is that at the end of this phase the mockingbird repeats motifs 45 and 46 exactly as M65 (8x) and M66.

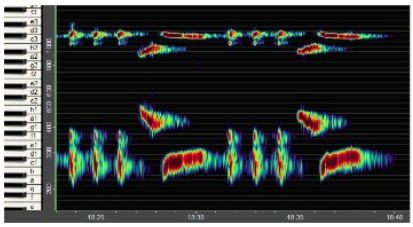


Video zu Motiv 45-48: "Mockingbird (3.8.9) - rhythmic and tonal variation of a motif"
https://youtu.be/9nQt1-6dn2k

(Only in the song of a skylark, which strings together countless motifs in its long-lasting song, have I once experienced a complex tone sequence being immediately repeated and improved. With the skylark there are only a few repetitions at long intervals).

Motif 59 - a long rhythmic sequence



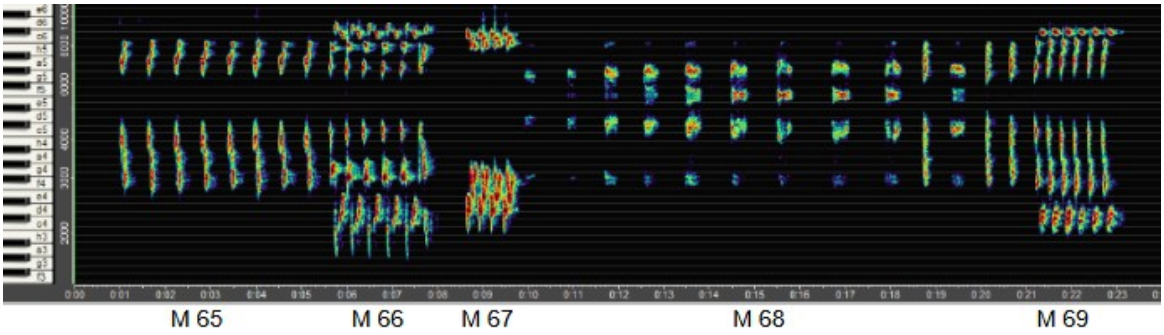


After a series of motif chains with very short motifs, a somewhat more complex motif is heard again in motif 58, in which a rhythmic sequence of notes can almost be recognized in the original. And before the special trill motif 10 is repeated in motif 60, a surprising and unique motif appears, very long at 9 seconds, in which a double glissando figure is repeated 9 times

with 3 or 4 very short sounds in between. Both glissandi are in opposite directions, one from the octave to the decime (Bb7/Bb8 → Ab7/C8) and one from the ninth to the octave (B6/C#9 → C#7/C#9).
The rhythmically very precise sequence of short notes is in fact a precise interval figure in the contrary motion (C#9-C-C#--- and fifth Bb6-F7-Bb6---).

Motif sequence 65-69:
5 motifs in succession - a dynamic development into a C# major sound

From the repetition of motifs 45 and 46 (= M65-66), a very special dynamic progression develops into a full C# major sound in motif 69. It seems as if the sequence of M45-46 - pause - motif 47-48 (M47 = variation of M46) now takes a different, creative turn. After motif 66 (= M46) there is again a clear but somewhat shorter pause, now followed by a very sonorous loud chain of motifs (M67), and then immediately only very airy sound noises can be heard. The bird has obviously not even breathed for the first very quiet sound.



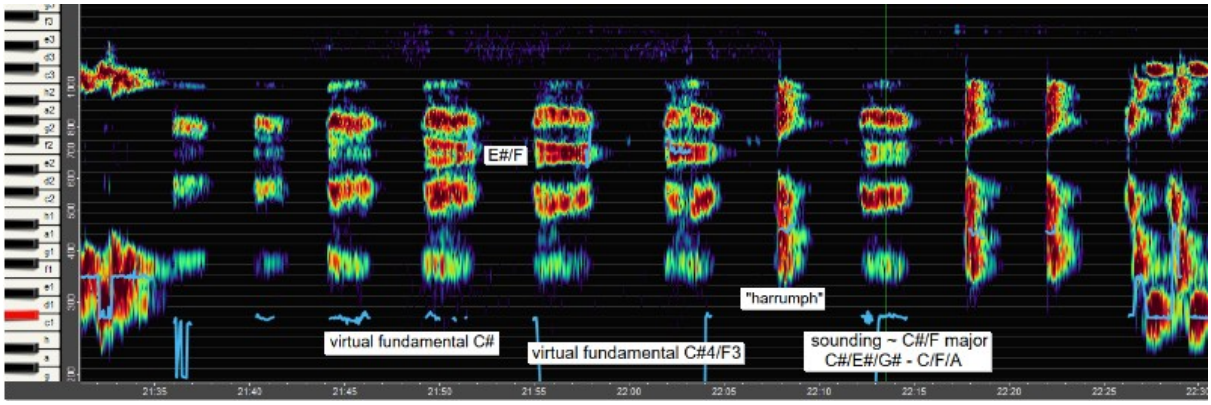
In a rhythmic sequence of “sound” and pauses, a very peculiar polyphonic sound phenomenon develops dynamically (M68), a fifth sound with "combination tones". Before the last sound, there is a violent short noise in the rhythm, which is repeated twice at the end of the motif. It almost sounds as if the bird is briefly clearing its throat, first for the last clear fifth sound (C#/G# = “C# major”) and then before the full song in clear C# major (M69 in 3 motif chains).

Video: "Mockingbird (3.8.10) - 5 motifs in a row – a dynamic development into a C# major sound"
https://youtu.be/mGszZBkHsYU

In this video I have combined motif 66 and 69 directly with each other, so that you can see impressively how motif 66 has an open ending just like M46 (C#/G# → F#/B → octave C#/C# → decime B/D) and how motif 69 ends from the fifth C#/G# through C#-7 (E#/C) in a radiant C# major sound (C#-C#7-C#-major).

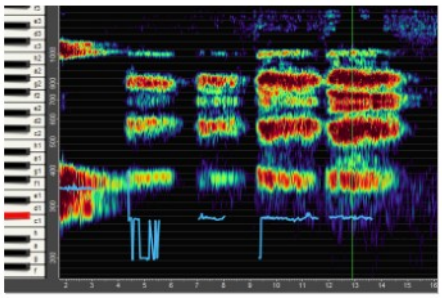
Motif 68 - Dynamic development of a fifth sound (C#/G#) with "combination tones"

Video: "Mockingbird (3.8.10a) - Mockingbird song (3.8.10a) - dynamic development of a quint spectral sound with combination tones" - https://youtu.be/SFKYOUbBbPc



Motif 68 in the 8-fold slowdown (shortened from 10 to 7 sounds)

The strong loud motif 67 ends in the fourth F#/B. The immediately following, aspirated sound (~“D/G”) has the effect of both membranes being blown on, almost like a real syrinx. In human singing, this is referred to as a breath on the voice. In addition, there is a trill movement with slight fluctuations in each voice, so that no clear pitch can be heard through the breeze and the trills.
In the spectrogram I can see that it is the half-tone trill G-G#-G in the slightly louder upper voice and D-C#-D in the lower voice. The 2-voice sound thus fluctuates between the fourth D/G and the fifth C#/G#.



The interactions between these two vibrations create a sound with a complex frequency structure in the air "tube" (!) above the two membranes. So-called *combination tones* are created, an emergence phenomenon in an interacting oscillation system, which I am also familiar with from the 2-voice singing of the blackbird.
In the first sound, in addition to the main sounds D/C#2 and G/G#2, these are: G/F#1 - E#2 - B2 (8x slowdown).
In the spectrogram, the blue line indicates the virtual fundamental C#1 or G when the sound structure changes.
The sound therefore oscillates between two spectra with its own virtual fundamental and its partials:
1) G (virtual fundamental) / G4(2nd) / D5(3rd) / G5(4th) - B5(5th)
2) C# (virtual fundamental) / C#5 (4th) / E#5(5th) / G#5 (6th)
As can be seen in the spectrogram, the fourth F#4/B5 at the end of motif 67 continues to sound in the beginning of motif 68 (F#-G4 and B5 as combination tones to the fourth D5/G5).

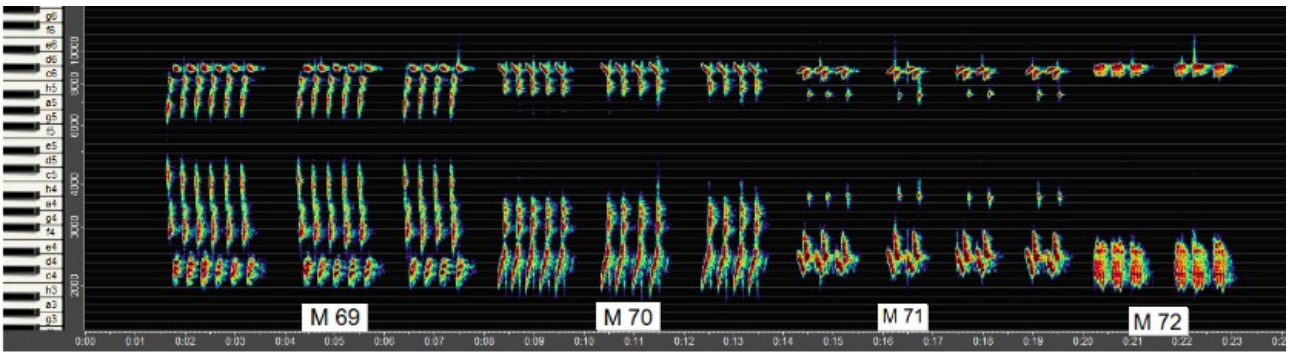
In the third 2-voice spectral sound, the trills and the volume in the fifth/quart sound become stronger. Both voices move from C#/G# to D/G. The virtual fundamental is now C#4.
From the fifth sound onwards, the stronger inner dynamics in the sound structure lead to the development of two combination tones in the third frequency due to the interference between a C# and an F# spectral sound, an E and an F#, which virtually merge into E# (=F) at the end.
In the last 3 sounds, the dynamics in the sound structure increase further. The two voices now move from the fifth C#/G# to the sixth C/A and back again, so that the sound oscillates between “C# major” and “F major” (C#/E#G# and C/F/A). The sequence of spectral sounds ends in a melodious fifth (C#/G#) with a weak third combination tone E#.

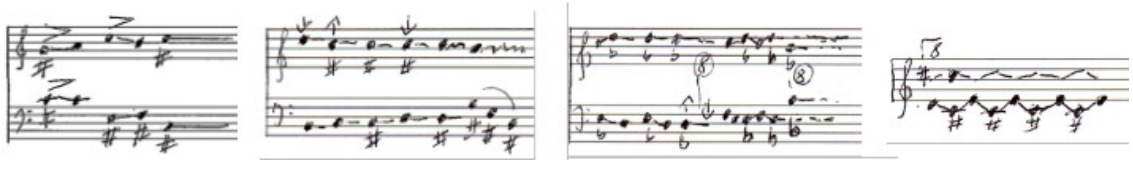
A detailed analysis of the sequence of spectral sounds can be found in the appendix (p. 52):

“A 2-part spectral sound (C#/G#) with its combination tones -
Exploring the inner life of a multi-layered sound with your ears”

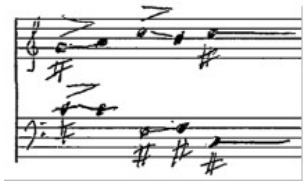
Motif 69-72 - iridescent modulations in a sequence of 4 motifs
the sonorous climax at the end of phase 3

Video: "Mockingbird (3.8.11) - https://youtu.be/KSS0cwSpduw





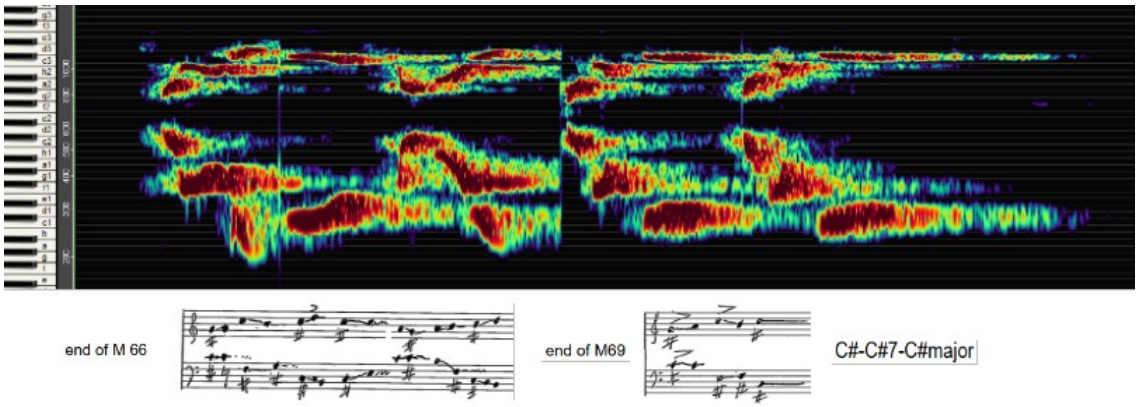
Motif 69 - **C#-C#7-C#-major**



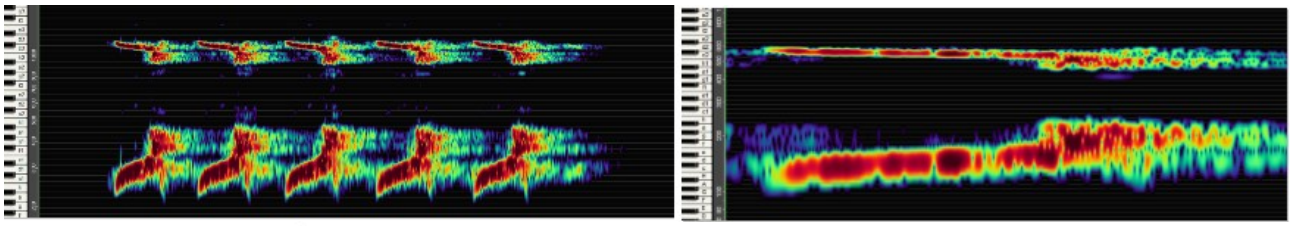
Above, in the motif sequence 65-69, I already mentioned how the modulation develops in motif 69 as a further development of M66: from the fifth C#/G# through C#-7 (E#/C), it ends in a radiant C# major sound (C#-C#7-C#-major).
And if I follow the modulation even more closely, you can hear it like this: C#-major / F-major / C#-7$^{\#}$ / B-major / C#-major

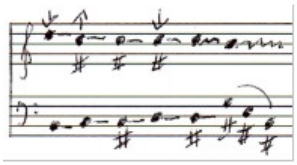
The chord sequence: C#/E#/G# - C/F=E#/A - C#/E#/G#C - D#/F#/B - C#/E#/G#/C#

C# major and F major are related via the third E#=F, C# major and B major are connected via the double subdominant.



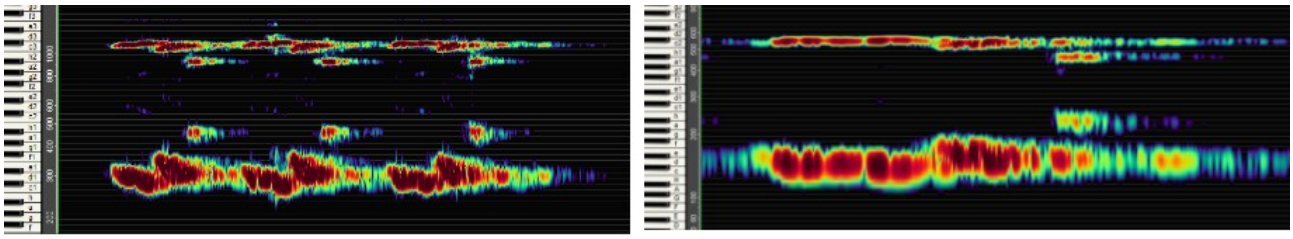
Motif 70 - chromatic tone sequences (semitone/quarter tone)

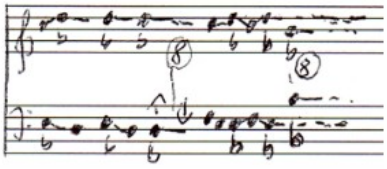




After the wonderful C# major sound comes another exquisite sound structure: a clear chromatic tone sequence in the lower voice (16x slowdown on the right) and in the upper voice, in counter-movement, a tone sequence in quarter tones that ends in a trill from C to B, while the lower voice performs a fast C# major triad downwards.
Motif 70 thus ends again in a C#-7 sound.

Motif 71 - Modulation Db → F7 → Bb minor

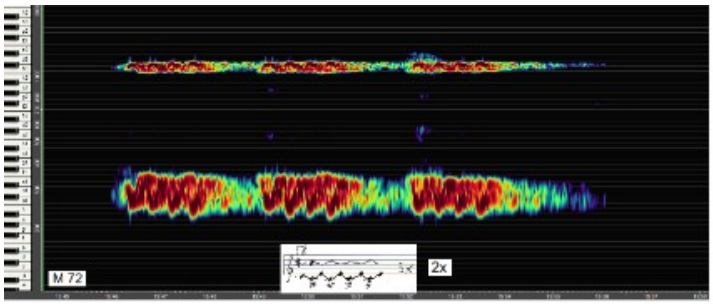




In motif 71, an interesting, peculiar modulation takes place.
At the beginning of the motif, the bird seems to be searching for the octave Db7/Db9. However, it does this in every repetition, i.e. it is probably intended to trigger a certain stimulus.
While the upper voice makes the Db9 sound rhythmically 4 times (see above right, 16x slowdown), the lower voice makes small movements from E7 to D7 in the same rhythm until it reaches the exact octave (8) to Db9. This does not sound dissonant and has

a special appeal for the ears because it makes the octave sound fuller and larger. The ear is then further stimulated by a quick half-tone trill on the C9 in the upper voice and an alternating F-Eb in the lower voice, an F7-sound (C/F/Eb). And then, while the Db9 continues to sound beyond the figure, both voices jump to the octave Bb7/Bb8.
The effect of this unusual sound is intensified by the special rhythmic and tonal phrasing: e.g. the introductory insistent Db in the upper voice, the trill on the C and the short impulse on the last Bb.

Motif 72 - 2-voice trill (A major/a minor)



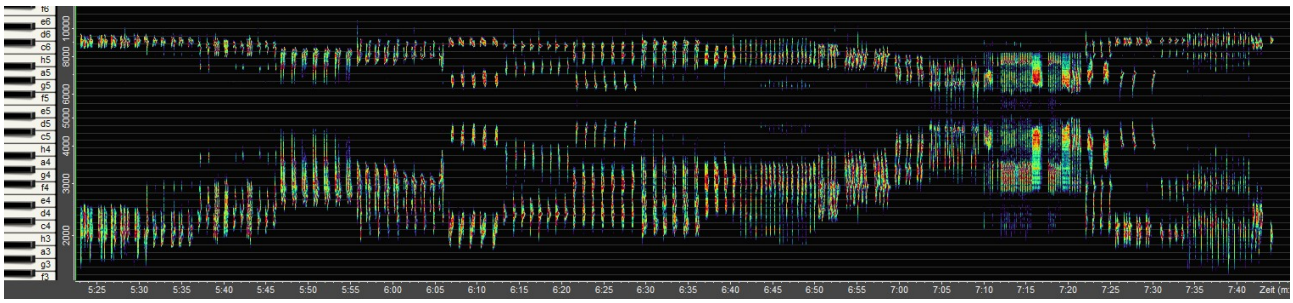
The sonorous conclusion of this very special sequence of motifs is a calmly swinging 2-voice trill, like all motifs with a delicate echo: in the lower voice the third C#-E-C# and in counter-movement to this in the upper voice the semitone trill C#-C-C#. With a little sound imagination, you can perceive a sound oscillating between A major and A minor, which is very appealing, just as all three motifs after the clear C# major have something dazzlingly ambivalent in their modulation: C#/C#7 - chromaticism - Db/F7 - F7/Eb7/Bb minor - A major/a minor.

By the way, the upper voice in all 4 motifs is based on C# at 554 Hz (slowed down 16 times).
Of course, the notation cannot capture exactly what it actually sounds like.

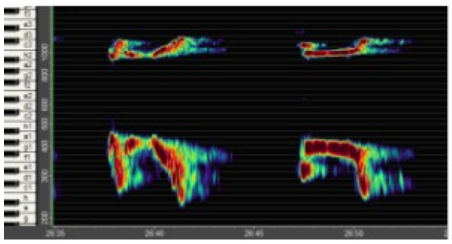
Recommendation: Listen to the motif sequence in 32-fold slowdown with headphones to experience the full richness of sound and the sonorous atmosphere inside these sound figures.

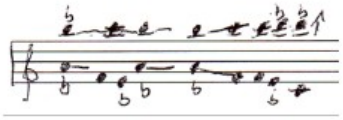
It is worth listening to the entire Phase 3 in the complete 4-fold slowdown, with all its repetitions and chains of motifs in all their complexity and variety.
Video: "Mockingbird 3.2" (12:00-21:17) - https://youtu.be/GTQyd0Er4EQ?si=s5x-1F2j8VpD5sm5

Phase 4



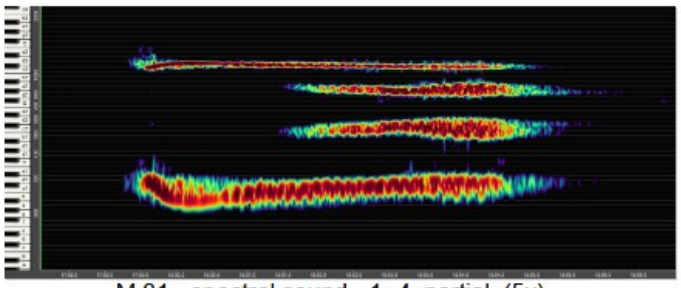
Phase 4 (5:23) moves in several large, intensifying wave movements towards a longer sequence with intense territorial sounds before the song ends with a few motifs.
It begins at motif 73, like the previous phases, with chains of simple motifs in a wide 2-octave position. Up to motif 78, the two voices come together up to a fifth.



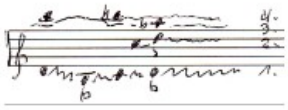


Motifs 79 and 80 are two motifs that follow one another, which are somewhat similar in form but clearly different in sound, M79 very complex in its tone sequences and M80 very simple and clear.

Motif 81 - an impressive 2-voice spectral sound



M 81 - spectral sound - 1.-4. partial (5x)



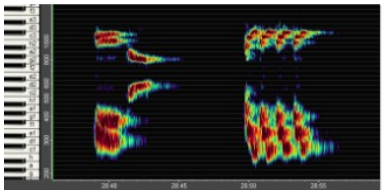
In terms of sound experience, this spectral sound is the spectacular highlight for me.
The combination of the two trills in the upper and lower voice (C#4/C#6) creates a full and colorful sounding spectral sound with C#5 and G#5 as the 2nd and 3rd partials through interacting processes between the octave frequencies in the space of the windpipe.

On page -- there is a detailed description and analysis of this special sound phenomenon.
Here is a short excerpt from the text:

“What happens after this 2-voice intro has something indescribably magical for me every time I hear it, even in the succession of repetitions. It is a sound phenomenon that I have never heard before and that I hear again and again as if for the first time. In the truest sense of the word, it is a sounding phenomenon that appears in my ears as sound. Where does it come from? What is this strange sound? Why does it touch me so much? It is no longer two voices, it becomes a sound that forms and shapes itself from the two voices, a sound shape that is more than the sum of its parts, no longer a two-tone sound, but also not an octave with its inner spectrum of partials.

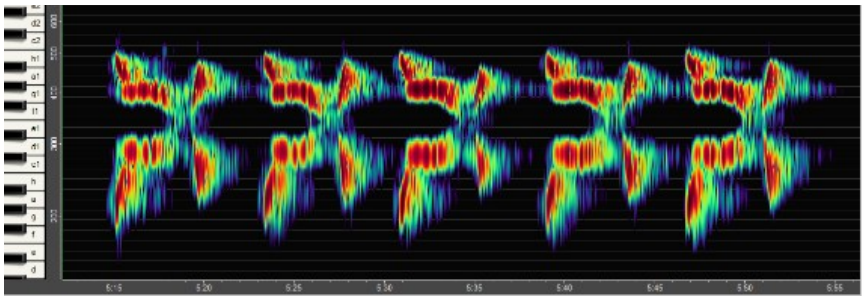
Does this sound phenomenon come from a distance or from a non-localizable interior? Does this gestalt have an aura or does it fill a space?”

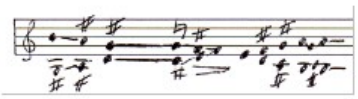
Video "Mockingbird (3.9) - an impressive 2-voice spectral sound" - https://youtu.be/rC3vUtcuW38



Motifs 83 and 84 are followed shortly afterwards by the repetition of motifs 42 and 43, which have already been described above.

Motif 91 - a 2-voice motif in rhythmic and harmonic symmetry

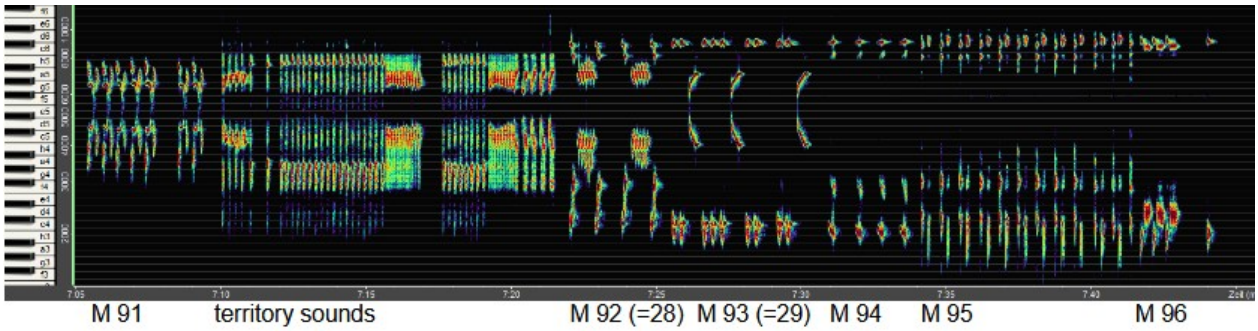




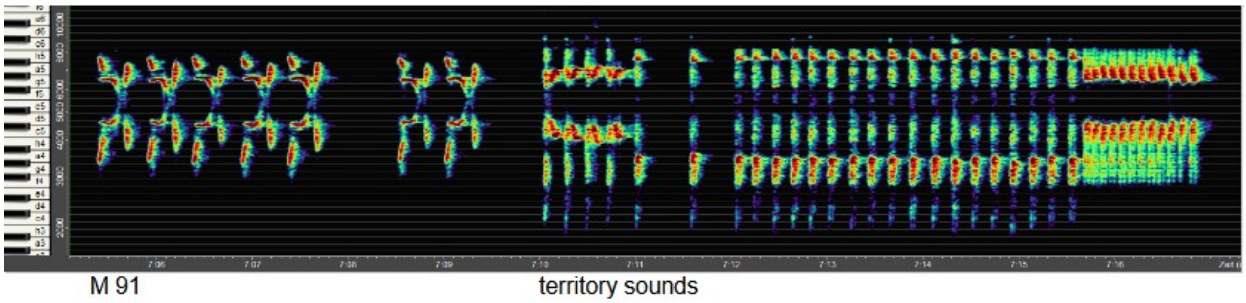
After an intensive trill motif, this completely symmetrical motif 91 is heard, for me the most beautiful sound figure in the entire song of the mockingbird (motif chains: 3 - 5 - 2). Listening to motif 90 and 91 in the original - first 6 short chirping noises and then a chain of high, very fine, short chirping sounds - it is completely unimaginable that such fantastic sound figures are hidden for our ears in this chirping. It is a 2-voice motif, perfectly symmetrical in form, 2 independent voices in the most beautiful coordination and correlation, rhythmically synchronized, tonally in contrapuntal counter-movement with a magical sounding “tritone” (D/G#) in the center.

