Artistic Project Report

Analysis of the adaptational techniques of dramatic sopranos when singing the operatic repertoire of Giuseppe Verdi and Richard Wagner

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Mestrado em Música - Canto

Agosto de 2021
Orientadora: M. Mus Siphiwe McKenzie

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Resumo

As cantoras de ópera que cantam repertório italiano e alemão dos séculos XIX e XX precisam de se adaptar vocalmente para serem fiéis ao espírito dos compositores. Cada vez mais, cantores de ópera e conservatórios internacionais de canto, consideram o *Bel Canto* como a referência técnica para o ensino do canto. Porém, uma cantora que canta Verdi canta Wagner de maneira bastante diferente, embora este repertório possa estar dentro da sua *Fach*. No contexto de *performance*, este projeto analisa essas adaptações vocais de sopranos dramáticos.

Em primeiro lugar, procedeu-se a uma análise bibliográfica comparativa das escolas de canto italianas e alemãs, apesar das fontes serem limitadas e frequentemente baseadas na pesquisa de Richard Miller. Em seguida, a par da análise percetual fez-se uma análise física através da audição de gravações e pesquisa espectral do canto gravado no referido repertório. O objetivo foi descobrir se existem diferenças de técnica quando as cantoras cantam a vogal |a|, e no caso de existirem, quais as suas adaptações em ambos repertórios, assim como, se estas diferenças são visíveis na intensidade dos harmónicos, nas mudanças de registro e no vibrato. Estudos anteriores identificaram as relações entre os formantes (as ressonâncias do trato vocal) e os harmónicos no canto lírico dos sopranos, sendo a mais comum o acoplamento de F1/H1 (o do primeiro formante com o primeiro harmónico). Este fenómeno é também conhecido como o timbre *whoop* (que ocorre quando o harmónico mais baixo, ou o tom cantado, corresponde à primeira ressonância). Partindo desses estudos já conhecidos, esta pesquisa analisa o espectro cantado em 12 gravações de Verdi e Wagner de 6 sopranos dramáticos diferentes, para descobrirmos as estratégias de ressonância e técnicas utilizadas. Foram encontradas adaptações vocais significativas no que diz respeito aos harmónicos, mudanças de registro e vibrato, quando as soprano cantam os dois repertórios diferentes.

Palavras-chave

Ópera, Verdi, Wagner, Técnica Vocal, Formantes, Harmónicos, Vibrato, VoceVista Video Pro

Abstract

Opera singers who sing Italian and German repertoire from the 19th and 20th centuries, need to vocally adapt to follow the spirit of the composers. More and more, opera singers and international conservatories consider *Bel Canto* as the vocal technique of reference for teaching singing. However, a soprano who sings Verdi sings Wagner differently, although having both these repertoires within her *Fach*. In the context of performance, this project consists of the analysis of vocal adaptations made by *Spinto* and Dramatic Sopranos when singing different repertoires.

The first phase of this analysis involved collecting a comparative bibliographic research of Italian and German schools of singing. The sources on this subject are limited and often based on Richard Miller's research (a noted voice specialist). The second phase of this study involved a perceptual analysis of listening to recordings, as well as a physical observation of the sung spectrum of repertoire. The objective was to find out if there are differences heard when using contrasting vocal techniques when singers sing vowel |a| and its modifications in one or the other repertoire. Moreover, if these differences are visible in physical parameters such as the intensity of harmonics, changes in vocal registers, and vibrato. Previous studies have identified specific characteristics in the relationship between formants (the resonances of the vocal tract) and harmonics for classical/operatic singing. One of the most important is the F1/H1, the coupling of the first formant with the first harmonic, also called the *whoop* timbre (which occurs when the lowest harmonic, or sung pitch matches the first resonance). Departing from these known studies, this research performed a spectrum analysis of 12 Verdi and Wagner recordings taken from 6 different sopranos, in order to find their technical resonance strategies. Significant vocal adaptations in harmonics, register changes and vibrato were found when the sopranos sang the two contrasting repertoires.

Keywords

Opera, Verdi, Wagner, Vocal Technique, Formants, Harmonics, Vibrato, VoceVista Video Pro

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List of Acronyms

LTAS: Long Term Average Spectrum
IPA: International Phonetic Alphabet
F1: First Formant or resonance
F2: Second Formant or resonance
H1: First harmonic or fundamental
Fo: Fundamental
H1, H2, etc.: Further harmonics or partial constituents of the sound

I Introduction

Classically trained opera singers normally at some point in their careers will specialize in the performance of certain repertoire, either more Verismo or more German school of singing. However, there are singers that perform both repertoires regularly. The goal of this study is to understand how dramatic sopranos adapt to different repertoire challenges by altering their technique. Let it be said at this point, that this is especially important to understand when performing both repertoires in the same recital, such as the one that I will do in my final vocal exam.

This subject has been a passion that I have had since I started singing Wagnerian repertoire, after having sung Verdi arias for many years. In listening to recordings of various singers, it became clear that their vocal quality differs when singing one or the other repertoire. I found the bibliographic sources about this subject limited. Most frequently there were references only to the work of Richard Miller and his research taken from his book “National Schools of Singing”, which was therefore considerably used in this investigation. The main motivation of this research was: the intense curiosity of objectively discovering what makes the sound of soprano voices differ in these two contrasting repertoires and what were the technical choices of the sopranos when performing the comparable arias.

1 Objectives

In this study, technical differences of 6 professional operatic sopranos singing Verdi and Wagner will be analyzed. Following a literary summary, a listening analysis and review of the background of the singers and a quantified study will be equally undertaken. The main objective will be to see if these professional operatic sopranos change their vocal technique when singing these two different repertoires. Sound samples of free available recordings are used for a spectral analysis for the vowel |a| of sung pitches, and further analysis is seen in comparable opera arias. The relationship between the harmonics H1 and H2 resonance strategies, register changes, vowel modification and vibratos will be extensively researched.

2 Theoretical Framework

2.1 Literary Summary

2.1.1 Vocal technique in Italian and German schools of singing

Opera finds its origins in Italy, born from the Italian Renaissance period and a revival of Greek drama, seeking a way of stories to be told as *opera in musica,* which can be literally translated as a work in music (Riding & Dunton-Downer, 2006).[1] This process was initiated in the final decade of the 16th Century and had Claudio Monteverdi (in the 17th century) as its most experimental composer with his opera Orfeo (Riding et al., 2006).[2] In the 18th Century, there were already two dominant genres: *opera seria* (dramatic) and opera *buffa* (humorous) with a structure including recitatives and arias, and later, composers in France and Germany chose to name the genres themselves (Riding et al., 2006).[3]

Parallel to operas being increasingly performed in languages other than Italian, new genres also originated in the 18th century, such as Glück's Orfeo ed Euridice which was called a *tragédie opéra*, as well as the German *Singspiel* and the French *Opéra Comique* that used spoken dialogue. Later in the 19th century, Verdi often chose to name most of his operas as melodramas and Wagner gave varied descriptions for his operas. (Riding et al., 2006).[4]

One of the first times that the term *Bel Canto* (or "beautiful singing") was seen in print, was in the title: *Dodici Ariette per Camera per L'insegnamento del Bel Canto Italiano* by Nicola Vaccai (1790-1848).[5] The term *Bel Canto* was also used later in the 19th century to contrast the Italian technical approach with the German style of Wagner. Among the many vocal methods, the most famous is Manual García's *Traité de l´art du chant* written in 1841.[6] Some of the most famous singers such as Lilli Lehmann were students of García (Elliot, 2006).[7] Technical terms of *legato* and *portamento* appeared in the 19th century. Free vibrato

[1] Riding, A., Dunton-Downer, L. (2006). (1st ed.). *Opera.* DK Publishing, a Penguin Company. p. 17
[2] Ibid, p. 17
[3] Ibid, p. 17-18
[4] Ibid, p. 16
[5] Elliot, M. (2006). *Singing in Style: A Guide to Vocal Performance Practices.* Yale University Press, New Haven and London. p. 126
[6] Ibid, p. 130. The Garcia family was very influential in the opera world of the 19th century. Manuel Garcia wasn't as successful on stage as his family (his sister Maria Malibran was a famous opera diva), but he became one of the most important voice teachers of his time.
[7] Ibid, p. 166

wasn't used and a steady or straight tone was mostly advocated if no special effect was required (much different from the opera vibrato used today).[8]

The nationalist movement in Europe that began in the early nineteenth century and continued into the twentieth century, had the result that composers had the desire to create music which was a reflection of their native countries, which one can call an extended form of nationalism. In Germany this was clear in the music of Wagner creating a new type of German opera: the *Musikdrama*, combining poetry with musical composition into a *Gesamtkunstwerk* ("a complete artistic work, merging the word with tone"). Wagner used innovative techniques such as the *Leitmotiv* (a recurring musical idea, melody, harmony or rhythm in the composition); more orchestration and complex harmonies but most importantly, he put a lot of relevance in the sung text. Though Wagner had many influences from French and Italian schools of composition,[9] in 1865 he advocated that there should be a national school of singing in Germany. He was of the opinion that the Italian school wasn't adequate for the German language and dramatic operatic singing, as he sought good diction and natural acting while still achieving a beautiful sound in his operas (Elliot, 2006).[10]

Around 1850, German pedagogues also started to reject the Italian school to create a technique that was more focused on articulation in order to give the voice more power to handle the new style of dramatic singing. The size and importance of the orchestra was also increased voluminously in size and the text was given a more dramatic purpose for the *Gesamtkunstwerk*[11]. Moreover, Wagner was the first composer to write his own librettos (Whitener, 2016).[12]

An aspect to take into consideration when describing singing according to the Italian and Germanic schools of singing, is the fact that though having been widely exported, they originated and are still predominantly active in those countries. The esthetics of the sounds taught mostly by "example imitation" of the teacher are not only influenced by one's own country's culture when adopting any of these schools of singing, but also by one's own native language. In professional opera singers, this is an aspect that can be overcome by years of experience. Different vowel and consonant sounds are deeply embedded in any singer's "speech template" when singing an aria in a language other than their own, as our brain

[8] Ibid, p. 129, 137-139
[9] Whitener, J. J. (2016). The German School of Singing: A Compendium of German Treatises 848-1965. *Jacobs School of Music, Indiana University,* p. 145
[10] Elliot, M. (2006). *Singing in Style: A Guide to Vocal Performance Practices.* Yale University Press, New Haven and London. p. 168
[11] Ibid, p. 161 *Gesamtkunstwerk* can be translated as a total work of art.
[12] Ibid, p. 147

relies on those phonemes acquired since birth (Nair, G., Howard, D. M., Welch, G. F. 2018).[13]

As schools of singing have emerged and have been exported, sound ideas were created. Many times this overlaps in the related repertoire, meaning for example that Italian arias may be sung using the German vocal school technique or the other way around. In "National Schools of Singing", Richard Miller describes the Italian and German schools of singing after having assisted hundreds of lessons in conservatories in Germany and in Italy. Miller says "…national preferences produce specific technical approaches…". (Miller, 1997)[14]

Italian is considered the favored language for singing by most singers of various nationalities as it has seven pure vowels: i| as in prima (or keen), |e| as in beve (or chaos), |ɛ| as in meglio (or bet), |a| as in camera (or task), |ɔ| as in morte (or soft), |o| as in non (or note), and |u| as in uso (or fool). To execute them, less resonator adjustments are needed than for German vowels and consonants. (Miller, 1997)[15]

The sounds of the German language make it more challenging for singing. German consonant clusters make the continuous flow of vocal tone more difficult (for example *ein Lichtstrahl).* The ich-laut, the ach-laut, the glottal plosives (obstructing airflow in the vocal tract or, more precisely, the glottis) and the "sh" sounds, are challenging especially when in combination with other consonants. Furthermore, the *Umlaut* adds to the vowel spectrum: the (ö) as in *öde*, (oe) as in *können*, (y) as in *Tür*, and (Y) as in *Schlüssel* need other resonance adjustments of the vocal tract. There are large numbers of *Vokalphoneme/*Vocal Phoneme which are thirty-eight phonetic symbols for possible vowel sounds with thirty-nine possible consonant symbols. Miller says that this complexity can contribute to the distinctive techniques of singing in the German school. However, for a certain group of German school singers who defend *Vornesingen*[16] (a technical term for placing the sound forward), it is just as possible and preferable to sing in a similar way to the Italian school when singing in German (Miller, 1997).[17]

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[13] Nair, G., Howard D. M., and Welch G. F. (2018). Practical Voice Analyses and their application in the Studio. Oxford Handbooks Online. DOI: 10.1093/oxfordhb/9780199660773.013.56. p. 8-9.

[14] Miller, R. (1997). *National Schools of Singing: English, French, German and Italian Techniques of Singing Revisited.* The Scarecrow Press, Inc. London. Kindle edition. p. 71, 181

[15] Ibid. p. 25

[16] *Vornesingen* literally means forward singing. This expression is also known as the placement of the voice in the mask, where the singer feels the vibrations in the face and nose, adding more brilliancy to the sound.

[17] Miller, R. (1997). *National Schools of Singing: English, French, German and Italian Techniques of Singing Revisited.* The Scarecrow Press, Inc. London. Kindle edition. p. 81, 171

The following are different aspects of vocal technique according to the two schools of singing. Starting with the attack or vocal onset, which is the pressure of the breath together with the tension of the vocal chords when beginning to phonate. Both schools describe a hard attack, *colpo della glottide* or *der harte Einsatz/Sprengeinsatz*; this consists of an exaggerated stroke of the glottis (the part of the larynx englobing the vocal chords and the opening between them) when phonation starts and can be defined as early adduction of the vocal folds and late subglottal[18] pressure. In addition, the soft attack or *der gehauchte Einsatz*, which is the early subglottal pressure and the late adduction of the vocal folds, allows some airflow through the vocal apparatus before starting singing; it is the most common in German singing and represented by (h) or unvocalized breath. In his research, Miller discovered that German teachers may think the Italian school prefers the harder attack. For the Italian school the ideal is called the *attaco del suono* [19] avoiding both the audible aspirate and the glottal click, relying on an audible subtle beginning (Miller, 1997).[20]

Addressing the importance of breathing technique, these two schools of singing differ substantially. The breath support *(Atemstütze)* for German-schooled singers, consists of a low-breathing technique with the greatest expansion of the ribs upon inhalation that occurs below the sternum together with a relatively low chest posture. This also involves an attempt to retard the inward movement of the epigastrium (abdominal wall), and the upward motion of the diaphragm by exerting outward pressure upon the abdominal muscles, a process called *Bauchaussenstütze* or distended belly support as well as belly breathing. Many times this is accompanied by firming the pelvic area, tightening the buttocks while trying to activate the lower back muscles. Some other breathing techniques advocated by the German singing school are the *Stauprinzip* (breath damming), a feeling of "sitting on the breath" with delayed inhalation and a minimal breath approach. This goes so far that some singers who followed this method regularly wore a *Kummerbund* (a corset or a belt), which they pushed outward, as a means of breath retention and support. Miller says that from a functional point of view some of these techniques aren't effective, as they can reduce the lung capacity because the ribs collapse as a result of having a low sternum and constricted lower trunk. (Miller, 1997)[21]

The Italian school opposes a lowered sternum and collapsed thoracic cage as seen in the German school. *Appoggio* (support) is the name of the muscular coordination of the

[18] The subglottal pressure is the air pressure under the vocal folds.
[19] Ibid. This is achieved through the conjunction of a proper breath support and the working of vocal folds when initiating singing phrases.
[20] Ibid. p. 5-6
[21] Ibid. p. 5, 22, 28-29, 87

breath management, which consists of a silent inhalation with a moderately high sternum throughout the breath cycle called “a noble posture”. The position of the diaphragm is partially determined by posture and if the sternum lowers, the diaphragm is less able to maintain distention[22]. Pressing outward upon inhalation, or pushing downward with the abdomen during the singing of a sustained phrase is absent in the Italian school, and neither is there a feeling of great expansion in the pectoral area as the aim is the muscular balance of *Appoggio* (support). This technique, according to Miller, is in less violation of natural physical function and can be considered the most efficient breath control in singing. (Miller, 1997)[23]

Concerning vowel formation, the German school advocates for all the vowels to remain equalized throughout the vowel sounds, from |i| through |u|, which can be achieved through a position of the mouth and the pharynx being as constant as possible, as well as a sufficiently open mouth. Miller gives an example of the vowel distortion of |i| as in *Liebe,* formed by a mouth posture not far from the vowel |a| as in *Labe*. Buccal rounding[24] for the vowels (*rundlippige Vokale*), is also preferred in opposition to the horizontal "smile position" present in the Italian school. (Miller, 1997)[25]

Mathilde Marchesi, a famous German born *Mezzo* and a singing teacher, was against the smiling position, as it caused the voice to produce a too open sound. She advocated instead for the mouth to be opened naturally, by letting the chin fall and kept immovable in this position. In her words: the smiling mouth, for example, favored by many singing teachers past and present is absurd and quite contrary to the laws of acoustics. (Marchesi, 1900)[26]

Following the preferred mouth and lip positions, the vowel |ö| (in English approximately the sound foe) is an important vocalizing sound in the German school. In the Italian school, “*Come si parla”* (as one speaks), is seen as the best buccopharyngeal adjustment in the formation of vowels in singing because the Italian language has the advantage of having a considerably less amount of vowels. The preferred vocalizing vowels

[22] The distended diaphragm and the raised sternum (but not raised shoulders) allow the normal breath cycle to be extended so that the singer can remain in the inspiratory position for as long as possible. This allows the muscles of the lateral abdominal wall to stay close to the position of inhalation and delay early rib cage collapse.
[23] Ibid. p. 41-44, 79, 81
[24] Buccal rounding can be defined as the rounding of the lips so that they form a circular opening.
[25] Ibid. p.47
[26] Marchesi, M. (1900). *Bel Canto: A Theoretical and Practical Vocal Method.* G. Schirmer; New York. p.3

are |i| and |a|. As the German school attempts to bring the high, closed vowels acoustically nearer to the lower vowels, the Italian tries to achieve the opposite. (Miller, 1997)[27]

As far as resonance in the German school, enlarging the pharynx as in the yawn position teachers instruct, is seen as producing a fuller and richer sound. This can however cause laryngeal muscle tensions. *"Hinten ganz breit machen"* (widening in the back), does increase the lower partials at the expense of the upper partials and therefore gives more *Rundung* (roundness), with some risk of sounding muffled to others but louder to the actual person singing. A stretched pharynx can sometimes unfortunately produce a sound similar to a *Knödel* (a dumpling or a small ball of dough) in the throat. (Miller, 1997)[28] As Richard Miller describes in his book “National Schools of Singing”, the low-positioned larynx is advocated by the German school and another author supports this claim after a thorough German treatises study. (Whitener, 2016)[29]

The *Kopfstimme*[30] (head voice) in the German school is not the same as the *voce di testa*[31] (also translated as head voice in English) of the Italian school. *Kopfstimme* seeks to be a *schwebender Ton* (a hovering tone) and normally needs to be sanft/soft and flötenähnlich/flutelike. According to the German school this can be attained through vocalizing the vowel (u) at a pianissimo level, and has a certain degree of breathiness (or *duftigkeit)* in the tone*.* Furthermore according to Miller, other techniques include the singers directing the tone "up the back of the throat wall and over into the forehead", which is called *Stirnresonanz* or forehead head resonance sending the tone "up the throat wall into the dome of the skull". (Miller 1997) [32]

The Italian school is all for forward placement of the tone, imagining it passing through the face without being retained in the “mask” (usually referred to as the face and nose where the singer feels the vibrations that add more brilliance to the sound). Its balanced sound can be both bright and dark, the *chiaroscuro*[33] tone, which can be obtained through the natural function of balancing the resonators. Metaphors such as "inhalation of the fragrance of a rose" are advised to achieve it. Applying the *appoggio* results in the fully

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[27] Miller, R. (1997). *National Schools of Singing: English, French, German and Italian Techniques of Singing Revisited.* The Scarecrow Press, Inc. London. Kindle edition. p. 47-55

[28] Ibid. p. 68, 144.

[29] Whitener, J. J. (2016). The German School of Singing: A Compendium of German Treatises 848-1965. *Jacobs School of Music, Indiana University.*

[30] In the German School it is not as much as a register the descriptive quality of the sound of a vocal timbre.

[31] The sound of the upper register.

[32] To achieve the flutelike and ethereal piano sound, teachers of the German School would tell the students to put the hand in the forehead, to direct the placement of the sound with its origin in the back of the throat. Ibid. p. 73.

[33] The vowels must have a bright sound, as well as depth and space in the tone.

resonant chiaroscuro timbre; achieved by: flexible resonator adjustments, a balanced laryngeal position, mobility of tongue, lips, cheeks, jaw, soft palate and breath support. (Miller, 1997) [34]

In "L'arte del canto", Francesco Lamperti (a composer and famous singing teacher of the 19th century) advises the expression of the mouth that most facilitates the emission of the voice as being the one of smiling: the lips should be drawn sufficiently tight to merely show the upper row of teeth, so that the sound, striking on a hard surface, may vibrate with greater intensity, and thus give a ring and brilliancy to the voice. (Lamperti, 1864)[35]

Regarding human vibrato, a frequency rate of six to seven times per second is generally accepted as vocal quality commonly found in the Italian school [36]. Vibrato rates are dependent on breath management and frequently a slower vibrato rate with wider pitch variation can denote declining skills and muscle power, or aging in a singer. The German school has a slower vibrato rate, coupled with a weightier, rounder quality of sound and has the tendency to near a vibrato rate to five times per second.[37] (Miller, 1997)

The Italian school advocates a three-register concept (chest, mixed and head), with the goal of blending these registers to achieve a balanced vocal range. The German school avoids any use of open chest or even chest mixture, and it uses exclusively head voice mixture. The aesthetics of the Italian school does allow usage of the open chest technique for dramatic purposes, although the sopranos need to be able to carry head mixture to the lower vocal range. In the Italian school, the *passaggio* (the transition area between the vocal registers in sung pitches) beyond which a soprano cannot carry up any chest mixture, is Eb4 above middle C. Dramatic and *Spinto* sopranos using this school might however carry some open chest to Eb4 and chest mixture up to G4, but this is not acceptable for other schools. From a vocal health point of view, chest mixture should not be done after D4. (Miller, 1997)[38]

In her book "How to sing", Lotte Lehmann states that Italians by nature have many words with a single syllable uniting other vowels, for example "tuoi" ('twɔi), which gives them more ease in connecting the vowels and coloring them with each other. German words are more difficult and more brutal, many often ending in with consonants instead of syllables, such as "zwingen" (tswi·ngen). (Lehmann, 1914)[39]

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[34] Ibid. p. 78, 81, 95.
[35] Lamperti, F. (1864). *The Art of Singing*. Schirmer's Library of Musical Classics. G. Schirmer, Inc., New York. p. 5
[36] Miller, R. (1997). *National Schools of Singing: English, French, German and Italian Techniques of Singing Revisited.* The Scarecrow Press, Inc. London. Kindle edition. p. 92-97
[37] Ibid. p. 92-97
[38] Ibid. p. 149-152
[39] Lehmann, L. (1914). *How to Sing.* New and Revised Edition. The Macmillan Company; New York. p. 223.

Vowel modification for a smooth register transition is important in the German school singing. The *Deckung* (covering) is a darkening of the vowel by altering it. A vocalize of an *arpeggio* (1- 3 - 5 - 8 - 5 - 3 - 1) on the vowel |a| in the key of F would sound as (a - ɔ - o - u - o - ɔ - a) in the middle and upper voice. The Italian-trained singers hardly have a *coperto* (cover) quality at the primo passaggio (for sopranos the first register change is at Eb4), and vowel modification happens only near the secondo passaggio (for sopranos the second register change is at F#5), happening naturally due to greater buccal aperture with the ascending pitch. An even scale is achieved through the *chiaroscuro* timbre, which is neither *aperto* (open) nor *cupo* (dark) and there are no sudden vowel covering registration points. (Miller, 1997)[40]

[40] Miller, R. (1997). *National Schools of Singing: English, French, German and Italian Techniques of Singing Revisited.* The Scarecrow Press, Inc. London. Kindle edition. p. 81, 139.

Figure 1 – IPA Symbols for Vowels (International Phonetic Alphabet)

IPA symbols	English	German	Italian	French
(i)	keen	Liebe	prima	lis, dire
(I)	thin	ich		
(e)	chaotic	Leben	sete	été, gai
(ɛ)	bet	Bett, Gäste,	sette	êtes, père crayon, mais, est, Neige, objet
(a)	task (American)			parle, partir
(*a*)	father	Stadt, Staat	camera	âme, classe, pas
(ɔ)	horse	Sonne	morto	sommes, joli, votre
(o)	note	Sohn	non	beaux, pauvre, gros
(U)	nook	Mutter		
(u)	gnu, fool	Mut	uso	ou
(ə) (schwa)	ahead	getan		demain
(y)	(approximates (i) plus (u))	müde		vaincu, une, volume, sur
(Y)	(approximates (ɪ) plus (U))	Glück		
(ø)	(approximates (e) plus (u))	schön		neveu, peu,
(oe)	(approximates (ɛ) plus (ɔ))	Köpfe		neuf, heure,
(ʔ)	(stroked glottal) uh-oh!	der Unteroffizier		
(h)	(glottal aspirate) house	Haus		
(ç)	(palatal fricative)	ich		
(x)	(velar fricative)	ach		
(ʃ)	(linguo-alveolar) Sh!	Stunde		
(ʁ)	(velar (r))			roi
(ɝ) (ɚ)	(Midwestern r) mother, rare (stressed and unstressed)			
(:)	(indicates that the preceding vowel is of longer than usual duration)			
(~)	(indicates nasality)			

Cited by Miller 2000.

In Figure 1, we can see vowel examples per language, their sound and their representation in IPA symbols. In Figure 2, the vowel modification chart represents the neighboring vowels of an unmodified vowel. The modification is achieved by closing the vowel or opening it (making it darker or more brilliant), to approach the neighboring vowel on the spectrum. This vowel modification also varies from language to language.

Figure 2 - Vowel modification guidelines

Closed Modification (Higher)	The Unmodified Vowel	Open Modification (Lower)
(none)	i (ee)	I (in)
i (ee)	I (in)	e (ay)
i (ee)	e (ay)	ɛ (eh)
e (ay)	ɛ (eh)	ə (uh) ɑ (ah)
a (sat)	ɑ (ah)	ɔ (aw)
ɑ (ah)	ɔ (aw)	o (oh)
ɔ (aw)	o (oh)	U (foot)
ɔ (aw)	U (foot)	u (moon)
(none)	u (moon)	U (foot)

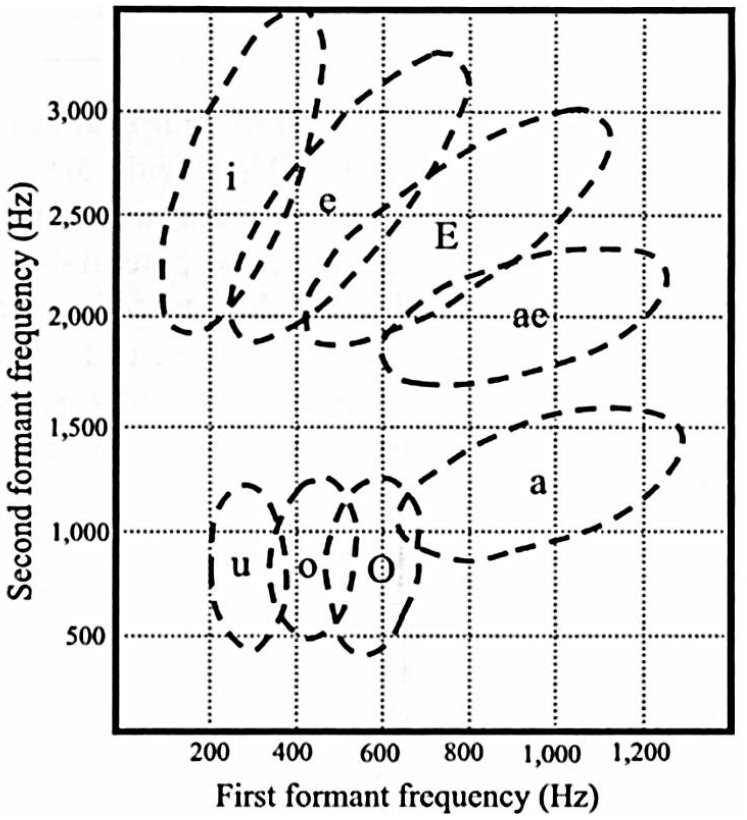
Cited in Miller 1997.

The intelligibility of the text can be challenging for sopranos as they ascend in sung pitches because they need to modify the vowels to tune the first formant [41] to the first harmonic, also called resonance tuning. They do this by opening the mouth and the width of the jaw is correlated with the vowels as each pitch rises, except for the vowel |a| where the jaw width is more constant. [42] (Sundberg, 1987) See Figure 3 for vowel resonance frequencies for the first and second formants. Here we can see that vowel |a| has the highest first formant resonance (between 700 and 1300 Hz).

[41] The first formant is the first acoustic resonance of the human vocal tract. The first two formants are important in determining the quality of vowel

[42] Sundberg, J. (1987). *The Science of the Singing Voice,* Northern Illinois University Press.

Figure 3 – Vowels frequencies for the first (F1) and second formants (F2)



Cited by Donald Miller, 2008. Cited by Donald Miller, 2008. In this graph Miller doesn´t use the standard phoneme notation (See IPA symbols in Figure 1) but instead standard letters: |i| as in k<u>ee</u>n, |e| as in ch<u>a</u>os, |E| or |ɛ| as in b<u>e</u>t, |a| as in f<u>a</u>ther, |O| or |ɔ| as in <u>a</u>ll, |o| as in n<u>o</u>te, |ae| or |æ| as in b<u>a</u>t and |u| as f<u>oo</u>l.

There doesn't seem to exist any written evidence about Wagner's intentions or if he was advised by sopranos, but some studies have concluded that he did take the acoustics of the soprano voice at higher pitches into account when setting text to his music. He also wrote his own librettos and could therefore make sure that intelligibility was achieved. He did this by vowel-pitch matching, which means that each vowel is sung with a fundamental frequency that is the vowel's usual range of resonance. In doing this, Wagner aided the acoustics of the soprano voice at high pitches when setting text to music by choosing vowels in the text that resonated with the right frequencies of the melodies that accompanied it. (Smith and Wolfe, 2009) [43]

[43] Smith, J., Wolfe, J. (2009). Wagner's music is even better than it sounds: implications of vowel-pitch matching for intelligibility and ease of singing. *The Second International Conference on Music Communication Science, 3-4 December 2009, Sydney, Australia.* p. 95.

2.1.2 Dramatic and Spinto sopranos *Fach*

The various *Fach*[44] types within the dramatic soprano voice will now be explained and described as follows. The *jugendliche dramatische Sopran* (young dramatic soprano) possesses a larger instrument than does the lyric soprano, requiring sustenance; age and dramatic power don't play a role, as these voices in this *Fach* need to be mature. Roles such as Agathe (*Der Freischütz,* Weber*),* Elsa (*Lohengrin*, Wagner), Sieglinde (*Die Walküre*, Wagner), Eva (*Die Meistersinger von Nürnberg,* Wagner) and Senta (*Der fliegende Holländer*, Wagner), Marschallin (Der Rosenkavalier, Strauss) would fall into this category. (Miller, 1997)[45]

If the voice gains weight, this soprano can later move to be a *Hoch Dramatischer Sopran; a* relatively high tessitura and a warm (round) voice with stamina is needed for this *Fach*. The *Hoch Dramatischer Sopran* (a dramatic soprano singing Brünnhilde, Isolde or Elektra), has extreme weightiness in the voice and a slower vibrato rate that often begins with a sustained note devoid of vibrato and then gradually vibrates as the phrase goes on. To hold or sustain long notes like this has the goal of expressing Wagnerian voluptuousness. This kind of vibrato might also be due to lower abdominal support, causing a glottal closure that excludes the initial onset of the vibrato. (Miller, 1997)[46]

The *Zwischenfach Sängerin* (a singer in-between vocal ranges of soprano and mezzo voices) is a type of soprano in the German lyric theater, both with dramatic power and lyricism. It can portray roles such as Aïda, Tosca, Sieglinde or Senta[47] and sometimes mezzo soprano categories such as Amneris from Aïda, Kundry or Ortrud[48]. The Italian version of the *Zwischenfach Sängerin* is called the *Falcone.*

In all three *Fach (jugendliche dramatische Sopran*, *Hochdramatischer Sopran and Zwischenfach Sängerin),* chest timbre is avoided which can have the effect of a weak sound in low-lying passages. [49] (Miller, 1997)

During the last century, it was common for sopranos to sing all soprano *Fach* roles

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[44] Miller, R. (2000). *Training Soprano Voices.* Oxford University Press, New York. p. 5. "…the category (*Fach)* of each female voice is largely determined by the physiology of the instrument itself, the location of voice- register demarcations, and adherence to specific tonal concepts".

[45] Miller, R. (1997). *National Schools of Singing: English, French, German and Italian Techniques of Singing Revisited.* The Scarecrow Press, Inc. London. Kindle edition. p. 141, 142, 146.

[46] Ibid. p.142

[47] Ibid. p.142

[48] Miller, R. (2000). *Training Soprano Voices.* Oxford University Press, New York. p. 11.

[49] Miller, R. (1997). *National Schools of Singing: English, French, German and Italian Techniques of Singing Revisited.* The Scarecrow Press, Inc. London. Kindle edition. p. 142.

regardless of vocal timbre, which is a sign that casting has changed throughout time. *Fach* doesn't always correspond to a voice type but is determined by ease of tessitura, register change and agility according to the demands of the score; this happens also to body types. In the world of opera, *Fach* describes a certain voice category of the roles sung. (Cotton, 2012)[50]

The *Lirico-Spinto* is a light dramatic soprano. This *Fach* can be translated as "to push" but it means extended (more temperament, timbre, color and volume). Some vocal specialists and some composers consider dramatic sopranos to be the same as *Spinto* sopranos. (Hartgraves, 2017)[51]

Richard Miller differentiates between *Lirico-Spinto* and *Spinto* sopranos. *Lirico-Spinto* is the soprano who can deliver lyricism and power and can still sustain a number of high tessiture that competes with the full orchestral sound. (Miller, 2000)[52]

Spinto sopranos are Verdi and Puccini heroines but can also be heard in Mozart, such as Donna Anna (Don Giovanni). Typically, roles in this voice type would be Verdi's: Aïda, Amelia, Leonora, Floria and Lady Macbeth as well as Puccini's: Turandot, Tosca, Cio-cio San, Manon and Minnie. This is further seen in Strauss': Ariadne, Salome, Arabella and Chrysothemis and Boito's Margherita in Mefistofole (Miller, 2000)[53]

In the Italian school, the *Lirico-spinto* soprano needs to support musical lines in crescendo while possessing the beauty of a lyrical tone. Being a larger voice than the *soprano Lirico,* it is however still brilliant unlike the Germanic *jugendliche*, and doesn't have the roundness of sound of Germanic sopranos. The *soprano drammatico* (the Santuzza, Turandot type) needs greater stamina and volume than the *lírico* or *spinto*, but is different from the German *Dramatischer Sopran* as she still has brilliance in singing and not the dark roundness of the latter. She also uses chest voice for dramatic possibilities in sudden shifts in and out of registers; using more chest mixtures in general which as we saw, isn't advocated by the German school of singing. (Miller, 1997)[54]

It's a general consensus today that it is much more difficult to find dramatic voices such as spintos for operas like *Don Carlos* and *La forza del destino* in the 21st century, than

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[50] Cotton, S. (2012). Fach vs. Voice Type: a Call for Critical Discussion. *Journal of Singing, November/December 2012, volume 69, Nº2,* p. 153-154,163-164

[51] Hartgraves, Y. J. (2017). Understanding the Lirico-Spinto Soprano Voice Through the Repertoire of Giovane Scuola Composers*. University of North Texas*. p. 2, 10.

[52] Miller, R. (2000). *Training Soprano Voices.* Oxford University Press, New York. p. 8, 9, 10.

[53] Ibid. p. 10

[54] Miller, R. (1997). *National Schools of Singing: English, French, German and Italian Techniques of Singing Revisited.* The Scarecrow Press, Inc. London. Kindle edition. p. 143, 148.

it was in the last century (which is already called the “golden age” of Verismo). This is a problem as 40% of the opera performances include repertoire of the late 19th, 20th and 21st centuries demanding more dramatic voices such as Maria Callas and Leontyne Price, who were able to project over a massive orchestra. This shortage could be explained by the disappearance of non-amplified singing, the fact that though these dramatic voices mature later, singers are engaged preferably in their late 20s/early to mid-30s and finally by the fact that looks became more important than the voice in our visual society. The decline of dramatic voices started around 1970-80 for both Verdi and Wagner. The most important factor still might be that lighter voices reach their maturity in their 20s but *spinto* an dramatic singers in their 30s, 40s or even older.[55] (Schmidt-Reiter, 2016) Furthermore, most if not all competitions and opera auditions, aren’t accessible to the singers at those ages for these voice types anymore because of age limits.[56] (Moravcsik, 2020)

Other factors that contribute to the production of singers of less quality are: the change of the speed of travel, this made everything become quicker with less rehearsal time; the internet, which has robbed the viewer of live experiences. During most of the last century, opera singers performed in fewer productions per year in order to have more rehearsal time available so that they could specialize and focus on the perfection of learning one part at a time; they didn’t need to race against the clock, compromising their own vocal, dramatic and musical quality.

Furthermore, while there are more opera houses in Germany, Austria and Switzerland than in the rest of the world, at the time of the fall of the wall in 1989, the German opera system changed, causing the salaries to be cut in half. The result is that while there are more singers they have less quality, as singers are created as quickly as possible and churned out having a greenhouse effect. The fact that we have internet and don’t require a ticket to see and hear an opera is important. In the post second world war period, more money was reserved for the arts as a form of escapism from what had happened. In the slower pace of most of the last century, there were more teachers with the patience and mastery to cultivate voices on the long term. Singers of the post second world war also sang with more intensity, most having already witnessed vast devastation; they recreated a form of rebirth and sang with a new energy, as if their lives depended on it. A modern day

[55] Moravcsik, A. (2016). Where have the big Verdi voices gone? *In Isolde Schmid-Reiter, ed. Poetischer Ausdruck der Seele: Die Kunst, Verdi zu singen*. ConBrio Verlagsgesellschaft, Regensburg. Germany. P. 83-87, 103.
[56] Moravcsik, A. (2020). Where have the Great Big Wagner Voices Gone? *In Isolde Schmid-Reiter, ed. Worttonmelodie. Die Herausforderung, Wagner zu singen (Regensburg: ConBrio Verlagsgesellschaft.* p. 23.

comparison are the effects seen in the arts of the current Covid pandemic. Here we see that virtual technology has hugely replaced the live experience and this fact has had a huge repercussion in the dramaticism and the intensity of the voices created in the opera studios of our times.

Teaching a *spinto* or dramatic voice to become an operatic instrument is a long process. During the first two decades, great *spinto* and dramatic singers often sound “ordinary”, sometimes large or even throaty. These voice *Fach*s are unlikely to be good for Baroque, Mozart or *Bel Canto* singers early on, and therefore this delayed maturity creates a 10–25-year career hole that many are not able to survive. For example, Kirsten Flagstad, first sang Wagner only in her mid-30s: Elsa (*Lohengrin)* at age 34, followed by Isolde (*Tristan)* at age 37, Sieglinde (*Die Walküre)* at age 38, and Brünnhilde (*Ring des Nibelungen)* at age 40. Furthermore, she appeared in staged Wagner operas until the age of 57, and in concerts and recordings into her 60s. (Moravcsik, 2020)[57]

Sopranos have a wide spectrum of vocal colors or timbre and weight. The German word *Fach,* indicates categories of voices through the analysis of main registration at identical pitches, which rarely vary by more than a half tone. The upper middle and upper *passaggi* can be used to determine vocal category in female voices; for example, C#5 and F#5 are the most frequently encountered pivotal points in the soprano voice; B4 and E5 in the mezzo voice, and A4 and D5 in the contralto voice. (Miller, 1997)[58]

2.1.3 Verdi vs Wagner and Strauss

From the end of the 18th century to the time of composer Carl Maria von Weber, a balance was maintained in Germany between German and Italian opera. However, in 1821 Weber was very successful with his new opera: *Der Freischütz*, and this was the first German operatic success since Mozart's *Zauberflöte*. The victory of *Der Freischütz* was a blow to the courtly Renaissance opera of the French-Italian genre in Germany but *Der Freischütz* still had some of the form of the *Singspiel* (a form of German language music drama, characterized by spoken dialogue). Weber still lacked the Romantic German operatic

[57] Moravcsik, A. (2020). Where have the Great Big Wagner Voices Gone? *In Isolde Schmid-Reiter, ed. Worttonmelodie. Die Herausforderung, Wagner zu singen (Regensburg: ConBrio Verlagsgesellschaft.* p. 23-24.
[58] Miller, R. (1997). *National Schools of Singing: English, French, German and Italian Techniques of Singing Revisited.* The Scarecrow Press, Inc. London. Kindle edition. p. 141, 142, 146.

idiom and mode of expression without the use of dialogue and an opera form composition. (Engländer, 1945)[59]

Giuseppe Verdi and Richard Wagner were born in the same year of 1813, but they never met. Verdi, who was born in *Le Roncole* in northern Italy, had always studied his competitors and eventually he also studied Wagner. Wagner was born in Leipzig and always created his own libretto and music. In 1865, Verdi wrote that he had listened to Wagner's *ouverture* of *Tanhäuser* and called him a "madman". With *Don Carlos*, Verdi was seen as "Germanizing" himself; which upset Verdi who constantly regretted that critics apparently forgot that he already had a 35-year career, before Wagner became famous. Little by little his attitude became one of respect for Wagner. He praised Wagner's disposition of the orchestra to be invisible for the public and in 1871 he went to a Lohengrin performance, which he found both musically beautiful and instrumentally impressive. After Wagner's death in 1883, there was a rebirth of Verdi's compositions, as found in the opera *Otello*. In his later years, Verdi confessed his deep admiration for *Tristan und Isolde*. (Conati, 2000) [60]

To many, Lohengrin is seen as the creation of German romantic opera. Wagnerian singers are expected to have extreme vocal volume and penetrating voices, as well as clear diction and projected German articulation maintaining a vocal mid-range tessitura; they would also need to be able to have vocal stamina, although this sustained, heavy singing can have consequences on vocal health. The challenge is to possess great volume in combination with very articulated diction (*Sprechgesang* or *Konsonanten-Spuckerei*), vocal stamina and penetration in a Wagnerian heroic role. (Parr, 2020) [61]

Many of the Wagner leading roles are lengthy, requiring extreme vocal strength and endurance for monologues such as Brünhilde's Immolation scene, from Wagner's *Götterdämmerung*. Notwithstanding Bayreuth whose acoustics are favorable, singing over a Wagnerian orchestra for an entire evening requires a constant ringing tone. For this purpose, emphasis was put on the importance of a low larynx technique in order to achieve vocal stamina, thus unifying registers for louder and sturdier high notes. All of these technical elements can cause decline of the voice, and singers' vibratos may eventually become slower and even widen to a possible vocal wobble. (Parr, 2020)[62]

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[59] Engländer, R. (1945). The Struggle between German and Italian Opera at the time of Weber. *The Musical Quarterly*, *Volume XXXI, Issue 4, October 1945,* p. 480-481

[60] Conati, M. (2000). Verdi vs Wagner. *Verdi Forum: No. 26, Article 2. Centro Internazionale per la Ricerca Sui Periodici Musicali.* p. 4 -12

[61] Parr, S. (2020). Wagnerian Singing and the Limits of Vocal Pedagogy. *Current Musicology*, p. 56-58

[62] Ibid. p. 65-69

Greater volume is often associated with breathing techniques (mostly in combination with a low larynx and a flattened tongue) like the *Stauprinzip* (which consists of breath damming, coupled with a feeling of "sitting on the breath" with delayed inhalation and a minimal breath approach) in a military-like posture. Here, the almost rigid lower body struggles with the air-filled lungs, aiming to build athletic vocal strength through the increase of high subglottal pressure in order to increase volume, extend longer phrases and achieve darker tones. To sound heroic, singers need to take considerable risks in their vocal adaptation. (Parr, 2020)[63]

Considering the aforementioned qualities needed when singing Wagner, the sound expectations are different when looking at the compositions of Verdi. Verdi didn't only want beautiful singing for the sake of it, as he was mostly concerned with a greater authenticity of the human drama in conjunction with the natural expression of the voice. The vocal music in his operas differ quite substantially between the soprano roles reflective of the evolution of his style of composition and the importance of the role of the orchestra. Though Verismo also has heroes and heroic singing, Wagnerian singing is the exponent of heroic singing, giving much less importance to bel canto. (Medlyn, 2016)[64]

To sing Verdi and Wagner's music meanwhile maintaining and sustaining a professional singing career, requires solid vocal technique and physical and vocal maturity. Interestingly enough, many singers find that it is an advantage for their vocal health to actually also be able to sing Verdi alongside Wagner. In addition, to work a role into the voice and body when singing these composers, one also needs a long study period of time lasting several months in order to give the muscles time to develop and build strength and resistance to sustain the musical demands of the role. To be type cast (for example through mainly physical appearance), can therefore be detrimental to vocal health. (Medlyn, 2016)[65]

In general, there has been a battle between Italian and German opera since Weber's time but the controversy still continues today. Some exceptions were gradually made such as Toscanini being the first Italian conductor at Bayreuth in 1930. (Engländer 1945) [66]. Things have definitely changed since then but there is still controversy between the two; such as, the inauguration of La Scala's season in 2013, which was the 200th anniversaries

[63] Ibid. p. 69

[64] Medlyn, M. (2016). Embodying Voice: Singing Verdi, Singing Wagner. *Victoria University of Wellington.* p. 105, 121,122, 123.

[65] Ibid. p. 136

[66] Engländer, R. (1945). The Struggle between German and Italian Opera at the time of Weber. *The Musical Quarterly*, *Volume XXXI, Issue 4, October 1945,* p. 491

of both composers. It was Wagner's Lohengrin which debuted that season and not Verdi, this was seen as unpatriotic by the Italians.

Richard Strauss was born in Munich in 1864, and is considered as one of the main representatives of late German Romanticism. Suffice it to say that Wagner was one of his most important influences. When composing the one act opera Salome in 1905, Strauss was influenced by Wagner's opera Parsifal, which is full of continuous melody and poetics creating an indivisible entity. However, in comparing Parsifal to Salome, one can hear that the modern musical progression is considerable. Even though using *Leitmotiv*, Strauss breaks free of Wagner's romanticism and tonalism. Expressionism leads him to update the theme of Tristan und Isolde as heard in Salome. Although the theme is the same (the excessive longing for love not being attainable), Salome's theme is a perverted obsession and not a pure and saving love.

Concerning the interpretation of these three composers (Verdi, Wagner and Strauss), according to Hines (cited by Parr, page 64)[67], Birgit Nilsson said that for Wagner, "you need *much* more body sound, to feel much more open. To sing Strauss: a little between Verdi and Wagner, a bit in the middle. Verdi…a slender sound. Wagner needs the most of the body. That is a solid sound you cannot use for Verdi". [68] (Parr, 2020)

2.1.4 The vocal tract articulation and resonances

The vocal tract can be seen as a combination of a sound producer (vocal cords) and several resonators [69]. The form and size of the resonators can be manipulated by the articulators to create specific resonance frequencies. The tuning of the vocal tract is called articulation. The vocal tract becomes flexible through the changes in the vocal tract shape (ex. bulge or hump of the tongue or lip shape). (Bozeman, 2014) [70]

The produced sound waves consist of a series of overtones or harmonics: H1, H2, H3, etc., of which the lowest frequency is called the "fundamental"; the lowest frequency is also perceived as the loudest and therefore our ear identifies it as the specific pitch of the musical tone, H1 is also sometimes indicated as f0 or f1.

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[67] Parr, S. (2020). Wagnerian Singing and the Limits of Vocal Pedagogy. *Current Musicology*, p. 64, citing Hines, Jerome. 1982. *Great Singers on Great Singing*. Garden City, NY: Doubleday.

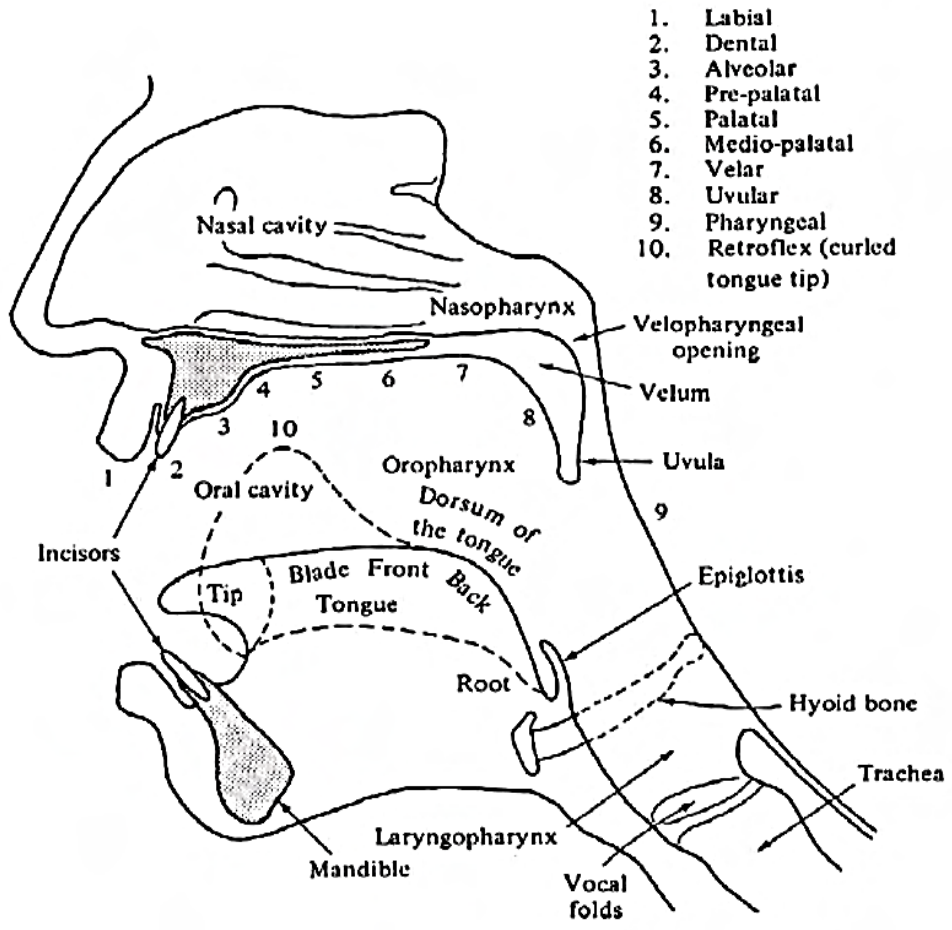
[68] Ibid. p. 64

[69] The vocal tract is constituted by resonators: bones, cartilages, muscles, nerves, membranes and ligaments. The larynx produces sound through the vocal folds, which are like a valve that opens and closes vibrating as the air passes through and that sound is amplified by the resonators.

[70] Bozeman, K. W. (2014). *Practical Vocal Acoustics: Pedagogical Applications for Teachers and Singers* (1st ed.). Pendragon Press; New York. p.12

These overtones are amplified by the resonators, also called formants. The air inside of the vocal tract vibrates at different pitches depending on its size and shape of opening; this creates a harmonic or group of adjacent harmonics that are stronger than the other harmonics due to the resonance, as they have the role of "forming" the timbre. The first and the second formants (F1 and F2) are responsible for vowel recognition, and F3, F4 and F5 for the quality of the timbre. (Sundberg, 1987)[71] In Figure 4 we can see the main articulators that change the cavities and vocal tract shape and also the resonances (formants) for the harmonics. (Miller, 1986)[72]

Figure 4 – Articulators of the vocal tract



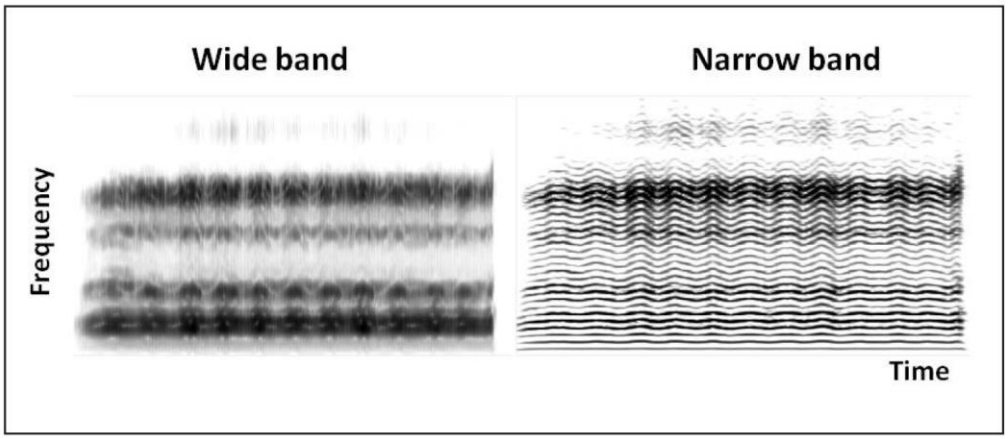
From *Normal Aspects of Speech, Hearing, and Language*, By Minifie, F. D., Hixon, T. J, and Williams, F. 1973, cited in Miller, 1986, p. 53.

