The "blind spot" or the deaf ears of brain and consciousness research:

the control circuit of vocalization-vagusnerve-hearing - integrated via the *Formatio reticularis* (Brainstem)

In 2023, Mark Solms' impressive book "The Hidden Spring: A Journey to the Source of Consciousness" was translated into German, which I read with great interest. I then read Antonio Damsio's book for the second time, which in a different way is written very inspiringly: "Feeling and Knowing. Making Minds Conscious", in German with the title "How we think, how we feel. The origins of our consciousness".

Solms' book has the subtitle in German: "Why we feel what we are". In his foreword, Solms writes that he and you place the focus of neuroscience "on the embodied nature of lived experience." And Damasio writes in his book that the classic gap that separated the physical body from cerebral and mental phenomena is bridged in a very natural way by feelings.

Damsasio writes in the chapter "Basic Feelings III" (in my retranslation):
"Since the actual *object* of feeling/perception is nothing other than a part of the organism itself, this object is located *within the subject/perceiver*.
Astonishing! Nothing comparable happens when we perceive the outside world, for example when we see and hear. The objects of visual or acoustic perception do not communicate with our body. The landscapes we see or the songs we hear are *not* in contact with our body, and certainly not within it. They exist in a physically separate space.
In the area of feelings the situation is fundamentally different. Since the object and subject of feelings/perceptions exist in the same organism, *they can interact*. The central nervous system can modify the physical state that gives rise to a certain feeling and thus also change the feeling. *This is an unusual organization that has no counterpart in the world of external perception.*"

And Solms writes in chapter 5 "Feelings":
"Affective states - hunger, thirst, fatigue, nausea, cold, urge to urinate and defecate, etc. - have a *hedonic valence* in contrast to other psychic states: they feel "good" or "bad". This distinguishes affective perceptions such as hunger and thirst from sensory perceptions such as sight and hearing. What we see or what we hear has no intrinsic value in itself - feelings do."

For that I have some fundamental questions and various considerations under the perhaps somewhat provocative title:

The "blind spot" or the deaf ears of brain and consciousness research: the control circuit of vocalization-vagusnerve-hearing, integrated via the F*ormatio reticularis*

Here are my **themes**:

1) The evolutionary development of the ear as an organ for orientation, balance, communication, perception of danger and stimulation of cortical electrical potential. Every listening experience is associated with vegetative and psychological arousal. (p. 4)

2) Internal and external perception - about inner hearing and the perception of one's own voice

3) Hearing is not the same as seeing (p. 7)
There are no tones or sound "out there", only periodic fluctuations in air pressure (Heinz v. Förster), which are transformed in the ear with the help of cochlear efferents into a spectral frequency pattern structured in time and space - a sound *gestalt* (already in the cochlea!).

- "*Music is the hidden arithmetic activity of the soul, which is not conscious that it is calculating.*" (Leibniz) - in humans in their music and in their singing and in the same way in the singing of songbirds !

4) Hearing and sound "consciousness" in vocal communication in songbirds in physical-spectral and harmonical sound order. The syrinx-vagus-ear control circuit and the “beautiful sound order”, the cosmos of bird song (p. 9)
What it is like to sing and hear as a bird ("Thomas Nagel"), in vegetative arousal, in hearing their own song, the song of their fellow birds (m/f) and communicating together in the spectral matrix

of their species (exactly measurable, calculable and analyzable in detail by octaving slowdown and spectral analysis)

Appendix

Vocalization - Vagus Nerve - Hearing

If you describe very clearly the basic homeostatic feelings that take place in the physical realm of the body - well-being, misery, hunger for food and air, thirst, pain, desire, pleasure - but:

Where is the *vocalization*, the *voice*, the existentially elementary need after *contact* and *social communication*, which is audible and expressed in every sound and every cry of a baby?

A baby that screams, for whatever "reason", that *is* the cry with its whole existence, that is the whole *body*, that is pure *sensation*. Screaming is not even an expression, and I wonder whether it can even be described as an affect ("af-fect"). When a baby cries, it's not just the vocal folds that vibrate, the eardrums vibrate, the whole body and the whole skull vibrate, including the whole viscera and the whole brain tissue.

On the other hand, when premature babies are stroked, if their mother talks to them or sings to them, if a doctor plays them music on the cello, then their breathing and heartbeat calm down and the vegetative system switches to the regenerative parasympathetic mode, which has a positive effect on the further development of the premature babies.
Vegetative arousal, vocalization, sensation, hearing, voice, sound, music - all this happens in *one* physical space of sensation and bodily perception; all of this together and each with its own degree of effectiveness has a high "intrinsic value".

The deep throat and larynx, this is *the core area of human life and survival*, where the paths of breathing, nutrition and communication intersect. And our entire lives, from the first breathing cry of the newborn to the last sigh when dying, resonate and reflect in this highly vulnerable physical space between inside and outside, outside and inside, all our deep, big and small sensations and feelings as a direct expression of our physical and mental life and experience.

In all vertebrates, even fish, vocalization is innervated by the vagus nerve. The cochlea developed from the lateral line organ of fish and the auditory ossicles developed from the jaw of reptiles.
In birds, feeding and breathing are separated, the syrinx is stable and well protected at the end of the trachea, and so the songbirds were able to develop the incredible cosmos of their song without conflict around 60 million years before Homo Sapiens - based on the same interactive control circuit of vocalization, vagus nerve and hearing, integrated via the reticular formation, as in humans.

You know that the vagus nerve, as an opponent of the sympathetic nervous system, controls the "big five" of the autonomic nervous system in a parasympathetic manner: heartbeat, breathing, digestion/micturition, sexual arousal and the larynx. (Sexual arousal means the erection of the clitoris and penis, and in birds the innervation of the testicles and ovaries.) At the same time, the vagus nerve has connections to the vestibular organ, the middle ear and the external auditory canal. The innervation of the larynx/syrinx is *purely sensory*; there is no direct muscular control of the voice and singing from the cortex !

(The vagus sensorily innervates the inner and outer larynx muscles as well as especially the mucous membrane tissue in the larynx and on the vocal folds via 2 branches. If the mucous membrane is inflamed, vocalization is fundamentally disturbed.)

When a baby screams or cries, this can also be an expression of a lack of social contact that is essential for survival. A toddler (from 1 year old) makes contact sounds 100 times in an hour, which can mean both that he feels and hears himself vocalizing, and which can also mean that he hears and feels the calming closer or somewhat distant presence of his mother. And when a small child cries or screams, it can be an emotion because something hurts or because he is hungry, it can be some kind of misfeeling, fear, anger or defensiveness. And a small child can scream persistently because he is flooded and overwhelmed by sensations and feelings that he cannot yet express emotionally and can intentionally direct towards an internal or external "object" of apperception.

In adulthood, however, ambivalences can arise when, for example, an actor is supposed to scream out of anger in a scene, but he cannot scream "genuinely" like in an affect because he wants to mentally "play" the screaming, which inhibits the reflexive and sensory activation of the vocalization. As a spectator, I can hear (in the outer space) that an actor (in German "show-player") is *playing* something like anger, but I am not touched or emotionally affected by his way of vocalizing, by the sound of his voice, it sounds "made".

If a highly qualified singer develops a myoma in the *musculus vocalis* or mucosal oedema because he sings with too much pressure (breathing pressure and closing pressure in the vocal folds interact) and the muscle fibres can no longer relax, he is singing with a vocal technique that is dysfunctional because vocalization is controlled by the sympathetic nervous system.
And this with an organ that has developed physiologically and functionally in evolutionary terms in such a way that it is extremely resilient. A baby does not become hoarse and does not get a vocal fold myoma even after hours of screaming. However, many children today have hoarse voices because they are under too much stress.

As a singing teacher with 40 years of experience, I could tell you a lot about the physiological, emotional and mental conflicts that arise from this complex. Attached you will find 3 condensed texts on these topics from my website (see appendix p. 19):

- Singing with a “Closing Muscle”? (*musculus vocalis*)
- "Control" of the Larynx? (*nervus vagus*)
- *Formatio reticularis* - the Sound in the Head and in the Ears

<u>Stimulation of the vagus nerve in a coma patient</u>

This patient had been in a vegetative state for 15 years. The neurologists gave him only 5 out of 23 points on the scale for impaired consciousness. For one month, they used electrical stimulation of the vagus nerve in the patient and were thus able to bring him to a higher state of consciousness (10 points). When the neuroscientists asked him to follow a mirror with his eyes, he suddenly succeeded. When they asked him to turn his head to the side, he did the same. He even smiled and cried when they played him his favorite music. (Angela Sirigu in "Current Biology" 2017)

The Basic Regulation of Phonation via the Reticular formation

"The reflex arc of the *M. tensor tympani* is connected via the reticular formation. The small ear muscle is therefore involved in the general proprioceptive impulses of the trigeminal nerve, which play an essential role in the tonic activity of the reticular formation. Restricted function of the mucous membranes and muscles (including the masticatory muscles) innervated by the trigeminal nerve hinders the meaningful work of the reticular formation.
This brainstem area is the central point for optimizing sensory stimulus selection. The activation level of the reticular formation also significantly influences the state of consciousness. It directs the intensity of sensations and perceptions. The actual decision-making processes linked to consciousness, from which self-movements also occur, do not originate in the cerebral cortex, but in the brain stem. In any case, the basic control for phonation or singing takes place from here,

which reflexively interconnects muscle tone, breathing and vocalization, again depending on the level of nerve tone in the reticular formation."
(Excerpt from a publication by Gisela Rohmert - in the appendix)

see also the “polyvagal theory” of Stephen Porges https://en.wikipedia.org/wiki/Stephen_Porges

It is completely incomprehensible to me why neither the book of Solms nor that of Damasio contains anything about these fundamental connections between vocalization, hearing and the vagus nerve!

About me and my research

As a voice-sound teacher and singer, I come from the "school" of the 'Lichtenberg Institute for Applied Voice Physiology', which has researched the function, physiology, sensory system and synergy of the voice scientifically and practically like no other institute (based on the evolution of laryngeal function). On my website https://www.entfaltungderstimme.de/ you will find some of my texts on topics such as: "Who wants to hear must sense" ("sentire" = feel/listen - *nervus facialis*), "Breathing and Singing in the Parasympathetic Mode", "Singing with a Sphincter?" (primary function of the larynx), "Control of the Larynx?" (*nervus vagus*).

For many years I have been studying the function, physiology and neurology of voice and singing as well as neurobiology, brain and consciousness research. For 6 years I have developed into a veritable researcher of bird song, who has explored and discovered in my own way *what* and *how* birds *really* sing and hear, what vegetative arousal they are in when singing, how they hear and communicate with each other, males and females, in the spectral matrix of their species - all in the control circuit and interactive system of syrinx-vagusnerve-hearing, in the physical, spectral and harmonical order of sound and, above all, with highly developed and complex hearing and sound consciousness. Everything can be measured, analyzed and documented and at the same time is an incomprehensible miracle. (a book publication is being planned)

In my bird song research, I "let myself be taught by nature" (Manfred Eigen, Nobel Prize for Chemistry) and thus gained fundamental insights and understanding, that do not only concern bird song. These are questions of ethology and cognition (song as behaviour / auditory and sound consciousness in humans and animals), function/physiology and neurobiology of vocalization in vertebrates (vagus nerve), cochlear afferents and (!) efferents (otoacoustic emissions from the formatio reticularis), the auditory system as a spectrum transformer (the ear hears logarithmically), innate auditory gestalt perception (according to Konrad Lorenz), sound-gestalt (fifth = 2:3 as gestalt), vocal learning, physical nature of sound / "sound of nature", the interacting system of vocalization-vagusnerve-hearing in songbirds and humans, sound-music-language.
These findings call some seemingly familiar things into question, but at the same time they open up many new perspectives.

Here is an overview:

1) Evolution of Hearing

Evolutionary, the ear is shaped as an organ for orientation, balance, communication, perception of danger and stimulation of the cortical electrical potential. (Hearing loss increases the development of dementia and depression.) Every hearing experience is associated with high vegetative and psychological arousal (sympathetic or parasympathetic).
The prehistoric functions of the ear shape the interaction between hearing and vocalization, both in hearing oneself in vocalization and singing as well as in hearing the voices and singing of other people. And they continue to shape how we listen to music today.
But the hearing as an organ for hearing danger can become an organ of sensation that can react to the finest and most intense vibrations with the considerable differentiation and complexity that it developed in the early fight for survival in evolution and thus receive and permeate an immeasurable wealth of frequency spectrum. Beyond the stress of everyday life, which is sufficiently influenced by the survival strategies of early humans, this primary sense of perception can open the gates to sensations of the highest excitement, comprehensive liveliness and deepest pleasure.

Even in our modern acoustic world of experience, the auditory system still reacts in its original function of warning and all-clear, activation and deactivation. The characteristically uneven babbling of a brook as well as the very evenly rushing noise-sound of ocean waves: both acoustic phenomena with a high-frequency sound character have a very strong stimulating effect on the nervous system via the auditory system - for some it can calm you down wonderfully and even put you to sleep, for others it causes nervous overexcitement, and for still others these stimulating sounds put them in a balanced, calm and wide awake state of mind, the balance of activation and deactivation.

The ear cannot be closed like the eye.
Even during sleep, the ear is a danger organ that reacts to external acoustic stimuli. When an insect approaches with its fine, very high frequencies, we wake up. And there are reports that some people have auditory perceptions even under anesthesia that are stored.

Humans can hear whether chickens are happy or frustrated.
In keeping with my comments on the evolution of hearing, I have recently read a report on an experiment by behavioral scientist Nicky McGrath (University of Queensland, Australia) in which chickens had learned to associate sounds with certain consequences that either promised a reward or would cause disappointment. In the experiment, people who have no connection to chickens were able to distinguish whether the chickens were looking forward to the reward or whether they were frustrated only by the type and sound of the clucking. Previous research has also shown that humans can recognize the emotional context of the calls of different animal species. Many animals express feelings in a similar way and humans can recognize their sounds. Already for early primates, this may have been a vital survival skill.

