AI translation provided courtesy of DeepL.com:

(...) a, e, i, o, u, ä, ö, ü, ä (...) forcefully against the soundboard, (...) these vocals resound quite clearly on the strings. (...)

It is only a matter of hitting the note in question exactly and holding it. More experienced

More experienced singers therefore succeed better in this attempt; my wife better than I do.
It also succeeds, but less clearly, if one lifts the mute from only one string. I think this experience is interesting for the theory of vocals.

(...) Even if you practise hearing (...) the higher secondary tones, which are there at all, it is still difficult to compare their strength to some extent with that of the fundamental. If one sings into the piano, one can easily make the strings of a, o and e, which correspond to the higher secondary tones, resonate; but one cannot sing u and i strongly enough to decide on their secondary tones in this way. If I call the fundamental the first tone, the higher tone, which makes two, three, four and so on times as many vibrations, the second, third, fourth and so on. tone, I believe I can describe the character of the main vowels as follows:

a. Next to the first, the third and fifth are clearly present, weaker 2, 4 and 7. o. Somewhat weaker than in A is 3, very weak 2 and 5. u. Almost alone the fundamental, weak 3. e. Very strong 2, the higher ones hardly audible. i. It seems to me that 2 and 3, in relation to the weak fundamental, determine the bright character of the vowel. - 5 is also faintly present.

By the way, the higher secondary tones can be heard very clearly if one carries out the (...) experiment and sings into the piano with the damper raised.

Hermann von Helmholtz ‚XIX. Die Vocale'. Archiv für die holländischen Beiträge zur Natur- und Heilkunde. Bd. I, S. 354–355. (1857) – quoted after: Wissenschaftliche Abhandlungen von Hermann Helmholtz, Vol. I, pp.395–396, Verlag Johann Ambrosius Barth, Leipzig 1882)

On Saturday I tried to finish the manuscript of the Croonian lecture. It was a dark rainy day, but I went to Kensington to see Professor Maxwell. He showed me some beautiful apparatus for colour theory, in which branch I had previously worked myself. There was a festive luncheon there with champagne and all sorts of delights. He had also invited me a colour-blind colleague, Professor Pole, on whom we did experiments.

Hermann von Helmholtz, in a letter to Anna von Helmholtz, Athenæum, London, 19. April 1864, in: Anna von Helmholtz, Ein Lebensbild in Briefen. edited by Ellen von Siemens-Helmholtz, Vol. I, p. 122, Verlag für Kulturpolitik, Berlin 1929)

Music has so far evaded scientific treatment more than any other art. Poetry, painting and sculpture at least take the material for their depictions from the world of experience; they depict nature and people. Not only can this material be critically examined for its accuracy and natural truth, but even in the investigation of the reasons for the aesthetic pleasure which the works of these arts arouse, scientific art criticism has made some progress, even if enthusiastic souls often deny it the right to do so. In music, on the other hand, those who reject the critical "dissection of its pleasures" still seem to be right for the time being. This art, which does not take its material from sensual experience, which does not seek to describe the external world, but only exceptionally to imitate it, thus withdraws from scientific observation most of the points of attack that the other arts offer, and therefore appears in its effects as incomprehensible and wonderful as it is powerful. For the time being, therefore, I must confine myself to the consideration of its artistic material, the tones or sensations of tone. It has always attracted me as a wonderful and particularly interesting mystery that precisely in the teaching of tones, in the physical and technical foundations of music, which among all the arts appears in its effect on the mind as the most immaterial, most fleeting and most delicate originator of incalculable and indescribable moods, the science of the purest and most consistent thinking, mathematics, proved so fruitful. The basso continuo is, after all, a kind of applied mathematics; in the department of tonal intervals, time signatures, etc., the ratios of whole numbers - sometimes even logarithms - play an outstanding role.

Mathematics and music, the sharpest contrast of intellectual activity that one can find, and yet connected, supporting each other, as if they wanted to prove the secret consistency that runs through all the activities of our mind and which also lets us suspect unconscious expressions of mysteriously working rationality in the revelations of artistic genius.

By looking at physical acoustics from a physiological point of view, i.e. by examining more closely the role that is assigned to the ear in the perception of sounds, many things seemed to become clearer in their connection, and so I will try to see if I can share with you some of the interest that these questions have aroused in me by (...) trying to illustrate some of the results of physical and physiological acoustics.

(...) The question of the cause of consonance.

In fact, it is certain that the oscillation numbers of consonant tones are always in a ratio of small whole numbers to each other. But why? What do the ratios of the small integers have to do with consonance? (...)

First, what is a tone? Common experience already teaches us that all sounding bodies are in a state of trembling. We see and feel this trembling, and with strong tones we feel the buzzing of the air around us even without touching the sounding body. More specifically, physics shows that any series of sufficiently rapid repetitive shocks that set the air vibrating produces a sound in it.