[71] Sundberg, J. (1987). *The Science of the Singing Voice,* Northern Illinois University Press.

[72] Miller, D. G. (2008). *Resonance in Singing: Voice Building Through Acoustic Feedback.* Inside View Press. New York.

Vocal pedagogy has been mostly based on oral transmitted learning. Over the past few decades, as applications and software systems of information became widely used in society, many authors studied ways of applying them to vocal pedagogy. The goal being to add the visual to the aural when teachers analyze sounds, complementing their skills with a less ambiguous feedback. (Welch G.F., Howard D.M., Himonides E., Bereton J. (2005)[73].

Figure 5 – Wide and narrow band spectrograms for vowel |e|

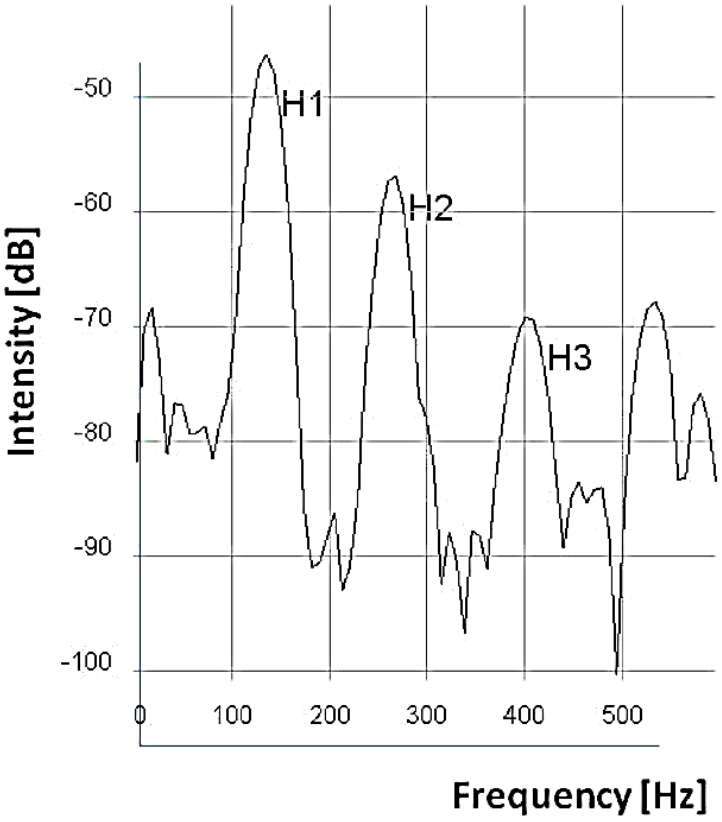


Cited in Lã, 2012.

There are several tools that can be used to analyze a voice or vocal sounds. A spectrogram displays time in the horizontal axis and frequency in the vertical axis; the darker the color, the stronger the intensity of the frequency bands. There are two types of spectrograms in Figure 5 for vowel |e|: wide band where we can see the formant frequencies in the darker color line and the narrow band where we can see aspects such as individual harmonic partials, voice onset and vibrato. (Lã, 2012)[74]

[73] Welch G.F., Howard D.M., Himonides E., Bereton J. (2005). Real-time feedback in the singing studio: an innovator action-research project using new voice technology. Music Education Research. p. 227-228.
[74] Lã. F. M. B. (2012). "Teaching Singing and Technology". *Die Fachzeitschrift zu Pädagogik, Kunst und Physiologie von Stimme, Sprache und Gesang.* Nürnberg, Germany: Vox Humana. p. 101.

Figure 6 – Spectrum of the vowel |e| and the intensity (decibels) of each harmonic

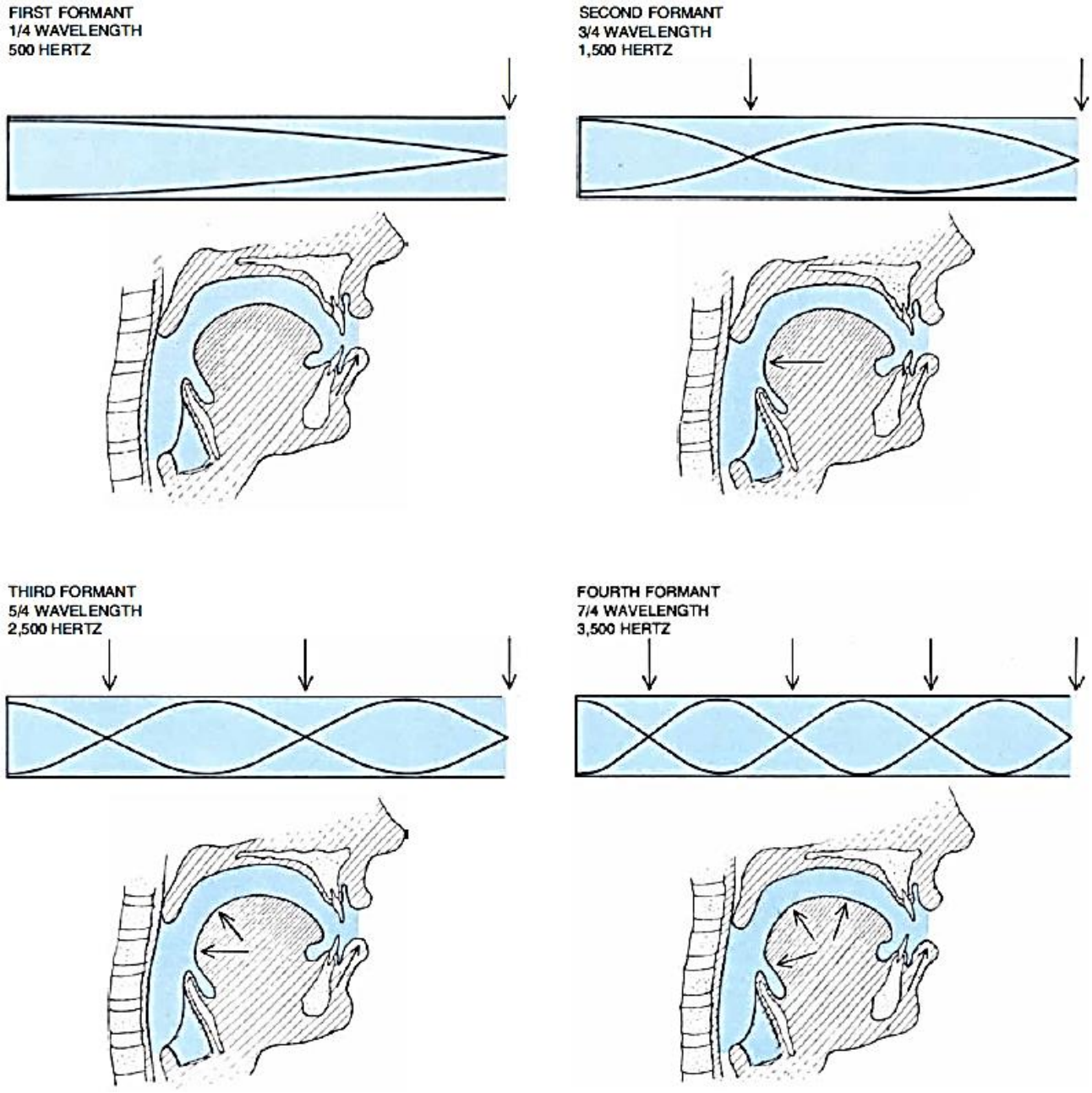


Cited in Lã, 2012.

Spectra represent the sound of a single moment in time, which allows us to view the frequency or the average of the frequencies in the case of LTAS [75] and the intensity of each harmonic partial in the voice; this is also called the spectral envelope (Figure 6), where H1 is equivalent to the fundamental frequency, which gives the sung tone the pitch. In Figure 6, we can see the spectrum of vowel |e| displaying the intensity of each harmonic partial H1, H2 and H3. (Lã, 2012) [76]

[75] The Long-Term Average Spectrum gives information on vocal timbre providing spectral information averaged over a certain time range.
[76] Ibid. p. 102.

Figure 7 – Formants in a tube equivalent to the vocal tract (in blue)



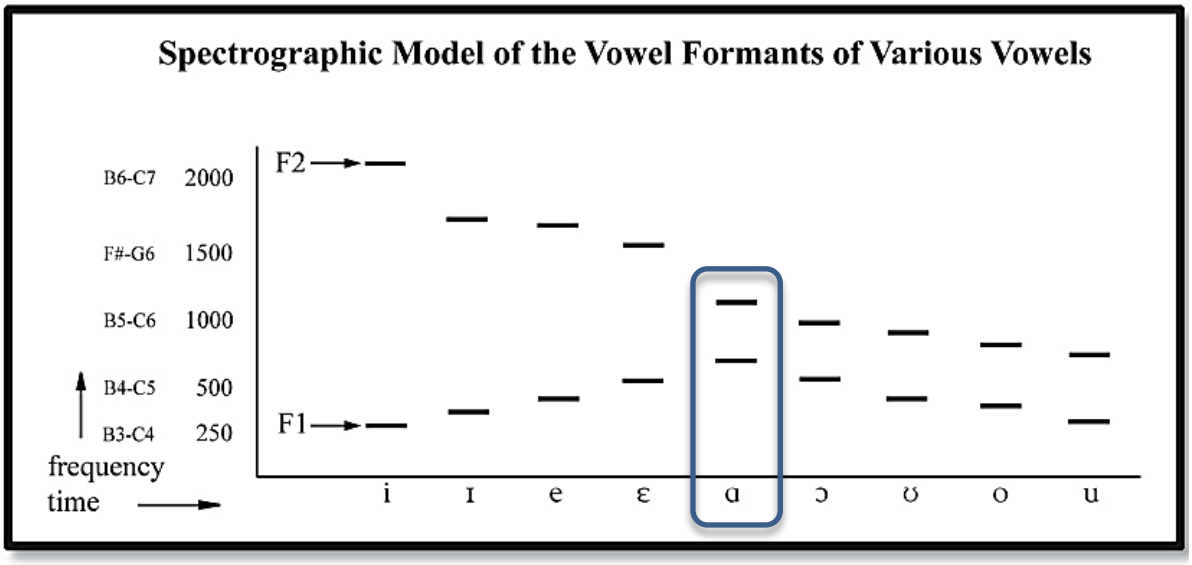
Cited in Sundberg, 1977.

In figure 7 we can see the first four formants explained with a cylindrical tube mirroring the vocal tract (colored areas in the drawing). If the area where the formant's pressure is at a minimum is increased or decreased, then the formant frequency will

respectively be lowered or raised, resonating certain harmonics. (Sundberg, 1977)[77] This can be done for example by changing the shape of one of the articulators in the vocal tract, such as rounding the lips (lowering the first two formants) or spreading the lips (raising the first two formants). F1 is strongly influenced by the opening of the jaw, F2 by the position of the body of the tongue, and F3 by the positioning of the tip of the tongue. (Björkner, 2006)[78] For female singers, the opening of the jaw increases with the rising of the pitch except for vowel |a| which also has a wide jaw opening and the higher the pitch increases, the less the vowel is recognizable especially after C5. (Sundberg, 1987)[79]

Formants F1 and F2 are directly connected to the vowel sounds that we hear. The harmonics musically change their position with each pitch but the formants have more or less fixed values associated with the timbre of the sung vowel. (Sundberg, 1987)[80] Each vowel has characteristic frequency values for F1 and F2 (see Figure 8), and vowel |a| has the highest first formant (F1) frequency.

Figure 8 - F1 and F2 (spectral peaks) locations for vowels



Spectrographic model of the first two vocal tract formants, the vowel formants
(Cited in Bozeman, 2014)

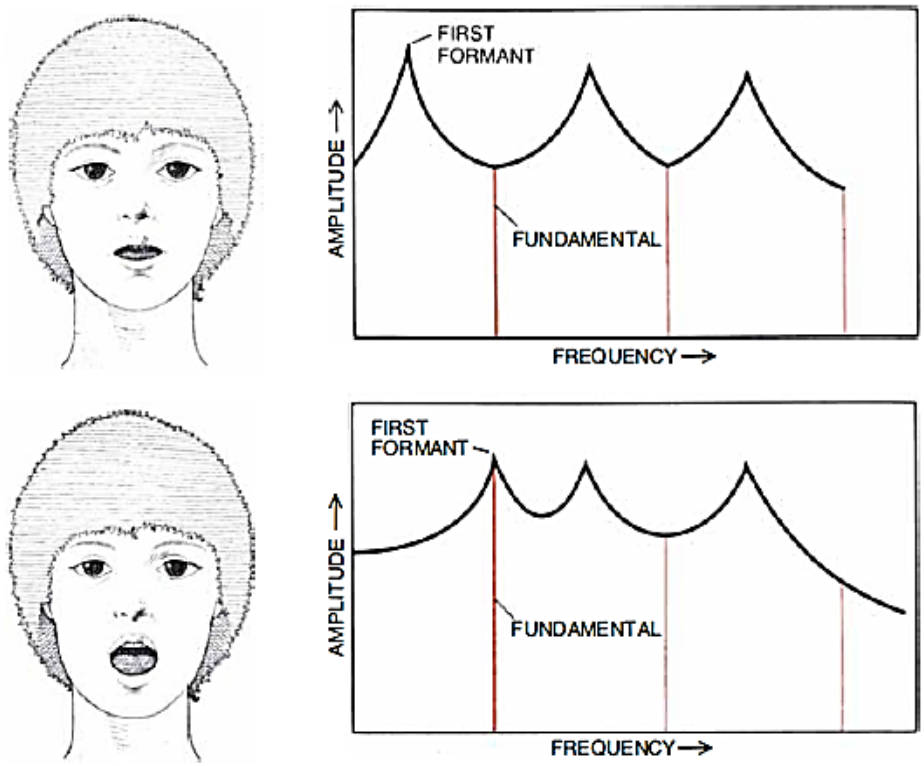
In Figure 8, we can also see the role that formants play in vowel formations. The first and second formants are F1 and F2, they are the most modifiable by the vocal tract shape

[77] Sundberg, J. (1977). Acoustics of the Singing Voice, *Scientific American,* March 1997.
[78] Björkner, E. (2006). Why so Different? Aspects of Voice Characteristics in Operatic and Musical Theatre Singing. *KTH School of Computer Science and Communication.* p. 10.
[79] Sundberg, J. (1987). *The Science of the Singing Voice,* Northern Illinois University Press.
[80] Ibid.

and therefore define the vowels. When a singer changes the shape of her vocal tract, a certain vowel is formed so that the shape of the vocal tract causes the formants to lower or rise in frequency. An example of this can be done through the bulge or hump of the tongue, or the size of the tube exit through the lip shape and this process is called articulation. (Bozeman, 2014)[81]

The female vocal tract is on average 20% shorter than that of the male and female ranges are about an octave higher than male ranges. For any given vowel, adult women tend to have higher formant frequencies than adult males. (Björkner, 2006)[82] Given a certain pitch, the singer cannot change the position of the harmonics, only their amplitude. Women have half as many harmonics for resonation, which makes tuning the first formant to available harmonics more important for female resonance. (Bozeman, 2014)[83]

Figure 9 – The need for a wide jaw opening in sopranos



Cited in Sundberg, 1977.

[81] Bozeman, K. W. (2014). *Practical Vocal Acoustics: Pedagogical Applications for Teachers and Singers* (1st ed.). Pendragon Press; New York. p.12

[82] Björkner, E. (2006). Why so Different? Aspects of Voice Characteristics in Operatic and Musical Theatre Singing. *KTH School of Computer Science and Communication.* p. 10.

[83] Bozeman, K. W. (2014). *Practical Vocal Acoustics: Pedagogical Applications for Teachers and Singers* (1st ed.). Pendragon Press; New York. p.12

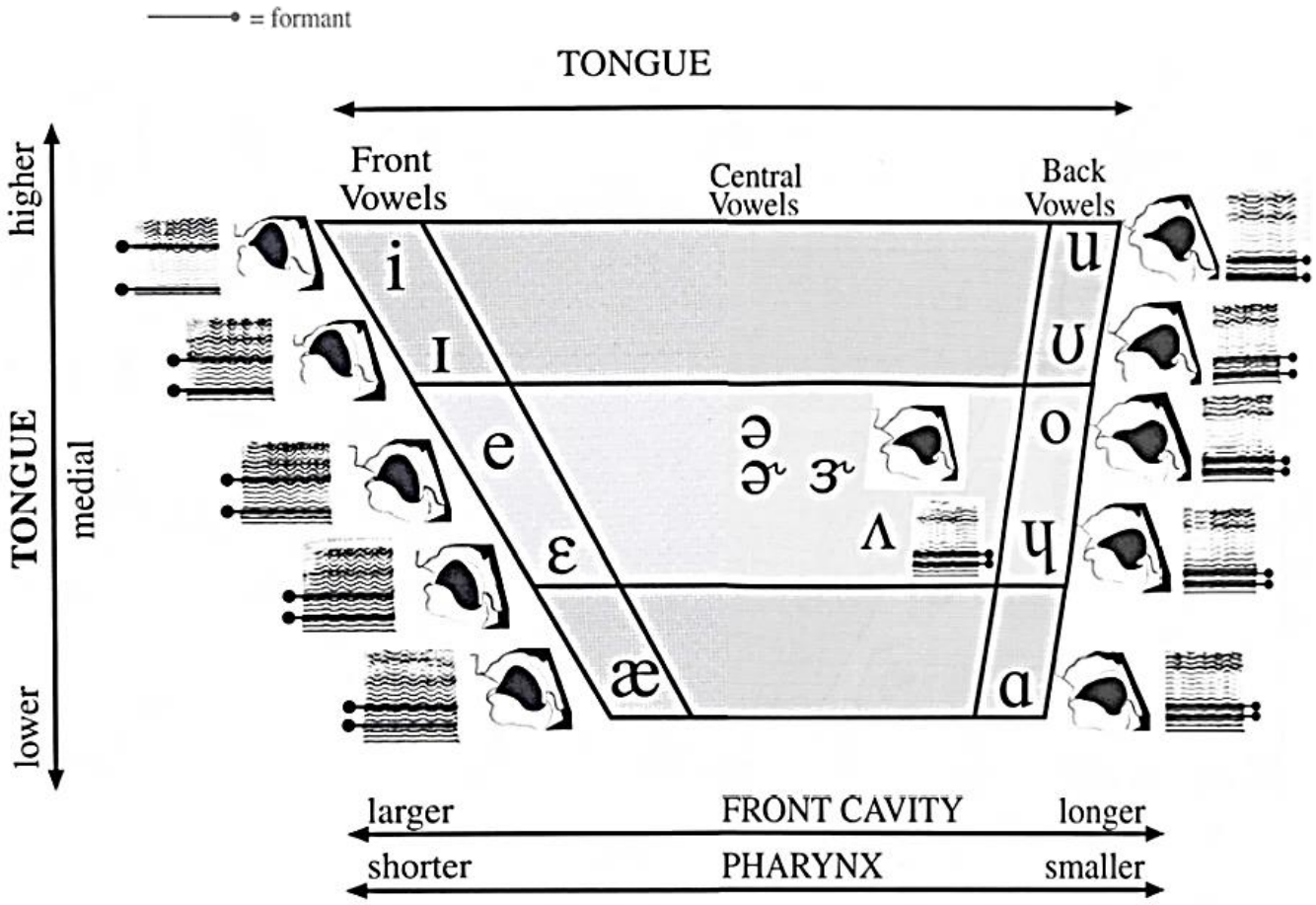
Sopranos must often sing tones, whose fundamental is higher than the frequency of the first formant of the vowel sung. In the image at the top of Figure 9, we can see that when that happens, the harmonic isn't boosted and the sound is weak; in the image at the bottom, we see that the opening of the jaw raises the pitch of the first formant in order for it to match the fundamental, boosting its amplitude and intensity. (Sundberg, 1977)[84]

Possible configurations of the vocal tract for various vowels are: posture of the posterior curvature of the tongue in the vocal tract; the degree of constriction between the tongue and the palate; the length of the tongue in relation to certain points of constriction in the vocal tract; the degree of separation of the lips; the rounding of the lips; the opening of the jaw; the velopharyngeal valve which is constituted by the velum or soft palate, side walls of the throat and the back wall of the throat (see also Figure 4); posture; the larynx (lowering has the effect of decreasing the frequencies of all formants) and constrictions of the tongue that occur to produce sounds. (Miller, 1986) [85]

[84] Sundberg, J. (1977). Acoustics of the Singing Voice, *Scientific American,* March 1997.

[85] Miller, R. (1986). *The Structure of Singing. System and Art in Vocal Technique.* Oberlin College Conservatory of Music. Schirmer Books. New York

Figure 10 – Front and back vowels and the postures of the tongue, jaw and lips



Cited by Nair, 1999.

In Figure 10, we can see formants F1 and F2, both in shape of the vocal tract and in the spectrogram, boosting the harmonics and creating the vowels, according to the posture of the articulators. (Nair, 1999)[86]

[86] Nair, G. (1999). *Voice Tradition and Technology: A State-of-the-Art Studio*, Cengae Learning. ISBN-10: 0769300286 ISBN-13 : 978-0769300283.

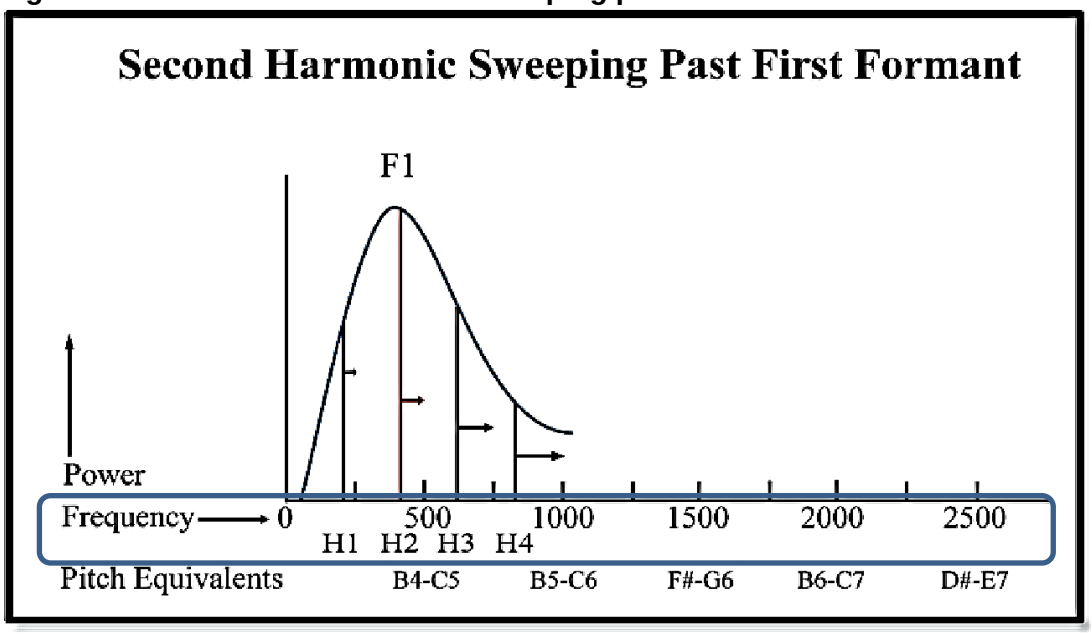
Figure 11 - Registers of the female soprano voice

chest		lower middle		upper middle		upper		bell	
g3	eb4	b3	c5	c#5	f#5	g5	c6	d6	a6

Adapted from Richard Miller, 1997.

Blending registers is very much needed for a healthy voice, and a necessary skill to having a good middle register. In Figure 11, we can see that for sopranos the middle register extends from Eb4 (above middle c) to F#5 or G5. There is however a division of this long middle register as seen in the lower middle voice from Eb4 to around C5-C#5. Above this area, is the upper-middle voice from C5 to F#5 or G5 which initiates the second *passaggio* or upper voice. After that a range of notes, referred to as the bell register begins above high D6 in the soprano voice. In the Italian school of singing, for these pitches the shape of the mouth has an exaggerated smile and elevated maxillaries, which is a shape not common among German teachers. (Miller, 2000) [87]

Figure 12 – The second harmonic sweeping past the first formant

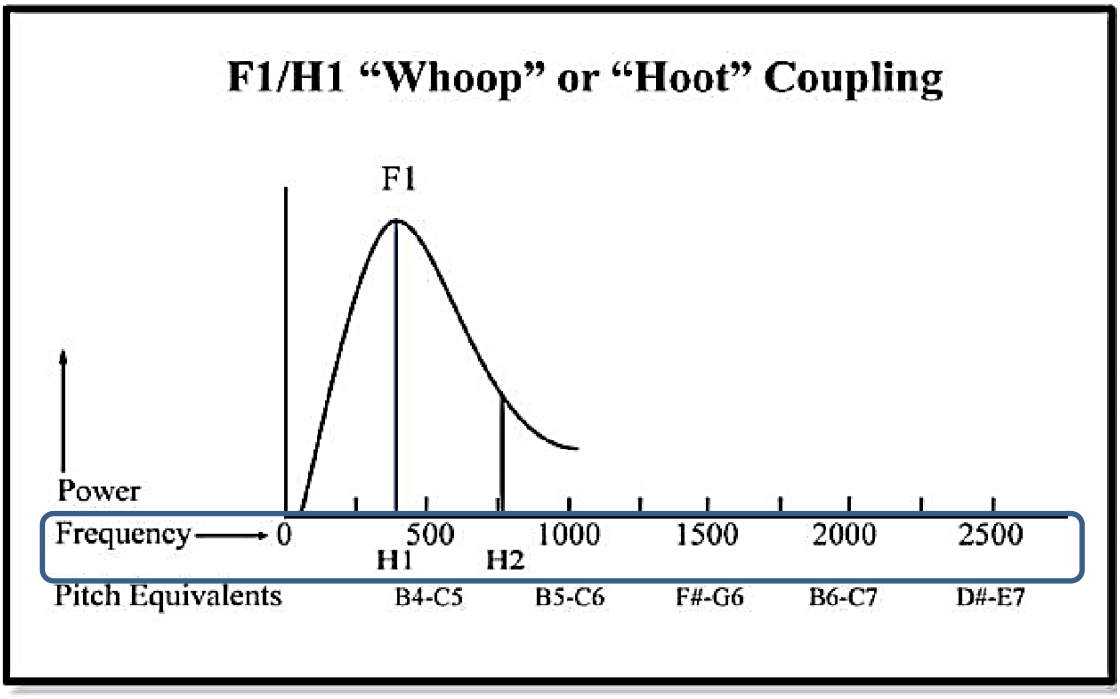


Power spectrum of turning over in which H2 (in red) has just surpassed F1. Cited by Bozeman, 2014.

In Figure 12, we see that in the middle register around B4 and C5, depending on the voice type, H2 still resonates with F1 to boost the sound, as it has still not surpassed the frequency of the first formant F1. (Bozeman, 2014)[88]

[87] Miller, R. (2000). *Training Soprano Voices.* Oxford University Press, New York. p. 25
[88] Bozeman, K. W. (2014). *Practical Vocal Acoustics: Pedagogical Applications for Teachers and Singers* (1st ed.). Pendragon Press; New York. p.24

Figure 13 – Power spectrum of F1/H1 of the coupling of the whoop timbre sung by classical singers



The F1/H1 coupling of whoop timbre which is typical of female classical singing.

Cited by Bozeman, 2014.

As the pitch increases, classically trained sopranos need to tune the resonance by coupling (or tuning) H1 to F1 as we see above in Figure 13. That change of coupling is called a turnover point. (Bozeman, 2014) [89] To keep the vowel timbre stable, the performer needs to change the resonance. This can be heard at the so-called "turnover" point, which is the pitch in an ascending scale where the H2 frequency becomes higher than the F1 frequency (Figure 12), and hence the sound "closes". The turnover points depend upon the locations of the first formant and therefore happen at different pitches according to the vowels. (Bozeman, 2014) [90]

Instead of keeping the F1/H2 resonance to higher notes after the turnover point, which would require more air pressure and result in the gradual disappearance of the vowel timbre, classical sopranos match the F1 resonance towards H1 and continue to ascend the scale with the "whoop" timbre (which occurs when the lowest harmonic, or sung pitch,

[89] Ibid. p. 25

[90] Bozeman, K. W. (2014). *Practical Vocal Acoustics: Pedagogical Applications for Teachers and Singers* (1st ed.). Pendragon Press; New York. p.12

matches the first resonance as in Figure 13). This starts by “closing” the vowel sound |a| and then gradually it becomes |U|) before returning to a more open vowel as seen in higher pitches. Classical singers prefer the F1/H1 strategy because it requires less air pressure (it allows flow phonation and decreases pressed phonation), and is placed in the head register instead of the chest register. In an ascending scale, the turnover point can be clearly heard as a closing of the vowels. (Bozeman, 2014)[91] The reason why classical and operatic sopranos need to raise the first formant or tune it at higher pitches is because there is no amplification and the vocal effort should be replaced by resonance for greater vocal achievement and vocal health.

An example of a resonance strategy through vowel modification is a recording of Elizabeth Schwarzkopf singing the aria *“Porgi amor”,* in the E flat scale passage from F4 to G5 on vowel |a|. She uses the resonances F2/H2 for the register change or passaggio to F1/H2. The soprano therefore tracks H2 (with F2 boosting H2 until D5), passing through E5 where the harmonics are balanced (both H1 and H2 are around the same intensity), until changing to H1/F1 at F5. This comes with a change in the vowel |a| (such as f<u>a</u>ther) in direction of |ɔ| (such as s<u>o</u>ft). (Miller, 2008)[92]

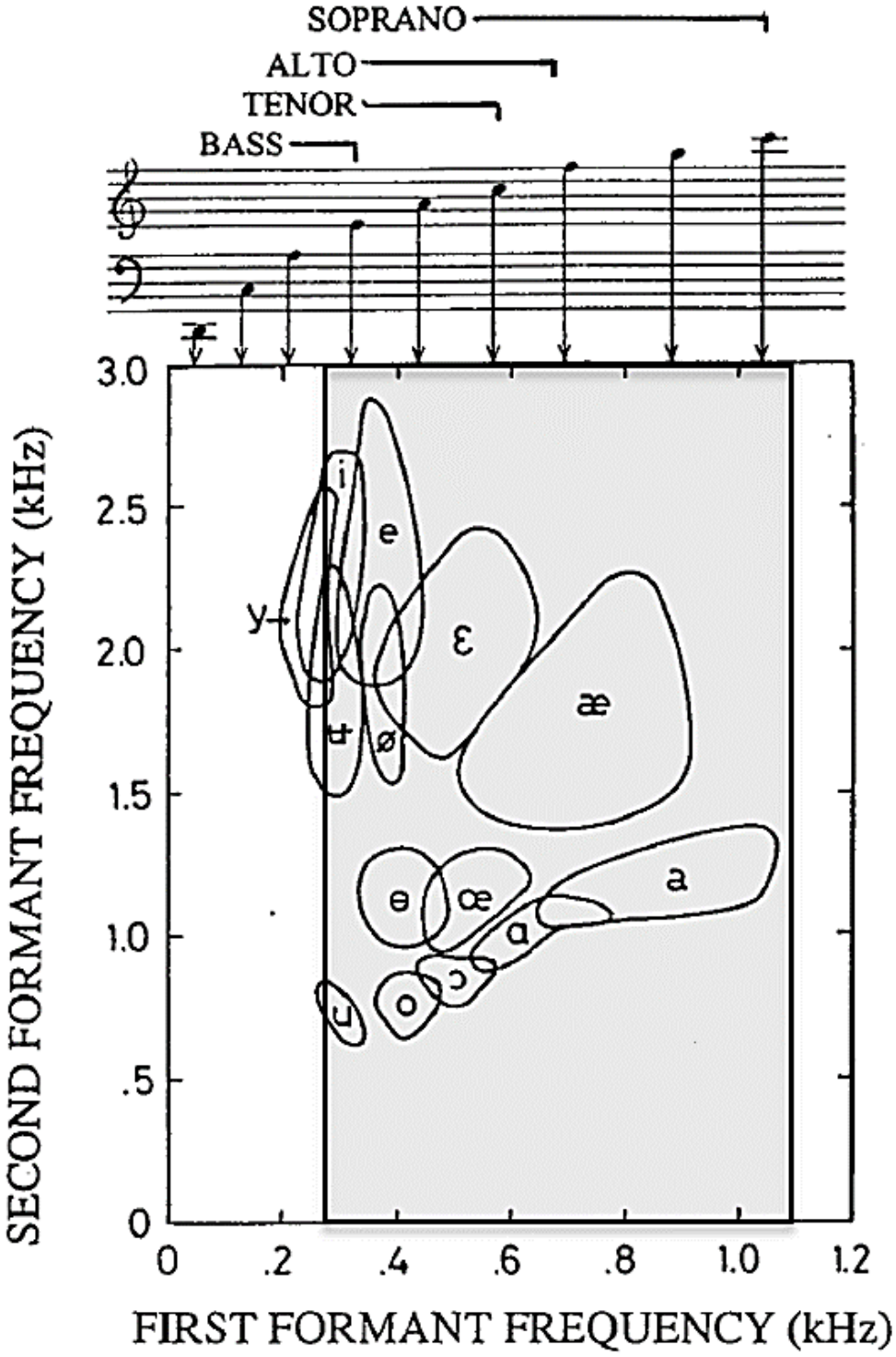
Different schools of singing have different strategies for blending registers and in the German school, H1/F1 is used much lower than B4 down until C4; this can make the lower middle register less audible. (Miller, 1997) [93]

[91] Bozeman, K. W. (2014). *Practical Vocal Acoustics: Pedagogical Applications for Teachers and Singers* (1st ed.). Pendragon Press; New York. p.26- 31

[92] Miller, D. G. (2008). *Resonance in Singing: Voice Building Through Acoustic Feedback.*

[93] Miller, R. (1997). *National Schools of Singing: English, French, German and Italian Techniques of Singing Revisited.* The Scarecrow Press, Inc. London. Kindle edition. p. 141, 142, 146.

Figure 14 – F1 & F2 chart with F1 given in musical notation at the top together with typical ranges of pitch of various voice types



Adapted from Sundberg and Skoog, 1995. The colored shape shows the extent of pitches that sopranos need to modify vowels to tune to the formants. One of the ways to raise F1 is through jaw opening.

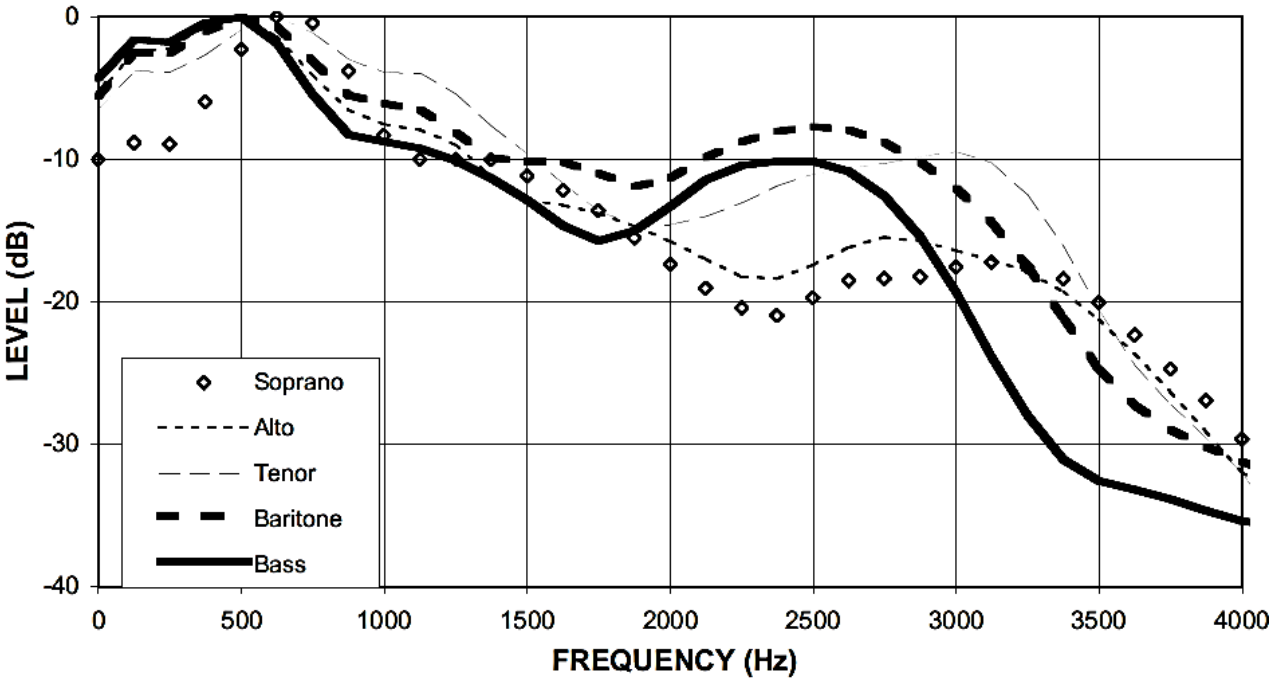
There is a debate as to what the best way is to raise F1 in closed vowels for formant tuning. Examples of this are seen in the lowering of the tongue and/or increasing the opening of the jaw, which are some of the options sopranos use, as they are the voice type that needs to tune formants the most (as seen in Figure 14). Because of this, sopranos need to constantly adapt the articulation in most vowels as the pitch rises because they are the voice type that is required to sing pitches above the frequency of the first formant (F1) the most as we also have seen in Figure 9. (Sundberg and Skoog, 1995)[94]

Concerning the singer's formant as shown in Figure 15, as the boosting of frequencies occur between 2000 and 3000 Hz, Sundberg states that the clustering of F3/F4 and F5 is only heard in male singers, because that allows them to be heard over the orchestra. The reason why sopranos might avoid the clustering of formants 3, 4, and 5 might be because this is not advantageous for the resonance of the sounds sung at high pitches. The fact is that at higher pitches, spacing of partials are wider and would be a risk for some pitches, because no partials would fall into the frequency range of the cluster. (Sundberg, 2001) [95]

[94] Sundberg, J., Skoog, J. (1995). Jaw opening, vowel and pitch. *Dept. for Speech, Music and Hearing, KTH Computer Science and Communication.* p. 43-44.

[95] Sundberg, J. (2001). Level and Center Frequency of the Singer's Formant. *Journal of Voice, vol 15, Nº 2, pp 176-186*.

Figure 15 – Mean LTAS indicating the singer's formant (2-3,5 kHz)



Cited in Sundberg, 2001.

It has been documented that sopranos do not cluster formants F3/F4 and F5, Sundberg also states that those formants and higher harmonics have a clearer perceptible effect on the vocal timbre and brilliance. (Sundberg, 1987) [96]

Another author suggests that spectrographic analysis of the female singing voice also "benefits from inclusion of sound up to at least 10kHz-12kHz", as this allows an analysis of aspects of the high voice that aren't visible between 5kHz-8kHz and that have a perceptual impact on how the voice sounds. (Howell, 2017, p. 7) [97]

In this research, LTAS (the Long-term Average Spectrum that displays the average sound level for each frequency over a certain time period) was used to determine harmonics and formants in vocal sounds. Furthermore, an analysis of register changes and a spectrogram analysis of vibrato rates was performed. The research was done featuring tones sung on the vowel |a| and its nearest modifications, for which the first formant can vary between 700 and 1300 Hz, and the second formant can vary between 900 till 1600 Hz

[96] Sundberg, J. (1987). *The Science of the Singing Voice,* Northern Illinois University Press.
[97] Howell, I. (2017). Necessary Roughness in the Voice Pedagogy Classroom: *The Special Psychoacoustics of the Singing Voice. Voice Prints, Journal of the New York Singing Teachers' Association.* p.7

(Figure 3). F1 and F2 strategies which are the main resonances of the harmonics in the vocal tract), are also important in detecting vocal technical changes. (Bozeman, 2014)[98]

2.1.5 The vibrato rate

The vibrato rate will also be analyzed. Vibrato is a regulated variation in pitch, consisting of a number of cycles per second in a degree of pitch variation. The supporting theory is described by Richard Miller in National Schools of Singing where he discusses vibrato rates, being circa 5 for the German school, and between 6 and 7 for the Italian school. (Miller, 1997)[99]

Vibrato is a natural part of healthy singing, and is caused by air pressure flowing through the vocal tract. The degree of tension in the vocal apparatus determines its size and speed. From the 20th century onwards, singers used vibrato to be heard over the orchestra in increasingly larger built opera houses. The vibrato of the early 19th century was used as a special effect for dramatic purposes and it was much more restrained than today's vibrato. In the late 19th century, smaller and more controlled vibrato was fashionable and it sounded as in the recordings of singers heard in the early 20th century (Elliott, 2006) [100].

[98] Bozeman, K. W. (2014). *Practical Vocal Acoustics: Pedagogical Applications for Teachers and Singers* (1st ed.). Pendragon Press; New York. p. 26- 31

[99] Miller, R. (1997). *National Schools of Singing: English, French, German and Italian Techniques of Singing Revisited.* The Scarecrow Press, Inc. London. Kindle edition. p. 141-142..

[100] Elliot, M. (2006). *Singing in Style: A Guide to Vocal Performance Practices.* Yale University Press, New Haven and London. p. 138

2.2 Research Question

My research question is, what are the differences in vocal technique and resonance strategies when 6 professional sopranos sing both Verdi and Wagner repertoire. In order to see if there is in fact a technical adaptation to different styles, languages and schools of singing, pedagogically this question deserves investigation and is put into practice in my own recital.

My research also involves a study that has to date not been performed, namely analyzing if there are technical differences of the same singer singing Italian school repertoire and German school repertoire. Richard Miller in: National School of Singing (Miller, 1997), states that it is regrettable that not much scientific comparative studies between the schools of singing have been done. However, he adds that though spectral analysis of singers of different schools would be useful for parameters such as vibrato rates, the subjective quality of the sound always needs to be analyzed as well. I found many approximate studies such as the analysis of specific recordings of opera singers bringing me to the conclusion that they had strong voice fundamentals (Björkner, 2006).[101] When analyzing this further, I wasn't able to find a spectral comparative study between Verdi and Wagner, or Italian and German schools of singing.

3 Methodology

To see if the various different sopranos changed their vocal techniques when 'crossing over' from Verdi to Wagner, 12 different opera arias were chosen as identical as possible in both repertoire selections per singer. The data collection focused on 6 dramatic spinto sopranos symbolized as S1-S6 from recordings found on the internet (see Table 1). The 6 sopranos were chosen according to their various different backgrounds and soprano voice types. Samples of tones heard in pitches on the vowel |a| were subjected to the VoceVista Video Pro Software which is a software that enables the feedback and spectral analysis of the recording of the human vocal sound.

In this study I aim to collect and analyze the data in a quantitative manner, bearing in mind replicability and possible generalization of the results, with the premise that the constituents of the sounds the singers produce can be analyzed and further explained with the assistance of professional software analytical tools called: Audacity, VoceVista Video

[101] Björkner, E. (2006). Why so Different? Aspects of voice characteristics in operatic and musical theatre singing. *KTH School of Computer Science and Communication.* p. 38.

Pro and Octave/MATLAB. I analyzed various recordings of different female opera singers and described the harmonics, vibrato and formants sung on the vowel |a| heard in two examples of different repertoires. If there is a pattern in the analysis, conclusions may be drawn from the change of vocal technique made by each individual singer. I accepted the premises of the previous studies covered in the literary review, that opera singers when singing operatic repertoire were found to have a stronger vocal presence in the fundamental. My questions are the following: does the vocal technique vary when one sings Verdi or Wagner, do the register changes occur differently and finally does the vibrato rate change? Considering the latter, an objective analysis of recordings of opera singers being attentive to the relationships between formants, harmonics and vibratos was executed.

The paradigm of this study is post-positivist with an emphasis on the quantitative analysis of the data. A hypothesis will be tested proving vocal technical changes heard between the various sopranos when singing both Verdi and Wagner. A certain generalization will be sought, as it would be in natural science, though the results or causal relationships will inevitably depend upon the number of singers and recordings analyzed.

The chosen theoretical ontological perspective is realism. I aim to collect and analyze the data with the premise that the reality of the constituents of the sounds the singers produce, are acknowledged and explained by scientific proof.

II Perceptual and spectral analysis of the technical differences
1. Description of the Project

1.1 Aesthetics, Repertoire and Interpretation

The reason and relevance for the repertoire chosen in this research, as this project is connected with a recital, is that the Spinto or Dramatic Soprano *Fach* roles have been in my repertoire for quite some time and considering this fact, I thought it might be of interest that a spectral and spectrogram analysis could reveal some relevant differences in vocal technique of sopranos when performing Italian and German repertoire of the 19th century.

The interpretation of the arias is considerably influenced by the schools the singers adhered to, as well as their cultural background and professional performance experiences. Considering the aforementioned statement, it is interesting to analyze the background of the singers involved and to see how their various nationalities may have influenced their choices of technique, aesthetics and interpretation.

When analyzing vocal instruction of both German and Italian schools, the aesthetics of the sounds are mostly taught by imitation of the teacher. Furthermore, beyond the influences of one's own country's culture and native languages, there is also the influence of the singing school of the teacher. The languages, the number of vowels and consonants according to Richard Miller, most probably have an influence in the technical choices of the German and Italian schools. As schools of singing have emerged and have been exported, overlapping of singers using the German school and singing Italian repertoire or the other way around is inevitable.

The soprano voice *Fach* studied in this research also has its own specifications regarding vocal technique. It is very exciting to see some differences in vocal technical parameters such as: resonance strategies and rates of vibrato for the very same singer performing Italian and German repertoire of the 19th century. One could argue that this flexibility isn't something to aim for, but the reality is that an opera singer will encounter many conductors and coaches in her career, either more oriented towards the Italian or the German school of singing that have specific interpretative demands and as a result, different vocal technical demands as well. Richard Miller, identifies the various schools of singing and their characteristics in explicit detail which was an incredible undertaking.

In the present time, the Italian school of singing enjoys the most popularity internationally as being the healthiest way of singing, but there are aspects of each school to take into consideration when performing German and Italian repertoire. My hypothesis was that this could also be measured by seeing if a soprano tends more towards one or the

other depending upon the various repertoire she sings, or if she is constant in her vocal technique employing both, and therefore likely also balanced in aesthetics and interpretation.

Aspects such as a lowered or depressed larynx and widening of the pharynx, can be advocated by teachers following the German school through imagery such as yawning. The latter may also however add tension to the voice known as a *Knödel* (a dumpling or the imagery of a small ball of dough in the throat). A lower larynx may actually be measured in scientific studies, as it increases the lower partials at the expense of the upper partials. The covered voice and the darker tones are caused by the lengthening of the vocal tract.

As we saw in the bibliographic research, the technique used by German-schooled singers in comparison with the Italian-schooled singers, also implies more vowel modifications/closing in the register changes of the middle and upper voice which can be measured in an in depth spectral analysis. In a vocalized *arpeggio* 1- 3 - 5 - 8 - 5 - 3 - 1 starting on the vowel |a| in the key of F it would sound as the following in IPA vowel sounds: a - ɔ - o - u – o - ɔ - a or in English vowel sounds: ah – aw – oh – oo – oh - aw - ah. The Italian-trained singer's vowel modification happens mostly near the *secondo passaggio*, and it occurs more naturally due to a greater opening of the mouth with the ascending pitch.

Contrarily, regarding the Italian school, we saw that in the literary review, the use of pure chest voice in sopranos for dramatic purposes (more often in the Spinto and Dramatic *Fach*) isn't the best way to promote good vocal health. Although pure chest is internationally contested, a chest-head or head-chest mix in the lower and middle registers are necessary, however the latter is almost always avoided in the teaching of the German school. Furthermore concerning the vibrato, a frequency rate of six to seven times per second is a common rate as heard in the Italian school of singing. The German school of singing has a slower vibrato rate in comparison, nearing a frequency of five times per second; again, this is something that can also be measured. Other interesting aspects such as resonance and amplitudes of H1, H2, H3 and H4, are useful for thematic content analysis, when listening to the recordings.

Let it be said that sopranos have the highest pitched singing voice and therefore quite often sing pitches higher than F1 or the first formant frequencies. To make sure the voice is vibrant and louder, they need to constantly adapt the articulation of all vowels. As a rule of thumb, the pitch frequency should not pass the first formant frequency and therefore they need to tune the first formant when higher pitches are sung, this means that the articulation is dependent upon the pitch. The vowel |a| has the highest formant so the

opening and the widening of the jaw, which is the most efficient way to raise F1, is already present and continues to function as such when singing pitches above 800 Hz frequencies. According to Sundberg, above these frequencies the opening of the jaw will be similar for all vowels. Continuing in this form of analysis, the observation is that F2 is much more sensitive to the shape of the tongue and F3 and F4 are responsible for the personal quality of the voice. This analysis gives its proof by being indirectly visible through the spectral and spectrographic analysis of the recorded professional sopranos.

1.1.1 Pieces analyzed

The aria: *Pace, Pace*, by Giuseppe Verdi; from the opera *La Forza del Destino*

Verdi's opera *La Forza del Destino*, was composed in 1861 and premiered in 1862 at the Bolshoi Theatre in Saint Petersburg in Russia. The plot describes Leonora wanting to escape the austere paternal home with her lover Alvaro. When she escapes, an accidental shot is fired from Alvaro's pistol, killing her father. When she learns that Alvaro later escapes to America, she enters a monastery as a hermit. The aria *Pace, Pace* is Leonora's prayer for peace longing for her own death. It begins with a cry in *messa di voce* (a singing technique that requires sustaining a single pitch while gradually making the voice louder or *crescendo* and then softer or *diminuendo*). It ends with *Maledizione* where she curses any person disturbing her hermit existence, who in the end turns out to be Alvaro. The role of Leonora is written for a dramatic soprano, the dramatic soprano must have a strong and voluminous voice. The demand for vocal creativity is high, which is why these roles are usually entrusted to vocally mature and experienced singers. The role requires a high resilience and endurance from the singer, and its range is from D4-Bb5.

Pace, pace, mio Dio!
Cruda sventura
M'astringe, ahimé, a languir;
Come il dì primo
Da tant'anni dura
Profondo il mio soffrir. L'amai, gli è ver!
Ma di beltà e valore
Cotanto Iddio l'ornò.
Che l'amo ancor.
Né togliermi dal core
L'immagine sua saprò.
Fatalità! Fatalità! Fatalità!
Un delitto disgiunti n'ha quaggiù!
Alvaro, io t'amo. E su nel cielo è scritto:
Non ti vedrò mai più! Oh Dio, Dio, fa ch'io muoia;
Che la calma può darmi morte sol.
Invan la pace qui sperò quest'alma
In preda a tanto duol.

Misero pane, a prolungarmi vieni
La sconsolata vita … Ma chi giunge?
Chi profanare ardisce il sacro loco?
Maledizione! Maledizione! Maledizione!

Peace, peace, O God!
Cruel misfortune
Compels me, alas, to languish;
My suffering has lasted for so many years,
As profound as on the first day. Peace,
Peace, O God! I loved him, it is true! But God
Had blessed him with such beauty and
Courage that I love him still, and cannot
Efface his image from my heart.
Fatal destiny! A crime
Has divided us down here!

Alvaro, I love you and in heaven above it is
Written that I shall never see you again!
O God, God, let me die, for only death
Can bring me peace.
In vain this soul of mine here sought peace,
A prey to so much woe.