An open laugh and an audible yawn have a contagious effect -
an evolutionary form of empathy and mutual stimulation via the ear

Laugh: In Chinese, there is the saying "Don't trust anyone whose belly doesn't shake when they laugh". In an open and lively laugh, the abdominal wall bounces, the diaphragm "dances", the larynx is deep and freely hanging, the deep throat is open, the root of the tongue is mobile, the jaw is loose, the mouth is wide open, all facial expressions are highly active, the eyes are bright, etc. All of this can be heard directly and experienced empathically in the sound of laughter, in the sound of the vowel "a", the most open and sonorous vowel.
All defenses, all stress and protective patterns (sympathetic nervous system) are neutralized and put out of action, such as tense abdominal muscles, tight diaphragm, high larynx, closed throat, tense tongue, clenched teeth, clenched lips or aggressive "smile" (teeth bared), etc.
The immediate auditory impression of the vividly excited openness in another person's laughter reaches the brain stem via the ears in the fastest and most direct way and triggers a reflex arc in the listener, in which afferents and efferents of the nerve connections of the vagus, glosso-pharyngeus, facialis and trigeminus are activated, so that the listener is reflexively placed ("animated") in the same state of trust, openness and liveliness: the abdominal wall jiggles, the diaphragm dances, the throat is permeable.
(Tensing the straight abdominal muscles automatically triggers a chain of tension (defense): Pelvic floor tense, larynx high, closing pressure on vocal folds (sphincter), throat tight).

Yawning: When yawning, you inhale in bursts, the chest expands tensely, the larynx is lowered, the deep pharynx is distended, the mouth is opened wide, the tongue and palate tense and close the oral pharynx and the Eustachian tubes (you hear less), the eye ring muscles contract --- and then, from this peculiar combination of the greatest possible tension and expansion, the increased muscle tone can dissolve into a sonorously relaxing yawn, a glissando downwards through the now released open resonance chambers (including the auditory tubes and the access to the middle ear) and into the deep open throat. The following inhalation then goes deeper of its own accord, which is possibly the purpose of the "exercise".
It is precisely this typical sound in yawning that triggers the same reflex arc via the auditory system as in laughter, in order to trigger a similar release process from over-tension in the listener.
In my singing lessons, too, the yawn reflex occurs in students from time to time when an over-tension or inhibition in the physiological framework of the voice-ear system wants to dissolve. Yawning can then act as a trigger for more parasympathetic toning. After a good yawn and a calm

inhalation, a full, open vocal sound can usually unfold in the permeable, flexible resonance rooms and in the ears.

see in the appendix p. 25 the detailed text: "Evolutionary imprints of the human ear - and how they affect the perception of singing voices"

2) Internal and External Perception - about I*nner Hearing* and the Perception of one's own Voice

The fetus' hearing is already fully developed after the 18th week of pregnancy. The high frequency ranges of the mother's voice (around 3000 Hz) in particular have an effect on the foetus' hearing via the spine and characterize this range as the one with the highest hearing sensitivity. The fetus also reacts to music. A baby cries in quint glissandi. Babies can recognize the prosody of their mother tongue (e.g. French or German). Even babies can recognize sadness and anger by the sound of their parents' voices. Even at the age of five months, they have an amazing social sense and can hear whether a group of laughing people are friends or not, i.e. whether it is an open, hearty laugh or whether it is a socially influenced, artificial laugh.

Inner hearing via bone conduction and the Eustachian tubes accompanies us throughout our entire lives. This not only affects the sounds of the intestines, the pulse of the heart and the rush of the blood, but also the unconscious, continuous perception of our own voice when speaking and singing. 70 percent of people don't like their speaking voice when they hear it on a recording. (Even a great singer like Dietrich Fischer-Dieskau didn't recognize his voice on some recordings and only found one recording with which he could identify with the singing quality. But he constantly sang to his students how they should sing, like most singing teachers)

Internal and external perception in children
In my singing courses, I often meet people who tell me that they were no longer allowed to sing together in elementary school because they could no longer hit the notes, but would sing "off-key" or incorrectly. They would "hum" (in German we say "brummen"). That was a very shameful experience for everyone.
It is well known among child psychologists that children at the age of 7/8 experience an alteration in connection with internal and external perception or self-perception and perception by others. During this phase, they learn to distinguish better between how they experience something from their internal perspective and how other people perceive something from their perspective. They then understand irony and "adult jokes", for example.
From this age, most children have a singing range of 1 octave and must first find their correct voice position. For some children, however, it is a problem in this transitional phase that the *coordination* between inner and outer perception is disturbed. This means that they cannot reconcile how a tone or melody sounds when they hear it from outside and how they hear a melody when they sing it themselves. Many children don't notice this at all or it disappears after a while. For some people, however, the experience of "singing wrong" and "not being able to hit the right notes" becomes a kind of trauma. However, some come to my courses or singing lessons as older adults, even though they still "can't hit the right notes" because the urge to sing is simply too great.
In my many experiences with this very complex problem, it is not only these people who show how strongly the reflexive control loop of ear and voice can be disturbed by shame, fear, inhibitions and social control.

My way of teaching singing is about unlearning the socially/culturally influenced and judgmental habit of hearing in order to create space and enable freedom that can promote sensory self-organization and synergetically efficient interactions in the voice-ear system. Then the ideas of "my voice" no longer need to be taken so seriously, a somewhat paradoxical process of alienation or weaning from the "*persona*", the "owner" of feelings and great teller of personal history and imaginative stories. (You know what I mean?) (see text "Control of the Larynx" p. 19)

If you cover your outer ear canals, you can still understand any spoken text and listen to music (via bone conduction). There is a difference in perception whether you cover your right or left ear (right/left brain). In order to neutralize my evaluative habitual hearing (right/wrong, beautiful/ugly, pleasant/unpleasant for others), I keep my outer ears closed when singing in order to leave the regulation of sound quality and sound efficiency entirely to the synergy effects of the self-organized voice-ear system without subjective, “personal” control.

a listening experience
A recommendation: Next time you go to a concert, I recommend that you place the cups of your hands behind the auricles of both ears, as people who are hard of hearing do. You'll be amazed at how close and direct the sound is to you, even if you're sitting in the back row. You probably can no longer distinguish whether your ears are in the middle of the orchestra or the orchestra is grouped around you, whether the sound is in your head or the head is in the sound. And if the oboe penetrates your ear canals too much or massages your cerebral convolutions, you can leave one hand out. I do this at every concert, in the sense of less "ascoltare" (hearing) and more "sentire" (listening/feeling), perceiving more of the inner spectrum of the sounds and being more deeply and impressively connected to the inner life of the music.

Inner Space and Outer Space (to a poem by Rainer Maria Rilke - my translation)

One space extends through all beings:
World inner space. The birds fly silently
through us. O, I who want to grow,
I look out, and *within* me the tree grows.

"Durch alle Wesen reicht der *eine* Raum:
Weltinnenraum. Die Vögel fliegen still
durch uns hindurch. O, der ich wachsen will,
ich seh hinaus, und *in* mir wächst der Baum."

Inner space and outer space, for the singer and for the listener: In hearing a voice, I am in the inner world of the singer and my tones as a singer penetrate my inner world and penetrate the inner worlds of the listener. Whether I want to or not, whether they want to or not - these are the "silent birds". Sound worlds and hearing worlds are always inner worlds *and* outer worlds - "*one* space". *As a singer and as a listener, the sound is in me and I am in the sound*.

3) Hearing is not the same as Seeing

"Not being able to see separates us from things, not being able to hear separates us from people." (Kant)

I hear the voice of someone I don't know on the phone and I can immediately feel benevolence or distance towards them. Or I hear the voice of a familiar person on the phone again after a long time and I can't look at how he dresses now, whether his hair is gray or he has more wrinkles, but when hearing the voice, a huge number of memories are immediately present as well very vivid impressions of his current state of being.
Experiments without visual contact have shown that the expressiveness of the voice, how and in what emotional tone something is said, is superior to all other indicators such as facial expressions or appearance. Even meaningless babbling effectively communicates emotional states.

Among the *Pygmies*, the oldest inhabitants of the Central African rainforest, there is still an ancient tradition of singing in pure vocalization, i.e. without language and text, both as solo singing and in groups. And when they cannot see each other in the dense forest, they communicate with sounds, with a sound language, i.e. with a speechless vocalization, through which they can hear, understand and communicate from an invisible distance where and at what distance someone is, what they are doing, what they see in their immediate surroundings, how they are doing, etc.
In their songs there are sound figures in which they follow the physical order of the "natural tones", i.e. they alternate between the 3rd, 4th and 5th partials (G - C - E). I have also found the same sound figures in different songbirds.

In contrast to sight, the sense of hearing is not just a distant sense that allows perception at great distances, even when the sound source is not visible. This is because the sense of hearing is also a *near sense*. Intense noises and high-frequency sound events can literally penetrate the ears. The bass at a rock concert makes your stomach and intestines vibrate. Deep sounds in relaxation music can have a vegetative calming effect that stimulate the peristalsis in a parasympathetic way. (However, my mother, who had experienced the bombing war on her own body (in German "closed to skin"), could not tolerate such low frequencies in relaxation music, as they reminded her of the deep droning of approaching bombers).

In hearing, there are no "objects" outside of me. There are no tones or sound "out there", only periodic fluctuations in air pressure (Heinz v. Förster), which are transformed in the ear with the help of cochlear efferents into a spectral frequency pattern that is structured in time and space - a *sound-gestalt* (already in the cochlea!). The auditory system in birds and humans is not a "recording device" for pitches, which are then "mapped" as "images" in a tonal topology in the auditory cortex, but an ***active-receptive spectrum transformer***.

Destruction of inner hair cells in the cochlea (1 row - afferent - receptive) leads to hearing loss, but if too little or no electrical potential is conducted from the brain stem via efferent pathways to the outer hair cells (3 rows), the incoming sound cannot be converted into the appropriate spectrum or we are deaf.

On the telephone, only frequencies of 300-3000 Hz are transmitted because physicists have discovered that smaller amounts of information can be transmitted in this way. This means that if I speak at about 120 Hz in the normal speaking pitch of a man, the pitch is not transmitted at all, but only the spectrum of my voice, i.e. the overtones, which range from 360 to 3000 Hz. (The complete spectrum of my speaking voice extends to over 12 kHz.) Nevertheless, the receiver not only hears the correct pitch, but also the dark coloration of my voice.
The same applies if I sing on the phone a Schubertlied in the range of 90-360 Hz, the receiver hears every single note with its respective spectrum, all the timbres, the performance and understands the text. However, overall perception of the sound is limited because high frequencies are not transmitted, which are important for the timbre of the voice and for consonants such as "s", "sh" or "t" (5-8 kHz). (When a branch cracks in the forest, the frequency is 5-7 kHz. This is where our ear is evolutionarily very sensitive.)

This addition of the spoken or sung pitch to the sound is not an illusion, not an acoustic deception and not a construction of the cortex (like at the "blind spot" in the eye) - it is pure physics, the nature of sound, because the spectrum makes the sound, and physically every tone is a sound, except for a pure sine wave, which does not exist in nature. According to physical laws (spectral analysis), our ear creates a precise and differentiated sound spectrum in (!) the cochlea, which can be reproduced in the same way in a spectrogram on the overtone analyzer, in which the non-sounding virtual fundamental tone is represented by the pitch marker as the lowest frequency of the sound wholeness is displayed.
There is a similar spectrogram image for spectral sounds with virtual fundamental tones produced by various songbirds. (see below for the Zebra finches)

Conversely, we hear a sound with a low frequency spectrum (colorless voice) completely realistically, as it sounds *in natura* and as other people hear it and how it can be documented in the spectrogram. But we cannot add overtones in our imagination that make the real sound vibrate more fully. However, a composer can imagine a variety of sounds "in his head" alone and write them down on paper in musical notation, just like Beethoven, even though he was deaf.

With the same power of imagination I hear in my dreams the most beautiful music that I have never heard in reality; and I can play music on the piano at sight (correctly!) that I don't know, but which I can write down when I wake up directly from a dream, as I usually do, or play the same thing on the piano when I'm awake; although I don't have absolute hearing, when I check the pitch on the piano immediately after waking up, the tones heard in the dream match the real pitch; or I don't recognize a chord correctly in the dream when I first read and play it, but then correct myself when I look closely. (The fingering for a normal seventh chord is well stored in my memory, but not so well for a septnon chord as it was written in the notes in the dream.)
Many years ago, in a dream, I heard a Schumannlied sung on an imaginary "recording" - no one was present to sing - in an ideal quality that I am not able to achieve in reality; I can still remember this quality today - it was the essence of this music and pure liedsinging.

Many songbirds produce spectralsounds with a virtual fundamental that are very differentiated and complex in their respective spectrum, with which they can communicate with each other, in a physical-harmonically order that is also understandable to our ears when we transpose them in the range of our listening capabilities.

(see Zebra finches p. 11 and in appendix p. 23 - the "C major" spectral sound of a blackbird)

***"Music is the hidden arithmetic activity of the soul,
which is not conscious that it is calculating."*** (Leibniz)

4) Music and Mathematics for Humans and Songbirds

In a major triad (e.g. C-E-G), a mathematical ratio of overtones is formed (4 : 5 : 6) - we experience this as pure, harmonious, clear, bright, uplifting, etc.
In a minor triad (C-E-flat-G), the minor third "E-flat" rubs against the "E" of the major third as the overtone of the fundamental (5th partial that resonates in every minor triad) - we experience this not as "durus" (hard), but rather as "molle", soft and somewhat wistful, touching, etc.
A fifth (the ratio 2 : 3) sounds open and empty to us in harmony, a fourth (3 : 4) sounds denser, more compact; in a sequence of intervals, a fifth opens into a wide space, while a fourth pushes into active movement.
If a tone vibrates at 200 Hertz, then the so-called "pure" fifth vibrates in a ratio of 3 : 2, i.e. at 300 Hz, and the fourth to the fifth in a ratio of 4 : 3, i.e. at 400 Hz, the octave to the tone at 200 Hz, i.e. in a ratio of 2 : 1. Our ear/brain "calculates" this very precisely and registers the smallest deviations, which we can perceive as incongruous or as a special stimulus like the minor third.

