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Chapter 15
Contesting the Musical Ear: Hermann von Helmholtz, Gottfried Weber and Carl Stumpf Analyzing Mozart

Julia Kursell

Abstract Music analysis emerged in the late nineteenth century as an occupation in its own right, independent from the education of composers. This chapter uses three case studies to describe how and with what aims three authors, in analyzing music by Mozart, produced samples to which to compare his music. It thereby traces how a pairing of the notions of analysis and composition increasingly created room for a concept of synthesis that eventually replaced the notion of the "fine ear" for music with procedures devised by the analyst that take into account a genuine malleability of hearing and listening. The cases are Hermann von Helmholtz's charts for indicating the harmoniousness of its component chords in Mozart's *Ave verum corpus*, K. 618; Gottfried Weber's fabricated alternatives to the famous dissonances opening the string quartet C major, K. 465; and, finally, Carl Stumpf's comments on his listening of the Serenade B-flat major, K. 361, after having extensively used the first technical analysis and synthesis of the sound of musical instruments.

Keywords Hermann von Helmholtz · Gottfried Weber · Carl Stumpf · Wolfgang Amadeus Mozart · Analysis · Music · Hearing · Listening

15.1 Introduction

"Mozart is certainly the composer who had the surest instinct for the delicacies of his art," Hermann von Helmholtz (1821–1874) wrote in his groundbreaking book *On the Sensations of Tone as a Physiological Basis for the Theory of Music* (Helmholtz 1863, 366; 1885, 225). To demonstrate that music corroborated his assumptions regarding the functioning of the ear, Helmholtz performed an analysis of Mozart's choral piece *Ave verum corpus*, K. 618. Composers such as Wolfgang Amadeus Mozart (1756–1791), Helmholtz argued, had access to that which in

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music teaching remained unexplained: “It was left to the musician himself to obtain some insight into the various effects of the various positions of chords by mere use and experience. No rule could be given to guide him” (224).

Whether Helmholtz’s notes on Mozart may be considered as amounting to a “musical analysis” is debatable. The historiography of the scholarly study of music generally considers musical analysis to have emerged in the late nineteenth century—after Helmholtz and after the foundation of the discipline of musicology, which, for the German speaking realm, is generally considered to have occurred in the mid 1880s, heralded by the foundation of the journal *Vierteljahrsschrift für Musikwissenschaft* in 1885.[1] However, the first examples of full-fledged musical analyses mentioned in scholarly literature stem from the first half of the nineteenth century. Gottfried Weber (1779–1839), an author and music teacher of private means, is typically included among the first to have published an analysis of music in the form that would subsequently become standard for the discipline: an extended discussion of a single composition according to explicit criteria. His analysis of the slow introduction to Mozart’s string quartet in C Major, K. 465 was first published in Weber’s own journal *Caecilia* in 1831 and later inserted into his three-volume teaching manual. Weber explicitly addressed his own procedure as such, using the German equivalent to analysis—namely, “taking apart” (*zergliedern*) as well as the Greek borrowing “Analyse.” More significantly, he did not assume the perspective of a composer wishing to learn from Mozart but that of a listener who wished to understand the composer’s music. It was this perspective—that of the informed listener—that would later go on to define the target of musical analysis.

While Helmholtz did not explicitly frame the discussion of the *Ave verum corpus* as an “analysis,” he did embed it into what he called “a correct and careful analysis of a mass of sound” (1885, 227). As such, it formed part of the core of his book, the testing of knowledge about hearing that may be in contradiction to his hypothesis about the functioning of the ear. He was aware that he would be unable to prove in vivo his claim that small bodies in the inner ear reacted selectively to the frequency components in sound. However, while confirming that his theory of selective resonance in the organ of Corti had “no immediate connection” to his investigation into music, he insisted that the theory could be said to gather “all the various acoustical phenomena with which we are concerned into one sheaf,” giving a “clear, intelligible, and evident explanation of the whole phenomena and their connection” (227). What mattered most was that his observations of Mozart’s piece did not contradict his findings on hearing.

The present chapter, which discusses three examples of nineteenth-century analyses of Mozart’s music, confronts two key approaches: listening to music versus hearing music. Both Helmholtz and Weber, who instantiate these two approaches respectively, used methods that are said to be analytical and implemented these

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[1] For a more recent general reference on the history of musicology, see Melanie Wald-Fuhrmann’s, entry *Musikwissenschaft, Zur Fachgeschichte* in: *MGG Online*, ed.by Laurenz Lütteken, New York, Kassel, Stuttgart 2016ff., published June 2022, https://www.mgg-online.com/mgg/stable/421611 (accessed June 29, 2024).

methods as such, but their emphases on listening and hearing afford different degrees of agency to the subject. While Weber emphasizes that his analysis empowers the listening subject to understand what Mozart was doing, Helmholtz's analysis empowers those to whom musical training was not accessible but nevertheless could not but hear music in the manner in which he demonstrated it to affect the ear. Helmholtz's instruments assisted "a researcher without any music training," as noted by Franz Joseph Pisko (1827–1888), author of a popular introduction to Helmholtz's new apparatus of acoustics, in 1865. "Even one who is hard of hearing can undertake acoustic studies, in which weak tones that are covered by a number of simultaneous sounds are supposed to be perceived" (1865, 7).

Marshaling his knowledge of mathematics, physics, anatomy, physiology *and* music, Helmholtz not only proposed a theory of hearing—which was later disproven by György Békésy, who was awarded the Nobel prize for his explanation of the mechanics that performed the selective analysis in the inner ear—but he also designed an *experimentum crucis* in which his analyses of sound were subject to a synthesis to test the validity of his hypothesis of the ear's capacity to discriminate sound. The coupling of analysis and synthesis within the domain of sound also exerted a considerable impact on musical discourse, as I shall argue in a third example in this chapter—a remark by philosopher and experimental psychologist Carl Stumpf (1848–1936) on Mozart's Serenade, K. 361, from his book *Speech Sounds* (1926) will be used to investigate whether and how the paired notions of analysis and synthesis in hearing music interfere with those of composition and analysis in listening to music. Stumpf prominently introduced sound analysis and synthesis into his psychological laboratory in the 1910s. Yet, his remark on Mozart, which concerns the role of timbre, reveals a trajectory of experiences that the individual listener—Stumpf, in this case—must have undergone before being able to analyze the features of a composition at a given moment. As the remark on timbre demonstrates, this experience may take any form, and the analysis, accordingly, may be just as well informed by sound analysis and synthesis.

Musical analysis will thus be discussed in this chapter from the following three perspectives. In the first part, which focuses on Helmholtz, I shall demonstrate that the criteria for analysis stem from an attribution of properties that operate on several levels while taking apart the matter at hand. The notion that sound can be analyzed and synthesized offers a new basis for arranging charts of the properties under discussion. In the second part, I shall trace how Weber was first obliged to instruct his readership about what they might expect. They first had to acquire the rules of composition. Once this stage was assumed, the process of "taking apart" could address a given piece. This section will emphasize how the object for analysis must be constituted, including not only the authority of the canonized piece but also the trajectory that leads to its understanding. The third part concerning Stumpf's remark on Mozart discusses how he takes the analysis and its object to be co-constituted both through listening and hearing. The working hypothesis at stake in this chapter is that the analysis of music always co-constitutes its objects. In observing how actors in three different fields use different strategies for this co-constitution, the chapter traces how the notion of musical analysis became detached from that of composition.