In the video “Mockingbird 3.8.6” (https://youtu.be/owmWdCs38D8) both voices can be heard separately and together, so that it becomes clear how the two voices with their own figures merge into a symmetrical sound shape.

Territorial sounds and last motifs



Immediately after the well-formed motif 91 and after 7 minutes of vocals in two voices at the highest level, an intense, veritable territorial singing follows immediately and completely surprisingly, lasting a whole 11 seconds.

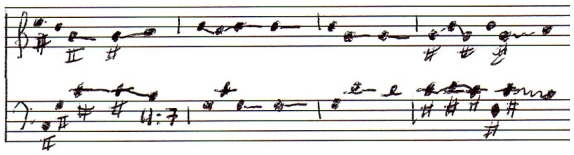


To me it sounded like the “scolding” of a blackbird, not actually a song, but a very rapid series of calls. At first I didn't pay any attention to it. But then, while writing this review, I listened to it in slowdown and looked at it in the spectrogram and was quite amazed that there were also 2-voice sound figures hidden in these noisy calls.

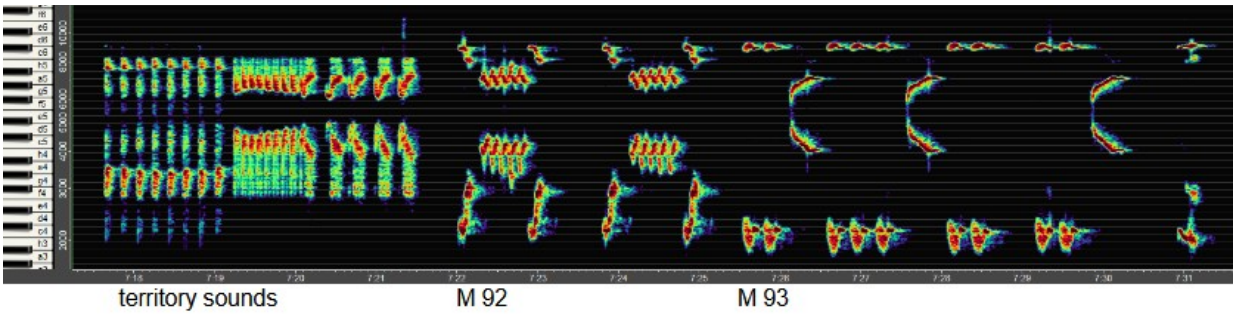
4 motifs from the territorial calls

4 motifs from the territorial calls (8x slowed down)

Through my sound research I know from other songbirds that the calls are usually produced with both membranes of the double syrinx, which sounds noisy to our ears in the original sound position. In reality, however, they are often complex, well-organized spectral sounds as in the zebra finches or even 2-voice intervals as in the crow. In this mockingbird, as in the full song of the motifs, there are also 2 voices in symmetrical sound figures, always in counter-movement, 3 motifs in a close position and proportional interval ratios (B/A = 4:7). It is interesting that the mockingbird immediately switches to the next motif at the end of motifs 1 and 3, but then only sings the entire chain of motifs after a pause.

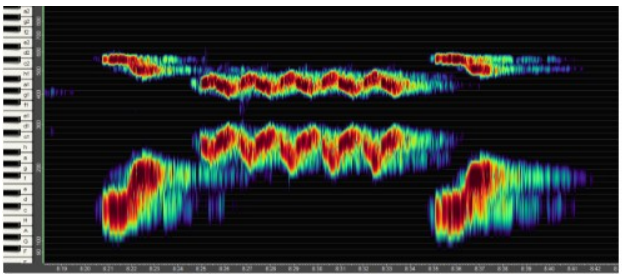


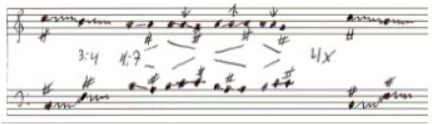
Video: "Mockingbird (3.12) - 4 motifs from territorial calls - 0-2-4-8-16x slowdown
https://youtu.be/2sg1MFOynDE

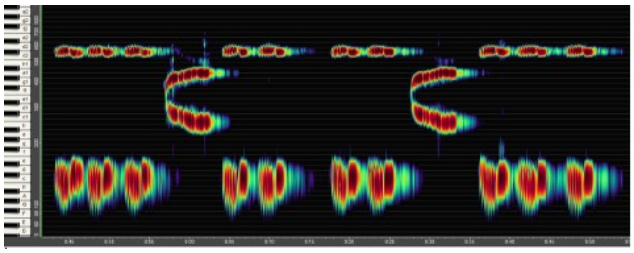


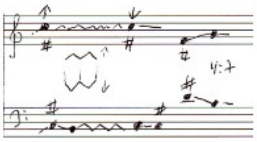
After these territorial calls comes another surprise: the mockingbird repeats motifs 28 and 29 in motifs 92-93, a particularly successful combination of motifs, and motif 28 now even twice; it is one of the most beautiful motifs in terms of gestalt and a special vocal achievement.

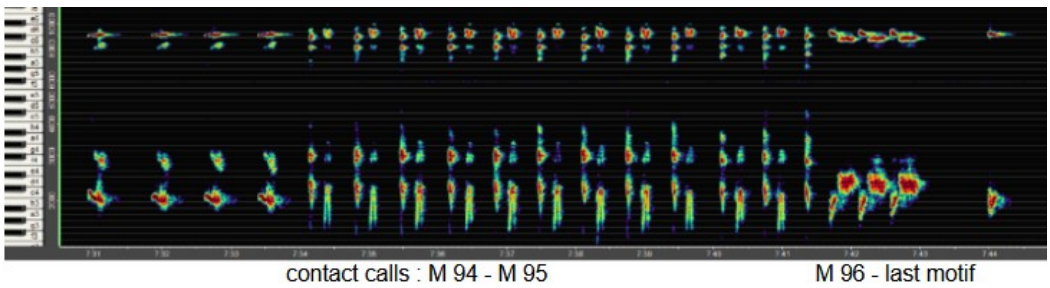
See above for the climax of Phase 1 (p. 6)



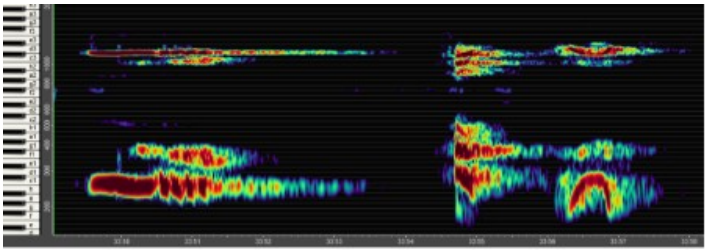


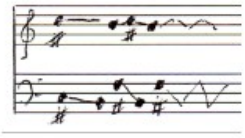


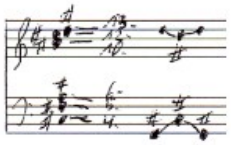




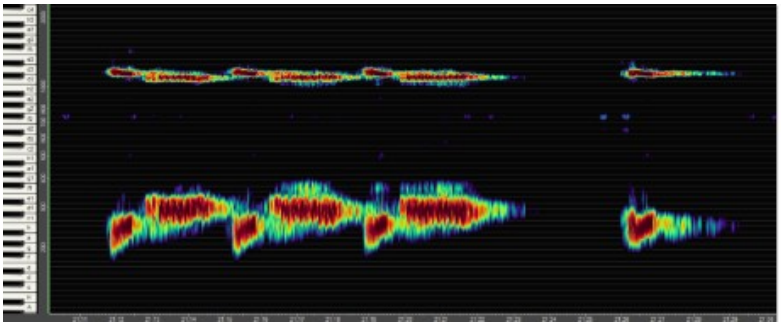
Two chains of motifs then follow towards the end of the song, which sound like contact calls but are actually 2-voice singing as well.
Motif 94 moves from the octave into a contrapuntal trill, a whole-tone trill in the upper voice and a fifth trill in the lower voice. And in motif 95 there is first a 2-voice spectral sound and then an opposing glissando figure. The spectral sound, which sounds like a noise, is made up of 2 spectral ranges of the virtual fundamental C#: lower voice - 4th-5th-6th partial and upper voice 10th-12th-13th partial.

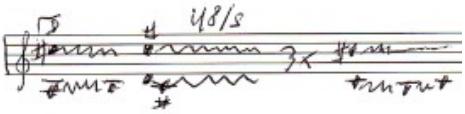






The more than 7-minute song (7:45) ends with an impressive trill motif in a wide position (2 octaves) and the last short sound after a pause of 1 second corresponds exactly to the very first sound from the beginning of the song.





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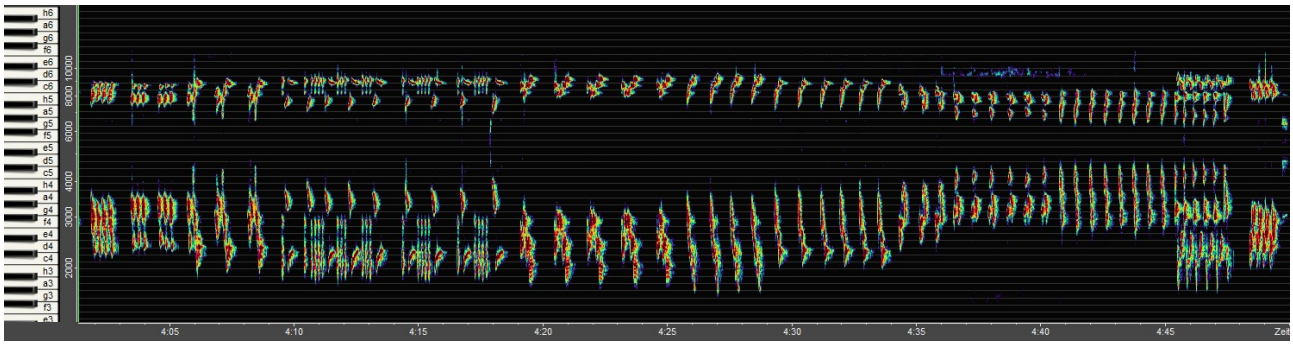
2) Listening to two voices – *one* voice *and* polyphonic 2-voice singing



The spectrogram clearly shows the two-part nature of this song, throughout the entire 7-minute song. But can I actually hear it? I know from many years of research that bird song in the range of 7-9000 Hz can only be perceived very faintly, if at all, both in nature and on recordings (e.g. the contact sounds of female blackbirds at 8000 Hz). And we hear virtually nothing of the real song of a female blackbird (6-10 kHz) during the male song, even if it can be seen in the spectrogram. If I reproduce this song separately in the filter, it is audible and at least as loud as the partials of the male song in this range.
When I applied a minus filter to the upper voice of the mockingbird's 2-voice singing, I couldn't hear any recognizable difference to the overall sound of both voices.

Upper voice solo in the filter
But when I listened to the upper voice separately in the filter, I hardly heard anything of the singing in this high register at 7-9000 Hz, even with good headphones, although the upper voice is only a few Hz quieter than the sounds of the lower voice. My ears, however, received a 7-minute series of short, very fine chirps, airy sounds, sometimes only sensed, sometimes fine acoustic stimuli. But when I amplified the upper voice by 10dB (twice as loud), a fine but intense continuous chirping could be heard through the headphones, as I know it from crickets that “sing” (chirp) at 8000 Hz.

See and listen to video: "Mockingbird song (3.10) - Stimulating the Ears - “Cricket sounds” at 7-9000 Hz" - https://youtu.be/CSLoYXMbI6E

Sometimes I feel the song of the mockingbird at this extremely high pitch for our human ear more as a fine sensation in the ears, as a sensory stimulus, which I sometimes even perceive tactilely on the eardrum like a slight tickle. Sometimes the high and fast vibrations also seem to be a little too strong for the membrane in the headphones (“distortion factor”).

This type of sound has a strong stimulating effect on our hearing, causes intense stimulation of the autonomic nervous system and can enable an energetic “charging” of the brain. (The vagus and facial nerves have branches into the ear canal and to the eardrum). When I listen to the recording through headphones while writing texts, I notice after a while that it becomes brighter in my head, that I become more alert and attentive.
In general and in phases or with certain motifs, the full song of the mockingbird can be very intense. I then not only hear this or that sound figure, perhaps also rapid tone sequences or a lively chirping, but I can really feel how such intense sounds penetrate my auditory canals. They seem to cause turbulence there, as if they are reflecting back and forth on the walls of the auditory canals, and it feels as if they are directly touching and exciting my eardrums. At the same time, I have the impression that I can hear the particularly energetic sounds in the middle of my head between both ears. This arousal of the ear can continue for a while after the recording has finished.
Such auditory experiences can also occur with other songs of the mockingbird, and can be heard particularly intensely in the song of the Tropical Mockingbird: https://youtu.be/OjhJfr5uoT4?si=FbMla1OmlmZFWBeQ
I am also familiar with such auditory “sensations” from my own singing, when very high vibrational energies, the brilliance formants, appear in the sound of my voice. It is therefore reasonable to assume that such an acoustic and auditory arousal also has an effect on the singing mockingbird.

Recommendation: listen to " **Mockingbird song (3.11) - Stimulating the Ears"** - intensive sounds at 3500-4500 Hz and at 1000-2000 Hz - each part of 2-voice singing filtered alone – 2x slowed down
https://youtu.be/iOxsOjpOR_E

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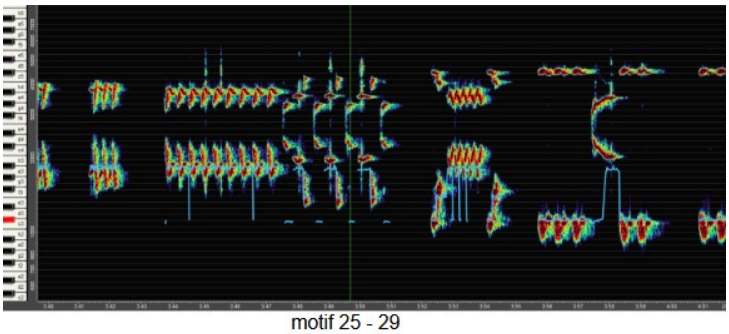
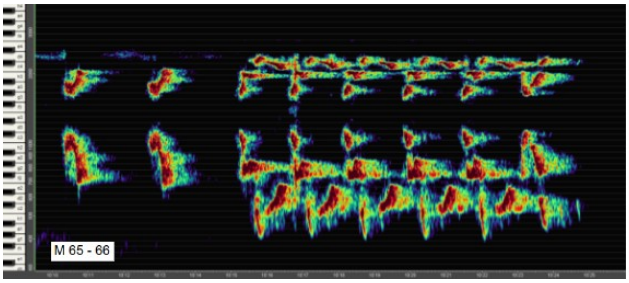
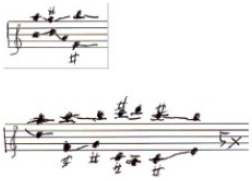
3) Overview of the octaving slowdowns

Listening to the 2-voice singing:
a unified noisy sound → 2 independent voices in one sound with metallic coloring → pure sound in the process of 2 voices sounding together with their own coloring - slight dominance of the bright intense upper voice to the dark soft lower voice → extended deep dimensions in a sounding space, in light-dark spheres of one sound


motif 25 - 29

In the **2x slowdown** (https://youtu.be/JU1WNBJJ51M), 1 octave lower and 1 time octave slower, everything sounds louder, more intense, more excited and, in a strange way, noisier to our ears. The sound often seems somewhat tinny, as if a metal is being struck or as if there is a background noise such as interference in the frequencies. In some motifs, despite the still very high tempo, I can recognize pitch changes, but without being able to define them precisely, or distinguish sound movements and sound figures.

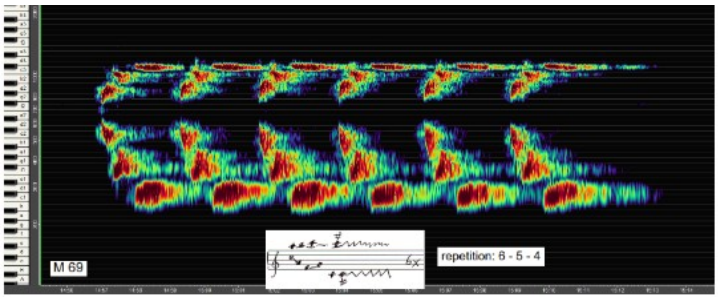


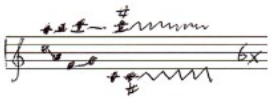


In the **4x slowdown** (~2000 / ~ 550 Hz), distinct and rhythmic sound sequences are clearly recognizable, in which I can already perceive certain sound figures, tone sequences and also intervals. What was already visible in the spectrogram in the higher registers can now also be perceived and differentiated by the ears: It is a song with 2 independent voices that are rhythmically synchronized and coordinated in every motif, in every pitch change, every interval and every glissando in contrapuntal, mirrored counter-movement. As many movements are still relatively fast, the sound has a predominantly metallic coloration.

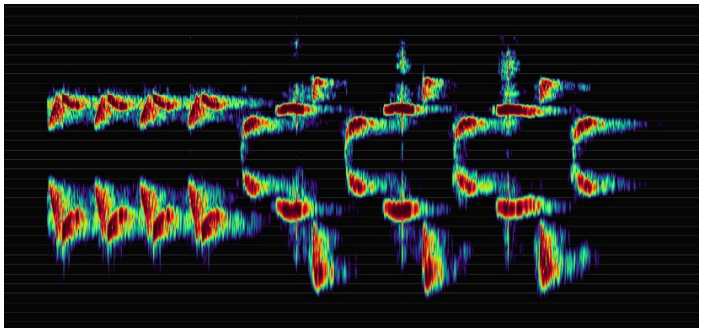
short version - https://youtu.be/cZBvc0i5PUs (17:02) - long version : https://youtu.be/GTQyd0Er4EQ (30:59)

8x slowdown (3 octaves lower - 300 Hz / 1000 Hz)



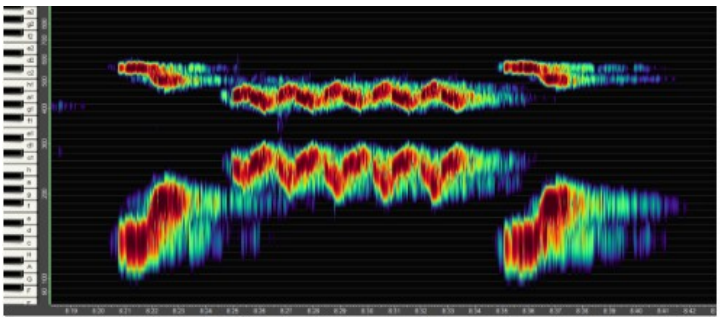


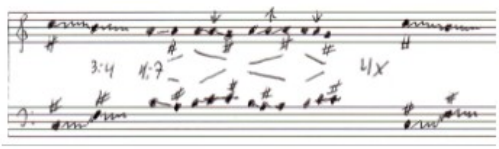
But then there is a tipping point in our acoustic perception with the change of register to **8-fold slowdown** (with notation https://youtu.be/d623E2e92oU). The soundscape changes, as we clearly hear 2-voice singing. Both voices are now in the frequency range familiar to our ears (300-1000 Hz), and the extended tempo allows us to experience the sound process in an even more differentiated way. It is pure sound without any metallic overtones. Each voice has its own coloration, the upper voice slightly dominant in its bright intensity, the lower voice darker and softer. If you listen into the sound, you can perceive the 2-voice singig together as an overall sound as well as focus your listening on one voice at a time or split your intentional attention in such a way that you can grasp both voices in their own way in parallel and follow them in their counter-movement.



see and hear also: https://youtu.be/ZtE6HP5lroc
"Mockingbird song (3.7) - Sound shapes in a 2-voice bird song" - 8x slowed down

16x slowdown (4 octaves lower - 150 Hz / 500 Hz) - https://youtu.be/DffxHG4L45k (36:53)
short version with notation : https://youtu.be/1IeAHjN42e4 (19:11)

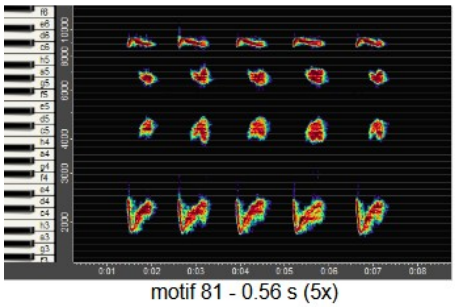


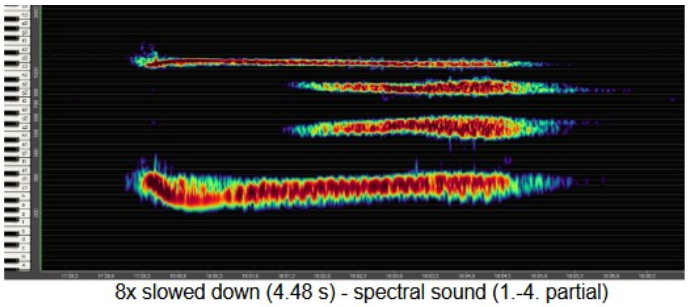


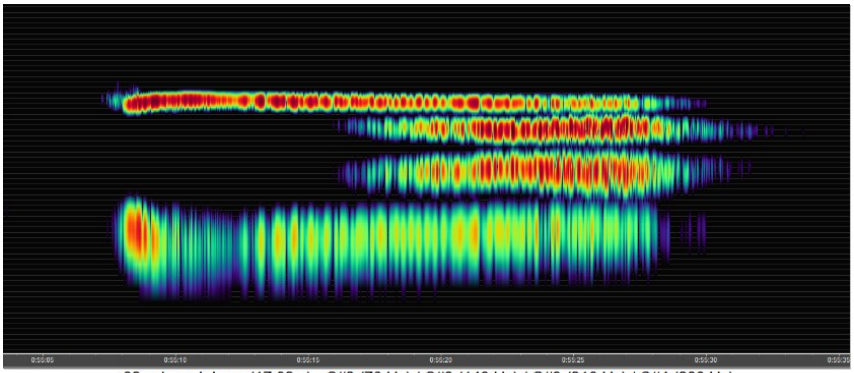
The 16-fold slowdown opens up a truly deep dimension of space and time. The depth of the sound can be heard not only in the frequency spectrum, but also in the depth of a wide echo space (through headphones!) as well as in the depth of a vibrating sound inner space. The overall sound appears as a wide space, a space in which both voices sound together and form one sound; an atmospherically vibrating space between the upper and lower voice; and a very specific space in each voice, in the sound spectrum, the vibrato, the trills, the glissandi and the interval ratios: dense and intense, as if glowing from within in the upper voice – in the lower voice sounds without a center and without boundaries in a widely vibrating echo space, as if a gong were being struck very softly in a large cave, in a wonderfully calm and soothing rhythm – pure vibration, without perceiving the trigger of these atmospheric vibrations.
The upper voice is now in the soprano range (C#5 - 550 Hz) and the lower voice in the bass range (B2/G3 - 125-200 Hz). In this familiar range, the overall sound is relatively homogeneous, despite the difference of up to 2 octaves. Both voices have their own coloration, but neither really dominates. Despite its mostly dense interval sequences (“quarter tones”), the upper voice appears quite concise, while the lower voice can also be heard sufficiently in the soft depths due to the larger intervals.
What is particularly striking in this register, however, is that the two voices do not mix well in any way, as would perhaps be desirable in a duet of soprano and bass (but is not always the case in human singing), but that the intonation of the two voices now miraculously blends and integrates.

The somewhat metallic and irritating accidentals in the higher registers, the somewhat strange-sounding sequences of intervals in connection with “quarter tones” in the upper voice and “triads” - fifths - thirds etc. in the lower voice - all appear integrated and well-ordered.
The interval ratios between the lower and upper voices in this register are always harmonical, i.e. in whole-number proportions of the frequencies: as an octave (1:2), fifth (2:3), fourth (3:4), third (4:5/5:6), sixth (5:8) and also as a well-sounding seventh (5:7) or ninth (4:9).
Sometimes a low fundamental tone even seems to form in the overall sound at the end of a motif. Even opposing trills in the upper and lower voices no longer seem strangely ambivalent and irritating when played together, but instead unfold their very own, stimulating-sounding appeal to the ears.
And if I filter the voices separately in this position, I can not only precisely determine the pitches and sound movements in both voices with the help of the pitch marker, but I also discover the astonishing quality with which each voice is phrased and shaped in a motif (variable vibrato, tenuto sounds, legato or portato, dynamic up and down swelling, arches and much more). All phrasing is performed in parallel and/or in contrary motion in both voices.

(See about this topic the detailed analysis of motif 10 in the text for “Mockingbird 3.8.7” p. 38)


motif 81 - 0.56 s (5x)


8x slowed down (4.48 s) - spectral sound (1.-4. partial)


32x slowed down (17.92 s) - C#2 (70 Hz) / C#3 (140 Hz) / G#3 (210 Hz) / C#4 (280 Hz)

32x slowdown
5 octaves lower (2240 Hz / 8960 Hz → 70 Hz / 280 Hz)
5 time octaves slower (0.56 s → 17.92 s)

"Mockingbird song (3.7.1) - Sound Shapes in Deeper Dimensions of Space and Time - an unusual sound experience - 32x slowed down" (https://youtu.be/4fmobAlXpqw)

The 32-fold slowdown (headphones!) opens up a really deep dimension of space and time. The depth of the sound can be heard not only in the spectrum, but also in the depth of a wide echo space as well as in the depth of a calmly vibrating sound inner space.

These are no longer two voices. Everything that swings and vibrates in infinite calm and moving slowness becomes a sound, a sound that cannot be defined and analyzed in terms of pitch, rhythm, tempo, timbre - polyphony in harmony (in "unison").

Listening becomes sensing and experiencing in an expanded dimension of sound, a process of lively sensation. I am drawn into unfathomable depths and touched by incomprehensible condensations of sound. Do these sound phenomena come from afar or from an interior that cannot be localized? Do these figures have an aura or do they fill a space?
I am taken in and enveloped by light-dark sounding spheres in which I no longer ask myself: what kind of sound is that, is it singing, are unknown instruments being played, where does the sound come from, where am I as the listener?