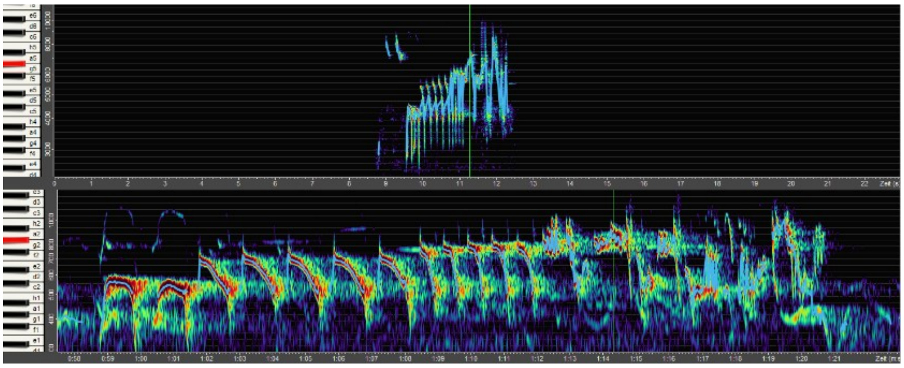
Of course, birds do not have such sensations of intervals, although they can sing such intervals as a sequence of notes and even in two parts with the separate membranes in their double syrinx. They don't sing minor triads either, because they only sound attractive in polyphonic music, but I have repeatedly heard a quartsext sound in the blackbird when it first sings a C and then a two-part F/A; we hear this as an inverted F major triad. Or the blackbird sings a C major triad three times in succession, first C--E---- and then the fifth G--- is added to the continuing E as the upper voice. (see spectrogram on page 17)

But the greatest and most astonishing discovery of my bird song analyzes was precisely that the songbirds, simply put, do not sing any sounds in which we sometimes think we hear this or that, but that all their singing, even at the highest speed and in the highest sound spheres, of which our ear can "only" perceive a stimulating twittering, that this highly complex and varied singing of the most diverse songbirds follows the *harmonical spectral order* of the physical nature of the sounds, in the structure and in the tone or sound sequences:
the mathematical integer proportions of 1:2:3:4:5:6:7:8:9: ... (octave, fifth, fourth, third, seventh, octave, ninth etc. ad infinitum).

This applies to Australian Pied Butcherbirds and Zebra finches as well as European blackbirds, nightingales and robins, the South American Orphean wren and the mockingbird and hermit thrush in North America. Pied Butcherbirds sing "natural sevenths" in a duet in a ratio of 4:7, a lark sings a non-dissonant-sounding tritone trill in an exact ratio of 5:7, the blackbird sings a two-part glissando in the opposite direction from the lower fifth to the upper fifth (upper voice downwards C→G, lower voice upwards F→C) - to name just a few examples of the highly developed musical vocal art of songbirds.

Seen and heard in this way, birds and humans have the same "musical soul" (Leibniz) and a comparable "auditory mind" or an analogous *"sound consciousness"*. The only difference is that the "ratiomorphic computing apparatus" (Konrad Lorenz) in the brain of birds is not disturbed by mental concepts of "beautiful" and "correct" singing or stress structures such as forcing or/and inhibition, whereas we easily get lost in "mental arithmetic" and confuse the notes and tones with the sounds and their spectrum.

With the help of the spectrograms of the *"Overtone-Analyzer*" (a software for vocal) I can analyze the song of songbirds in a quality and accuracy that has never been practicized before. Bird song research uses sonagrams that only show schematic sound figures, no exact pitch, no detailed and dynamically differentiated partial tone spectrum, a linear instead of a logarithmic scaling.
My special and basic method of analysis is that the song is slowed down octaving in pitch and time. This does not change anything in the data, but the tremendously fast and high-pitched sound is merely transposed into a spectrum range and a time proportion that is accessible to our hearing. Whistles and chirps become melodies and tone sequences, diverse sound figures and harmonic sounds come to our ears in a variety and complexity that is almost incomprehensible. It is always an overwhelming and exciting experience for me when I hear a bird song slowed down for the first time and thus become the "first homo sapiens" to hear these millions of years old worlds of sound.



above the verse of a *Superb Fairy Wren* in the original with over 30 motifs (2.7 s, 6-8 kHz)
below 8x slowed down (22 s, 375-1000 Hz)

With this wren, even when slowed down 8 times, the various sound figures at the end of the verse are still so fast that we cannot follow them with our ears. With birds like blackbirds or larks, you have to slow down 32 times to be able to analyze what they are singing at all.
At 8 times slower, no highly qualified human singer would be able to sing such music at this tempo, which is still fast by human standards, with this flexibility, virtuosity and precision, not to mention memory and the art of improvisation.

(The blackbird sings about 500 different verses of the highest complexity in a morning song lasting 40 minutes, different ones every morning in a different sequence.)

Here as an inspiring example a video of **a lark singing**, slowed down 0-2-4-8-16 times with notation: https://youtu.be/1IWLVR1ZD-w?si=2LNivQAo3L_w4wHs

At the end of the video, after the 16-fold slowdown with the notation, when the original song of the lark can be heard once again, you will perhaps feel like me: it is simply incomprehensible what an incredible variety of musically highly artistic motifs are hidden in this endless chirping singing.

And here is another special highlight of bird song from Australia:

*"**4-part Choral Singing** of the Pied Butcherbirds - synchronized and coordinated, correlating and corresponding in intonation, harmony, tempo, rhythm, phrasing, gestures".*

In the summary of the analysis of this "choral singing" I wrote:
"In the singing of PBBs there are beautiful sound figures, the highest level of skill in the variation, flexible ornamentation, musical imagination, differentiated intonation, precise coordination as well as harmonic order and variability in sound and rhythm. All this not only with 1 bird like with the blackbird, but in the alternating 4-part singing of 4 birds.
The slowing down in octaves makes it obvious that the same *harmonic order of the nature of the sounds* is at work in the sound cosmos of bird song as they are by Pythagoras discovered and how it underlies the most diverse forms and cultures of music in the same way, which was discovered, found, invented by humans in this natural harmonic order and was and is practiced and performed according to this "beautiful order", in singing and making music together with other human beings.
Millions of years before the dawn of human musical culture, songbirds developed beyond biological functionality the ability to listen to one another and to sing together, in the same pulse, in the one varied and multidimensional harmonical spectrum of sounds. So today we can still hear how each genus and each species of songbirds has found its specific *way of singing lively and creatively, that is shaping sounds and music creatively and thus bringing the cosmos of sound to life, letting it come alive in swinging and vibrating singing."*

Here in English the whole analysis with video and notation:
https://www.entfaltungderstimme.de/pdfs/Klangkosmos/4_Pied_Butcherbirds_singing_in_choir.pdf

see also in appendix p. 27: "Harmonical resonance in a planetary system, in the sound of the piano, in the song of a blackbird and in human singing"

The philosopher Ludwig Wittgenstein was skeptical: "If a lion could speak, we would not be able to understand it." In the case of a lion, this may be true about the "language of nature" or the "language" of animals, but what if it could sing? Alexander Kluge (German writer) came up with the bon mot: "What I can't speak about, I have to sing about." Can we then "understand" songbirds or at least understand what and how they sing?

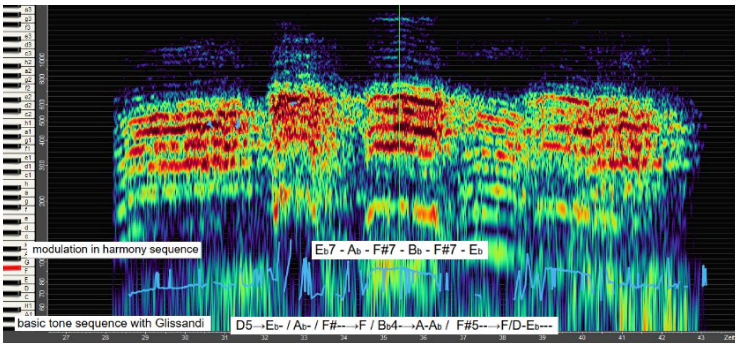
The philosopher Thomas Nagel explains in his well-known text "What it's like to be a bat" that no scientist or generally no person can ever take on the perspective of a bat's experience.
My position: Through my documented analyses I can justify that of course we cannot know what it is like to be a blackbird, but that I can understand, describe, explain, sensually experience myself and also vegetatively experience what and how a blackbird ("he and she") sings and how all the other songbirds sing, and that accordingly I can also analyze and understand how they hear, and even how they hear each other, react to each other and communicate vocally with each other.

(Speaking of bats: human hearing can also be imagined as a kind of sonar with the basic excitation of the outer hair cells and the otoacoustic emissions that interfere with the incoming sound waves and form spectral sound shapes.)

Criticism of Bird Song Research
This research is mainly concerned with the Zebra finch, a swarm bird whose behavior is studied in isolation in the laboratory. She believes that the Zebra finch sings such simple "syllables" that vocal learning could be studied in the laboratory. To this end, it is genetically manipulated (FOXP2 gene), dissected and parts of the brain are sclerosed in order to find out the neurobiological basis of human language (?!). And at the same time, I can say this so clearly, all these researchers simply have no idea what and how birds really sing, i.e. they do not know the actual song and do not really understand the physiology, function and acoustics of vocalization of songbirds.

It is simply incomprehensible:
For decades, all bird song research has been based on the assumption that the muscles in the larynx in primates and humans and those in the syrinx in songbirds are innervated by the motor XII. cranial nerve (hypoglossus). It is even said that vocalization is "motor-controlled" (?!) by the auditory cortex and an area that is supposed to correspond to Broca's area (?!) via the hypoglossus. And then they want to find the genetic basis of vocal learning in songbirds.
What sense does that make?!

What and how Zebra finches really sing and hear:



4 zebra finches in "conversation" - 6 spectral sounds with virtual fundamental and 4th-7th partials in a highly interesting and wonderful sounding harmonic sequence:

modulation: Eb7(a) - Ab(b) - Gb7(c) - Bb(d) - Gb7(c) - Eb(a)

What can be heard and experienced in this short sound sequence of the 4 zebra finches are extremely lively vocalizations that express a vegetative state of excitement (vagus nerve→syrinx) and at the same time have a stimulating effect on the basic vegetative excitation via the hearing (ear→syrinx→vagus nerve). This process of interaction applies to the *ear/syrinx/vagus nerve system* in each individual bird, to the effect from bird to bird, and to the acoustic field and arousal level of the entire group.

I know the interaction between hearing, voice and vagus nerve well from my own experience with my own singing, listening to singing voices and experiences with birdsong. It is the high vibrational energies in the sound of my voice (brilliance formants around 3000 Hz and higher) that are an expression of the efficient regulation of sound production and increase the efficiency of the vibration in the vocal folds in a control circuit (a self-organized process). I don't just hear these high vibrations in the sound, I feel them in (!) my ears and I specifically feel them as vibrations in the ear canals. (In the ear canals, the brilliance formant is amplified by 3000 Hz due to acoustic impedance in tubes.)

I have a similar feeling when my ears are stimulated by the brilliance of other singers' voices. After hearing such voices, my singing has a higher energy level. And it's no different with many bird songs. When I listen to intense bird song, I often experience the chirping, high-energy sounds literally entering my ear canals, causing intense turbulence. Such experiences always have a direct effect on the vegetative mood of my organism, a feeling of lively excitement.
When I discovered this amazing harmonic sound sequence in the 6 spectral sounds, which also means that I listened to them again and again, I was completely moved and physically excited by this discovery alone (breathing, heartbeat). But when I finally found out what the Zebra finches are actually singing, what an incredible modulation it is, and then played the pure extract of this sequence in the simple chord progression on the piano, I was overcome with such excitement that my heart wasn't just pounding but my pulse went extremely high.

When I played this harmony sequence on the piano for my partner, without her knowing what it was, she spontaneously said: "That sounds beautiful!" This sequence of 6 chords obviously exerted a strong stimulus not only on their ears due to the special type of modulation, but also directly on their sensory feeling and their preconscious sense of pleasure, before any aesthetic evaluation or classification. Every acoustic perception is filtered (pleasant / unpleasant) in the limbic system before it reaches the auditory cortex.
So much for the interaction between hearing and the vagus nerve. Analogies to the mood in group singing of Zebra finches are probably obvious.
In the singing and hearing range we are familiar with, our human ears are primarily oriented towards the same spectrum range in which the Zebra finches have their core spectrum, between the 4th and 8th partial tone, in which the octave, the third, the fifth and the sevenths oscillate as partial frequencies.

And songbirds also need stimulation from the rapid oscillations of high frequencies for their singing skills, for learning their songs and for communicating with their fellow birds, especially in the frequency ranges that are still above their singing spectrum, which in any case oscillate faster than that which our human hearing is able to recognize and which cartograph and defines our auditory concepts as pitches and tone sequences. The intense vibrations in complex spectrum patterns - this is the crucial *nerve nourishment* for energetically charging the autonomic nervous system (vagus nerve), the hormonal balance and all brain functions from the brain stem to the cortex.

a sonorous "conversation" among Zebra finches

What can be seen in the spectrogram above is an excerpt (0.9 s) from a recording (1 min) of contact calls from 12 Zebra finches (male and female). I slowed down this singing 8 times in pitch and tempo (3 octaves lower and slower) and then analyzed it on the Overtone-Analyzer in the spectrogram with a logarithmic scale (!). It is a sequence of 6 spectral sounds with a virtual fundamental and 4th-7th. partial tone, sung by 4 Zebra finches, whose spectrum correlates with each other in such a way that an astonishingly complex harmonic modulation results for our understanding of sound.
In the YouTube video "Zebra Finches (1) - What they really sing" (https://youtu.be/0eK9--aq3fA) I used spectrograms and notation as well as analytical descriptions and discussions to document what the Zebra finches obviously have to "communicate" to each other in their type of communication or in what way they engage in "conversation". To put it more simply: the way in which each finch expresses its vegetative arousal through the sound of its voice and how they all react to one another in their respective "mood" and "tuning", all in a common sound matrix.

As I have documented in this video, Zebra finches (like all songbirds) don't have "absolute hearing", they do not need the names of tones, no idea of pitches and no theory of harmony. Whether in calls or in song and regardless of the level of development of their song, they are all oriented towards the *spectrum structure* of their sounds.
They repeat exactly the same spectral sound at different stages of their communication; they sing the same sound at the same time as another; they take up a spectrum and lead it into another sound, which in turn is related to the previous sound via certain partial frequencies; they let a D major D7 sound from one finch be followed by a G major sound from another finch; 4 or 6 finches form coherent sequences of spectral sounds that are put together and interwoven in such a way that all spectra are related to each other; they react in a modulating manner to the sound of another while singing (!); or even correct themselves in singing if the coordination of the two membranes does not work (!).