15.2 Experimental Sensory Physiology: Helmholtz Analyzing K. 618

Helmholtz's experimental physiology of hearing made extensive use of music as an object of experimentation. Like its counterpart, the *Physiological Optics* (1867), the book *On the Sensations of Tone as a Physiological Basis for the Theory of Music* (1863) has a tripartite structure that covers the physical, physiological, and psychological conditions of sensory—in this case, auditory— physiology. However, while the *Optics* discussed stereoscopic vision as the main object for discussing the highest level of sensory processing in physiology, the *Sensations of Tone* turned to music instead. Music permeated all three parts of the research presented in the book. Periodic sound was the privileged object not only of Western tonal music but also of acoustic science, and Helmholtz's work fostered its status as an aesthetic premise of music composed in the nineteenth century.

In the first part of the *Sensations of Tone*, which discusses the physical and anatomical preconditions for audible sound entering the ear up to the nerve endings, Helmholtz's presented his resonance theory of hearing. According to this theory, minute bodies along the inner ear's basilar membrane were capable of selectively resonating, each in its respective eigenfrequency, with incoming frequency components. This theory and, more specifically, the claim of resonating bodies whose eigenfrequencies covered the range of hearing could not be proven. The minute dimensions of the inner ear, located within the hardest bone of the human body, prohibited observation, and no resonance was demonstrable by post-mortem anatomy. It was only in the twentieth century that the basilar membrane became visible in action. For Helmholtz, the workings of the inner ear remained inaccessible to verification by autopsy.

The wealth of experiments and knowledge accumulated in Helmholtz's book centered on his desire to fill this gap. Anything known about sound and music that was within reach—from the sound of musical instruments through speech sounds and compositions to music history and non-European theoretical writing—was used in the interest of excluding contradictions to the main hypothesis. The second part—on the physiology of hearing proper—focused on distortions that could reveal the ear's functioning by exposing its limitations. Again, music provided most of the phenomena on which he reported, as the distortions in question were those that occurred from simultaneously given periodic sounds. Helmholtz proposed, for instance, that the beats resulting from the superposition of periodic waves could be correlated with the musical notion of dissonance, and he speculated that the happy or gloomy impression conveyed by major and minor modes, respectively, was partly due to the emergence of combination tones that occurred when the sound's amplitudes exceeded the ear's dimensions. The non-linear distortion that he was able to calculate had not previously been described for hearing. Its discovery, published in *Annalen der Physik und Chemie* in 1856, granted Helmholtz his entry into the field of auditory physiology.

Helmholtz's new explanation of combination tones—difference tones, to use today's terminology—turned the field of auditory physiology upside down. If musical tones had previously been held to be a figment of the imagination—namely, as that which the mind makes up from the physical vibration—the understanding of the ear as a distorted auditory channel showed that the body produced what would be perceived in the mind. The notion of acoustics as a branch of physics was thus unnecessary, according to Helmholtz, as it did not relate to any properties of vibration that might not hold to inaudible vibration. The bodily conditions of sound production now had to be integrated into the physical study of sound. This also entailed that physics did not stop before the ear to leave perception to the mind: rather, physics entered the body. In the ear itself, two tones could produce a third, and the mind—or, for that matter, the music listener—could not but hear it.[2]

Two tones or periodic sounds producing a third meant that two musical notes would produce a third note that was unwanted by the musician. That this phenomenon was of the same kind as the culturally produced musical tones made music an interesting object of inquiry. Mozart's choral piece, *Ave verum corpus*, K. 618, which, Helmholtz writes, was praised for its beauty and simplicity, could serve his purposes for an examination of whether a composer such as Mozart could avoid the combination tones or use them artfully.

Prior to Helmholtz's discussion of the piece, the composer and author Hector Berlioz (1803–1869) had mentioned the *Ave verum corpus* in his treatise on instrumentation, the *Grand traité d'instrumentation et d'orchestration modernes* (1844). There, it served to exemplify the use of the human voice in choral music. One feature that Berlioz noted as particularly remarkable was the indication "sotto voce"—that is, with a soft voice—that applied throughout the entire piece. Berlioz acknowledged the difficulty of singing softly in a controlled way over a lengthy period of time and remarked that it was therefore advisable to use the range in which the singers would feel most comfortable. The composer, he wrote,

> should use only notes of the medium [range] in an Andante with soft and sustained sounds; those alone can possess the suitable quality of tone, dwell with calm and precision, and be sustained without the least effort in a pianissimo. This is what Mozart has done in his celestial prayer: "Ave verum corpus." (1858, 179)

Such soft sound production would be unlikely to produce distortion of the kind that interested Helmholtz. Nevertheless, Mozart's piece was one of two compositions that he scrutinized in a laboratory setting, the other being a *Stabat Mater* by

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[2] On Helmholtz's research into combination tones, see Pantalony 2005; Kursell 2009, 2015; Hiebert 2014. In Kursell 2018a, I attempt to link the research on combination tones, e.g. in Johannes Müller and Jan Purkyne, to that on "subjective phenomena." On the latter, especially Johan Wolfgang Goethe's notion of subjective phenomena, see Crary 1990; Vogl 2007; Schimma and Vogl 2009; Schäfer 2011.

Renaissance composer Giovanni Pierluigi da Palestrina (ca. 1525–1594). On a keyboard instrument that Helmholtz had constructed for his experimental acoustic work—a harmonium with a steady sound that was tuned according to his instructions—he investigated an aspect of the combination of notes that he had found to be neglected in harmony textbooks:

> In musical theory, as hitherto expounded, very little has been said of the influence of the transposition of chords on harmonious effect. It is usual to give as a rule that close intervals must not be used in the bass, and that the intervals should be tolerably evenly distributed between the extreme tones. And even these rules do not appear as consequences of the theoretical views and laws usually given, according to which a consonant interval remains consonant in whatever part of the scale it is taken, and however it may be transposed or combined with other. They rather appear as practical exceptions from general rules. (1875, 339)

Helmholtz himself completed an extensive study of these distributions, as he expected them to differ with respect to their degree of distortion. These distortions are prominent, for example, in the piercing sound of recorder ensembles who need not play falsely to sound so: the disturbing additional pitches emerge in the listeners' ears. The measurements and experimental verifications that Helmholtz undertook using his harmonium resulted in a list of the "best sounding combinations" (1875, 229) of triads and tetrads in major and minor. He then turned to actual compositions to determine whether his conjectures were borne out by any composer. The *Ave verum corpus*, he wrote,

> is particularly celebrated for its wonderfully pure and smooth harmonies. On examining this little piece as one of the most suitable examples for our purpose, we find in its first clause, which has an extremely soft and sweet effect, none but major chords, and chords of the dominant Seventh. All these major chords belong to those which we have noted as having the more perfect positions.[3]

He then enumerated the frequencies of chords as they were ranked in his chart of harmoniousness, disregarding their melodic and harmonic sequence in the piece. However, he discussed the larger formal units again, continuing,

> It is very striking, by way of comparison, to find that the second clause of the same piece, which is more veiled, longing, and mystical, and laboriously modulates through bolder transitions and harsher dissonances, has many more minor chords, which, as well as the major chords scattered among them, are for the most part brought into unfavourable positions, until the final chord again restores perfect harmony. (339–340)