Wretched bread, you come to prolong
My inconsolable life. – But who comes here,
Daring to profane this sacred retreat?
A curse! A curse!

The aria: *Tu che le Vanità,* by Giuseppe Verdi; from the opera Don Carlos

The opera Don Carlos is based on the dramatic play “Infante of Spain”, by Friedrich Schiller. The first version performed in Italy, was in Bologna in March 1867. The opera’s story is based on conflicts in the life of Carlos, Prince of Asturias (1545–1568). His beloved Elisabeth of Valois, was married to his father Philip II of Spain instead of him, thus ending the Italian War of 1551–1559 between the houses of Habsburg and Valois. *Tu che le vanità* is an aria for a dramatic soprano from the first scene of the final act of Verdi's opera Don Carlos, it has a range of B3 to B5. Elisabeth de Valois (the young French princess) prays at the tomb of the former Emperor King Carlos V asking that he weep for her suffering. She offers his tears to the almighty on her behalf and prays that Carlos will fulfil his destiny as a great ruler of Spain. In the aria she recalls her homeland and her happiness during her engagement to Carlos, communicating at the end of the aria that she longs for the peace which she will have in her grave. This vocally demanding aria displays the singer's high and low registers; forte and pianissimo volumes; legato and bel canto singing techniques; as well as several dramatic emotions such as reverence, longing and resignation.

Tu che la vanità conoscesti del mondo
E godi nell’avel il riposo profondo,
Se ancor si piange in cielo, piangi sul mio
Dolor, E porta il pianto mio al trono del
Signor. Si! Carlo qui verrà!che parta e scordi
Ormai, A Posa di vegliar sui giorni suoi giurai,
Ei segua Il suo destin, la gloria il traccerà,
Per me, la mia giornata a sera è giunta già!
Francia, nobil suoi, si caro ai miei verd’anni!
Fontainebleau! ver voi schiude il pensier i
Vanni. Eterno giuro d’amor
Là Dio da me ascoltò, E quest'eternità un
Giorno sol durò. Tra voi, vaghi giardin di
Questa terra ibéra, Se Carlo ancor dovrà
Fermare i passi a sera Che le zolle, i ruscelli,
I fonti, i boschi, i fior, Con le lor armonie
Cantino il nostro amor. Addio, bei sogni d’or,
Illusion perduta! Il nodo si spezzò, la luce è
Fatta muta! Addio, verd’anni ancor! cedendo
Al duol crudel, Il core ha un sol desir: la pace
Dell’avel!

Tu che le vanità conoscesti del Mondo E godi
Nell’avel il riposo profondo,
Se ancor si piange in cielo, piangi sul mio
Dolor, e porta il pianto mio al trono del
Signor. Se ancor si piange, si piange in cielo
Ah, Il pianto mio, reca a’ piè del Signor.

You have known the vanities of this world,
And now enjoy the grave’s last rest, if there is
Still pity in heaven mourn over my sorrow
And carry my tears at the Lord’s presence.
Carlos will come! he must leave and forget…
I’ve sworn to Posa to watch over him.
He must fulfil his destiny, glory will show him
The way. As for me, my day Has already
Come to an end! France, noble land,
So loved in my younger days! Fontainebleau!
All my thoughts. There I swore eternal love
To God who heard me go to you! and eternity
Lasted only one day. O merry gardens of this
Iberian land, if Carlos should yet stop here at
The end of the day, let the tufts, the Brooks,
The fountains, the woods and Flowers with
Their melodies sing of our love. Farewell,
Farewell golden dreams, lost hopes!
The knot was cut, light has lost its splendour!
Farewell, farewell, my younger years!
Giving in under the cruel suffering my heart
Has only one desire: the peace of the grave!
You have known the vanities of this world,
And now enjoy the grave’s last rest, if there is
Still pity in heaven mourn over my sorrow
And carry my tears at the Lord’s presence.
If there is still pity in heaven,
Ah, carry my sorrow at the feet of the Lord!

The aria: *Vieni t'affretta!…or tutti,* by Giuseppe Verdi; from the opera Macbeth

Macbeth is an opera in four acts by Giuseppe Verdi, with an Italian libretto by Francesco Maria Piave based on William Shakespeare's play "Macbeth". Written for the *Teatro della Pergola* in Florence, it was Verdi's tenth opera and it premiered on the 14th of March in 1847. The opera Macbeth, came before the great successes of Rigoletto, Il Trovatore and La Traviata (1851-1853), which propelled Verdi into universal fame. In this aria and scene, Lady Macbeth reads a letter from her husband telling of the thrilling encounter he had with the witches. She wants to make Macbeth king at all costs (*Vieni! t'affretta!/ Come on, hurry up!*). Lady Macbeth is told that King Duncan will stay in the castle that very night and she decides that she must kill him in order to fulfill her wish for Macbeth to take the throne: (*Or tutti, sorgete* / "Arise now, all you ministers of hell"). This aria requires both a dramatic dark tone, stamina for sustained high notes and a substantial amount of flexibility in singing the *coloratura,* its range is B3-C6.

Ambizioso spirto tu sei, Macbetto Alla grandezza aneli ma sarai tu Malvagio?	Macbeth, you are an ambitious man. You want to be great, but will you be Wicked?
Pien di misfatti è il calle dell potenza, E mal per lui Che il piede dubitoso vi pone, e retrocede! back.	The way to the power is full of crimes, And plague on him That begins that way doubting and then Goes
Vieni! t'affretta! Accendere ti vo' quel freddo core! L'audace impresa a compiere Io ti darò valore. Di Scozia a te promettono Le profetesse il trono... Che tardi? Accetta il dono, ascendivi a regnar.	Come on! Hurry up! I will fire your cold heart! I will make you able to complete the bold undertaking. The witches promise you The Scottish throne... What are you waiting for? Accept this gift! Ascend it and reign!
Or tutti sorgete, ministri infernali, Che al sangue incorate, spingete i mortali! Tu, notte, ne avvolgi di tenebra immota; Qual petto percota non vegga il pugnale!	And now all you, infernal ministers, rise up, You who thrust and urge the mortals to Blood! You, night, wrap us in motionless darkness; The dagger doesn't see which breast it Strikes!

The aria: *Liebestod,* by Richard Wagner; from the opera *Tristan und Isolde*

Tristan und Isolde (Tristan and Isolde) is an opera in three acts based on the 12th-century German romance 'Tristan' by Gottfried von Strasburg, where by both the music and the libretto are composed and written by Richard Wagner. It was composed between 1857 and 1859 and premiered at the *Königliches Hoftheater und Nationaltheater* in Munich on the 10th of June in 1865 with Hans von Bülow conducting. Wagner's composition of Tristan und Isolde was inspired by the philosophy of Arthur Schopenhauer, as well as Wagner's affair with Mathilde Wesendonck (a German poet and author, who wrote the verses for the Wesendonck Lieder composed by Wagner). *Tristan und Isolde* was notable for Wagner's unprecedented use of chromaticism, tonal ambiguity, orchestral color and harmonic suspension. *Liebestod* in German means 'love death' and is the title of the climax of the finale of the opera where Isolde sings over Tristan's body. The range is from D#-Ab5 composed for a dramatic soprano, with challenges comprising of sustained notes, and pianos.

Mild und leise, wie er lächelt	Softly and gently, see him smiling
Wie das Auge hold er öffnet,	How the eyes that open fondly,
seht ihr, Freunde?	see it Friend?
Seht ihr's nicht?	Don't you see?
Immerlichter, wie er leuchtet	Ever lighter, how he's shining
Sternumstrahlet hoch sich hebt?	Borne on high amongst the stars?
Seht ihrs nicht?	Don't you see?
Wie das Herz ihm mutig schwillt	How his heart so bravely swells
Voll und hehr im Busen ihm quillt?	Full and calm it throbs in his breast?
Wie den Lippen, wonnig mild,	As from lips so joyfully mild,
Süsser Atem sanft entweht	sweet the breath that softly stirs
Freunde! Seht!	Friends! Look!
Fühlt und seht ihr es nicht?	Don't you feel and see it?
Höre ich nur diese Wiese	It is only I that hear this way
Die so wundervoll und leise	So wondrous and gentle
Wonne klagend, Alles sagend,	Joyously sounding, telling all things,
Mild versöhnend	reconciling
Aus ihm tönend, in mich dringet,	Sounding from him, penetrating me,
Auf sich schwinget	rising upward swinging on itself
Hold erhallend um mich klinget	Echoes fondly around me ringing
Heller schallend, mich um wallend,	Ever clearer, wafting round me,
Sind es Wellen sanfter Lüfte?	are they waves of gentle breezes?
Sind es Wolken wonniger Düfte?	Are they clouds of sweet fragrance?
Wie sie schwellen, mich umrauschen,	As they swell and murmur round me,
Soll ich atmen, soll ich lauschen?	Shall I breathe them, shall I listen?
Soll ich schlürfen, untertauchen?	Shall I sip them, plunge beneath them?
Süß in Düften mich verhauchen?	Breathe my last amid their sweet smell?

In dem wogenden Schwall	In the billowy surge,
in dem tönenden Schall	in the gush of sound
In des Weltatems, wehenden All	In the World's Spirit's, Infinite All
Ertrinken, versinken, unbewusst	To drown now, sinking, unconscious,
Höchste Lust!	void of all thought
	Highest Bliss/Desire!

1.1.2 Cultural and musical background of the singers featured in this study

Our first soprano is Eileen Farrell who was an American dramatic soprano born on February the 13th in 1920, to parents who were Vaudeville singers. Ms. Farrell has been noted to say that her greatest vocal technical influence was given to her by her principal teacher Eleanor McLellan, who taught her for over a period of 15 years. Ms. McLellan particularly taught her breath control, meaning to sing as you exhale and not to breathe from the upper chest but rather support and inhale from the diaphragm. Eleanor McLellan taught her that when singing in different spaces, not to listen to yourself, but go by the way it feels inside, as it will sound different in each place or space, and if one adapts too much, it can create vocal problems. Furthermore, she advised her to sing as if you're speaking, in her book Ms. Farrell insists on her technical approach of using: good diction, the lips, tongue and teeth. Her teacher advocated no register changes in the voice but when moving to the upper register, to have the sensation as if you are actually doing the opposite, singing lower and vice versa. She was also adamant of the singer being communicative and telling the story.

Farrell performed mostly recitals as a soloist with orchestras and felt that she should not compete with the size and volume of the orchestra, but rather think of herself as another solo instrument such as a cello.

Her main roles were Santuzza in Mascagni's *Cavalleria Rusticana*, the title role in Glück's *Alceste*, Maddalena in Giordano's *Andrea Chénier*, the title role in Ponchielli's *La Gioconda* and Leonora in Verdi's *La forza del destino*. She said that she might be best known for her role of Magda in Menotti's *The Consul*. She very often worked with well-known conductors such as Leonard Bernstein and Leopold Stokowski. She was also a frequent recording artist, notable examples of this are heard in her recordings of Brünhilde's Immolation scene from the opera *Götterdämmerung*, *Tristan und Isolde's Liebestod* and the *Wesendonck Lieder* composed by Wagner. Besides being a classically trained singer, she was also a very popular recital and radio singer; she was proficient in various styles like Jazz and Blues and even recorded with Frank Sinatra. (Farrell, E., Kellow B., 1999)[102]

[102] Farrell, E., Kellow, B. (1999). *Can't Help Singing. The Life of Eileen Farrell*. Northeastern University Press. Boston. P.53-57

Gwyneth Jones, is a Welsh singer born on the 7th of November in 1936. She studied voice at the *Royal College of Music* in London, the *Academia Musicale Chigiana* in Siena and at the *International Opera Studio* in Zürich. Among her teachers were Maria Carpi in Geneva and Eva Turner (who was a famous dramatic soprano and prepared Jones for the role of Turandot) in London.

Having started as a mezzo-soprano, she switched *Fachs* early on to become a soprano. Throughout the late 1960s and 70s she dominated the Bayreuther Festspiele and was one of the most important Wagnerian sopranos of the 20th century. Her vast repertoire included: Senta in *Der Fliegende Holländer*, Sieglinde in *Die Walküre*, Eva in *Die Meistersinger von Nürnberg*, Elisabeth and Venus in *Tannhäuser*, Kundry in *Parsifal*, Brünnhilde in *Der Ring des Nibelungen cycle,* Isolde in *Tristan und Isolde*, Ortrud in *Lohengrin*, Octavian in *Rosenkavalier*, Marschallin in *Rosenkavalier*, Helena in *Die ägyptische Helena*, Ariadne in *Ariadne auf Naxos*, the title role and Herodias in *Salome*, the *Färberin* in *Die Frau ohne Schatten*, Chrysothemis, Klytämnestra and the title role in *Elektra*, Amelia in *Un ballo in Maschera*, Lady Macbeth in *Macbeth*, Leonora in *La Forza del destino*, Desdemona in *Otello*, the title role in *Aïda*, Elisabetta in *Don Carlos*, the title role in *Butterfly*, the title role in *Tosca*, the title role in *Turandot*, Minnie in *Fanciulla del West*, Leonora in *Fidelio*, Donna Anna in *Don Giovanni*, Poppea in *L'incoronazione di Poppea*, the title role in *Medea*, Santuzza in *Cavalleria Rusticana*, Elle in *La Voix Humaine*, the woman in *Erwartung*, Kostelnička in *Jenufa*, Kabanicha in *Kát'a Kabanová*, Begbick in *the Rise and Fall of the City of Mahagonny*, Hannah Glavari in *The Merry Widow* and Unsuk Chin's Queen of Hearts in *Alice in Wonderland*. In interviews she said that she mostly tried to approach singing from a lyrical and piano stand point, and waited many years before singing dramatic repertoire.

Alessandra Marc was born on July the 29th in 1957 and is an American dramatic soprano. She is specifically known for her interpretations of the works of Richard Strauss, Richard Wagner, Giuseppe Verdi and the title role in Puccini's *Turandot.* Marc studied at the University of Maryland and privately with soprano Mary Cotlow, who she met during an audition when Cotlow told her that she was not a lyric soprano, but rather a Strauss and Wagnerian soprano.

Birgit Nilsson was born on the 17th of May in 1918 on a farm in Malmö, Sweden. Although she studied at the *Royal Academy of Music* in Stockholm, she considered herself self-

taught. She was quoted as saying “the stage is the best teacher, you only then learn how to project the voice by singing on the stage”. Being technically self-taught, she was known to have questioned the methods of her teachers; for example, her teacher Sunnegård told her that she had to produce the consonant D with the tongue on the lower teeth and not on the upper teeth. Furthermore she was also advised that when singing low tones to use raw chest voice and not to mix the chest voice with head voice. Another teacher gripped her larynx and pressed it down and these bad experiences made her completely avoid singing teachers. Turandot was one of Nilsson’s most favorite roles, she was noted for saying that “Isolde made me famous but Turandot made me rich”. Nilsson achieved worldwide fame by becoming the leading Wagnerian soprano of her time, succeeding Kirsten Flagstad for her portrayal of Brünhilde. However, she also sang many other famous soprano roles, among these were the title roles in: *Forza del destino*, *Aïda*, *Turandot*, *Tosca*, *Elektra* and in *Salome*. (Nilsson, 2007)[103]

Eva-Maria Westbroek was born on the 26th of April in 1970 and studied voice at the *Royal Conservatory of The Hague* from 1988 to 1995. Her vocal teachers included Iris Adami Corradetti and the american star tenor James McCray. In 2001, Westbroek initiated a 5-year contract as a company member of the *Staatsoper in Stuttgart*. Her roles there included: Carlotta (Schreker, *Die Gezeichneten*), the title role in *Tosca*, Emilia Marty (Janáček, *Věc Makropulos)*, Desdemona (Verdi, *Otello*), Donna Anna (Mozart, *Don Giovanni*), Giulietta (Offenbach, *Les Contes d'Hoffmann*), Marie (Smetana, *The Bartered Bride*) and The Duchess of Parma (Busoni, *Doktor Faust*). Her debut at the *Bayreuther Festspiele* came in 2008 as Sieglinde in *Die Walküure* and reprised the role there again in 2009. Westbroek made her debut at the Staatsoper in München in 2008 as Chrysothemis in *Elektra*. She later returned to München as *Jenůfa* (title role), Ariadne (*Ariadne auf Naxos*) and Georgetta (*Il Tabarro*). Westbroek created the role of Anna Nicole Smith in 2011 of Mark-Anthony Turnage's opera *Anna Nicole* at the Royal Covent Garden Opera House in London. Other roles she performed at the Royal Covent Garden Opera House in London include: Giorgetta (*Il Tabarro)*, Dido (*Les Troyens*), Maddalena (*Andrea Chénier*), Santuzza (*Cavalleria Rusticana*), Katarina (*Lady Macbeth of Mtsensk*), Minnie (*La Fanciulla del West*) Sieglinde *(Die Walküre*) and Elisabeth (*Tannhauser*). Westbroek made her Metropolitan Opera debut on April 22nd in 2011

[103] Nilsson, B. (2007). *La Nilsson. My Life in Opera.* University Press of New England. Hanover and London. p. 41-42, 121-122.

singing the role of Sieglinde in the premiere of a new production of Wagner's *Die Walküre* directed by Robert Lepage.

Nina Stemme is a Swedish dramatic soprano and was born on May the 11th in 1963. She attended the *Adolf Fredrik's Music School* in Stockholm (no specific names of teachers are publicly available on the internet but she was the protégé of Birgit Nilsson) and won the *Operalia World Opera Competition* in 1993 in Paris. Stemme is regarded as one of the greatest Wagnerian sopranos of all times. Her roles include: Rosalinde in *Die Fledermaus*, Mimì in *La Bohème*, Cio-Cio San in *Madama Butterfly*, the leading roles in: *Turandot*, *Tosca* and *Manon Lescaut*, Sister Angelica in *Suor Angelica*, Euridice in Gluck's *Orfeo ed Euridice*, Katerina in *Lady Macbeth of Mtsensk*, the Countess in *Le nozze di Figaro*, Marguerite in *Faust*, Agathe in Der *Freischütz*, Marie in *Wozzeck*, Nyssia in *König Kandaules*, the title role in *Jenůfa*, Marschallin in *Der Rosenkavalier*, Eva in *Die Meistersinger von Nürnberg*, Elsa in *Lohengrin*, Senta in *Die Fliegende Holländer*, Sieglinde in *Die Walküre*, Elisabeth in *Tannhäuser* and Isolde in *Tristan und Isolde*. The latter brought her critical acclaim at the *Glyndebourne Festival Opera* in 2003 where she later recorded it for EMI Classics with Plácido Domingo.

The background of the sopranos was obtained through information freely available on the internet, from Wikipedia.com, as well as YouTube interviews and through the personal biographies mostly written by the sopranos themselves.

1.2 Process, Selection and Planning of the project

1.2.1 The data collection

The data collection is focused on the recordings of 6 different operatic sopranos (coded as S1-S6). The headings listed on the graph are*:* 6 Spinto or Dramatic Sopranos (Eileen Farrell, Gwyneth Jones, Alessandra Marc, Birgit Nilsson, Nina Stemme and Eva-Maria Westbroek). The data analysis has gathered 6 Verdi and 6 Wagner opera aria recordings. The recording analysis is proven to be of value as it was the result of extensive research due to additional examples taken from Bozeman[104] and Howell[105].

Table 1 – List of the Sopranos, pieces and YouTube address of the recording

	Voice Type	Music/ Author	Song/Aria	Vowel	Youtube address
S1 – 1 Eileen Farrel	Dramatic Soprano	Verdi/La Forza del Destino	Pace, Pace	a	https://youtu.be/o4L4eNWvWuE
S1 – 2 Eileen Farrel	Dramatic Soprano	Wagner/Tristan und Isolde	Liebestod	a	https://www.youtube.com/watch?v=Etw5sdLa0Qg
S2-1 Gwyneth Jones	Dramatic Soprano	Verdi/Don Carlos	Tu che le Vanità	a	https://youtu.be/c1ouuad0ZRw
S2-2 Gwyneth Jones	Dramatic Soprano	Wagner/Tristan und Isolde	Liebestod	a	https://youtu.be/Pjf89brYwHw
S3 – 1 Alessandra Marc	Dramatic Soprano	Verdi/La Forza del Destino	Pace, Pace	a	https://youtu.be/-yZfXbm7p5E
S3 – 1 Alessandra Marc	Dramatic Soprano	Wagner/Tristan und Isolde	Liebestod	a	https://youtu.be/0jRO5PTQ3yg
S4-1 Birgit Nilsson	Dramatic Soprano	Verdi/Lady Macbeth	Vieni! t'affretta!… or tutti…	a	https://youtu.be/sk5T6LBP9xQ
S4-2 Birgit Nilsson	Dramatic Soprano	Wagner/Tristan und Isolde	Liebestod	a	https://youtu.be/gQ5k5qcbFkc
S5-1 Nina Stemme	Dramatic Soprano	Verdi/La Forza	Pace, Pace	a	https://youtu.be/pjjTq2Epc4g
S5-2 Nina Stemme	Dramatic Soprano	Wagner/Tristan und Isolde	Liebestod	a	https://youtu.be/PiOzs35e-Kc
S6 – 1 Eva-Maria Westbroek	Dramatic Soprano	Verdi/La Forza del Destino	Pace, Pace	a	https://www.youtube.com/watch?v=uKgVd3XWNuk
S6 – 2 Eva-Maria Westbroek	Dramatic Soprano	Wagner/Tristan und Isolde	Liebestod	a	https://www.youtube.com/watch?v=g8gkZdfiKYo

[104] Kenneth Bozeman is a Professor of Music, has degrees from Baylor University and the University of Arizona, is chair of the voice department at Lawrence University and is the chair of the editorial board of the NATS Journal of Singing.

[105] Ian Howell is a member of the voice faculty of the New England Conservatory of Music, directs the graduate voice pedagogy program and is the research director of the NEC Voice and Sound Analysis Lab.

1.2.2 The data analysis

I have deepened my knowledge in the research theme so that I can point out the most relevant aspects of the analysis. The data analysis is determined by the post-positivism paradigm[106], the goal being, to describe the results of the analysis given by the software. This is done in order to objectively describe the results in a quantifiable manner explaining the evolution of the formants and harmonics as well as the rates of vibrato, in addition to seeing if indeed the vocal technique changed between the two different repertoires. We will further see that the relationship between formants and harmonics can be quantified when analyzing the differences found in the vocal spectrogram of the various singers, as well as the way the singers vocally adapt as seen in the changes of their vibrato rates. The data processing was done with Octave/MATLAB[107] which also created the graphics.

1.2.3 The method of measurement

Measuring the sound spectra is normally executed in scientific setups with controlled recording facilities where singers are asked to sing in more favorable conditions, obviously this would not have been possible in my experiment. Not only do I not have access to professional recording facilities but the sopranos that I have chosen are not available for a laboratory experiment. Regardless, a substantial amount of material taken from performances is available on YouTube and other internet and social media facilities. For this research it was necessary to collect as many measuring points as possible from the various singers involved.

For this process I needed several specialized software systems: the Audacity Software for editing and equalizing the sound material, the VoceVista Video Pro software to analyze the spectra and the specially developed Sing2 (with GNU Octave/MATLAB) to further process the data from VoceVista Video Pro.

First, I collected two arias for each soprano, one from Verdi, the other one from Wagner. Then I normalized the audio tracks of every piece in the Audacity software to -3 dB and searched for as many sound clips as possible.

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[106] While positivists emphasize quantitative methods, post-positivists consider both quantitative and qualitative methods to be valid approaches.

[107] GNU Octave is a software featuring a high-level programming language, primarily intended for numerical computations. Octave uses a language that is mostly compatible with MATLAB.

The audio clips had to meet a number of important conditions:

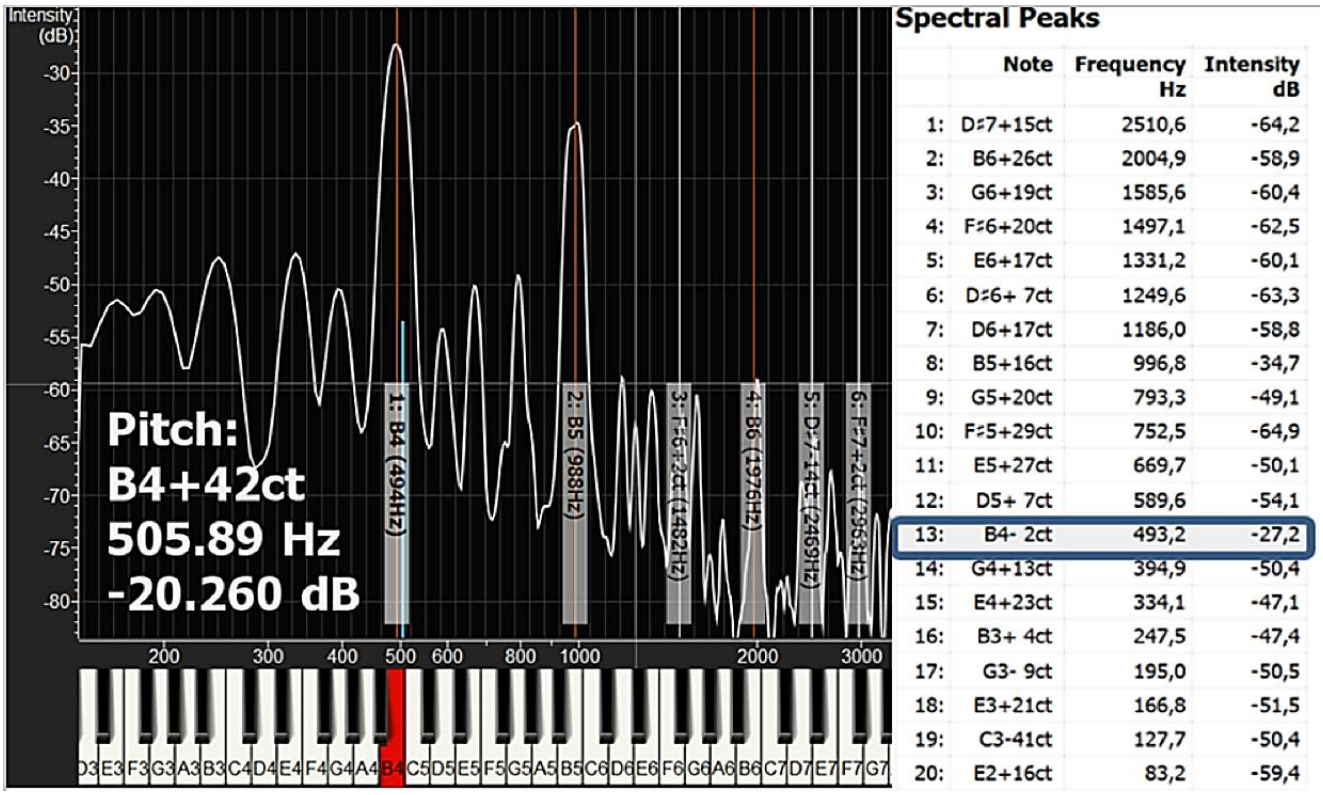
1. Each excerpt had to be a minimum of 0.5 seconds spanning a maximum of 2 seconds.
2. The audio clip had to contain a clearly recognizable |a| sound, with some vowel modifications or variations, this meaning: |ə| (away), |A| (cup), |ɑ| (arm) and |ɔ| (call). It was irrelevant whether the sound also belonged to the letter "a" in the sung text since the excerpt only concerned the sound itself.
3. The orchestra had to be minimally audible in the audio clip and on a different pitch.
4. The vibrato in the audio clip had to be as stable as possible so that when the vibrato was developing from slow to quick speeds on a note, which happened often in Wagner, I chose the part of the audio clip that was the most stable.

All of the audio clips were carefully defined and numbered in the Audacity software and finally exported in wav-format. This resulted in 12 datasets each containing about 25-40 audio clips, concluding 378 clips in total. I loaded the audio of every clip into the sound analysis software VoceVista Video Pro. This software gives you the possibility to track the twenty strongest peaks in the spectrum, as can be seen in Figure 16 below.

VoceVista Video Pro was configured to determine the Long-Term Average Spectrum (LTAS) over the total length of the clip.[108]

[108] The window size was 8192 samples (which is a factor of about 5.4 Hz resolution) with a sampling rate of 44100 samples/second and the window was Blackman (a window type for the spectral analysis).

Figure 16 – VoceVista Video Pro LTAS for Eileen Farrell Liebestod tone B4 and vowel |a|



Spectral Peaks

	Note	Frequency Hz	Intensity dB
1:	D♯7+15ct	2510,6	-64,2
2:	B6+26ct	2004,9	-58,9
3:	G6+19ct	1585,6	-60,4
4:	F♯6+20ct	1497,1	-62,5
5:	E6+17ct	1331,2	-60,1
6:	D♯6+ 7ct	1249,6	-63,3
7:	D6+17ct	1186,0	-58,8
8:	B5+16ct	996,8	-34,7
9:	G5+20ct	793,3	-49,1
10:	F♯5+29ct	752,5	-64,9
11:	E5+27ct	669,7	-50,1
12:	D5+ 7ct	589,6	-54,1
13:	B4- 2ct	493,2	-27,2
14:	G4+13ct	394,9	-50,4
15:	E4+23ct	334,1	-47,1
16:	B3+ 4ct	247,5	-47,4
17:	G3- 9ct	195,0	-50,5
18:	E3+21ct	166,8	-51,5
19:	C3-41ct	127,7	-50,4
20:	E2+16ct	83,2	-59,4

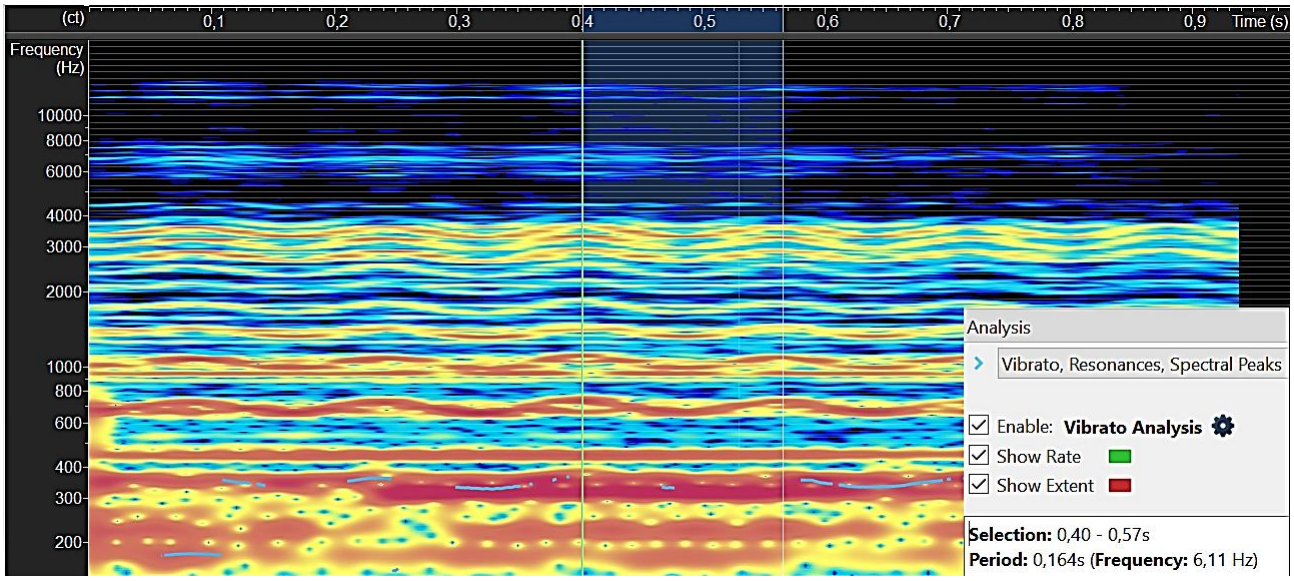
As we can see on Figure 16, VoceVista Video Pro provides several tools to analyze the spectrum of a sound clip. Here we can see the Long-Term Average Spectrum (this displays the average sound level for each frequency over a certain time period) of the vowel |a| on pitch B4 sung by Eileen Farrell in Wagner's *Liebestod*; the following dataset seen is numbered as example 2, of clip number 36 where the peaks are created by all of the major resonances in the sound. In this spectra, I was interested in focusing on the harmonics, their *frequencies* (Herz) and *magnitudes* (dB).

On the horizontal line we can see the frequencies in Herz, that correspond to the notes of the harmonics as seen in the piano representation (B4 being the first harmonic or fundamental). On the vertical line, we can see the sound levels of the partials in decibels. From left to right, the vertical lines indicate the four first harmonics H1 (B4: 494 Hz), H2 (one octave higher on B5: 998 Hz) , H3 (one fifth higher F#6: 1482 Hz) and H4 (one quarter higher B6: 1976 Hz). These are approximate values because VoceVista Video Pro can't automatically find the harmonics in the spectrum.

To find the precise values of the harmonics, it was necessary to use the list of spectral peaks which we can see on the right side of the screenshot of Figure 16. These are automatically tracked by VoceVista Video Pro. Careful study of the list tells us that the H1 is on peak 13 (493,2 Hz) with a magnitude of -27.2 dB, and H2 is on peak 8 (996,8 Hz) with a magnitude of around -34,7 dB. This process of finding the harmonics would be very time consuming if done manually, therefore this extraction was done by the program: Sing2 which we will discuss later. To transfer the peak list from VoceVista to Sing2, the peak values were first manually exported to excel from VoceVista Video Pro and from there loaded into the Sing2 software.

Furthermore, analysis of the vibrato rates (in Hz) for every audio clip were determined either manually or with the VoceVista Video Pro vibrato-analyzer.

Figure 17 – Vibrato calculation for the Spectrogram of the VoceVista Video Pro Software



As we can see in Figure 17, I used the spectrogram representation to analyze the vibrate rates. In this image, the waves are created by the vibrato in the voice and can be clearly recognized. On the horizontal axis at the top, the time in which the vibrato fluctuations occur is displayed and on the left we can see the frequency. Figure 17 shows us the vibrato rate calculation of 6,11 Hz at the lower right corner, for the selected manual measurement per cycle

in VoceVista Video Pro software.[109] The rates of the vibrato found, were also collected in the excel sheet per dataset in the same order as the other data points.

All further analysis of the spectral peaks and the vibrato rates was done in program Sing2, which was especially designed for this task in GNU Octave (a software featuring a high-level programming language used for numerical computations and compatible with MATLAB). This step was absolutely necessary because the excel sheet of all 24 data sheets contained around 7500 peak values; obviously, this amount of data could not be analyzed by hand.

Program Sing2 performed the following tasks:

1. Extraction of the first six harmonics from the list of peaks which were calculated by VoceVista Video Pro and loaded via the excel sheet. For every harmonic found, the frequency f_n in Herz and the sound level L_n in dB were registered. The subscript n indicates the number of the harmonic.
2. Calculation of the level differences $L_{n/1} = L_n - L_1$ in dB for the harmonic H_n. These values are called in scientific literature: level ratios[110] and I used this mainly for the $L_{2/1}$ ratio, which gives the strength of harmonic 2, relative to harmonic 1. For example in Figure 16 we found L_1= -27,2 dB and L_2= -34,7 dB thus $L_{2/1}= L_2 - L_1$=-34,7-(-27,2)= -34,7+27,2= -7,5 dB. We can conclude that the 2nd harmonic is -7,5 dB weaker than the 1st harmonic.
3. Correction of all the peaks in the spectra were performed for every piece/dataset to compensate for differences in the spectral balance.
4. Averages were calculated per dataset/singer and per genre (Italian/German) over the following data mentioned above: $L_{n/1}$ (levels of harmonics in dB or H_n relative to the H1 harmonic) for the first six harmonics and the vibrato rates. The statistical errors were also calculated for all averages.
5. All data was collected and stored in one table and saved in file: singdata.txt, so that this data could be further processed on an excel sheet.
6. The program Sing2 gives the user possibilities for monitoring the data, making selections for analysis and the possibility to exclude questionable data.
7. All the relevant graphs of the main harmonics, level ratios and vibrato rates for further analysis and presentation were created by Sing2 with standard Octave software functionalities.

[109] In some cases VoceVista Video Pro wasn't able to determine the right vibrato rate and therefore this has been done manually by measuring the period of the vibrato.

[110] Pabon, P., Ternstöm, S. (2020) Feature Maps of the Acoustic Spectrum of the Voice, Journal of the Voice, Vol. 34, N. 1.

To clarify the above-mentioned tasks and their meanings, we will discuss here some of the points in more detail. First of all, extraction of the harmonics (point 1) was essential because VoceVista Video Pro only determined the peaks in the LTAS (Long-Term Average Spectrum), not the harmonics. I also found that the automatic pitch-tracker of VoceVista Video Pro in many cases failed, so precise determination of the pitch was crucial and was performed aurally. Sing2 takes this pitch value to search for relevant peaks found in each harmonic in an indicated interval around the expected frequency value. In our case a deviation of +/- 10-20% gave good results.

The calculations found as seen in dataset 2, are of major importance for this study because it is not possible to compare the absolute values of the measured harmonics. Every clip has a different sound level, so the harmonics in the spectrum change from clip to clip. When starting this project, I assumed that the fundamental peak (the first harmonic), could probably be a good calibration measure, so I decided to use the difference between the second harmonic and higher with the first harmonic. From this type of study, we can easily say that not all the absolute levels of the harmonics were used but only the relative values were taken in relation to the fundamental. These results and others are consistent with the previously mentioned studies seen in point 2 from Pabon and Ternström (2020), ultimately justifying this choice.

Comparing levels in the spectra taken from very different sound sources is challenging. The reason being, that every recording has a different spectral equalization[111] (in simple words, some recordings have more higher tones, others more lower tones). Some recordings are older and carry the sound of that time, others are newer and are closer to "reality". A 100% reliable comparison is only possible in lab conditions where all recordings are made in the same setup. In the case of this research, in order to compare the levels of different harmonics in the recordings as formerly described, it was desirable to adjust the equalization of the different recordings.

To achieve this, average spectra (LTAS) was determined for every aria with the Audacity software,[112] in order to be able to find the equalization of that specific recording. These levels were exported and loaded into Sing2 which corrected the peak levels of all datasets to a standard equalization. This standard equalization was derived from the most "naturally" and "balanced" recording sound that I had, which was of Eileen Farrell singing Verdi.

[111] Every mic and every space has a specific frequency characteristic that determines the filtering of some frequencies and/or boosting others.

[112] The settings used were: Window 2048 samples, Hann and 21 Hz resolution.

To achieve the goal of this investigation, averages of all harmonics and vibrato rates were calculated per note, per singer and per genre[113]. I checked the quality of the sound clips in order to be certain that the final data would be as accurate as possible. This resulted in the exclusion of 21 clips of the 378 due to two reasons. In some clips the sopranos sang a different vowel other than the mentioned sounds in vowel |a|. In the other sound clips, the sound of the orchestra was too loud making the vowel sounds inaudible.

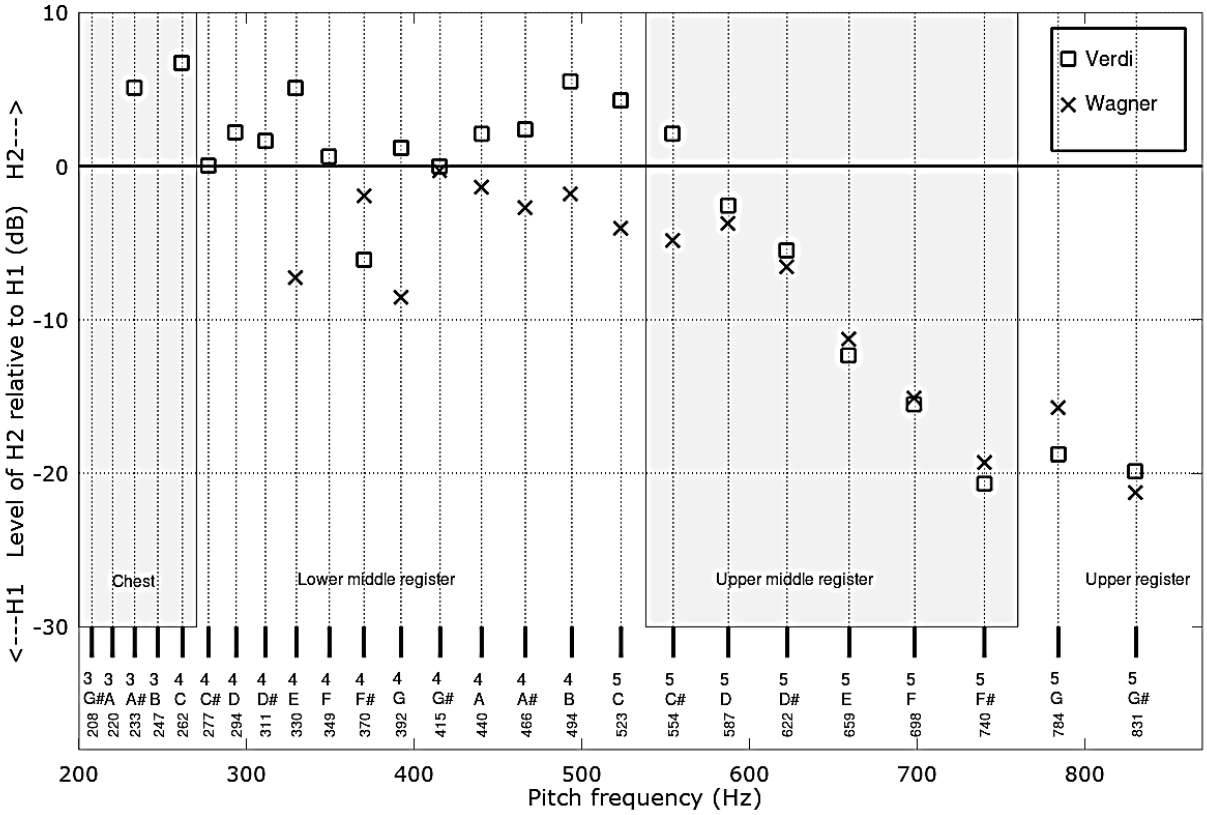
2 Research
2.1 Results

The harmonics H2-H6 relative to H1 were compared between Verdi and Wagner for all six sopranos. Significant differences were found in the H2-H1 levels between E4 and C#5 (the lower middle register and the beginning of the upper middle register); in Verdi, H2 was the dominant resonance found, while in Wagner H1 was stronger than H2. This can be seen in Figure 18, from the Verdi recordings, H2 was circa 3,7 dB higher than H1 in the lower middle register compared to Wagner.

Remarkably, considering the variety of material and sopranos analyzed, in the upper middle and the upper registers the H2-H1 level decreased with 1 dB per 10 Hz for all sopranos and their various pieces. This linear descending trend towards the higher frequencies can be seen on Figure 18, which means that with the increased height in pitch, H1 became much stronger. This is due to formant tuning as H1 is being coupled with the first formant F1 therefore meaning that H2 will be weaker and weaker in relation to H1.

[113] It was not possible to find the same number of sound clips for every pitch. Of course, this makes the precision of the levels for different tones unequal and this is reflected in the fluctuating statistical errors, which are visible in the results.

Figure 18 – Average H1 and H2 resonance for all 6 sopranos singing Verdi and Wagner



In the above graph, one can also see that in the upper middle and upper registers no significant differences of H2-H1 levels were found between Verdi and Wagner.

We´re now going to zoom in and focus on the middle register of all the sopranos.

Figure 19 – Individual H1 and H2 resonance in the lower middle register (from E4 to C5) for all 6 sopranos when singing Verdi (gray) and Wagner (white)

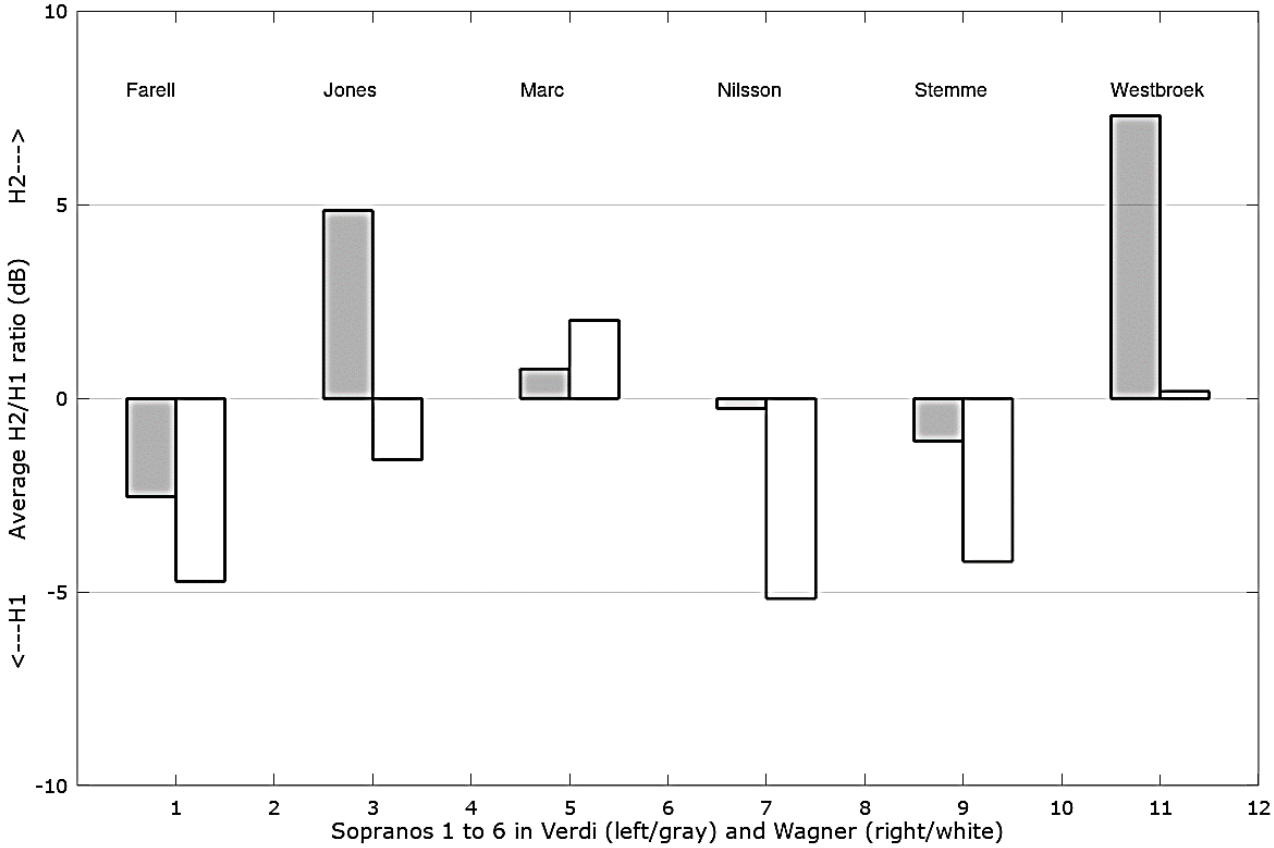


Figure 19 shows how strong the individual differences of H2-H1 levels are. The majority of singers have significant differences in technique between the two repertoires. Jones and Westbroek adapted their vocal technique when singing Verdi by enhancing H2 in circa 5 dB and 8 dB compared to Wagner. On the other hand, Farrell, Nilsson and Stemme have adapted their vocal technique with a stronger H1 of circa 5 dB in Wagner compared to Verdi. As for Marc, the results are not as significant if we take the margin of error into consideration.

In Table 2 we can see the values of the bars in the chart above with the statistical errors for each soprano and aria.

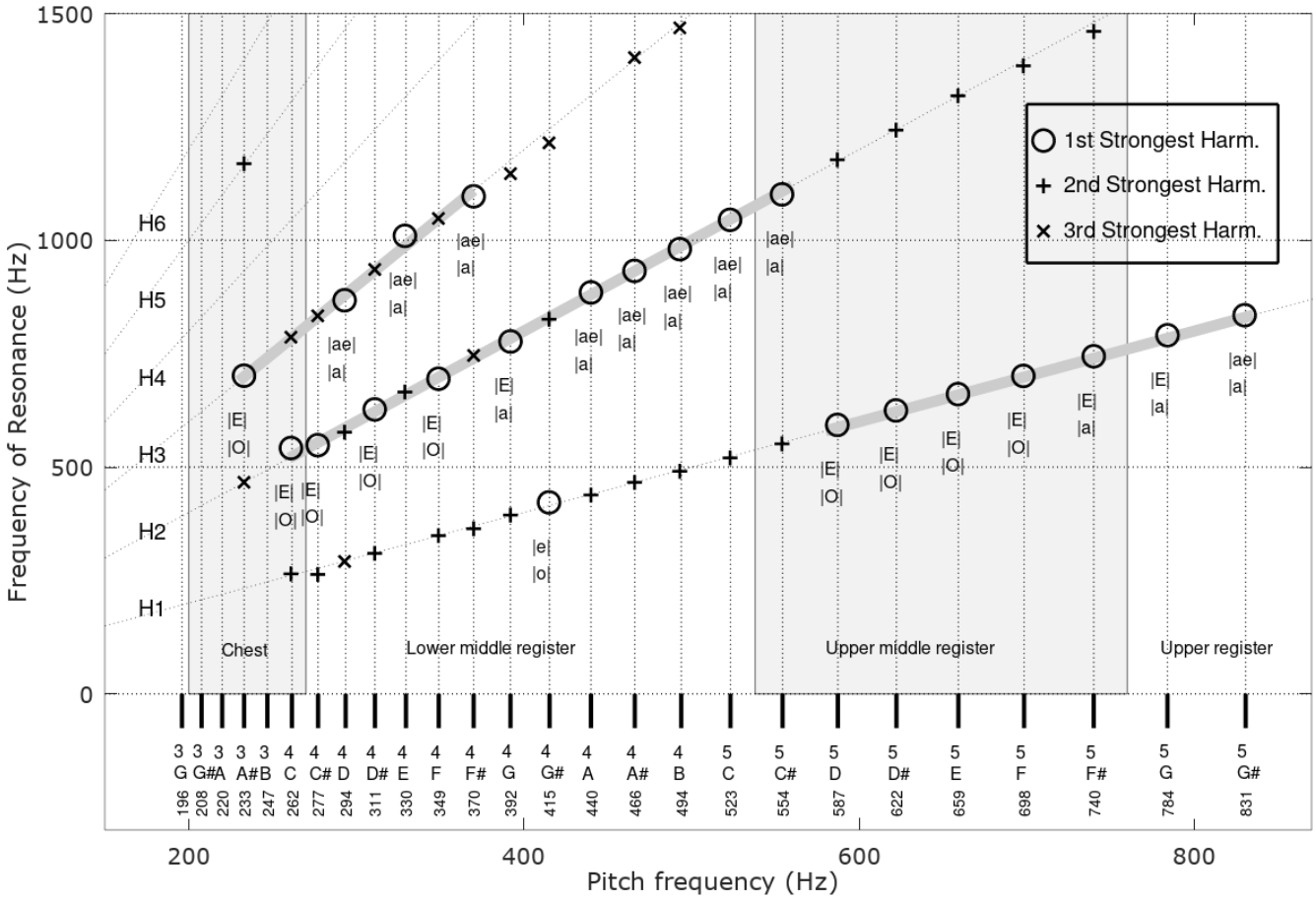
Table 2 – Average H1 and H2 values in the lower middle register (from E4 to C5) with statistical errors of each soprano and aria

	Verdi		Wagner		Average Difference Verdi/Wagner
Singer	$L_{2/1}$ average dB	Statistical error	$L_{2/1}$ average dB	Statistical error	Average dB
Eileen Farrell	-2,5	1,7	-4,7	1,2	2,2
Gwyneth Jones	4,9	2,8	-1,6	2,3	**6,4**
Alessandra Marc	0,8	2,4	2,0	3,2	-1,3
Birgit Nilsson	-0,3	1,8	-5,2	2,1	**4,9**
Nina Stemme	-1,1	2,9	-4,2	1,9	**3,1**
Eva-Maria Westbroek	7,3	1,5	0,2	2,0	**7,1**
All singers	1,5	2,2	-2,3	2,1	**3,7**

When analyzing the data of this study, Jones, Nilsson, Stemme and Westbroek have adapted their vocal technique the most when singing Verdi in comparison to Wagner. Negative values mean more H1 and positive values, more H2 (see numbers in bold). Note that the overall statistical error is about 2,2 dB, which means that the previously mentioned differences that are highlighted in the table are significant. Marc had minimal changes when singing the arias of both composers.