There can be no better proof of the *voice-ear interaction system*.

5) Auditory Gestalt Perception in Humans and Songbirds

Humans and songbirds such as the blackbird can hear and sing a fifth because there is a corresponding circuit in their auditory/vocalization system, an innate gestalt perception for sound structures such as the gestalt of a fifth. This innate circuitry is rooted in the physiology and function of hearing, which has evolved to perceive and transform sound events according to the physical order of the natural laws of sound and vibration. It is the "unconscious ratiomorphic apparatus" (Konrad Lorenz) that calculates the vibration ratio 2:3 from the sound - the pattern or the gestalt "fifth". This "fifth" can represent the simultaneous and consecutive sounding of 2 tones (C and G) with their own spectrum and the ratio of two partials to each other in a spectrum (2:3, 4:6:, 6:9, 8:12, 12:18 etc.). And this applies to a fifth of the blackbird at B6 and F#7 (2000:3000 Hz) in the same way as for a fifth that I sing from B2 to F#3 (125:187.5 Hz). The hearing of songbirds and the hearing of humans calculates logarithmically (base number 2). This is why the scaling of the frequencies ("pitch") in the spectrogram is not linear, but logarithmic. Humans and songbirds hear logarithmically.
Spectral structures in which there is friction and no clear proportions have less sound energy and cannot be perceived as clearly. If a blackbird has not succeeded exactly in a two-part motif, e.g. one of the two voices was slightly too high in a sixth (which my ears can also hear and which I can measure in the spectrogram), then it corrects this detuning when it repeats this motif perhaps 30 verses later. In the video "Listening to a blackbird composing" I have documented how a blackbird with an extraordinary ability develops individual motifs in several attempts and then puts them together in verses. (https://youtu.be/ml0DJh8RGwY?si=PPG7tdHXt_jSXhQC)

Songbirds also have an ascending and a descending central auditory pathway and therefore cochlear afferents and efferents. They can only sing in this way because what they hear from their own singing and from the sounds of their conspecifics is also transformed in their ears into a spectral frequency pattern that is structured in time and space - a *sound-gestalt*.

As with humans, birds also have an *innate auditory conception of gestalt*. In birds, too, hearing is already fully developed in the egg. Even embryos that are not dependent on learning a particular song are able to perceive the vocalizations of their conspecifics while still in the egg (this increases the heart rate).
Songbirds that are sung to in the nest by the incubating mother learn these sounds and later sing exactly the same sounds that they heard from the mother in the egg.
Bird embryos can perceive the warning calls of their parents and transmit this information by vibration to other embryos in their eggs in the nest that have not heard these warning calls. (Some eggs were exposed to the warning call, others were not.) Because the birds communicate with each other before hatching, the chicks that were only warned by their siblings also produce more stress hormones and react more quickly to danger.
If a cuckoo has laid its egg at the wrong time in a foreign nest and this embryo develops its hearing ability later, it can happen that the cuckoo nestling makes different begging calls so that it is not fed in the same way as the real nestlings.

Spectral Frequency Patterns in the Cochlea

In humans, it has been researched that these spectral frequency patterns are already formed in the cochlea. The periodic pressure waves transmitted through the eardrum and via bone conduction run as "traveling waves" through the cochlea along the basilar membrane. This moves the sensory hair cells (cilia) according to the spectrum pattern, so that an electrical voltage change is generated, which is converted into "action potentials".
(3500 auditory sensory cells form the row of inner hair cells for afferent stimuli and 12000 form the 3 rows of outer hair cells for the efferent "action potentials" from the descending central auditory pathway via the *Formatio reticularis*).
The outer hair cells, which can lengthen and shorten to the rhythm of the "traveling wave", produce high-frequency vibrations that cause modulations of frequencies and amplitudes in the incoming sound spectrum. The interactions of the individual frequencies within a specific spectrum structure form an overall pattern, a sound-gestalt, which in its entirety is more than the sum of its parts.

"The whole is more than the sum of its parts." Aristotle

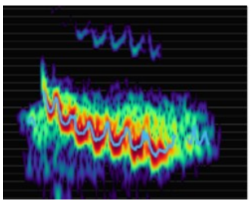
The "action potentials" of this sound-gestalt are converted into a temporally correlated sequence of nerve impulses and transmitted via the auditory nerve (VIII cranial nerve) to the brain stem, in the nerve cell area of the *cochlear nucleus*. Via five to six switching stations (including the F*ormatio reticularis*), partly on separate and crossing channels (right and left ear), the information from the ears is transmitted via the ascending central auditory pathway to the "primary auditory cortex" in the cerebrum. The spectrum and structure of the sound-gestalt generated in the cochlea remains in its spatial arrangement until it reaches the "primary auditory cortex", where it is stored in a spatially fixed engram. Only after further processing in the cerebral cortex do we perceive what we hear as tones, sounds or music. However, before we perceive anything at all, a sound is evaluated after a few hundredths of a second in the limbic system, pleasant or unpleasant and danger or stimulation.

The audio psychophonologist Alfred Tomatis conducted an experiment in which he fed singers their own sound through headphones while they were singing. He connected a filter between the microphone and the headphones, which amplified the high frequencies in the sound of the voice (around 3000 Hz). If this frequency range was previously weak, the higher sound energy in the cochlea caused the brilliance in the singer's voice to become more pronounced, a direct coupling of the cochlea, brain stem, vagus nerve and vocal fold vibration. The model also has the corresponding effect when I hear the filtered sounds of a bird's song at 5-8000 Hz through headphones while singing.

I recorded the original sound of a blue tit as a loop in a video: "Cricket" song at 7000 Hz - stimulation for ears and brain - https://youtu.be/Olw7mN3oDww?si=6PbWasv7XQr8JH7U

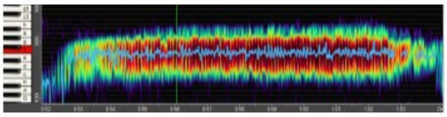
<u>Reflex Circuit between Ear and Voice</u>
If I strike a note "blindly" on the piano, I can sing it in 0.1 seconds without knowing which note I am singing. When I play the lowest C on the piano, I hear a strongly vibrating sound, but I can't hear a specific pitch. And if I then sing a note in my vocal range to this very low C, I still can't hear whether my note is the C 2 octaves higher. Only when I check my pitch on the piano do I realize that my ears have tuned my voice to the exact pitch.

<u>Pitch regulation</u> occurs sensory via a branch of the vagus nerve that innervates the outer laryngeal muscles, the vocal fold tensioner (m. cricothyroideus - ring-shield-cartilage muscle). Through gradual, continuous tension, a sound glides upwards and, when relaxed, downwards (glissando). At the same time, large and small intervals, scales, whole tones, semitones and even quarter tones can be sung through a complex interplay of ear, vocal fold vibration and pitch regulation. The special ability of human vocal physiology is that it can be used to regulate pitch, volume and sound quality in a mutually independent manner (although this is not always successful).



Primates can also sing glissandi because they have the same vocal fold tensioner outside their larynx, which is also innervated by the vagus nerve. In contrast, there is no separate external pitch regulation in the syrinx of songbirds. It is all the more astonishing that songbirds can also sing longer sustained tones at a certain pitch, as well as glissandi in any form, and that at the same time their pitch

regulation always occurs in flexible and variable movements, in tone sequences, at intervals and also in two-part singing.
(The picture above shows a chromatic tone sequence with small glissando waves, which is repeated exactly in the tone sequence, even 10 verses later.



The nightingale has a special sound, a very fast, whirring trill in which I can't hear any particular pitch, even if I slow it down 4 octaves into my register (picture). I then simply tried to imitate this strange sound without knowing which pitch I should hit and what the nightingale is actually doing with its voice. The recording then showed in the spectrogram that I had produced the same sound figure at the same pitch that was displayed in the spectrogram. But even as a very experienced singer, I didn't know how I had done this with my "vocal tools". I still don't know exactly how to do it and I can't explain to anyone else how to do it, but I can repeat the sound spontaneously. When I then accelerated my singing by 4 octaves, I heard no difference to the sound of the nightingale.
So much for the ear-voice feedback system.

Another note on "Tone" - "Sound" - "Spectrum"
The philosopher Edmund Husserl dealt intensively with the phenomenon of how the sense unit of a melody is formed from a sequence of tones in our perception.. Some brain researchers are still trying to fathom the topology in which "tones" are stored in the auditory cortex and how the perception of a coherent melody can result from the individual tones. And in many descriptions of the hearing process, the arrangement of the sensory hair cells in the cochlea is compared to the keyboard of a piano. The hair cells at the entrance are said to respond to sounds with high frequencies and at the end of the cochlea to those with low frequencies.

This picture is simply nonsense. The cochlea has not developed in evolution to be able to distinguish individual "tones", and likewise the most elementary form of vocalization is not the production of individual tones with a specific pitch, but a gliding movement without pitch fixation as in the singing gibbon apes with their octave and fifth glissandi. Even with a single tone, not only high or low hair cells are excited, but lower and higher complexes of hair cells, i.e. a spectrum. Even with sine tones, there is no single "key" for this frequency. And if another "tone" is heard after the first one, the oscillation of the hair cells is of course not stopped with the first sound, rather they oscillate a little further. And this creates a reciprocal relationship between the two sounds and their respective spectrum, in which the two sounds can form a proportional relationship in a specific type of correlation (e.g. C→A = 6:5 - the sound gestalt "minor third", called "call third"). The upper sound still resonates in the lower sound. The vibration of the first "tone" is not stopped by the damper when the next "tone" is sounded, as is the case with the piano. In the piano, too, three strings vibrate with each "tone" so that the sound is richer in overtones, and even after damping, the sound continues to vibrate in the soundboard of the piano. In the same way, the "tone" with its entire resonance is processed by the ear.
And if after the first two "tones" another "tone" were to cause the hair cells to vibrate, an extended correlation to the previous sounds would arise, so that three sound gestalts, three correlating frequency spectra could network to form an acoustic sense unit, a corresponding pattern, the sound-gestalt of a 3-tone sequence (as above in the modulating sequence of spectral sounds in Zebra finches).
I orient myself to this correlation and correspondence in the matrix or network of sound spectra when singing and in singing lessons, when playing the piano, when leading a choir and, of course, when listening to and analyzing music and, in the same way, when listening to and analyzing birdsong

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"In our perception, an entity becomes **Gestalt** exclusively through correlations that reproducibly modify the ever-present statistical discharges of the nerve cells. Gestalt is therefore everything that stands out from a statistically uncorrelated "rushing noise scenery" ("Rauschkulisse") in our perceptually accessible space-time-world." (from the background rhushing noise "out there" and from the rushing in the head and ears, the excitations from the *Formatio reticularis* J.Q.)

"The essence of the concept of Gestalt is expressed in its *oversummarization* as well as in its *transposability*. (Manfred Eigen, in: The Game. The laws of nature control randomness p. 89)

Sound "Gestalt" without Visual Metaphors

I am currently expanding a text entitled "Why can blackbirds and humans hear and sing a fifth without having learned it", which deals, among other things, with the auditory concept of Gestalt. I was inspired by the thoughts of C.F.v. Weizsäcker (physicist and philosopher) on the "innate conception of Gestalt" in his text "Parmenides and the Greylag Goose", in which he relates the philosophy of Parmenides to the research of the ethologist Konrad Lorenz and his greylag geese (in "Unity of Nature"). At the same time, I am trying to apply the findings of Konrad Lorenz from his book "The Back Side of the Mirror. Attempt at a Natural History of Human Cognition" for the song-auditory-brain complex and the auditory conception of gestalt.

C.F. v. Weizsäcker, from: Parmenides and the gray goose

(Concept - Gestalt - the Gestalt in things - Gestalt as an example of the general)

"Even animals can 'recognize' figures, i.e. react correctly to them, indeed one can say that they react to nothing else. This correct behavior can be innate, learned without insight or insightful. From insightful behavior, one will still distinguish the human reflection on insight, the response to the gestalt as a gestalt. Let's stick with the simplest example, innate behavior. The nestling bird opens its beak in the face of the feeding mother, but also in the face of a suitable dummy. It only "recognizes" the stimulus gesture "feeding" in examples, but also in every example, and it does not differentiate between the examples with regard to the reaction "opening the beak".
Exactly this behavior must be expected cybernetically if the "innate gestalt conception" corresponds to a clear circuit diagram in the central nervous system. The circuit diagram reacts to a stimulus that can be determined conceptually, i.e. as a gestalt.
If the ability to react in a defined way to a defined stimulus may be called the "practical concept" of the animal, then the practical concept itself is a gestalt of behavior that is lawfully assigned to an encountering gestalt. What is general about the concept here is the lawfulness, the possibility of the recurrence of examples. The practical concept, however, does not "grasp" the generality, it grasps the general only in each recurring example. In this respect, the gestalt is indistinguishable from the example; it "is" the example." (my translation)

C.F. v. Weizsäcker: Die Einheit der Natur. München 1971, S. 464 (The Unity of Nature)

The following is a short excerpt from my text
"Why can blackbirds and humans hear and sing a fifth without having learned it":

In acoustics and in the "cosmos of sound", the *term Gestalt* actually loses its all too easily attached image of figurativeness and external form or shape. Of course, we humans can perceive sound figures and pictorial gestalts in sounds or in music, just as songbirds can probably distinguish in some way between a protracted glissando and a trill and react differently to a melodious song than to a vehement, fast motif of excitement. But if I want to detach the concept of Gestalt from all visual connotations in order to grasp the specifically acoustic, it can only refer to the "inner life" of a sound, the way it vibrates as a whole, respectively the type of oscillations in the sound spectrum (partial frequencies and formants), the inner movements in space and time that order and characterize it, i.e. its spectrum in its range, its extension, its structure, its dynamics, its inner and reciprocal relationships, above all in its whole-number proportional relationships.