The status of the chords in this investigation is remarkable. To define them, Helmholtz did not resort to harmony teaching manuals, at least not directly, but rather created his own chart of building blocks. Chapter 12 on "chords" presents a table that aligns the intervals he discusses two chapters earlier with regard to their consonance and dissonance (Fig. 15.1). In the top left corner, the letter C indicates the lower of two notes, the second of which is aligned vertically and horizontally

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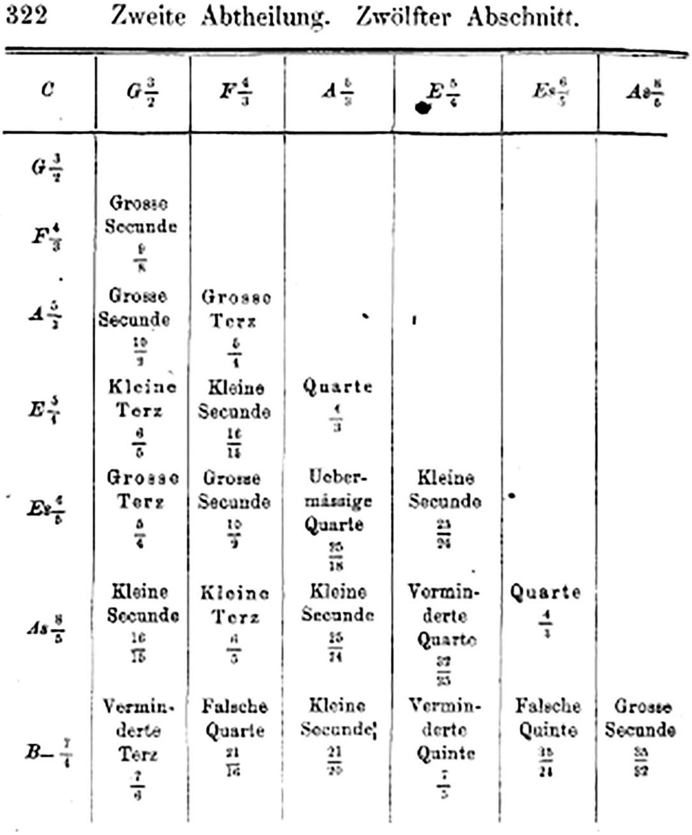
[3] The German original is even more affirmative than Ellis' translation: "Alle diese Durakkorde gehören den von uns als vollkommen wohlklingend bezeichneten Akkorden an" (366).



322 Zweite Abtheilung. Zwölfter Abschnitt.

C	G $\frac{3}{2}$	F $\frac{4}{3}$	A $\frac{5}{3}$	E $\frac{5}{4}$	Es $\frac{6}{5}$	As $\frac{8}{5}$
G $\frac{3}{2}$						
F $\frac{4}{3}$	Grosse Secunde $\frac{9}{8}$					
A $\frac{5}{3}$	Grosse Secunde $\frac{10}{9}$	Grosse Terz $\frac{5}{4}$				
E $\frac{5}{4}$	Kleine Terz $\frac{6}{5}$	Kleine Secunde $\frac{16}{15}$	Quarte $\frac{4}{3}$			
Es $\frac{6}{5}$	Grosse Terz $\frac{5}{4}$	Grosse Secunde $\frac{10}{9}$	Uebermässige Quarte $\frac{25}{18}$	Kleine Secunde $\frac{25}{24}$		
As $\frac{8}{5}$	Kleine Secunde $\frac{16}{15}$	Kleine Terz $\frac{6}{5}$	Kleine Secunde $\frac{25}{24}$	Verminderte Quarte $\frac{32}{25}$	Quarte $\frac{4}{3}$	
B– $\frac{7}{4}$	Verminderte Terz $\frac{7}{6}$	Falsche Quarte $\frac{21}{16}$	Kleine Secunde $\frac{21}{20}$	Verminderte Quinte $\frac{7}{5}$	Falsche Quinte $\frac{35}{24}$	Grosse Secunde $\frac{35}{32}$

Fig. 15.1 Chart of consonant intervals that produce the most consonant triad. (Helmholtz 1863, p. 322, cf. 1885, 212)

with the letter C. These are positioned in such a way as to present intervals that decrease in consonance. The ratio between C and G is the simplest next to self-identity or a doubling of the frequency—that is, an octave in musical terms. C–G, or the "fifth," indicates a ratio of 2–3 between the fundamental frequencies of two sounds. The next, "F" or the interval with a ratio of 3–4 is slightly less consonant, producing more beats, as Helmholtz calculated two chapters earlier, where he famously proposed the explanation of dissonance as the presence of interferences between two notes' spectra. A, following Helmholtz, is the next-best note to sound together with C, followed by E, E-flat, etc. He now fills in the fields that result from the horizontal and vertical alignments, indicating the interval that results between the notes that denote the further lines and columns in the chart. Thus, self-identity is left empty; below, a column of resulting intervals follows it. If the resulting interval is consonant, its name is rendered in spaced print.

From this, he obtains a list of just six consonant combinations of three pitches (Fig. 15.2).

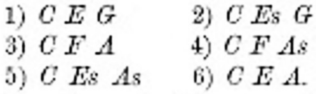
To the reader who is familiar with musical harmony teaching, the result is rather banal. Helmholtz, however, explains it again, adhering strictly to the logic of his own deduction:

> The two first of these triads are considered in musical theory as the fundamental triads from which all others are deduced. They may each be regarded as composed of two Thirds, on major and the other minor, superimposed in different orders. The chord C E G in which the major Third is below, and the minor above, is a *major triad*. It is distinguished from all other major triads by having its tones in the closest position, that is, forming the smallest intervals with each other. It is hence considered as the *fundamental chord* ("Grundakkord oder Stammakkord") or basis of all other major chords. The triad C E-flat G which has the minor Third below, and the major above, is the *fundamental chord* of all *minor triads*. (1885, 212)

In the next step, the rankings of the most harmonious triads and tetrads result from distributing the intervals over more than one octave and observing how strongly the distortions come to the fore when played on a harmonium in just intonation. On this instrument, the approximation to the integer ratios that are taken to define the intervals is closer than on a piano. Helmholtz even had a harmonium built for laboratory purposes according to his own instructions as to how its double keyboard should be tuned. Mozart's "fine ear" was thus replaced in the experiment by an instrument. Figure 15.3 shows the triad ranking with the triads themselves in hollow notes (half note or minim) and the distortions in black notes (quarter note or crotchet).

Next, Helmholtz expanded this procedure to more than three simultaneous notes, ranking "the most perfect positions of major tetrads within the compass of two octaves" (Fig. 15.4) as well as minor tetrads and less favorable positions.

The second position, encircled in Fig. 15.4, equals the position of the choir's voices in the beginning of Mozart's piece (see Fig. 15.5).