Let's now focus deeper into the strategies, the sopranos followed in Verdi and in Wagner relating to the strength of the harmonics and vowel formants.

Figure 20 – Partial resonance and register changes for all 6 sopranos when singing Verdi



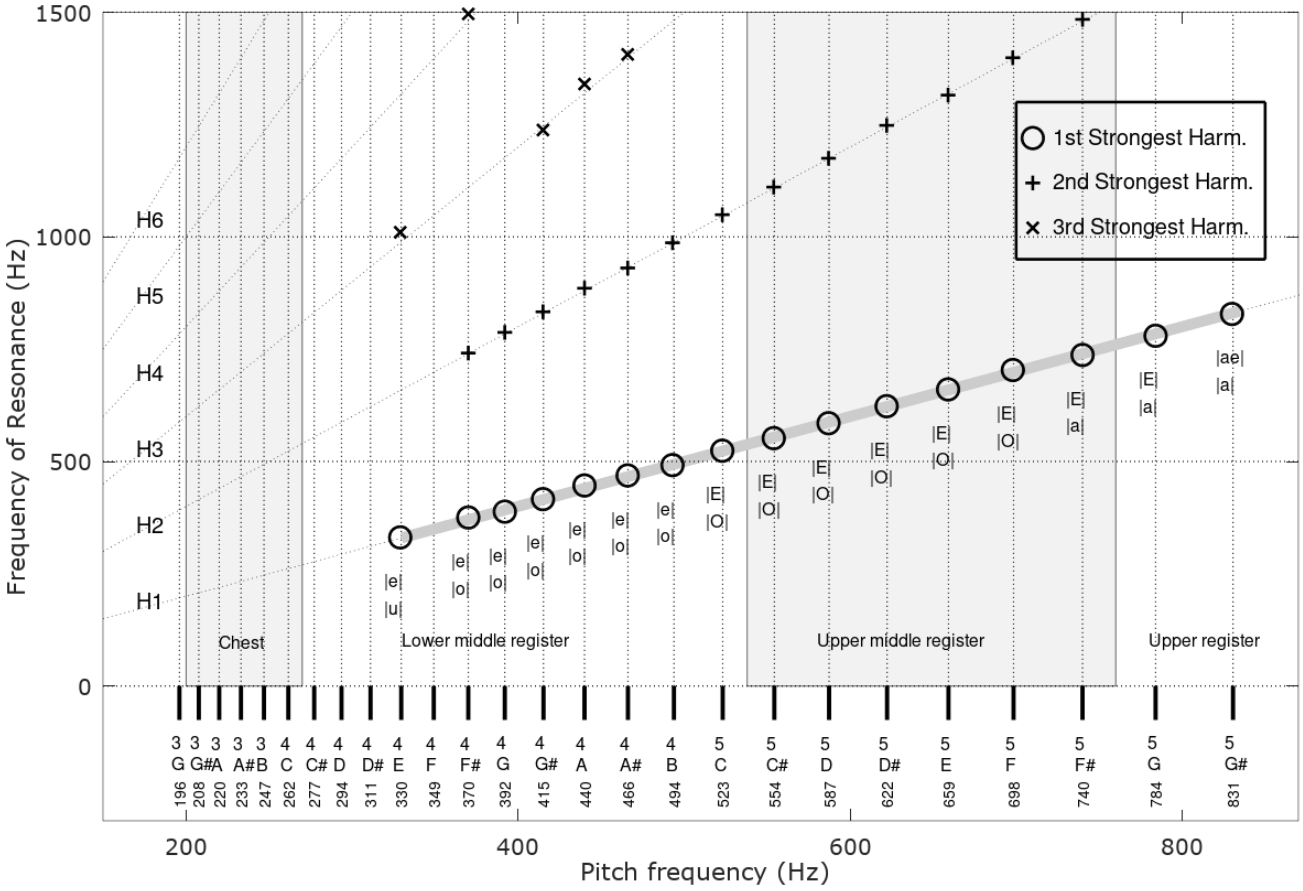
Figures 20 for Verdi and 21 for Wagner show the partials (harmonics) as straight lines for all sopranos. The lowest being the first, the next line seen at a higher position as the second and so on. We can see the circle signaling the strongest harmonic, the plus the second strongest and the x the third strongest. In Figure 20, we can clearly see that when singing Verdi, the sopranos use either H2 or H3 resonance between A3 and F4 and only H2 between A4 and C#5. The first harmonic takes over at D5 and becomes the main resonance, what happens is that the two harmonics switch their position due to formant tuning at the point of the register change. With the change of pitches, the sound of the vowels also change. In Figures 20 until 23, the two vowels that can resonate the most based on the first formant frequencies, are indicated as follows: the upper vowel is the front vowel and the lower vowel is the back vowel.[114]

[114] The frequencies and phonetic notations are derived from Miller´s chart (Figure 3) and the IPA symbols

Front vowel	|i| (k<u>ee</u>n)	|e| (ch<u>a</u>os)	|E| or |ɛ| (b<u>e</u>t)	|ae| or |æ| (b<u>a</u>t)
1st formant	100-300 Hz	300-500 Hz	500-800 Hz	800-1200 Hz
Back vowel	|u| (f<u>oo</u>l)	|o| (n<u>o</u>te)	|O| or |ɔ| (<u>a</u>ll)	|a| or |ɑ| (f<u>a</u>ther)
1st formant	200-350 Hz	350-500 Hz	500-700 Hz	700-1300 Hz

When singing Wagner in the lower middle register where H1 is chosen as the stronger resonance, the vowels used are mostly back vowels for a darker timbre. When singing Verdi in the lower middle register with H2 as the strongest resonance, front vowels are preferred for a brighter timbre. Formant tuning is used to keep the timbre of the vowel over a broad pitch range, such as shown in Figures 20 and 21.

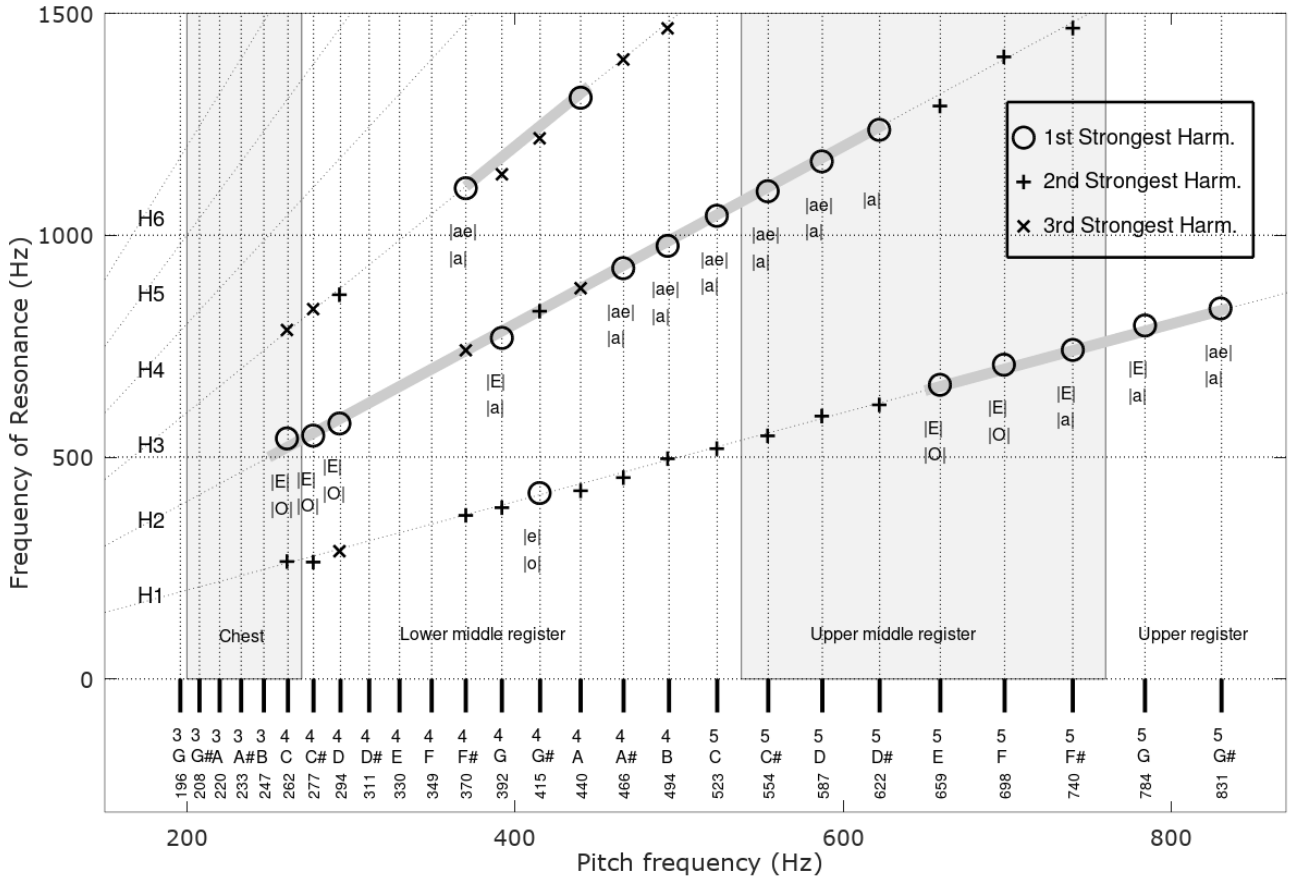
Figure 21 – Partial resonance and register changes for all 6 sopranos when singing Wagner



In Figure 21 displaying the Wagner extracts, we can see that the H1 tuning is used over the whole range of the lower middle, upper middle and upper registers, which is completely different from the resonance strategies of the sopranos in Verdi seen in Figure 20. In Wagner, the singers tune the first formant very early to the H1 resonance and keep H2 as the second strongest resonance.

The following charts are now going to show the individual strategies of the singers.

Figure 22 – Resonance and register changes of Gwyneth Jones when singing Verdi

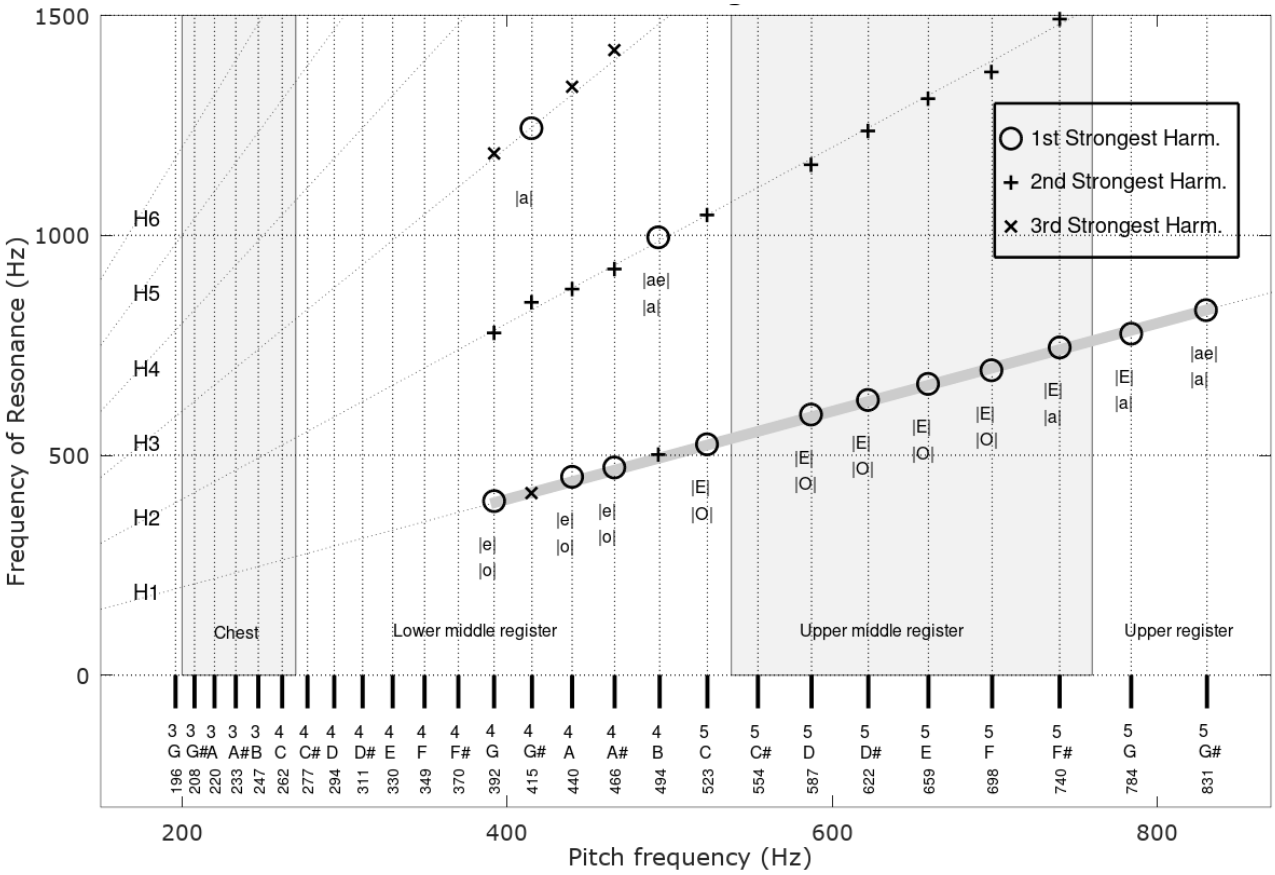


Figures 22 and 23 show the difference in resonance between singing Verdi and Wagner of Gwyneth Jones. When singing Verdi, Jones makes different choices in the lower middle register than when singing Wagner. In Figure 22, we can see that Jones generally has a stronger H2 partial when singing Verdi from C4 to D#5 and a stronger H1 or fundamental when singing Wagner from E4 to G#5.

This is a result of a technical adaptation to different repertoire, likely related with the opening of the jaw, the height of the larynx and opening of the pharynx (responsible for F1), as well as the lowering of the tongue (responsible for F2).

Register changes are also done differently, as we can see in Figure 23 for Wagner. Here Jones mostly pursues the F1/H1 formant tuning from G4 to G#5, while in Figure 22 for Verdi only at E5 does she switch from H2 to an H1 predominant resonance.

Figure 23 – Resonance and register changes of Gwyneth Jones when singing Wagner



In Figures 22 and 23, we can see further what influences the choice of H1 or H2 resonances have in the color of the vowels sung by Jones. When compared, these two graphs show that Jones uses a more open and brighter vowel (|a|) modification for the middle register in Verdi and a more closed and darker vowel modification (|O|) for the middle register in Wagner.

Figure 24 – Vowel formant resonances with the first and second harmonic for sopranos

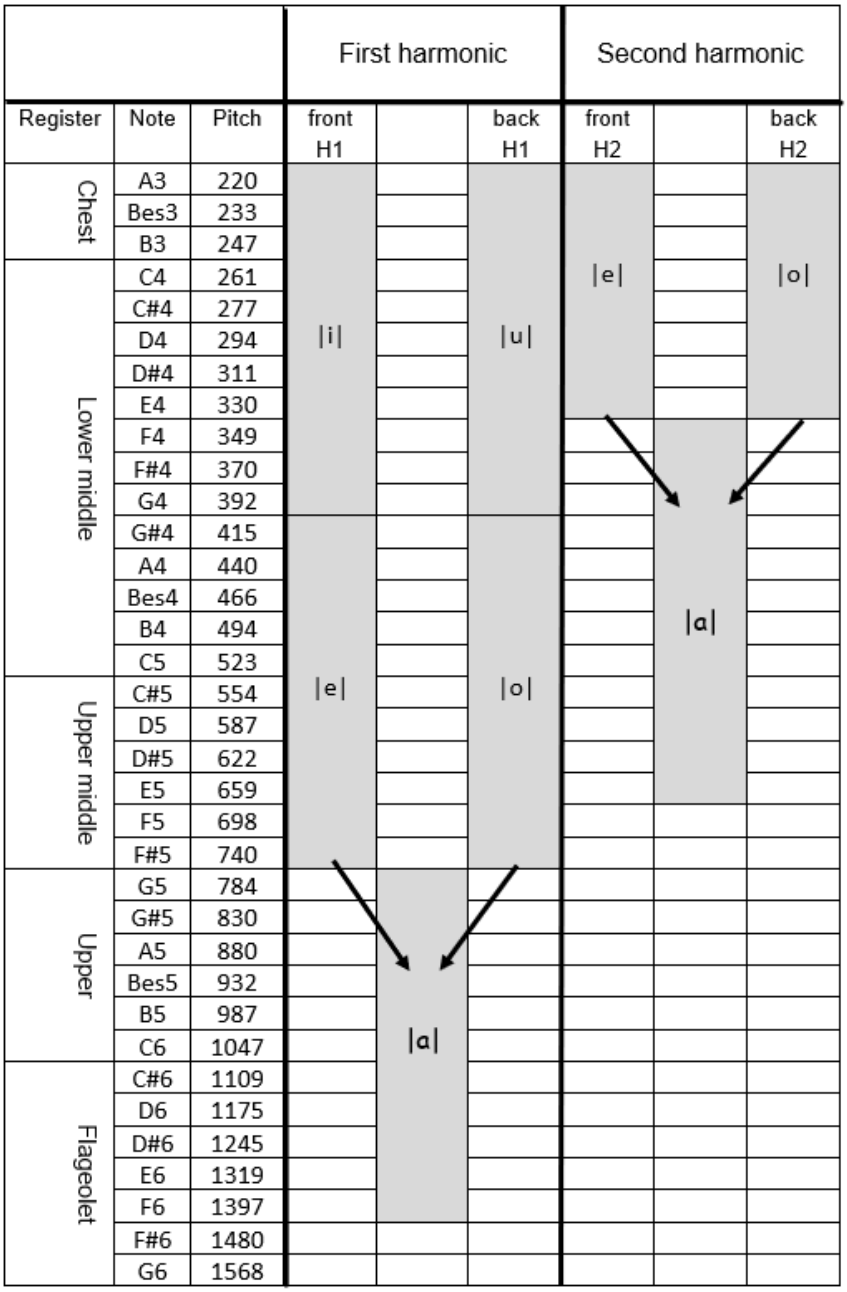
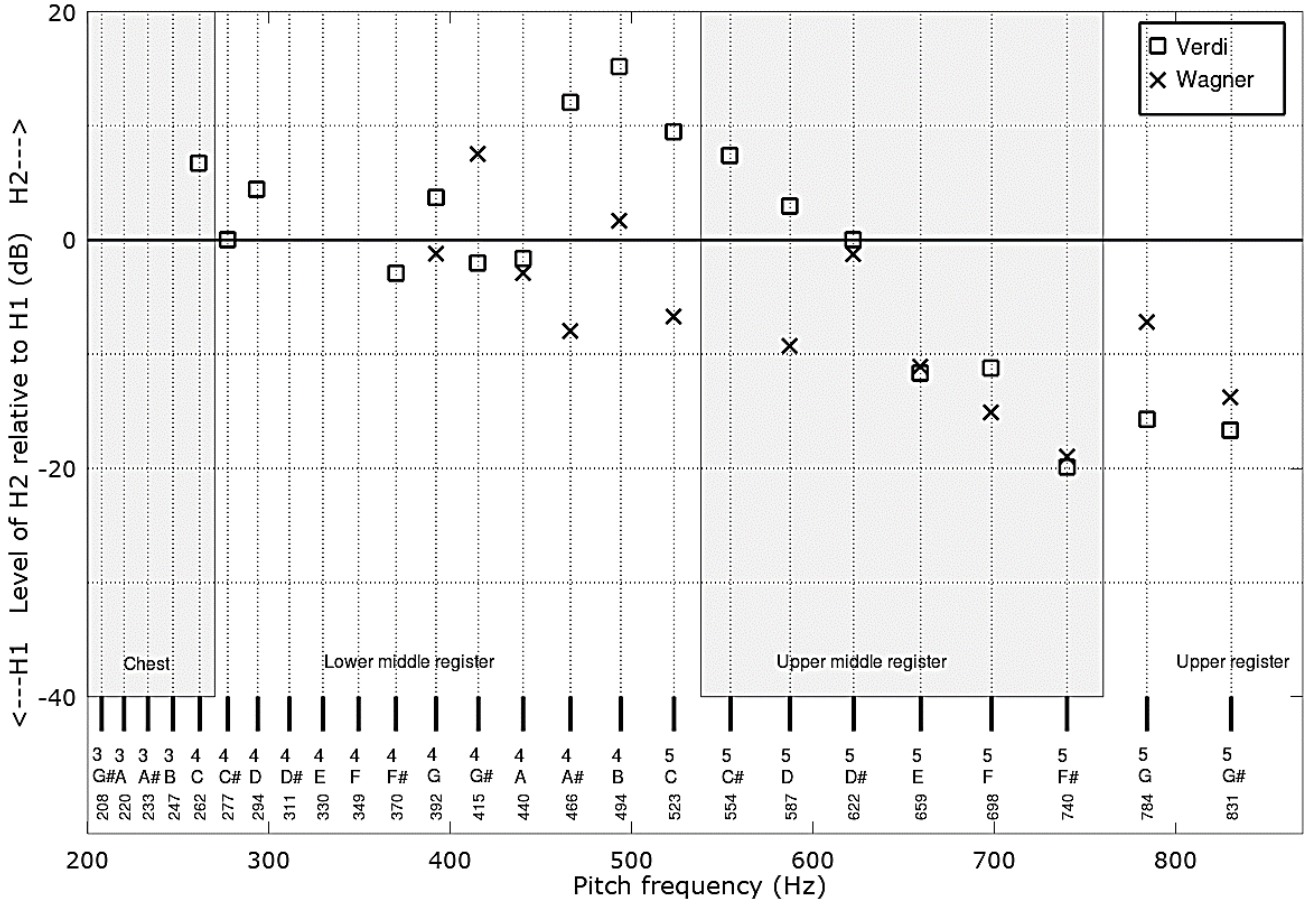


Figure 24 shows the possible vowel resonance strategies taken from the vowel chart in Figure 3, which was used as the basis for the analysis of the vowel strategies in all 6 sopranos (Figures 20 and 21) and in the individual sopranos such as Jones in Figures 22 and 23. Here we see the vowel modification sounds were included along with the strongest harmonic (the circle), to give an idea of how the resonance strategies affect the vowel coloring (see appendix 1 for all individual soprano resonance strategies and vowel modifications).

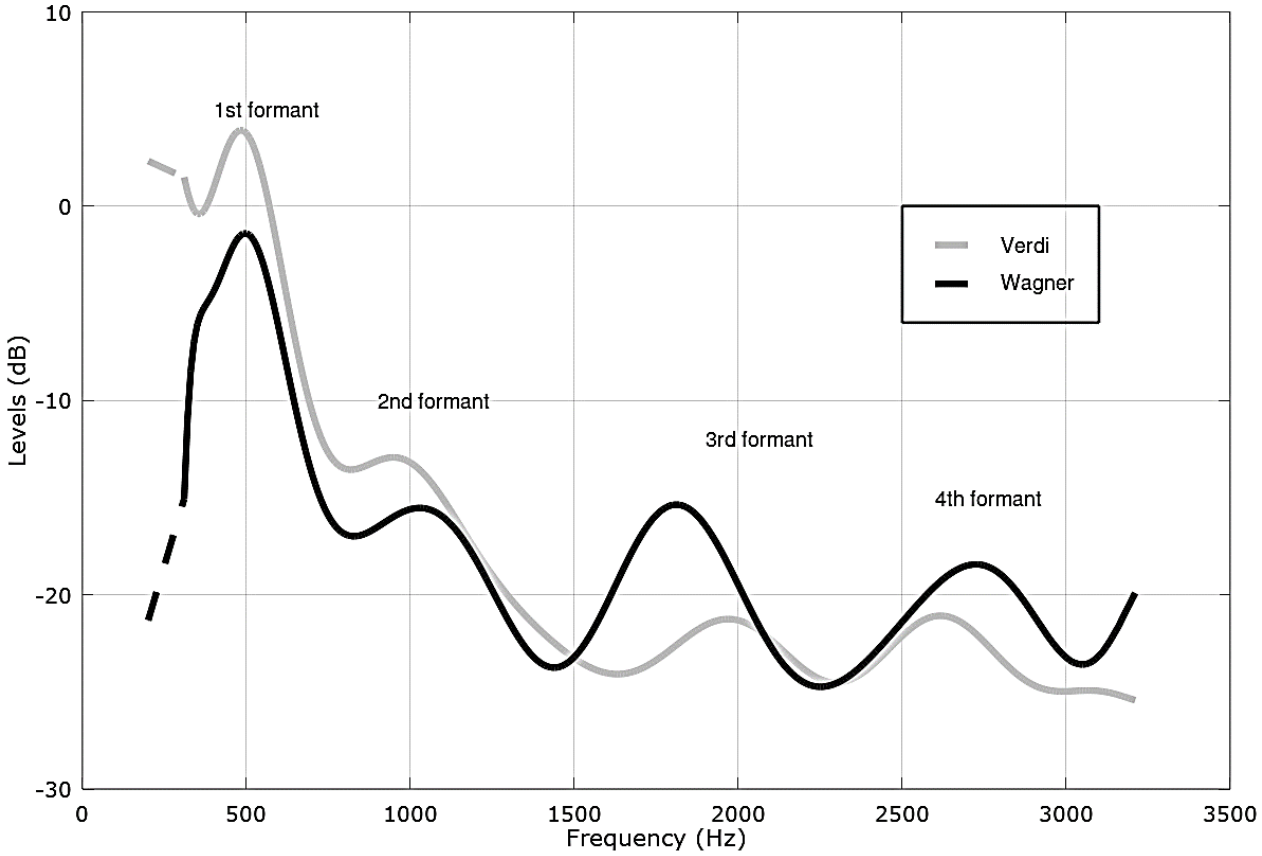
Figure 25 – H1 and H2 resonance graph for Jones singing Verdi (square) and Wagner (cross)



In Figure 25, we can compare both H1 and H2 harmonics for Jones in both arias which we consider one of the most significant adaptations. In this graph, graphic values above 0 mean a predominant H2 resonance and under 0 a predominant H1 resonance. We can see that there is an H2 dominance in the lower and upper middle register in Verdi compared to Wagner. In the upper register, the level of H1 in Wagner isn't as strong as in Verdi.

The following is the explanation for the graph for figure 26. The upper partials were analyzed collectively and some differences were found between the recordings of the two repertoires. H3, H4, H5 and H6 harmonics were found stronger in Wagner in the upper middle and upper registers for almost all individual singers, boosted by the frequencies of the third and the fourth formants of vowel |a|. This gave the singers a more metallic sound allowing them to be heard with more volume above Wagner's orchestration[115].

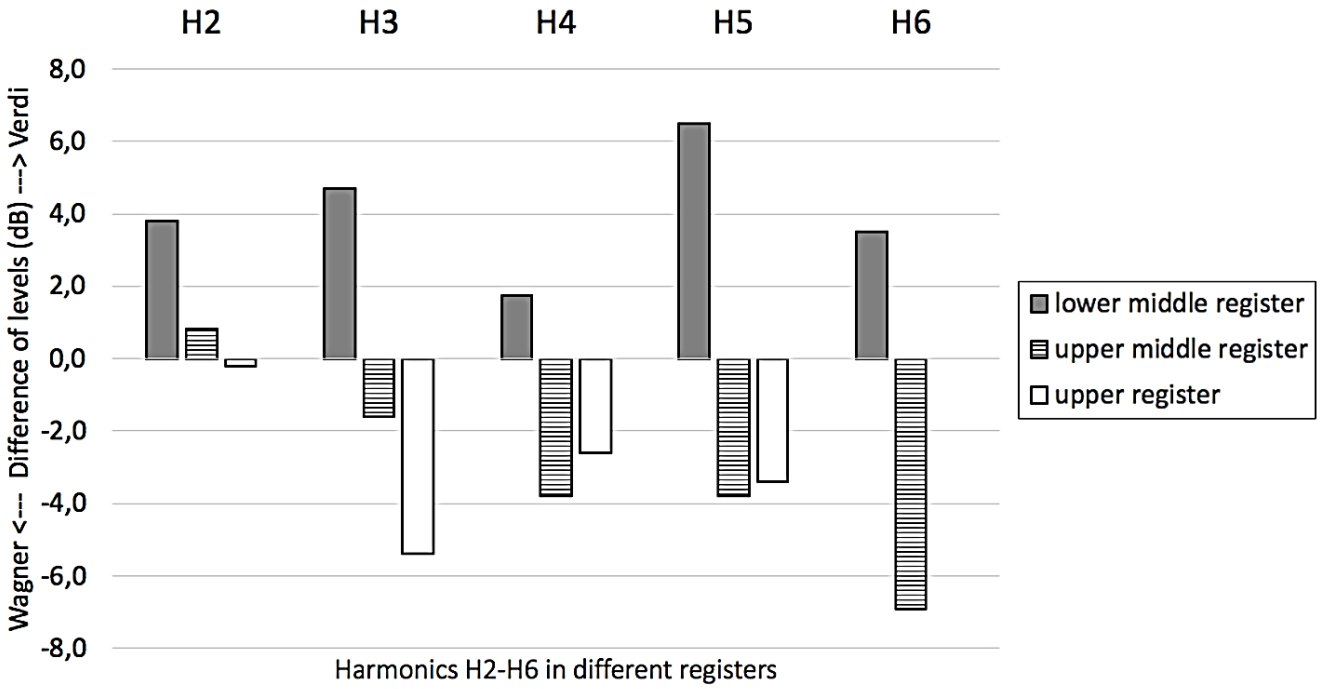
Figure 26 - Average formant structure of vowel |a| for all pitches in the vocal spectra of the recordings of Verdi (square) and Wagner (cross) sung by all 6 sopranos



As we can see in the above graph, in the upper middle and upper registers the higher partials are stronger in Wagner with peaks between 1500 and 2000 Hz; from 2500 and 3000 Hz and again after 3300 Hz. Differently, for the middle register: H3, H4, H5 and H6 harmonics are stronger in Verdi (see also Figure 27).

[115] Verdi gives room for his orchestration for the soprano to be featured as a soloist while Wagner sees the voice as just another instrument that needs to compete with the sound of the orchestra.

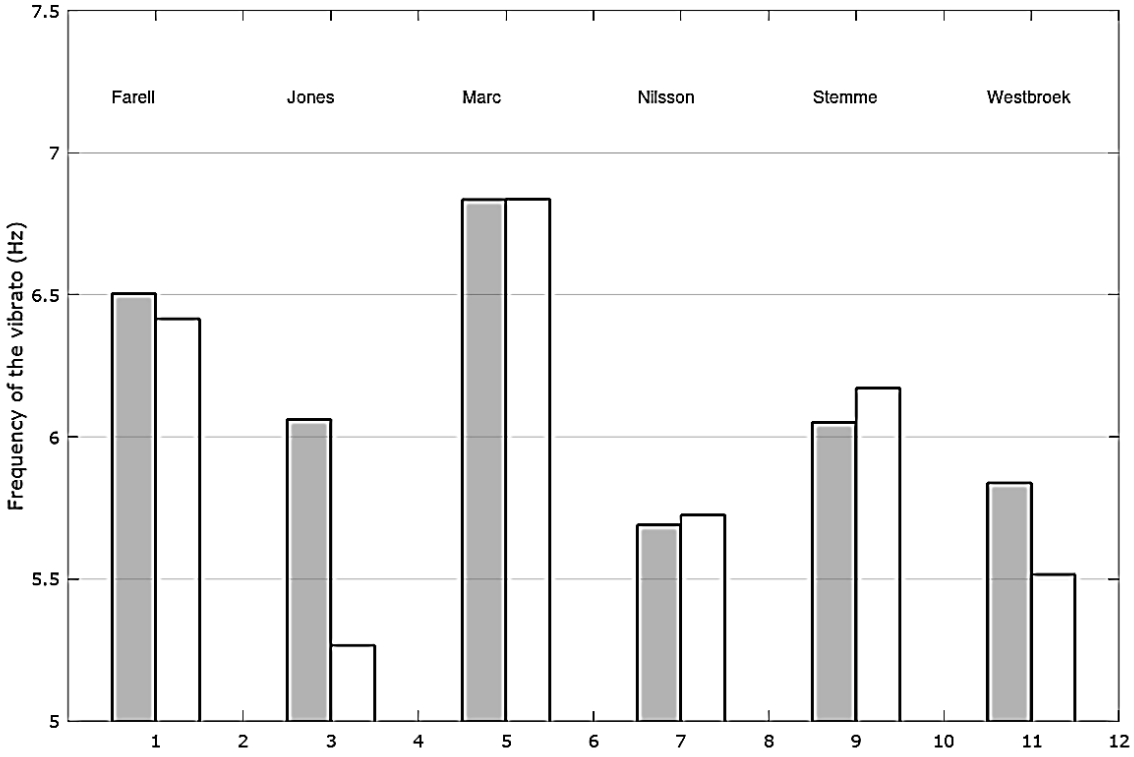
Figure 27 - Average differences of the higher partial levels in dB between the Verdi and Wagner recordings sung by all 6 sopranos



In Figure 27, we can see the use of higher harmonics in all registers. A positive value means a higher level in Verdi and a negative value means a higher level in Wagner. In the lower middle register the higher partials are clearly stronger in Verdi than in Wagner which can be due to a stronger H1 in Wagner. In the upper middle register and the upper register we find the opposite, where higher harmonics are stronger in Wagner giving the high notes a different timbre and add a metallic sound or buzz.

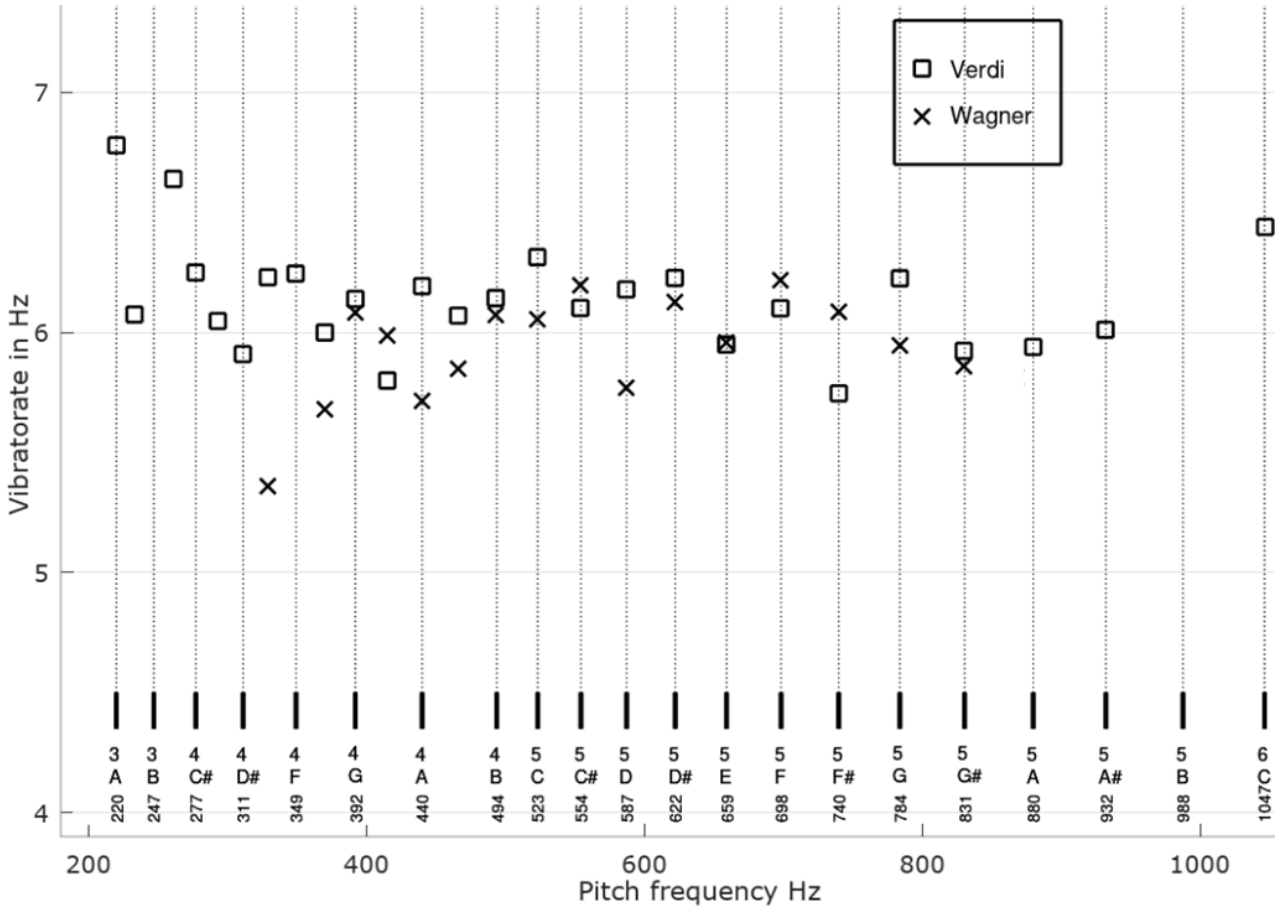
We will now observe if there are differences in the vibrato rates seen in the voice spectra of the 6 sopranos performing the various Verdi and Wagner arias.

Figure 28 - Vibrato rates seen in the vocal spectra software for all 6 sopranos singing Verdi and Wagner



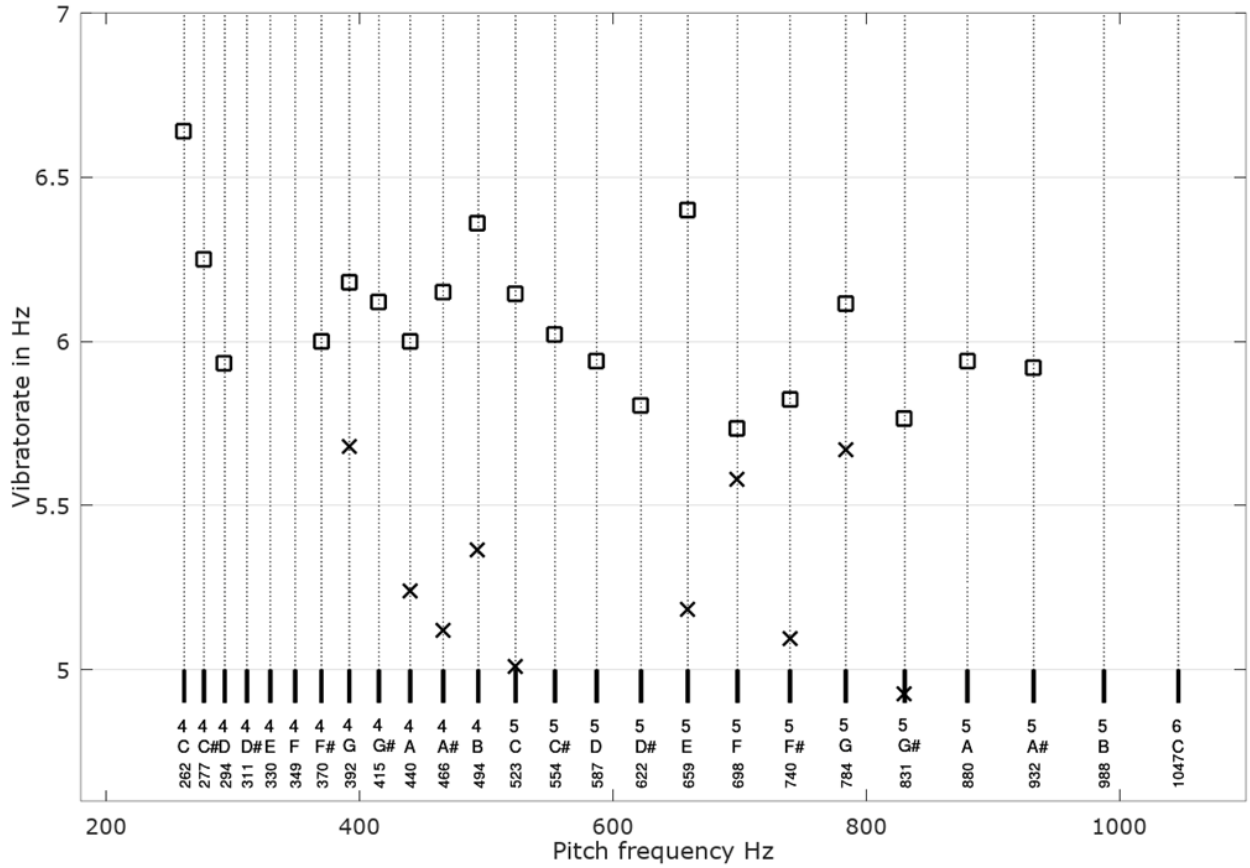
The average vibrato rate values can be found in Figure 28 (the gray bars indicate Verdi, the white bars indicate Wagner). As seen in the above graph, three sopranos utilize a slower vibrato rate when singing Wagner. Gwyneth Jones has the most significant adaptation between Verdi and Wagner as well as an increased vibrato with almost 1 Hz. Furthermore, depending upon the repertoire sung by Westbroek, she has a different vibrato rate; her vibrato rate is slower singing Wagner with 5.5 Hz than singing Verdi with 5.8 Hz. Farrell makes a slight difference in her vibrato rate, it is 0.1 Hz slower when singing Wagner. Although Alessandra Marc sings with a consistently fast vibrato rate of circa 7 Hz, when compared to all other 6 sopranos, there were no differences found. Nilsson and Stemme just like Marc, have a slightly faster vibrato when singing Wagner. The slowest vibrato rates are from Jones and Westbroek when singing Wagner, respectively 5.2 Hz and 5.5 Hz**;** and for Nilsson, Westbroek and Stemme: between 5.5 Hz and 5.8 Hz in both repertoires. Farrell and Marc have the fastest vibratos, respectively around 6.5 Hz and 7Hz.

Figure 29 – Comparison of vibrato rates for all 6 sopranos singing Verdi and Wagner



As we can see in Figure 29, while the vibrato rates seem to be faster for all sopranos singing Verdi than Wagner, no significant differences in vibrato rates relating to the different registers or pitches were found.

Figure 30 – Comparison of vibrato rates of Jones when singing Verdi (square) and Wagner (cross)



When analyzing the above figure, the results found are compelling when evaluating the vibrato rates of Gwyneth Jones, who has a remarkably slower rate of vibrato when singing Wagner compared to singing Verdi.

2.2 Conclusions

1. From the analytical material drawn, one can see that there are measurable differences in almost all of the six sopranos using more H1 or H2 resonance between Verdi and Wagner arias. (See Figure 18)
2. These adaptational techniques can mainly be found in the middle register beginning on F#4 and ending on C#5. The emphasis being on H1 resonances for most singers when singing Wagner, the H2 resonance was found more common in the sopranos when singing Verdi. In the upper head register, there is still a slight difference between the two repertoires. (See Figure 19)
3. There are strong individual personal differences in formant tuning choices and register changes, as can be seen in Figures 20, 21, 22, 23 and the individual charts in Appendix 1.
4. Significant differences were found in vibrato rates in three sopranos singing Wagner where the vibrato rate was slower than the other sopranos (See Figure 28 and 29).

2.3 Summation of the analysis

In published research related to this subject, investigators not only used signal processing, but also several measurement tools connected to the body of the tested persons (such as EGG), as well as high quality sensors and microphones. Those measurements were performed in isolated setups, where background sounds could be eliminated. It must be clear that our setup was much less accurate and elaborate. The recordings used in this research contained the sound quality of each singer and the accompaniment consisting of different quality sound levels, influenced by the date and place of the recording. The advantage of this study is the amount of material that is available, which is considered to compensate and overcome inaccuracies.

As far as the criteria that was followed when selecting the singers, the combination of both Verdi and Wagner repertoires sung by professional dramatic sopranos was the most important element. Disregarding the scarcity of dramatic sopranos, it was challenging to find those who sang both Verdi and Wagner publicly in recordings and other available sources such as YouTube, as most dramatic sopranos specialize in one or the other. The majority of native Italian dramatic sopranos tend to specialize in dramatic Italian repertoire and German dramatic sopranos in German dramatic repertoire, making recordings publicly available displaying their most common repertoire. Another important fact to consider is that there are not many available

biographies giving much detail regarding the sopranos formative and basic teaching instruction.

The optimal situation would have been to have had various sopranos recording Verdi and Wagner arias live (without them being aware of the goal of the research, in order not to influence the results), in a controlled environment of a recording studio without accompaniment of other instruments, and then asking them to give an interview about their backgrounds, in order to be able to draw conclusions about how the aforementioned influenced their interpretive and technical choices.

From the known information drawn from the 6 singers analyzed in this research, Jones' significant adaptations found in this study could be a result not only of her vocal genius but also of her extensive and varied background. We know from interviews and various sources that Gwyneth Jones, originally a Welsh singer, had a diverse background of various singing schools. She studied at the *Royal College of Music* in London, at the *Academia Musicale Chigiana* in Siena in Italy and at the *International Opera Studio* in Zürich. Besides her formative vocal instruction, Jones started by singing many dramatic Verdi roles and only later on in her career did she attempt to sing Wagner roles which dominated the *Bayreuther Festspiele* throughout the late 1960s and 70s.

In general, one can say that the choices in resonances and vibratos of the singers are too significant to be random, that background performance and experience of the sopranos could also have influenced their choices in how they approached singing Verdi and Wagner; further influencing their vocal sound beyond other factors such as language, aesthetics and culture.

About the prevalence of higher harmonics of H3, H4, H5 and H6 in the results of Wagner compared to Verdi, it would be difficult to draw conclusions without measuring the subglottal pressure while the singers are singing. The fact that singers could have increased volume in Wagner compared to Verdi and that this is causing the higher partials could be confirmed by future studies performed in controlled lab conditions. Another factor is that the contact time of the vocal folds might be longer when singing Wagner, but in our case we can´t measure this either as I have analyzed publicly available recordings of sopranos and did not record the singers.

In this research, none of the sopranos were native German nor Italian. There were 2 American, 2 Swedish, 1 British and 1 Dutch. It is difficult to say if the singers had more Italian or German schools of singing in their vocal education, as it is not always clear in their biographies and there is little information available on the internet about the teachers who were active at that time, more than 20 years ago. The many singing schools have been exported to

other countries and there is often a mix or a blend in one's education. In addition, regardless that some singers like Gwyneth Jones studied in German speaking countries as well as in Italy, all of the other singers analyzed have had international experience ranging in different degrees of successful careers.

In conclusion, the hypothesis confirmed that for pedagogical reasons a female singer can measure her own singing voice, seeing if the standards of self-observation as practiced in this study are also applicable when singing the same or different repertoire.

If I had found studies in this respect measuring vibrato rates when singing Verdi and Wagner as well as the differences between H1 and H2, it would have been interesting to have a point of comparison. I could only find standard theories such as those in Miller's book from the "National Schools of Singing", stating that the Italian opera singing has a vibrato rate of around 6 Hz and that German opera singing around 5 Hz, subsequently using a low larynx technique would also cause a difference in the partials by actually lowering them.

Future studies could add more depth to the research quality such as: including the country where the sopranos studied their vocal technique; knowing the origins of their native languages; learning of their experiences with directors; being informed of the technique their teachers advocated, all giving more knowledge and evidence supporting their vocal adaptations. Future studies with the means of recording singers from various schools of singing in a controlled environment and by performing exactly the same repertoire, would add more profoundness and insight to this study.

Technology has advanced and improved our world immensely. No matter how helpful and astute software tools can be, the simple fact remains that the human ear is still the most effective form to hear and analyze sound. It was my human ear that listened for continuous hours and analyzed these historical singers without having any guarantees whatsoever, if my auditory conclusions were accurate. At the time of the analysis, with the support of the software, my hypothesis was confirmed by most soprano singers in the findings of the spectrum.

This research reveals that combining scientific technology with human instincts, can bring a singer to a whole new level of technical knowledge. Hopefully this study can help other singers to observe and analyze themselves whether it be via recording and or the usage of modern software, allowing themselves to understand their own technical adaptations upon singing and creating any vocal sound.

Bibliography

Björkner, E. (2006). Why So Different? Aspects of voice characteristics in operatic and musical theatre singing. *KTH School of Computer Science and Communication.*

Bozeman, K. W. (2014). *Practical Vocal Acoustics: Pedagogical Applications for Teachers and Singers* (1st ed.). Pendragon Press; New York.

Conati, M. (2000). Verdi vs Wagner. *Verdi Forum: No. 26, Article 2. Centro Internazionale per la Ricerca Sui Periodici Musicali.* http://scholarship.richmond.edu/vf/vol1/iss26/2

Cotton, S. (2012). Fach vs. Voice Type: a Call for Critical Discussion. *Journal of Singing, November/December 2012, volume 69, Nº2, pp. 153-166*

Elliot, M. (2006). *Singing in Style: A Guide to Vocal Performance Practices.* Yale University Press, New Haven and London.

Engländer, R. (1945). The Struggle between German and Italian Opera at the time of Weber. *The Musical Quarterly*, *Volume XXXI, Issue 4, October 1945, Pages 479*–491 https://doi.org/10.1093/mq/XXXI.4.479

Farrell, E., Kellow, B. (1999). *Can't help Singing. The Life of Eileen Farrell*. Northeastern University Press. Boston.

Hartgraves, Y. J. (2017). Understanding the Lirico-Spinto Soprano Voice Through the Repertoire of Giovane Scuola Composers*. University of North Texas*.

Howell, I. (2017). Necessary Roughness in the Voice Pedagogy Classroom: *The Special Psychoacoustics of the Singing Voice. Voice Prints, Journal of the New York Singing Teachers Association*

Lã. F. M. B. (2012). "Teaching Singing and Technology". *Die Fachzeitschrift zu Pädagogik, Kunst und Physiologie von Stimme, Sprache und Gesang gemeinsam herausgegeben von Bundesverband Deutscher Gesangspädagogen BDG und evta-austria und österreichischer Gesangspädagogen*, 88-109. Nürnberg, Germany: Vox Humana.

Lamperti, F. (1864). *The art of singing*. Schirmer's Library of Musical Classics. G. Schirmer, Inc., New York.

Lehmann, L. (1914). *How to sing.* New and Revised Edition. The Macmillan Company; New York.

Marchesi, M. (1900). *Bel Canto: A Theoretical and Practical Vocal Method.* G. Schirmer; New York.

Medlyn, M. (2016). Embodying Voice: Singing Verdi, Singing Wagner. *Victoria University of Wellington.*

Miller, D. G. (2008). *Resonance in Singing: Voice Building Through Acoustic Feedback.* Inside View Press. New York.

Miller, R. (1986). *The structure of singing. System and Art in Vocal Technique.* Oberlin College Conservatory of Music. Schirmer Books. New York

Miller, R. (1997). *National Schools of Singing: English, French, German and Italian Techniques of Singing Revisited.* The Scarecrow Press, Inc. London.

Miller, R. (2000). *Training Soprano Voices.* Oxford University Press, New York.

Moravcsik, A. (2020). Where have the Great Big Wagner Voices Gone? *In Isolde Schmid-Reiter, ed. Worttonmelodie. Die Herausforderung, Wagner zu singen (Regensburg: ConBrio Verlagsgesellschaft.*

Nair, G. (1999). *Voice Tradition and Technology: A State-of-the-Art Studio*, Cengae Learning. ISBN-10 : 0769300286 ISBN-13 : 978-0769300283

Nair, G., Howard D. M., and Welch G. F. (2018). Practical Voice Analyses and their application in the Studio. Oxford Handbooks Online,

Nilsson, B. (2007). *La Nilsson. My Life in Opera.* University Press of New England. Hanover and London.

Pabon, P., Ternström, S.(2020) Feature Maps of the Acoustic Spectrum of the Voice.Journal of Voice, Vol. 34, No.1

Parr, S. (2020). Wagnerian Singing and the Limits of Vocal Pedagogy. *Current Musicology*, (105). https://doi.org/10.7916/cm.v0i105.5403

Riding, A., Dunton-Downer, L. (2006). (1st ed.). *Opera.* DK Publishing, a Penguin Company.

Schmidt-Reiter, I. (2016). *Poetischer Ausdruck der Seele: Die Kunst, Verdi zu singen*. ConBrio Verlagsgesellschaft, Regensburg. Germany.

