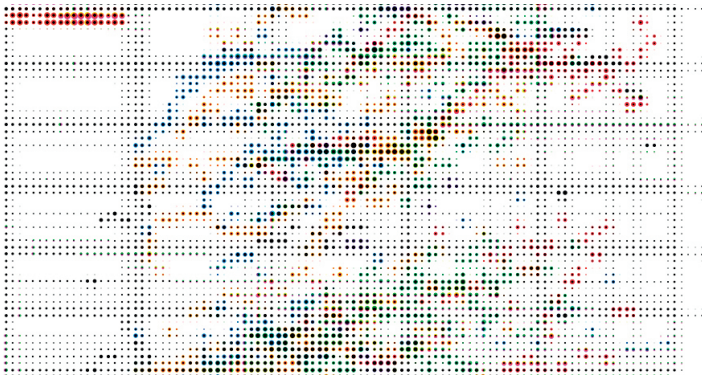
Voice Map Method

Enhancing Composer-Singer Communication

MIIKA HYYTIÄINEN



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Sibelius Academy of the University of the Arts Helsinki, 2022
EST 64

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Abstract

Communication issues often occur between singers and composers in the context of creating new vocal music. The Voice Map Method (VMM), developed here, facilitates more fluent communication and thus supports the artistic process. The VMM consists of two parts: a computer-aided Voice Map Analysis (VMA) and a questionnaire entitled List of Good Questions. This systematic process involves collecting information about a specific singer's voice; it reveals some of the most essential aspects of the singing voice, which is particularly beneficial to less experienced composers. During the VMA stage, the composer listens to the singer's voice, to get to know it acoustically. Afterwards, both parties read through the VMA together and proceed to discuss it.

The VMA is based on the Voice Range Profile (VRP), an analytical tool used in voice studies to efficiently collect numerical data on the voice. The result of the VMA, the Voice Map, reveals the possibilities of the singer's voice in visual form, indicating each area ('area' being analogous to 'register') and the dynamic range (range of sound pressure levels) of each tone. Lastly, the singer's formant is analysed automatically and the audio is stored for later reference.

Field tests involving different voice types validate the technical functionality of the VMA and optimise the analysis process. Nevertheless, since the VMM is designed to improve communication between artists, the ultimate testing and validation happens in the artistic context, in the form of composing three operas.

The development is iterative: questions arising from the artistic work are analysed against the theoretical background for creating a new version of the VMM. This is then used in a new artistic work. The development project is grounded in communication theory, collaborative creativity (as per Keith Sawyer), and the analysis of the composer's work. Furthermore, the voice studies provide a theoretical background for the vocal registers, singer's formant, vibrato, voice range profile, and the German Fach system. While the Fach system itself is a fundamental component of the opera industry, it is often misapplied outside of that context. Structural gaps in the standard training programmes cause inexperienced composers to resort to the Fach system in an uninformed way, often composing unidiomatically and too vaguely for a voice type.

Keywords
Communication, composer, contemporary music, fach, opera, soprano, vocal music, voice range profile

Tiivistelmä

Kun laulaja ja säveltäjä luovat uutta vokaalimusiikkia, on kommunikaatiossa usein haasteita. Voice Map Method (VMM) on menetelmä, joka tukee sujuvampaa kommunikaatiota ja siten auttaa myös taiteellisessa prosessissa. VMM koostuu kahdesta osasta: tietokoneavusteisesta analyysistä Voice Map Analysis (VMA) ja kysymyslistasta List of Good Questions. Tämä systemaattinen prosessi auttaa kokoamaan ja välittämään tietoa tietyn laulajan äänestä ja paljastaa sen tärkeitä ominaisuuksia, jotka ovat erityisen hyödyllisiä laulumusiikissa kokemattomalle säveltäjälle. VMA-prosessin aikana säveltäjä myös kuuntelee laulajan ääntä tutustuen siihen akustisesti. Myöhemmin molemmat osapuolet käyvät yhdessä läpi VMA:n tulokset ja jatkavat keskustelua sen pohjalta.

VMA perustuu analyyttiseen menetelmään nimeltä Voice Range Profile (VRP), jota logopediassa käytetään numeerisen datan tehokkaaseen keräämiseen äänestä. VMA:n tulos, Voice Map (äänikartta), näyttää laulajan äänen mahdollisuudet visuaalisessa muodossa. Kartta kuvaa äänen eri alueet (“alue”, ‘area’, on analoginen sanan “rekisteri” kanssa) ja jokaisen siihen kuuluvan äänen dynaamisia mahdollisuuksia (äänenpainetason ylä- ja alarajan). Lopuksi äänestä analysoidaan laulajan formanttia ja ääni tallennetaan mahdollista myöhempää tarkastelua varten.

VMA:a testattiin eri äänityyppejä edustavien laulajien kanssa, mikä vahvisti sen teknisen toimivuuden ja auttoi optimoimaan analyysiprosessin. Koska VMM on suunniteltu taiteilijoiden väliseen kommunikaatioon, voi lopullinen testaus kuitenkin tapahtua vain taiteellisessa kontekstissa. Menetelmää hyödynnettiin kolmen oopperan sävellystyössä.

Kehitystyö oli iteratiivista: taiteellisen työn herättämät kysymykset analysoitiin teoreettista viitekehystä vasten, mikä toimi innoittajana seuraavalla versiolle VMM:sta. Tätä puolestaan käytettiin uuden taiteellisen teoksen luomiseksi. Kehitystyön pohjana toimivat kommunikaatioteoriat, jaettu luovuus (collaborative creativity, Keith Sawyer) sekä säveltäjän työn analyysi. Lisäksi mukana on logopedian tarjoama teoreettinen pohja vokaalirekistereille, laulajan formantille, vibratolle ja VRP:lle. Fakkijärjestelmä taas on perustavanlaatuinen osa oopperateollisuutta, mutta toisissa konteksteissa sitä käytetään usein väärin. Koska säveltäjien peruskoulutuksessa on usein rakenteellisia aukkoja laulumusiikissa, he käyttävät fakkijärjestelmää tulkiten sitä väärin ja päätyvät säveltämään epäidiomaattisesti ja epämääräiselle äänityypille.