1) *C E G* 2) *C Es G*
3) *C F A* 4) *C F As*
5) *C Es As* 6) *C E A.*

Fig. 15.2 Combinations of three tones, resulting from the chart in Fig. 15.1 (Helmholtz 1863, p. 322)

Fig. 15.3 The most perfect positions of major triads (Helmholtz 1863, 332, cf. 1885, 219)

Fig. 15.4 Best positions of major tetrads within the compass of two octaves. Here, the distortions are not indicated. (Helmholtz 1863, 337, cf. 1885, 223)

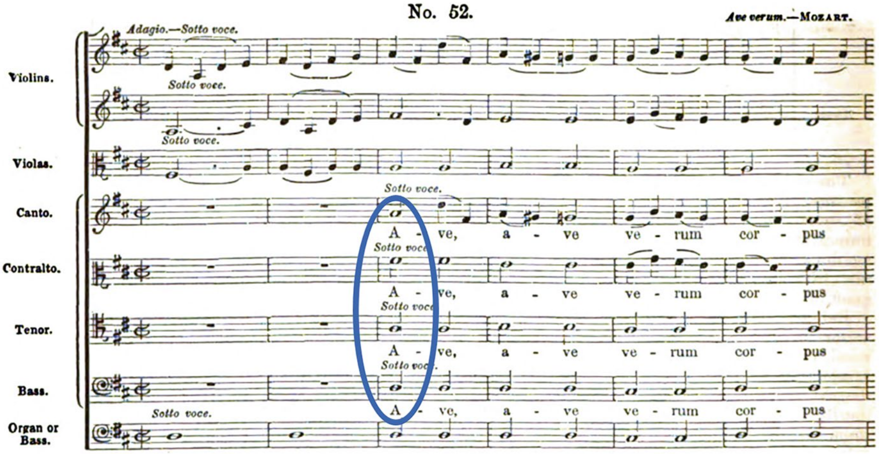


Fig. 15.5 The opening of Mozart's K. 618. Encircled: the entry of the choir in Helmholtz's "position 2"

The total ranking of Mozart's choices is, according to Helmholtz, as follows: "Position 2 occurs most frequently, and then 8, 10, 1 and 9. It is not till we come to the final modulation of this first clause that we meet with two minor chords, and a major chord in an unfavourable position" (1885, 225). Together with his description of the more "veiled" atmosphere of the second part and the bright conclusion, this results in the following distribution, given here for clarification (Fig. 15.6).

This idea of describing the overall harmonic sphere of a piece rather than following the voices and describing the transitions from chord to chord was wholly new. Rather than being built upon the rules of harmony and counterpoint, it had its roots in Helmholtz's new approach to the analysis of sound. To quote Pisko again, Helmholtz's major contribution to research in acoustics was the "analysis and

Fig. 15.6 Schematic depiction of the result of Helmholtz's analysis of Mozart's *Ave verum corpus*: A: the harmonious first part; B: less harmonious second part; F: the harmonious final chord

synthesis of sound" (1865 passim).[4] The "apparatus for the artificial composition of vowels" (*Apparat zur künstlichen Zusammensetzung der Vokalklänge*, 1912, v) that Helmholtz had designed for his acoustic research was based on his assumption that periodic sound could be analyzed into sinusoidal components in integer ratios. Following Jean-Baptist Fourier's theorem, Helmholtz further assumed that the results produced by such analyses were relevant to the ear. If two periodic sounds—or musical tones—of the same pitch and the same overall loudness could still be distinguished as stemming from different instruments or as instantiating two different vowels of the German language, then the ear would require some information regarding what made these sounds different. Based on Fourier's theorem, Helmholtz claimed that the strength of the sinusoidal components was responsible for that difference. Consequently, the organ of hearing required some ability to detect the frequencies in a sound selectively and according to their intensity. While the inner ear was inaccessible to observation, its abilities to distinguish sound could be tested.

To test this assumption, the apparatus (Fig. 15.7) was composed of a set of tuning forks and resonators, all tuned to the first eight—later the first twelve—frequencies in a harmonic spectrum. Surrounding these tuning forks with coils and connecting the coils to an "interrupter fork" that was tuned to the same frequency as the lowest of the forks, he could set all forks electromagnetically in motion. The interrupter then served to move every vibration of the lowest fork, every other vibration of the second lowest, every third vibration of the third fork, and so on. To manipulate the audibility of the forks' sound, the resonators were tuned to each fork's main frequency. The combination of fork and resonator would make the fork's soft sound audible while simultaneously eliminating unwanted additional components from its sound. As the—inharmonious—spectra of the forks and the resonators only converged in one frequency, what became audible in this experimental setup were single frequencies or "simple tones," to use Helmholtz's terminology. The resonators, in turn, could be opened and closed with movable lids, and their distance from the forks could be changed, as could the current that passed through the electromagnets with which they were surrounded. The tones would become audible when the lid of the adjacent resonator was open and almost inaudible when the lid was closed.[5]

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[4] According to the state of Google's Ngram Viewer while this chapter was written, Pisko is the first to speak of an analysis *and synthesis* of sound. Helmholtz himself does not speak of sound synthesis but of the artificial composition (*künstliche Zusammensetzung*) of vowels (translated as "apparatus for the artificial construction of vowels" by Ellis in Helmholtz 1885, vi).

[5] The manipulation of phase will not be discussed here. To my knowledge, Helmholtz was the first to use the term "phase" consistently to refer to acoustic waves (Kursell 2018a, 269).

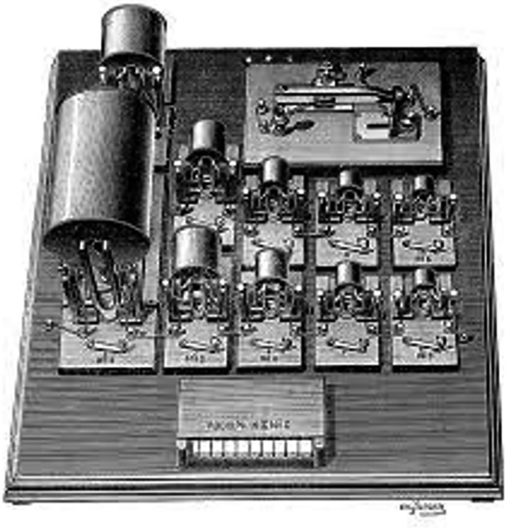

Fig. 15.7 Apparatus for the artificial construction of vowels after Helmholtz with twelve sets of tuning forks and resonators, an interrupter fork and a keyboard, taken from Koenig 1889, p. 26

Using this apparatus, Helmholtz re-instantiated the data he had gathered from analyzing sung vowels with sets of resonators of his invention. These were tuned to one Fourier series of frequencies and could be held to the ear. If a component of the series in question was prominently present in the sound under scrutiny, the resonator would single it out from the overall sound. For the synthesis, the components of the Fourier series of frequencies would then be adjusted to the values obtained in this way. Although the sounds that the 8 or 12 forks produced did not resemble any vowel sound in particular, a faint resemblance seems to have been possible when the settings were quickly switched for individual vowels. For this, a keyboard was added to the apparatus, with each key connected to one of the resonators' lids. That there was any difference at all, however, was sufficient to prove that the results of the Fourier analysis were relevant to the ear. Helmholtz termed the sound differences that he obtained in this way "musikalische Klangfarbe" or timbre.[6]

All these experiments presupposed the possibility of producing tones with a single frequency component. If such a sound was audible, an investigation of tones that were not equivalent to a musical note but to a mathematic symbol might be successful. This affected the basic concepts used in musical discourse. While German-language music theory continued to speak of one "tone" when one note was perceived, Helmholtz consistently exchanged "tone" with "tones," given that every note potentially contained multiple audible periodic components.[7] His description

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[6] See Kursell 2013, 2017, 2018a, 2018b.