To hear and experience such a sound event, to immerse myself with both ears in such worlds of sound, is always so overwhelming and fulfilling for me that I have no words to describe it. I am simply gripped by a great sense of wonder and deep awe in the auditory experience of such spheres and dimensions.

1 h sound and listening meditation – the nature of sound in the sound of nature
pure sound shapes in very deep dimensions of space and time

the singing in 32-fold slowdown without motif repetitions and with shortened pauses
Listen to what can be heard : https://youtu.be/-fwseMkKSbw

Volume in the different positions

Both voices are generally about equally loud, although the upper voice is barely audible in the high registers and appears significantly louder to our hearing when slowed down 8 times. One of the reasons for this is that our hearing has different sensitivity thresholds in different frequency ranges. The overall sound is just as loud in all slowdowns as in the original, even if it seems louder to us in the lower registers. For playback, the sounds in the 16- and 32-fold slowdowns are too strong even for loudspeakers and headphones due to the large amplitude. That's why I reduced the volume in the very low registers by 5-15dB in most of the videos (minus 10dB = half the volume).
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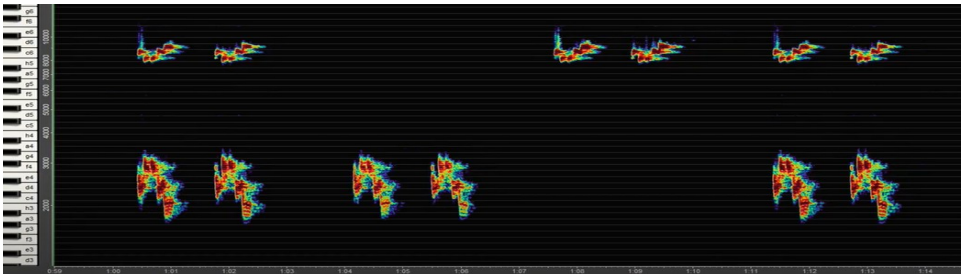
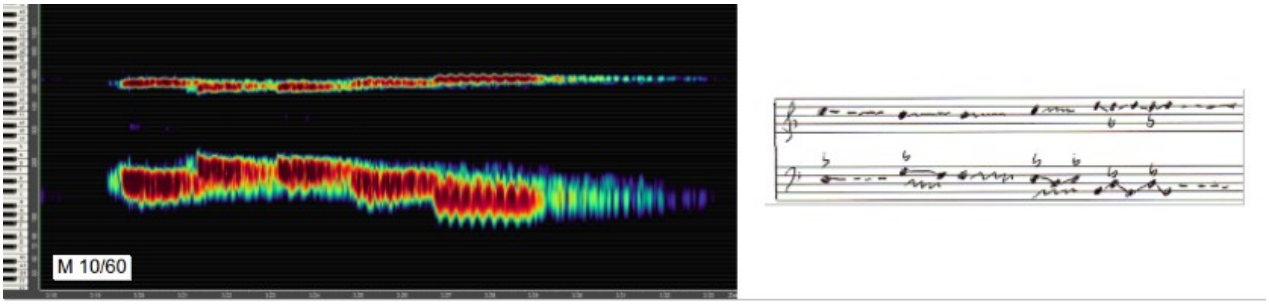
4) Sound explorations in two-part harmony – polyphonic listening

Upper and lower voice in “unison” harmony and as a solo in the filter

Mockingbird song (3.6) - 8 motifs (30-31-38-39-40-60-89-90) - https://youtu.be/GIDOahtZjUw
2 voices in the same rhythm and in counter-movement
both voices in unison and each voice filtered alone
0-2-4-8-16x slowed down (16x with notation)



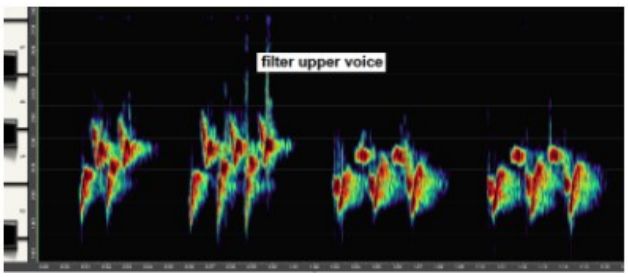


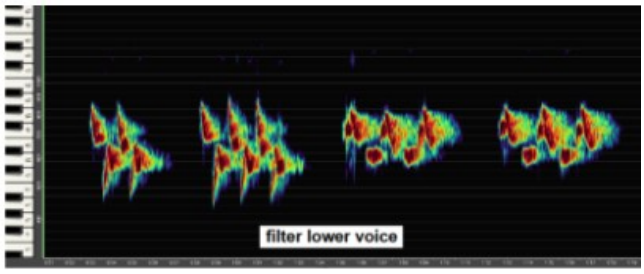
I have selected 8 characteristic motifs from the song of the mockingbird in order to make the high virtuosity of this diverse 2-part song audible and comprehensible. Each motif demonstrates both the seemingly limitless ingenuity of this songbird and its species (without imitations!) and the genuine musical art of rhythmic and harmonic counterpoint. From the original to the 8-fold slowdown, more and more is revealed about what is hidden for our ears in the intense, noisy chirping song with its many repetitions: it is not just pure sound without any metallic overtones, it is not one voice or a unison of two voices, but the “perfectly” coordinated and synchronized sounding together of two independent voices down to the smallest sound movement.
In each motif, each voice has its own characteristic position in the sound spectrum with its own coloration of frequencies and with certain interval ratios. What is a major third in the lower voice is just a semitone (= 500 Hz) in the upper voice (2 octaves higher). Each voice fills its specific sound space, is complete and independent in itself, has its own character in the pitch movements, the intervals, the sound figures, the dynamics, the phrasing, the timbre etc. And at the same time, both voices move completely parallel to each other. And at the same time, both voices move completely parallel and in correlation to each other, but in *contrapuntal counter-movement*.

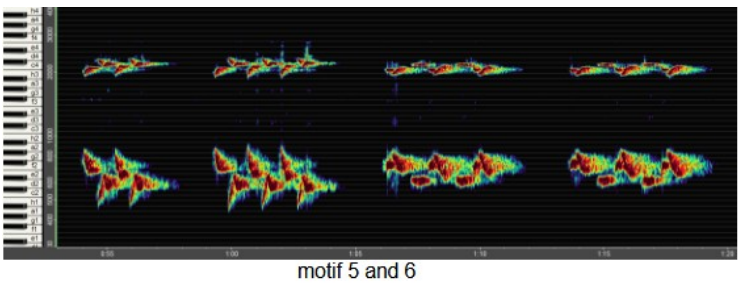
The video offers the opportunity to explore further and deeper in each position how the two voices seem to sound together as “Uno-Suono”, how each voice sounds on its own and how the two voices can be heard when they sound together. If you listen into the sound, you can perceive the two voices sounding together as an overall sound as well as focus your listening on one voice at a time or split your intentional attention in such a way that you can grasp both voices in their individuality in parallel and follow them in their counter-movement. Looking at the spectrogram of course facilitates receptive and active intentional listening – a good training for the ears - for polyphonic listening!
At the end of the video, all 8 motifs can be heard in 2 voices with notation in the 16-fold slowdown.

In the following two videos with the complete song of the mockingbird separately in both voices (slowed down 4 and 8 times) it becomes even clearer how the upper voice and lower voice each represent and perform an independent, self-contained, complete singing voice.

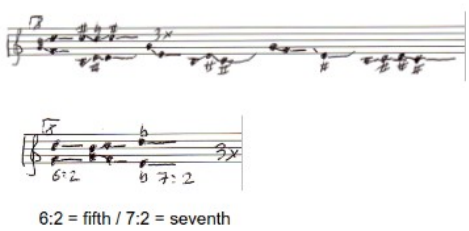
Mockingbird 3.6.1 – each voice filtered alone - 4x slowed down - https://youtu.be/4cogUjB66kg



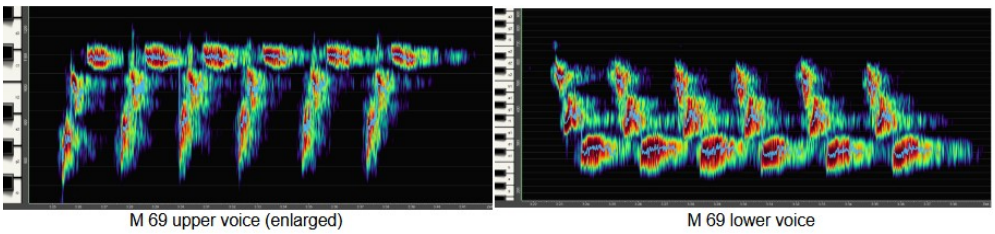




motif 5 and 6

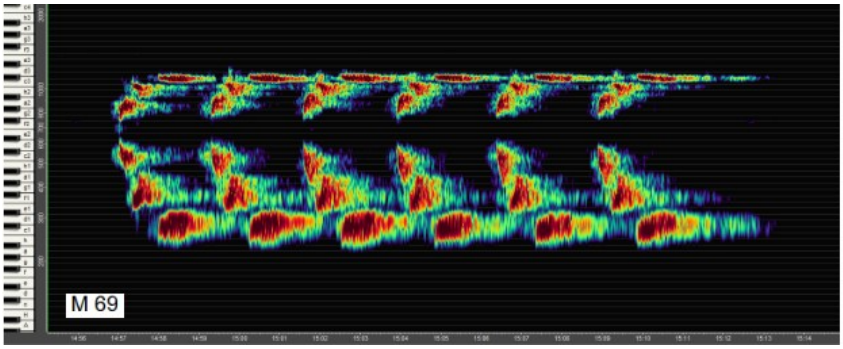


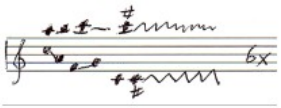
Mockingbird 3.6.2 – each voice filtered alone - 8x slowed down - https://youtu.be/eadW21Caf-s



M 69 upper voice (enlarged)

M 69 lower voice





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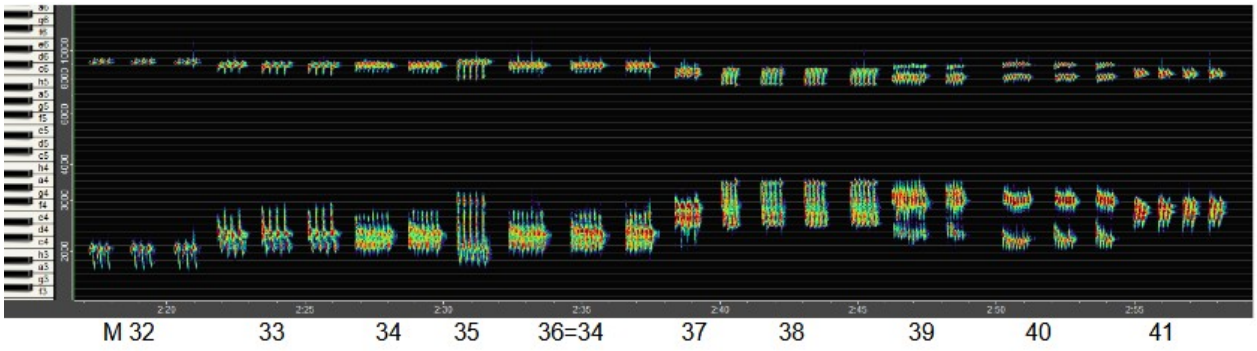
5) Listening experiences in different dimensions of time and space

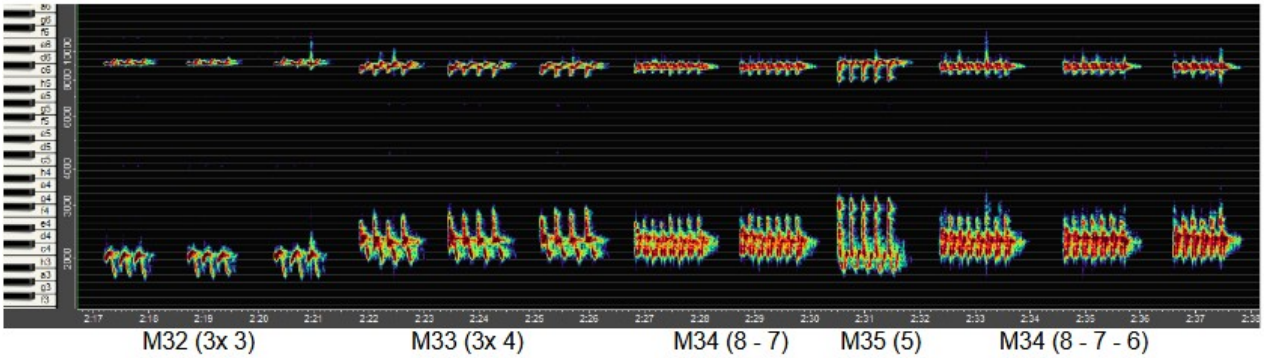
several motifs in a row and/or individually slowed down 0-2-4-8-16x and transposed back
to the original position (8-4-2-0x) - at the end, direct comparison of 8-fold slowdown and original

Mockingbird 3.8.1 - 9 motifs in a row (M 32-41)
with multiple repetition of motif chains - https://youtu.be/yp2u_6pLpMQ

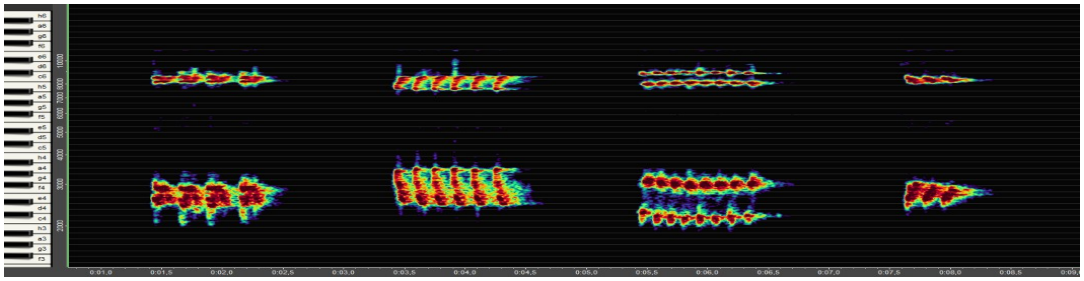
M32 (3 chains of 3 motifs) - M33 (3x 4) - M34 (repetitions: 8 - 7) - M35 (5) - M36 = M34 (8 - 7 - 6) - M37 (4) - M38 (4 - 5 - 5 - 6) - M39 (9 - 5) - M40 (8 - 6 - 5) - M41 (4x 3)



Mockingbird 3.8.2 - 4 motifs in a row (M 32-35) - https://youtu.be/WCK6t0-E0HQ

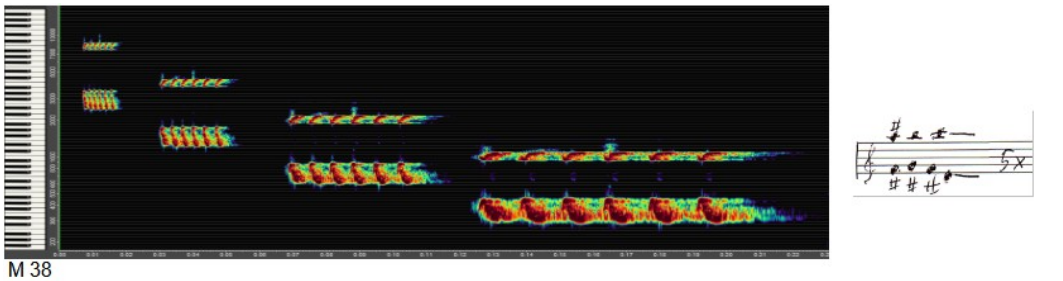


Mockingbird 3.8.3 - 4 motifs (37-38-39-41)
in a row and individually slowed down - https://youtu.be/ZRm_EPTXNeE

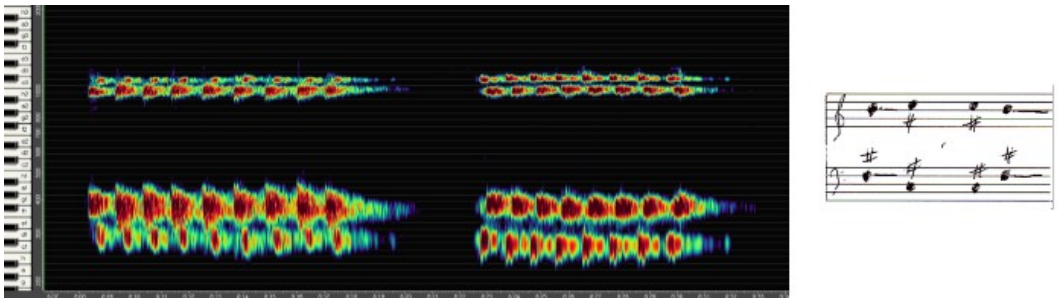


Mockingbird 3.8.4 - motif 37-38-39 individually slowed down - https://youtu.be/e6FjuikbfhE

Mockingbird song (3.8.5) - 2 motifs in rhythmic and harmonic counterpoint
motif 39-40 - 0-2-4-8-16-32x slowed down - https://youtu.be/vgBr8gk9wbk

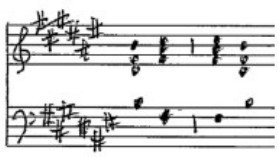


M 38



I have used these two motifs, which are relatively simple compared to many others, as examples to describe the effect singing has on hearing in different registers. And I have analyzed what the actual sound is in these chirping sounds and what kind of singing and musical quality this very special 2-part singing has. (p. 34)

Excerpt:
"This results in a very special sound phenomenon, a so-called fourth sound consisting of two layered fourths C#/F#/B. In part 2 of the video, this fourth sound can be heard in the 8-fold slowdown in the filter (C#4/F#4/B5).



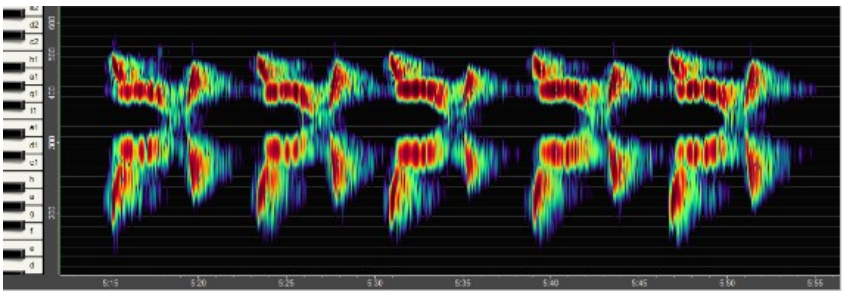
This diversely structured sound spectrum creates the impression in the 16- and 32-fold slowdown that two harmonic spaces are altering with each other with the characteristic fourth movement in the bass:
in M39 B major→F sharp major (b→c# in the upper voice and b→f# in the “bass” / in M40 F sharp major→B major (c#→b in the upper voice and f#→b in the “bass”).

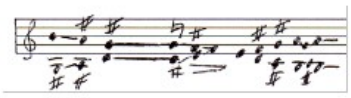
I can play this harmony sequence simultaneously on the piano to the sound of M39 and M40.

What fascinating sounds emerge from the chirping of the mockingbird in the deeper and expanded dimensions of space and time!"

Mockingbird song (3.8.6) - a 2-voice motif in rhythmic and harmonic symmetry
motif 91 - 0-32x slowdown - https://youtu.be/owmWdCs38D8

"2 voices in the most beautiful symmetry and correlation, rhythmically synchronized, tonally in contrapuntal counter-movement and with an intervallic sound in the center from which a strange sound magic emanates. There are two voices in unison, like one sound and a sound with its own timbre, neither a fifth nor a fourth.

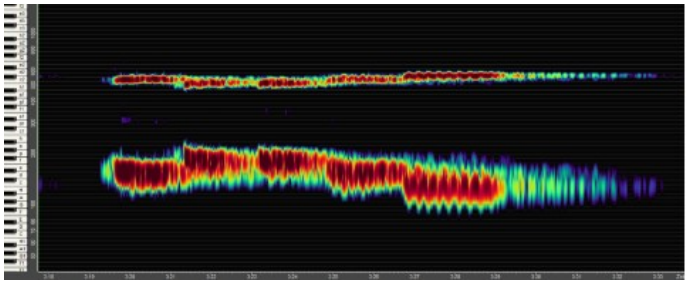


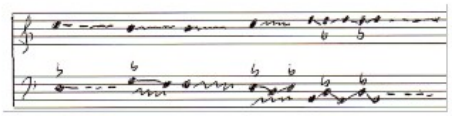


Motif 91 is one of the very few motifs in which the two voices are very close together, even move towards each other, come even closer together in a duple tone and then slide apart again in an impulse." (see the whole text p. 36)

Mockingbird song (3.8.7) - a 2-voice trill motif in counter-movement
motif 10 = motif 60 - https://youtu.be/VvOKl0fV_8I

From a metallic noise sound, a harmonically integrated two-part singing unfolds -
from an energetic acoustic stimulus pattern down and into a deep, wide sound space.

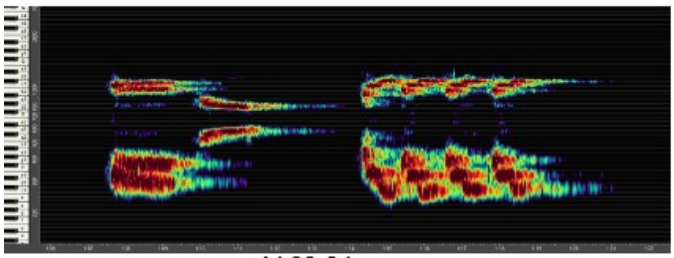




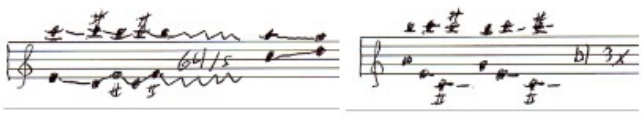
"And then in the **8-fold slowdown** (1000/300 Hz), the sound process is transformed, as a 2-voice singing is clearly heard, in which the upper voice is now the dominant voice, clearly audible as a distinctive “semitone” movement. These are vibrating sounds with a timbre as if they were being played on a flute. The lower voice with its soft, dark sounds forms a beautiful contrast to this. However, the B major triad in the lower part is no longer clearly recognizable. The intonation of the two voices together seems strange to our ears, but also very attractive and interesting. The singing cannot simply be taken in as information. This is particularly true of the trills in the last interval.

The echo sound of the triad tones can be seen very clearly in the spectrogram. The trill B-C#-B is still accompanied by the third D#, which naturally increases the intensity and color of the sound." (see text p. 38)

Mockingbird song (3.8.8) - a 2-voice D-major-7# trill and an A-major-7 sound
motif 42-43 = motif 83-84 - https://youtu.be/X3-aUjtHsbk



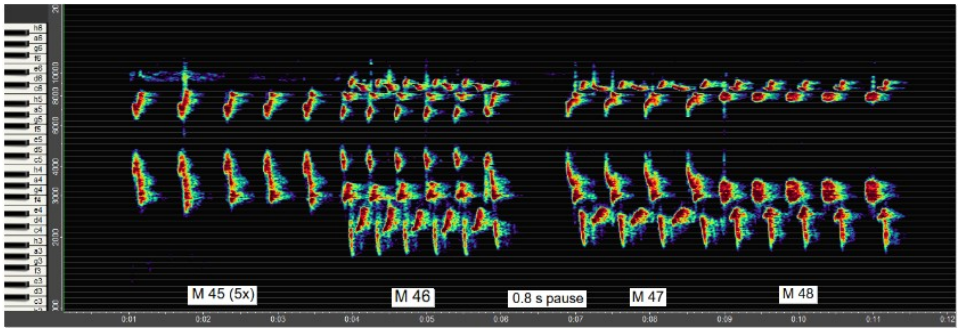
M 83-84



Motif 42, a spectacular motif that “sounds” like an intense rubbing noise in the original and which turns out to be a highly complex sound structure in the 8-fold slowdown. It is a third trill (D-F#-D) in the lower voice and a whole-tone trill (C#-B-C#) in the upper voice, both trills with 64 pulses per second in counter-movement, both trills very loud and in violent vital (!) movement, then, into the echo of the trills, followed by a rather soft and supple-sounding glissando from the sixth C/A into the fourth D/G, and this 7 times in exact repetition

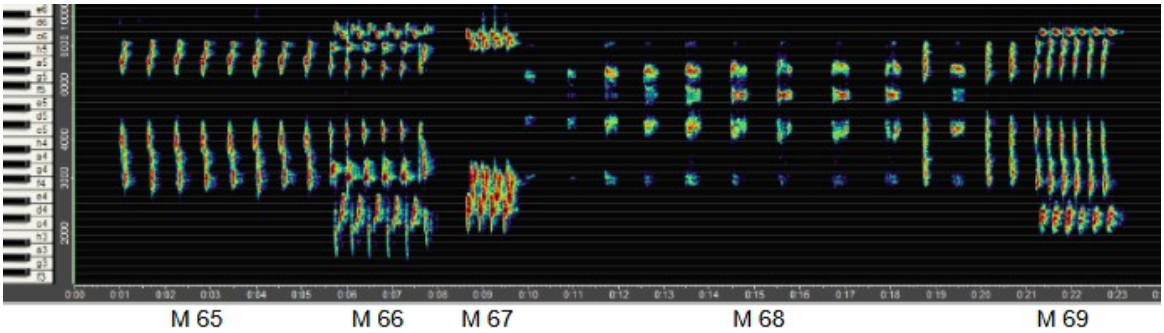
Motif 43: In the 8-fold slowdown, a semitone sequence can clearly be heard in the upper voice and a triadic break in the lower voice, which ends in the octave to the upper voice. Rhythmically, the sixth E/C is emphasized, followed by the octave C#/C#. The whole figure can be heard as an A major seventh chord, with the diminished triad G-E-C# clearly audible in the slowdown in the lower voice.
(Analysis of both motifs above in the text p. 9)

Mockingbird song (3.8.9) - rhythmic and tonal variation of a motif (M 46/47)
motif 45-48 - https://youtu.be/9nQt1-6dn2k



Motif 46 is not completed in the 5th repeat, it ends in an open phrase, the bird makes a long pause and then begins again with the same sound figure, but in a varied rhythm and slight changes in the intonation. The 4th repetition is also not fully executed, instead motif 48 follows immediately, an intensely sounding 5-fold trill figure followed by the same wide interval (H6/D9) as in motif 46, but now not via a diverging glissando, but in a clear sequence of intervals, from the seventh into the decimal. The trill in motif 48 is a whole-tone trill (G#-F#-G#) in the lower voice and a fine half-tone trill (A#-B-A#) in the upper voice. Both trills move in contrary motion as usual.
In the harmony of the trills and with the high D at the end, the motif sounds like a G major triad.
(Excerpt from analysis above in the text p. 44)

Mockingbird song (3.8.10) - 5 motifs in a row -
a dynamic development into a C# major sound (M 65-69) https://youtu.be/mGszZBkHsYU



In this video I have combined motif 66 and 69 directly with each other, so that you can see impressively how motif 66 has an open ending just like M46 (C#/G# → F#/B → octave C#/C# → decimal B/D) and how motif 69 ends from the fifth C#/G# through C#-7 (E#/C) in a radiant C# major sound (C#-C#7-C#-major).
(See text in the overview on p. 11)

Mockingbird song (3.8.11) - iridescent modulations in a sequence of 4 motifs
motif 69-72 - 0-32x slowdown - https://youtu.be/KSS0cwSpduw

the sonorous high point at the end of phase 3

Motif 69 - C#-C#7-C# major / Motif 70 - chromatic tone sequences → C#-7 / Motif 71 - modulation Db → F7 → b flat minor / Motif 72 - 2-part trill (A major/a minor)

see analysis of all 4 motifs in the overview p. 12
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6) Auditory pattern formation and pattern recognition
a later interesting listening experience with motif 10

In my overall analysis of the 2-part song of this mockingbird and also in the individual analysis of particularly interesting motifs, I had not paid any attention to motif 10/60, although it certainly appealed to my sense of sound. After I had completed the research work on 3 songs of the mockingbird ("Mockingbird song 1 - 2 - 3") and all the videos were finished, I listened to other videos of the mockingbird's song on YouTube, simply out of curiosity to see if there was anything else interesting or if there were perhaps other mockingbirds that sing in two voices.
I discovered videos from Central and South America with songs of the "sinsonte" (Spanish name for mockingbird). I came across the video "Sonidos de Colombia", songs from Colombia with a parrot in the title picture. When I first listened to it, I thought it sounded a bit like a mockingbird. And then suddenly, at 1:19 min, my ears reacted surprisingly to a certain sound, without discovering or even recognizing anything in particular. I let the video run back and when I listened to it again, it seemed somehow familiar to me, with this particular stimulus in my ears and the minimal hint of a tone sequence. In the rest of the recording (duration 4:39) I didn't notice anything special.