Sound-Gestalt as the "Inner Life" of a Sound

In the octave slowdown, a sound is transposed over several octaves into a lower frequency range and at the same time slowed down by the same octave on the time axis. A 16-fold slowdown means that the original sound now sounds 4 octaves lower and 4 time octaves slower, i.e. 16 x slower. It sounds different in the lower spectrum and because of the slowing down we can distinguish more and more differentiated in the sound, but its sound-gestalt, what I have called the "inner life" of the sound, does not change. The "system" and the structure of each individual sound and each sound figure remains the same in terms of pitch, volume, intervals, sound figures, in the vertical layering and distribution of frequencies as well as in the temporal and dynamic proportions, especially in the case of two-part sounds as with the blackbird. On the overtone analyzer, all of this is visible and measurable in the spectrogram, with the pitch accurate to a hundredths of Hz and the volume to tenths of decibel. How loud each partial frequency is is visible in color and displayed in decibels. How extensive and differentiated the spectrum of a sound is can be recognized at a glance, more precisely than with the ears. The "sound image" provides information about whether a sound figure still has a noisy effect even when slowed down due to the high speed of its progression. Sound figures such as trills, glissandi, 2-part spectral sounds leave a perceptible and tangible auditory impression in me (not as an image!). Even without hearing a sound, I can aurally grasp it in its gestalt with my auditory imagination via the spectrogram image, if not even comprehend it, form an auditory concept of it. Of course not in its concrete form, but this can certainly be a consciousness of sound combined with a sensual acoustic sensation.

"The map is not the territory" and the "map" of the spectrogram image is not the sound landscape, ("soundscape"), but with my eyes in the image of the spectrum and with the sound in my ears, or with my ears in the sound, I can orient myself via the pictorial gestalts in the spectrogram in a sound-gestalt, in the living inner landscape of a sound, a multi-dimensional, dynamic and colorful space experienced in time, an interior space of sound, an interior space of listening and also an interior space of singing. In such an interior sound space, I can detach myself from all the pictorial, visual elements that we are used to adding to sounds. Whether singing/hearing a fifth glissando or listening to the song of a blackbird with the two-part glissando from the fifth F/C to the fifth C/G, "a circuit diagram in the central nervous system reacts to a stimulus that can be determined conceptually, i.e. as a Gestalt" - and this obviously also applies to singing/hearing of a blackbird (see quote from C.F. v. Weizsäcker above).

If the sound balance in the inner resonance spaces is right, i.e. efficiently regulated (low breathing and vocal pressure as well as favorable shaping of the resonance space), *"standing waves"* can form with a feedback effect on the vibration process, whereby the intensities in the sound and the formation of formants are intensified. In the 2-part song of the blackbird, this process has an even stronger effect, especially as the trachea ("air tube") directly above the syrinx is an ideal resonator. In human singing, it is primarily the laryngeal vestibule directly above the vocal folds and below the epiglottis in which the formation of standing waves can be efficiently stimulated.
The higher condensed sound energy in the high, faster vibrating frequency ranges in turn has a more stimulating and energizing effect on the auditory system, and feedback via the vagus nerve stimulates a correspondingly efficient and energy-rich sound production in the syrinx or larynx - an interacting feedback control loop. Heard in this way, the formants in the spectrum range of the high and highest vibrations could be seen as an interaction field of sound energy.

The conditions for the formation of high intensities in sound are more favorable in songbirds than in humans, as breathing and feeding are separated, the syrinx is stably positioned at the end of the trachea, the oral cavity is more clearly contoured and the tongue is less flexible. (In birds and humans, the larynx closes and protects the upper entrance to the windpipe during swallowing).

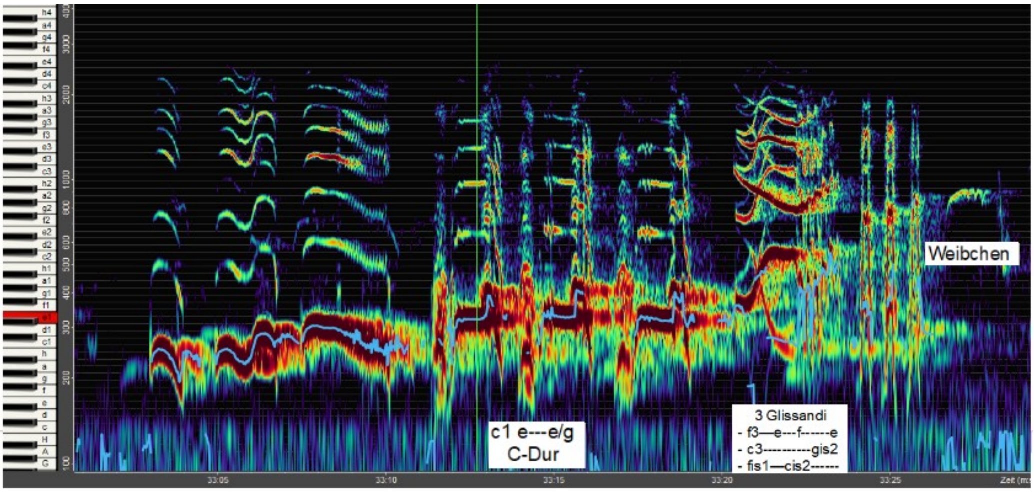
This excerpt comes from a text that discusses some fundamental questions about a very special, highly complex motif of a blackbird, a two-part contrary glissando from the lower fifth into the upper fifth (upper voice down C→G, lower voice up F→C) with a combination tone at E in the fifth C/G:

"*The sounding three-dimensional Möbius loop* - a sound exploration"
including the following topics:
- "The whole is more than the sum of its parts" -
  emergence phenomena in a 2-part singing
- "Combination tones" - real sounds, not psychoacoustics
- 5 sound spaces and their dimensions in *one* sound
- Self-organization and emergence in the "system" of sound - space and interaction
- Sound "Gestalt" fifth

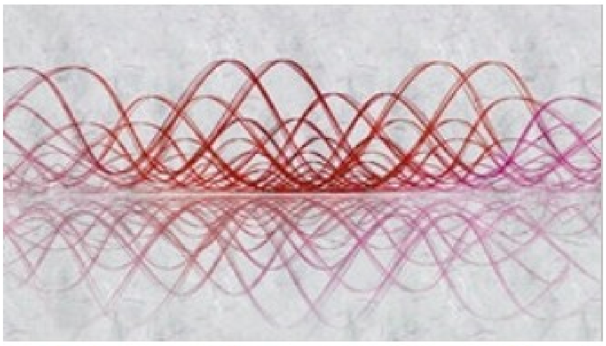
on this in German 2 texts on my website with video and the sound analysis with spectrograms:

https://www.entfaltungderstimme.de/pdfs/Klangkosmos/Amselgesang-7.6_Kombinationsklaenge.pdf

https://www.entfaltungderstimme.de/pdfs/Klangkosmos/Amselgesang-7.6.2_klingende-Moebius-Schleife.pdf



1 verse from the morning song of a blackbird with a triple "C major triad"
and the 2-part contrary glissando with combination sound ("3 Glissandi") - slowed down 8x

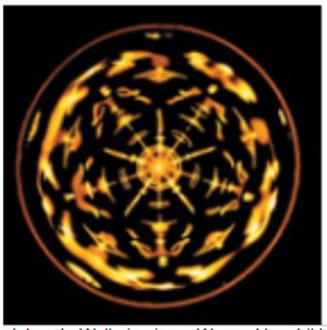


Schwingungswellen in einem Klangspektrum

Vibration waves in a sound spectrum

stehende Wellen

In the concentrically propagating water waves, there is an oscillating wave corresponding to the visible wave, which runs back from the edge to the center.



stehende Welle in einem Wasserklangbild

Standing Waves

A round vessel of water is vibrated from below by sine waves. A lamp positioned vertically above the water surface allows the distribution of the crests and troughs of the waves to be recognized, as the light is only reflected back upwards into the camera from these. Depending on the temperature, the amount of water and other influencing factors, so-called "standing waves" can emerge from the penetration of the wave at certain frequencies:
the different wave movements do not interfere with each other, but form a uniformly vibrating whole. In the midst of water vibrating everywhere, a superordinate resting structure suddenly emerges.
The organizing principles of such oscillating fields can serve as a blueprint, a matrix for the most diverse formations.

"Water-Sound-Pictures" - Website of Alexander Lauterwasser (His books are highly recommended.)

http://wasserklangbilder.de/index.html?html/home_d.html

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literature:
Konrad Lorenz: Die Rückseite des Spiegels. Versuch einer Naturgeschichte menschlichen Erkennens
(The reverse side of the mirror. An attempt at a natural history of human cognition)
Rupert Riedl: Biologie der Erkenntnis. Die stammesgeschichtlichen Grundlagen der Vernunft
(Biology of cognition. The phylogenetic foundations of reason)
Rupert Riedl: Die Strategie der Genesis (The strategy of Genesis)
Manfred Eigen: Das Spiel. Naturgesetze steuern den Zufall (The Game. The laws of nature control randomness)

Appendix

Singing with a "Closing Muscle"?

In its primary function, the larynx is not an organ for singing or speaking. The vocal folds are a sphincter that opens or closes access to the lungs. For thriving or perishing, oxygen must be able to get into the lungs, and for thriving or perishing, nothing wrong must not get into the trachea. It's no wonder that the patterns and habits that help you survive in one way or another aren't necessarily helpful for belting out a song at the top of your lungs.

A bird that is afraid does not sing.

And when singing is associated with stress and anxiety, the **closing and protective functions** in the larynx and pharynx are naturally alarmed and potentiated. In some types of singing, these protective functions are unknowingly activated and trained, and with the same zeal, appropriate counter-measures are mobilized, which in turn are intended to "open" the voice - a vicious circle and very laborious.
Or seen another way:
Precisely the "Conscious-Being" (bewußt sein / Bewußtsein) of our **vulnerability** in this human core area of life and survival, where the paths of breathing, nutrition and communication cross, and which is therefore sufficiently equipped with wonderfully helpful protective functions, may allow us to imagine that it is precisely here, at this gate between inside and outside, outside and inside, and precisely when it is <u>not</u> about survival, the vocal folds can vibrate freely under these conditions, in a state of homeostasis, and **a space can open up** in which nothing wants or needs to be protected :

*Breathing and singing in parasympathetic mode - in a state of **homeostasis** *) and lively **arousal**.*

The whole world can and may hear that I have nothing to hide and that I pose no danger, and the whole world can and may hear how a human feels who has the courage to express himself in singing in all his vulnerability and sensitivity and to show himself in all his power.

When singing - in the regular opening and closing of the vocal folds (on the note A4 - 440 times per second) - the sound forms a vibrating membrane between the inner and outer world, which, on the one hand, in singing, prevents the breath from slipping away in sighs and groans, and which, on the other hand, allows the lungs to feel protected. In the **membranous vibration** of the vocal folds and their mucous membranes, this "closing muscle" is released from its protective function, and in the space of sound, the interior and exterior merge into an open expanse.

And it is precisely in such **openness** that the membrane-like nature of the sound is a **signal** for the intimate **contact** between the vocal folds and their mucous membranes, as if the "silver thread" in the sound should not break when opening and closing. The dilemma in the protective function of the sphincter, either to build up pressure in the compression of the vocal folds (inflexible sound) or to want to avoid precisely this pressure (little sound), is resolved in a membranous sound in the polarity of openness and contact, permeability and connection, closeness and distance, movement and calm.
The membranous nature of the sound (the singer formant about 3000 Hz) can manifest itself as a fine, concentrated brilliance, as a shiny silver "thread", as buzzing ("sirren"), whirring ("schwirren"), glowing ("gleißen"), insect noise and similar phenomena from sound and noise - condensed vibrations with the highest energy, with the strongest excitation potential for the ears and with a pure stimulating effect on the autonomic nervous system.

A bird unfolds its full singing potential in relaxed full song -
when it's about nothing.

From a pragmatic point of view, singing for us humans means - physiologically and functionally - *neutralizing and overcoming the swallowing and gag reflex*.

In birds, food intake and vocalization are physiologically separate. Their larynx closes and protects the upper entrance of the trachea (air pipe) during swallowing, just like in humans. Irrespective of this, the vibrations of both membranes in the syrinx at the end of the trachea, i.e. at the lower entrance of a stable (!) tube, can form an oscillation field of "standing waves" with efficient functionality.

*) *Vegetative homeostasis*: All parameters on which life and survival depend are kept in the optimum range (e.g. oxygen content in the blood).
Acoustic homeostasis: Breathing force and vibrational force interact with each other and are balanced in such a way that the subglottic space also begins to vibrate. In the deep open throat, *"standing waves"* are formed by the superimposition of traveling waves moving in opposite directions.
All partial frequencies of a sound form a uniformly vibrating whole; a superordinate resting structure is created, a highly efficient vibration field organized according to physical principles - *a sound-gestalt*.

"Control" of the Larynx?

For all of us who would love to have control over what comes out of our throat, it is a real problem that the larynx in all its functions is not nervously controlled by the cerebrum, but by the *nervus vagus*, this vagabond of the vegetative nervous system, which, as an opponent of the *sympathicus*, the stress manager, regulates, in addition to the larynx, breathing, heartbeat, digestion and sexual arousal - in the balance of calm and lively excitement.

So all optimization strategies for the “vocal organ” run into the void and all desire and effort is exhausted in manipulation, compensation and substitute actions.

In singing we can experience that there is a trap lurking behind every sentence that begins with "I", especially behind sentences like "I want...", "I can..." and "I know...". And we are probably surrounded by such traps in other areas of life too or are stuck in them without really noticing it. We humans differ from animals, which also have a vegetative nervous system, in that we can invent justifications and stories for all our actions and feelings and are hardly aware of how much we succumb to the most beautiful self-deceptions in this inventiveness.

And this "core problem" is therefore precisely *the* chance, in singing, to immerse ourselves in the border areas of voluntary and involuntary, conscious and unconscious, of intention and reflex, and to tap into unimagined potential in our singing (and in our lives?).

If the ear (not the evaluative habitual hearing) and the voice in their reflex-like oscillatory movement (a "self-organized process") can be coupled with the physical sensation and perception in a control loop with interaction, then the voice can unfold and develop.

Formatio Reticularis - the Sound in the Head and in the Ears

(Excerpt from a publication by Gisela Rohmert)

The reflex arc of the *M. tensor tympani* (Ear drum tensioner) is connected via the reticular formation. The small ear muscle is therefore involved in the general proprioceptive impulses of the trigeminal nerve, which play an essential role in the tonic activity of the reticular formation. Restricted function of the mucous membranes and muscles (including the masticatory muscles) innervated by the trigeminal nerve hinders the meaningful work of the reticular formation.
This brainstem area is the central point for optimizing sensory stimulus selection. The activation level of the reticular formation also significantly influences the state of consciousness. It directs the intensity of sensations and perceptions. The actual decision-making processes linked to consciousness, from which self-movements also occur, do not originate in the cerebral cortex, but in the brain stem. In any case, the basic control for phonation or singing takes place from here,

which reflexively interconnects muscle tone, breathing and vocalization, again depending on the level of nerve tone in the reticular formation.