[7] The literature on Helmholtz tends to overestimate the relevance of the equivalence between note and periodic sound, even today. Helmholtz apparently was not reluctant to let go of an assumption that could be dropped without running into contradictions. By contrast, he took the greatest pains to eliminate the impact of phase on hearing. As he did not know about the early connection of both ears' nerves, he assumed that spatial hearing happens individually and is thus not subject to his

of Mozart's music is based on this renewed terminology. In two notes, all the components could potentially produce distortions, such as beats or combination tones, though his chart could only consider those that were most likely to occur. Yet, this new approach to defining a note explains the great care he took to explain the basic terminology of music from scratch — and why Pisko would call this an investigation even for those lacking musical education or being hard of hearing. Only those components that could be safely predicted would be taken into account. A phenomenological approach to the piece's perception, while not irrelevant, was only given in the final stage: the alternating harmonious and veiled character of the *Ave verum corpus* ultimately yielded a correlation with the predictable distortions in the sound.

15.3 Music Theory: Gottfried Weber Analyzing K. 465

Reflecting on his investigations of harmoniousness, Helmholtz summarized his findings on distortions in the conclusion to the second part. There, he attributes joy to the acknowledgment of order, also in music listening. He writes,

> A combination of tones will please us when we can discover the law of their arrangement. Hence it may well happen that one hearer finds it and that another does not, and that their judgments consequently differ. The more easily we perceive the order which characterizes the objects contemplated, the more simple and more perfect will they appear, and the more easily and joyfully shall we acknowledge them. But an order which costs trouble to discover, though it will indeed please us, will associate with that pleasure a certain degree of weariness and sadness (*tristitia*). (1885, 230)

A case in point to instantiate this claim may be found in a discussion of another piece by Mozart that caused early nineteenth-century music scholars to suffer from a heavy dose of such *tristitia*. A rather fierce debate had taken place between the Belgian music theorist and scholar François-Joseph Fétis (1784–1871) and his German counterpart, Gottfried Weber, between 1829 and 1832. Fétis found the slow introduction to Mozart's string quartet in C major, K. 465 so bold that he assumed the piece needed a correction, while Weber opposed the notion that Mozart made mistakes but felt the need to state,

> As regards *my own* ear, I frankly confess that it does *not* receive pleasure from sounds like these;—on this subject I can freely speak as I think, and, in defiance of the silly and envious, dare even take up the haughty words and say: *I know what I like in my Mozart*. (754)

The article that Weber wrote in answer to Fétis counts as one of the first examples of musical analysis before it became consolidated only in the late nineteenth century. Reference works mention Jérôme-Joseph de Momigny's *Cours complet d'harmonie et de composition* (1806), E.T.A Hoffmann's essay about Ludwig van

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own terms of sensory physiology. Moreover, given his experimental means and the fact that he was first to consider phase at all, the concept of phase as a factor in spatial hearing did not enter the scope of his investigation.

Beethoven's *Fifth Symphony* (1810) next to Weber's article on Mozart's string quartet K. 465. Weber first published his analysis of this quartet in the music journal *Caecilia* in 1831 and republished in his multi-volume treatise *Versuch einer geordneten Theorie der Tonsetzkunst* (1832).[8] These texts are considered "milestones" (Gruber 1994) and "classic examples" (Moreno 2004, 19) of music analysis, as they proposed new approaches to describing music with specific sets of criteria that are expounded in the texts themselves.

Ian Bent's definition of music analysis as "that part of the study of music that takes as its starting-point the music itself, rather than external factors" in the music encyclopedia *The New Grove* (Bent and Pople 2001) is poised within a Western notion of music theory that builds upon centuries of text production on music. Since the early Middle Ages, a corpus of texts had developed from mainly expounding rules for singing toward an extensive prescription of how to compose any kind of music within the symbolic system of musical sound and eventually up to what has mostly been addressed in music theory as the analysis or "interpretation" of the classical music repertoire. A break occurred in this developmental trajectory when the bulk of theoretical writing became descriptive rather than prescriptive. One of the explanations for this break has been seen in the rise of the bourgeois middle class and its concept of the "masterwork" (*Meisterwerk*) that was set forth in opposition to aristocratic representational aesthetics (Gruber 1994). New types of literature divulged the canon of masterworks and fostered a discourse on music for the non-expert who mainly listened to music rather than producing it (Thorau and Ziemer 2019).

Weber's contribution to this development is situated at a point when the composer or "Tonsetzer" was still the main addressee. While Weber himself has been described as a *Bildungsbürger* and dilettante (Holtmeier 2007), the style of the analysis that he demonstrated in the journal *Caecilia* presupposed a high level of musical education. Weber had founded the journal himself, and he frequently used it as a platform from which to convey his own standpoint within musical discourse. In the case of Mozart's string quartet K. 465, the discussion surrounding the first movement's slow introduction had been ongoing. The debate had begun immediately after the publication of Mozart's six quartets dedicated to Joseph Haydn in 1785, earning K. 465 the nickname "Dissonance" (*Dissonanzenquartett*), and flared up when the Belgian music theoretician François-Joseph Fétis published a note on Mozart's alleged "mistakes" in 1829. The note appeared in the *Revue musicale*, founded by Fétis himself.

The bone of contention was the abundance of so-called "unintroduced dissonances" and "false relations" with which the piece opens. Experts invoked these

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[8] See the entries on "Analysis" in, e.g., *MGG* (Gruber 1994), *Grove Music Online* (Bent 2001), *Lexikon der systematischen Musikwissenschaft* (Utz 2010). De Momigny provides reductions of opera settings, in which those adhering to the most practiced method of musical analysis in the English-speaking realm of scholars, so-called "Schenkerian" analysis, could see a precursor. E.T.A. Hoffmann, in turn, provided an early example of a hermeneutic interpretation with a similar impact on those who continued to work in this vein.

terms to refer to a particularly daring and sometimes even unruly use of the rules of counterpoint. In many ways, however, Mozart's piece alluded to exactly these rules and eighteenth-century musical learnedness by stretching the rules as far as possible. The first movement's slow introduction combines one of the oldest techniques in polyphonic setting—namely, an "imitation" (whereby a voice "imitates" the melodic steps of the preceding part)—with a feature of baroque basso continuo setting, whereby the bass repeats a single note like a foot on an organ pedal, above which a harmonic progression unfolds (with the bass note adding to the intricacy of that harmonic progression into which it does not fully fit). Furthermore, a slow introduction was not a regular feature of string quartets but rather was more characteristic of symphonies. The slow introduction to a symphony can often be seen to present features of the piece's chosen key, exploring, as it were, the tonal realm in which the piece is going to take place. This was a frequent feature in Haydn's symphonic music, for example. Mozart thus made a bow before his dedicatee. In K. 465 in addition, there is a witty contrast between the difficulty of the slow introduction and the bright and happy character of the main part after the introduction. The slow introduction reminds the addressee—listener and dedicatee—that C major was also the key in which Mozart is known to have composed his most adventurous explorations of tonality. C major normally needs no sharps or flats, yet Mozart's explorations of the limits of tonality in this key abound in so-called "accidentals." As such, this slow introduction showcased difficulty.