In the spectrogram on the overtone analyzer I then saw and heard that it was a 2-part singing, and in the slowing down I also recognized motif 10 from "Mockingbird 3". So should there be another mockingbird that also sings in two voices and has the same motifs in its repertoire?
But then, on closer analysis, it turned out that the author of this video had combined a 2-minute excerpt from the 7-minute song from "Mockingbird 3" with other songs.

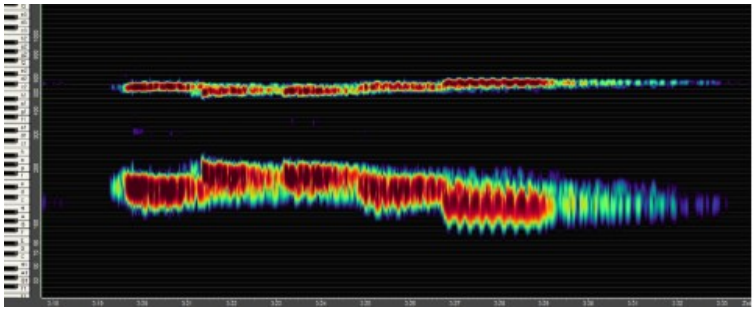
Conclusion:
After I had studied the song of the mockingbird for weeks, had thoroughly analyzed hundreds of motifs in the slowdown, so my memory was overflowing with a wide variety of impressions, my hearing reacted spontaneously and immediately to a certain, specific, noisy vibration pattern, below the conscious threshold of perception. It was a spatially and temporally coordinated spectrum pattern, an acoustic sound gestalt, which had obviously activated and reactivated a corresponding pattern in the brain (subcortical) with its high energetic charge.

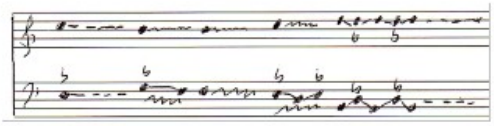
It was not a diffuse pure noise, but a real sound or a sound process, rhythmically and spectrally ordered and structured, which only seemed noisy to our perceptive faculty and which we therefore could not classify and define.
It was a very specific pattern, namely two voices in a wide register (2 octaves), which in this kind of harmony in this high position (8000/2000 Hz) trigger a special sensory and acoustic stimulus and stimulate the nervous system.
And it was a very specific pattern to which my hearing reacted immediately, almost reflexively, without any distinguishing and sorting consciousness, namely precisely this singing of two voices, each voice with its own sequence of notes, coordinated with each other in the interval proportions, coordinated with each other in counter-movement, through phrasing and through the trills in a certain dynamic of movement.
It is exactly the same oscillation pattern that we can recognize somewhat more clearly and differentiatedly in deeper spectral ranges and in extended time dimensions with our familiar categories of perception and that we can name and define with the terms we have learned.
At the same time, it is all the more impressive that these concepts and names can only vaguely grasp the virtuosity and quality of this birdsong, just as little as the spectral order of the sounds and the interacting dynamic forces in the sound process.

So with what accuracy and at what level of complexity does the unconscious auditory and acoustic pattern formation and pattern recognition function in our brain ?! - Fascinating !

7) The most beautiful sound shapes – 16 sound images with notation

motif 10 = motif 60



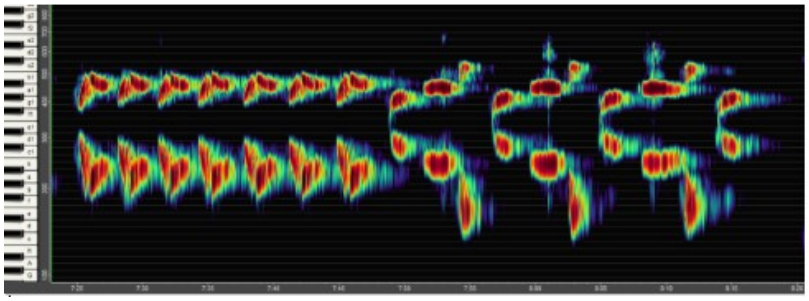


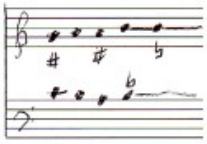
Mockingbird song (3.8.7) - a 2-voice trill motif in counter-movement
https://youtu.be/VvOKl0fV_8I

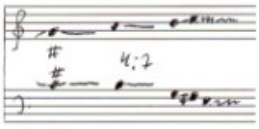
A harmonically integrated 2-voice singing unfolds from a metallic noise sound - from an energetic acoustic stimulus pattern downwards and into a deep, wide sound space

detailed text in the appendix (p. 38)

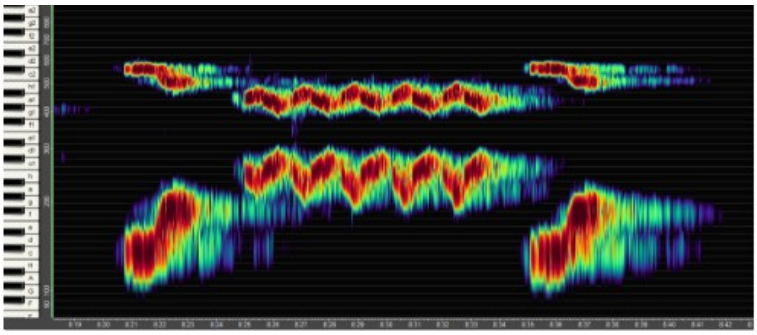
motif 26-27

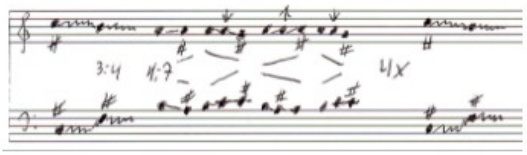




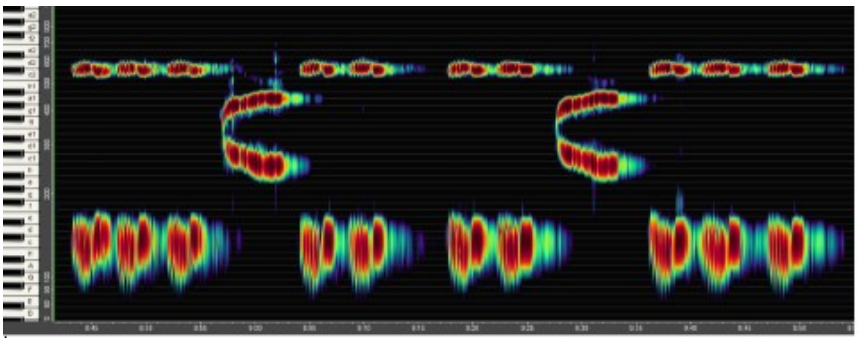


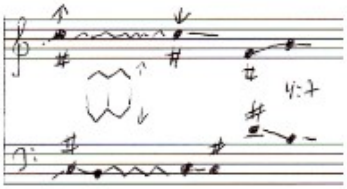
motif 28 = motif 92 (2x)





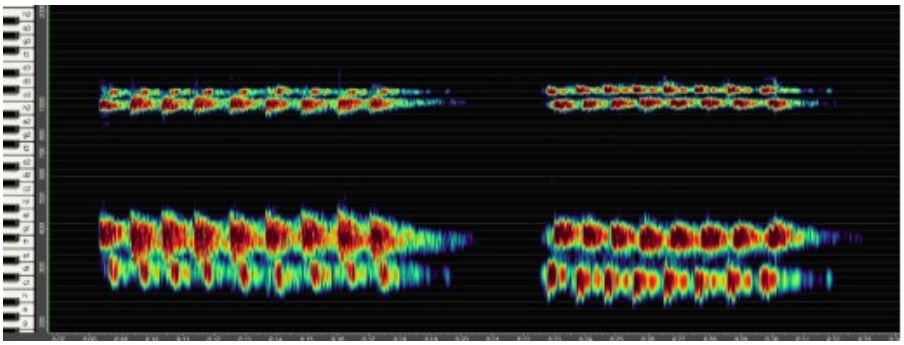
motif 29 = motif 93

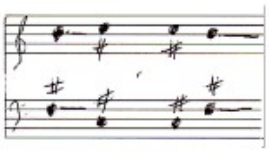




motif 26-29 see overview p. 6

motif 39-40

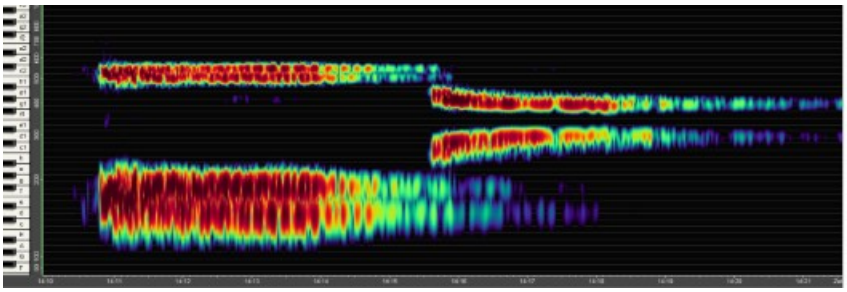


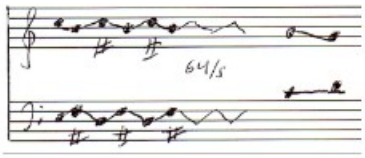


Mockingbird song (3.8.5) - 2 motifs in rhythmic and harmonic counterpoint
a listening experience in different dimensions of space and time

text in the appendix p. 34 https://youtu.be/vgBr8gk9wbk

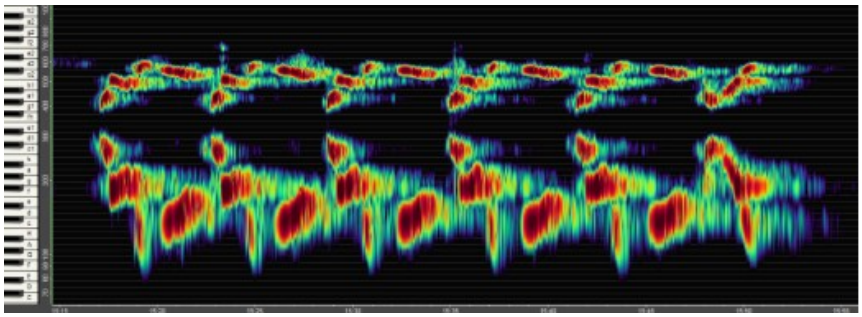
motif 42 = motif 83

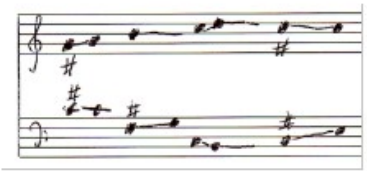




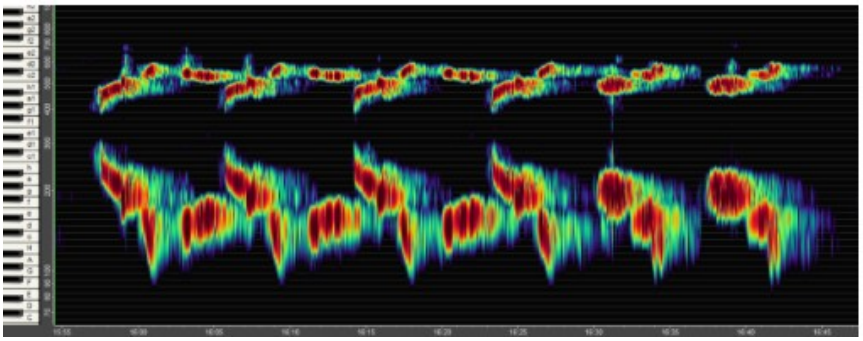
Video zu Motiv 42-43: "Mockingbird (3.8.8) - a 2-voice D-major-7$^{\#}$ trill and an A-major-7 sound"
https://youtu.be/X3-aUjtHsbk - see overview p. 9

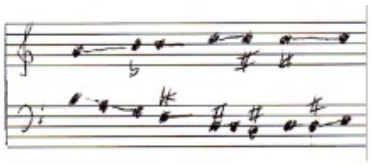
motif 46 = motif 66

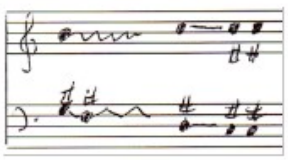




motif 47-48

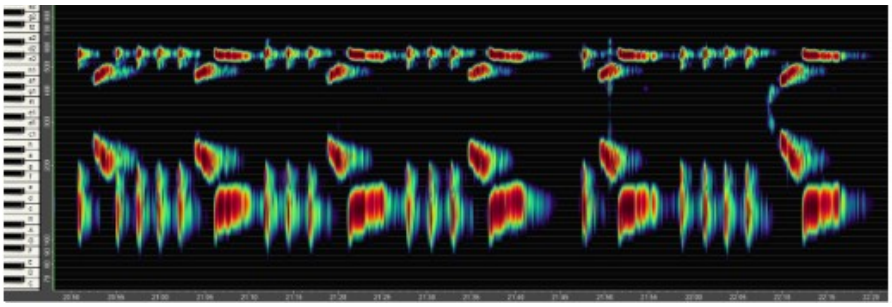


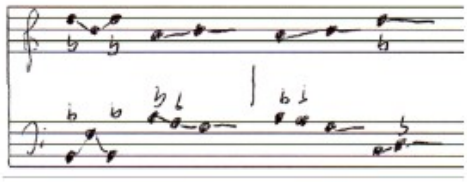




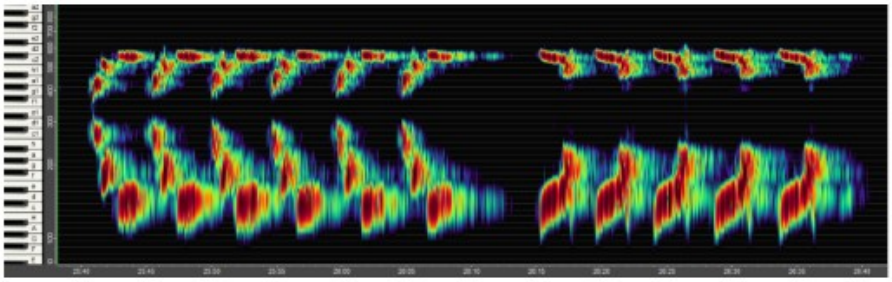
motif 45-48 see overview p. 9

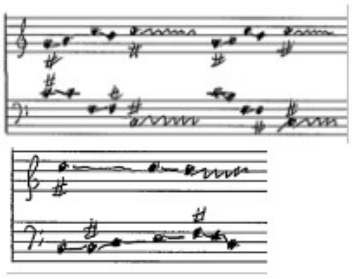
motif 59



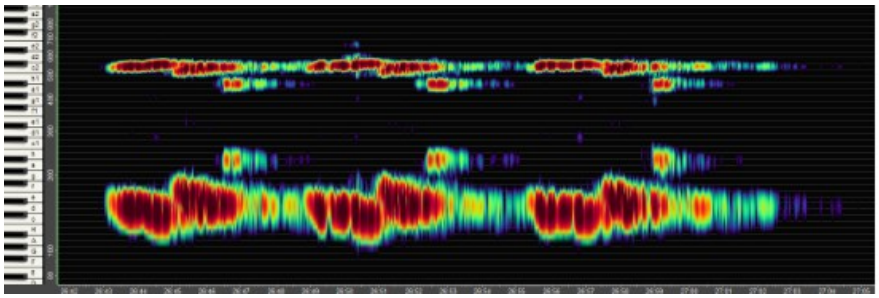


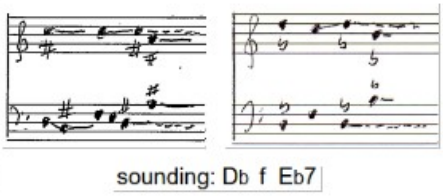
motif 69-70





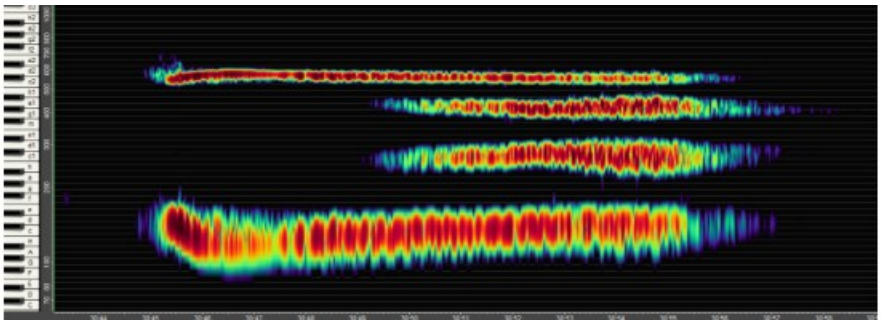
motif 71

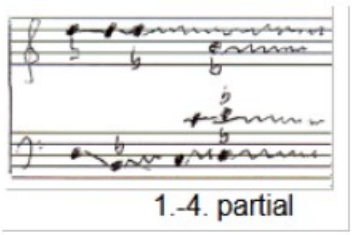




Motif 69-72 - iridescent modulations in a sequence of 4 motifs
video: "Mockingbird (3.8.11) - https://youtu.be/KSS0cwSpduw - see overview p. 12

motif 81

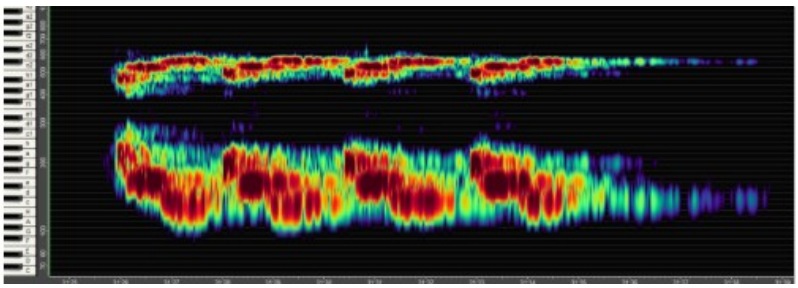


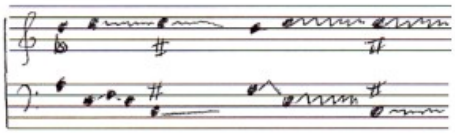


Mockingbird song (3.9) - an impressive 2-voice spectral sound
A full-sounding vibrating spectral-sound unfolds from a whirring noise-sound - a sounding emergence phenomenon! - https://youtu.be/rC3vUtcuW38

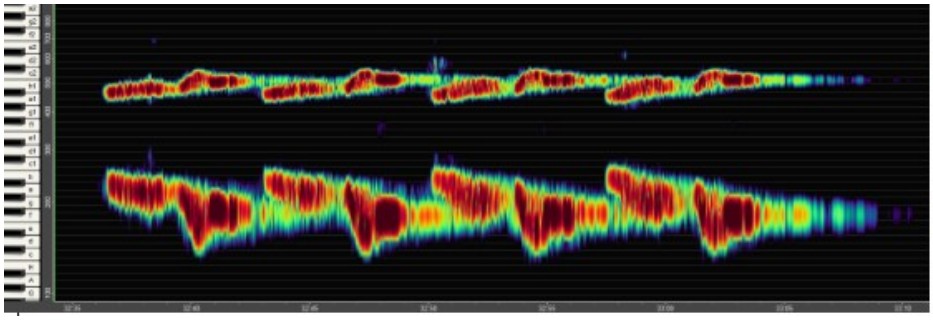
text in the appendix p. 44

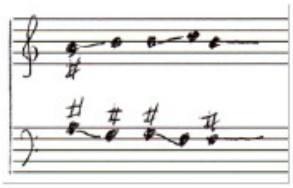
motif 84



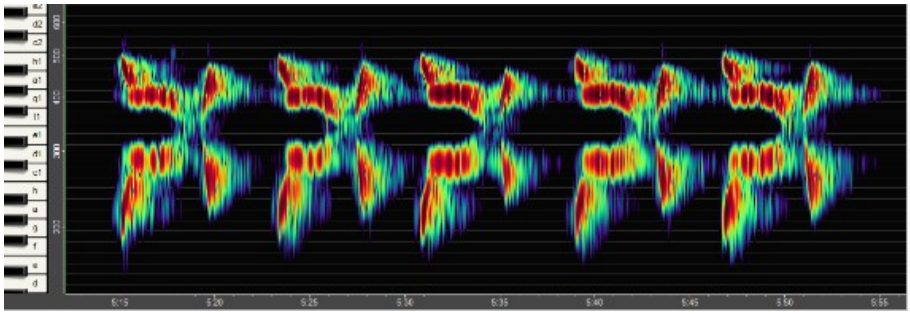


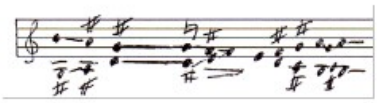
motif 89





motif 91





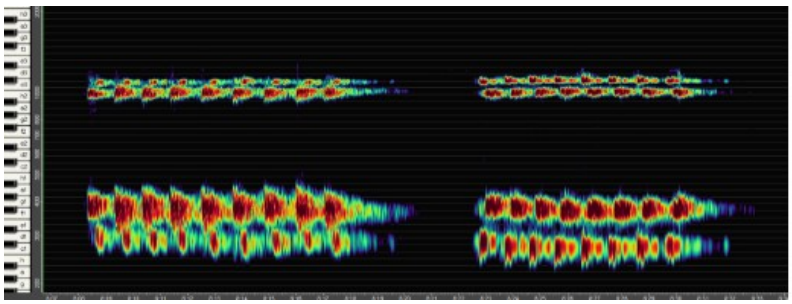
video "Mockingbird 3.8.6" (https://youtu.be/owmWdCs38D8)
see appendix p. 36

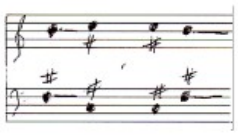
next page appendix

Mockingbird song (3.8.5) - 2 motifs in rhythmic and harmonic counterpoint

a listening experience in various dimensions of space and time

motif 39/40 - 0-2-4-8-16x slowed down – video: https://youtu.be/vgBr8gk9wbk





2 motifs from the 7-minute 2-voice song of a mockingbird - see the video:
"Mockingbird song (3.4) - a very special 2-voice singing - all 96 motifs with notation 8x slowed down" - video: https://youtu.be/d623E2e92oU

I would like to use these two motifs, which are relatively simple compared to many others, as examples to describe the effect the singing has on hearing in the different registers. And I would like to analyze what the actual sound is in these chirping sounds and what kind of vocal and musical quality this very special 2-voice singing has.

If you listen to the two motifs in their original position in connection with motif 38 and motif 40, you cannot recognize that they are different motifs. One motif sounds a little noisier, another a little brighter, in fact you only hear repetitions of short, intense sounds. If I only hear the chain of M39 and M40, M39 seems a little brighter and M40 a little louder in sound. These are sounds that can be heard from many birds.

As in the entire 2-voice original song, it makes no difference to the auditory impression of these two motifs whether I hear the entire sound or just the lower voice. And although the lower voice is in the range of 2-3000 Hz, you can't recognize any tones or tone sequences like you can with the blackbird when it sings its melodies in this range. It sounds more like chirping, which is usually heard at 4-5000 Hz in other birds.

2x slowed down: Now it sounds much more differentiated. You can hear a rhythm in the motif chains, so instead of a chain of 9 sounds, there is a 2-note rhythm in each sound. The sound seems a little tinny, as if a metal is being struck or as if there is a background noise. However, if I only listen to the lower voice in the filter, I hear an intense, clear and rhythmic sound sequence in which I can almost perceive an interval. The upper voice in the filter still sounds like a series of 9 bright sounds.

Then, however, an octave lower and an octave slower (600/2000 Hz): A rhythmically concise sequence of fourth intervals is clearly audible, in M 39 as 4-1 / long-short and in M 40 as 1-4 / short-long. The sound of the interval is so clear that I can sing it spontaneously in my own register. The same applies if I only hear the upper voice: a rhythmically equally clear interval in the same rhythmic proportion, which I can also sing or whistle directly. It is a whole tone, but in rhythmic mirroring, in M39 it is 1-2 parallel to 4-1 and in M40 it is 2-1 to 1-4, so in both motifs there is a counter-movement in the two voices (what is musically called a counterpoint) and in both motifs there is a contrapuntal mirroring in the rhythm: in M39 long-short / in M40 short-long.
On the Over-tone-Analyzer I can check the pitches of the intervals with the keyboard or have them displayed by the pitch marker: In the lower voice it is F# and C#, in the upper voice B and C#. In the overall sound, the fourth movement dominates in this register with the F# as the loudest sound.

One register lower, in the 8-fold slowdown (300/1000 Hz), the sound is again clearly transformed: it is pure sound without any metallic connotation, only now it is not primarily the fourth that can be heard, but the whole tone B5-C#6 or C#6-B5 in a very bright and intense sound coloration. However, if I listen more closely to the sound and keep an eye on the spectrogram, I can also hear

the contrapuntal counter-movement in the lower voice with its darker and softer timbre, without the fourth movement being directly recognizable.