Smith, J., Wolfe, J. (2009). Wagner's music is even better than it sounds: implications of vowel-pitch matching for intelligibility and ease of singing. *The Second International Conference on Music Communication Science, 3-4 December 2009, Sydney, Australia.* http://marcs.uws.edu.au/links/ICoMusic09/index.html

Sundberg, J. (1977). Acoustics of the Singing Voice, *Scientific American,* March 1997*.*

Sundberg, J. (2001). Level and Center Frequency of the Singer's Formant. *Journal of Voice, Vol 15, Nº 2, pp 176-186*. *The Voice Foundation.*

Sundberg, J. (1987). *The Science of the Singing Voice,* Northern Illinois University Press.

Sundberg, J., Skoog, J. (1995). Jaw opening, vowel and pitch. *Dept. for Speech, Music and Hearing, KTH Computer Science and Communication.*

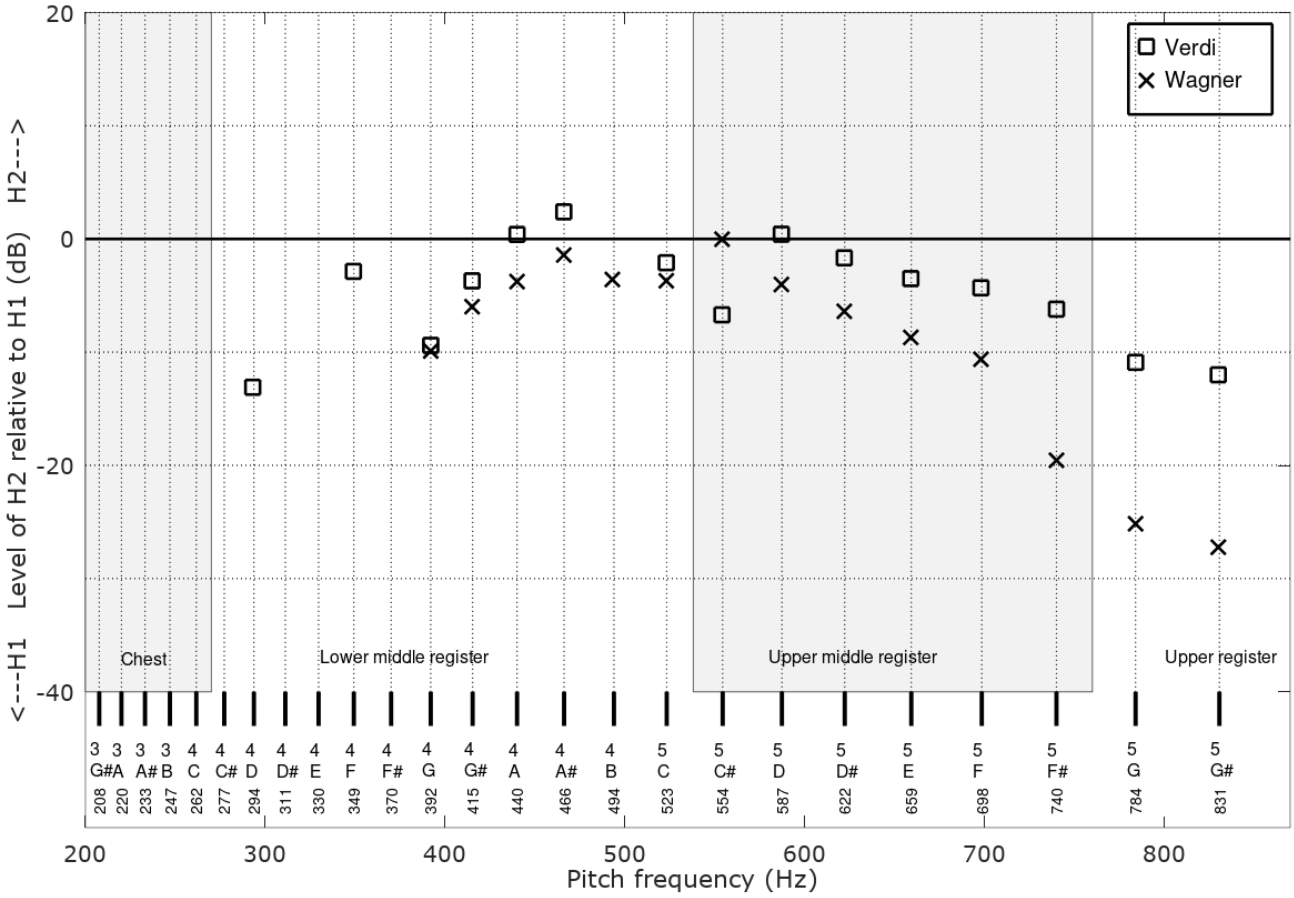
Welch G.F., Howard D.M., Himonides E., Bereton J. (2005). Real-time feedback in the singing studio: an innovator action-research project using new voice technology. Music Education Research 7:225-249.

Whitener, J. J. (2016). The German School of Singing: A Compendium of German Treatises 1848-1965. *Jacobs School of Music, Indiana University*

Appendices

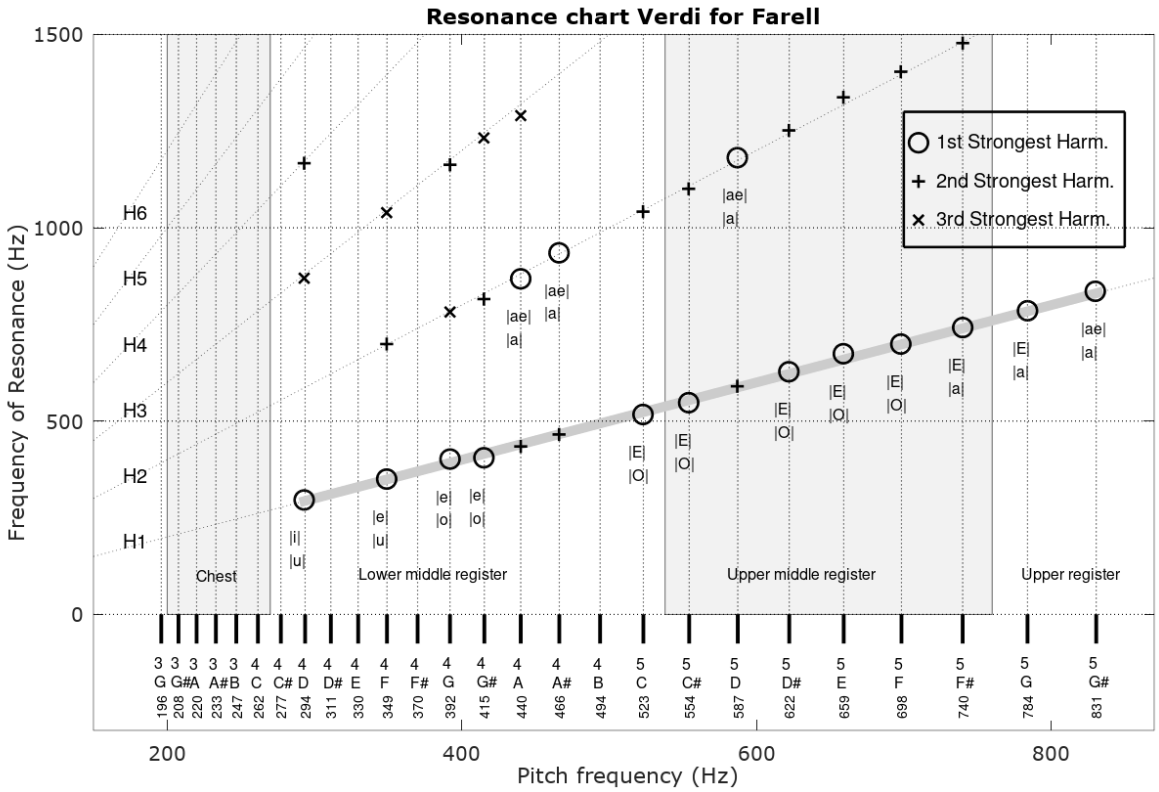
1 Data for the individual sopranos when singing Verdi and Wagner (for Jones please see Figure 22,23 and 25)

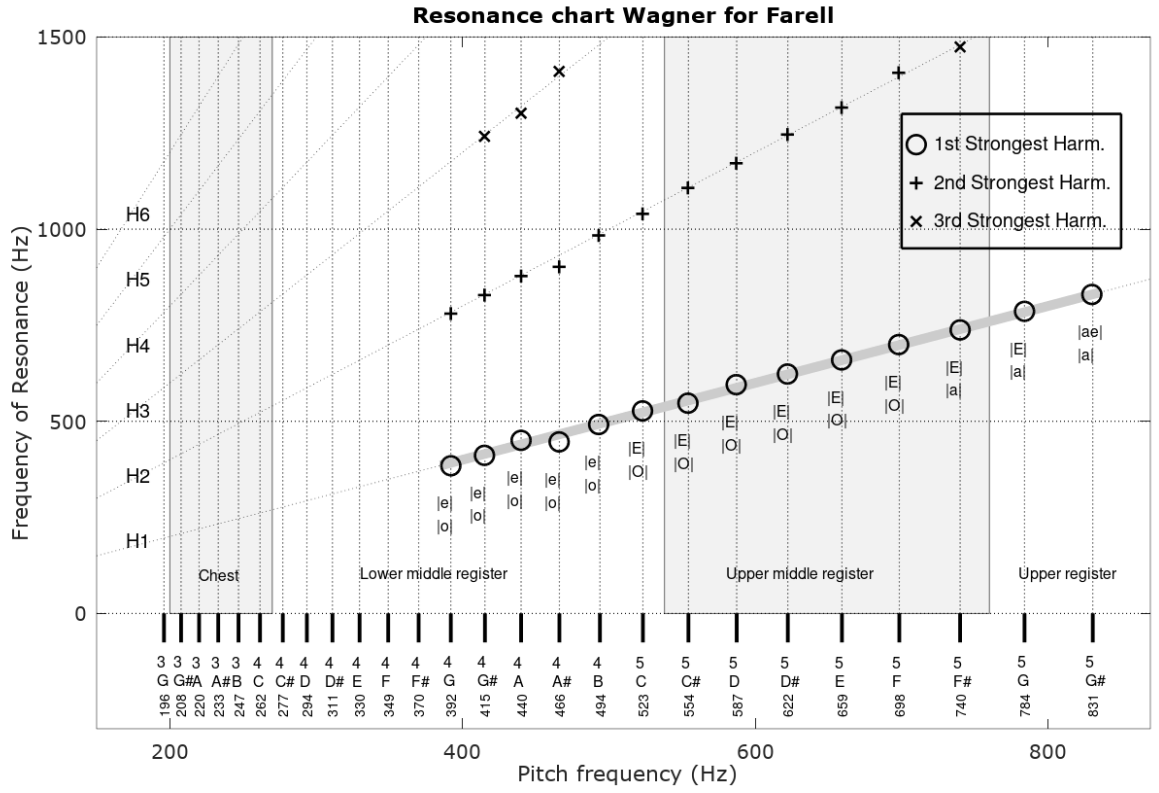
H1 and H2 resonance graph for Farrell singing Verdi (square) and Wagner (cross)



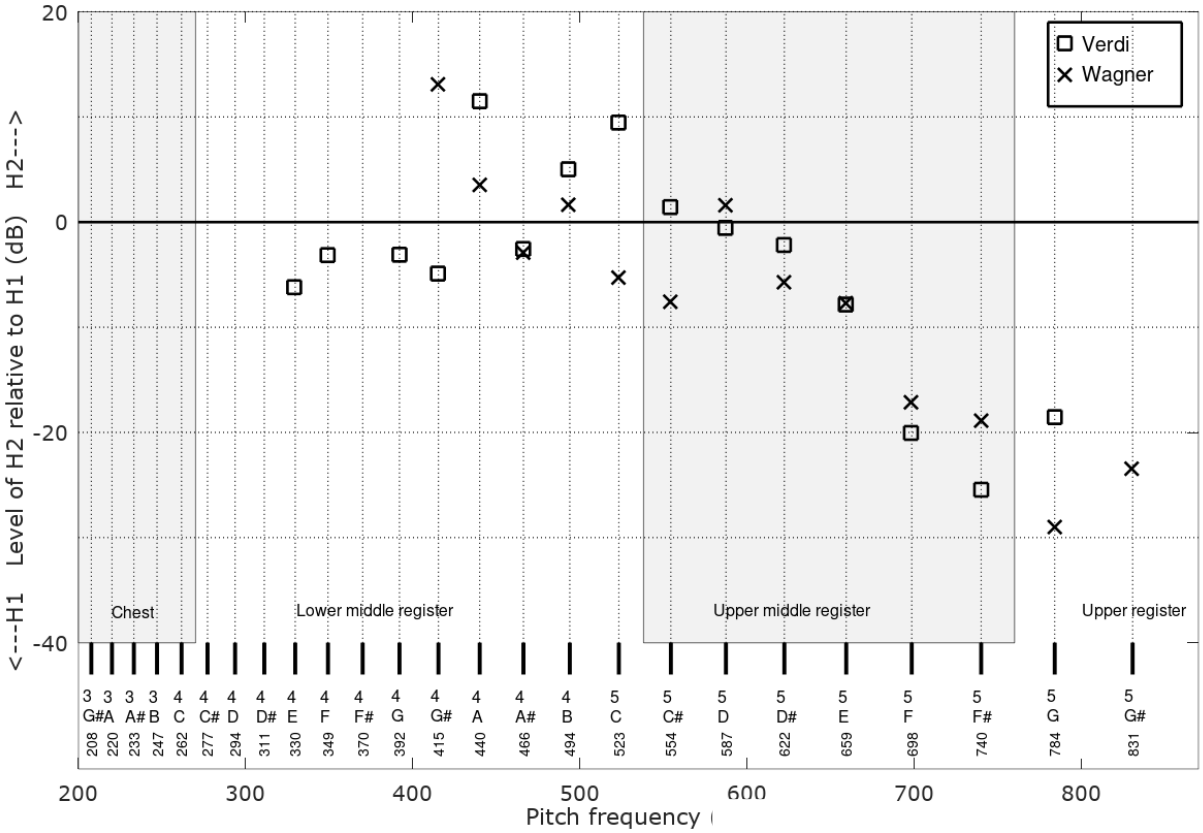
The above graph shows that Eileen Farrell keeps the H1 as her main resonance focus in the upper and lower middle registers for both repertoires. Further analysis shows us that we can see a slight but constant difference of more H1 in Wagner compared to Verdi, as seen in the lower middle register from G4 to B4 and in the upper middle and register (from D5 to G#5).

The resonance charts on the next page show that Farrell predominantly uses a F1/H1 strategy in both repertoires with darker vowels. In Verdi she sometimes uses a F1/H2 formant tuning for a brighter vowel sound.


Resonance chart Verdi for Farell
Frequency of Resonance (Hz)
Pitch frequency (Hz)
1st Strongest Harm.
2nd Strongest Harm.
3rd Strongest Harm.
H1
H2
H3
H4
H5
H6
Chest
Lower middle register
Upper middle register
Upper register
|i|
|u|
|e|
|o|
|ae|
|a|
|E|
|O|

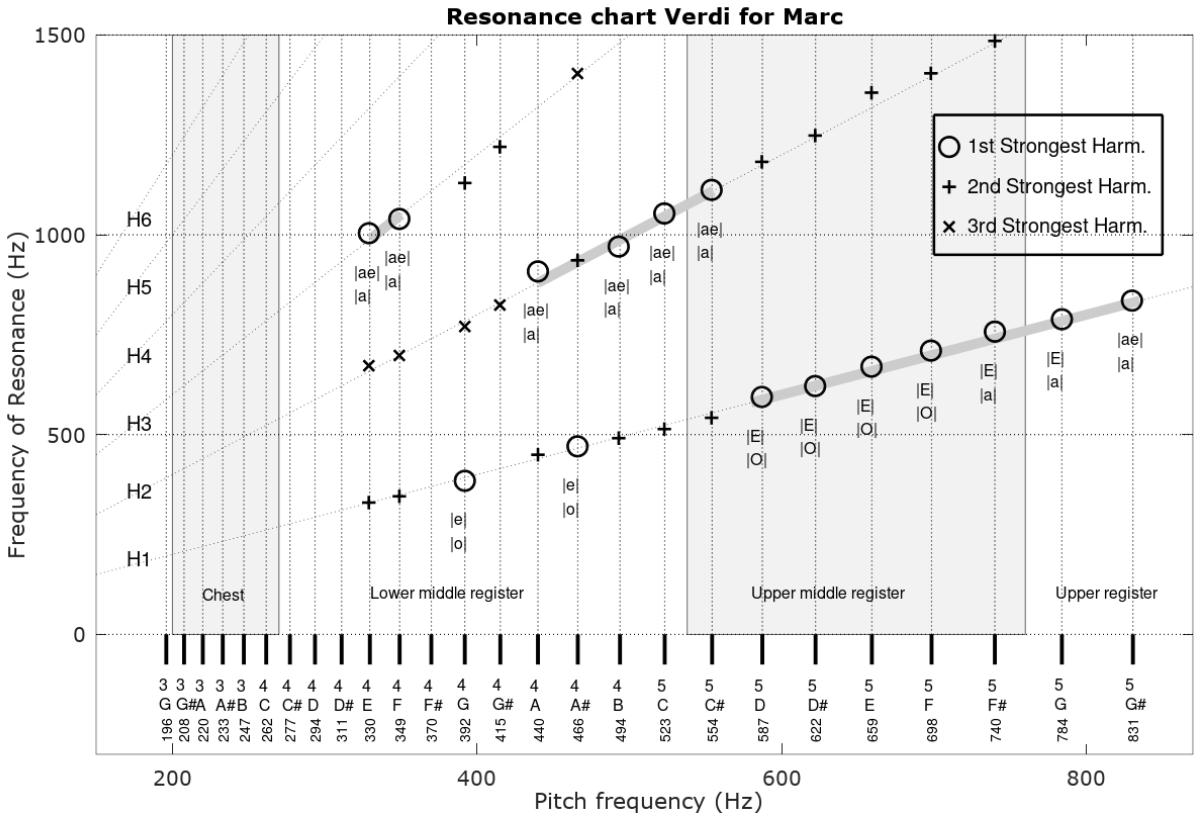

Resonance chart Wagner for Farell
Frequency of Resonance (Hz)
Pitch frequency (Hz)
1st Strongest Harm.
2nd Strongest Harm.
3rd Strongest Harm.
H1
H2
H3
H4
H5
H6
Chest
Lower middle register
Upper middle register
Upper register
|e|
|o|
|E|
|O|
|ae|
|a|

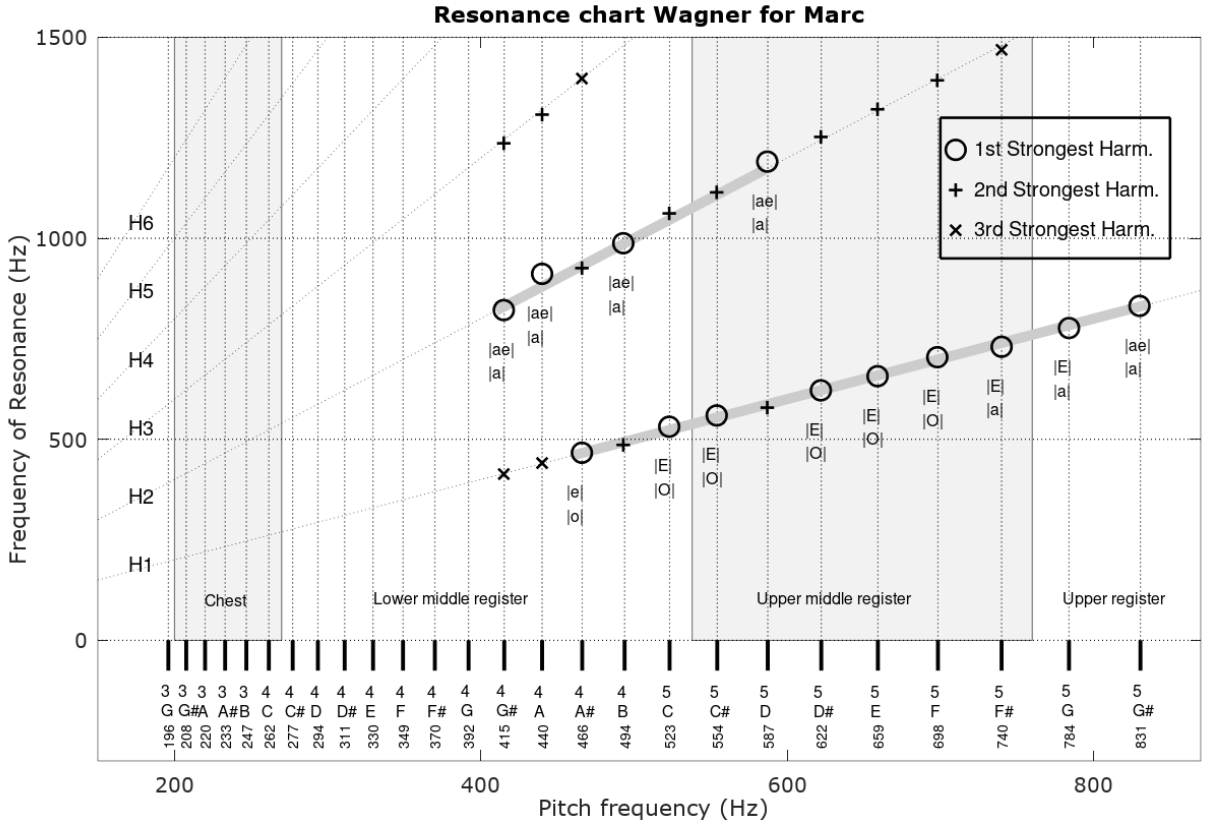
H1 and H2 resonance graph for Marc singing Verdi (square) and Wagner (cross)



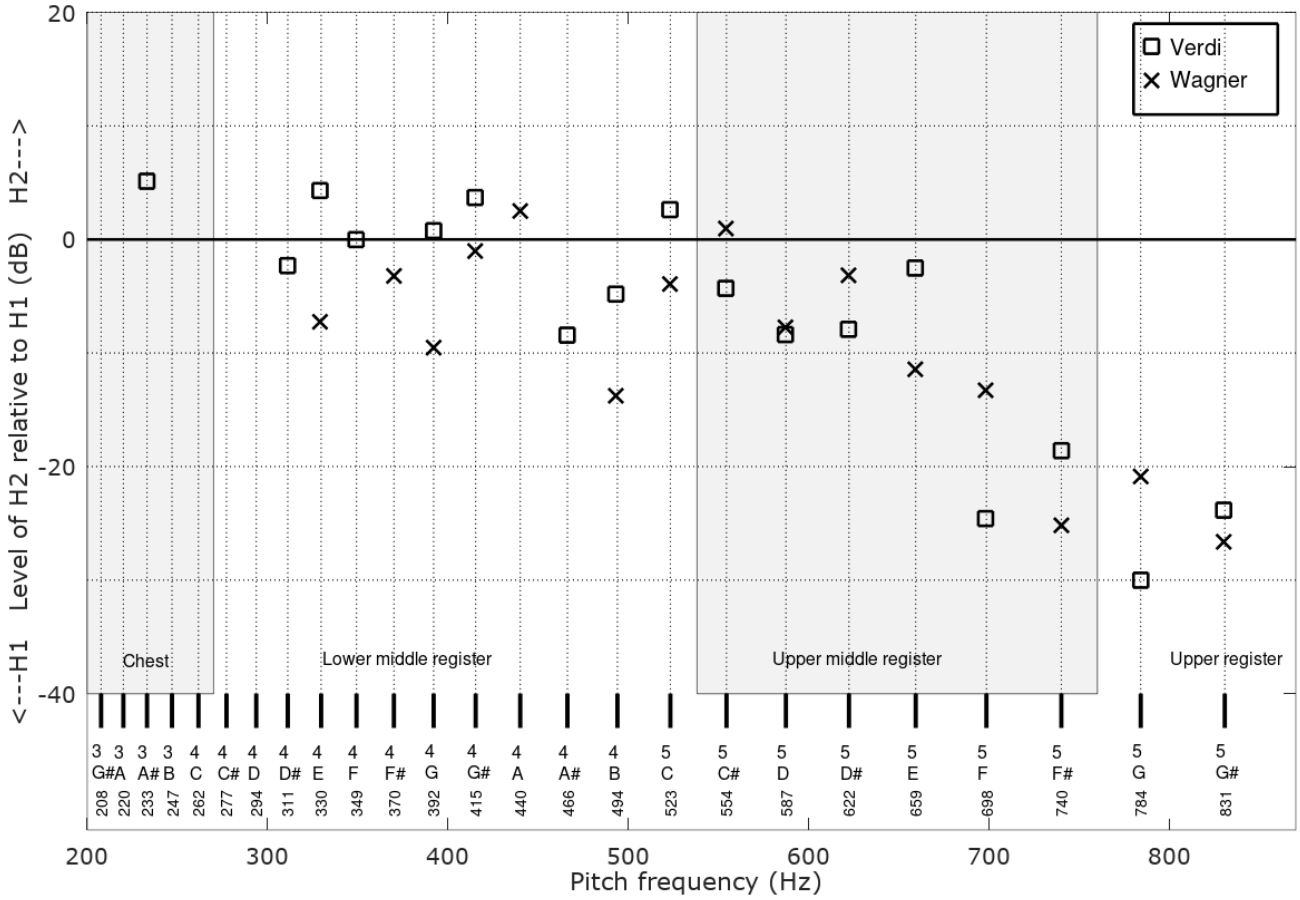
The above graph, shows that Marc mostly doesn´t have a differentiated H1 and H2 resonance strategy when singing Wagner and Verdi.

The resonance charts on the next page, show that Marc both uses F1/H1 and F1/H2 strategies in both repertoires before switching to only F1/H1 around D5. When singing Verdi she formant tunes to H3 as the predominant harmonic in the beginning of the lower middle register.


Resonance chart Verdi for Marc
Frequency of Resonance (Hz)
Pitch frequency (Hz)
1st Strongest Harm.
2nd Strongest Harm.
3rd Strongest Harm.
H1
H2
H3
H4
H5
H6
Chest
Lower middle register
Upper middle register
Upper register

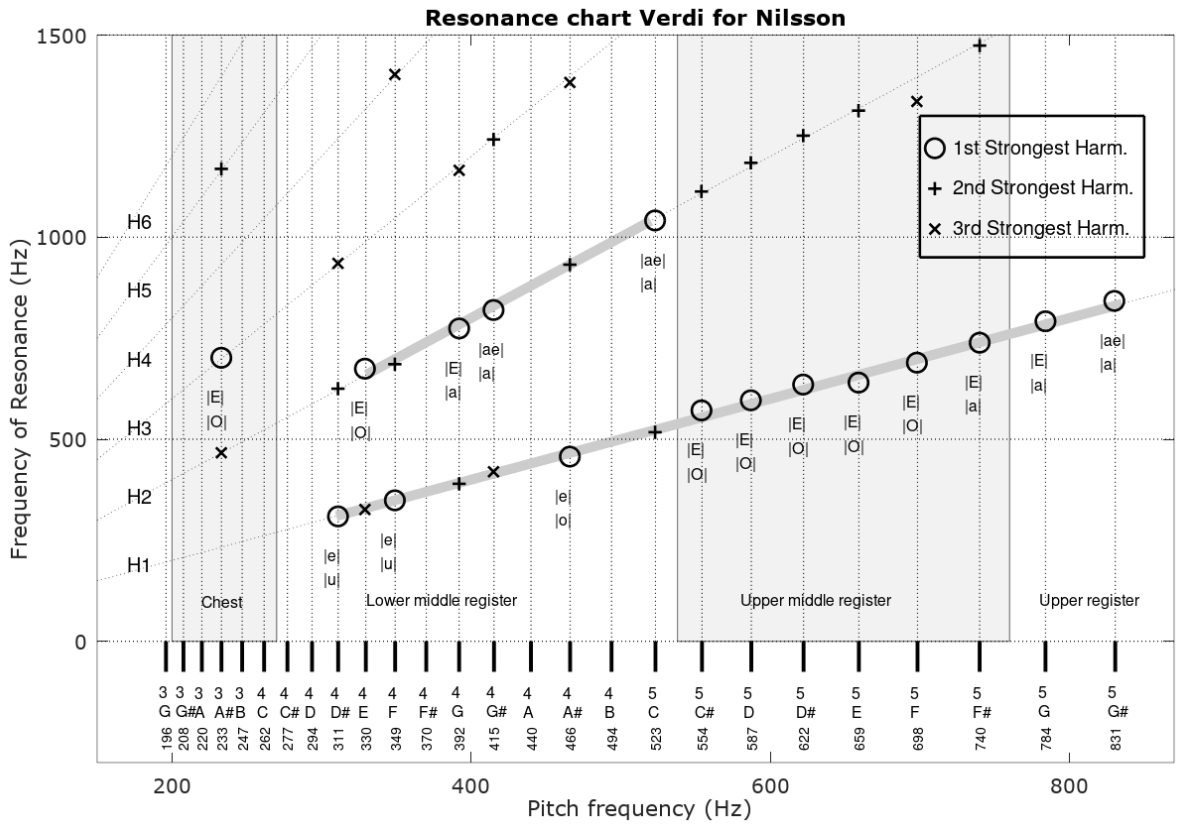

Resonance chart Wagner for Marc
Frequency of Resonance (Hz)
Pitch frequency (Hz)
1st Strongest Harm.
2nd Strongest Harm.
3rd Strongest Harm.
H1
H2
H3
H4
H5
H6
Chest
Lower middle register
Upper middle register
Upper register

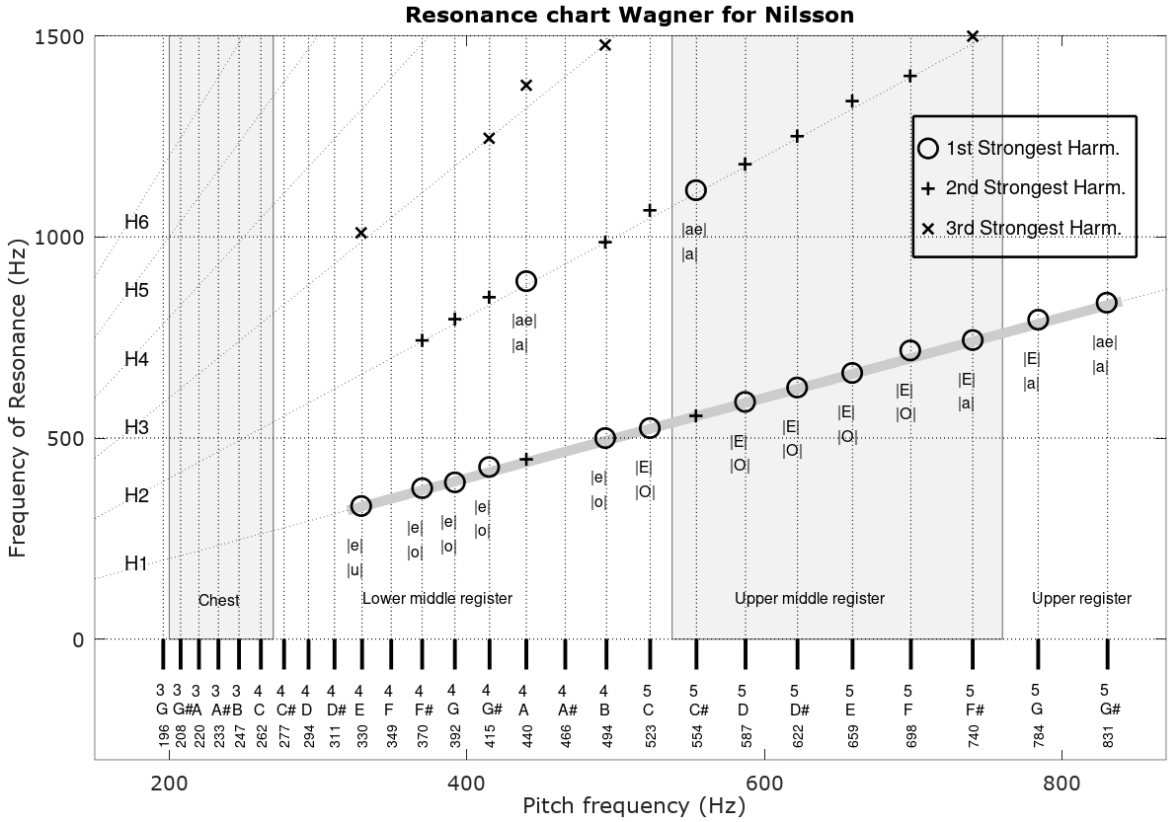
H1 and H2 resonance graph for Nilsson singing Verdi (square) and Wagner (cross)



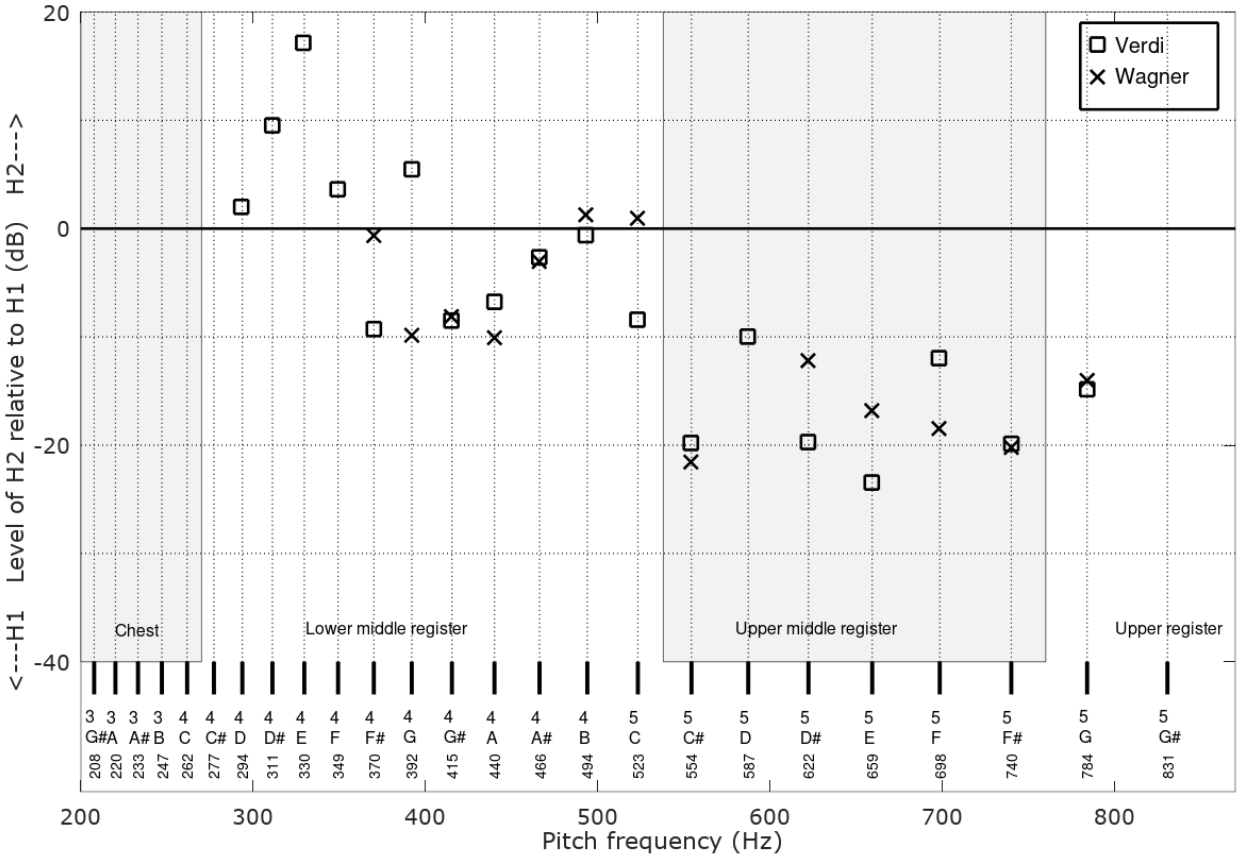
In the above graph, we can see that Birgit Nilsson enhances H1 (as displayed under 0) as her main resonance source when singing Wagner in the lower middle register.

The resonance charts on the next page show that Nilsson predominantly uses a F1/H1 strategy in both repertoires with darker vowels. In Verdi, there is a predominance of F1/H2 formant tuning for the lower middle register which enables a brighter vowel sound.


Resonance chart Verdi for Nilsson
Frequency of Resonance (Hz)
Pitch frequency (Hz)
1st Strongest Harm.
2nd Strongest Harm.
3rd Strongest Harm.
H1
H2
H3
H4
H5
H6
Chest
Lower middle register
Upper middle register
Upper register
|E|
|O|
|ae|
|a|
|e|
|u|
|e|
|o|

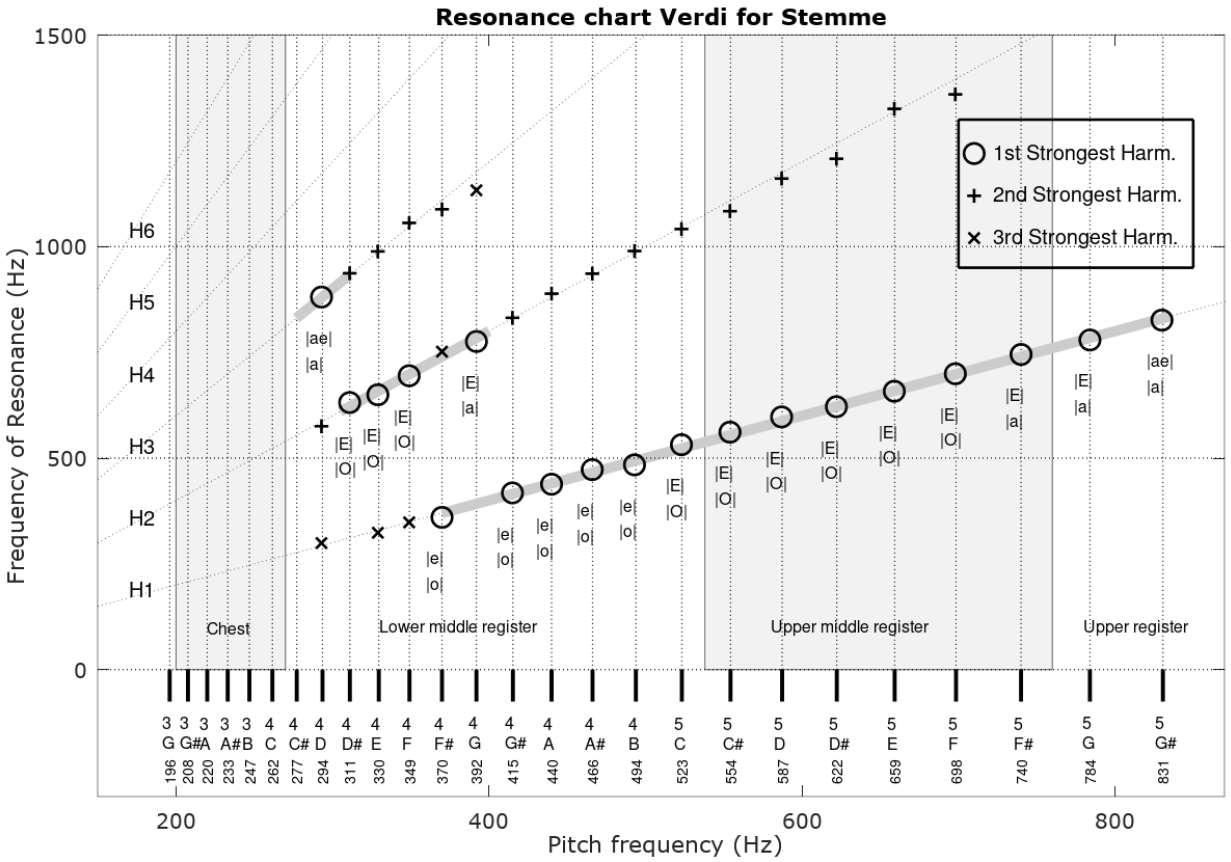

Resonance chart Wagner for Nilsson
Frequency of Resonance (Hz)
Pitch frequency (Hz)
1st Strongest Harm.
2nd Strongest Harm.
3rd Strongest Harm.
H1
H2
H3
H4
H5
H6
Chest
Lower middle register
Upper middle register
Upper register
|E|
|O|
|ae|
|a|
|e|
|u|
|e|
|o|

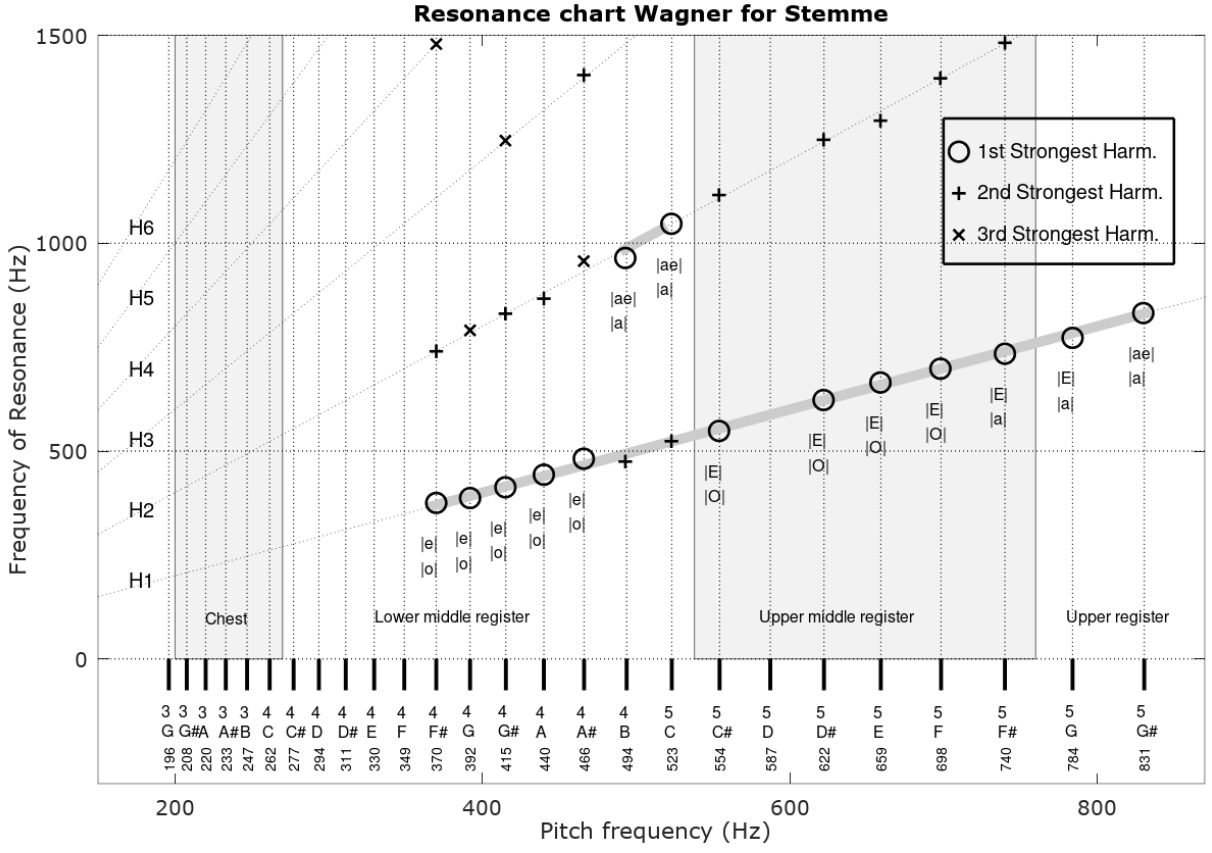
H1 and H2 resonance graph for Stemme singing Verdi (square) and Wagner (cross)



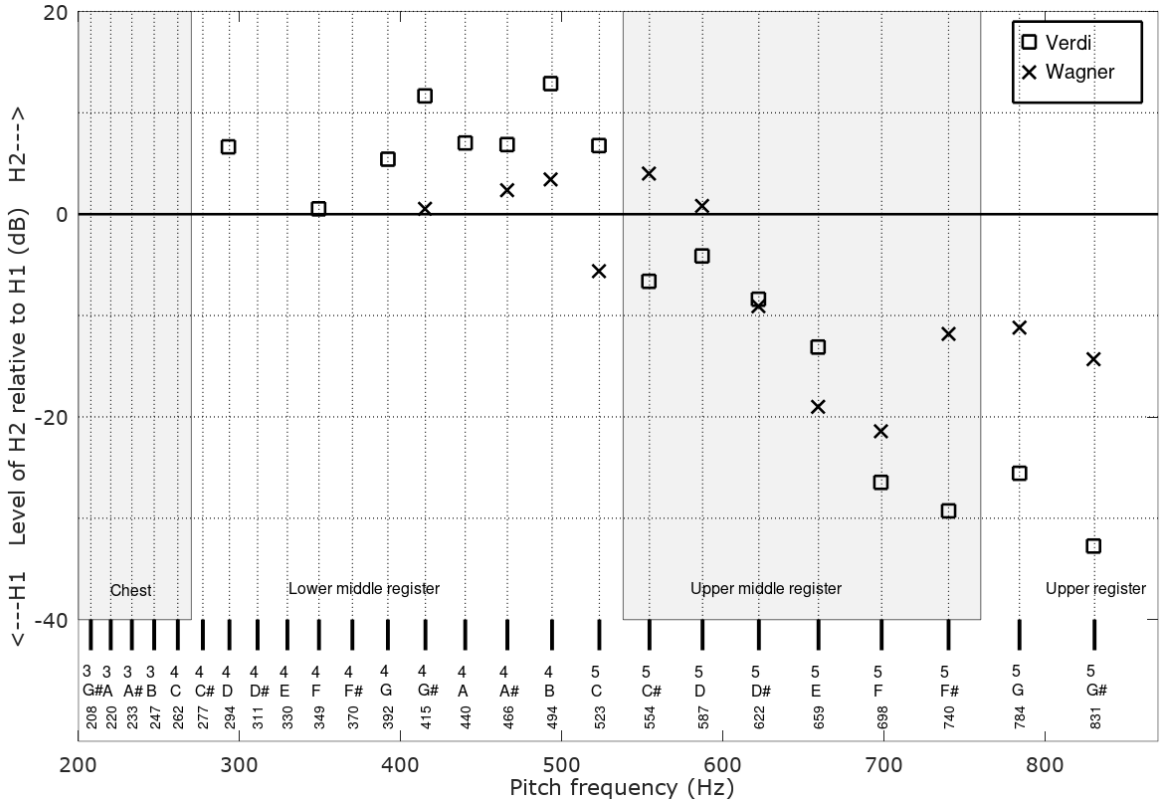
In the above graph, we can see that Nina Stemme mostly enhances H1 (as displayed under 0) as her main resonance source when singing Wagner, in the lower middle register.

The resonance charts on the next page, show that Stemme predominantly uses a F1/H1 strategy in both repertoires with darker vowels. In Verdi, in the beginning of the lower middle register, there is a predominance of H2 and H3 formant tuning which enables a brighter vowel sound.


Resonance chart Verdi for Stemme
Frequency of Resonance (Hz)
Pitch frequency (Hz)
1st Strongest Harm.
2nd Strongest Harm.
3rd Strongest Harm.
H1
H2
H3
H4
H5
H6
Chest
Lower middle register
Upper middle register
Upper register
|ae|
|a|
|E|
|O|
|e|
|o|

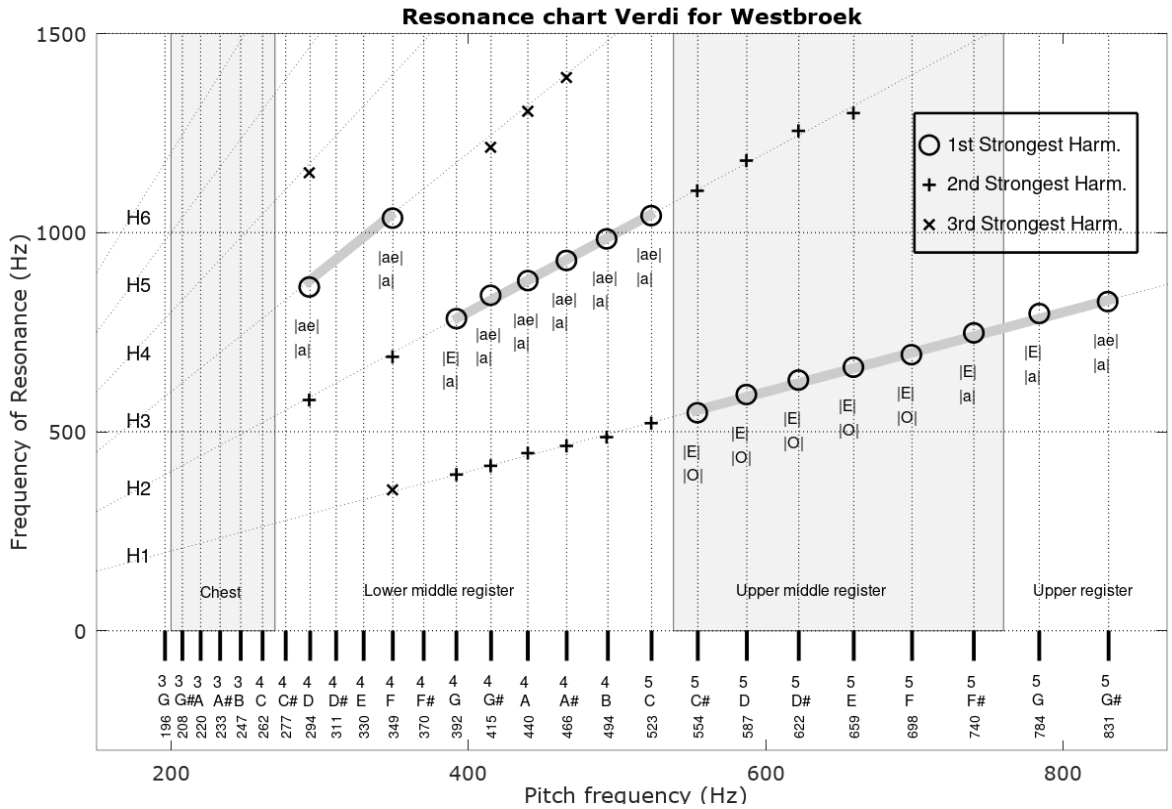

Resonance chart Wagner for Stemme
Frequency of Resonance (Hz)
Pitch frequency (Hz)
1st Strongest Harm.
2nd Strongest Harm.
3rd Strongest Harm.
H1
H2
H3
H4
H5
H6
Chest
Lower middle register
Upper middle register
Upper register
|ae|
|a|
|E|
|O|
|e|
|o|

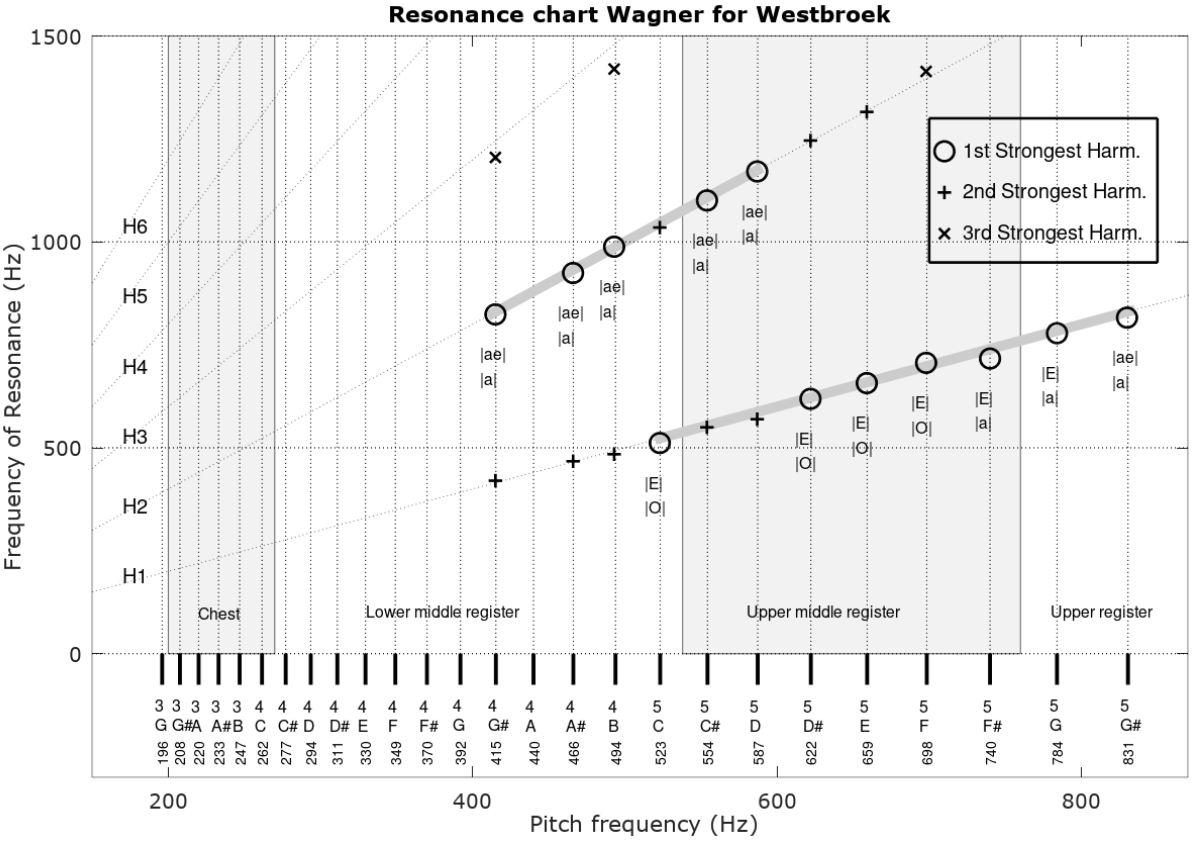
H1 and H2 resonance graph for Westbroek singing Verdi (square) and Wagner (cross)



In the above graph, we can see that Westbroek does the opposite compared to Farrell, Nilsson and Stemme by instead using much more H2 resonance. She adapts to the repertoires by using more H2 in the lower middle register and more H1 in Verdi in the upper register compared to Wagner.