A stimulable frequency code (brilliance of the vocal formant around 3000 Hz, in the range of highest hearing sensitivity J.Q.) - its archetypal imprint - excites the areas innervated by the trigeminal nerve (mucous membrane, muscles) in a specific way so that normally separate spaces can coordinate. Exciter frequency (from the larynx or vocal tract) and resonant frequency (impedance minimums in the middle ear) match. In this way, a highly complex sound is amplified and stabilized via feedback. Last but not least, the *M. tensor tympani* and *M. tensor veli palatini* influence this coordination process. At the same time, their quality of work influences the quality of work of the brainstem, the reticular formation. Acoustic and physiological optimization in singing are mutually dependent.

The Sound in the Head

The attempt to describe an inner-body perception phenomenon that is not familiar to everyone can lead to the suspicion of an illusory digression. However, the motivation to refer to a rarely discussed acoustic signal in the head is based on a long phenomenological examination of this sound perception and the recognition of what it can physically trigger. The prerequisite for a serious interpretation of such a sound feature - similar to a high-frequency chirping - is its connection to brain physiological functions.
The origin of this chirping ("zirpen" - sound of crickets) in the head can be found in the reticular formation.
The FR is primarily regarded as an integration and processing system for vegetative and sensory stimuli. Special functions of this area of the brain include

- the tone control of the muscles with the help of the gamma nervous system
- the influence on the sensitivity of our sense organs
- the control of the waking and sleeping rhythm
- the attention control
- the reflexive process of breathing
- the reflex control of the larynx functions

The FR can react to acoustic signals independently of the actual hearing ability, i.e. it has a specific hearing ability. This is confirmed by animal experiments that demonstrate hearing performance despite severed auditory nerves.
The fact that their neuronal density generates a permanent, largely interference-free sound signal is reminiscent of the otoacoustic emissions of the ears, which are based on the intrinsic excitation of the sensory hairs in the cochlea.
The continuous tonus of this brain stem region apparently transforms into a sound phenomenon that can be modulated, bypassing the classic auditory conduction pathways.

(Johannes Quistorp: In my opinion, the otoacoustic emissions too are based on excitation of the outer hair cells by cochlear efferents from the brain stem, the electrical potential of which can be demonstrated by measurements. The detection of these emissions in newborns is used to test hearing ability. The potential of these cochlear efferents in the outer hair cells enables spectral analysis and pattern recognition of the incoming sound signals acting on the inner hair cells and their conversion into spectral sound patterns and their transformation into electrical signals that are transmitted to the brain via a temporally correlated sequence of nerve impulses.)

For many people, the sound in the head is initially below the threshold of perception. Everyday behavior distorts and clogs the wafer-thin boundary to the perception of the subtle (cf. background sensations, Damasio 1996). But even if a brain acoustic emission touches consciousness, the mind cannot immediately recognize a meaningful connection. Defensive reactions or trivialization arise.
Astonishment, curiosity, trust can instead accompany turning to this whirring, gently modulating vibration. A careful focus of attention and a communicative relationship would result in an intimate state of lively stillness. While listening to the sound of the FR, a control loop is created between empathic sound perception and physiological reactions.

A developed relationship to this acoustic essence allows it to act like a key physiological stimulus:

- alertness becomes calmed alertness
- attentiveness becomes fascinated attentiveness
- tonus regulation is intensified by tissue liveliness, which is experienced as sensory alertness
- sensory organs react in a networked and casual manner
- breathing calms and deepens

The balancing function of this interrelationship between acoustic stimulus and physiological reaction can lead to a state of extended sense of time and silence of thought.

The knowledge of the connections between an internal permanent vibration sensation and external sound goes back to early times.
The cricket, called Tettix in ancient Greece, became the prophetess of the Muses (protective goddess) in the succession to Orpheus. She is considered to be the cause of the chirping ("zirpen") vibrational essence that was incorporated into the artist with beguiling effectiveness.

from: Gisela Rohmert, Lichtenberger Dokumentationen Band 1 - Erkenntnisse aus Theorie und Praxis des physiologischen Singens, Sprechens und Instrumentalspiel (2015) https://www.lichtenberger-institut.de/
(Insights from theory and practice of physiological singing, speaking and instrumental playing)

Some additions from my own experience:

I myself have this whirring, subtle sound almost constantly in my head, mostly in my left ear, without it bothering me too much. It is more of a faithful companion to my vegetative mood.
At times I can hear my heartbeat pulsating in a glittering whir. And in certain phases of excitement it is as if very, very small crystals are hitting each other with glassy clicks. When I'm busy analyzing birdsong, the buzzing becomes more intense. It also happens again and again that this inner ear noise is stimulated with every sound when playing the piano. In my own singing there is always a contact from within through the Eustachian tubes to the excitement in the ears. In singing lessons I experience the fact that a student's high-frequency enriched sound penetrates into my ears from the inside, and then the singer confirms to me that she also experienced the inner contact with her ears in her sound. And when playing the piano, the inner sound is stimulated and amplified by the piano sound, which I perceive as an audible and tangible stimulus in the external ear canals.
An interesting experience is that in certain situations I hear a high-pitched whistling sound in my head (at 7000 Hz), usually for 10-20 seconds. Most of the time they are transitions into another state of vegetative arousal, both in the direction of higher arousal and also as a signal of fading overexcitation.

The Writer Jean Paul (1763-1825) on the Rushing Noise ("Rauschen") in the Ears

At the beginning of the 19th century ringing in the ears was considered a characteristic and distinction of highly sensitive souls.

Jean Paul: *"The ear is the depth of the soul and the face is only its surface; sound speaks to the deeply hidden order of our inner being and condenses the spirit; seeing disperses and breaks it down into surfaces."*

A paraphrase of Jean Paul's thoughts:

According to Jean Paul, inner hearing is a hearing of hearing, a listening of oneself in hearing, in which the ego experiences itself and at the same time the presence of a higher world.
He distinguishes between sensory images ("Empfindbilder") and imaginary images ("Vorstell-bilder"). In the case of acoustic images, the "mute mental images of sounds" are duller and weaker because they are more abstract than the "quiet sensory images" of sounds that resonate in us after listening to music.
Seeing is discrete: there is usually a caesura between what is seen and what is imagined. Above all, between someone who sees and something seen. In contrast, what is actually heard and what is imagined are localized in a continuum. This is why the auditory image, as a "creature of the brain", resonates with the "auditory sensation (the daughter of the nerves)" received from outside.

There is a place where the subject's innermost self, its self-activity, and the outer world coincide. And this is an acoustic place: a sound that fades softly into the distance, in which the self and the world are integrated. Hearing therefore provides us with a much richer, more profound access to the world than the sense of sight.
In waking life, the ear is the actual imaginative organ. The acoustic imagination produces musical phenomena much more often than other kinds of sound phenomena: "Outside of dreams, sensory images of sounds occur to us more often than of speech and noise; after a night of music, the moved soul can arbitrarily make melodies sound again, but not conversations".

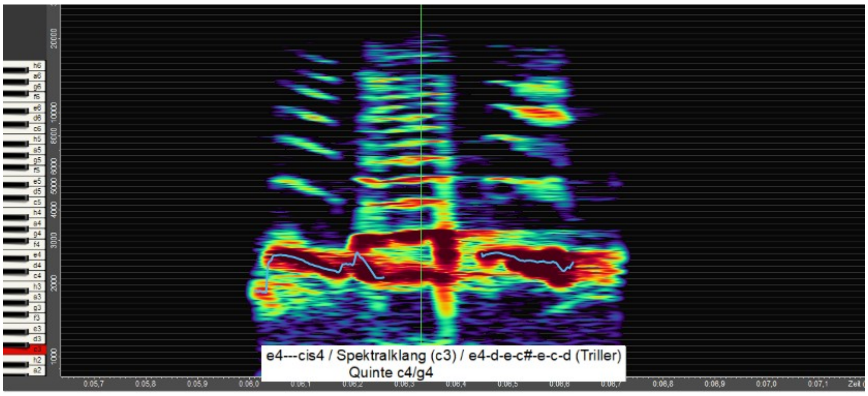
The gestalt-like inner tones cannot be understood as a mechanical consequence of blood and nerve impulses. Rather, the inner tones must be understood as self-affection. This is why Jean Paul distinguishes the acoustic sensory images from a vulgar tinnitus, as it were. There is the "ringing in the ears" ("Ohrenbrausen") as a physiological, nervous phenomenon. And there are auditory sensory images in which an acoustic imagination, including an acoustically composed memory, resonate with the distant vibrations and quiet oscillations of the spiritual world.

The point of indifference between inside and outside is to be found in the acoustic. In sensitive 'tinnitus', the world within us unites with the world around us. Thus, in hearing there is actually nothing inside or outside.

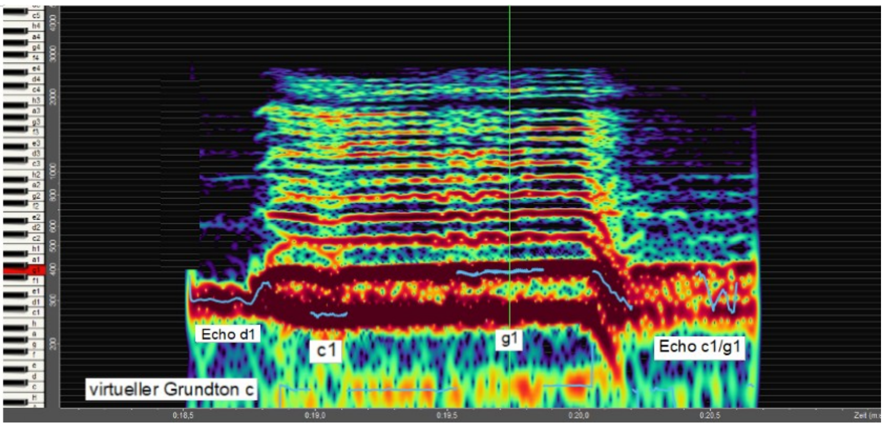
A summary from: Uwe C. Steiner - Ohrenrausch und Götterstimmen.
(Ringing in the ears and voices of the gods) A cultural history of tinnitus (2012)

2-part "C major" Spectral Sound of a Blackbird -
2 voices form a unified and complex overall sound - a Sound-Gestalt

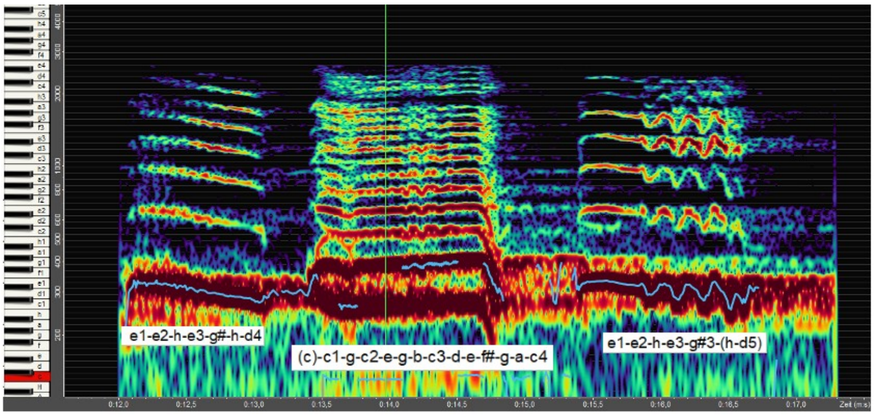
Video: "Amselgesang (7.3) - ein 2-stimmiger C-Dur-Spektralklang - eine Klangerkundung"
https://youtu.be/FzA9abeKy34



in the original: a 2-part spectral sound C7 (2094 Hz) / G7 (3141 Hz) - virtual fundamental tone C6 (1047 Hz)
C6 - 1st partial / C7 - 2nd partial / G7 - 3rd partial
range of frequency spectrum: 2nd (C7) to 13th partial (A9 - 14 kHz), formant: around C10 (16.8 kHz)



Slowed down 8x - sounding fifth C4/G4 - heard as a "C major" sound



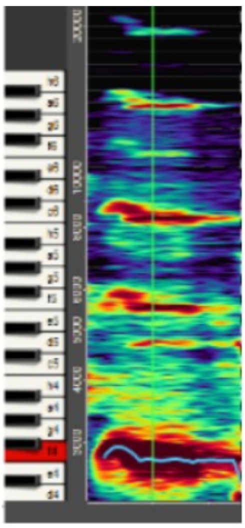
E4 C4/G4 E4 trill

E4 (1st-7th partial) : E4-E5-B-E6--G#-B-D7
C4/G4 (2nd-13th partial) : C4--G-C5-E-G-Bb-C6-D-E-F#-G-A, virtual fundamental: (C3), formant: about C7
E4 with trill (1st-5th partial) : E4-E5-B-E6-G#

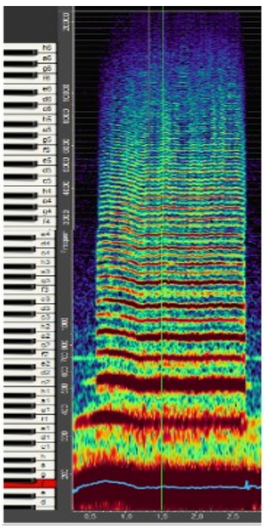
The overtone analyzer displays the overall spectrum of a sound with all partial frequencies that are contained in this *one* sound or resonate and sound in it. However, a sound is not simply made up of the sum of its lower and higher partials, nor does it consist of just one sounding pitch as the fundamental tone with the integer series of overtones above it. Depending on the number and different dynamics of the individual partial frequencies and depending on the dominance of a frequency, which does not always have to be the fundamental tone of a spectrum, and depending on whether a fundamental tone (1st partial tone) resonates at all in the overall spectrum, this results in *one* overall sound that is both uniform and complex. The proportions of the partial frequencies and their relationship to each other determine the color, character and expression of a sound in its overall spectrum.