The sound becomes musical when the rapid impacts are repeated in a completely regular manner and at exactly the same times, while irregular vibrations of the air only give rise to noises. The pitch of a musical tone depends on the number of such shocks that occur at the same time; the more shocks in the same time, the higher the tone. As has been noted, there is a close connection between the known harmonic, musical intervals and the number of air vibrations. If one tone vibrates twice as much in the same time as another, it is the higher octave of the other. If the ratio of vibrations in the same time is 2 to 3, both tones form a fifth, if it is 4 to 5, they form a major third.
If you remember that the number of vibrations in the tones of the major chord CJEGC is in the ratio of the numbers 4 to 5 to 6 to 8, then you can derive all the other tone ratios from this by imagining a new major chord built over each of the tones mentioned, which shows the same vibration ratios. The number of vibrations, as can be seen from a calculation made according to this rule, is extraordinarily different within the range of audible tones. Since the higher octave of a tone makes twice as many vibrations as its fundamental, the second higher makes 4 times as many, the third 8 times as many. Our newer pianofortes comprise 7 octaves; their highest note therefore makes 128 vibrations in the same time as their lowest note makes one vibration.
(...) The musical height of the tone depends only on the number of air vibrations per second, not on the manner in which they are produced. It makes no difference whether it is produced by the vibrating strings of the piano and violin, by the vocal chords of the human larynx, by the metal reeds of the harmonica, the reeds of the clarinet, oboe and bassoon, by the vibration of the lips of the blower in the mouthpiece of brass instruments, or by the refraction of the air at the sharp lips of organ pipes and flutes.

A tone with the same number of vibrations is always of the same pitch, regardless of which of these instruments produces it. The difference between the note A of the piano and the same note A of the violin, flute, clarinet and trumpet is called timbre. (...)

1. a series of air blasts which follow each other sufficiently quickly give a tone. 2. the faster they follow each other, the higher the tone.
3. if the ratio of the numbers of vibrations is exactly 1 to 2, they give a pure octave; if it is 2 to 3, a pure fifth; if it is 3 to 4, a pure fourth, etc. Every slightest change in these ratios affects the purity of the consonance.

When different simple waves are combined on the surface of the water, the combined wave form only remains for a moment, because the longer waves travel faster than the shorter ones, so they separate again immediately, and the eye has the opportunity to recognise that there are several wave trains. But when sound waves are similarly compounded, they do not separate, because long and short wills propagate through the air-space with equal velocity; but the compounded wave, going on as it is, remains as sip, and where it meets the ear, no one can tell from it whether it originally arose in this form from a musical instrument, or whether it was compounded on the way from two or more wave trains.

What does the ear do now, does it dissolve it or does it grasp it as a whole? - The answer to this question can vary according to the meaning of the question, for we must distinguish two things here, namely, firstly, the sensation in the auditory nerve, as it develops without the interference of mental activity, and the idea which we form as a consequence of this sensation. We must therefore distinguish, as it were, between the bodily ear of the body and the spiritual ear of the imaginative faculty. The physical ear always does exactly what the mathematician does by means of Fourier's theorem, and what the piano does with a compound tone mass; it resolves the wave forms, which do not already originally correspond, like the tuning fork tones, to the simple wave form, into a sum of simple waves, and perceives the tone belonging to each simple wave individually, whether the wave originally emerged in this way from the source of the tone, or was only composed on the way.
(...) It follows from this that in the cochlea of the ear, too, every external tone will not only set the platelet corresponding to its fundamental tone in sympathetic vibration, and excite the associated nerve fibres, but also those corresponding to the overtones, so that the latter must be felt just as well as the fundamental tone.
According to this, a simple tone is only one which is excited by a wave train of the pure wave form. All other waveforms, as produced by most musical instruments, excite multiple tone sensations.

From this it follows that, strictly speaking, for sensation all the tones of musical instruments are to be regarded as chords with a predominant fundamental.
(...) If one examines the vowels of the human voice, one easily recognises with the help of the resonators that the overtones of each individual vowel are particularly strong in certain regions of the scale, for example those of the o in the region of the single-stroke b\ those of the A in that of the double-stroke one octave higher.