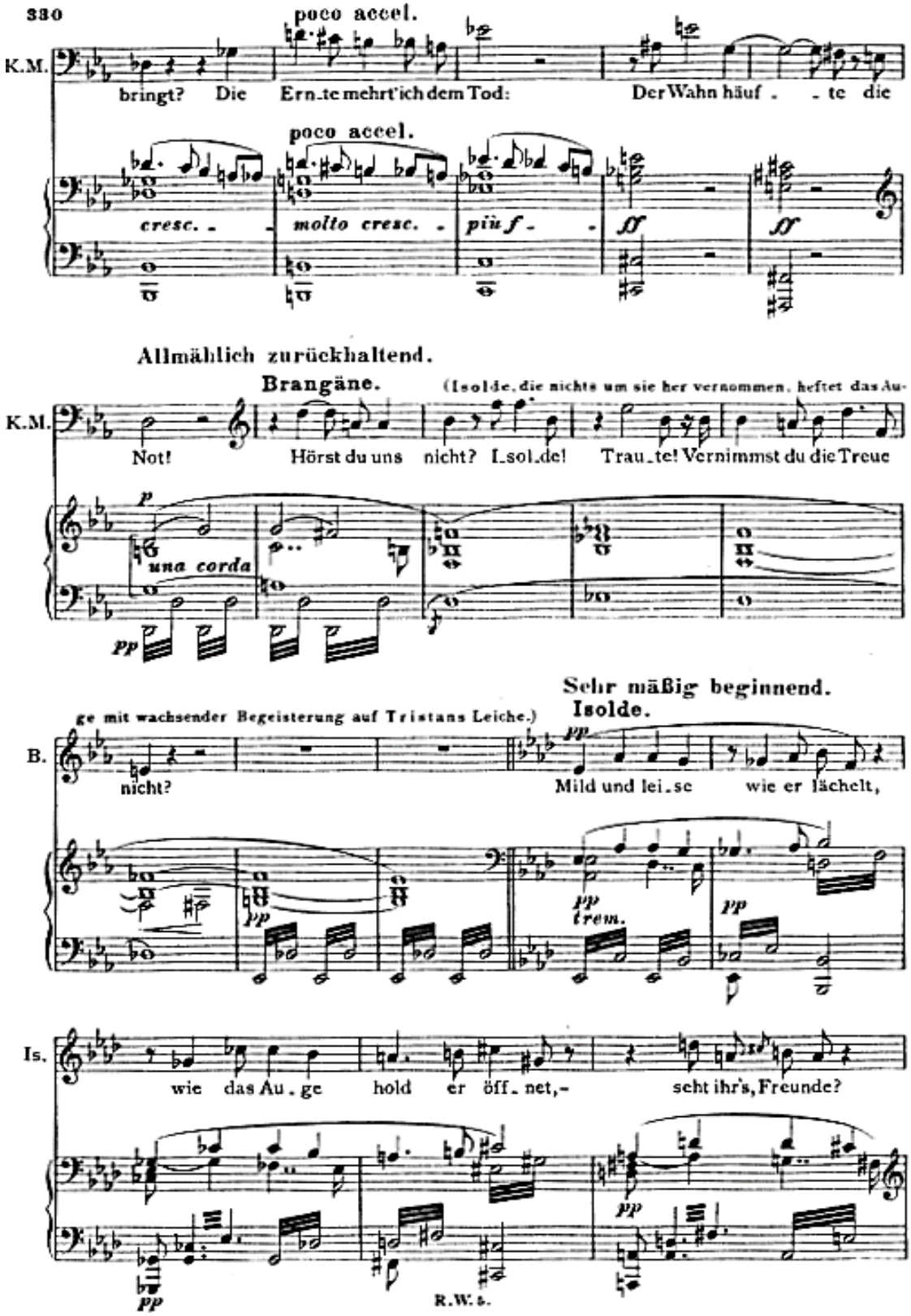
The resonance charts on the next page show that Westbroek predominantly uses a F1/H2 strategy in the lower middle register in both repertoires, which enables brighter vowels. In Verdi in the beginning of the lower middle register, there is a predominance of H2 and H3 formant tuning which enables a brighter vowel sound.

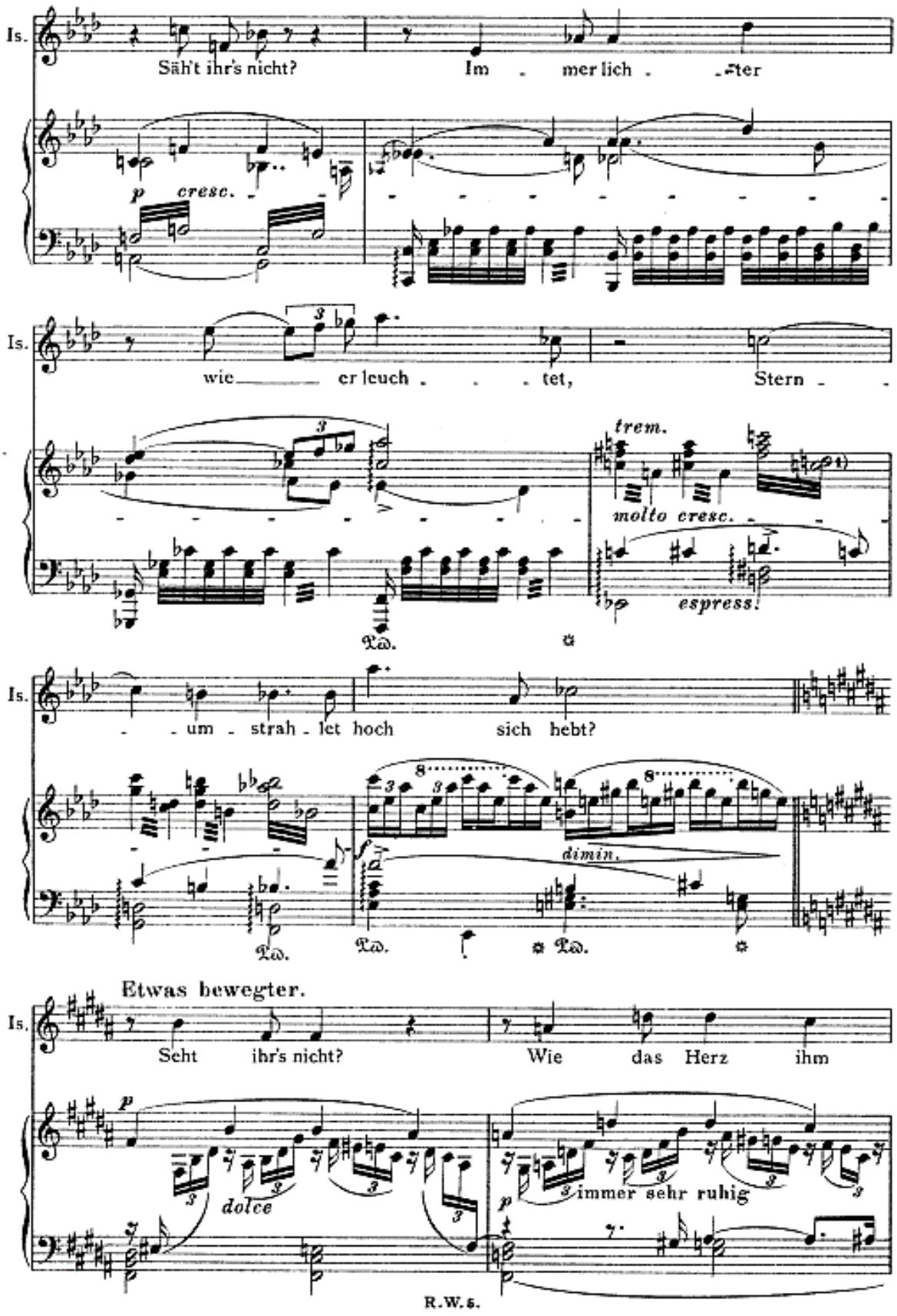

Resonance chart Verdi for Westbroek
Frequency of Resonance (Hz)
Pitch frequency (Hz)
1st Strongest Harm.
2nd Strongest Harm.
3rd Strongest Harm.
H1
H2
H3
H4
H5
H6
Chest
Lower middle register
Upper middle register
Upper register


Resonance chart Wagner for Westbroek
Frequency of Resonance (Hz)
Pitch frequency (Hz)
1st Strongest Harm.
2nd Strongest Harm.
3rd Strongest Harm.
H1
H2
H3
H4
H5
H6
Chest
Lower middle register
Upper middle register
Upper register

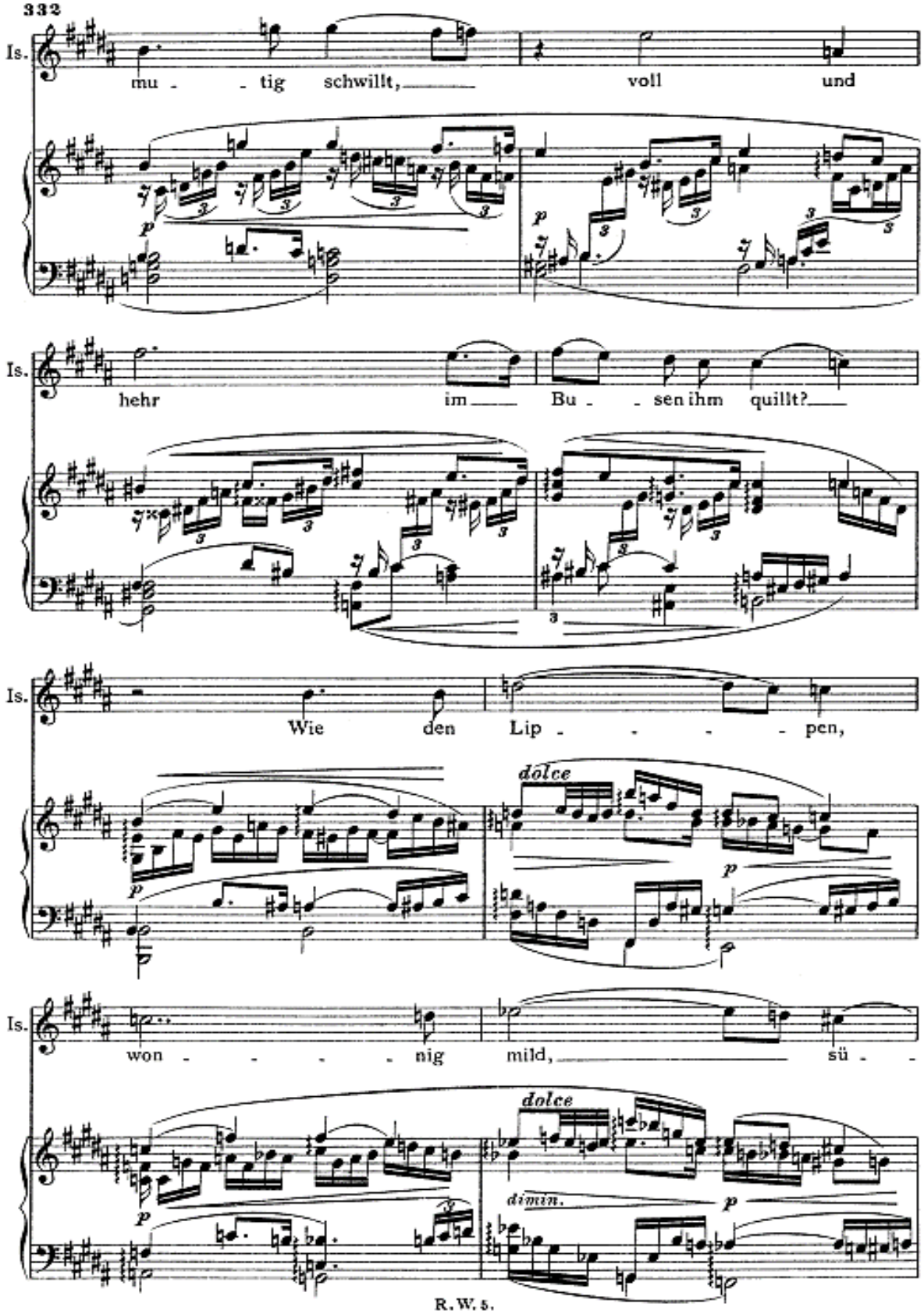
2 Scores

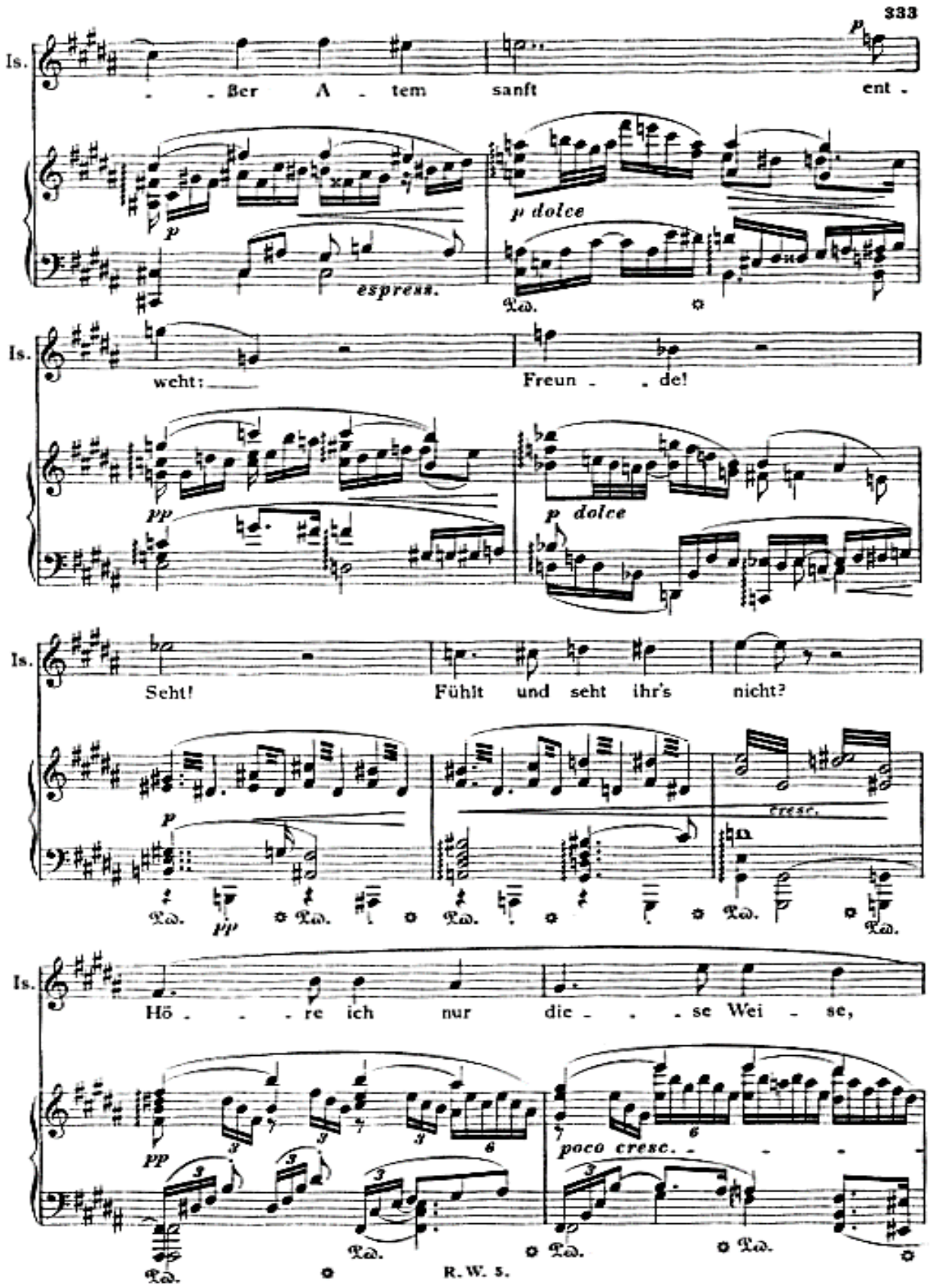
Score: *Mild und Leise – Tristan und Isolde* from R. Wagner

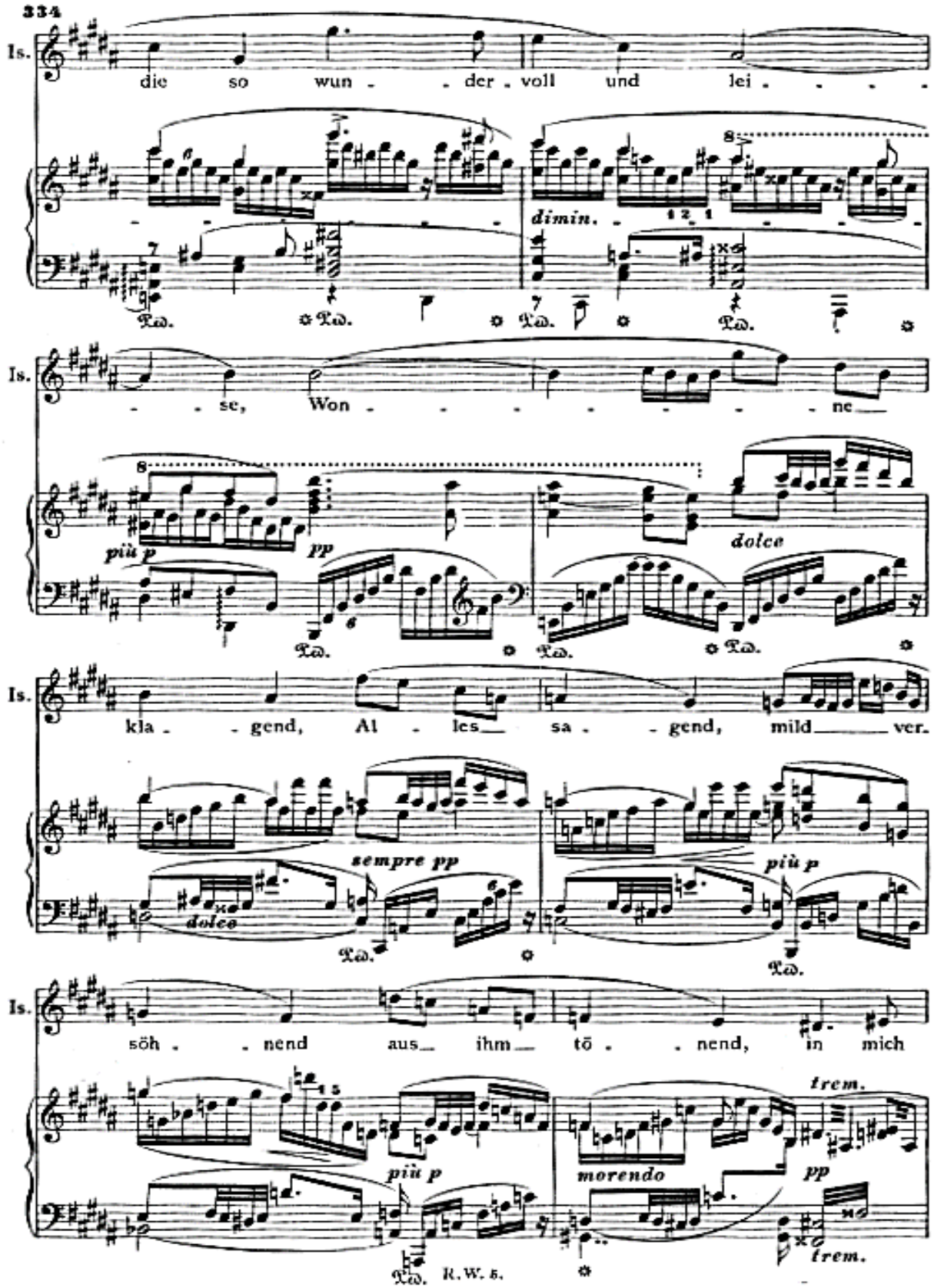


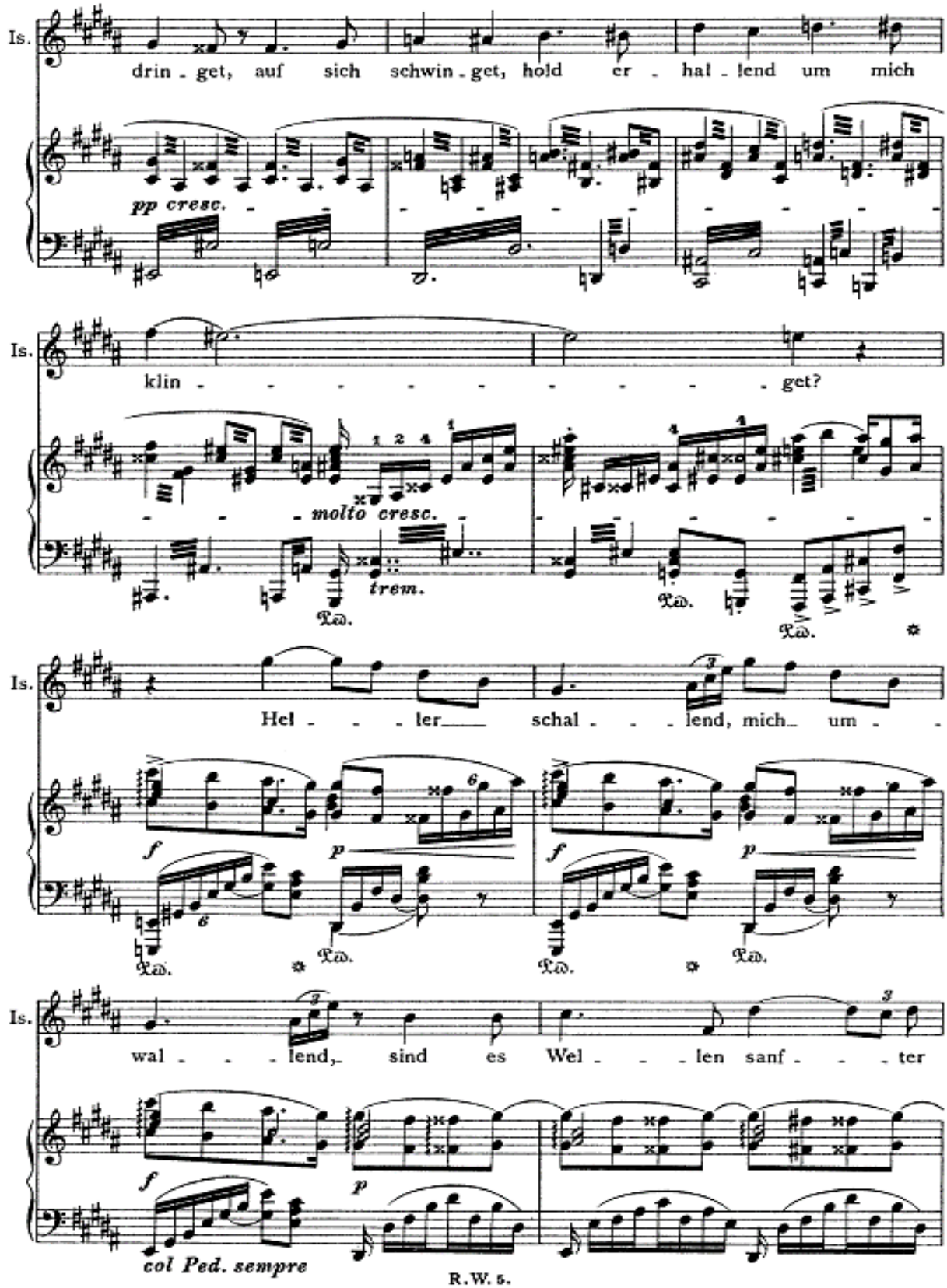

Is.
Säh't ihr's nicht?
Im mer lich ter
p cresc.
Is.
wie er leuch tet, Stern
trem.
molto cresc.
espress.
Ped.
Is.
um strah let hoch sich hebt?
dimin.
Ped.
Ped.
Ped.
Etwas bewegter.
Is.
Seht ihr's nicht?
Wie das Herz ihm
p
dolce
p
immer sehr ruhig

R.W. 6.

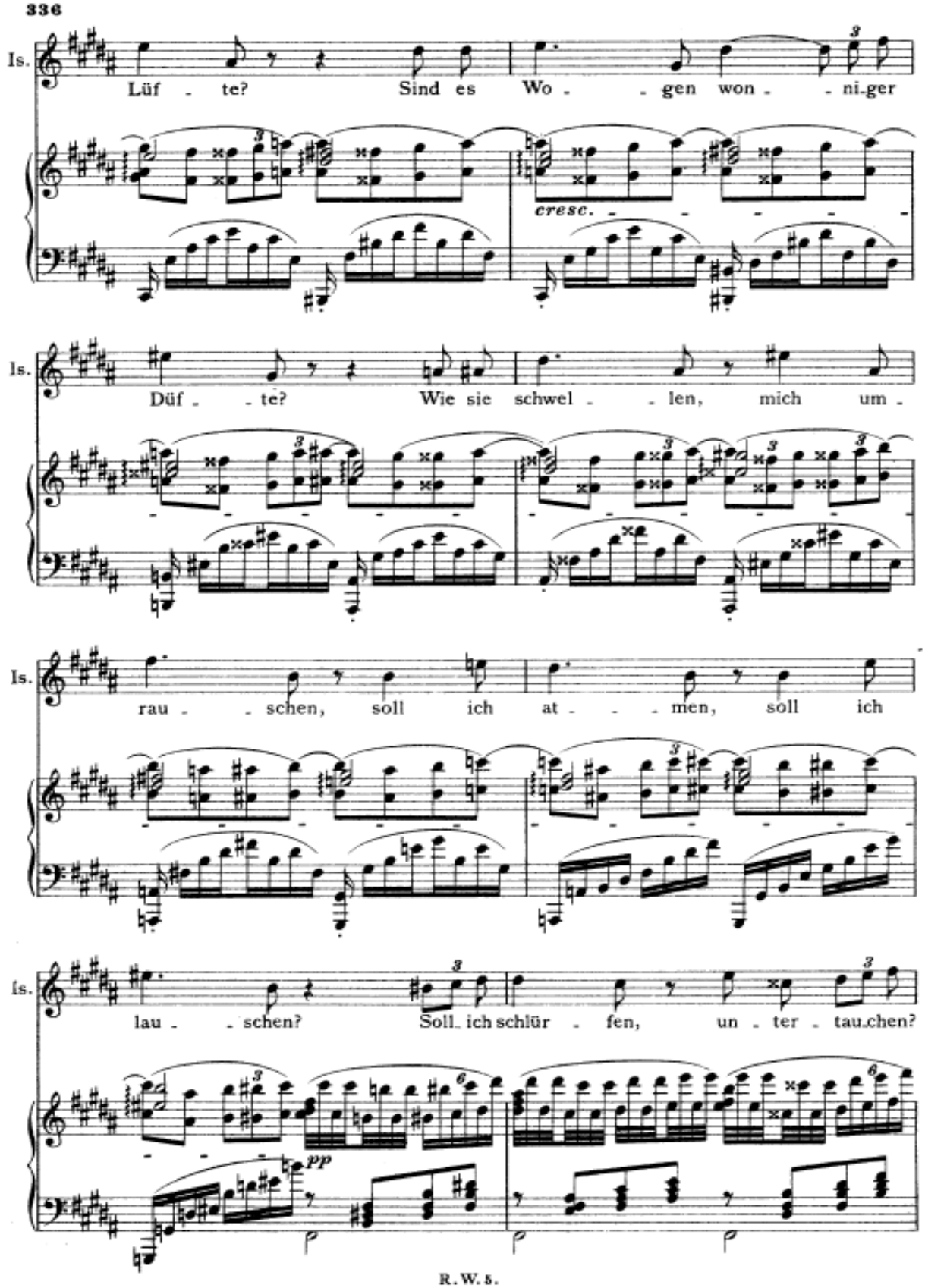

332
Is.
mu - - tig schwillt, voll und
hehr im Bu - - sen ihm quillt?
Wie den Lip - - - - pen,
won - - - - nig mild, sü - -
dolce
dimin.
R. W. 5.


Is.
- - ßer A - tem sanft ent -
p
p dolce
espress.
Ped.
Is.
weht: Freun - - de!
pp
p dolce
Is.
Seht! Fühlt und seht ihr's nicht?
p
cresc.
Ped.
pp
Is.
Hö - - - re ich nur die - - - se Wei - se,
pp
poco cresc.
Ped.
R. W. 5.

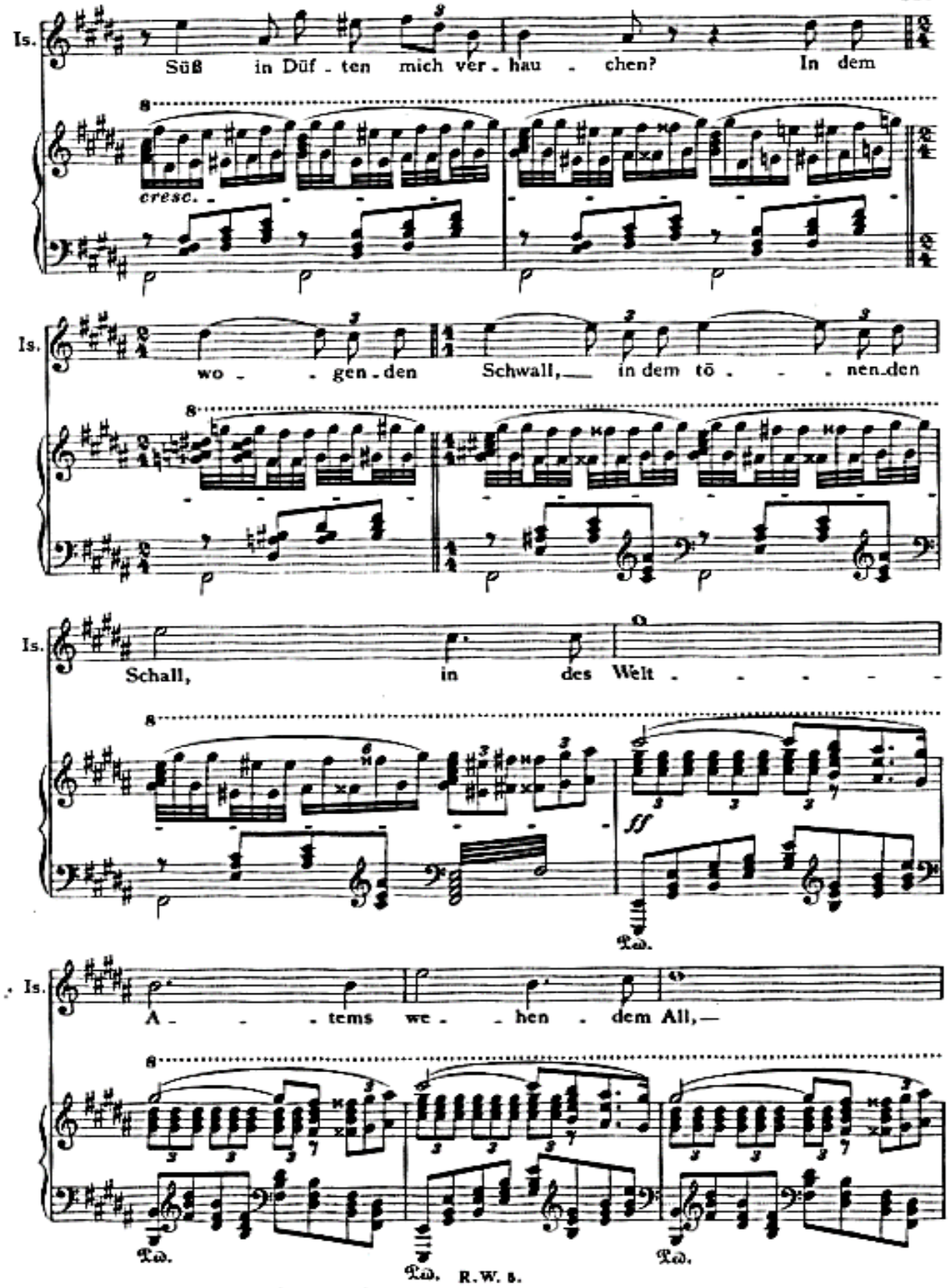

334
Is.
die so wun - - der - voll und lei - - - -
dimin.
Ped. * Ped. * Ped. * Ped. *
Is.
- - se, Won - - - - - - - - ne
più p
pp
dolce
Ped. * Ped. * Ped. *
Is.
kla - - gend, Al - les sa - - gend, mild ver.
sempre pp
dolce
più p
Ped. * Ped.
Is.
söh - - nend aus ihm tö - - nend, in mich
più p
morendo
pp
trem.
trem.
Ped. * R.W. 5.


Is.
drin - get, auf sich schwin - get, hold er - hal - lend um mich
pp cresc.
Is.
klin - - - - - - - - - - get?
molto cresc.
trem.
Ped.
Ped.
Ped.
Is.
Hel - - - ler schal - - - lend, mich um -
f
p
Ped.
Ped.
f
p
Ped.
Ped.
Is.
wal - - - lend, sind es Wel - - - len sanf - - - ter
f
p
col Ped. sempre

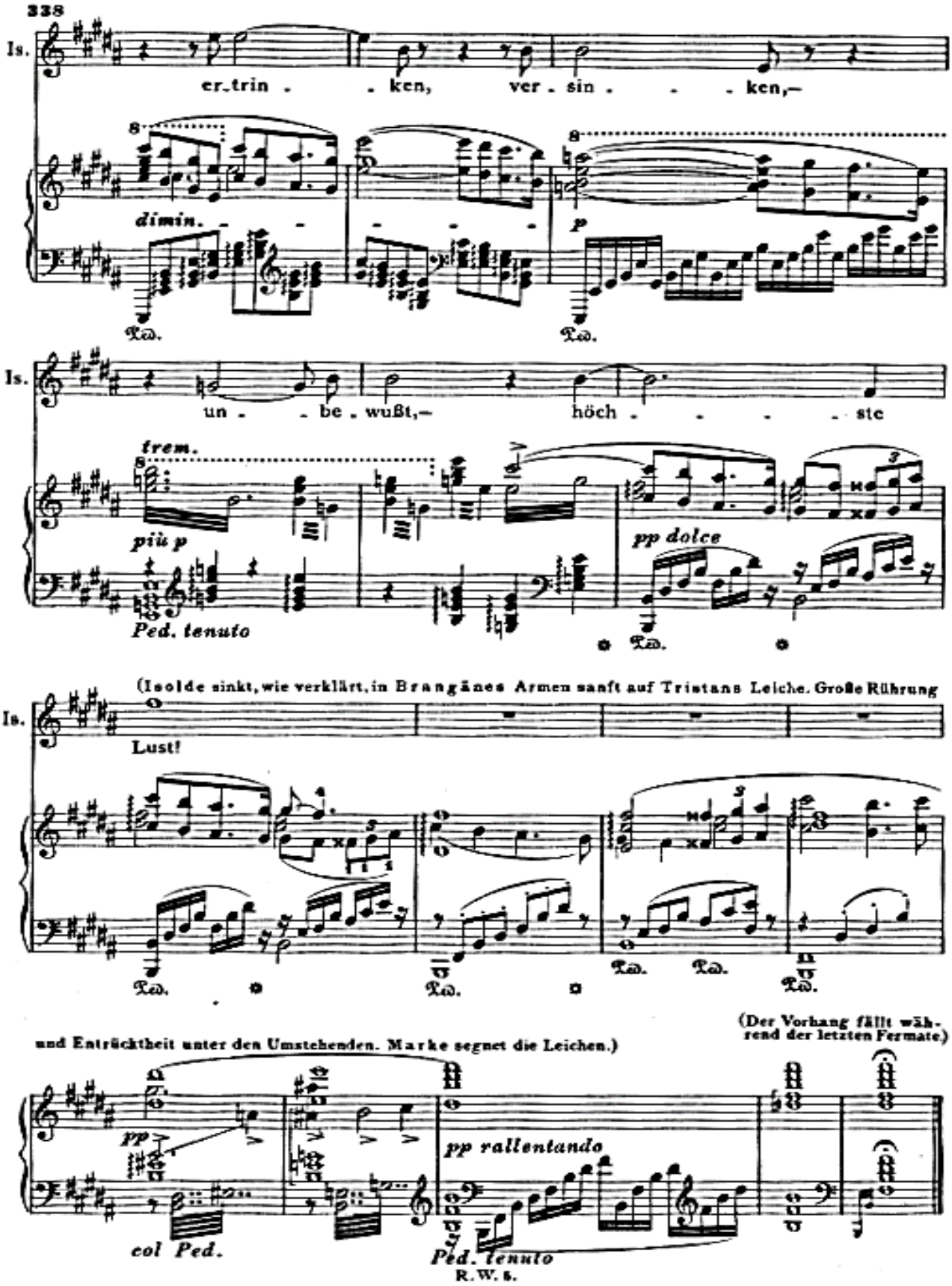
R.W. 5.


336
Is.
Lüf - te? Sind es Wo - - gen won - - ni-ger
cresc.
Is.
Düf - - te? Wie sie schwel - - len, mich um -
Is.
rau - - schen, soll ich at - - - men, soll ich
Is.
lau - - schen? Soll ich schlür - fen, un - ter - tau-chen?
pp

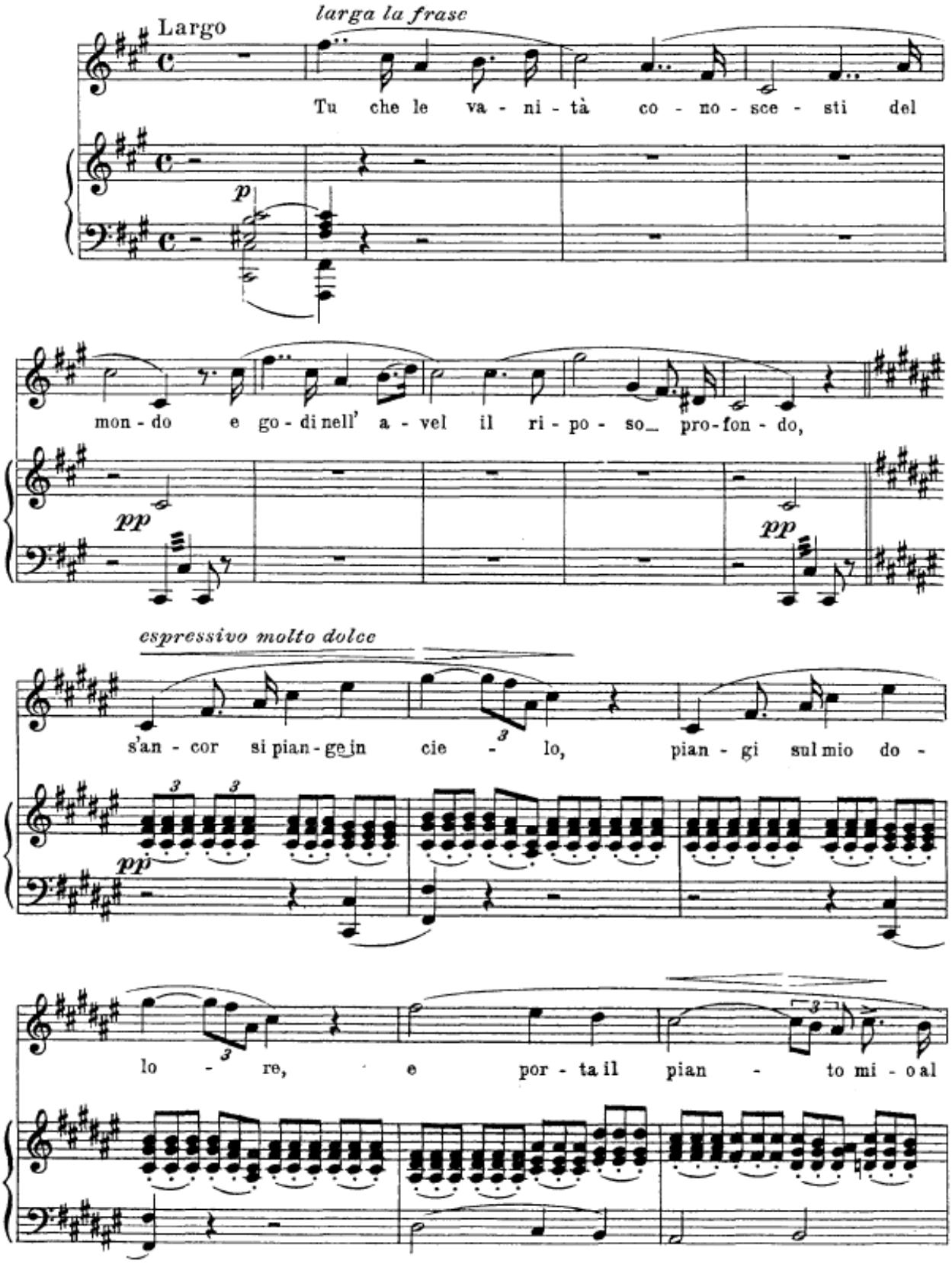
R. W. S.

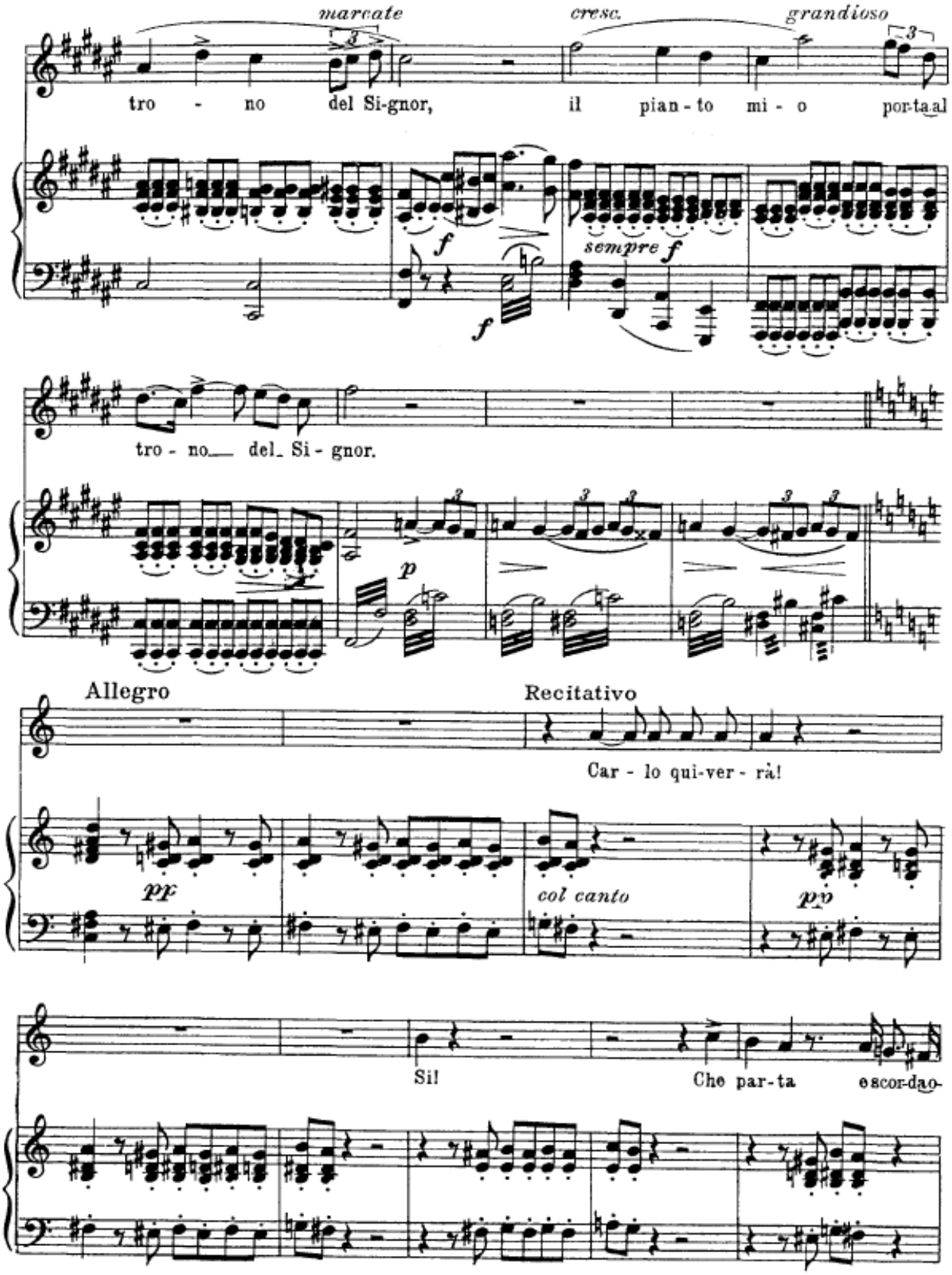

Is.
Süß in Düf - ten mich ver - hau - chen? In dem
cresc.
Is.
wo - - gen - den Schwall, in dem tō - - - nen - den
Is.
Schall, in des Welt - - - - -
ff
Ped.
Is.
A - - - tems we - - hen - dem All, —
Ped.
Ped.
Ped.

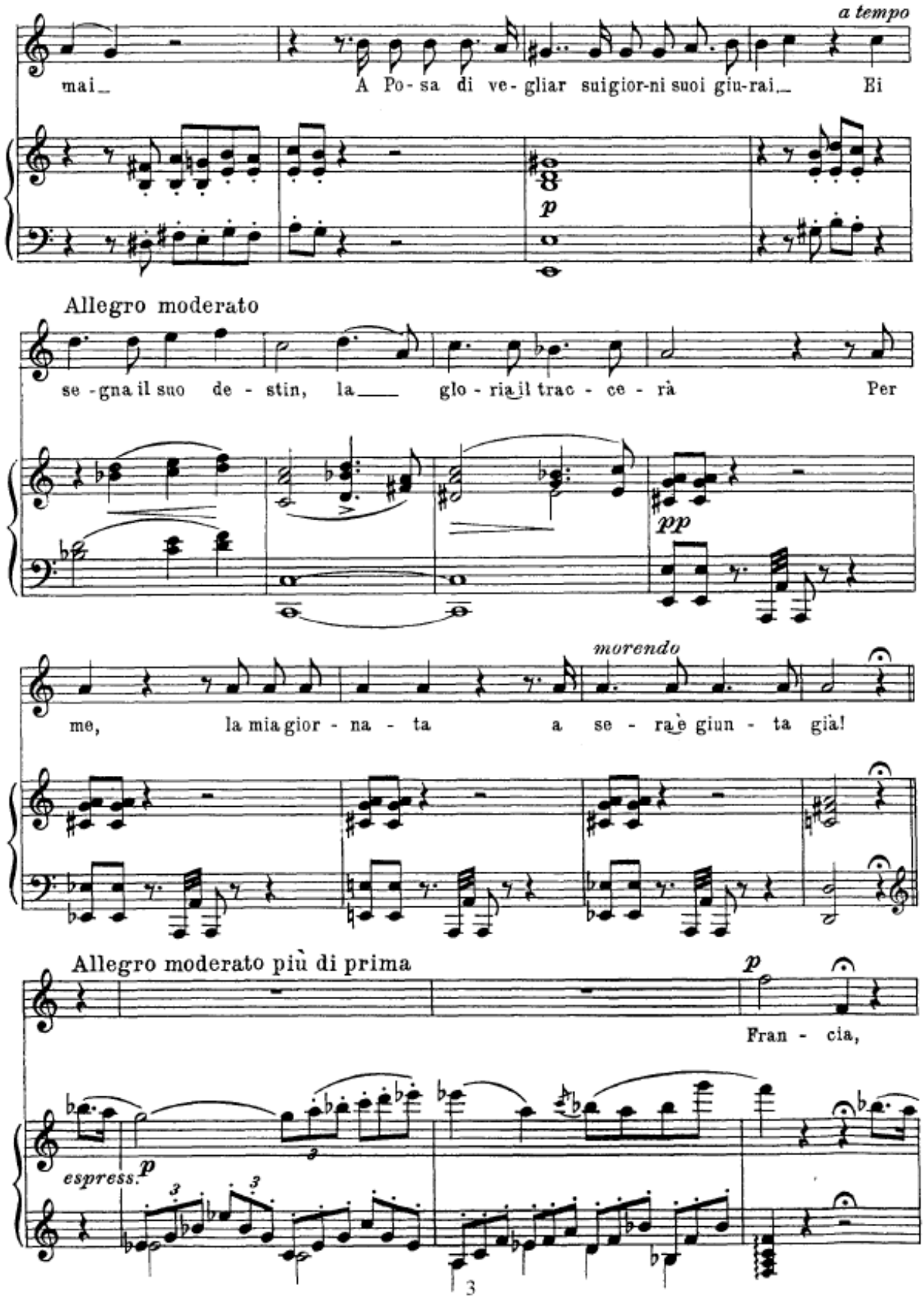
R. W. 5.