Even two-part singing is not simply the sum of two sounds with their sounding pitch and their respective frequency spectrum. Depending on the relationship and ratio of the two voices to each other, a unified, complete sound is formed with its own complex spectrum and a very specific timbre and sound structure. The complete spectrum of the two voices sounding together comes into an interactive feedback relationship with each other. This can lead to an amplification or attenuation of individual frequencies in the respective spectrum, which gives the overall sound a different coloration and character; a separate virtual fundamental tone can be formed from the combination of the two voices, a non-sounding frequency, which is, however, indicated in the spectrogram by the pitch marker as the fundamental tone of this one overall spectrum; and matching frequency-proportions can accumulate in such a way that a certain frequency acts and sounds like an individual voice.

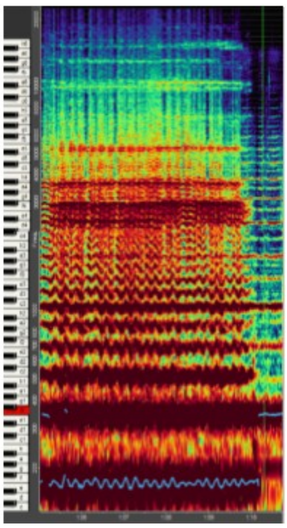
Blackbird Sound and Humans Sound



blackbird F7



blackbird F3



sung by me: F3

blackbird sound: F7 in the original - 2800 Hz (1st-6th partial) - 6th partial C10 (20.8 kHz)
blackbird sound slowed down 16 times and re-recorded: F3 - 175 Hz - spectrum up to 22 kHz, which corresponds to 352 kHz (!) in the original sound - countable spectrum up to the 48th partial at C9 (8400 Hz = 124.4 kHz in the original) - all odd partials have a higher intensity (1.-3.-5.-7.-9.-11.-13.-15.-17. etc.) - a peculiarity of many songbird sounds !

F3 sung by me: Spectrum up to 22 kHz - f6 (11.2 kHz) - countable up to 32nd partial at F8 (5600 Hz) - uniform decrease in intensity towards the higher frequencies full spectrum up to the 2nd third (10th partial A6, 1750 Hz)
Formants: 3000 Hz / 3500 Hz / 5000 Hz /10 kHz / (14 kHz / 16 kHz)

Transposability of sound-gestalts
The wave recording only shows up to 22 kHz in the original. The newly recorded transposed sound reveals the complete specific spectrum that actually sounds in the original - in the same sound-gestalt.

"The essence of the concept of Gestalt is expressed in its supersumptuousness as well as in its transposability." (Manfred Eigen)

Evolutionary Imprints of Human Hearing -
and how they affect the perception of singing voices

Human hearing, as it has evolved with the development of mammals, fulfills vital functions: It serves **orientation**, **balance**, **communication** and the **perception of danger and prey**. For early humans, survival in the unprotected conditions of the savannah depended crucially on the ability to hear. It was particularly important to be able to pick out surprising noises from the familiar ambient noises and sounds, and also to react to a surprising silence when animals stopped making sounds because they sensed danger. The cracking ("Knacken") of a branch, the rustling ("Rascheln") in the grass, the ("Sirren") of an insect - everything could be understood as a **warning**. As the onomatopoeic words in German with the noisy consonants (k, s, sch, r) already indicate, the ear reacts highly sensitively to such noises in the frequency range of 3000 - 20,000 Hz, even at the lowest dynamic levels. Even during sleep, the ears were attuned to alertness; crackling, rustling, pattering - fine and strong noises with high frequencies that could signal a threat or warning of fire, storm and rain. This high sensitivity of the sense of hearing was also a great advantage in the fight for survival when tracking prey and stalking game.

Hearing surprising and unfamiliar things, acoustic changes in the immediate surroundings and in the vastness of the savannah, orientation in the thicket of the forest, the atmosphere in the darkness of a cave - all these listening experiences were naturally associated with elementary **vegetative and psychic excitement**, with curiosity and hunting fever, with increased attention and alert readiness to react, but also with fear and anxiety, with defense and readiness to flee.

On the other hand, for early humans, hearing also provided an **all-clear**, **reassurance** and **relaxation** - when the atmosphere became calmer, when the birds began to sing again, when the wind blew gently through the grass, when the crickets "sang", when the voices, sounds and calls of other people conveyed a feeling of safety and freedom from danger. These usual, normal and **familiar sounds and noises**, whether they were very close or came from the wider environment, also had a direct effect on the vegetative nervous system and the limbic system (pleasure and displeasure). And, as with the alarm and warning function, it is the high frequencies and subtle vibrations in the human voice, the chirping of birds, the buzzing of insects, the familiar sounds of nature, which transfer our nervous system via the auditory system into the parasympathetic **mode of calm and lively arousal**.

Even in our modern acoustic world of experience, the auditory system still reacts in its original function of warning and all-clear, activation and deactivation. The characteristically uneven babbling of a brook as well as the very evenly rushing noise-sound of ocean waves: both acoustic phenomena with a high-frequency sound character have a very strong stimulating effect on the nervous system via the auditory system - for some it can calm you down wonderfully and even put you to sleep, for others it causes nervous overexcitement, and for still others these stimulating sounds put them in a balanced, calm and wide awake state of mind, the balance of activation and deactivation.

And with what kind of vegetative and psychic arousal do we react to certain qualities of of the human ear to certain qualities of **singing voices**, including our own voice?

Does a certain type of loudness, sharpness, shrillness or effort in a voice trigger alarm in me? Or do I experience it as a warning of danger? Is someone calling for help with great effort? Or am I threatened by danger? Do I hear fear or a threat to which I react with defense? Or is the voice coming too close to me with its power or in its plight and is it pressuring me?

At least it could be that some characteristics of a singing voice that we hear and some subliminal impressions that we have when we sing ourselves trigger such archaic reactions in our vegetative nervous system. And it is also possible that an unconscious fear of such reactions would like to protect the ear from unpleasant surprises in exciting listening states and relies on the dampening relaxation of familiar habitual sounds.

Can we experience other qualities of a singing voice vegetatively in a completely different way?

- The effortless and unforced power of a voice could awaken my own dormant strength, while at the same time I can relax and listen to the powerful singing without feeling that I have to help someone in need or have to join in the fight for survival.

- Can I hear from the chirping in a singing voice, the high, brilliant frequencies with which the birds chirp, that a bird is singing that is not afraid, or that it is singing because it is not afraid? And do the chirping cricket noises in the voice also signal to me that there is no danger, that I can safely and fearlessly expose my ears to the stimuli and stimulation of the high vibrations?

- High dynamic intensities in the sound of a voice with their haunting and penetrating qualities could also break through the defensive sound barrier of habitual listening in my ears, a listening that plays it safe, that seals itself off against too much positive excitement controlled by the sympathetic nervous system, against surprise, palpitations, goose bumps, exuberance, lust.

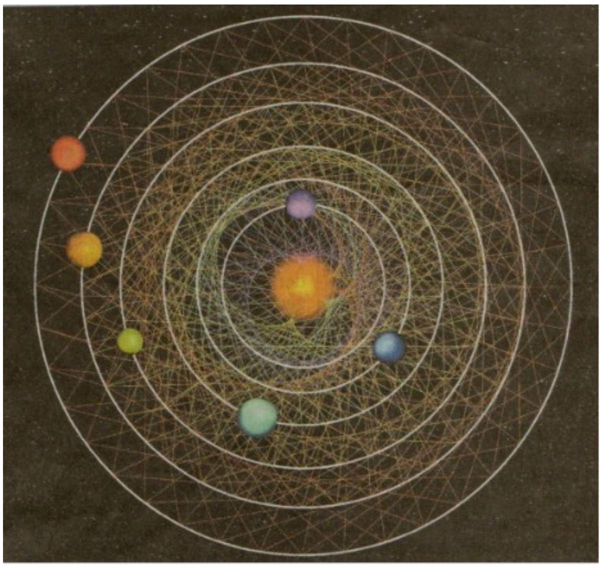
- If our ears are evolutionarily designed to "smell" danger in the finest acoustic events, then they can also sense from the finest vibrations of a singing voice how open and sensitive, how fearless and stress-free this other, foreign person is, how much he is in contact with himself and how sociable he is with other people and with the world. Naturally, my defenceless ears open wide to such sounds, and I can let them approach me just as openly and sensitively, without fear or stress, and open myself to them with all my sensitivity.

- If I can hear in a singing voice that the singing human has open ears and an open throat, then I could also perceive "beyond or into" a space in the sound and a sound space that goes into the expanse and that harbors the atmosphere of closeness, a space in which my ears can expand into unlimited expanses and in which they can sense the inner sound events very closely and directly.

Hearing as an organ for hearing danger can thus become an organ of sensation that can react to the finest and most intense vibrations with the considerable differentiation and complexity that it developed in the early fight for survival in evolution and thus receive and permeate an immeasurable wealth of frequency spectrum. Beyond the stress of everyday life, which is sufficiently influenced by the survival strategies of early humans, this primary sense of perception can open the gates to sensations of the highest excitement, comprehensive liveliness, deepest pleasure and lust.

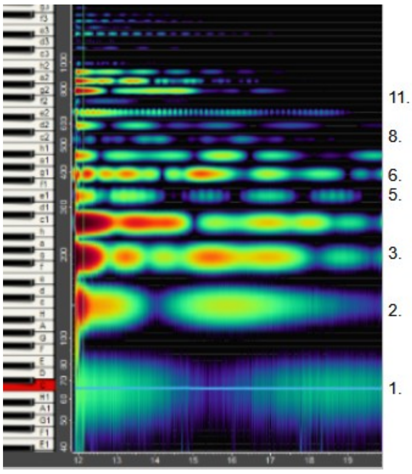
The whole world can and may hear that I have nothing to hide and that I pose no danger, and the whole world can and may hear how a human feels who has the courage to express himself in singing in all his vulnerability and sensitivity and to show himself in all his power.

Harmonical Resonance in a Planetary System, in the Sound of the Piano, in the Song of a Blackbird and in Human Singing



About 100 light years away, astronomers have discovered a planetary system around a star that is slightly smaller than our sun, but twice as old.
6 planets orbit the star "in resonance" - i.e. in sync. This is highly unusual, as it means that the orbits have remained stable for 8 billion years.
(Note the lines of force drawn in the picture between the sun and all the planets and between the planets).
If the orbital periods are calculated in days, these periods result in integer ratios, i.e. their relationships form resonances with the sun and with each other:
2:3 - 3:5 - 5:6 - 6:8 - 8:11 -
that is *harmonical resonance*.

There is not only a relationship and a certain proportional frequency ratio between the planets and the sun, but also exact proportions between the frequencies of the individual planets. The force of the sun keeps the planets in their orbits, the force such as the periodic orbit of each planet stabilizes it and has a reinforcing effect on the respective force of the other planets.



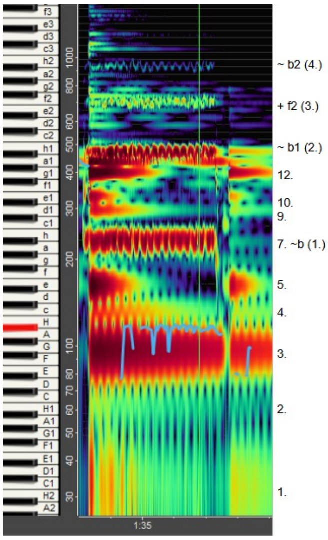
The proportions in the frequency ratios of the planets correspond to the integer proportions of a sound spectrum. If the sun is determined as the fundamental tone, then the following frequency ratios result between the partial tones from 1 to 11:
octave (1:2) - fifth (2:3) - sixth (3:5) - minor third (5:6) - fourth (6:8) ~ "tritone" (8:11).
Expressed in pitches:
C2(1.) - C3(2.) - G3(3.) - E4(5.) - G4(6.) - C5(8.) - ~ F#5(11.).
The 11th partial lies between F5 and F#5 on the "tempered" tuned piano.
The picture on the left shows the sound spectrum of C2 on the piano: The sound 'C' (the "sun") as the fundamental (1st partial) with 2nd to 14th partials. The fundamental is displayed as a pitch, but sounds 4.5 times as quiet as the loudest partial, the 2nd octave C4(4.). The fifth G3(3.) is almost as loud as C4.

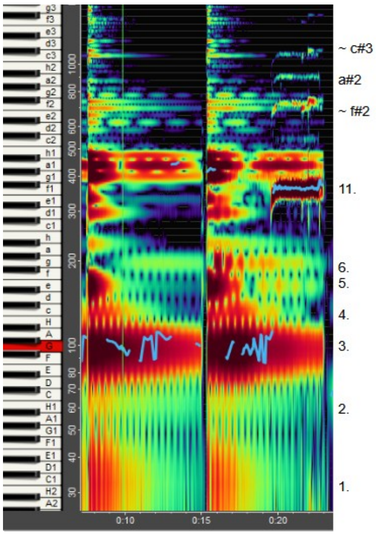
When I play the planetary sound to the sound of the "sun" on the grand piano, you can clearly hear that the F#5 is not in resonance with the other planetary frequencies because it does not correspond to the 11th partial of the fundamental. In the resonance space of the sound inside the grand piano, however, you can clearly hear that the vibrations of the 7 strings react mutually with each other, so that the C spectrum is amplified. From the dissonant-sounding F#5, the resonance of the vibrating strings audibly develops the modulation F#-G-E, from the non-resonating F#5 ("11th partial") to the 12th and then to the 10th partial. Now all partial frequencies are in resonance in one sound-gestalt, as in the spectrogram of the fundamental C2 (picture above).
(C2 is the lowest tone of the cello and the lowest tone of a bass voice).

If I transpose the fundamental tone of the piano sound 1 octave lower (double bass C1), I can sing the 11th partial "pure" and in resonance with the piano sound of C1, as well as the 7th partial, the seventh Bb3, a tone between A and Bb, which does not exist on the piano either.

This is the *"hidden arithmetic activity"* (Leibniz) of my ears, which "calculates" the 7th or 11th partial from the spectrum of the piano sound.

I only have to sing in the correct register and mobilize my auditory conception of gestalt through inner hearing by imagining the 2nd octave (4th partial) for the seventh to the low C1 in the piano sound and then, hearing it internally, I can sing the frequency-accurate 7th partial directly via the 4th-5th-6th partial (see left picture below).