(...) If you sing the vowel A on any note of the piano, A will sound out again quite clearly, and if you sing 0 or U, the strings 0 and U will resonate. All that matters is that you hit the note of the piano that you want to sing quite accurately. The vowel sound is only produced by the higher strings, which correspond to the harmonic overtones of the indicated tone. If you leave the mute on these, the attempt will not succeed.
Thus, in this experiment, the tones of many strings are excited by the tone of one source, namely the voice, and thereby an air movement is produced which is equal in form, and thus also in timbre, to that of the simple tone.
Hermann von Helmholtz ‚Über die physiologische Ursache der musikalischen Harmonie', in: ‚Populäre Wissenschaftliche Vorträge', Erstes Heft, Verlag Friedrich Vieweg und Sohn, Braunschweig 1865

A musical tone is produced by a periodic movement of the air which repeats itself in the same way in equal and sufficiently small periods of time. Within each individual period of oscillation, the movement remains completely arbitrary, if only the same movement that took place within the first period recurs in the same way in all subsequent periods.
If the air particles move back and forth once during each period of oscillation in exactly the same way as the centre of gravity of a pendulum times during a very small oscillation, then we hear only a simple and single tone whose musical pitch is determined by the number of equal periods contained in one second. In this case, both the velocity and the pressure of the air at each individual point of the oscillating mass of air can be simply expressed mathematically by an expression of the form A sin (2 n nt + c). In an earlier work on combination tones, I myself demonstrated a method by which one can produce such simple pendulum-like oscillations of the air particles, or, as I proposed to call them, simple air waves. I used tuning forks which, when struck and held freely in the air, do not communicate their vibrations to the air mass in any noticeable way. If, however, they are held in front of the opening of resonance tubes whose lowest tone is in harmony with that of the tuning fork, this lowest tone of the tuning fork is powerfully communicated to the air. Even though the tuning fork can produce higher tones when struck, it is easy to arrange in such a way that the higher tones of the tuning fork are not in harmony with the higher tones of the resonance tube, and therefore, not amplified by the resonance tube, remain

inaudible.

(...) Is the distinction of musical timbre based only on the perception of overtones of different strengths, or does the ear also distinguish the phase differences?
The decision of this question was most easily obtained when one virtually tried to produce tones of different timbre by direct composition of simple tones, such as can be produced by tuning forks. The various vocals of human speech presented themselves as one of the most suitable objects of imitation, because these can be produced as evenly sustained musical tones and kept fairly, though not entirely, free from unmusical noise.
My apparatus consists of a series of 8 tuning forks corresponding to the B (in the lowest octave of the male voices), and its harmonic overtones up to the b2 (in the highest soprano notes), namely the notes B, b, f, b' d2, f2 as2 and b2. Each tuning fork is fixed between the legs of a small electromagnet bent in the shape of a horseshoe, and connected to a tuned resonance tube. resonance tube. The openings of the resonance tubes are provided with movable covers which can be pulled away by threads whose ends are attached to a small keyboard. The tuning forks are set in motion by intermittent electric currents which are generated according to the principle of Neef's hammer, and whose number per second is equal to the number of vibrations of the lowest fork, namely 112. The devices are so well made - I had to struggle with quite considerable difficulties - that, after the apparatus has been set in motion, one hardly hears a slight buzzing from the forks as long as the resonance tubes are all closed; as soon as, however, one or some of the resonance tubes are opened by means of the keyboard, the respective tones emerge strongly. The strength of the tones that one wants to indicate can easily be regulated by opening the respective tubes more or less completely.

I proceeded in such a way that I first combined the two lowest tones, then the third and gradually added more and more, and tried to imitate the resulting sounds with my voice. In this way I gradually learned to imitate the various vowel sounds more or less completely, and quite well and clearly u, o, ö, e, somewhat less well i, ü, in which the whispering of the air in the oral cavity, to whose different character in the vowels Donders drew attention, is relatively loudest, and a and Ä less well, because in these a very large number of tones must work together, the strength of which cannot all be so completely controlled individually, and in the case of a there would even have to be a series of higher tones, for which I had no more forks.

In general, it should be noted that the vowel sounds composed by means of tuning forks were more similar to the sung sounds of the human voice than to the spoken ones. In the dry sound of ordinary speech, a different kind of intonation is chosen, in which the fundamental tone is much weaker than the higher secondary tones and the noises; (...).

Hermann von Helmholtz ‚XX. Ueber die Klangfarbe der Vocale', Gelehrte Anzeige der k. bayrischen Akademie der Wissenschaften. Sitzung vom 2. April 1859. Nr.67-69; pp.537-541; pp.445-541; pp.553-556. Poggendorff's Annalen, Vol.108, pp.280-290. – quoted after: Wissenschaftliche Abhandlungen von Hermann Helmholtz, Vol.1, pp.397-407, Verlag Johann Ambrosius Barth, Leipzig 1882

At Becker's I found an invitation from Werner Siemens to meet Mr. Edison at the castle hotel, and on the way I found the whole Siemens family, and after a long wait also Mr. Edison with a very pretty young wife. He is a beardless man, somewhat similar to Napoleon I, only more good-natured and with very intelligent eyes. In response to our questions, he told us a lot about his way of working, which was very interesting. Mannesmann, the great tube-puller, was also present. At last we went down to the museum with Mr. Edison to see the latest phonograph which his assistant was producing to a packed crowd there. Through a listening tube set in the pipe, this phonograph did indeed sound extraordinarily clear, about like a good and strong-acting telephone. It also produced the Radetzky March, performed by a full military band, so that one could hear the individual instruments. Mr. Edison promised to send me such an instrument and Dr. Pernet has been rehearsed on the treatment.