Fétis, in any case, was certain that Mozart had committed errors. He was prompted to publish his note on the passage in question by the opportunity to examine Mozart's original manuscript, owned by a London-based harp maker. Fétis noted,

> My first worry was thus to check this quartet where I hoped to find a confirmation of my conjectures; but I had to convince myself immediately of my own error. The passage that had received so much critique was written by Mozart unambiguously and without any sign of hesitation as it had been engraved in all editions, and the inconceivable dissonances without any aim that disrupt the ear are taken down by his hand. Thus, there is no longer any doubt about this error of a great artist. We may trust the evidence, but we should stick to saying, as did Haydn, that he had his reasons for writing this way; because mistakes of this kind hurt reason, senses, and taste. (606, my translation)

The conjectures that Fétis mentions here concerned an example that he gave in the same brief article. Including the printed score of the piece's beginning, he added an illustration of his own musical conjectures in an alternative to the quoted opening. Fétis reassured the reader that his alternative contained only minimal interventions, which, for him, made it all the more mysterious that Mozart would not have preferred not to use them immediately. He writes:

> On examining carefully this harmony that had been the object of so much astonishment and conjecture, I was struck by how easy it would have been to remove its defects, without changing either the main phrase or the form of the accompaniments, and even to make the imitation which seemed to be the cause of the gross errors that one notices in it more exact and more in keeping with the rules of all schools. (602)

Thus, the difference between the original and the alleged correction is rhetorically downplayed to render Fétis' astonishment about the faulty original even more prominent.

Weber opposed the notion that Mozart had made mistakes. He accepted the piece as a given and spoke of choices rather than mistakes. His own treatise of harmony spelled out the rules Fétis appeals to in the several volumes of his treatise on composition. An extended appendix on Mozart in the final part provided him with the occasion to discuss the breaching of the rules. However, he refrained from a "judgment on the frequently disputed theoretical allowableness and irregularity of the passage in question" (737/200), proposing instead to "observe" and "analyze" what Mozart did and how. He prepares the reader by distinguishing music from science:

> Once for all, music is not a science endowed with mathematical deduction and completeness; it is not a system presenting us with absolute rules of permission or prohibition, the adoption of which can in all cases determine — like "twice two are four"—the value or worthlessness, the accuracy or inaccuracy, the lawfulness or unlawfulness of this or that combination or succession of tones; and all the pretensions of those who have imagined they could found the theory of music on mathematics, and from such an assumed foundation deduce and establish absolute precepts, appear on the slightest examination as empty and ridiculous dreams, the fallacy of which can be clearly proved by the first best example. (Weber 1851, 737)[9]

Weber framed his activity as analyzing or "taking apart" (*zergliedern*), and he called the result an analysis (*Analyse*). His main method in doing so was to describe, note by note, not only the rules that explained the notes' correctness and contextualized the alleged breaches but more specifically the effect that each note might have exerted on a potential listening instance. This instance, he addressed as "Gehör" (ear), occasionally "Gehörsinn" and "Ohr"—that is, the sense and the organ of hearing—and presented it as having internalized the rules of composition and their possible application. In so doing, he also appealed to his readership to carefully study the book so as to be able to follow him now in applying the rules for analysis.

In musicological research, Weber has been said to track "an idealized listener's perception of the passage chord by chord. The result is an analysis that is historically noteworthy for its elegant descriptive language and its quasi-phenomenological awareness of musical harmony as it unfolds in time" (Bernstein 2002, 787). Most frequently, commentators have pointed to the excessive number of alternatives that Weber provides (e.g. Christensen 2019). Similar to Fétis' conjectures, these alternatives demonstrated what Mozart could have done, and they also instantiate what

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[9] Die Tonkunst ist nun einmal keine mit mathematischer Consequenz und Absolutheit begabte Wissenschaft, kein System, welches uns absolute, verbietende oder gebietende Regeln darböte, aus deren Anwendung auf jeden vorliegenden Fall sich, wie 'Zweimal zwei ist vier' der Werth oder Unwerth, die Richtigkeit oder Unrichtigkeit, Erlaubtheit oder Verbotenheit dieser oder jener Verbindung und Zusammenstellung von Tönen bestimmen liesse, und alle Anmasungen derjenigen, welche träumten, die Tonsatzlehre mathematisch begründen und aus solcher anmaslichen Begründung absolute Präcepte ableiten und aufstellen zu können, zeigen sich bei der leichtesten Prüfung als leere, nur belachenswerthe Träume, deren Trüglichkeit sich durch das erste beste Beispiel handgreiflich zeigen lässt. (Weber 1830–1832, 202).

Weber takes to be the ear's—or the listener's, for that matter—expectations of how the music could, but does not, continue. Musicologist Jairo Moreno argues that Weber was intrigued by the ambiguity of Mozart's music, attributing that interest of Weber's to "Romantic irony."[10]

Other authors have confirmed that the emergence of the listener in the first decades of the nineteenth century relates to Romantic subjectivity (e.g. Dahlhaus 1988; Johnson 1996). In the context of a history of musical analysis, Weber's conjectural examples are particularly interesting in that they demonstrate how the pairing of the notions of "composition" and "analysis" is juxtaposed with a production of conjectural samples by the analyst. These samples do not have the status of compositions, as the author himself calls them conjectural and introduces them using a conditional clause: *if* that note in Mozart's setting were to be understood in such and such a way, *then* the next notes could have been the following (204, 208). This method spells out the ambiguities: the note in question is conjecturally explicated and heard "as" a particular symbol in the tonal system, which, in turn, is made understood by the provision of a continuation that pins down the ambiguity to one of its meanings. Weber describes the attitude of "the ear" as awaiting "further instruction and conformation" about the still underdetermined tonal key (205). One sample is integrated into a question—"etwa so?" (211; "for instance, like this?"; not translated in 1853/5).

The samples instantiate not only unrealized possibilities arising from the ambiguity of the setting but also alternatives that could mitigate harsh effects or alleviate the ear's responsibility for fitting what is heard into the tonal system. Where Fétis gave one alternative, Weber provides six alternatives to Mozart's imitation, introducing them with yet another conditional clause—"That the strangeness principally arises from the union of the above circumstances will be evident, if we so alter the passage as to omit them" (747). However, where eight bars were printed in the *Revue musicale*, Weber's readers were presented with only the first two bars and were obliged to complete the rest on their own. Inviting the reader to participate in a series of musical thought experiments, he challenges them to follow his suggestions based on the knowledge of the rules, "the comprehension of which will now present no farther difficulty to the reader of all that precedes" (746). After all, this remark appears in the third volume of a textbook on harmony.

The mode that the reader is intended to pursue in the explication of unused possibilities is to play the alternative samples on a piano. Almost all the examples are presented in piano reduction—that is, in the usual notation for piano players on two

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[10] In spelling out the ways in which Weber's text continually renews that ambiguity, Moreno (2003) is inspired by a remark, communicated to him in a letter from his colleague Kevin Korsyn: "Weber generates an almost absurd proliferation of detail, taking more than 15 dense pages to analyze four or five bars and giving almost every pitch a series of multiple and contradictory interpretations. One could relate this profusion of detail to the trope of irony, in the extended sense proposed by Hayden White. Irony is the trope that sanctions multiple linguistic perspectives on reality, because one realizes that language is not adequate to capture experience. One searches for multiple linguistic redescriptions of events." (99) In an exemplary gesture, the author Moreno publishes this private note, which contains the kernel of his argument.