What is already hinted at in the 8-fold slowdown becomes quite obvious in the 16-fold slowdown: Our ears react not only or not primarily to this or that interval or a particular sound figure, but above all to the elementary stimulus that these sound events trigger in the cochlea and brainstem. The chains of rhythmic sound impulses, the fourths, the fifths, the whole tone, the octaves, the "da---dam" and the "dam-da---", all of these resonate in one another and in succession, the pulsating sounds continue to resonate in a wide echo space and cause a deep, active and at the same time calmly continuous basic excitation in the perception of sound, not only acoustically, but also vegetatively via the vagus nerve.

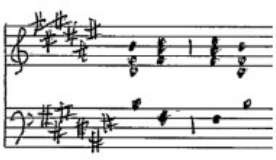
In the chain of M39, the pause between the motifs lasts just as long as the sound pulses. You can listen to this echo space very well through headphones.
Incidentally, the 16-fold slowdown is the frequency and temporal extension that most closely corresponds to our ability to perceive sounds and tone sequences. The responsiveness, perceptiveness and apperception of songbirds is therefore in the 4 octaves higher frequency range and is 16 times faster than our corresponding possibilities and abilities.
(1 second = 16 seconds)

Sound structure and harmonic counterpoint

In the 8-fold slowdown in M39, the whole tone B5-C#6 is heard in the upper voice parallel to the fourth F#4-C#4 in the lower voice, i.e. in the overall sound a movement from the fourth F#/B into the octave of C#. In M40 this is the whole tone C#6-B5 in the counter-movement to the fourth C#4-F#4.
Both intervals, fourth (F#4/B5) and octave (C#4/C#6) lie in a wide range with an octave's distance between the two voices, as in a bass and a soprano voice, opening up a wide space in which both voices can develop their own sound as well as correspond and complement each other, in the tone sequence (F#4→C#4) and in the harmony of the echo as an interval (C#/F#). In this way, 5 intervals with their spectrum can be heard in an extended sound and echo space:

whole tone B5/C#6 (8:9) - fourth F4/C#4 (4:3) - fourth F#4/B5 (3:8) - octaves C#4/C#6 (1:4) - fifth F#4/C#6 (2:6)

This results in a very special sound phenomenon, a so-called fourth sound consisting of two layered fourths C#/F#/B. In part 2 of the video, this fourth sound can be heard in the 8-fold slowdown in the filter (C#4/F#4/B5).



This diversely structured sound spectrum creates the impression in the 16- and 32-fold slowdown that two harmonic spaces are altering with each other with the characteristic fourth movement in the bass:
in M39 B major→F sharp major (b→c# in the upper voice and b→f# in the “bass” / in M40 F sharp major→B major (c#→b in the upper voice and f#→b in the “bass”).

I can play this harmony sequence simultaneously on the piano to the sound of M39 and M40.

What fascinating sounds emerge from the chirping of the mockingbird in the deeper and expanded dimensions of space and time!

Mockingbird song (3.8.6) - a 2-voice motif in rhythmic and harmonic symmetry

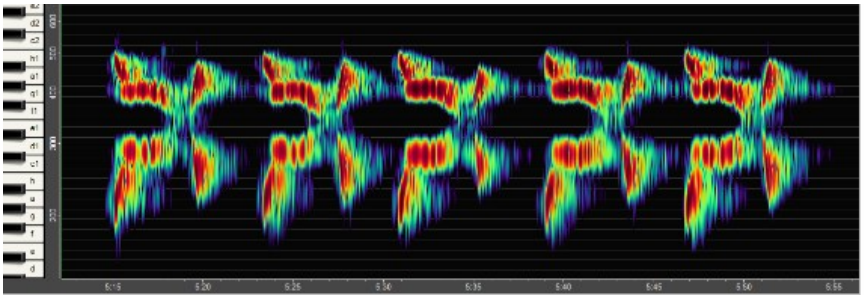
both voices separately and sounding together

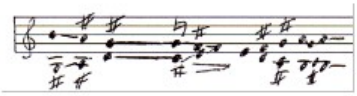
0-2-4-8-16-32x slowdown - video: https://youtu.be/owmWdCs38D8

A 2-voice motif, perfectly symmetrical in form, 2 independent voices in the most beautiful coordination and correlation, rhythmically synchronized, tonally in contrapuntal counter-movement with a magical sounding “tritone” (D/G#) in the center

Motif 91 from the 7-minute 2-voice song of a mockingbird - see the video:
"Mockingbird song (3.4) - a very special 2-voice singing - all 96 motifs with notation - 8x slowed down" - video: https://youtu.be/d623E2e92oU

At the very end of this very special 2-voice singing of a mockingbird with a total of 94 motifs, this beautifully shaped motif appears, only once in 7 minutes, combined in 3 chains of motifs with a short pause in between, first 3 repetitions, then 5 (see picture) and then 2 more. It lasts 0.36 s alone. The lower voice is at 3400-5600 Hz and the upper voice at 5600-7600 Hz.

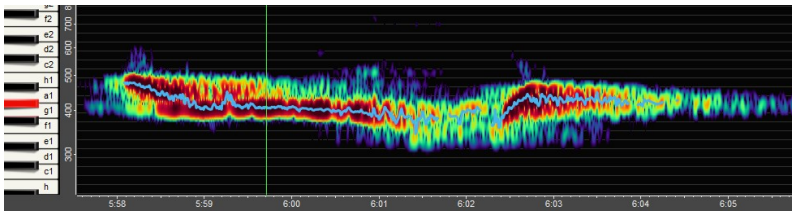


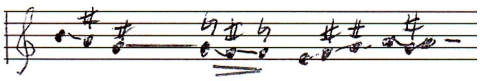


After a series of very intense motifs beforehand (including 2-voice trills in a seventh), motif 91 seems like a series of very fine, short chirp sounds. And astonishingly, the mockingbird enters immediately afterwards without any particular pause with vehement territorial sounds lasting 12 seconds. At first hearing, you think this is nothing special.
(In German, these short, very high-pitched sounds are called “zirpen” as opposed to “zwitschern” = chirping. Crickets “zirpen”, blue tits and other birds “zwitschern”. “Zirpen” and ‘zwitschern’ are very onomatopoeic, noisy-sounding words in German.)

In the 2x slowdown, an interesting rhythmically moving sound figure can be heard with a slightly metallic resonance. In the 4x slowdown, the rhythm is even more concise and the timing more differentiated. And you can already hear the two-part sound. However, it does not yet correspond to what I see as a sound figure in the spectrogram.
But then, in the 8x slowdown, the special character of this impressive motif becomes fully apparent both visually and audibly: 2 voices in the most beautiful symmetry and correlation, rhythmically synchronized, tonally in contrapuntal counter-movement and with an intervallic sound in the center from which a strange sound magic emanates. There are two voices in unison, like one sound and a sound with its own timbre, neither a fifth nor a fourth.
Motif 91 is one of the very few motifs in which the two voices are very close together, even move towards each other, come even closer together in a duple tone and then slide apart again in an impulse.

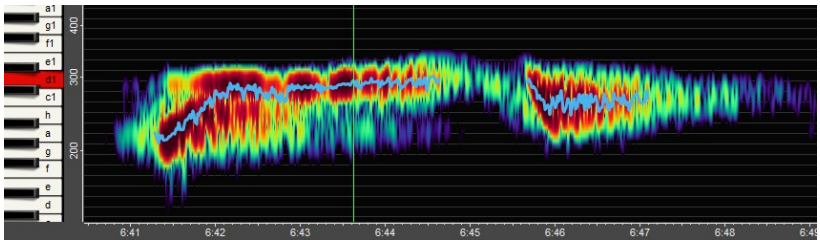
But only in the 16x slowdown was I able to analyze what exactly happens and sounds in each of the two voices in the spectrogram by filtering and using the pitch marker.

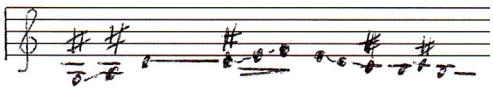




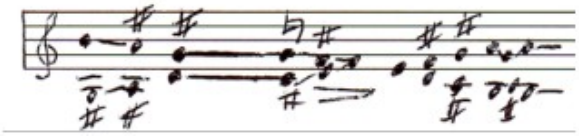
The upper voice opens with the semitone B4-A#4 and then begins with a tenuto sound on G#4, which fades out in a chromatic decrescendo to F4. And after an echo sound in a fast upward

movement E4-F#-G# to A4, it ends with a fast semitone ornamentation A-G#-A, which is followed by another long echo.





The lower voice makes the exact contrapuntal counter-movement. It begins with the whole tone G#3-A#3 and then jumps to the D4, which vibrates in the same pulses as the G#4 and then also moves in a decrescendo and chromatically to the F4 of the upper voice. With the upper voice, it also begins on E4 and moves downwards via D-C# to B3, which ends parallel to the upper voice in a fast whole-tone movement B-C#-B.



In the ensemble, the motif begins with a minor third in the octave (G#/B), which leads to the “tritone” D/G#, which fades out in unison on F. From the E unison it then moves in counter-movement to the seventh B/A.

All intervals sound in the following frequency proportions in all repetitions of the motif:

Minor third - 5:6(12) - G# = third-parton (5th) / B = fifth-parton (6th)
“Tritone” - 5:7 - third partial / seventh partial (7th) - D = 285 / G# = 404 (285:5=57 / 404:7=57/58)
“Septime” - 4:7 - B = octave partial (4th) / A = seventh partial (7th)

(“Tritone” and “seventh” in the frequency proportions of 5:7 and 4:7 do not correspond to the interval ratios on the piano. Both intervals sound in no way dissonant in this proportion and do not strive towards a resolution. Sounding together, they appear completely homogeneous like the “pure fifth” (2:3) and have a specific timbre. They can be heard in many different bird songs and are apparently very popular due to their special acoustic stimulation.)

In the 32-fold slowdown, the full magic of this complex motif can be experienced. I have left out the keyboard and the time scale in the spectrogram so that these sound figures with their atmosphere and inner sound space can be fully appreciated by the eye and ear.

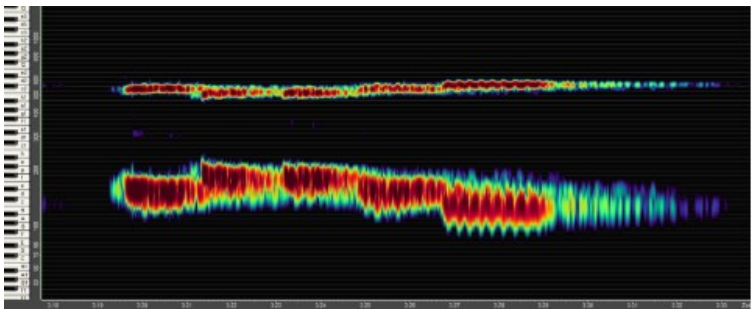
(The volume corresponds to the original in all positions, only in the 32-fold slowdown I have reduced it by half, because otherwise it would be too strong even for good speakers).

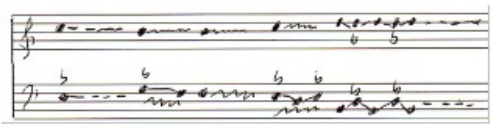
Mockingbird song (3.8.7) - a 2-voice trill motif in counter-movement

A harmonically integrated 2-voice singing unfolds from a metallic noise sound -
from an energetic acoustic stimulus pattern down and into a deep wide sound space

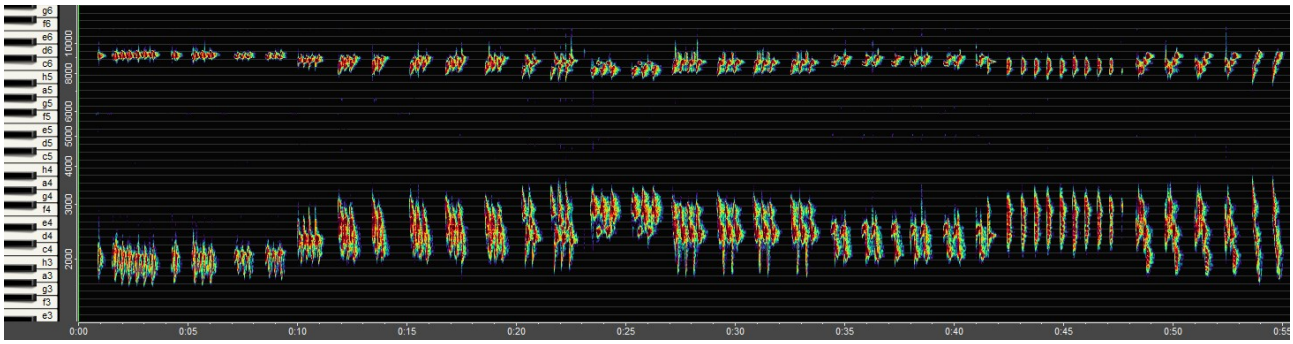
motif 10 and 60 - 0-2-4-8-16-32x slowed down

Video: https://youtu.be/VvOKl0fV_8I



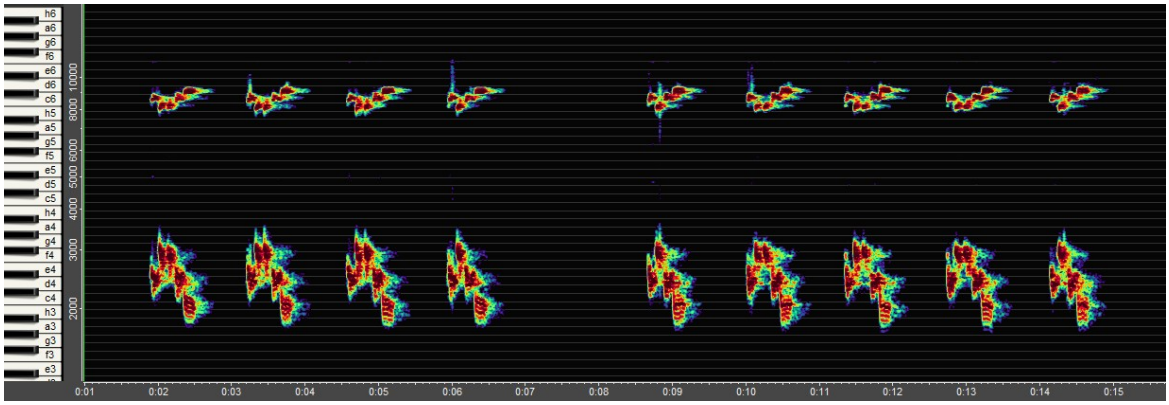


Motif 10 and 60 from the 7-minute 2-voice song of a mockingbird - see the video:
"Mockingbird song (3.4) - a very special 2-voice singing - all 96 motifs with notation - 8x slowed down" - video: https://youtu.be/d623E2e92oU



motif 10

The 2-voice singing of this mockingbird begins with a series of simple third figures, a chain of short call-like sounds that gradually increase in intensity about a third higher, vary rhythmically and calm down again somewhat. This is followed by a chain of very short, intense territorial sounds and then, what is that? It sounds like a real sequence of notes, four times and then it's over again.
It was a very special energetic stimulus that my ears had reacted to without understanding or really recognizing what it was.
In the further course, chains of shorter sounds or very fast tone sequences can be heard again, from which increasingly complex chains of motifs develop audibly and visibly.
When I repeat motif 10, I think I hear a rapid succession of 5 rhythmically ordered notes that sound somewhat iridescent and slightly metallic and therefore cannot be clearly defined in terms of pitch.
The fact that the 4th repetition consists of only 4 notes is hardly noticeable.

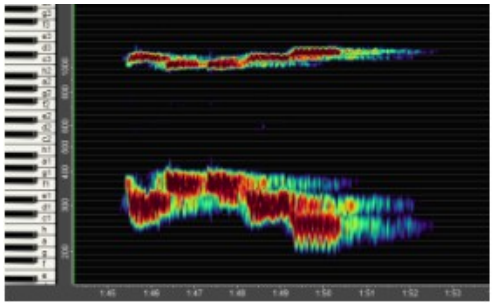


motif 10 motif 60

In the video, motifs 10 and 60 can be heard in succession in the original register (see above) and in 2x slowdown, in the lower registers only motif 60 with the 4-note sequence at the beginning and end.

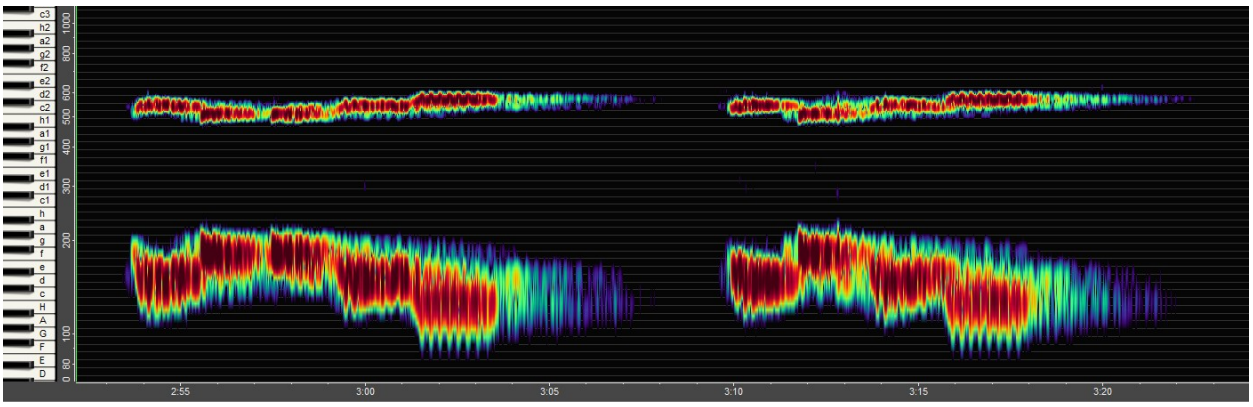
In the **2-fold slowdown**, 1 octave lower, the tone sequence seems even more iridescent with an even stronger metallic overtone, but surprisingly I can whistle the tone sequence immediately. It sounds like a B major triad (D#-F#-F#-D#-B), which, however, seems to be slightly out of tune. (When I whistle the triad, these are exactly the same frequencies at 1-2 kHz).
As with all the other motifs in this 2-voice singing, only the lower voice can be heard in the 2x slowdown. In fact, I hear nothing of the upper voice when I listen to it solo in the filter, although I can recognize the counter-movement to the lower voice in a small, dense sequence of intervals in the spectrogram. In the spectrogram I could read the sequence C#-C-C-C-C#-D two octaves higher. However, these pitches do not correspond to the notes on the keyboard; they seem to be quarter tones. In the C9 of the upper voice, a semitone includes almost 500 Hz and in the C7 of the lower voice about 120 Hz.
If I now listen to the motif again in its original register, I can perceive it much more differentiated and recognize the pitch movement of the lower voice.

In the **4-fold slowdown**, 2 octaves lower and slower (~2000 / ~ 550 Hz), the sound appears more vibrant. In the spectrogram, the trill can already be seen in the last note of the lower voice. What is now remarkable, however, is that I recognize the triad downwards, as in the higher registers, but at the same time perceive the high sound of the upper voice for the first time in the last note, as if an intense, brightly ringing and vibrating “overtone” appeared in the low B, not as a pure sound, but as a somewhat irritating stimulus, which can already be felt in the ear throughout the whole figure, especially in the D#.

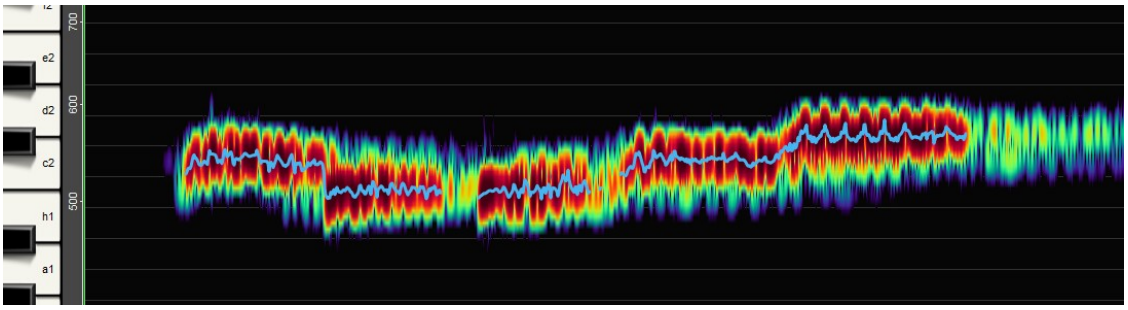


And then in the **8-fold slowdown** (1000/300 Hz), the sound process is transformed, as a 2-voice singing is clearly heard, in which the upper voice is now the dominant voice, clearly audible as a distinctive “semitone” movement. These are vibrating sounds with a timbre as if they were being played on a flute. The lower voice with its soft, dark sounds forms a beautiful contrast to this. However, the B major triad in the lower part is no longer clearly recognizable. The intonation of the two voices together seems strange to our ears, but also very attractive and interesting. The singing cannot simply be taken in as information. This is particularly true of the trills in the last interval.
The echo sound of the triad tones can be seen very clearly in the spectrogram. The trill B-C#-B is still accompanied by the third D#, which naturally increases the intensity and color of the sound.

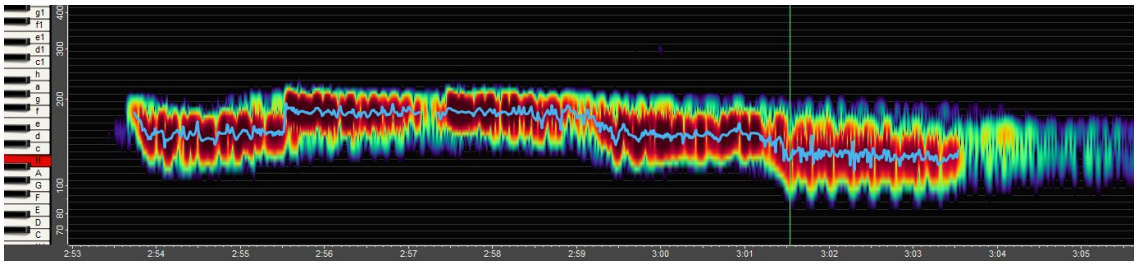
Incidentally, both voices are almost equally loud, although the upper voice is barely audible in the high registers and seems much louder to our ears when slowed down 8 times. One of the reasons for this is that our hearing has different sensitivity thresholds in different frequency ranges.
The overall sound is just as loud in all slowdowns as in the original. I only reduced the volume by 5dB (25 %) in the 32x slowdown, because otherwise the sound would have been too strong for the speakers.



In the **16-fold slowdown** (headphones!) a wide space opens up in the overall sound, a space in which both voices sound together and form one sound; an atmospherically vibrating space between the upper and lower voices; and a very specific space in each voice, in the sound spectrum, the vibrato, the trills and the interval ratios:
dense and intense, as if glowing from within in the upper voice - in the lower voice, sounds without a center and without boundaries in a widely vibrating echo space, as if a gong were being struck very softly in a large cave, in a wonderfully calm and soothing rhythm.
The upper voice is now in the soprano range (C#5 - 550 Hz) and the lower voice in the bass range (B2-D#3-F#3 - 125-200 Hz). In this familiar audible range, the overall sound is relatively homogeneous, despite the 2 octave difference. Both voices have their own coloration, but neither dominates. Despite its dense sequence of intervals, the upper voice appears quite concise, while the lower voice can also be heard sufficiently in the soft depths due to the triad breaking.
What is particularly striking in this register, however, is that the two voices do not mix well in any way, as would perhaps be desirable in a duet of soprano and bass (but is not always the case with human singing), but that the intonation of both voices now miraculously integrates into one another. The somewhat metallic and irritating sound elements in the higher registers, the somewhat strange-sounding interval sequences in connection with “quarter tones” and “triads”, all appear integrated and well-ordered. And even the opposing trills (B/D-C#-B/D) at the end no longer seem strangely ambivalent and irritating in their harmony, but instead unfold their very own, stimulating-sounding appeal to the ears. It is not simply the fundamental note of a B major triad, which one would expect after the sequence D#-F#-F#-D#, but the trills around the octave C# allow the end of the motif to iridesce, opening up the sound process and leading it atmospherically into expanded dimensions.

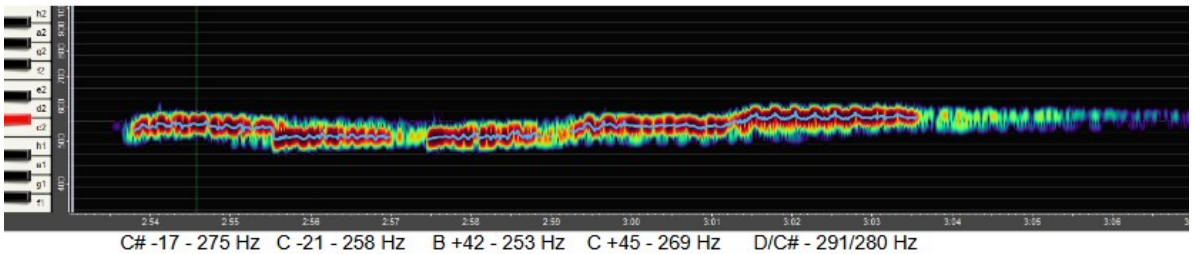


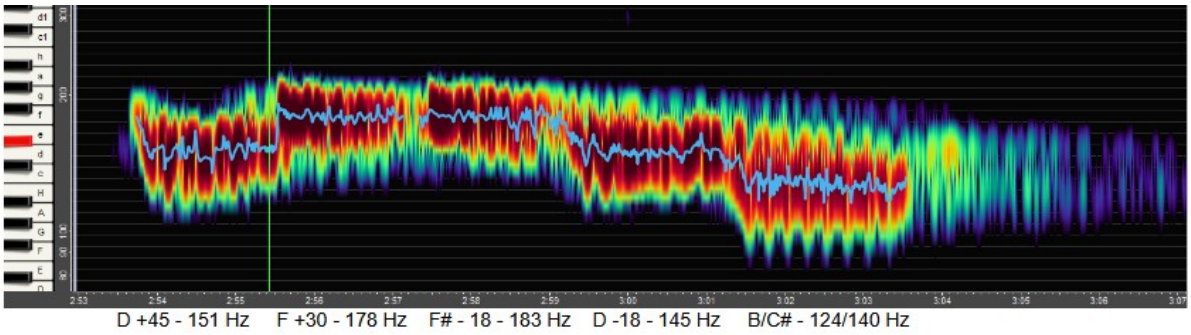
If I play the upper voice solo in the filter, the different intonation of the quarter/half notes can be differentiated well. The phrasing of the 5 notes is very musical. All notes have a vibrato; the first note makes a slight curve in the intonation towards the second; the second and third are in the same rhythm, but somewhat shorter and louder, with a stronger emphasis at the beginning, which continues in an even vibrato; the third moves slightly towards the fourth at the end; the fourth makes a small trill at the beginning and continues to swing into the final trill, an even semitone trill D-C#-D with exactly 8 trill pulses in all repetitions (!).