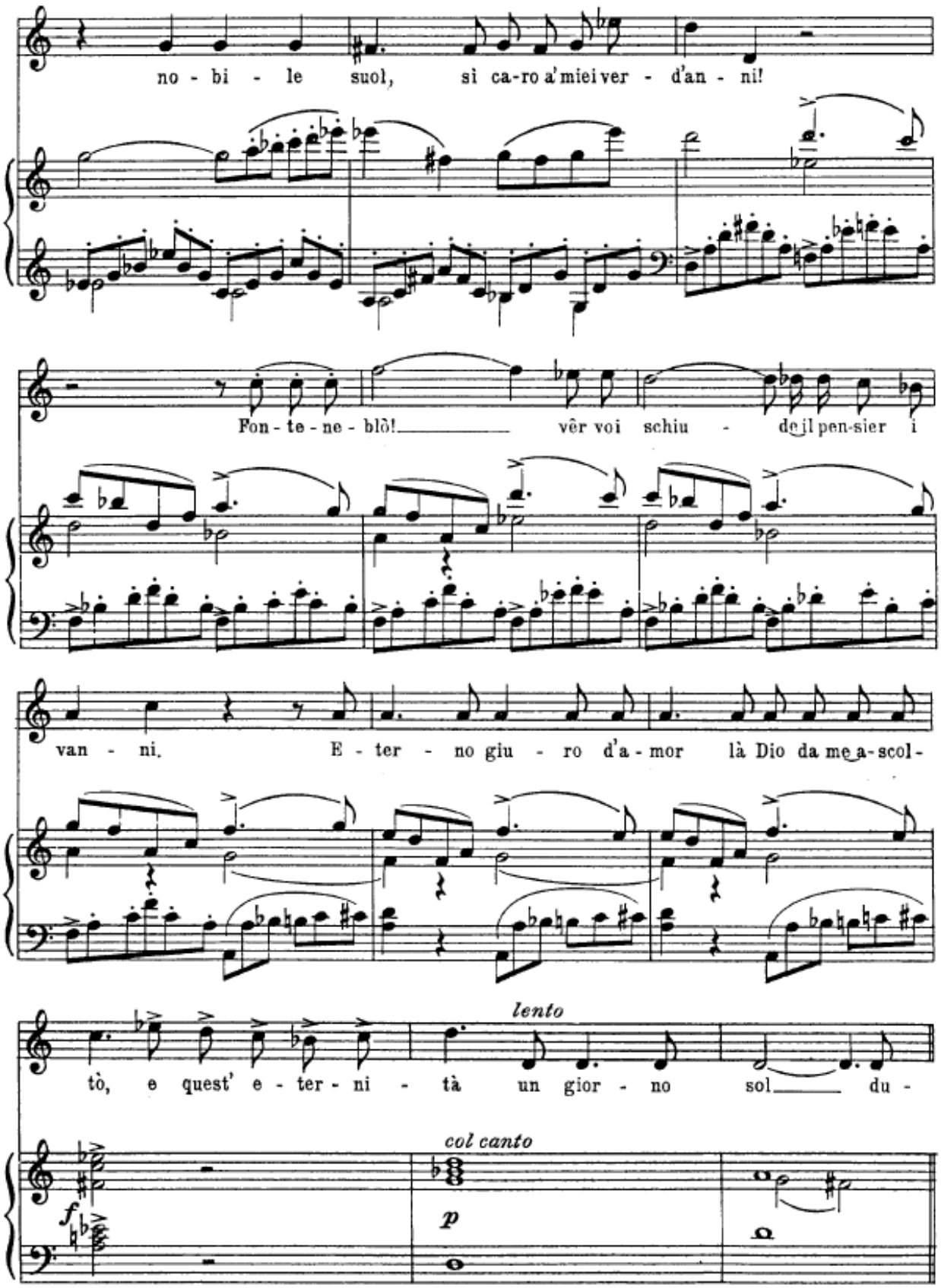

338
Is.
er_trin . . ken, ver . sin . . . ken,—
dimin.
p
Ped.
Ped.
Is.
un . . be . wußt,— höch . . . . ste
trem.
più p
pp dolce
Ped. tenuto
Ped.
(Isolde sinkt, wie verklärt, in Brangänes Armen sanft auf Tristans Leiche. Große Rührung
Is.
Lust!
Ped.
Ped.
Ped.
Ped.
(Der Vorhang fällt während der letzten Fermate)
und Entrücktheit unter den Umstehenden. Marke segnet die Leichen.)
pp
pp rallentando
col Ped.
Ped. tenuto
R. W. s.

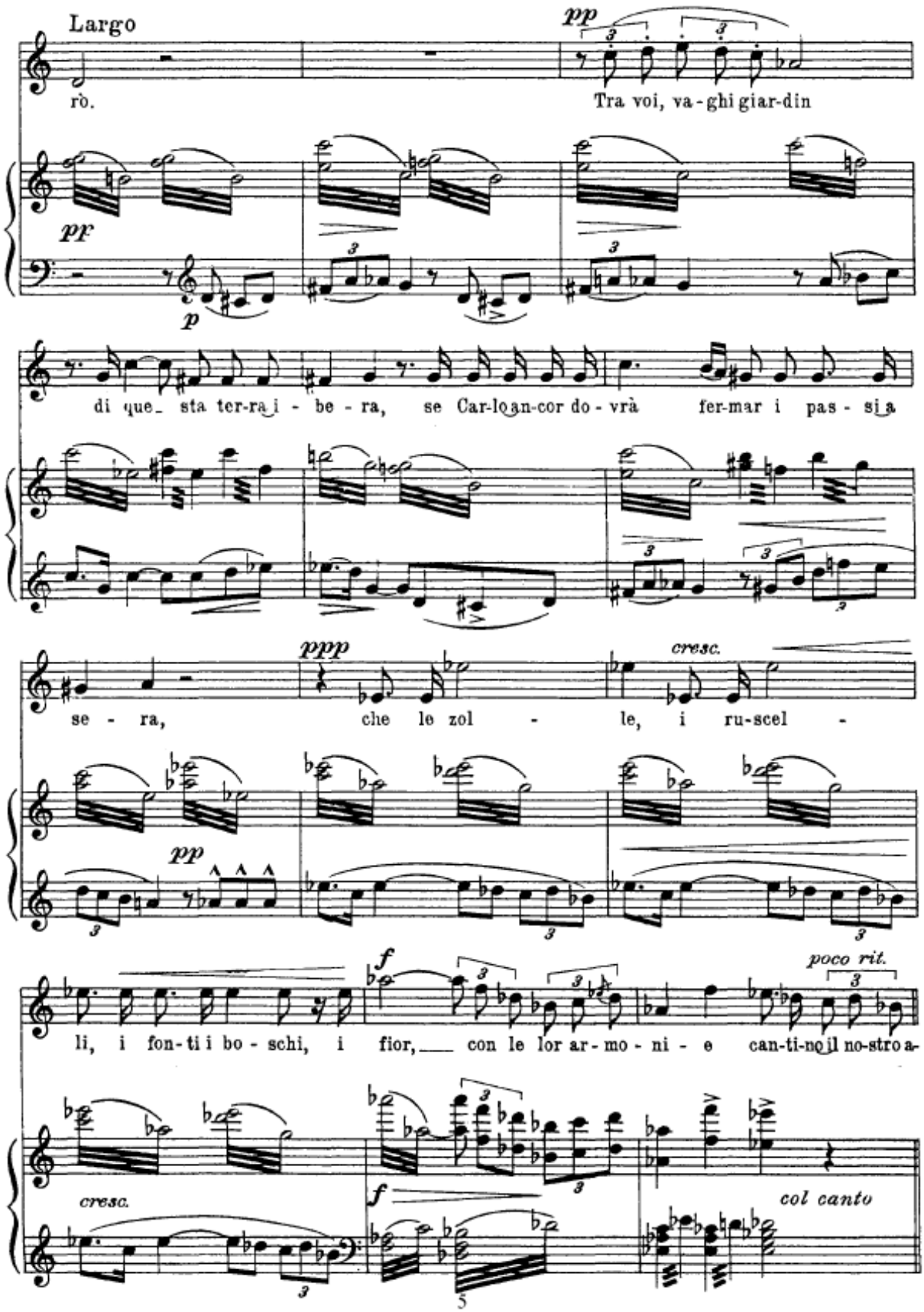
Score*: Tu che le vanità – Don Carlos* from G. Verdi

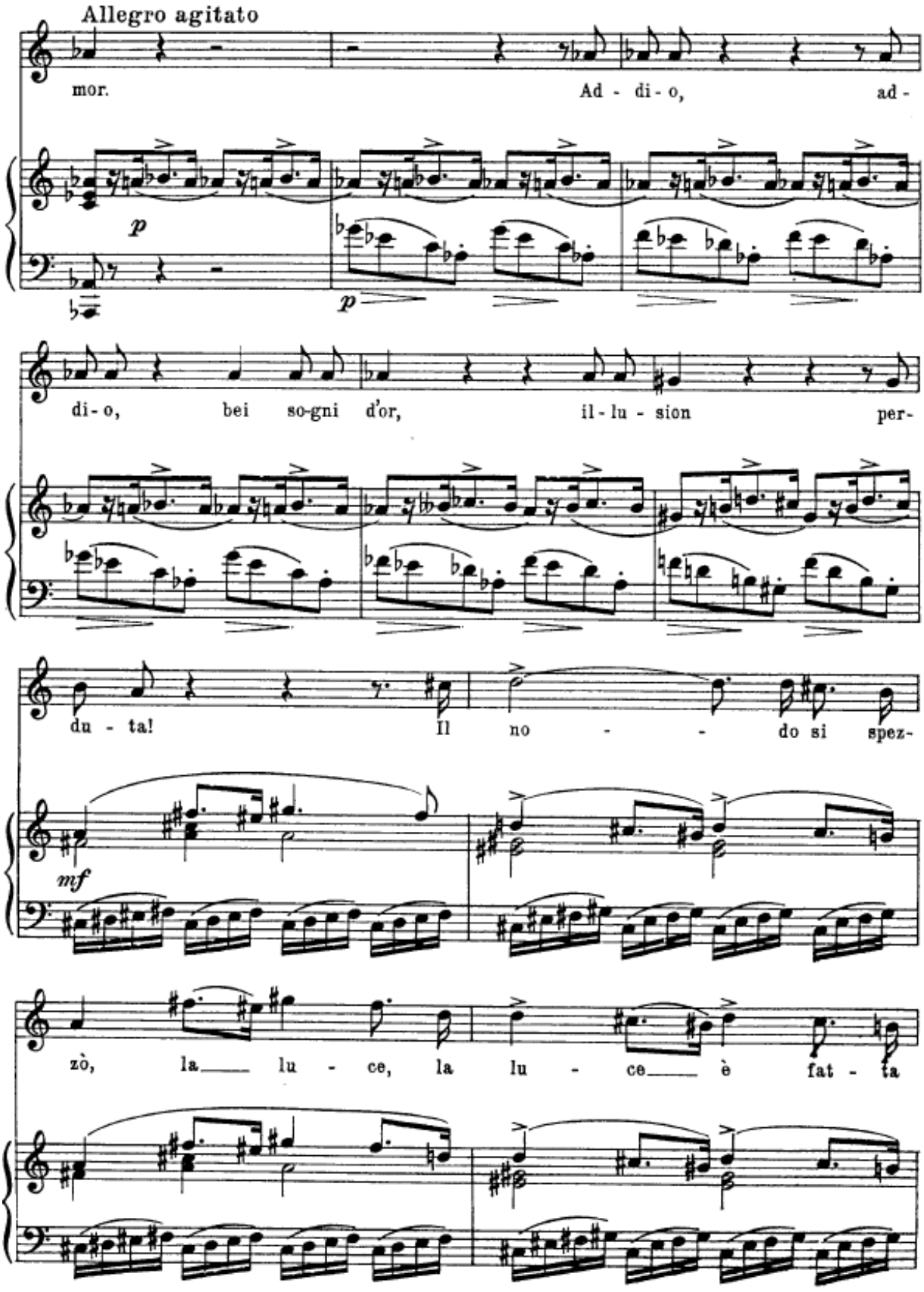


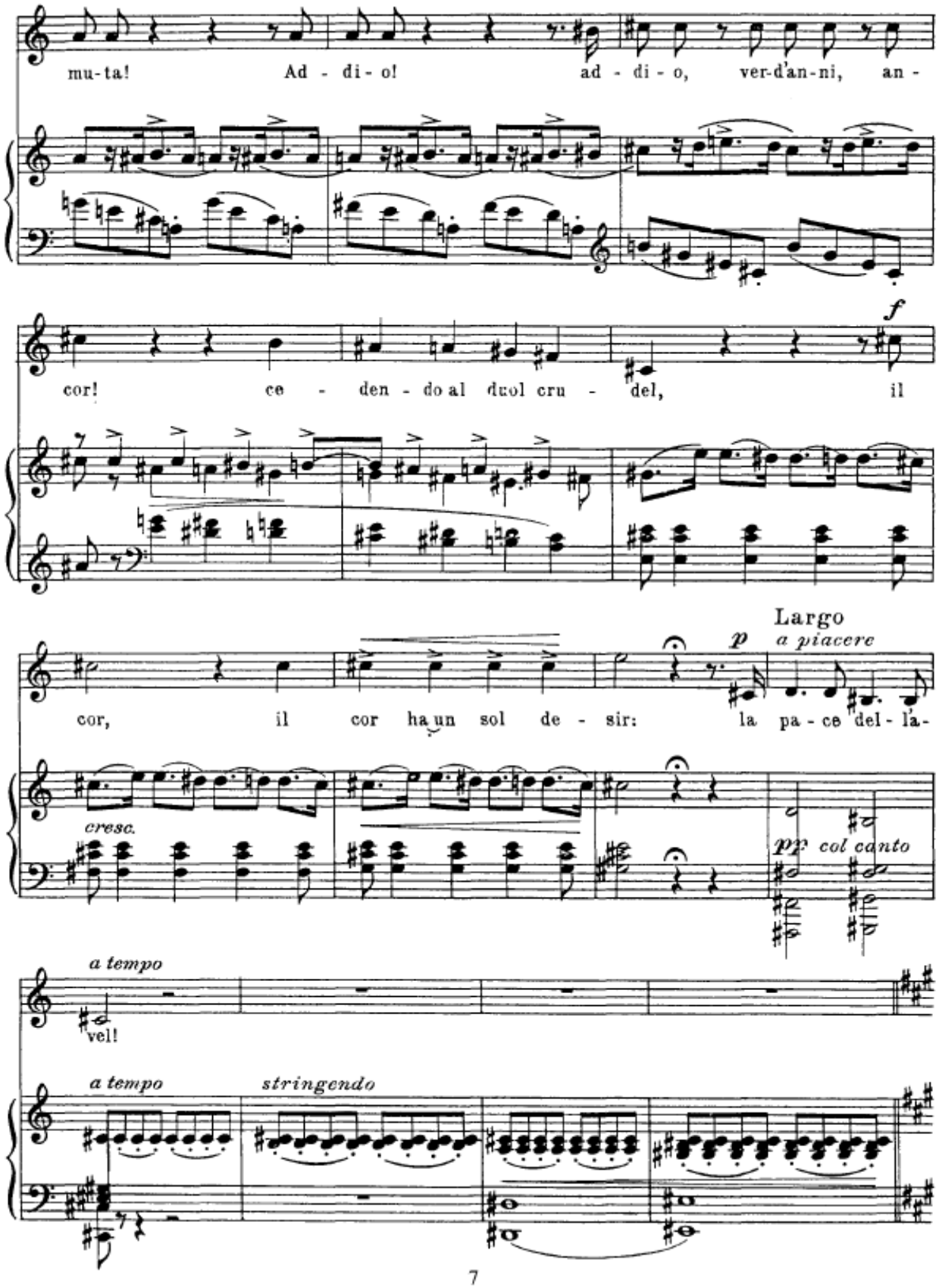

marcate
cresc.
grandioso
tro - no del Si-gnor, il pian-to mi - o por-ta al
sempre f
tro - no del Si - gnor.
Allegro
Recitativo
Car - lo qui-ver - rà!
col canto
Sì!
Che par-ta e scor-dao-

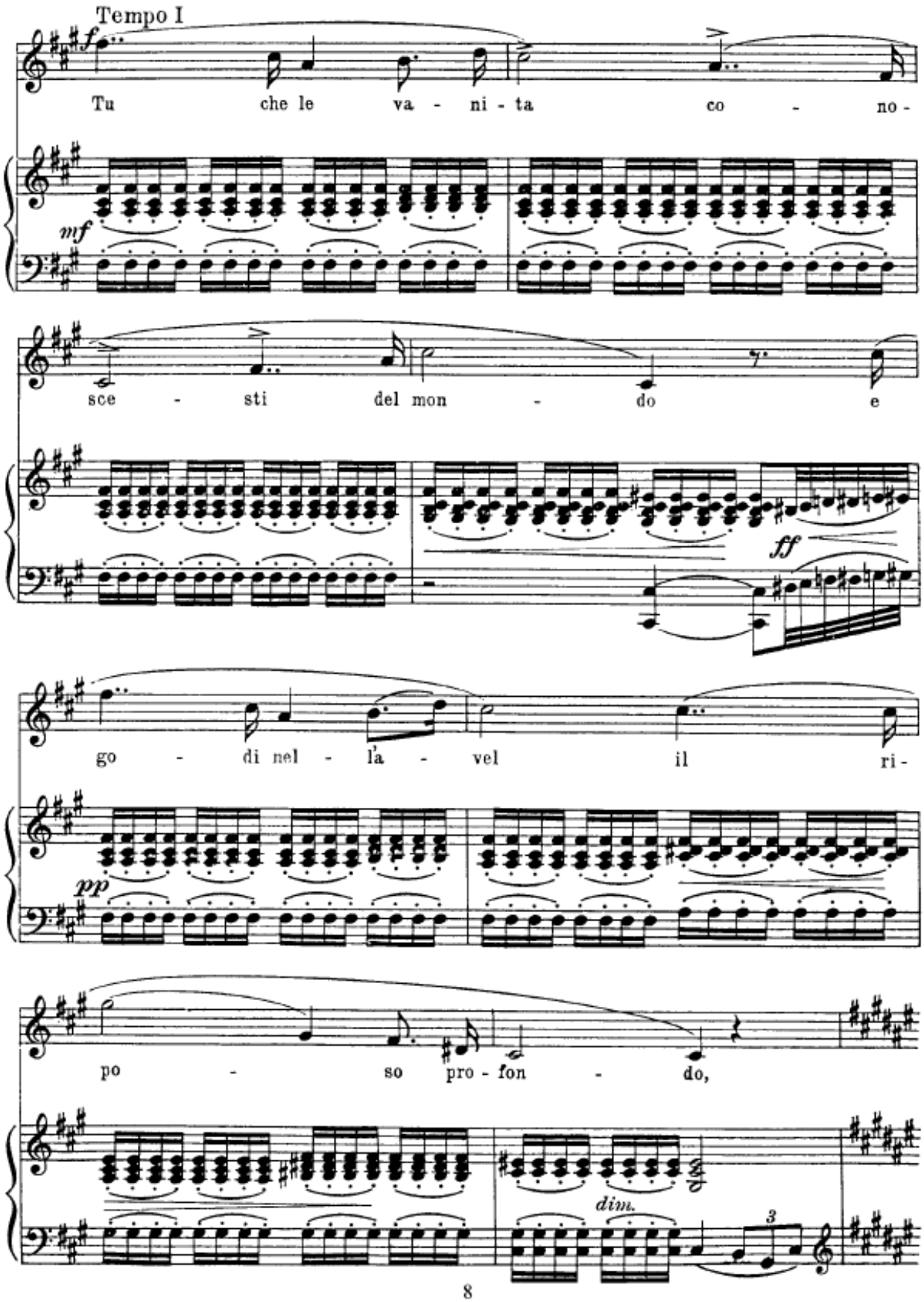

a tempo
mai_ A Po- sa di ve- gliar sui gior-ni suoi giu-rai_ Ei
p
Allegro moderato
se -gna il suo de - stin, la___ glo - ria il trac - ce - rà Per
pp
morendo
me, la mia gior - na - ta a se - ra è giun - ta già!
Allegro moderato più di prima
p
Fran - cia,
espress.
p
3
3
3
3

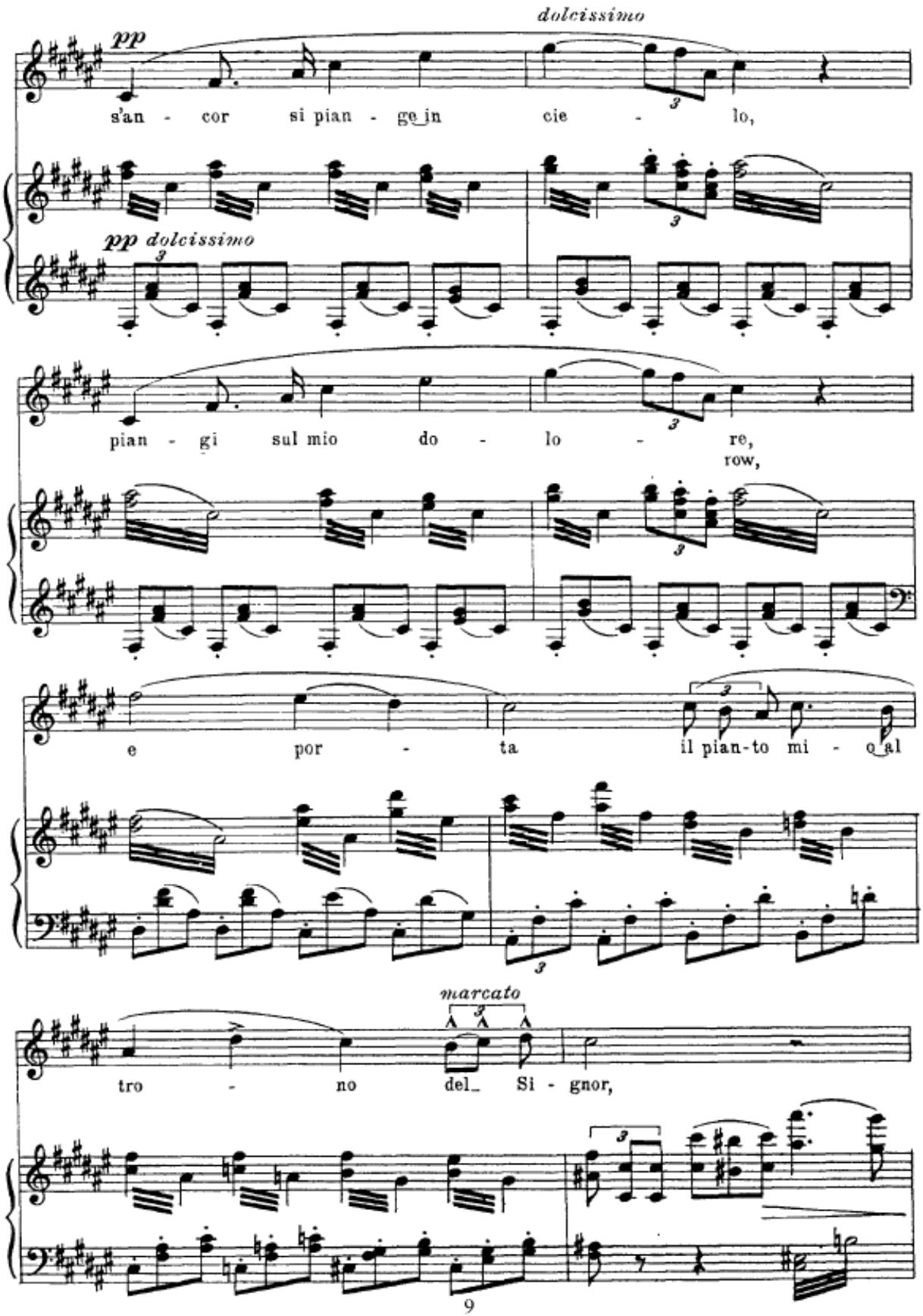

no - bi - le suol, si ca-ro a'miei ver - d'an - ni!
Fon - te - ne - blò! vêr voi schiu - de il pen-sier i
van - ni. E - ter - no giu - ro d'a - mor là Dio da me a-scol-
lento
tò, e quest' e - ter - ni - tà un gior - no sol du -
col canto
f
p

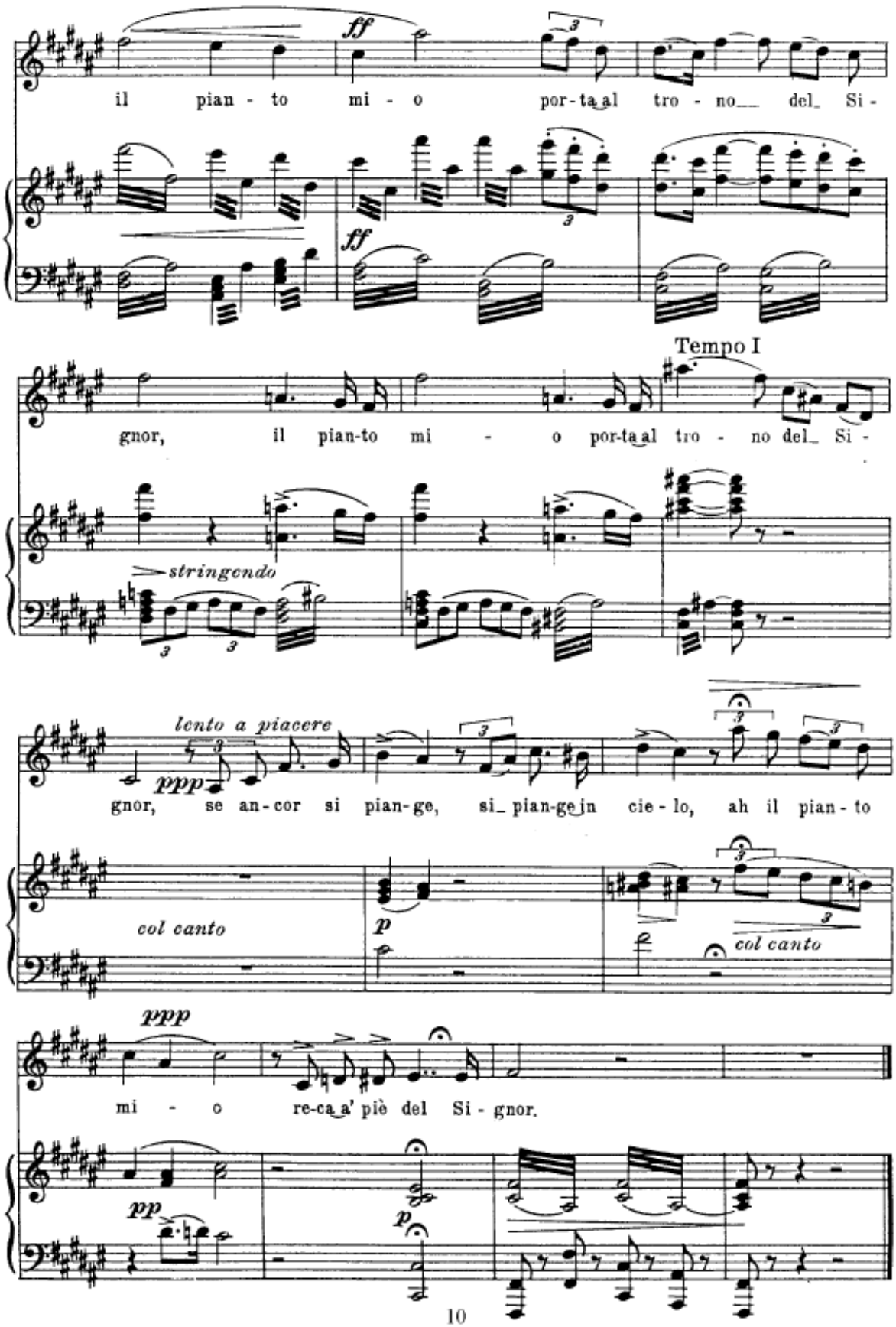

Largo
pp
rò.
Tra voi, va - ghi giar-din
pf
p
di que_ sta ter-ra i - be - ra, se Car-lo an-cor do - vrà fer-mar i pas - si a
ppp
cresc.
se - ra, che le zol - le, i ru-scel -
pp
f
poco rit.
li, i fon-ti i bo - schi, i fior, con le lor ar - mo - ni - e can-ti-no il no-stro a-
cresc.
f
col canto
5


Allegro agitato
mor.
Ad - di - o,
ad -
p
p
di - o,
bei so-gni d'or,
il - lu - sion
per -
du - ta!
Il no - - do si spez -
mf
zò,
la___ lu - ce, la lu - ce___ è fat - ta

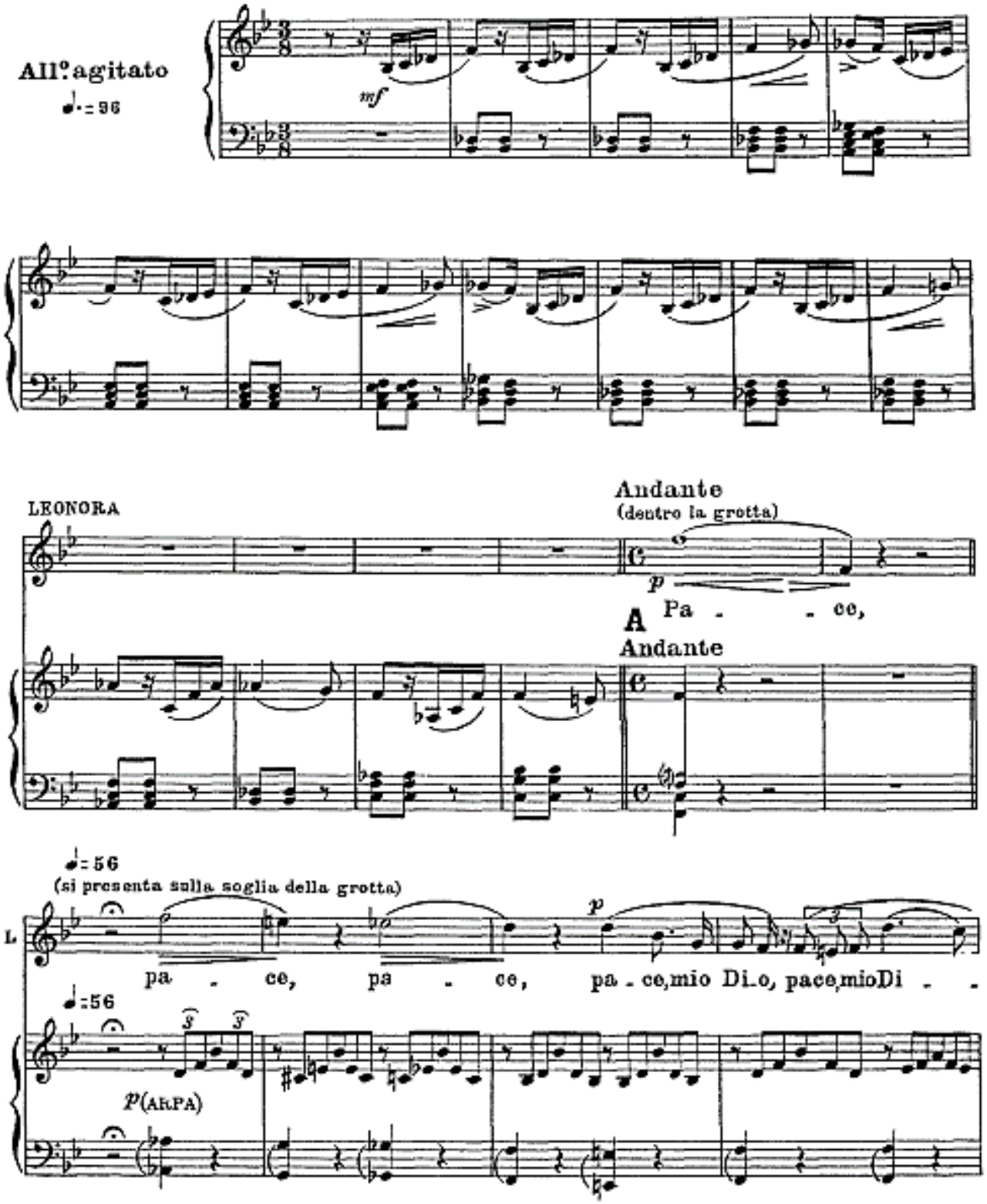

mu-ta! Ad - di - o! ad - di - o, ver-d'an-ni, an -
f
cor! ce - den - do al duol cru - del, il
Largo
p
a piacere
cor, il cor ha un sol de - sir: la pa - ce del - la -
cresc.
pp col canto
a tempo
vel!
a tempo
stringendo

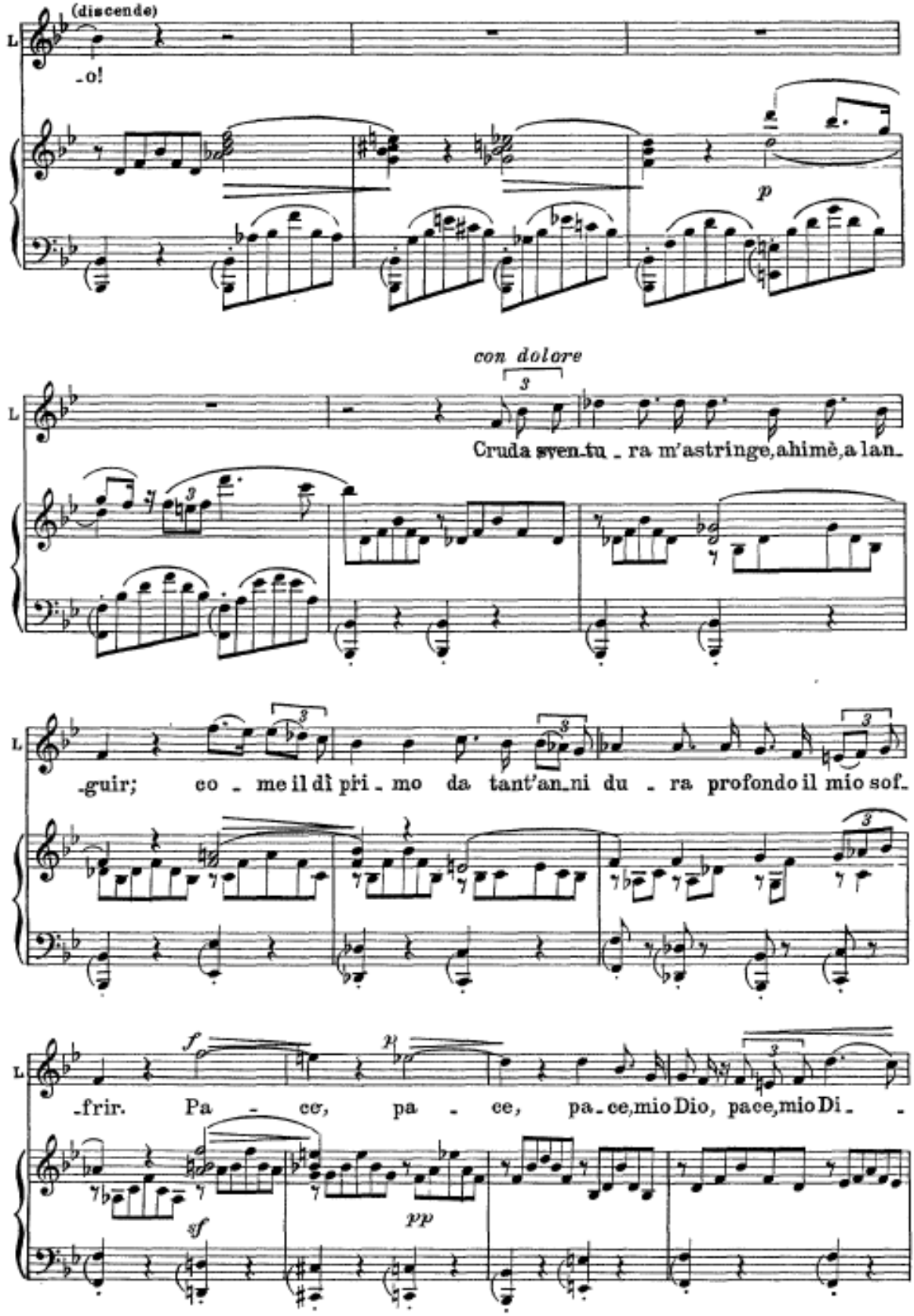

Tempo I
Tu che le va - ni - ta co - no -
sce - sti del mon - do e
go - di nel - la - vel il ri -
po - so pro - fon - do,
dim.

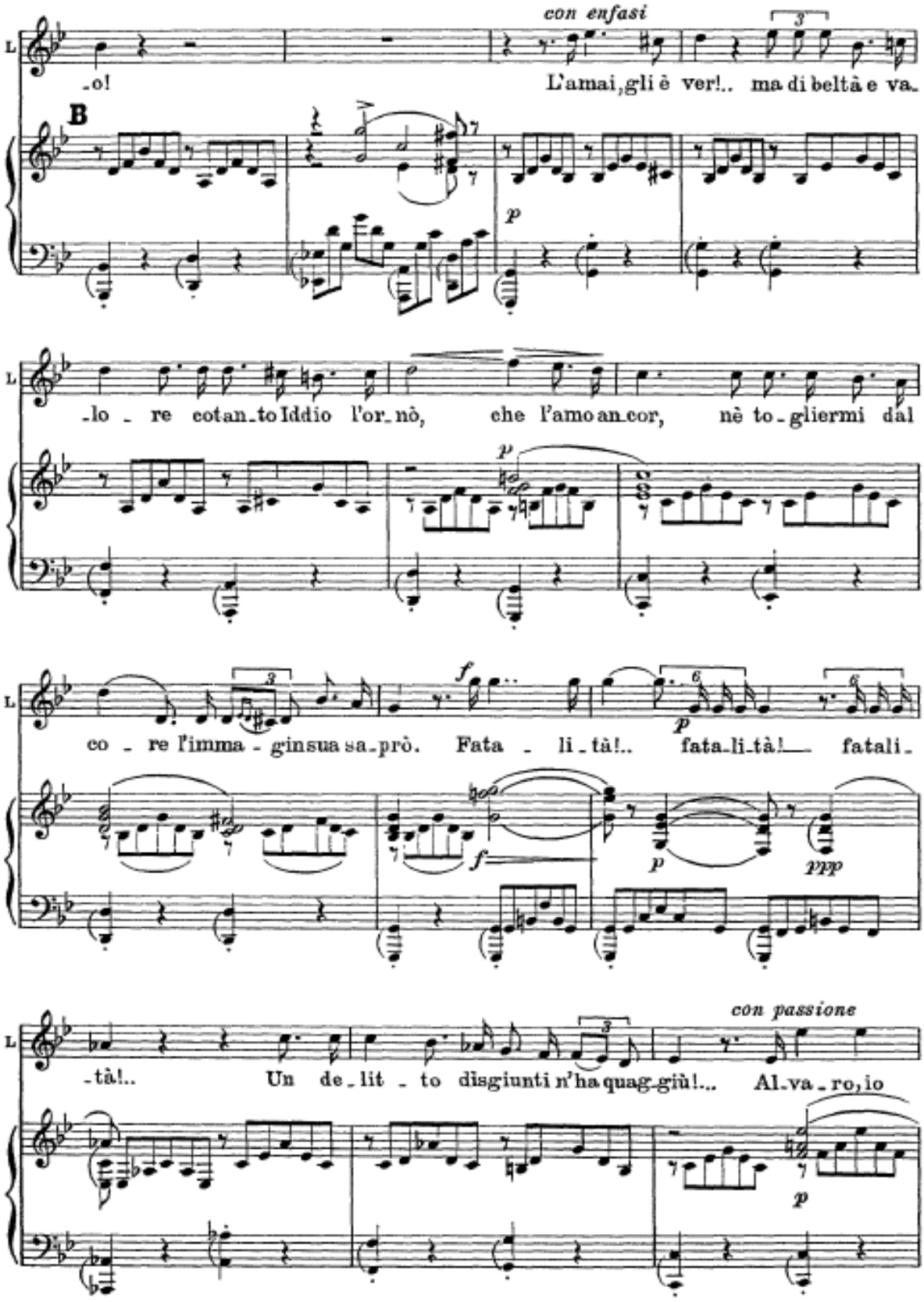

dolcissimo
pp
s'an - cor si pian - ge in cie - lo,
pp dolcissimo
pian - gi sul mio do - lo - re,
row,
e por - ta il pian-to mi - o al
marcato
tro - no del_ Si - gnor,

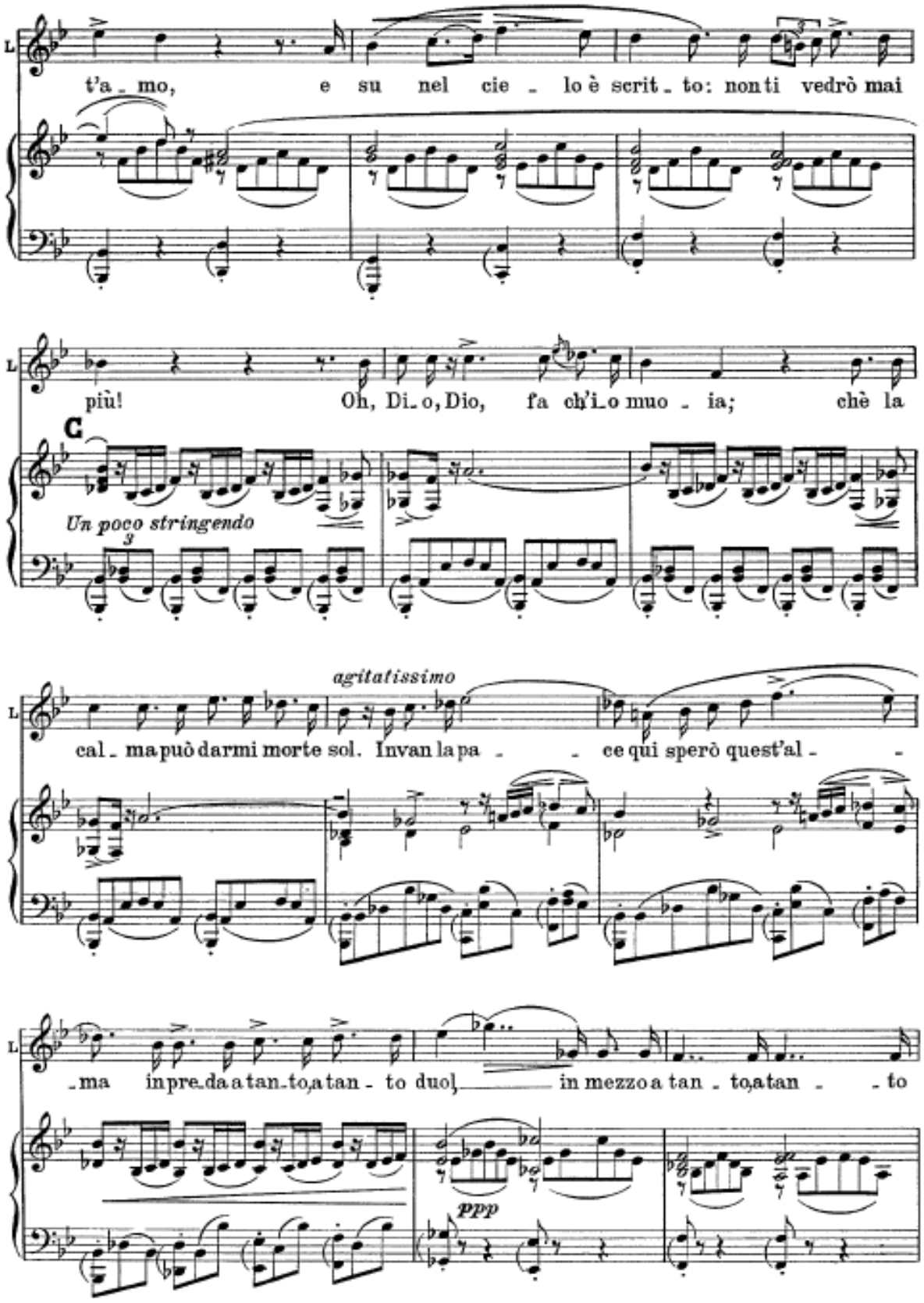

ff
il pian - to mi - o por-ta al tro - no del Si -
ff
Tempo I
gnor, il pian-to mi - o por-ta al tro - no del Si -
stringendo
lento a piacere
ppp
gnor, se an-cor si pian-ge, si pian-ge in cie-lo, ah il pian-to
col canto
p
col canto
ppp
mi - o re-ca a' piè del Si - gnor.
pp
p

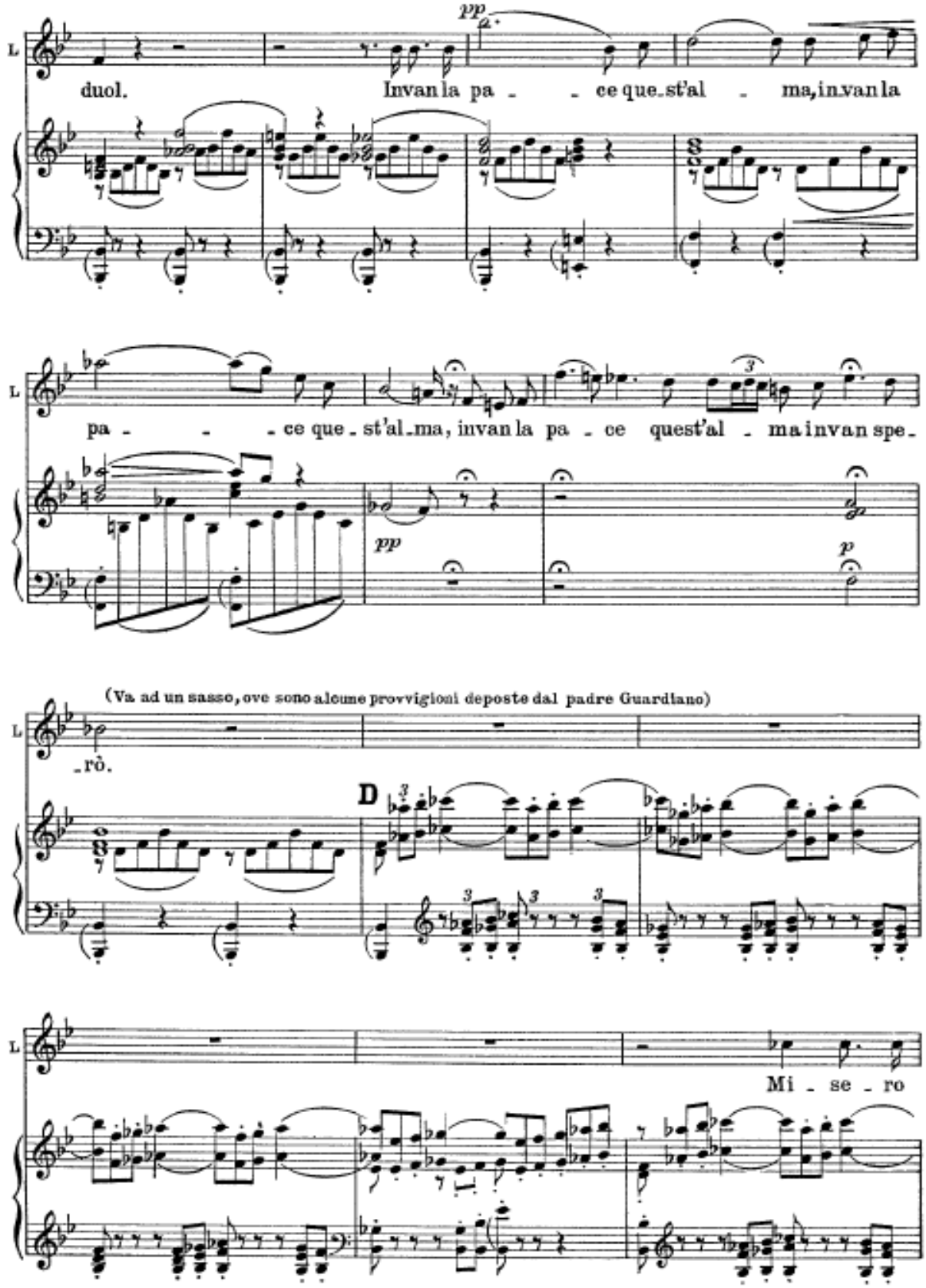
Score: *Pace, Pace* - *La Forza del destino* from G. Verdi

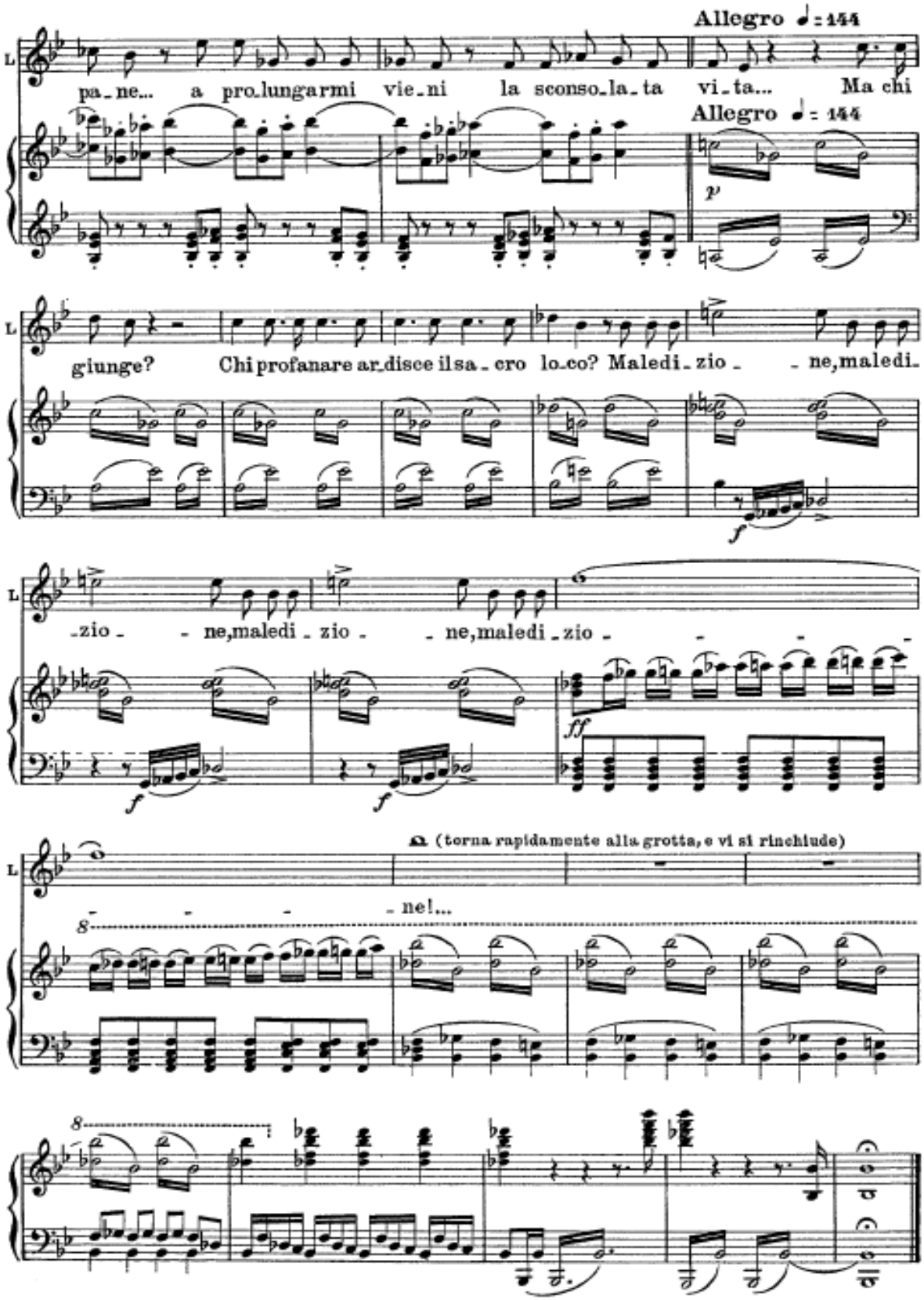



(discende)
-o!
p
con dolore
Cruda sven-tu - ra m'astringe, ahimè, a lan-
-guir; co - me il dì pri - mo da tant'an-ni du - ra profondo il mio sof-
f
-frir. Pa - ce, pa - ce, pa-ce, mio Dio, pace, mio Di - -
sf
p
pp