Fig. 15.8 Diagrammatic overview of the harmonic progression in measures 3–4 of K.465 (Weber 1851, 749)

musical staves rather than the system of four staves used for a string quartet. The music notation for pianists provided an overview of all simultaneous notes. In addition to saving space on the printed paper, it allowed the reader to walk to their piano and hear what was written by playing it. Weber even speaks of "*anschlagen*"—hitting the keys of an unmentioned piano—where he addresses the sound effect more specifically. This is not how string players produced sound. Instruments of the violin family are not struck, as pianos are; typically, rather, the bow is drawn across the strings. However, Weber also does not address actual sound production. This is most conspicuous in one of the rare examples in which he uses a diagram to give an overview of the harmonic skeleton of the passage in question (Fig. 15.8). Even there, he writes, "the fundamental third B in the bass is again struck anew." (749)

It is important to note that Mozart's piece no longer appeared as an example for other composers to emulate in the context of Weber's analysis. Mozart's mastery was not intended to be within the reader's reach, including his eccentric application of the rules. The fabricated alternatives instead spelled out the educated listener's attempts to cope with ambiguities. They unfold the hesitation among possible interpretations into sequential conjectures. Rather than merely explaining the rules and breaches, these fabrications cause the reader to feel them. This transcends mere rhetoric, as it also fulfills a knowledge-making function. Although Weber guided the readers' listening, he explicitly refrained from imposing any "correct" application or interpretation of the piece, leaving the last word to the listener, among which he counted himself.

15.4 An Experimental-Experiential Trajectory: Stumpf's Analysis of K. 361

The most prominent attempts to follow up on Helmholtz's research into the analysis and synthesis of sound—before electronically produced simple tones became a standard in psychoacoustics laboratories—happened under the guidance of philosopher and experimental psychologist Carl Stumpf at Berlin University. Beginning in 1913, Stumpf had a two-part structure built at the university's Institute for Psychology for the analysis and the synthesis of sounds by interference. When the construction began, Stumpf had already turned 65. His interest in Helmholtz's research, however, dated back 40 years, to the moment when Stumpf had assumed his first professorial position at Würzburg University, where he followed his former mentor Franz Brentano as professor of philosophy in 1873.

In 1883, when Stumpf had moved from Würzburg to the German University at Prague, the first volume of his book *Tonpsychologie* (Tone Psychology, 2020) appeared. This, together with the second volume of 1890 in addition to his philosophical work, earned the reputation of an experimental psychologist, which eventually brought him via Halle and Munich to Berlin. In the foreword to *Tonpsychologie's* first volume, Stumpf gave credit to Helmholtz's "classic work." Notwithstanding the wealth of inspiration that psychologists could gain from it, they had left the greatest share still to do (1883, v; 2020, lxi). If Stumpf considered his first volume to already be bulky, he likely did not expect that it would keep him busy for several decades to come. The interference apparatus turned his interest in sound perception and cognition in Helmholtz's wake into cutting-edge experimental research.

The experiments with musical instruments in particular surprised Stumpf himself, who was well aware that their spectra exceeded the range of possibilities with his interference device. That device's operation principle worked as follows: it used interference to cancel out select frequency components in periodic sound that traveled through a system of tubes. To produce interference, spikes of various lengths were inserted into the main tube. A spike would cancel any wave with a wavelength of four times that of the spike, projecting the reverse pattern of rarefication and densification on that particular wavelength, thereby canceling it out. When all spikes were inserted, which covered a wide frequency range rather densely, any periodic sound should ideally disappear and gradually reappear when the spikes were taken off again.

The device worked best for vowel sounds, whose spectra are situated in the rather small range of the greatest frequency resolution in human hearing. Speech sound, however, traveled so well through the complicated design of the amassed tubes that some of the problems that the apparatus posed remained unnoticed. For the sounds of the instruments, by contrast, the deformation of the sound through the system of the tubes became audible and disturbing. For instance, funnels had to be added at the points where musicians produced the sound, so that it could enter the system of the interference tubes without loss. Where possible, narrow tubes were replaced with wider ones. Any experiment on the frequency components present in the sounds of instruments had to begin by testing whether the instrument could be recognized through the system of tubes at all. If this was not the case, "then one has to renounce this way of researching" (382). If the study could continue, however, it proved "extremely instructive" (383) even beyond the mere description of the formants. Joined by Curt Sachs, an eminent expert on musical instruments, the researchers observed the gradual composition of the sounds from their fundamental frequency up to the full (transmittable) spectrum and discovered several expected and unexpected phenomena.

As was to be anticipated, for example, the fundamentals stripped from the higher partials resembled one another for all instruments. However, they were often found to be rather weak. Given the fact that musical notes were understood as representing the pitch that equaled the fundamental frequency, the fundamental's weak presence in the spectrum was a surprise.[11] For many instruments, even the perceived pitch only emerged once the fundamental had been joined by at least one, sometimes several, of the higher partials—by removing the canceling spikes and thereby reversing the procedure of analyzing the sound. Again, the appearance of the perceived pitch based on several partials raised questions. It was unclear, why the ear would nevertheless depend on the fundamental for determining the overall perceived pitch. In other cases, however, the opposite occurred, and the ear was found to follow one of the partials for determining the pitch of an instrument rather than hearing the fundamental as its pitch. Sometimes, dissonant chords suddenly appeared in the spectrum, at other times, beats among partials could be perceived, or the likeness of the timbre to a vowel sound was observed.

Although many instruments were analyzed using the interference apparatus, only two— the clarinet and bassoon—are extensively described. A third, the French horn, added to the curious phenomena that Stumpf and Sachs observed: its second partial could not be isolated in analysis. The analysis of the French horn's sound, Stumpf added, had to remain incomplete, as it exceeded the technical means. The horn's sound, however, was also emulated in a series of sound synthesis experiments that used the second part of the structure composing the interference apparatus, which eliminated the overtones of continuous pipe sounds until only their fundamental remained audible. This resulted in a range of simple tones—that is, tones with only one frequency each. They build a Fourier series as had been the case in Helmholtz's apparatus, but a far greater number of them was available in this device. The simple tones could be selected, their strength modified, and the resulting modified selection be merged into a single sound in the control room of the interference device. In this way, the patterns obtained from the various modes of analysis could be re-instantiated.

The resulting synthetic sounds were compared to the natural sound of the respective instruments. For this, some concessions were made with respect to the situation of such observation. "Only those partials that come up for the characteristic features of a sound at some distance were observed, even though more partials can be found at close vicinity when using the resonance method" (1926). That is, the nearness or distance at which a sound was heard significantly altered the spectrum. Stumpf and his team chose to work only on those spectra that withstood propagation. In the experiments, the distancing was achieved by placing the musicians and observers in

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[11] Here and elsewhere, I use the notion of the "spectrum," although this was introduced for acoustics only in the later 1920s, when it had become too complicated to address the frequency composition of sounds otherwise.

opposite rooms across a corridor, or the door to the control room was simply opened with the musician staying on the corridor while playing the test notes.

Experiments with the analysis and synthesis devices, in turn, were particularly instructive when single partials were omitted by interference or by excluding them from the re-synthesis. The second partial of the horn sound, for instance, which had been inaudible in the interference experiments, proved decisive in the synthesis experiments. When it was omitted from the synthesis, the sound resembled that of a clarinet. Joined by other experts, including Georg Schünemann, also a professor of musicology, and Emil Prill, first flutist of the Staatskapelle Berlin and professor at the music academy (Musikhochschule), Stumpf and Sachs listened to the synthetic and natural sounds in this way. The experts judged the synthetic sounds to be "very good," as Stumpf reports with some amazement.