A solo in the lower voice reveals the same quality of musical phrasing, only everything is mirrored in the counter-movement, starting with the bow at the beginning and ending in the whole-tone trill B-C#-B.

I have entered the pitches and frequencies for the following spectrograms of the filtered voices. In the filter, the pitch marker shows the exact pitch of each voice. Based on the frequency information, I can calculate the proportions of the intervals, which can be determined with minimal deviations of up to 5 Hz. (next page)

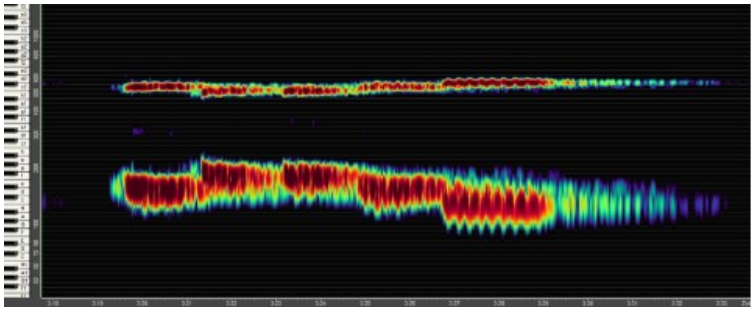


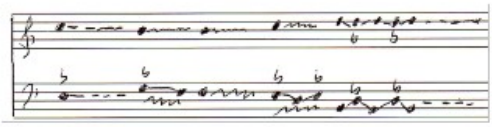


For the frequency proportions between the two voices, I have calculated the frequencies of the upper voice an octave lower. “D +45” means ‘D’ in the keyboard plus 45 cents - 100 cents = 1 semitone.
The notation below is adjusted. The trill is clearly in contrary motion like all 2-voice singing trills in the mockingbird's song.

Lower voice: B major triad (4:5:6)
B : F# - 124 Hz : 183 Hz = 2:3 (octave / fifth)
D# : F# - 151 Hz : 183 Hz = 5:6 (third / fifth)

Lower voice/upper voice:
D# : C# - 151 Hz : 275 Hz = 5:9 (third / ninth)
F# : C - 183 Hz : 253 Hz = 5:7 (third / seventh)
B : C# - 124 Hz : 280 Hz = 4:9 (octave / ninth)
Trill last sound:
B-C#-H / D-C#-D - C#:C# - 140 Hz : 280 Hz = 1:2





32-fold slowdown
5 octaves lower (70 Hz / 280 Hz) and 5 time octaves slower (0.66 s → 21.12 s)

The 32-fold slowdown opens up a truly deep dimension of space and time. The depth of the sound can be heard not only in the spectrum, but also in the depth of a wide echo space as well as in the depth of a calmly vibrating sound interior.
These are no longer two voices. Everything that oscillates and vibrates in infinite calm, in moving and touching slowness becomes one sound, a sound that cannot be defined or analyzed in terms of pitch, rhythm, tempo or timbre. Listening becomes sensing and living in an expanded dimension of sound, a process of experience.
I am drawn into unfathomable depths and touched by incomprehensible condensations of sound. Do these sound phenomena come from afar or from an interior that cannot be localized? Do these shapes have an aura or do they fulfill a space? I am taken in and enveloped by light-dark sounding

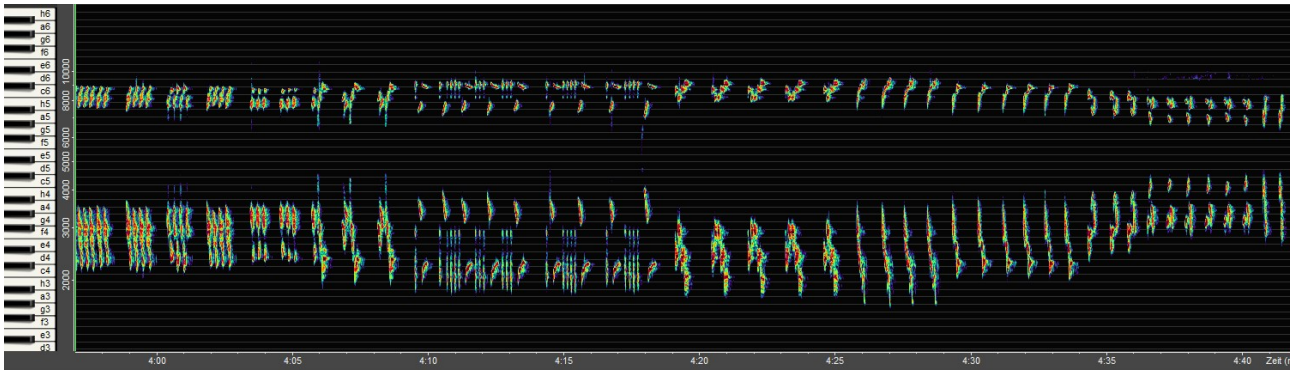
spheres in which I no longer ask myself: what kind of sound is that, is it singing, are unknown instruments being played, where does the sound come from, where am I as the listener?
To hear and experience such a sound event, to immerse myself with both ears in such worlds of sound, is always so overwhelming and fulfilling for me that I have no words to describe it.
I am simply gripped by a great sense of wonder and deep awe in the auditory experience of such spheres and dimensions.

May everyone be all ears in their own way - for the sound of nature and the nature of sound:

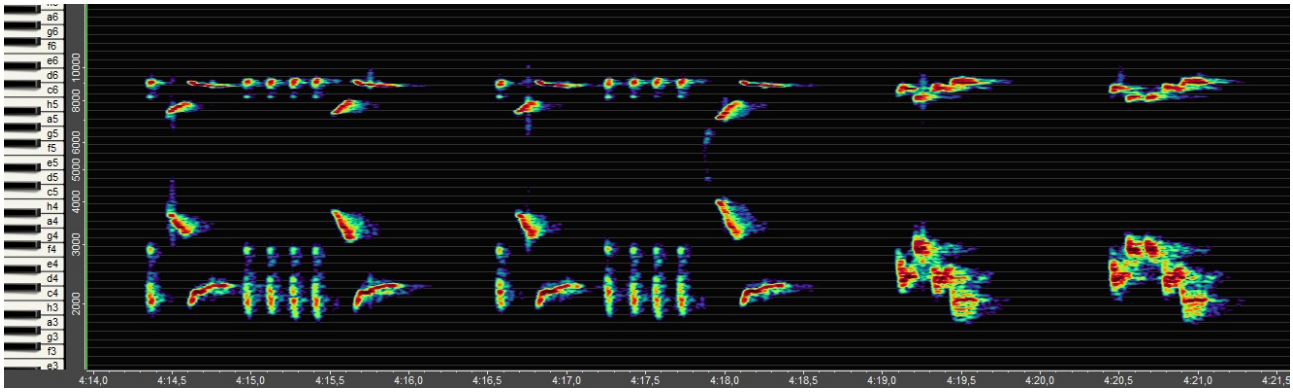
Hear what is to be heard !

And when, at the end of the video, the sound of this very special motif is brought back up into the natural high and fast dimensions of the mockingbird's song, I am always amazed that this short sound event actually conceals such vocal virtuosity and musical quality.

This occurs within an incessant succession of diverse other motifs with a similar and sometimes even greater complexity. And then, 3:30 minutes later, it appears again, 50 motifs later, each motif strung together in a chain in multiple repetition, directly after a completely different, very special and uniquely designed motif (see below), which, like motif 60, is also repeated 5 times.
The only difference to motif 10 is that motif 60 is constructed symmetrically, the threefold 5-note sequence framed by the 4-note sequence.
The sound sequence, the pitches, the trills, the phrasing - all identical!



motif 60 = motif 10



A later interesting experience with this motif

In my overall analysis of the 2-voice singing of this mockingbird and also in the analysis of individual particularly interesting motifs, I had not paid any attention to motif 10/60, although it certainly appealed to my sense of sound. After I had completed the research work on 3 songs of the mockingbird (“Mockingbird song 1 - 2 - 3”) and all the videos were finished, I listened to other videos of the mockingbird singing on YouTube, simply out of curiosity to see if there was anything else interesting or whether there might be other mockingbirds that sing 2-voice singing.

I discovered videos from Central America with songs of the “sinsonte” (Spanish name for mocking-bird). I came across the video “Sonidos de Colombia”, songs from Colombia with a parrot in the title picture. When I first heard it, I thought it sounded a bit like a mockingbird. And then suddenly, at 1:19 min, my ears reacted surprisingly to a certain sound, without discovering or even recog-nizing anything in particular. I let the video run back and when I listened to it again, it seemed somehow familiar to me, with this particular stimulus in my ears and the minimal hint of a tone sequence. In the rest of the recording (duration 4:39) I didn't notice anything special.
In the spectrogram on the Overtone-Analyzer I then saw and heard that it was a 2-voice singing, and in the slowdown I also recognized motif 10 from “Mockingbird 3”. So should there be another mockingbird that also sings in 2-voice and has the same motifs in its repertoire?
But then, on closer analysis, it turned out that the author of this video had combined a 2-minute excerpt from the 7-minute song with other songs.

Conclusion:
After I had studied the song of the mockingbird for weeks, had thoroughly analyzed hundreds of motifs in the slowdown, my memory was therefore overflowing with a wide variety of impressions, my hearing reacted spontaneously and immediately to a certain, specific, noisy vibration pattern, below the conscious threshold of perception. It was a spatially and temporally coordinated spectrum pattern, an *acoustic sound gestalt* that had obviously activated and reactivated a corresponding pattern in the brain (subcortical) with its high energetic charge.
It was not a diffuse pure noise, but a real *sound* or a *sound process*, rhythmically and spectrally ordered and structured, which only appeared noisy to our perceptive faculty and which we were therefore unable to classify and define.
It was a very specific pattern, namely two-part with the two voices in a wide range (2 octaves), which in this kind of harmony in this high range (8000/2000 Hz) trigger a special sensory and acoustic stimulus and stimulate the nervous system.
And it was a very specific pattern to which my hearing had reacted immediately, almost reflexively, without distinguishing and sorting consciousness, namely precisely this singing of two voices, each voice with its own sequence of notes, coordinated with each other in the interval proportions, coordinated with each other in counter-movement, through phrasing and through the trills in a certain dynamic of movement.
It is exactly the same pattern of vibration that we can recognize somewhat more clearly and differentiatedly in deeper spectral ranges and in extended time dimensions with our familiar categories of perception and that we can name and define with the terms we have learned.
At the same time, it is all the more impressive that these concepts and names can only vaguely grasp the virtuosity and quality of this birdsong, just as little as the spectral order of the sounds and the interacting dynamic forces in the sound process.

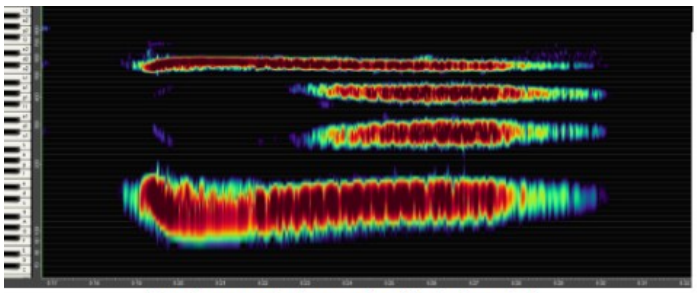
With what precision and to what degree of complexity does the unconscious auditory and acoustic pattern formation and pattern recognition function in our brain?!
Fascinating!

Mockingbird song (3.9) - an impressive 2-voice spectral sound

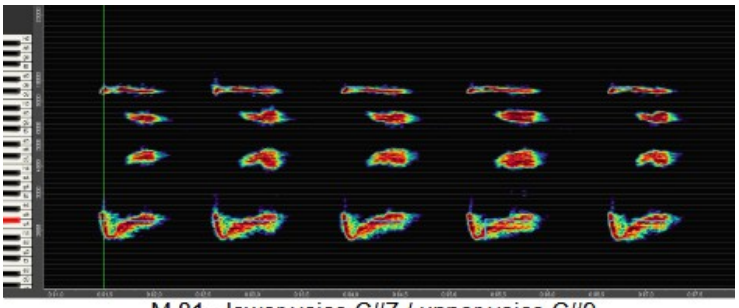
A full-sounding vibrating spectral-sound unfolds from a whirring noise-sound -
a sounding emergence phenomenon !

0-2-4-8-16-32x slowed down - video: https://youtu.be/rC3vUtcuW38

Motif 81 from the 7-minute 2-voice song of a mockingbird - see the video:
"Mockingbird song (3.4) - a very special 2-voice singing - all 96 motifs with notation -
8x slowed down" - video: https://youtu.be/d623E2e92oU

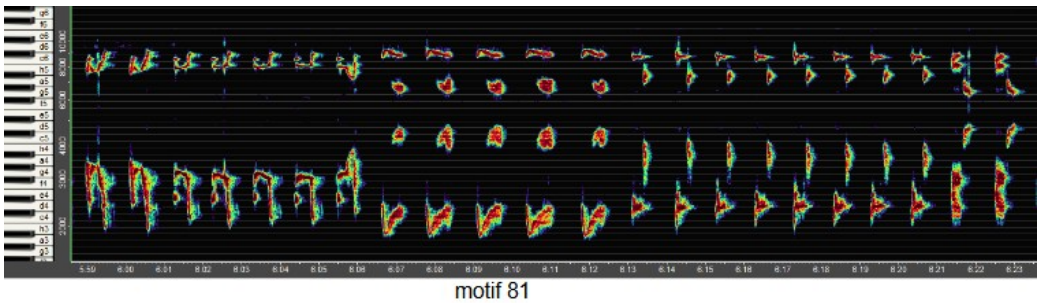


2-voice spectral sound with 1.-4 partial

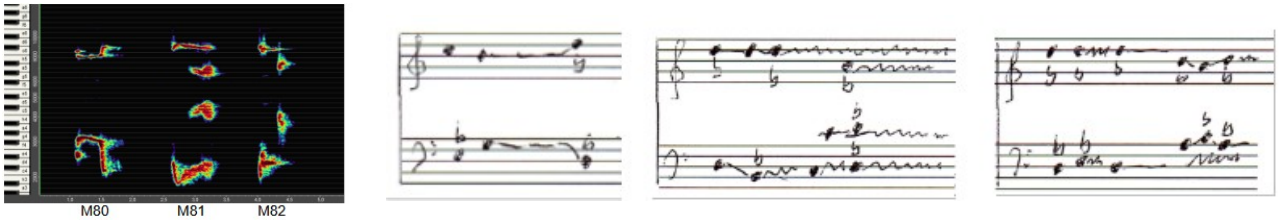


M 81 - lower voice C#7 / upper voice C#9

Motif 81 appears only once in the 7-minute song. It is repeated 5 times and lasts 0.65 s, the pause between the motifs is 0.5-0.7 s long. It is part of a rhythmically evenly structured series of motifs that are repeated singly with a pause in between (M79 - 5x, M80 - 5x, M82 - 8x, M83 - 7x).

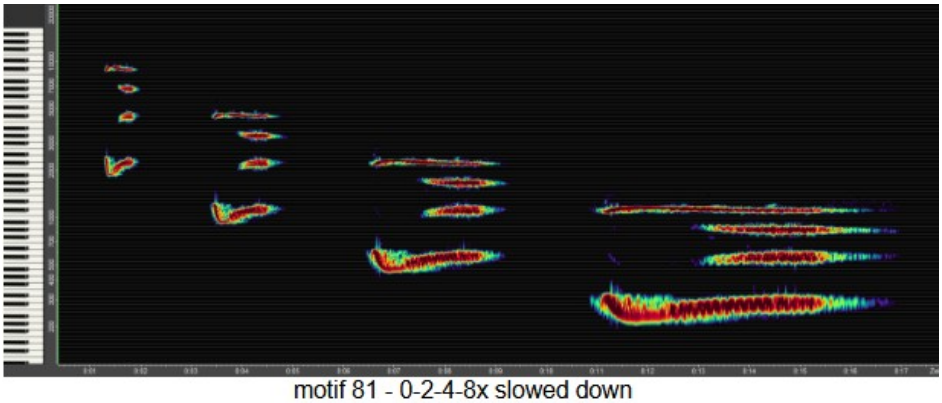


motif 81



M 80-81-82 form a certain contrast. In M80 I can even recognize and whistle a concise pitch in this high register around 3000 Hz, g4---- with a downward glissando. In M82 I hear 2 short sounds, in the first a small movement around a note and in the second a short bright whirring. I spontaneously whistle the d4 with the following fifth. Despite the brevity, I hear a quick glissando downwards in M81 (minor third) followed by an indefinable whirring (in German "schwirren" - a bright, fast, intense movement).

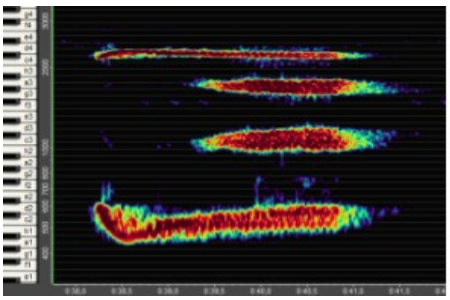
In the spectrogram, the two voices in the 2-voice song can be recognized in all 3 motifs, the lower voice and upper voice visibly moving in counter-movement as in the whole song. After my experience in analyzing bird songs, I saw at first glance that M81 must be a 2-voice spectral sound, a sound figure that I was familiar with from the song of the blackbird, for example.
As I can read in the spectrogram, a C#7 is heard in the lower voice and a C#9 in the upper voice 2 octaves above it. The sounds in between are the C#8 and the G#8, i.e. the 2nd and 3rd partials (octave and fifth). It is the only time in this song that partials of the lower or upper voice can be seen and heard, as is usually the case in the song of the mockingbird.



motif 81 - 0-2-4-8x slowed down

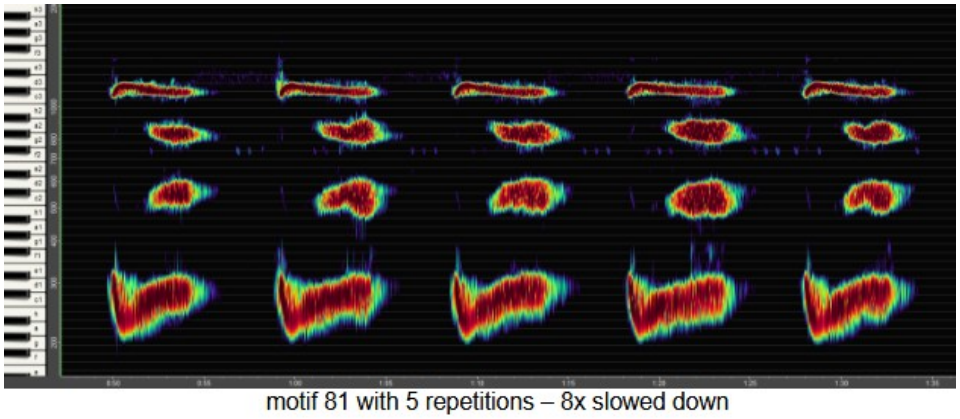
As with all the other motifs, the upper voice (C#9 at 8800 Hz) in motif 81 is virtually imperceptible in its original register when I play it alone in the filter. If I add the fifth partial (G#8 at 6640 Hz), I can at least hear a very fine chirping, like a cricket. In the lower voice (C#7 at 2240 Hz) I recognize the third glissando and the noisy bright whirring sound back to C#7, as described above.
In combination with the octave partial (C#8 at 4320 Hz), the bright whirring is significantly more intense and noisier. In the lower voice and the partials, the frequencies vary slightly in the individual repetitions. Both voices and the partials are about equally loud. There is a trill with 48 pulses per second in both voices and in the partials. In the lower voice, the amplitude of the trill is a third, which is one reason for the intense whirring in the high registers.

In the **2-fold slowdown**, the sound seems louder and stronger, although the volume is the same in all registers, even in the slowdown. At the beginning of the motif, a 2-voice sound is briefly recognizable, while the spectral sound exerts a strong stimulus on the ear but cannot be assigned to any pitch. In this register, the upper voice can also be heard alone like a silvery whistling. Overall, the motif in this register has a somewhat tinny timbre.



In the **4-fold slowdown**, more sound unfolds. The upper voice (2200 Hz) alone produces a finely vibrating, bright whistling tone and, parallel to this, the lower voice (560 Hz) produces a soft flute sound that leads into the fundamental via the glissando and merges into a very fast trill, as can already be seen in the spectrogram image. In the spectral sound, a very dense and intense, slightly metallic whirring sound is formed, in which the fundamental C#, stimulated by the high whistle note C#4, can be adequately defined.
If I only hear the spectral sound without the glissando at the beginning and only with the octave and fifth frequencies, it is a pure noise sound, comparable to the “noise” that cicadas make. The reason for this kind of cicada “song” is the fast trills with the large amplitude. They cause an extremely strong irritation to the ears.

But then, from the 4-fold to the **8-fold slowdown**, there is a tipping point in our acoustic perception with the change of layer. Both voices are now in the frequency range familiar to our ears (C#6 - 1100 Hz and C#4 - 275 Hz), and the extended tempo enables us to hear the sound process in a somewhat more differentiated way. Overall, the sound seems softer, more spacious and rounder. The trill manifests itself like a subtle tremor in the sound.



motif 81 with 5 repetitions – 8x slowed down

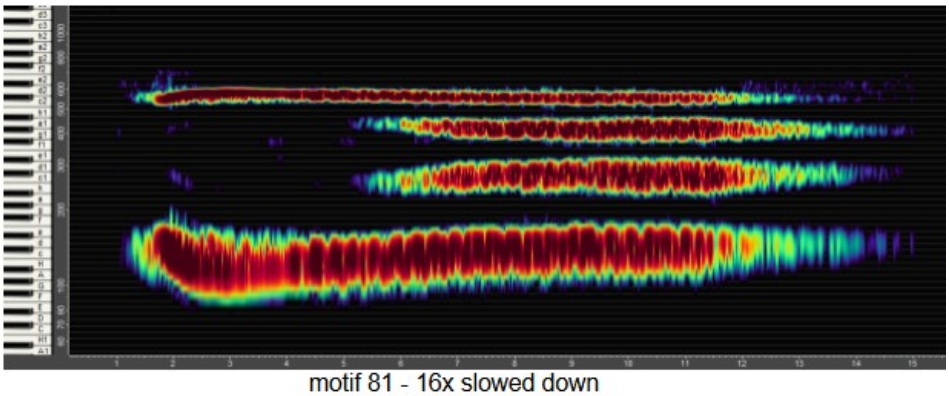
In the clear two-part texture at the beginning of the motif, the upper voice dominates in the upper register, beginning with a small wave from C# to D and then very gradually and barely noticeably gliding back to C#. In striking contrast to this, a strong counter-movement can be heard in the lower voice when it glides from C# a minor third into the lower register and then, after the turning point, gradually ascends from B into an audible whole-tone trill with a large amplitude, while the upper voice, again in slight contrast, begins to trill very delicately (with a quarter-tone trill).
In the detailed analysis I found that the trills have the same pulse and at the same time make a counter-movement, as occurs in other motifs. So there is also a counterpoint in the trills, which considerably increases the arousal potential of this singing.

What happens after this 2-voice intro has something indescribably magical for me every time I hear it, even in the succession of repetitions. It is a sound phenomenon that I have never heard before and that I hear again and again as if for the first time. In the truest sense of the word, it is a sounding phenomenon that appears in my ears as sound. Where does it come from? What is this strange sound? Why does it touch me so?
It is no longer two voices, it becomes *one* sound that forms and shapes itself from the two voices, a sound gestalt that is more than the sum of its parts, no longer a two-tone sound, but also not an octave with its inner spectrum of partials.
Does this sound phenomenon come from faraway or from an interior that cannot be localized? Does this gestalt have an aura or does it fill a space?

The spectrogram shows that the upper voice moves completely continuously and evenly, from D6 (-42ct) to C#6 (-17ct), that is 75 cents, i.e. not quite a semitone (100 cents), and exactly the same in all repetitions. Understandably, the lower voice does not move quite as evenly in the large trill glissando through the third A#→C# and it moves slightly differently in each repetition. The octave frequency (2nd partial) begins at C5 when the lower voice has reached C4 and then glides parallel with the lower voice to C#.
In the opposite movement, the fifth frequency (3rd partial) begins at A5 when the C# begins to sound in the upper voice and then glides on to G#5. This glide from A to G# can be heard beautifully in the overall sound.
When I play only the two upper voices, I hear to my ears and my sense of sound a very longing semitone sequence: C#-D-C#--A---G#---. If I add the octave frequency, there is an additional attraction in that it begins parallel to the A5 of the fifth frequency with C5 and then glides on to C#5, while the A2 continues and later leads into the long-sounding G#5. For a transition, therefore, the major sixth C5/A5 is heard first, which changes to the minor sixth C#5/A5, which resolves into the fifth C#/ G#.

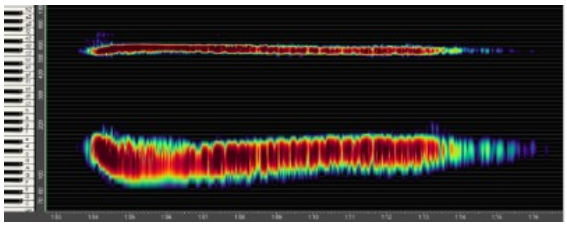
The strange thing is that in the final sound, after all the semitone or quarter-tone modulations, I don't hear a fifth sound that sounds like C sharp major with the fundamental C#4 and its octaves. One of the secrets of this sound process from the 2-voice singing into the spectral sound seems to be that the minimal turn C#6-D6-C#6 at the beginning already sounds like a modulation from the fifth into a minor sixth (F sharp minor→H minor→F sharp minor) and the glide from A5 to G#5 in the fifth frequency sounds like the turn from the minor sixth (F sharp minor) into the fifth of C sharp minor. All is continuously in motion in opposing glissandi and dynamic trills and so it is probably the charm of this motif that a full-sounding spectral sound unfolds and at the same time everything remains slightly suspended.

(At the end of the sound, however, the 2 octaves between the lower and upper voices only deviate by minus 17 cents from the exact proportion of 1:4, whereby a semitone comprises 100 cents).