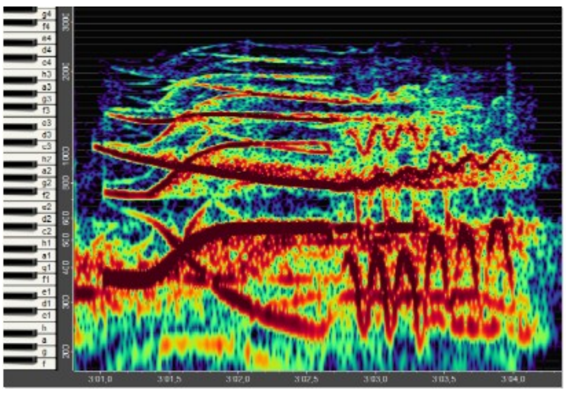
The pitch marker of the overtone analyzer shows the octave below my sung B♭3 as the virtual fundamental. The 2nd and 3rd partials of my sound can still be recognized, whereby my fifth partial (~F5) of course does not match the 11th partial of C1 at ~F#5.
So with the fundamental of my sung B♭3 I can be in resonance with the seventh of C1, while in my spectrum there are divergences to the spectrum of C1.
In the right picture, only the piano sound of C1 can be seen in the left spectrogram.

To my ears, the C1 sounds so low and so blurry that I cannot recognize any pitch, although it is a very sonorous and distinctive sound. Interestingly, the pitch marker is also "searching" for the correct pitch, as you can see from the blue lines in the area of G2 (3rd partial), the loudest low note in the spectrum. The fundamental and the octave are hardly shown in the spectrogram. In this respect, the spectro-gram corresponds to my acoustic perception, as I cannot recognize the fundamental tone either.

After I had roughly oriented myself on the piano as to where F#4 and F4 were, I spontaneously sang the 11th partial to C1 in the piano sound (right spectrogram) and surprisingly hit it exactly on frequency, as I was then able to check in the spectrogram. While singing, I had no idea whether it was the 11th partial and briefly struck the F5 and F#5 on the piano to check. As you can see above, my 11th partial is exactly in between.

Another interesting phenomenon can be recognized in the spectrogram. The resonance of the piano sound and my vocal sound has resulted in a combination sound that would not appear at all in my sound when sung alone, namely the A#5 between the 2nd and 3rd partials. This is the third to ~F#4, which in the spectrum is actually only at A#65 as the 5th partial.

Blackbird song: harmonical resonance of (1) : 2 : 3 : (5) and of 7 : 9 : 11



In a blackbird song I discovered the following highly complex motif, a 2-part sound in the fifth C5/G5 with 2 combination tones, which were created by self-reinforcing resonance from the glissando movement of the 2 voices, C4 and E5. (pitch slowed down 8x) The upper voice glides from C6 to G5 and the lower voice from F4 to C5, i.e. a song from the fifth F/C to the fifth C/G. Dynamic resonance thus creates the spectrum:
C4(1.) : C5(2.) : G5(3.) : E6(5.).

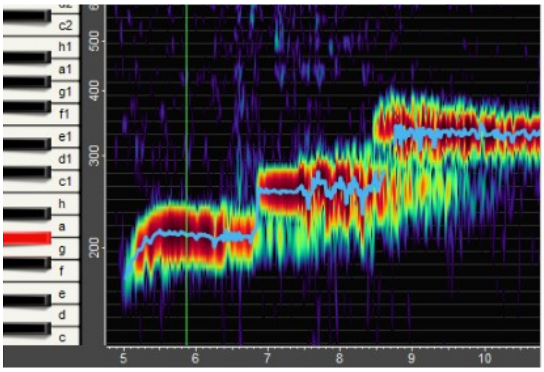
Each voice is produced separately in a membrane of the double syrinx and both vibrations form a common 2-part sound in the windpipe directly above the syrinx. Each of the 2 voices has its own spectrum with a specific frequency structure and its own resonance space. The upper voice glides continuously down a fourth, while the lower voice glides directly from a resonance space (fifth F/C) into the higher fifth (C/G). In the opposing glissando movement, both spectra interact with each other, correspond and correlate with each other, penetrate and cross each other. This dynamic

interaction in space (sound interior space in the space of a tube = standing waves) creates
2 further sounds with their own spectrum, 2 combination sounds - an *emergence phenomenon*.

One is a glissando from F5 to C4 and the other a glissando from F6 to E6.
In the harmony at the end of the motif, the lower one to the fifth C/G (2:3) forms the difference tone C4 (3-2=1), i.e. the 1st partial, and the upper one, the fifth G5, the summation tone E6 (2+3=5), i.e. the third as the 5th partial. In the proportion 1:2:3:5, all 4 spectral spaces together form a space, a sound-gestalt, a *sounding Möbius loop,* as I have called it.

This is not psychoacoustics, as it is written in the acoustics textbooks, but real measurable physical sound, which I analyzed and documented for the first time.

https://www.entfaltungderstimme.de/pdfs/Klangkosmos/Amselgesang-7.6.2_klingende-Moebius-Schleife.pdf



7 : 9 : 11 as a melody

In a blackbird song from England I heard (slowed down 8x) a melodic motif in a verse, a strange but magical-sounding triad:
G# - C - E (C and E with trill).
When I calculated the frequencies, I realized that it was not a major triad (4:5:6), as I could also hear. But it was also not a augmented triad with two major thirds, as one might assume from the three pitches (played on the piano).

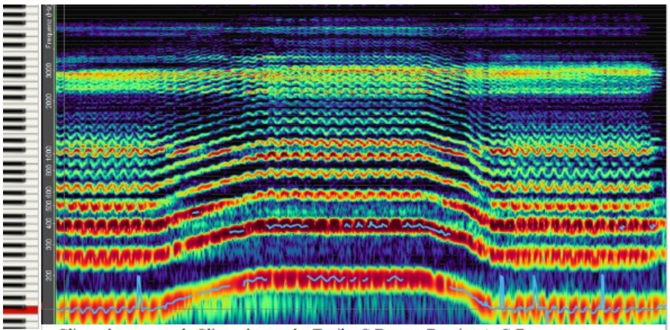
The three sounds together form the proportion: 7 : 9 : 11, beautiful variably designed.

In classical music, the augmented triad is one of the sharpest and most vehement sounds that can be formed with 3 notes, because it breaks up the physical order of sounds, the proportionally structured space of an octave (4:5:6:8). The octave is divided linearly and not logarithmically into three major thirds: C - E - G#/Ab - C, so that this triad can be inverted at will, which can trigger great tension and intensity in the ear. Singing this triad is very difficult. You really have to practise it and consciously construct it anew in your head (cerebrum) each time. Our ear is not built for this, but it has its own attraction, which is why it has a great effect in music.

What a marvel of nature this triad melody of the blackbird is (duration 0.7 s)! It does not simply sing a sequence of 3 notes with a certain pitch, but each sound is variably designed in itself, including trills and different vibrato. In the proportion of 7:9:11, the sounds move in a matrix, correlate and correspond with each other, reinforce each other and thus generate more "free" energy, an energy that in its efficiency stimulates the nervous system of the singer as well as that of the potential addressee, the female (and incidentally even my vegetative nervous system and, in addition, my judgmental sense of beauty).

next page: Harmonical resonance in human singing

Harmonical resonance in human singing - fifth 2:3



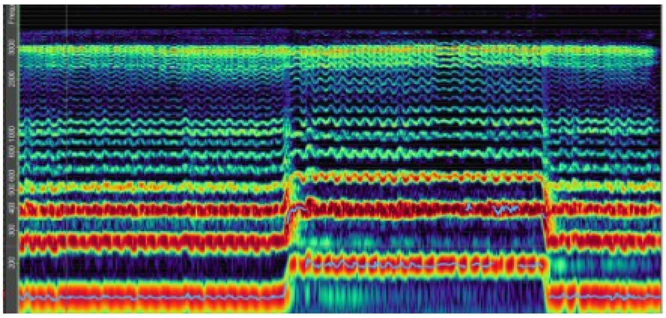
Glissando c - g - c als Glissando von der Tonika C-Dur zur Dominante G-Dur

Spectrogram of a glissando C-G-C as a glissando from the tonic C major to the dominant G major and back again

fundamental C3 with full spectrum up to the 10th partial E6 (intense 3rd partial, fifth G4) fundamental G3 with full spectrum up to 9th partial A6 (2nd partial louder than fundamental and high intensity at 5th and 6th partial, third / fifth)

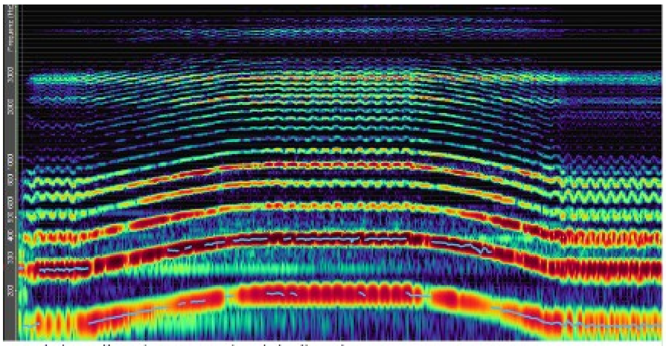
Correlations in the spectrum of C3 and G3 - 2:3 = fifth:
3rd partial (fifth G4) = 2nd partial (octave) - 9th partial (ninth D6) = 6th partial (fifth - 9:6 = 3:2)

Brilliance at 2500-3000 Hz: the efficiency regulator in the self-organized "sound system" - high-energy compression (formant) in the high frequency spectrum independent of pitch changes and vowel color
Efficient coordination and correlation produces "free" energy (low effort with optimal use of force), which in turn, as a synergetic "folder" in the sound process, promotes an interactive balancing of all forces.



Fifth C / G / C as interval -
equal correspondences in the fifth correlations -
3rd partial (C) = 2nd (G)
9th partial (C) = 6th (G)

Modulation from "C major" to "G major" with orientation to the continuous fifth G (and the double fifth, the ninth D - 2:3 = 6:9)



Tonhöhen-Glissando c - g - c mit Vokal-Glissando u-o-a-o-u

Pitch glissando C-G-C in combination with a vowel glissando u-o-a-o-u

The sound remains in the glissando in the spectrum of "C major", in a matrix of frequency proportions, from C3 as the fundamental into the fifth ("C major") and glides further into a fuller sounding spectrum with C3 as the fundamental and the distinctive sounding "C major triad" at C5 / E5 / G5 (4 : 5 : 6).

Fifth as a Sound Gestalt

The fifth is the 2nd "overtone" to the fundamental after the octave (fundamental C, octave C1 and fifth G1). Represented in partials, the fundamental C is the 1st partial, the octave C1 the 2nd partial (ratio 1 : 2) and the fifth G1 the 3rd partial (ratio 2 : 3). If, for example, a fundamental tone vibrates at 100 Hz, then the octave vibrates twice as fast, i.e. at 200 Hz and the fifth at 300 Hz. The fifth G in the 1st octave (G1) therefore always resonates in the sounding note C, as of course it does in the other octaves above it. The fifth as an "overtone" opens up the infinite series of "overtones". The fifth could therefore be described as the gateway to the entire spectrum of "overtones", the higher the denser and at the same time the finer all the way into the inaudible.
In older musical times, it was not called the "divine" fifth for nothing.
If the fifth is already heard as an "overtone" in every sound, it becomes even more clearly perceptible when I sing the corresponding tone more distinctively as a fundamental, just as the sung tone becomes more clearly audible as a fundamental when the fifth in the fundamental appears more distinctively as an "overtone".

If I sing the **fifth as an interval** (C - G or G - C) or as a sequence of intervals (C-G-C or G-C-G), I could of course sing it as an interval or a sequence of intervals of *two different pitches*. However, this would make little sense musically and soundwise, and for the singer it is rather strenuous to sing from a lower to a higher note, as it sounds rather strained to the listener too.

If, on the other hand, I sing the fifth "C-G " as an interval from the fundamental tone to the fifth and not as an interval from one (fundamental) tone to another, higher (fundamental) tone, I can remain in a sound spectrum, and for the singer as well as for the listener the pitch change is not in the foreground, but rather the *modulations* and *shifts* in the sound spectrum, which can be much more interesting and mysterious, simpler and more complex than the simple *information* of the pitch change.
Above all, it is much more interesting and exciting *for our ear or brain* if the impression is created in the sung fifth interval that a *sound event simultaneously remains the same and changes*, that a sound event appears at the same time very present and very indirect -enigmatic - that it is a *process* and not a *linear sequence of information*.

In the *"sound process"* of the fundamental-fifth interval, a *polarity of continuity and development* arises, two polarities that have a reciprocal effect on each other, both in singing, i.e. in the process of creating the sound, and in the process of perceiving the sound, for the singer as well as for the listener.

The more I orient myself in singing to the *continuity in the sound spectrum*, the easier and more complex the sound can develop in the interval, and the less I simply change the pitch, the less effort and manipulation are necessary for the *"change"* from one tone to another.

The more I am interested in the *development and unfolding* of the sound in singing, the more easily a continuous, unified sound structure - a *sound-gestalt* - appears in the interval, and the less I equalize the different tones of the interval and conceal the "tone step", the more the two "steps" of the interval, fundamental and fifth, interpenetrate and complement each other.
The change in pitch does not have to sound " smeared" (you could also pass it off as portamento), nor does the higher note have to be "set" again.
On the contrary, in this sound process the pitches are, on the one hand, sufficiently differentiated from one another, and on the other hand the interval sounds natural and meaningfully coherent.

For the *perceptual process* during singing, this means:
The fifth G can already be heard in the fundamental C, the fundamental still resounds in the fifth and the fifth G echoes in the fundamental C. As if there were an echo of the fifth in the fundamental and a resounding of the fundamental in the fifth, multiple echoes in the sound space of the interval.

Or heard differently: In the fundamental-fifth-fundamental sequence, the sound layer of the fifth can be heard continuously in the frequency spectrum. As if there were a fine, *bright band of energy* in the overall sound that continuously lights up in the sound event.

The fundamental tone with its countless overtones sounds in its full, colorful spectrum and the fifth appears less as a higher tone and more as a brighter, specific partial spectrum of the fundamental tone. It is as if the fifth-partials of the fundamental are emphasized in a *focused* way, so that the fifth seems to shine with a silvery brilliance.
The fifth thus becomes the *gateway to brilliance* in the sound of the voice.