As an example of Stumpf's methods of sound analysis, the description of the experiments on the bassoon's sound is particularly instructive. According to Stumpf, four regions could be discerned in that instrument's sound with the help of the interference device. Even when it reached the upper end of its main formant, it still remained closer to a trombone. Above, a buzzing sound resulting from superimpositions of the higher partials joining became audible. Adding yet higher partials, the sound acquired one of its characteristic features, which Stumpf called "nasal" (385), until finally, with the last partials that could be addressed with the interference, he made the typical "furry" sound of the bassoon reemerge. He added,

> These four stages of the development can also be discerned in the full sound, but this is equivalent to the discrimination of single partial tones: one hears them in all degrees of clearness, depending on one's attitude. If one concentrates fully on one zone [meaning a bandwidth of partial frequencies], however, then, of course, the impression of the timbre itself disappears. If one concentrates somewhat less on that alone, then the timbre remains present next to the partial impression of the zone. (385)

With the interference apparatus, the bassoon's sound was transformed into a sequence of otherwise unnoticeable frequency compounds. In reconstructing the spectrum from the fundamental back to full transmission, the compounds were added to one another like building blocks. Stumpf rounded off the research on the sounds of musical instruments with an excursion in small print that described his impression from a concert in which he had heard Mozart's Serenade no. 10 for 13 instruments, the so-called *Gran Partita*, K. 361. He wrote,

> Observations concerning the impact of the register on the sound of wind instruments in musical performance can be particularly fruitful, when several of them come together in a *concertante* style. I noted much to that matter in an execution of Mozart's Serenade for 13 wind instruments by members of the Berlin State Opera Orchestra (Staatskapelle). For instance, the pitch of the French horn playing *piano* or *mezzoforte* often appeared to be an octave lower due to the softness and expanding width of its sound, as this is also the case for simple tones; the oboe in its low register (c^1–g^1) sounded like a cornet, very beautiful and closer to the vowel A then E, which pointed to stronger partials in the 2-lined octave, etc. (1926, 391f.)

The analytical hearing that was used and trained in these experiments continued to shape the experience of the concert with the Staatskapelle. That the object of the study was now a piece by Mozart is not accidental. The serenade is a genre that was originally played in the open air and therefore uses wind instruments, whose sounds carry further than strings. Traditionally, a serenade consisted of several movements, and the examples known from earlier times often had single instruments excel as concerting soloists, while simultaneously seeking an equilibrium between all instruments in the ensemble. This also holds for Mozart's K. 361, in which some of the movements feature select smaller constellations of the instruments while in others sometimes one or two instruments serve as soloists of the ensemble.

Mozart's music was not the main target of Stumpf's description. The music served as yet another sample for study that entered into the context of the experimental research that Stumpf engaged in both before and after. Nonetheless, the listening on which Stumpf reported explicates the *concertante* style of this particular composition in an original fashion. Stumpf freely associated previous experiences with the sounds that instruments produced, referring as much to his own trajectory as a listener as to the experimentation. Thus, experimental and experiential knowledge were combined, undergirded with the acquired knowledge that was presented in the book's preceding argument.

15.5 Musical Analysis in Three Different Contexts

Musical analysis—in the context of Western composition, which is relevant here—relied on established categories. Where expounded at greater length, analyses served the purpose of providing models for composers—that is, those who put together what was taken apart in the analysis. A layer of a guided subjectivity was added in the nineteenth century to analysis, when listening became the predominant mode of engaging with music. Weber's proposal that Mozart's alleged blunders be reconsidered is exemplary in this respect. His analysis informed the way in which his readers would listen to the piece, enabling them to appreciate each note's complex relationship to the rules of composition and to grasp all the options that were virtually present, as Weber claimed, but that were not selected by the composer. This approach to educating his readers would not mitigate the cognitive dissonance that resulted from the superimposed instances of bending the rules of composition but, rather, the opposite. Weber's avowal that he disliked the passage he analyzed is telling in this respect: The fabricated examples summarize what the readers were supposed to have learned by the time they read the analysis. They presented artificial results of the application of the rules distilled in the book. Although these were "correct" alternatives, they were intended not to substitute Mozart's composition but rather to enrich its listening.

Fétis's alternative version, in turn, shows that a "correction," even when introduced as a substitute, by the same token was not a synthetic counterpart of analysis. The relationship to the analyzed item being one of authority, there was no way of producing similar alternatives.[12] The same holds true for Weber's conjectural examples: they are syntheses in the sense that they synthetically using the rules of composition to produce correct music. However, they re-instantiated the analysis of Mozart's piece only in so far as the piece was already instantiated in the listener's mind. Musical analysis, as it was practiced in the nineteenth century, still took composition as its point of departure. Analysis was possible only to the extent that its object was constituted by composition. No demand yet existed for a concept of synthesis. What was new in the nineteenth century was that the addressee of the analysis was no longer the composer but the listener, who was initiated into the rules while learning to analyze at the same time. Any synthetic activity would, then, occur in the listener's mind. As Weber's analysis shows, this eventually resulted in a new way of perceiving the analyzed piece.

Stumpf's setup of analysis and synthesis refers to both this context and the new notion of analysis and synthesis that Helmholtz had brought from the natural sciences into the study of hearing. As Helmholtz had in his work on vowels, Stumpf used the interference device to generate data from analyses of the frequency composition of speech sounds and the sounds of musical instruments. Contrary to Helmholtz, whose attempts to synthesize sound were restricted to the crucial question of whether the ear *distinguished* the synthesized sounds among themselves, Stumpf used synthesis systematically to verify the *quality* of his analyses, apparently with some success, and he even reports that his analyses found some sounds of musical instruments to be very good. What the remark on the sounds of musical instruments in Mozart's serenade reveals, then, is that Stumpf concluded from both the learning trajectories that musical analysis designed for its new readership *and* from Helmholtz's appeal to harmony teachers that they shape their listening in the concrete material setting in which they undergo such trajectories. Most significantly, however, Stumpf integrated his own trajectory of learning from his experimental work into his analytical listening. His description of Mozart took into account the fact that his hearing had changed. The music as it is synthesized in the listener's mind was his point of departure for analyzing the listener's previous trajectory.

These three examples thus demonstrate that musical analysis was co-constituted in three different ways. In Weber, the reader underwent a trajectory of learning rules—to follow Mozart and to follow Weber analyzing Mozart. In Helmholtz, the analysis of vowel sounds seems to relate to a stable object. This stability, however, is precarious. The distinction was more than ephemeral: it depended on the quick change between preset choices of the partials' strengths. Helmholtz' analysis of Mozart's *Ave verum corpus* reaches stability via a different route. The confirmation the analysis of the moods in the piece's two parts and conclusion is in line with the analysis is achieved by extrapolating a stable set of chords, whose actual sequence is not considered. The stability of a statistics of harmonious or less favorable chords is, in addition, based on features that are extrapolated in a new, experimental setting, notwithstanding the fact that they are unlikely to appear in a performance. Stumpf,

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[12] Perhaps the closest to this would be the slow introduction to Hyacinthe Jadin's (1776–1800) string quartet in E-flat major op. 2, No. 1, which is closely modelled after Mozart's but reverses the direction of his melodic lines.

finally, not only co-constitutes his object—namely, an experience of listening to Mozart that is informed by his previous encounters with the sounds he hears, but he explicitly refers to this as a trajectory of learning that co-constitutes his analytical listening. It would not be until later in the twentieth century, when—for instance, in ethnomusicology or cultural musicology—new constellations of listening to other communities' music became the subject of new modes of analysis, that attempts to reconstitute the communities' rules of compiling music would become a synthesis that was up for discussion but now in a social act of communication.

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