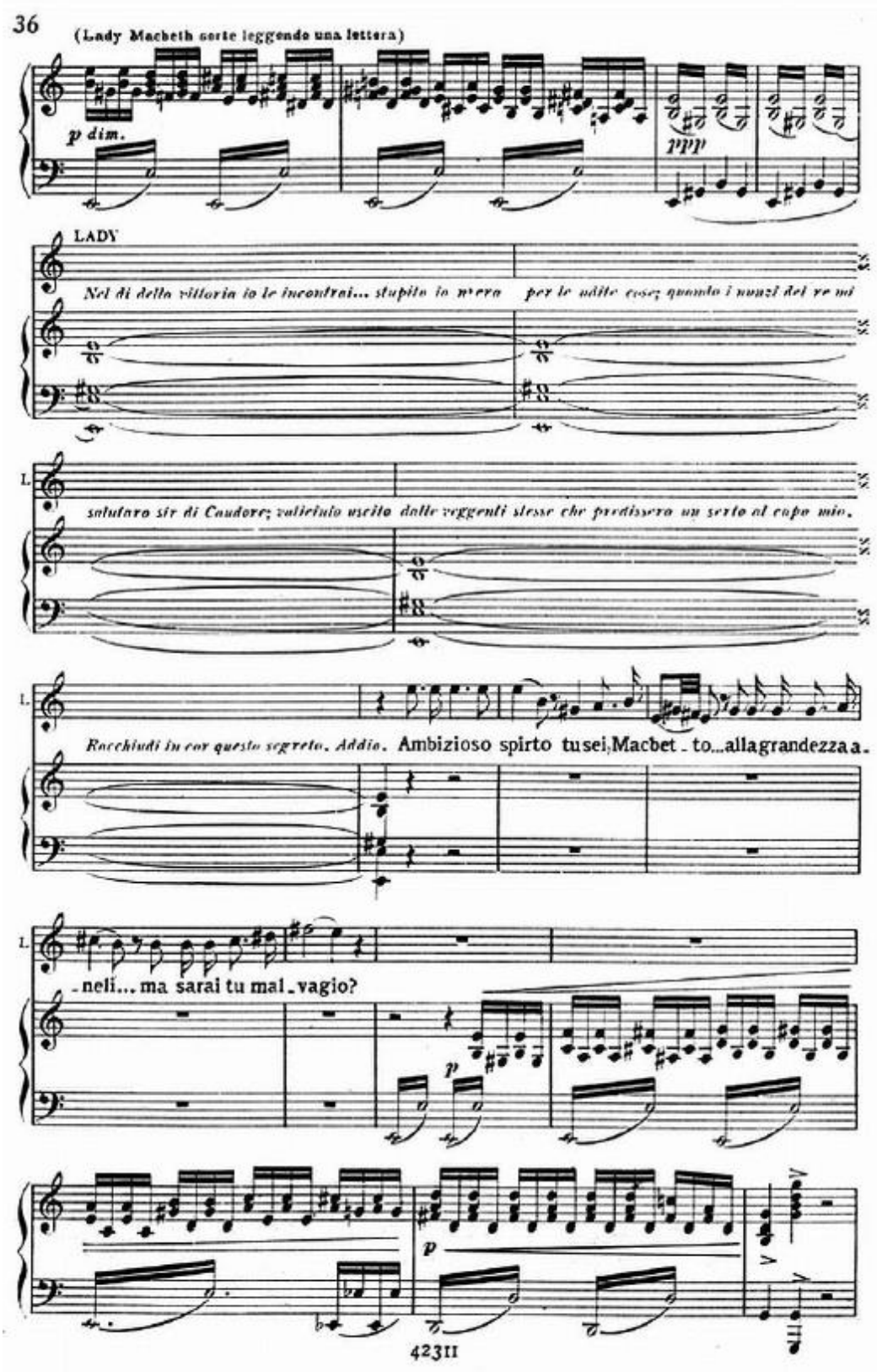

con enfasi
-o!
L'amai, gli è ver!.. ma di beltà e va-
B
-lo - re cotan-to Iddio l'or-nò, che l'amo an-cor, nè to-gliermi dal
co - re l'imma - ginsua sa-prò. Fata - li-tà!.. fata-li-tà! fatali-
-tà!.. Un de-lit - to disgiunti n'ha quag-giù!... Al-va-ro, io
con passione

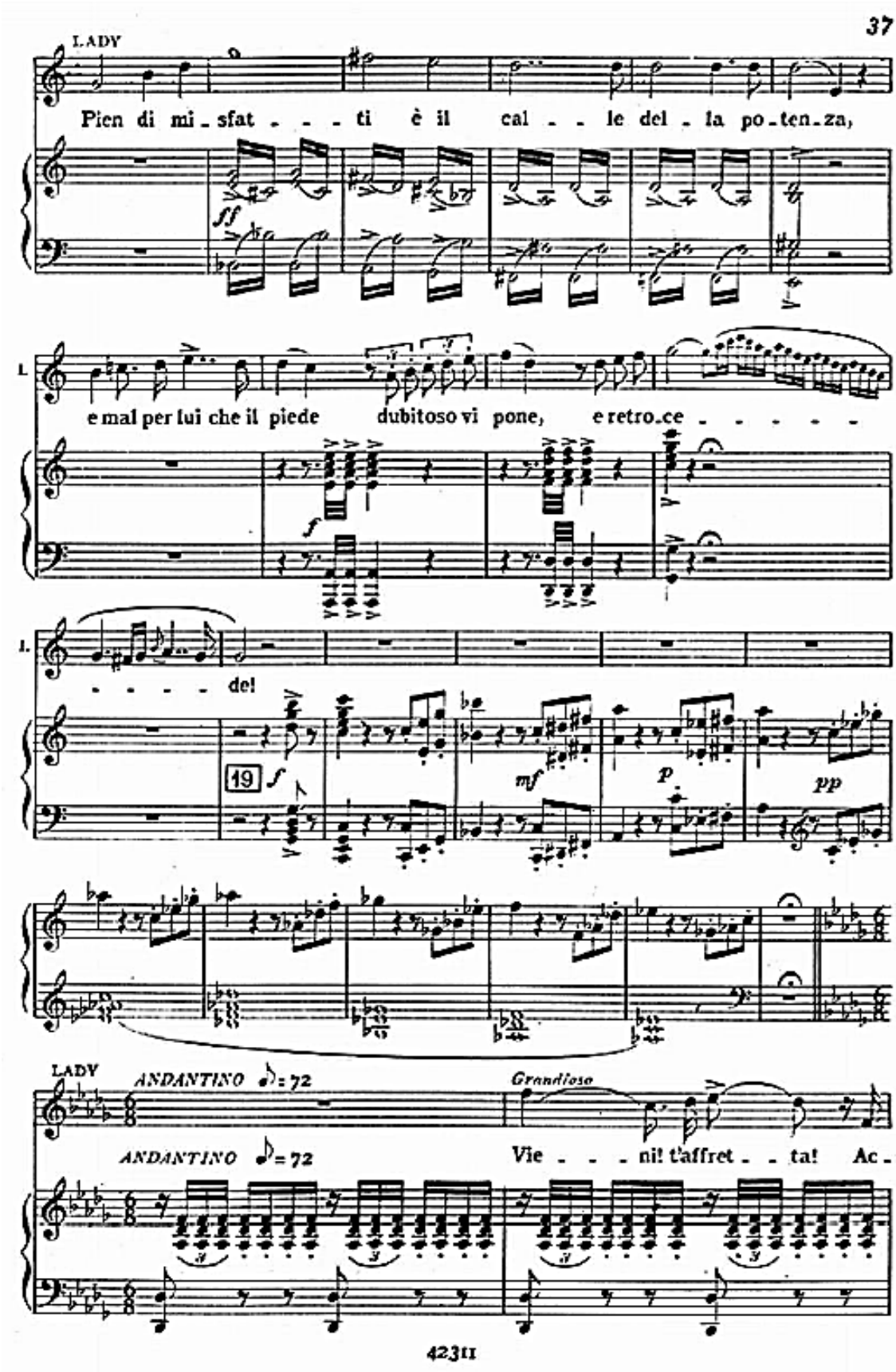

t'a - mo, e su nel cie - lo è scrit - to: non ti vedrò mai
più! Oh, Di - o, Dio, fa ch'i - o muo - ia; chè la
C
Un poco stringendo
agitatissimo
cal - ma può darmi morte sol. Invan la pa - - ce qui sperò quest'al - -
- ma in pre - da a tan - to, a tan - to duol in mezzo a tan - to, a tan - - to
ppp


L
pp
duol.
Invan la pa - - ce que_st'al - ma, invan la
pa - - - ce que_st'al_ma, invan la pa - ce quest'al - ma invan spe_
pp
p
(Va ad un sasso, ove sono alcune provvigioni deposte dal padre Guardiano)
_rò.
D
Mi - se - ro

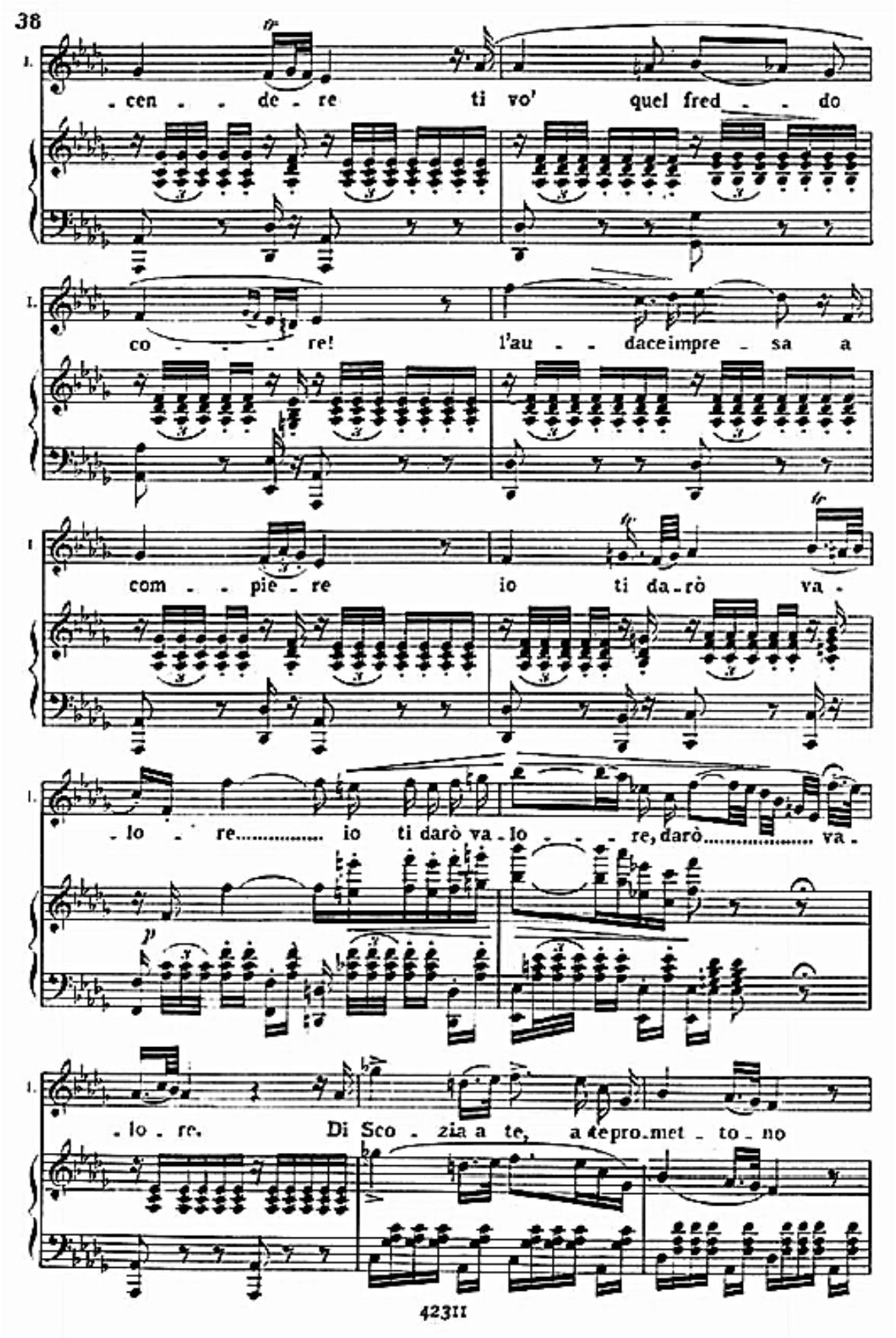

Allegro ♩= 144
L
pa_ne... a pro_lungarmi vie_ni la sconso_la_ta vi_ta... Ma chi
Allegro ♩= 144
p
giunge? Chi profanare ar_disce il sa_cro lo_co? Maledi_zio _ _ ne, maledi_
f
_zio _ _ ne, maledi_zio _ _ ne, maledi_zio _ _ _ _
ff
f
f
(torna rapidamente alla grotta, e vi si rinchiude)
_ _ _ _ ne!...
8
8

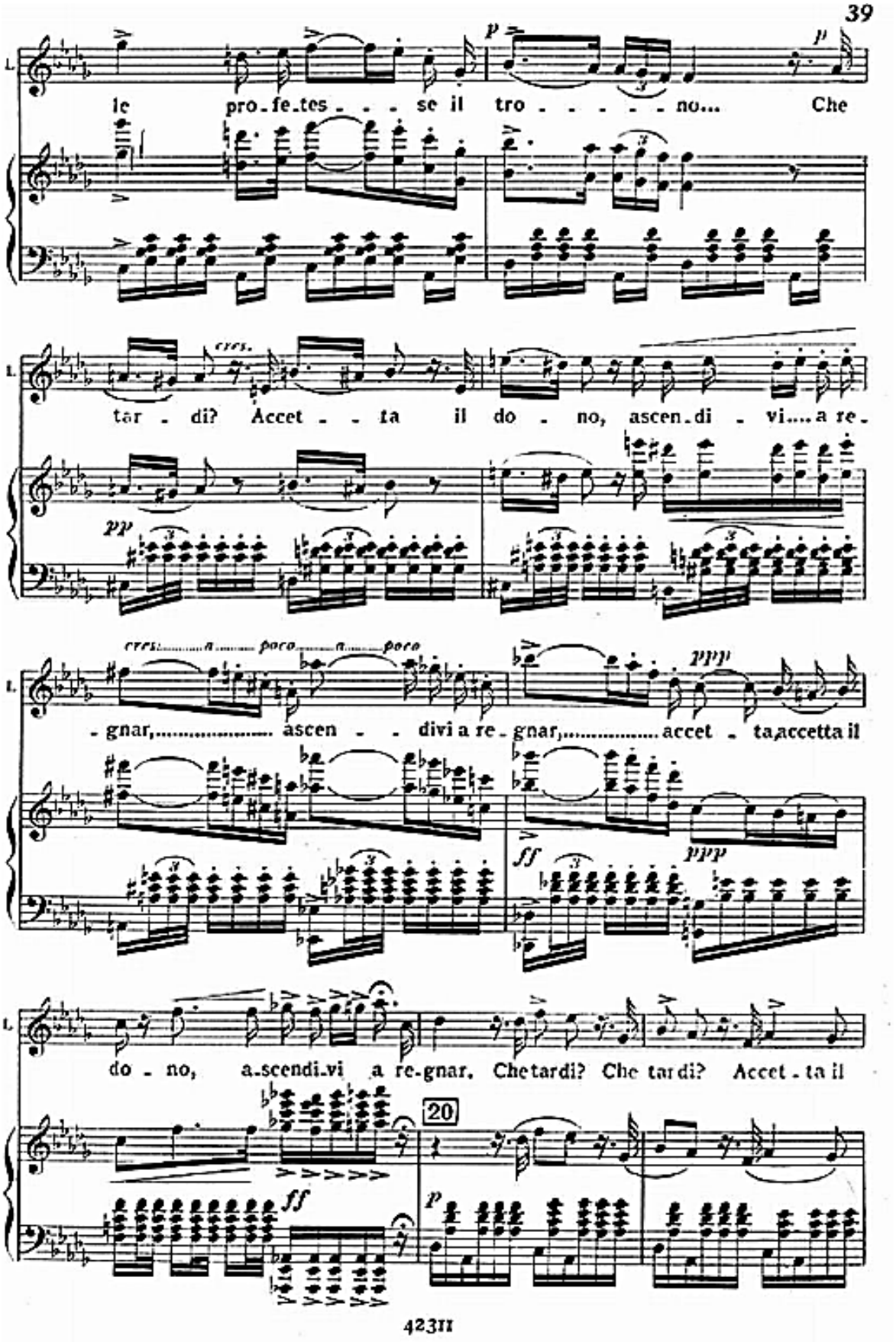
Score: *Vieni! T'affretta!...or tutti*… - Lady Macbeth from G. Verdi

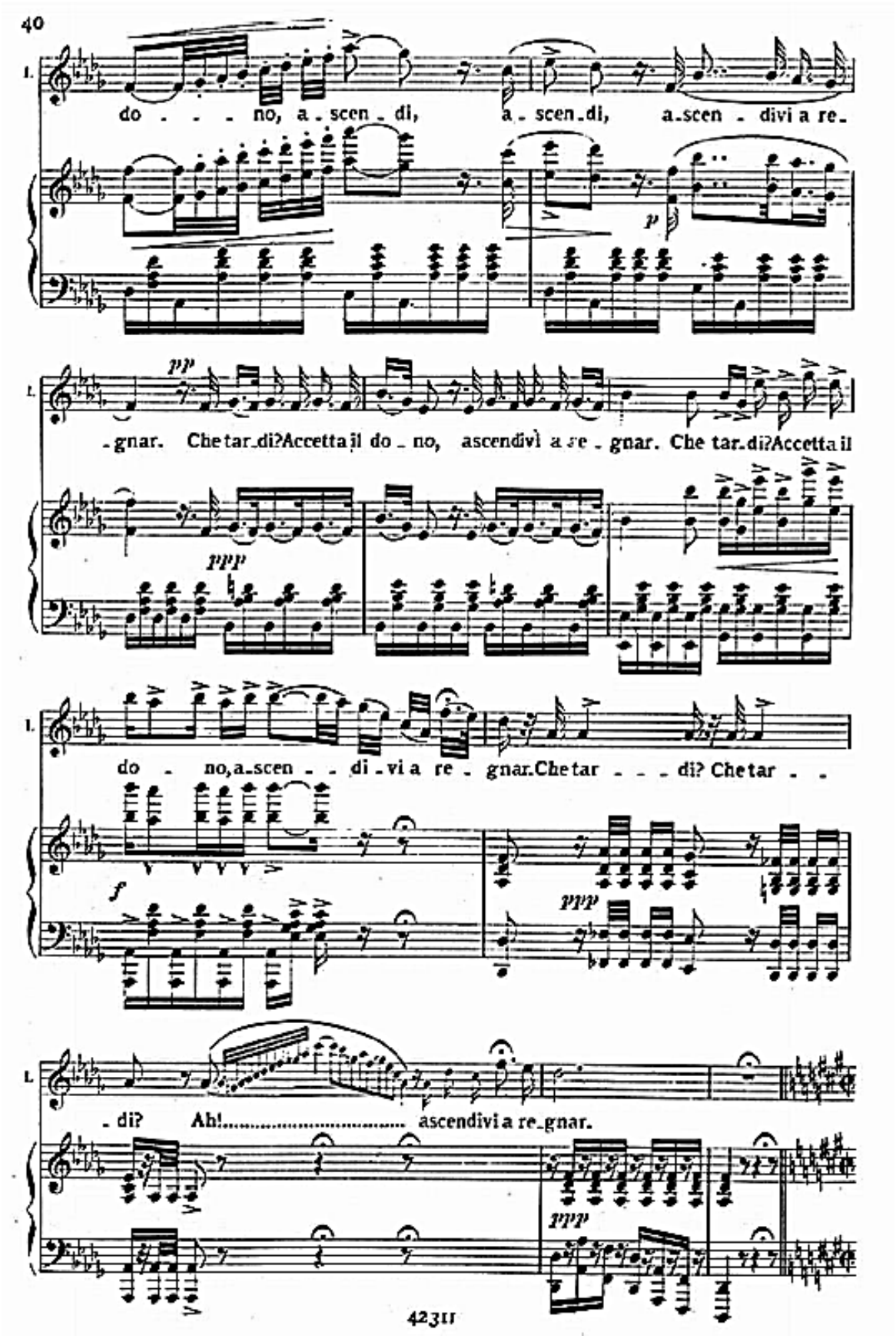


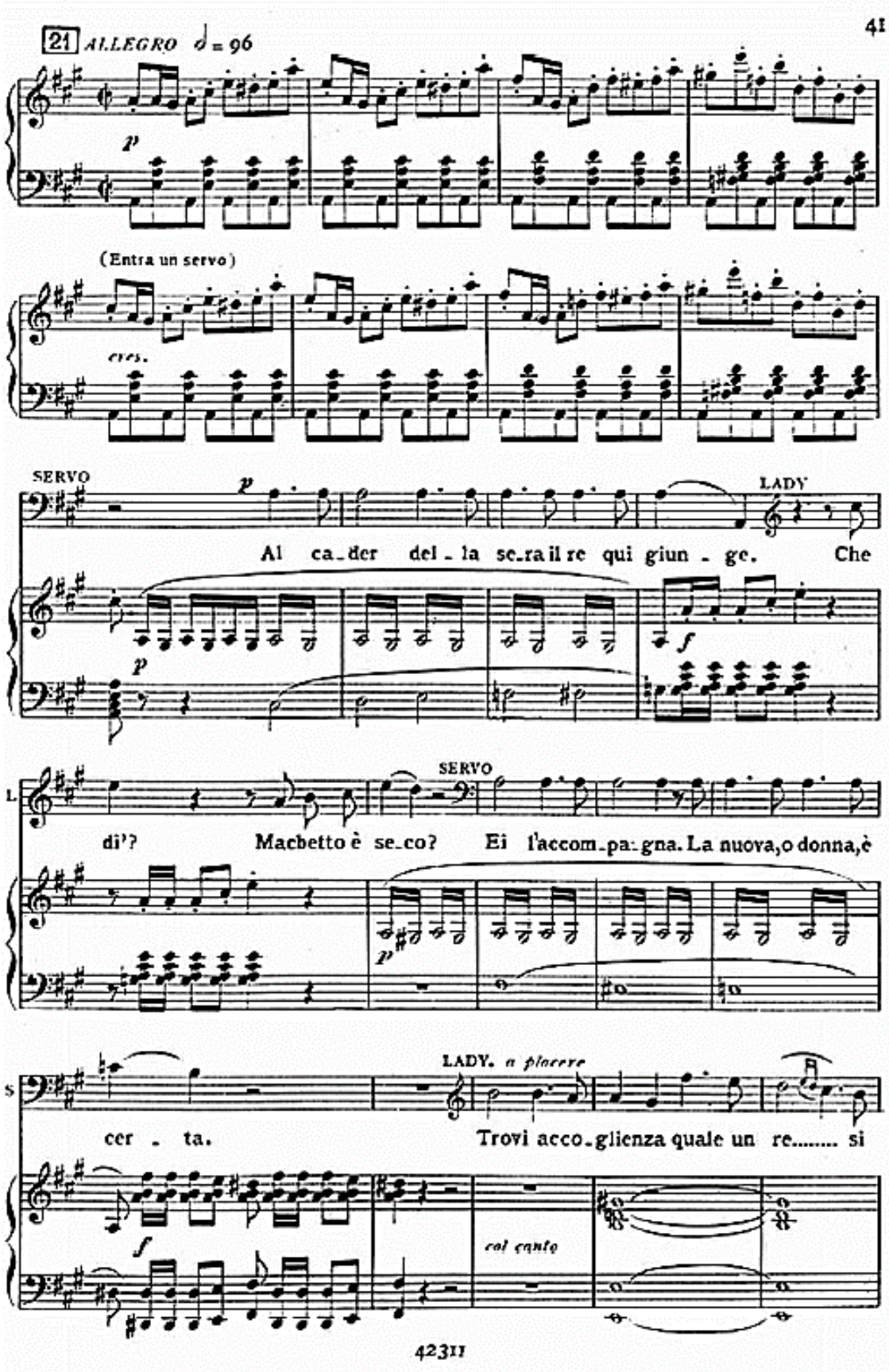

L.ADV
Pien di mi_sfat_ _ _ti è il cal_ _le del_la po_ten_za,
e mal per lui che il piede dubitoso vi pone, e retro_ce_ _ _ _ _
del
19
LADV
ANDANTINO ♪= 72
Grandioso
ANDANTINO ♪= 72
Vie_ _ _ni! t'affret_ _ta! Ac_

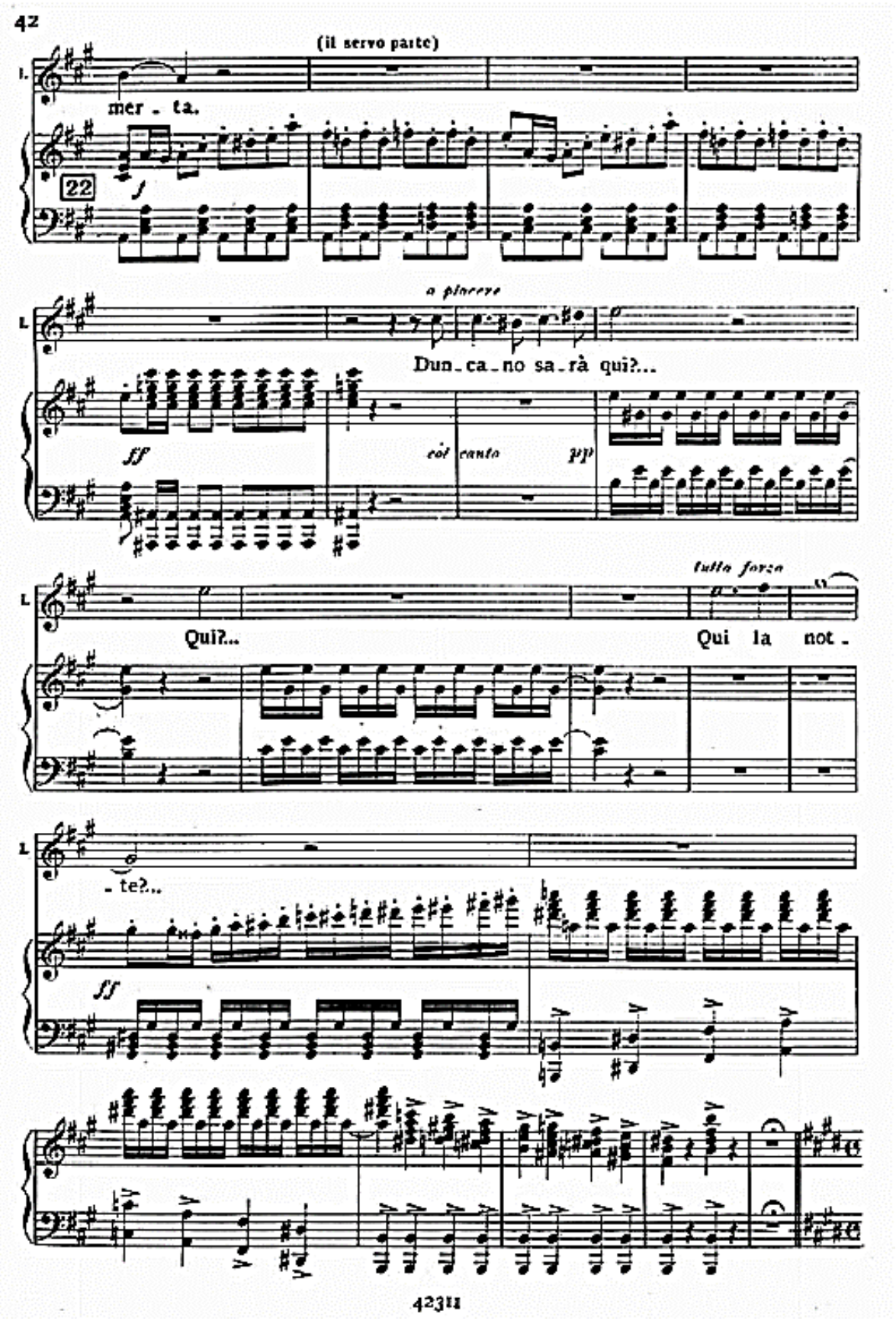
42311

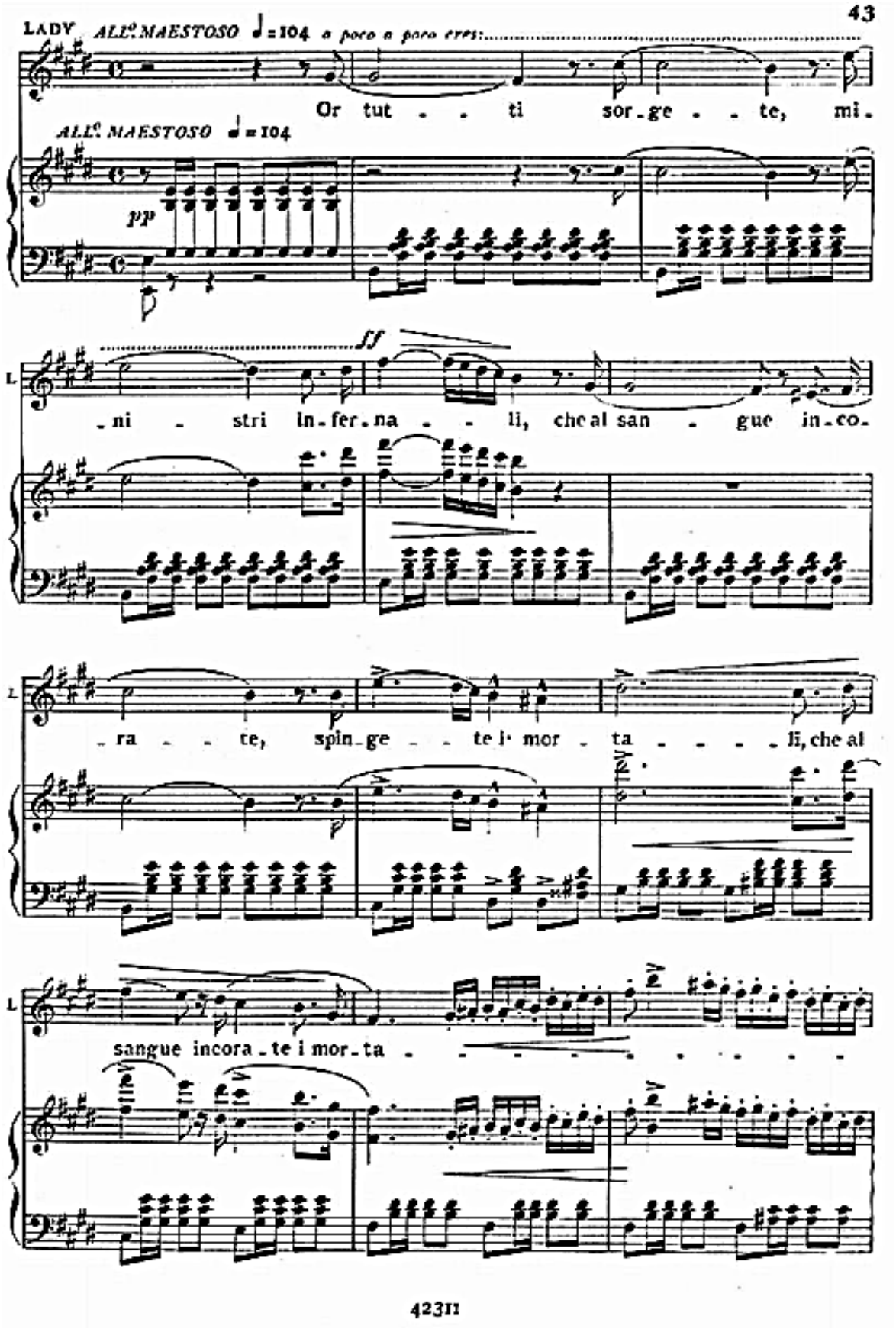

38
I.
-cen - - de - re ti vo' quel fred - - do
I.
co - - - - re! l'au - - daceimpre - sa a
I
com - - pie - re io ti da-rò va -
I.
- lo - re..... io ti darò va - lo - - - re, darò..... va -
I.
- lo - re. Di Sco - zia a te, a te pro-met - to - no
42311


le pro-fe-tes- - - se il tro- - - - - no... Che
tar - di? Accet - - ta il do - no, ascen-di - vi.... a re-
cresc. poco a poco
- gnar,..... ascen - - divi a re-gnar,..... accet - ta,accetta il
do - no, a-scendi-vi a re-gnar, Che tardi? Che tardi? Accet - ta il
20

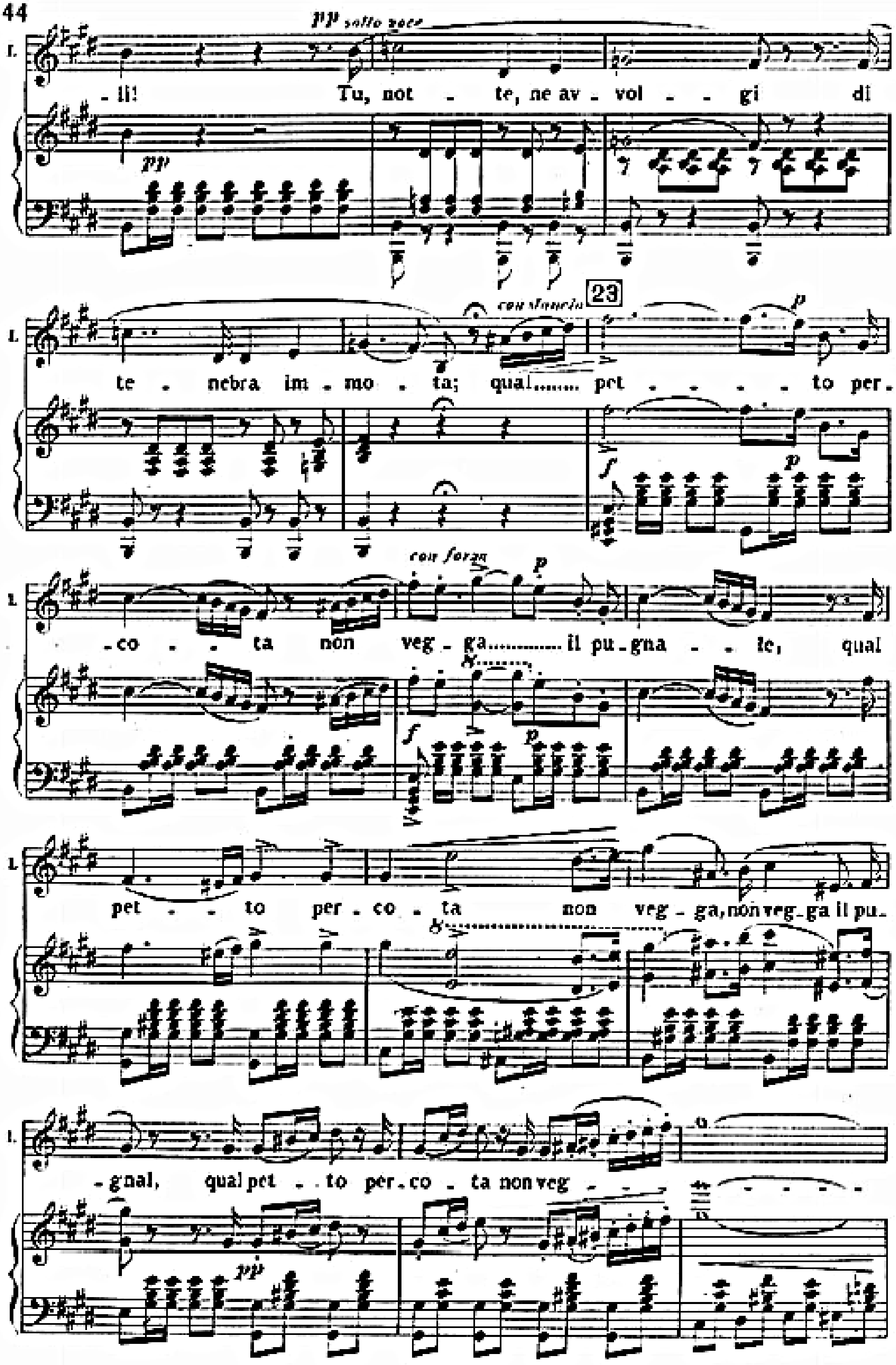

40
I.
do . . . no, a . scen . di, a . scen . di, a . scen . divi a re .
p
pp
. gnar. Che tar . di? Accetta il do . no, ascendivi a re . gnar. Che tar . di? Accetta il
ppp
I.
do . no, a . scen . . di . vi a re . gnar. Che tar . . . di? Che tar . .
f
ppp
I.
. di? Ah! ..... ascendivi a re . gnar.
ppp
42311


21 ALLEGRO ♩ = 96
p
(Entra un servo)
cres.
SERVO
p
LADY
Al ca_der del_la se_ra il re qui giun_ge. Che
f
p
L
SERVO
di'? Macbetto è se_co? Ei l'accom_pa:gna. La nuova, o donna, è
p
S
LADY. a piacere
cer_ta. Trovi acco_glienza quale un re..... si
f
col canto
42311

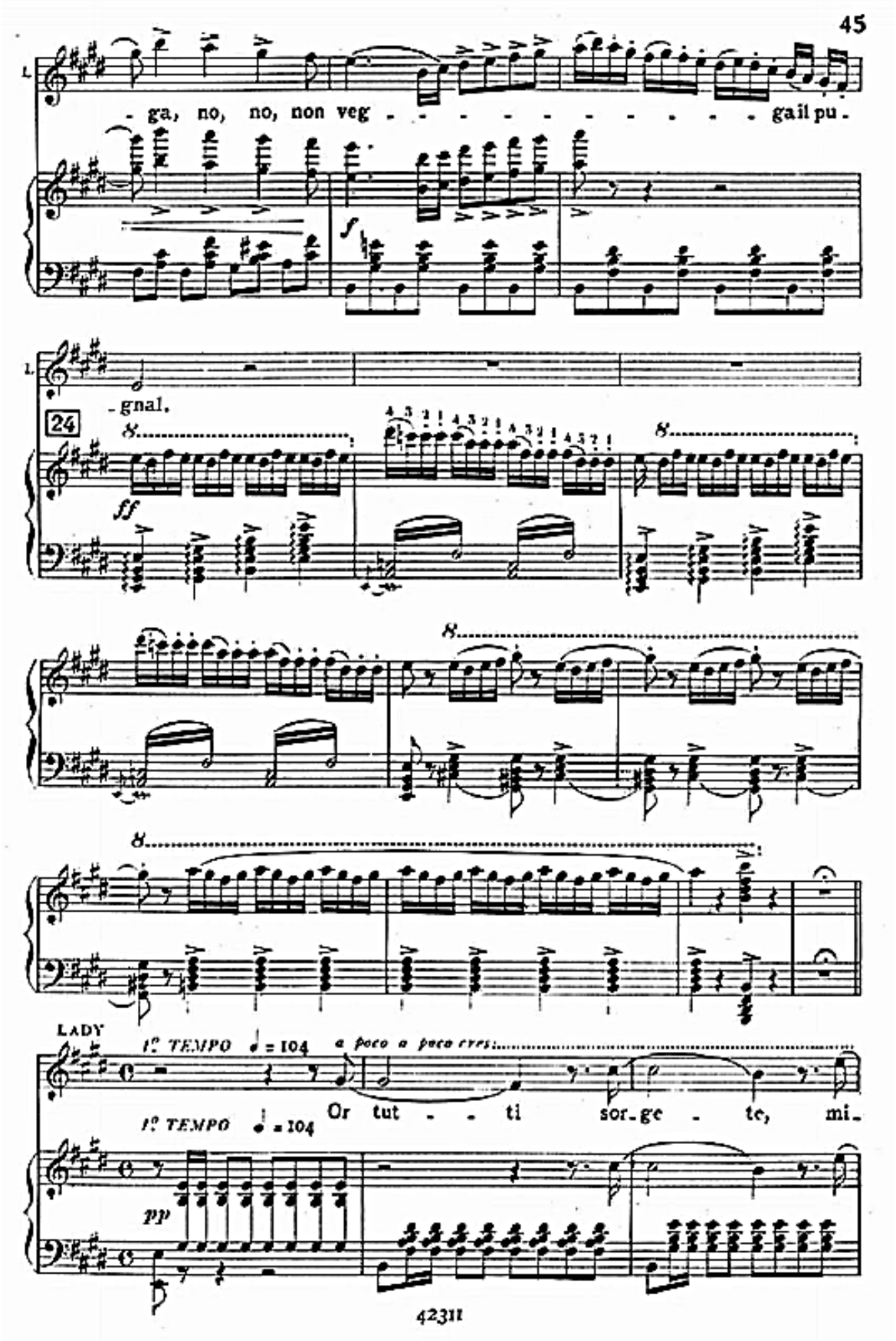

42
(il servo parte)
mer - ta.
22
a piacere
Dun - ca - no sa - rà qui?...
col canto
Qui?...
tutto forza
Qui la not -
- te?...
42311

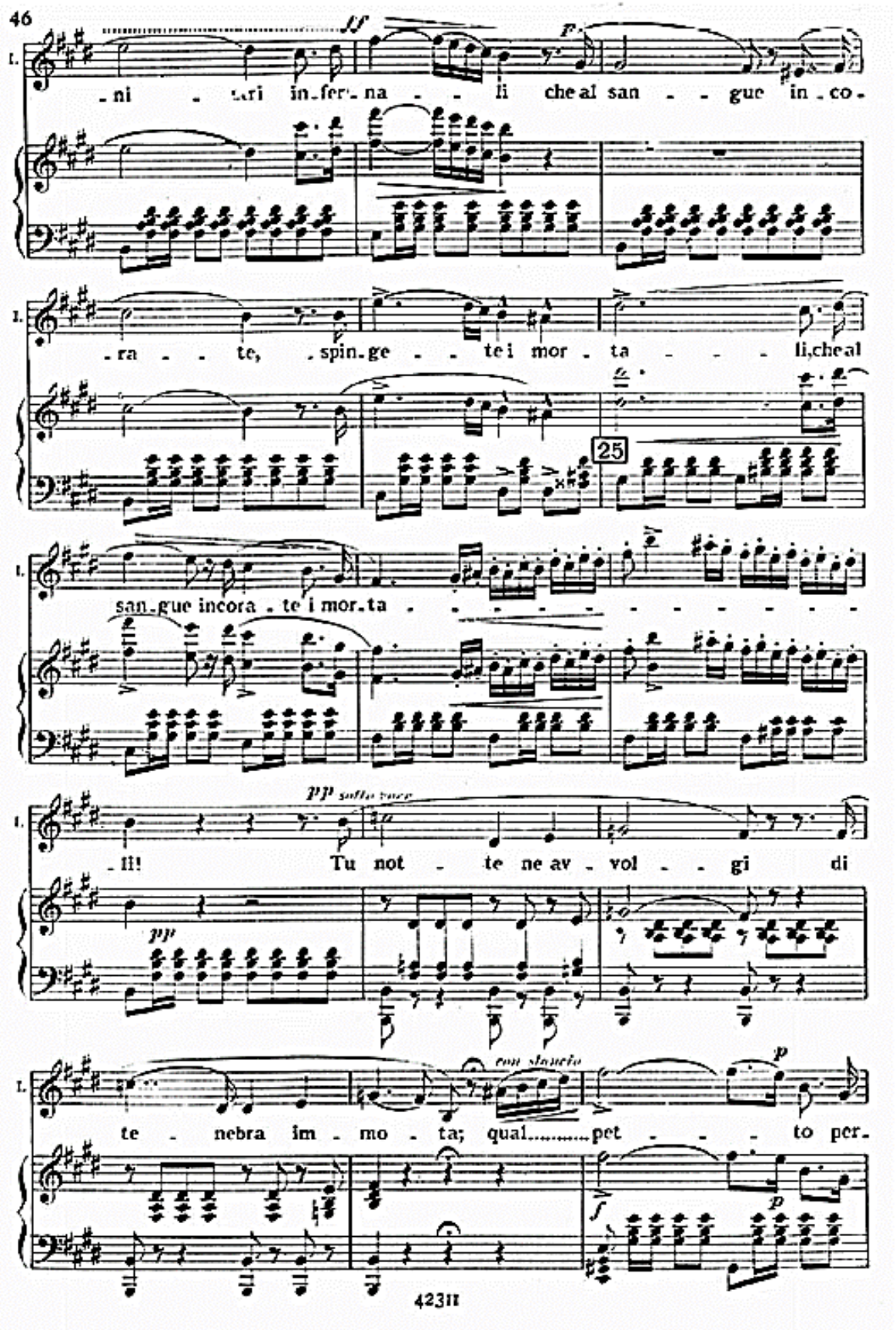

LADY ALL° MAESTOSO ♩=104 a poco a poco cres:
Or tut . . ti sor_ge . . te, mi.
ALL° MAESTOSO ♩=104
pp
ff
_ni _ stri in_fer_na . . li, che al san _ gue in_co.
_ra . . te, spin_ge . . te l' mor _ ta . . . . li, che al
sangue incora_te i mor_ta

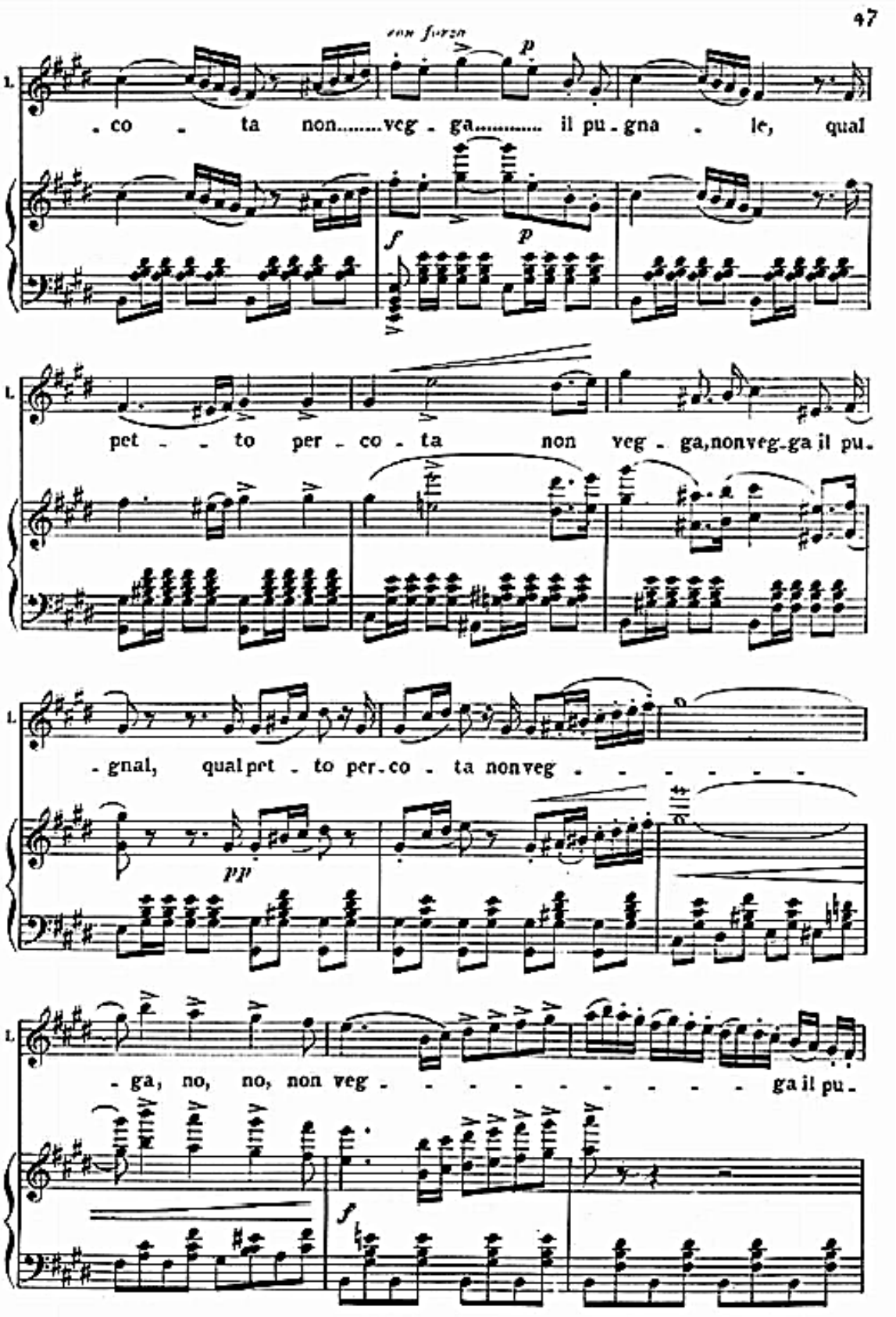
42311

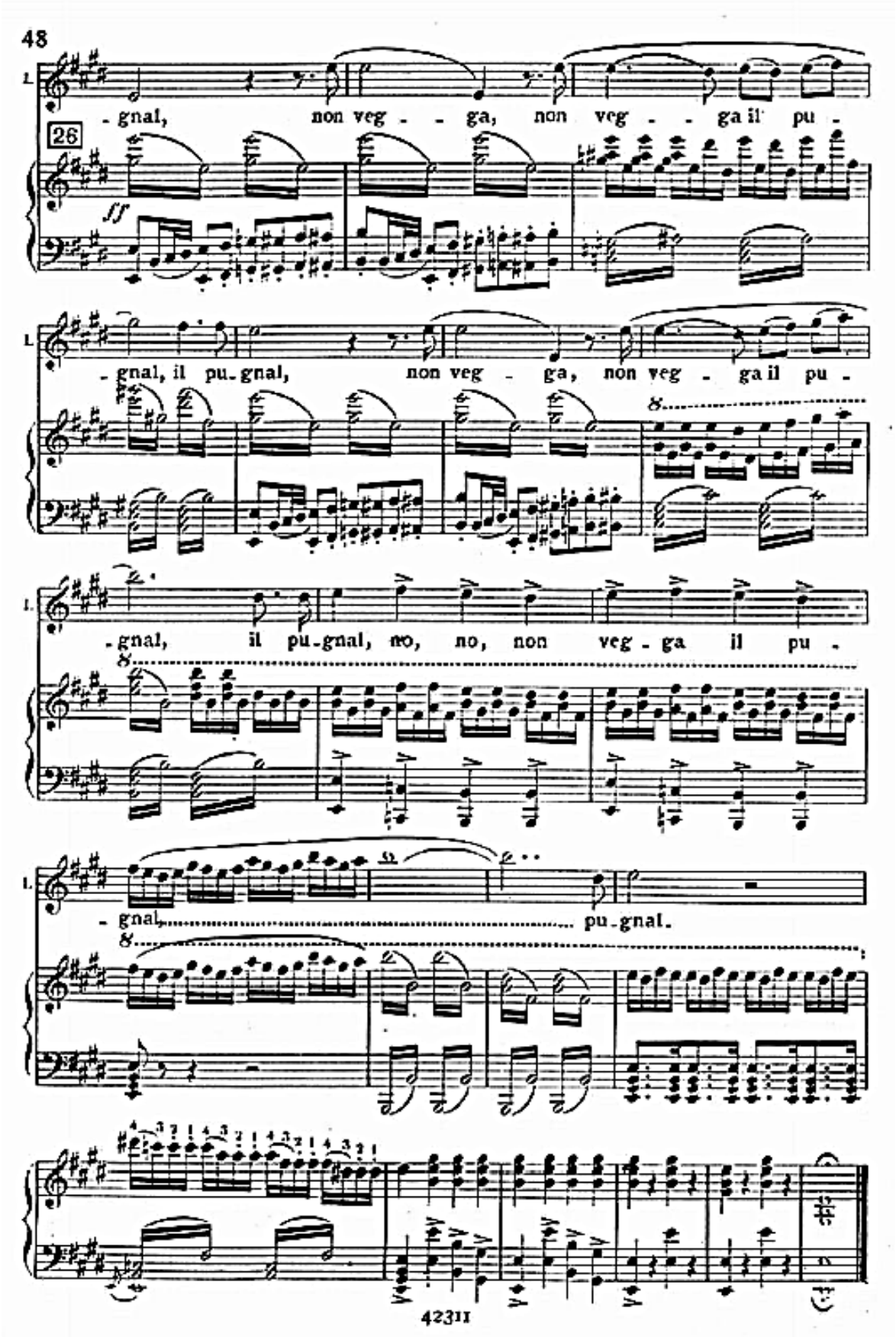

pp sotto voce
li! Tu, not - te, ne av - vol - - gi di
pp
con slancio
23
te - nebra im - mo - ta; qual....... pet - - - - - to per.
f
p
con forza
- co - - ta non veg - ga............ il pu - gna - - le, qual
pet - - to per - co - ta non veg - ga, non veg - ga il pu -
- gnal, qual pet - - to per - co - ta non veg - - - -

42311


L.
- ga, no, no, non veg - - - - - - - - - - gail pu -
L.
- gnal,
24
ff
LADY
1° TEMPO ♩ = 104
a poco a poco cres.
Or tut - - ti sor - ge - te, mi -
1° TEMPO ♩ = 104
pp
42311


46
ff
f
I.
-ni - tari in-fer-na - - li che al san - - gue in-co-
-ra - - te, spin-ge - - te i mor-ta - - - li, che al
25
san-gue incora-te i mor-ta - - - - - - - - -
pp sotto voce
-li! Tu not - te ne av-vol - - gi di
pp
con sfogato
p
te - nebra im-mo-ta; qual.....pet - - - to per-
f
p
42311


con forza
p
f
p
. co . ta non.....veg . ga..... il pu . gna . le, qual
pet . . to per . co . ta non veg . ga, nonveg . ga il pu .
. gnal, qualpet . to per . co . ta nonveg . . . . . .
pp
. ga, no, no, non veg . . . . . ga il pu .
f


48
L.
-gnal, non veg - - ga, non veg - - ga il pu -
26
ff
L.
-gnal, il pu-gnal, non veg - ga, non veg - ga il pu -
8
L.
-gnal, il pu-gnal, no, no, non veg-ga il pu -
8
L.
- gnal, pu-gnal.
8
42311