On Thursday they had elected me chairman of the Physical Section in advance and scheduled my lecture as the first, which I then delivered somewhat extempore. In the evening I put it down on paper; the natural scientists had a banquet at the museum.
Today was the public meeting in the museum. First a lecture by Professor Hertz, which was really extraordinarily good, also very accomplished in form, tactful and tasteful - and provoked a storm of

applause.

Then a great debate on amendments to the statutes, by which the German Naturalists' Assembly should be brought closer to the British Association, the plan for which I once fought in vain in Bonn. Here, too, there was strong opposition and Virchow, who defended the plan, was very much pressed. I also spoke out several times and was told afterwards from various quarters that Bergmann and I had saved the day by intervening. In the end, everything was pushed through with only a few changes.

Hermann von Helmholtz, in a letter to Anna von Helmholtz, Heidelberg, 20. September 1889, in: Anna von Helmholtz, Ein Lebensbild in Briefen. edited by Ellen von Siemens-Helmholtz, pp.18-19, Vol.2, Verlag für Kulturpolitik, Berlin 1929

Harmony and disharmony are distinguished by the fact that in the former, the tones flow next to each other as evenly as each one on its own, while in disharmony incompatibility takes place and they divide each other into individual shocks. You will see how everything that has been discussed works together to achieve this result. First of all, the phenomenon of shocks or beatings is based on interference of wave motion; it could therefore only come to sound because it is a wave motion. On the other hand, in order to determine the consonant intervals, the ear had to be able to perceive the overtones and to resolve the composite wave systems into simple ones according to Fourier's theorem. The fact that the overtones of the musically useful tones are in the ratio of the integers to one to the fundamental, and that the oscillation ratios of the harmonic intervals therefore correspond to the smallest integers, is entirely based on Fourier's theorem. How essential the aforementioned physiological peculiarity of the ear is, becomes particularly clear when we compare it with the eye. Light, too, is a wave motion of a special medium spread through space, the light ether; light, too, shows the phenomena of interference. Light, too, has waves of different periods of oscillation, which the eye perceives as different colours, namely, those with the greatest period of oscillation as Roth; then follow orange, yellow, green, blue, violet, whose period of oscillation is about half that of the outermost Roth. But the eye cannot separate composite light-wave systems, i.e. composite colours, from one another; it perceives them in a simple sensation that cannot be resolved, that of a mixed colour. It is therefore indifferent to it whether basic colours of simple or non-simple oscillation ratios are united in the mixed colour. It has no harmony in the sense that the ear has; it has no music.

Aesthetics seeks the essence of the artistically beautiful in its unconscious rationality. I have (...) sought to uncover the hidden law that determines the euphony of harmonic tone combinations. It is actually an unconscious law, in so far as it is based in the overtones which, although felt by the nerves, do not usually enter the realm of conscious imagination, but whose compatibility or incompatibility is nevertheless felt without the listener knowing where the cause of his feeling lies.

These phenomena of purely sensual euphony are, of course, only the lowest degree of musical beauty. For the higher, spiritual beauty of music, harmony and disharmony are only means, but essential and powerful means. In disharmony, the auditory nerve feels tormented by the blasts of incompatible tones; it longs for the pure outflow of tones in harmony, and pushes towards it in order to dwell in it soothed. Thus both alternately drive and calm the flow of tones, in whose incorporeal movement the mind gazes at an image of the current of its ideas and moods. Similar to the

the rhythmically repetitive and yet ever-changing manner of movement captivates it here and carries it away with it. But whereas there only mechanical forces of nature blindly prevail, and therefore in the mood of the observer the impression of desert prevails, in the musical work of art the movement follows the currents of the excited soul of the artist. Sometimes gently flowing, sometimes gracefully leaping, sometimes fiercely excited, jolted by the natural sounds of passion or violently working, the flow of tones transmits in original liveliness undreamed-of moods, which the artist has eavesdropped on his soul, into the soul of the listener, in order to finally carry him up into the peace of eternal beauty, to whose proclaimers among men the divinity has consecrated only a few of its chosen favourites.

Here, however, are the limits of natural research and command me to stop.

Hermann von Helmholtz ‚Über die physiologische Ursache der musikalischen Harmonie', in: ‚Populäre Wissenschaftliche Vorträge', Erstes Heft, Verlag Friedrich Vieweg und Sohn, Braunschweig 1865