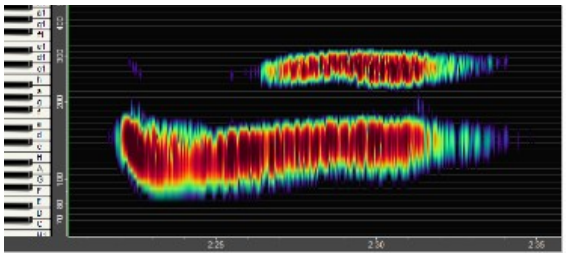


motif 81 - 16x slowed down

The **16-fold slowdown** (140 and 554 Hz) opens up a truly deep dimension of space and time. The depth of the sound can be heard not only in the frequency spectrum, but also in the depth of a wide echo space (via headphones!) as well as in the depth of a vibrating sound interior. Listening becomes sensing and experiencing in an expanded dimension of sound, a process of experience. I am taken in and enveloped by light and dark sounding spheres in which I no longer ask myself: what kind of sound is that, is it singing, are unknown instruments being played, where does the sound come from, where am I as the listener?
At the beginning, you might think there are two strange instruments playing, one bright and intense in the high register like a kind of oboe and one at a great depth like a soft, somewhat airy bass flute. And then: from the wide space between these two differently colored “tones”, a sound reaches my ears that I can hardly describe. It seems to come from a mysterious depth, envelops me and draws me into its vibrant and shimmering inner life.

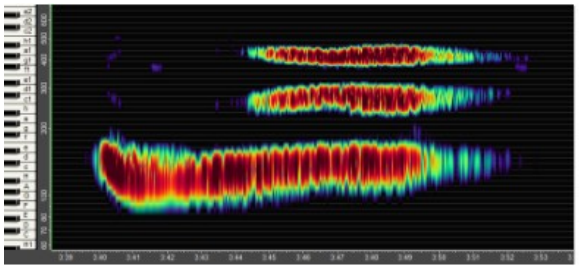


To further deepen the experience of this fascinating and impressive sound, I have used a filter in the video (from 06:38) to combine the various sound spheres in different ways. With the two voices alone, you can follow the trill movement at this slow tempo. This is possible because the trill frequency of 48/s in the original position is relatively slow, as the mockingbird usually trills at frequencies of 96/s or 192/s, i.e. at exactly 2 and 4 times the speed.
The upper voice also appears very smooth in the fine trill and dominates the timbre, while the lower voice makes the sound pulsate with its strong trill movement. And although the trill frequency is the same in both voices, there is a stimulating irritation for the ears because the trills make a counter-movement and because the amplitude is very different.

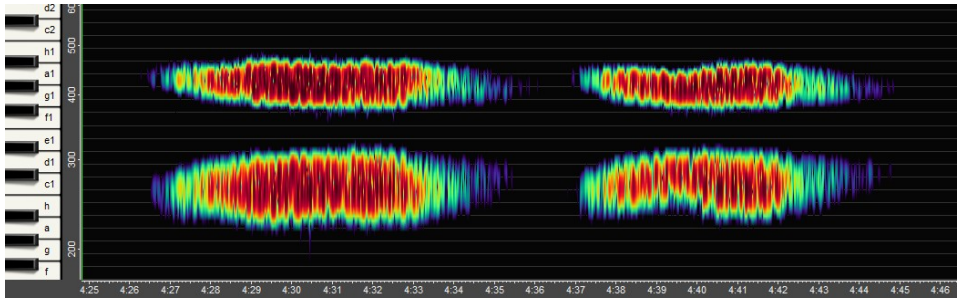


In the combination of the lower voice plus the octave frequency, you can clearly follow the movement of the whole-tone trill. It begins very calmly and evenly, but when the octave frequency forms, there is obviously a feedback or interaction between the two frequencies, as can also be seen in the spectrogram. The octave frequency appears gradually and initially has the calm pulse of the lower voice in the same amplitude movement. However, it then becomes more complex, more colorful and no longer has such a clear pulse, which is certainly due to the interactions between all frequencies in the overall sound.
When heard single, the octave has a very moving and iridescent effect. It is as if sound waves were breaking against the round walls like in a tube, leading to amplified resonances within the sound. It should be noted that the octave and fifth frequencies are created by the interaction of the upper and lower voices in the resonance chamber of the windpipe, as I will explain below.

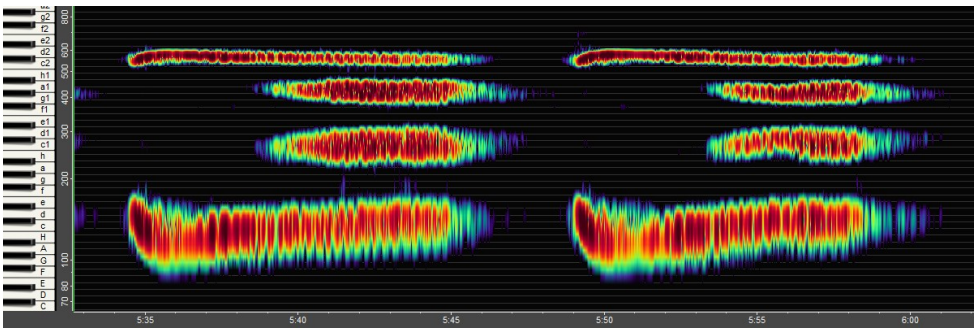
(In a monophonic trill singing or a vibrato sound, the pulse is completely identical in frequency in all partials, in humans and in songbirds).

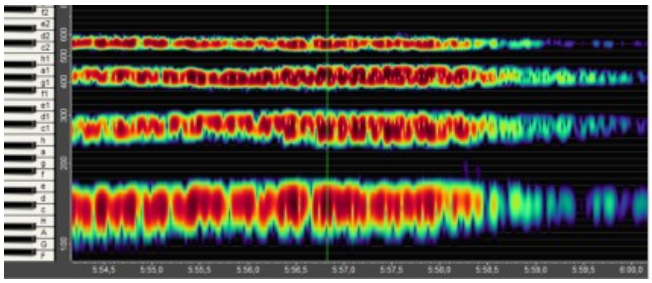


In combination with the quint frequency, you can see and hear in the spectrogram how the calm pulse in the lower voice is overlaid by compressions and intensifications resulting from the acoustic feedback. They are even stronger in the fifth frequency.
(In the spectrogram image, the red coloration is darker, i.e. the dynamic level is higher).
At the beginning of the fifth sound, it can be recognized that the trill has the same counter-movement to the trill of the lower voice as the upper voice in its amplitude movement. In the harmony of the three frequencies there is an audible contrast between the rather calm pulse of the lower voice and the resonant dynamics in the octave and fifth.



In the filter with the octave and fifth frequencies, a striking difference is noticeable in the spectrogram image in the 4th and 5th repetition, which can also be heard. In the 4th repetition there is hardly any change in pitch and compression, dynamics and amplitude are high. The sound whirrs intensely without a recognizable pulse. In the last repetition, on the other hand, there is a small pitch movement in the opposite direction and, surprisingly, a steady trill pulse can be heard here, even in the high intensity of the second half.
In the lower picture of the overall sound, you can recognize the reason: the lower voice makes a different movement each time. In the 4th repetition, the trill glides very quickly from the low register from A# to C and then continues gradually until it reaches C# at the end. In the last repetition, the lower voice glides evenly from A# to C#, on which it lingers for the last third of the sound. The octave and fifth frequency starts a little later and is 2 s shorter than in the previous version. The sound lasts 1.5 s longer in the 4th repetition and, remarkably, the resonant frequencies sound slightly longer than the two voices, while they end together in the last version.



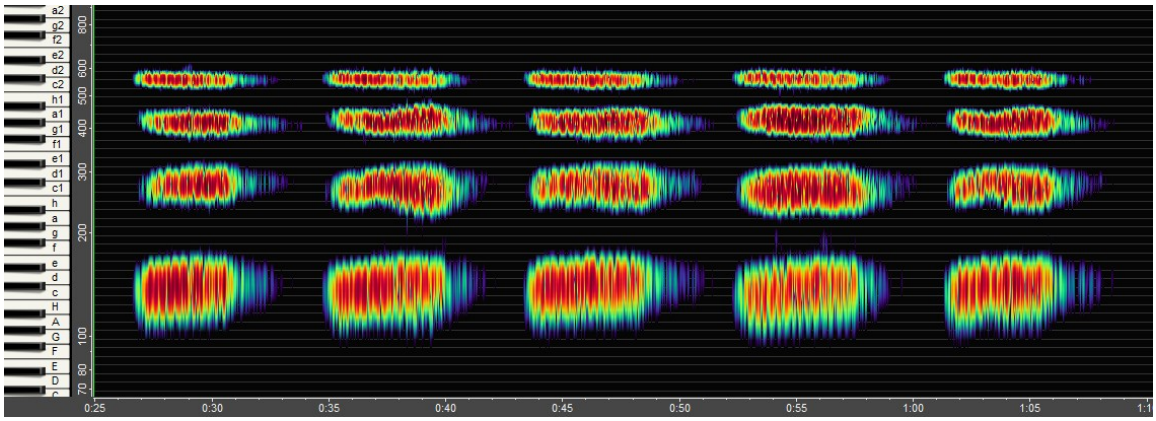


One could almost have the impression that the 4 repetitions were attempts to lead this sound model from the two trill glissandi into a full-sounding, 2-octave spectral sound. The picture on the left shows (cursor in the middle) how the overall sound unfolds dynamically. The interacting resonances in the sound become so strong that the dynamics get another audible impulse.
If I look closely at the spectrogram, I can see that at that moment the lower trill amplitude in the octave frequency and the upper trill amplitude in the fifth frequency become louder (counter-

movement of the trills). It sounds as if the spectrum locks into an inner corresponding and correlating structure.
(This is a phenomenon that I know from my singing, when I arrive at the fifth from a fifth glissando and the sound quasi locks into the spectrum of the fundamental).

Incidentally, I had to reduce the volume by 5dB, i.e. by half, in the 16- and 32-fold slowdown, because otherwise the speakers would have been overwhelmed. (Remember: the vocals have the same volume in all registers).

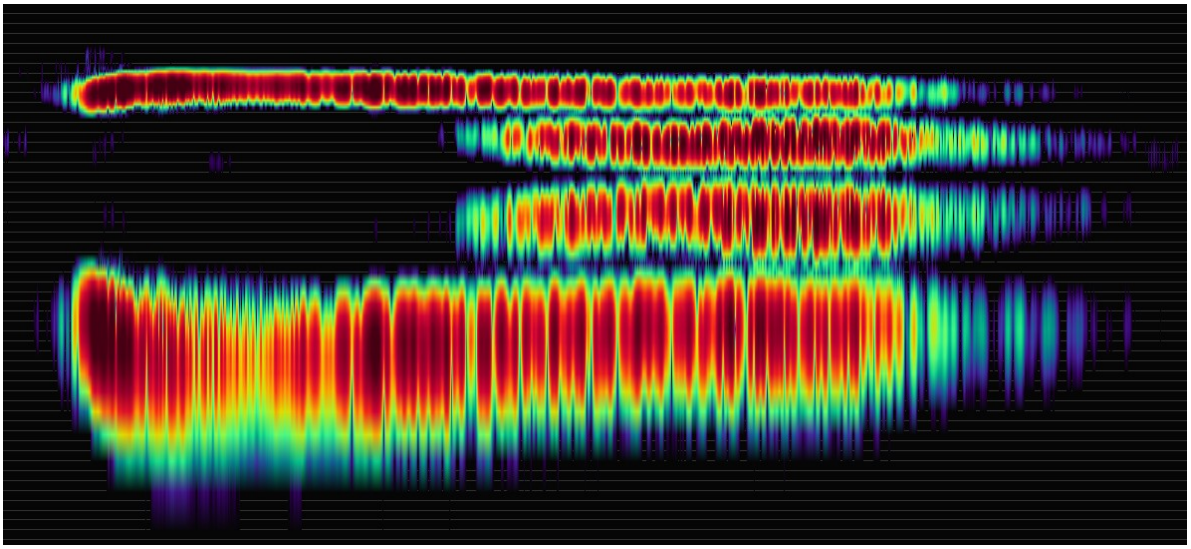
The pure spectral sound



At the end of the video (12:44), I recorded the pure spectral sound with an excerpt from the motif, slowed down 8-16-32 times.

An exploratory journey for the ears into the space and inner life of a 2-voice spectral sound

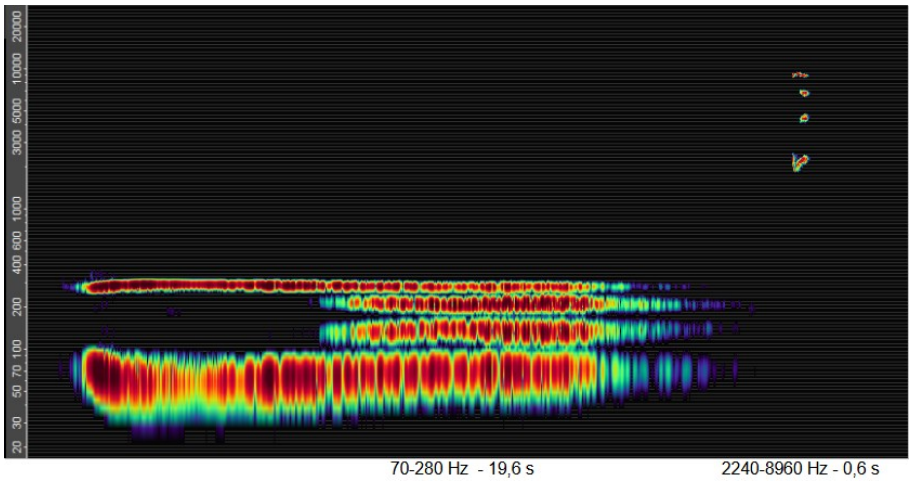
- Interactions in the spectrum of voices and sounds
- Interactions in the ear canals and the convolutions of the cochlea
- Interactions of sensory impressions and receptiveness
- a journey into unimagined and unheard-of spheres and dimensions of the nature of sound



32x slowdown : C# - C# - G# - C#

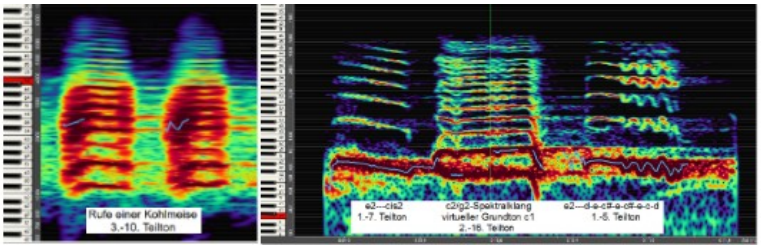
Hearing and experiencing this sound sensation is always so overwhelming and fulfilling for me that I have no words to describe it. I am simply gripped by a great sense of wonder and deep reverence in the auditory experience of such spheres and dimensions. May everyone be all ears in their own way - for the sound of nature and the nature of sound:

Hear what is to be heard !

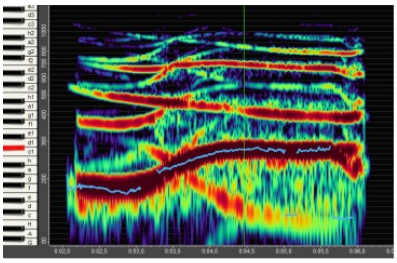


How a spectral sound is developed

With their double syrinx, all songbirds have the ability to produce spectral sounds, which are produced when the membranes in both parts of the syrinx vibrate simultaneously and are more or less coordinated with each other in such a way that a uniform sound is formed from both vibrations in the resonance chamber of the trachea above the syrinx.



This can be a sound without a specific pitch, i.e. without a fundamental tone or with a virtual fundamental tone, a noise-like sound for our ears that is composed of certain partials, usually a specific section of a frequency spectrum, as in the call of a great tit on the left with the 3rd-10th partial (virtual fundamental F - 3rd partial/fifth C - 10th partial/third A). Or it can be a 2-voice song with a fifth as in the blackbird on the right, when the C vibrates in one syrinx and the G in the other. Both oscillations then form a common spectrum with the virtual fundamental C, the fifth as the 2nd and 3rd partial and a full spectrum up to the 16th partial.



Or, as with the mockingbird, it can be a 2-voice counter-running glissando, as on the left in a blackbird song, in which so-called combination tones are formed in the resonance chamber through interactions between the spectra of the two sounds, in this example the third E (5th partial) to the fifth C/G (2nd/3rd) with the virtual fundamental C.
(see in German: “Combination tones in blackbird song - the sounding Möbius loop” - C:\Users\johan\Documents\1 Amsel Texte\Amselgesang-7.6.2_klingende-Möbius-Schleife.pdf)

I have found such 2-voice spectral sounds with combination sounds several times in blackbird song. In all examples, as here in the mockingbird, there are 2 voices in counter-movement, which begin in a wide register and are brought together in a different type of movement, i.e. in a process of constant change, into a transformed integrated sound. In motif 81 it is the very gradual minimal glide of the upper voice by less than a semitone in contrast to the larger glissando movement with a sweeping trill in the lower voice.
Both voices do not consist of tones, but form a diverse and structured whole of partial frequencies with their respective spectrum. In the trachea, as a tube an optimally shaped resonance chamber, complex standing waves are formed in which frequencies can reinforce each other through feedback and interactions and vibrational energies can potentiate in such a way that emergences can form in the overall spectrum in a correlating, proportional, whole numbered structure to both voices: 1:2:3:4 - lower voice C# / octave frequency C# / fifth frequency G# / upper voice C# - *the nature of sound.*

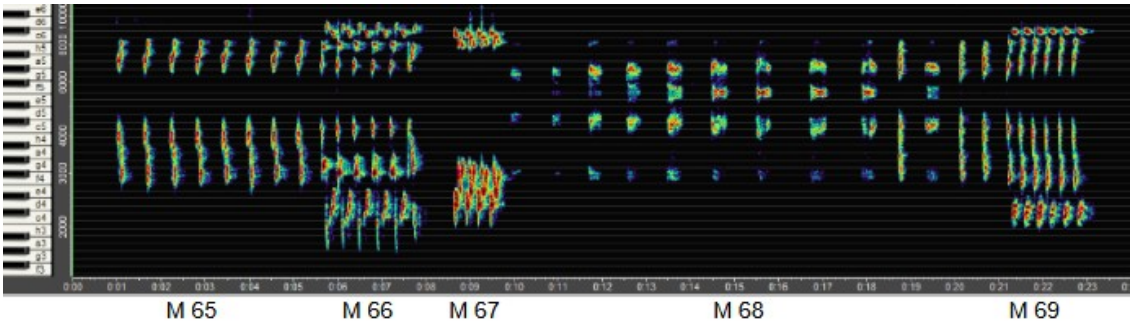
Motif 68 – a 2-voice spectral sound (C#/G#) with its combination tones

Spherical spectral sounds –
explore the inner life of a multi-layered sound in its development with your ears

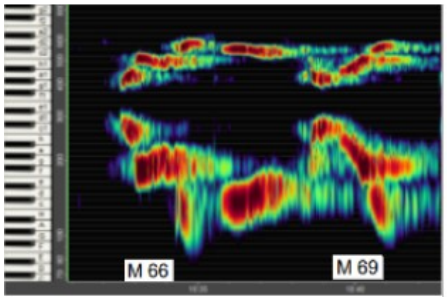
Motif sequence 65-69: 5 motifs in succession - a dynamic development into a C# major sound

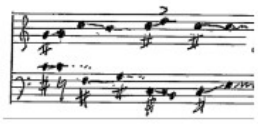
Video: "**Mockingbird (3.8.10)** - 5 motifs in a row – a dynamic development into a C# major sound" https://youtu.be/mGszZBkHsYU

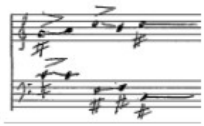
Video: "**Mockingbird (3.8.10a)** - Mockingbird song (3.8.10a) - a 2-voice spectral sound (C#/G#) with its “combination tones” - https://youtu.be/SFKYOUbBbPc



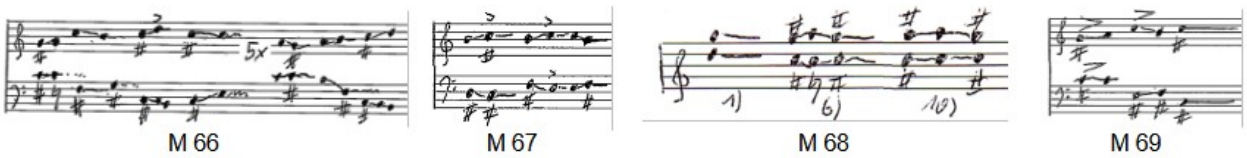
From the repetition of motifs 45 and 46 (= M65-66), a very special dynamic progression develops into a full C# major sound in motif 69. It seems as if the sequence of M45-46 - pause - motif 47-48 (M47 = variation of M46) now takes a different, creative turn. After motif 66 (= M46) there is again a clear but somewhat shorter pause, now followed by a very sonorous loud chain of motifs (M67), and then immediately only very airy sounds can be heard. The bird has obviously not even breathed for the first very quiet sound.
In a rhythmic sequence of “sound” and pauses, a very peculiar polyphonic sound phenomenon develops dynamically (M68), a fifth sound with combination tones. Before the last sound, there is a violent short noise in the rhythm, which is repeated twice at the end of the motif. It almost sounds as if the bird is clearing its throat briefly, first for the last clear fifth sound (C#/G# = “C# major”) and then before the full song in clear C# major (M69 in 3 motif chains). However, the “clearing of the throat” could also be understood as a signal for the beginning of the increase in the following chains of intense motifs. (on “clearing the throat” see p. 56)







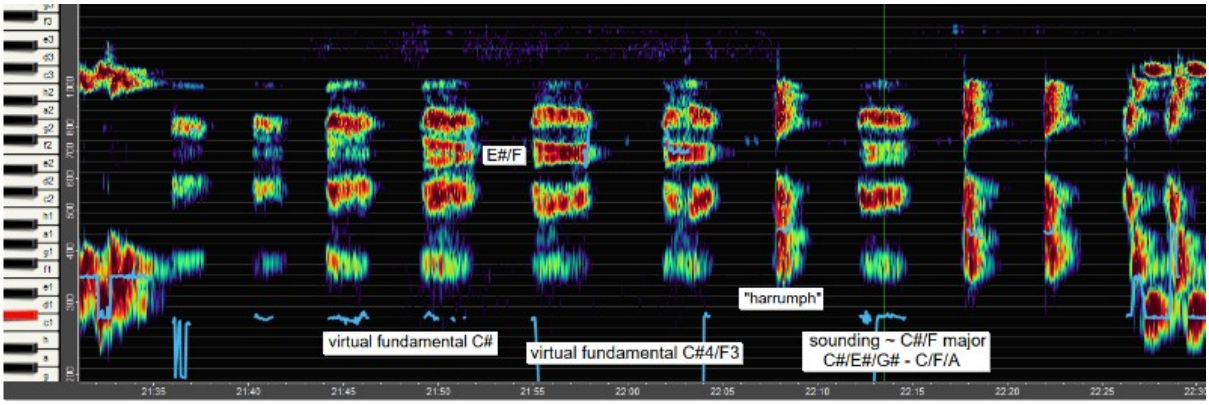
In the video “Mockingbird (3.8.10)” I have combined motif 66 and 69 directly with each other, so that you can see impressively how motif 66 has an open ending just like M46 (C#/G# → F#/B → octave C#/C# → decimal B/D) and how motif 69 ends from the fifth C#/G# through C#-7 (E#/C) in a radiant C# major sound (C#-C#7-C#-major).



The development of the main sounds in the motifs M66-M69:
M66: C#/G#→C#/C#-B/D - M67: C#/C#-F#/B-C/C-F#/B - M68: D/G-C#/E#/G#-C/F/A-C#/G# - M69: C#/G#-C/A-F#/B-C-C#/C#

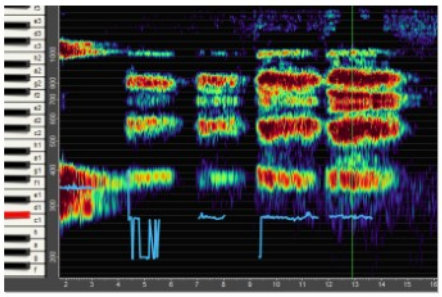
When heard in the sound spectrum, this results in the following modulation:
C#+ - G+ - C#+ - B+ - C+ - B+ - G+ - C#+ - F+ - C#7 - B+ - C#+

Motif 68 – a 2-voice spectral sound (C#/G#) with its combination tones



Motif 68 in the 8-fold slowdown shortened from 10 to 7 sounds

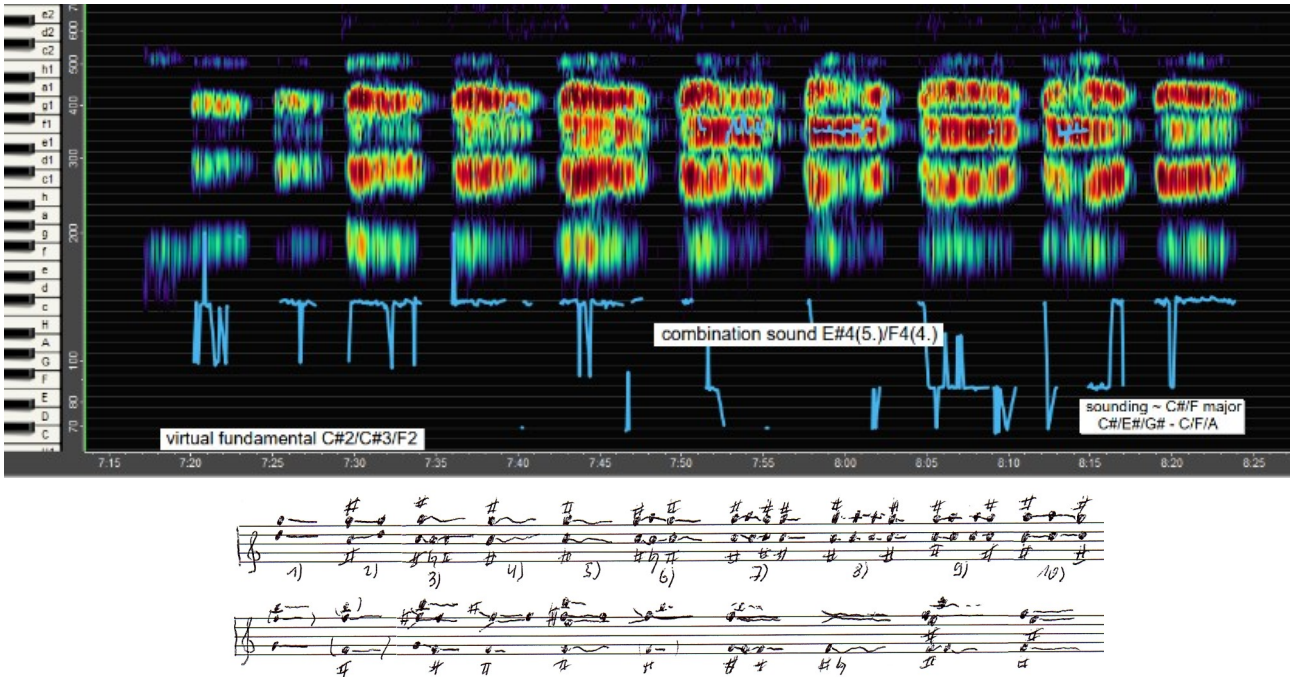
The strong loud motif 67 ends in the fourth F#/B. The immediately following, aspirated sound (~“D/G”) has the effect of both membranes being blown on, almost like a real syrinx. In human singing, this is referred to as a breath on the voice. In addition, there is a trill movement with slight fluctuations in each voice, so that no clear pitch can be heard through the breeze and the trills.
In the spectrogram I can see that it is the half-tone trill G-G#-G in the slightly louder upper voice and D-C#-D in the lower voice. The 2-voice sound thus fluctuates between the fourth D/G and the fifth C#/G#.



The interactions between these two vibrations create a sound with a complex frequency structure in the air "tube" (!) above the two membranes. So-called *combination tones* are created, an emergence phenomenon in an interacting oscillation system, which I am also familiar with from the 2-voice singing of the blackbird.
In the first sound, in addition to the main sounds D/C#2 and G/G#2, these are: G/F#1 - E#2 - B2 (8x slowdown).
In the spectrogram, the blue line indicates the virtual fundamental C#1 or G when the sound structure changes.
The sound therefore oscillates between two spectra with its own virtual fundamental and its partials:
1) G (virtual fundamental) / G4(2nd) / D5(3rd) / G5(4th) - B5(5th)
2) C# (virtual fundamental) / C#5 (4th) / E#5(5th) / G#5 (6th)
As can be seen in the spectrogram, the fourth F#4/B5 at the end of motif 67 continues to sound in the beginning of motif 68 (F#-G4 and B5 as combination tones to the fourth D5/G5).

In the third 2-voice spectral sound, the trills and the volume in the fifth/quart sound become stronger. Both voices move from C#/G# to D/G. The virtual fundamental is now C#4.
From the fifth sound onwards, the stronger inner dynamics in the sound structure lead to the development of two combination tones in the third frequency due to the interference between a C# and an F# spectral sound, an E and an F#, which virtually merge into E# (=F) at the end.
In the last 3 sounds, the dynamics in the sound structure increase further. The two voices now move from the fifth C#/G# to the sixth C/A and back again, so that the sound oscillates between “C# major” and “F major” (C#/E#G# and C/F/A). The sequence of spectral sounds ends in a melodious fifth (C#/G#) with a weak third combination tone E#.

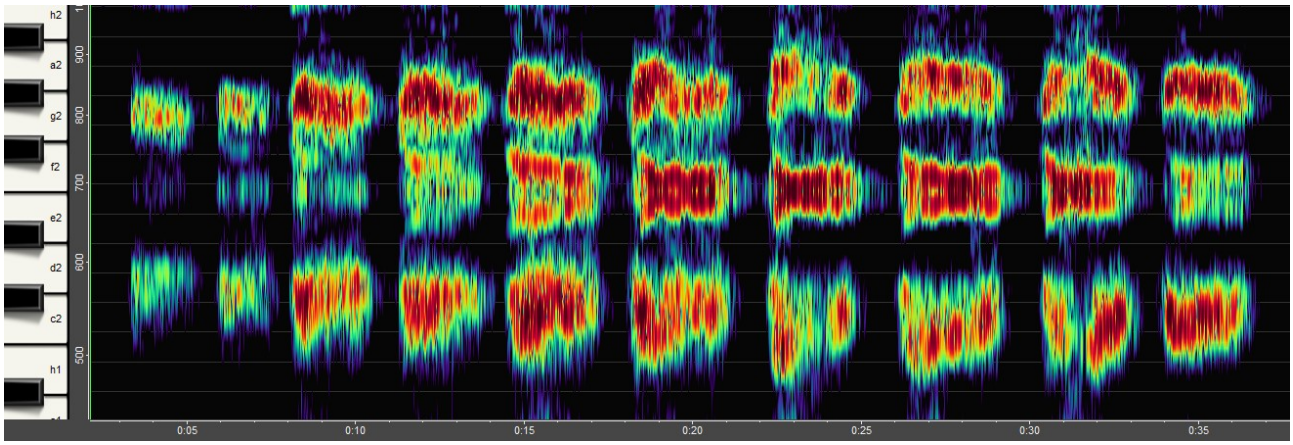
Next page the complete motif 68 in 16-fold slowdown
(without pauses and without the “clearing of the throat”)



above the development of the fifth sound - below the combination tones (approximate notation)

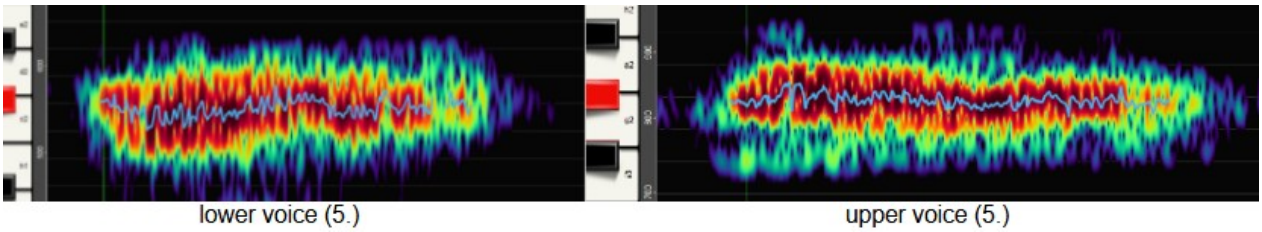
The magic of this dynamic sequence of spectral sounds unfolds in the 16- and 32-fold slowdown. There are no 2 voices, no quint sound with “additional” frequencies such as fundamental tones or overtones. Throughout the entire sequence, it is again and again and more and more *one* sound, a sequence of similar, peculiar and unusual sound phenomena that make the atmosphere in a wide space vibrate more and more, sound phenomena whose colors oscillate and glow in an iridescent spectrum, sound formations whose interiors are filled with darkly quivering vibrations and which radiate a bright glow from within.

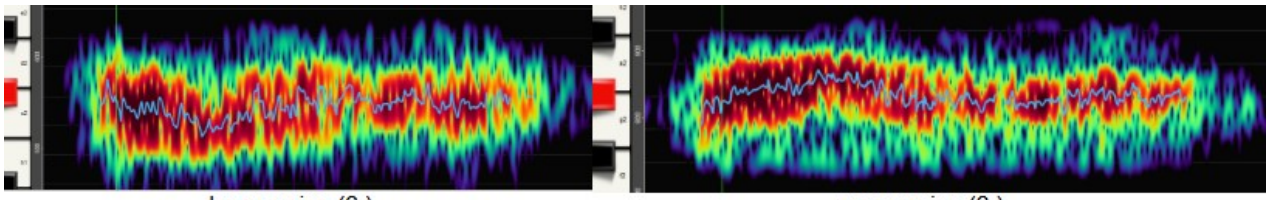
Explore the inner life of a multi-layered sound in its development with your ears

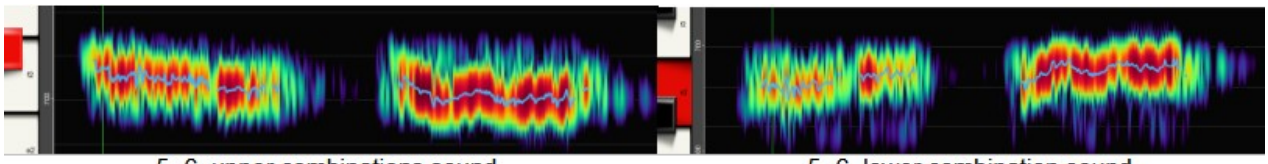


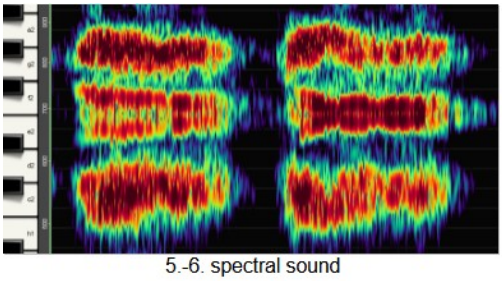
In the spectrogram above, it is easy to follow with the eyes how the inner life of this sequence of spectral sounds develops, unfolds and organizes itself, which cannot be directly understood by listening to the multi-layered sounds. For each sound is more than a 2-voice quint sound, more than the sum of two voices. In its specific spectrum pattern, its structure, its inner and outer movements and its inner dynamics, every sound and every sound structure forms a *whole*, a *Gestalt*, a *unity* whose elements are expressed in its colors, its intensities, its clarity or diffuseness, its energetic effect on the ears.
From the after-sound of motif 67, the fourth F#/H, a diffuse fourth (D/G) is formed, which slightly moves towards each other as it fades away. The 2nd sound, which is still diffuse, expands to the fifth C#/G# and at E# there is a slight hint of the third combination tone. From the 3rd to the 5th sound there is a great increase in intensity. Each sound forms a wave that begins strongly and then fades out somewhat, both voices at the beginning in a contrapuntal counter-movement from the fifth more and more into the sixth C/A. From the 5th to the 6th sound there is almost

a double wave movement (simplified for the upper voice: G#-A-G#-G-G-G#-A-G#), whereby the amplitude of the “sine wave” becomes smaller and smaller. In the individual spectrograms below you can see that both voices have the same rhythm in the counter-movement, but the amplitude can be different.
The overall picture above shows how, from the 3rd to the 6th sound, ever stronger *interactions* between the two voices apparently arise, caused by the varied dynamics of movement in each voice and between the two voices, so that two *combination tones* develop, the lower of which correlates with the upper voice and the upper with the lower voice. The upper combination tone moves from F# to F (simplified) and the lower one from a low E via F to a high E (E#?).


lower voice (5.) upper voice (5.)


lower voice (6.) upper voice (6.)

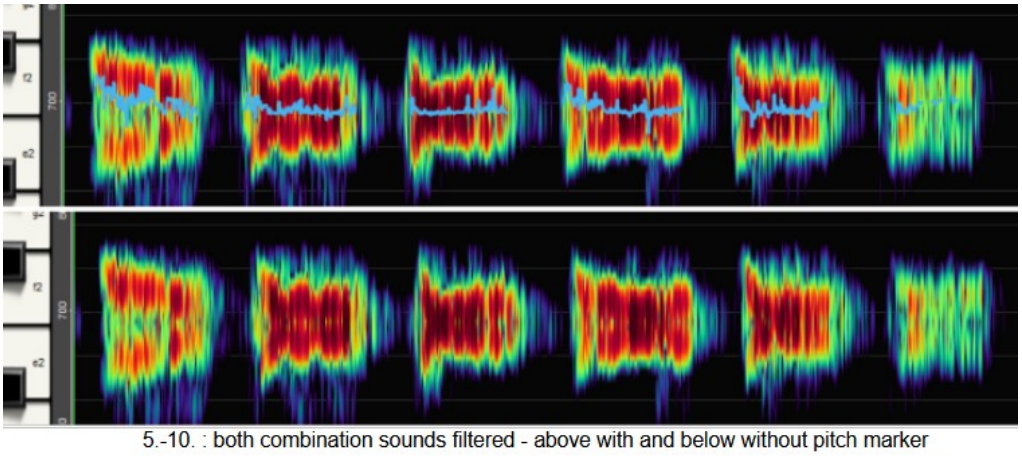

5.-6. upper combinations sound 5.-6. lower combination sound


5.-6. spectral sound

Interferences
In the 6th sound, the interaction or rather the multiple interactions within the entire sound spectrum become so strong that interference forms between the waves of the two voices, between the likewise opposing wave movements of the two combination tones and between the vibration of each voice and the combination tone correlating with the other voice. In a multi-layered oscillation system, as it is formatted in a tube (trachea), these interferences naturally also have a feedback on the wave formations. Feedback alternating effect means nothing else.
And when I speak of multilayeredness, this does not mean a vertical 2-dimensional layering of “high” and “low” frequencies, but each “tone” (C# or G#) is a *sound*, i.e. a 3-dimensional structure of spectrally structured frequencies (partial tones) that moves in time. (“High” and “low” only means that a frequency oscillates faster or slower in the same “time-space”). And when I filter each combination tone separately (as heard in the video), each “tone” is an audible more or less intensely vibrating sound that travels in the same wave motion as the correlating upper or lower voice. And if I filter both combination tones together, a different sound can be heard in each case, depending on how strong the interactions are in the overall spectrum, how close the two sounds are to each other or how strong the wave motion is.

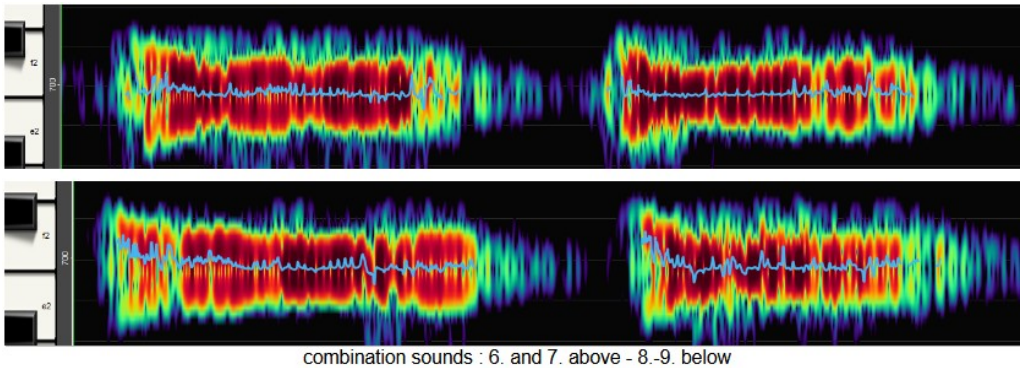
In the 5th sound, you can hear how the two “tones” move towards each other; initially the upper sound is louder, and when they are closer together, the overall sound is more intense. (The pitch marker “searches” for the loudest frequency. see picture below) In the 6th sound, the opposing wave movement of both combination tones so close together creates an intense so-called “beating”, which has a strong stimulating effect on the ear. In the 7th sound, both wave movements penetrate each other in such a way that at times only one sound between E and F can be heard.

In the 8th and 9th sounds the undulation in both combination tones becomes less, both come more into coincidence, so that in the last even fifth sound of C# and G# the interaction becomes so weak that virtually only the “third” E# resonates slightly in the harmony.

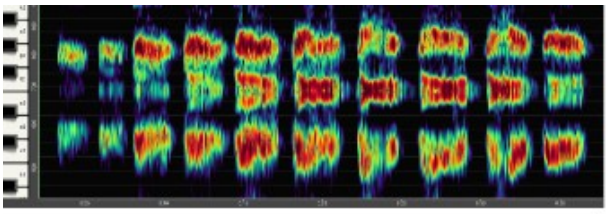


5.-10. : both combination sounds filtered - above with and below without pitch marker

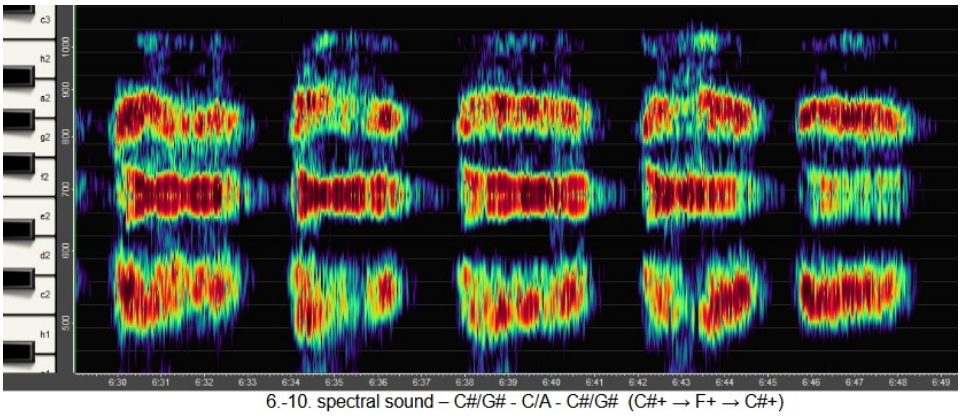
The enlargements (below) clearly show the inner structure and the inner movement in the sounding together (= beating) of the two combination tones.



combination sounds : 6. and 7. above - 8.-9. below



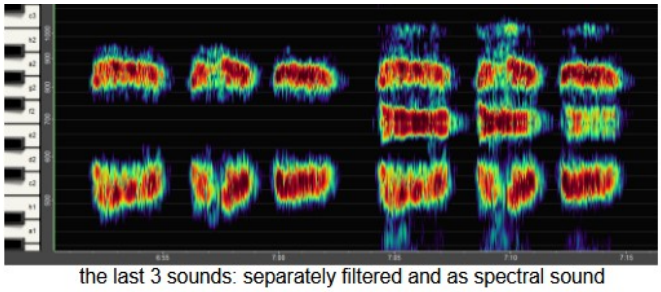
As can be seen in the overall spectrogram of the sequence of spectral sounds, there are no combination tones at the beginning of a quiet fourth/fifth. They only arise in the course of the sequence with the increase in volume and the development of the wave movement in both voices. They even become louder than the two voices, as if the sound energy is condensed in the center of the overall sound and thus the sound radiates more into a wide space (C#/G#→C/A “=” C#+→F+).



6.-10. spectral sound – C#/G# - C/A - C#/G# (C#+ → F+ → C#+)

What is particularly remarkable in this dynamic sound process is that both voices no longer sound continuously at the same volume, but seem to fade out after the first wave and then settle back in at the end of the wave, while at the same time the combination sound swells in intensity and calms down again in the fifth (7th and 9th sound - see above). In the 6th and 9th sounds, the intensity

swells and subsides several times in both voices in the course of the wave, parallel to the dynamics in the combination sound.



the last 3 sounds: separately filtered and as spectral sound

In the video (20:18), I filtered the last 3 sounds of the two voices separately. Immediately afterwards you can hear the complete spectral sound. With the two voices alone, the special phrasing can be heard in the swelling and diminishing (as described above). The sound is clear with an enveloping, bright shimmer. In the overall sound, in the 8th-9th sound, the condensed center shines more intensely, and the sound with its manifold inner colors is filled with multiple inner movements. The last sound then appears very pure and balanced as a luminous fifth sound, at the beginning with a finely shimmering color modulation between C# major and F major.

The modulation from C# major to F major has a very special attraction for the ear and the sensation. It is used in music as a special turn in the sound process, which causes an increased brightening of the sound, as can also be experienced in the song of the mockingbird. C# major and F major are two harmonies that are not connected by the fifth, as is usually the case, but are related by the third (E# = F) (“third relationship”). The “middle” of the C# major triad is transformed into the fundamental of the F major triad. F major is therefore called the “mediant” of C# major.

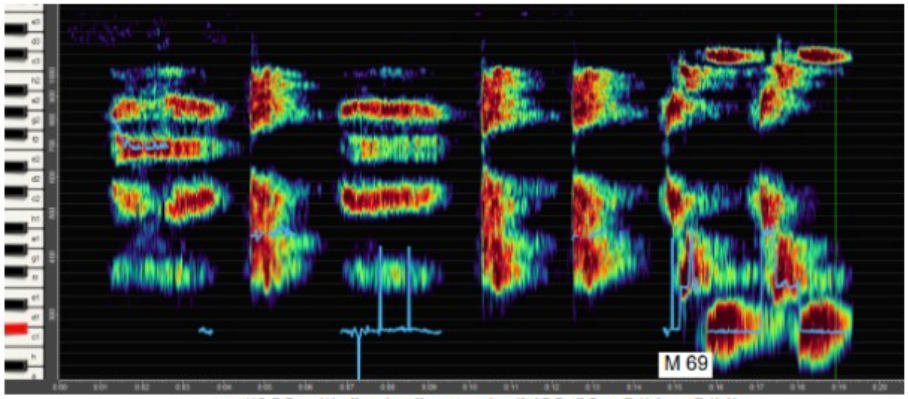
The development and unfolding of these spherical spectral sounds could also be heard and described as a large dynamic wave:

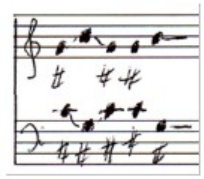
diffuse fourth/fifth → fifth louder / wave movement stronger → condensation in the center / widening and solution of the interval frame → sounding fifth with a fine third in the center

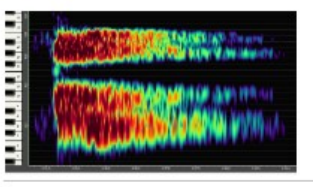
Looking at Motif 68 as a whole, I cannot recognize in this sequence of peculiar sounds any random attempts to set the voice in motion or to produce a “harmonious” fifth. The bird's song, in this dynamic development of spectral sounds, obviously follows the forces at work in the natural order of sounds, interactions in a specific spectral structure and in a system of space-time patterns moving, changing, interacting in each sound. It can perhaps be described as a *process of self-organization*, with the regulator of highest efficiency in the sounding together of the two voices and in the balancing of the interactions in the fifth as attunement or intonation for the following “C# major” motif.

Beyond these descriptions, analyses and explanations, I wish every listener “Happy New Ears” with the recommendation to be enchanted again and again by this impressive sequence of spherical spectral sounds from the sound cosmos of birdsong sung by an extraordinarily virtuoso representative of the mockingbird family, who does not imitate any other songbird, but on the contrary has created his very own way of singing with 2 voices in rhythmic and harmonic counterpoint.

The “noise” sounds at the end of motif 68

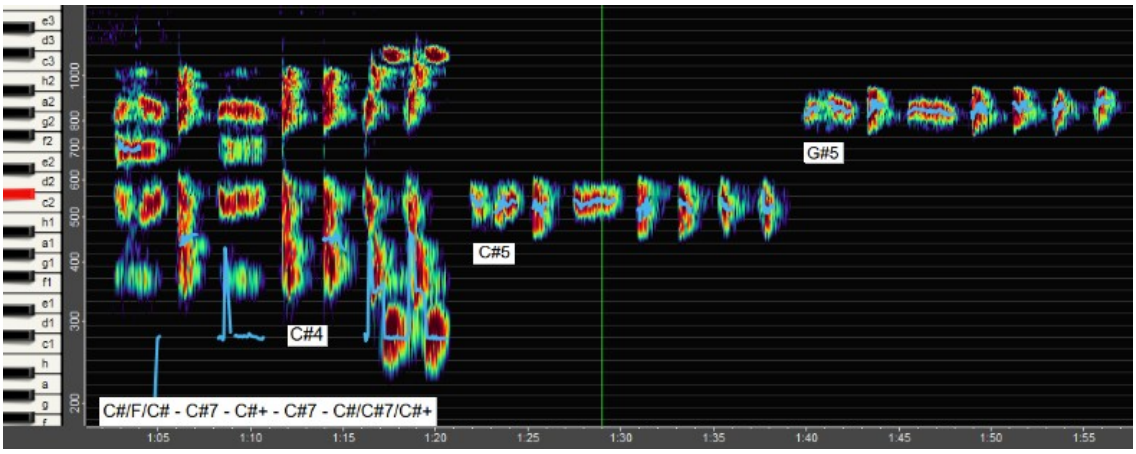




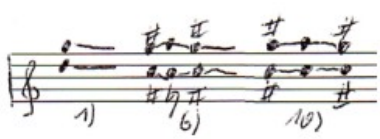


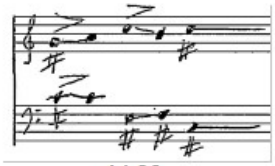
motif 68 with "noise" sounds (M68-69 : C#4 = C#4)

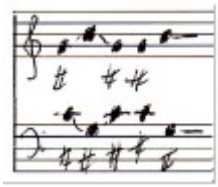
In the original position, three short signal sounds can be heard at the end of motif 68, which make a very intense noise with a strong echo effect in the 8-fold slowdown. The noise sound is obviously also 2-voice, and in the 16-fold slowdown you can hear a rhythmic pitch change in the sound, which is visible in the echo with 4 notes in the spectrogram: G#4 / C#5 / G#5 / B5.
It is hard to believe, but a C#7 sound is actually heard in this violent noise, completely coherent and in harmony with the transition from M68 to M69, and all this with a stimulating rhythmic energy.



In the video I have filtered all C#5 and G#5 sounds from the transition from motif 68 to 69, so that you can clearly hear that the sequence sounds in the spectral matrix of C#4 as a virtual and as a real fundamental tone:
C#+→F F→C# (9th sound) - C#7 (“noise”) - C#+ (10th sound) - C#7 C#7 - C#/F/C#7/C#+ (M69)

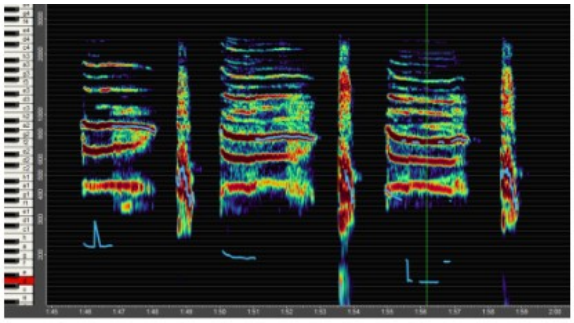

M 68


M 69



In the original position it sounded like a signal sound and in the 2- and 4-fold slowdown like a violent noise, as if the bird was briefly “clearing its throat”, before the C# major fifth and twice more before the C# major motif 69 at the end of the development from motif 65 to motif 69.
However, the noisy sound turns out to be a very fast, rhythmic 2-voice sound figure: 2 voices in contrapuntal counter-movement through a C# major seventh sound. It is a harmonically functional sound figure for the intonation of the C# major fifth and as an attunement to the following series of C# major motifs with the modulation:
fifth C#/G#→second C/A(F+)→C#7→octave C#(C# major).
The English expression for harrumph is “clearing the throat”. And so this sound of the bird cannot be understood as a clearing of the throat in the sense that a disorder or dysfunction in the throat is to be cleared, because singers should not clear their throat noisily before and during singing.
In terms of vocal technique, it would also be very risky to interrupt the development of the spectral sounds in motif 68 and the transition to motif 69 with any kind of noise. The sound balance in and between these spectral sounds is far too delicate for that. A break in the matrix of the sound structures would fundamentally disturb the sensory and acoustically balanced fine adjustment of the vibration in the membranes.
Heard in this way, this sound figure could be understood as a kind of “vocal exercise” or singing practice, with which a singer loosens up the throat and makes it supple by means of a fast rhythmic tone sequence, e.g. through a vocally and harmonically functional exercise such as a scale, a triad or even a chord break through a C# major seventh chord: C#-E#-G#-H. In this way, not only does the throat become and remain flexible, but the ear is also adjusted and tuned for the development and unfolding of the C# major sound.

Addition



In the song of another mockingbird there is also a motif with 2-voice spectral sounds, but they do not have such a complex structure. They are 2-voice thirds that run fairly flat and parallel.
In their proportions, they correspond to the 4th and 5th partials of a virtual fundamental (here A, G, D).
The combination of the two voices creates a matching overall spectrum from the 3rd to the 8th partial.

The singing of this mockingbird is also very virtuosic. However, it is predominantly monophonic with many different complex sound figures. In some motifs the two membranes alternate in one motif, resulting in 2-voice overlaps.

Video: “Mockingbird 1.3 - 8x slowdown with notation” - https://youtu.be/sCGxua3DuVM