Hakusanat

Kommunikaatio, säveltäjä, nykymusiikki, fakki, ooppera, sopraano,. vokaalimusiikki, voice range profile

PREFACE

Acknowledgments

It takes a village to raise a child, make an opera, or finish a project like this. I am deeply grateful to each and every one of you.

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My friends and family, for showing me that between the maximum and minimum levels, things can be quite simple.

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Definitions and Abbreviations

Area, vocal area: A group of consecutive tones that are similar in timbre and laryngeal mechanism, as judged by the respective singer and composer. This term is applied in the Voice Map Method and relates to register.

Bel canto: A singing style originating in the 17th century that is associated with classical Western music, forming part of a singer's classical training.

Classically trained singer: A singer who has had substantial training in classical Western music and in bel canto, from a music conservatory or similar.

Equalisation: Manipulation of the singing voice to eliminate any differences in timbre in the different registers. Achieving the skill essential in bel canto is a time-consuming aspect of classical training.

Experimental music theatre: An aesthetically-focused group of transmedial pieces that combine music and other art forms in a very fundamental way.

Fach system: An elaborate system devised to categorise singers into different voice types, called Stimmfächer or simply Fächer, each with their designated singing parts.

Inexperienced composer: A person experienced or trained in composition but with limited experience of vocal music.

Laryngeal vibratory mechanism or voice mechanism: A specific glottal configuration associated with a register. Different mechanisms include M0 (vocal fry), M1 (modal), and M2 (head).

Max/MSP: A visual programming language that is especially effective in real-time analysis and manipulation of sound, used by many composers.

Opera industry: The socio-economic aspect of opera companies, associated with the globalisation of opera and dating from the 19th century.

Passaggio: The transitional area between registers.

Register, vogal register: A group of consecutive tones that are similar in timbre and laryngeal mechanism – used in vocal training and in voice studies. See also Area in VMM.

Singer's formant: The resonance frequency region (around 3 kHz) in a classically-trained singer's voice that has energy concentration and enhances the audibility through the orchestra.

Sound pressure level: An indication of the sound pressure relative to a reference value, measured in decibels (dB).

Virtual soprano: The mental image held by an inexperienced composer based only on the composer's interpretation of the Fach system.

Voice Map: The visualisation of the registers and the possibilities of an individual voice.

VMA: Voice Map Analysis, the structured process of creating a Voice Map. The VMA is based on the Voice Range Profile.

VMM: Voice Map Method, the subject of this study. Developed to enhance communication between singers and composers, it comprises the VMA and the List of Good Questions.

Voice Range Profile: A system of analysing the limitations of a voice — mainly used in voice studies.

Applied Studies programme – portfolio

This report forms part of the portfolio required for the doctoral degree in music, in the Applied Studies programme. It consists of a description of the development project and supporting appendices.

The portfolio comprises: this report, a software package for the Voice Map Analysis, and three opera compositions (Voice Box, Nomictic Solutions, and Voice is Voices). The development object is the Voice Map Method (VMM), which enhances communication between singers and composers, to enable the creation of new vocal music. The VMA software is available as a stand-alone patch and in full source code format. It is obtainable here: miika.info/VMM. Testing was done on MacOS (version 10.13), but the patch is also functional on other platforms running Max/MSP 4 or later.

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Part II Development

Part III Conclusions

Foreword

“Well, finally! We could certainly use something like that!” After repeatedly hearing this comment from singers about my idea for the project, I felt that the need for a communication-enhancing method was not only justified, but rather urgent. And so it came to pass, the Voice Map Method was developed.

Although the requirement was quite evident, creating a satisfactory solution was not easy. A multifaceted background of experience was needed. I’ve worked in a multidisciplinary way throughout my professional career, combining various roles: sometimes as a composer, sometimes as a director, and prior to that as a vocal performer. Singing in operas and music theatre were, indeed, the earliest experiences that led me to become an artist.

I was probably never cut out to be a professional opera singer. Still, understanding the processes operating in the singer's brain and body has helped me delve deeper into vocal music. The journey has been slow, and missteps occured. On the following pages, I am presenting cases where communications have been ineffective, and in several of those cases, the composer who chose the unsuccessful communication strategies was I. I’ve learned from my own mistakes and also those of others. Through the various productions, I made mental notes of the good tactics and less successful strategies in order to develop them further.

Contributing to the collection of information were my own studies in composition at the Universität der Künste Berlin, although (or because) the topic was not adequately addressed during the teaching process. Apparently vocal music is not a central subject at most universities, at least in Germany. In addition, the quality, length, and frequency of teaching vocal music varied considerably in the sparse number of workshops and projects that included vocal music. As my experience grew, singers wanted to work with me more and more, and I also consulted other composers. This

was encouraging, although admittedly, on some occasions I felt like an interpreter trying to create mental bridges between the different languages and ways of thinking. The technicality of reading complex contemporary scores and the physicality of the singer needed to be linked. The more I understood, the more I wanted to know, so to research the subject academically became an exciting option. I decided to develop my intuitive ideas into a structured method.

I have university degrees in composition and mathematics, and together these form the cornerstone of this project. The function of composition is probably obvious. During the development process, the needs of the composer and singer were prioritised above acoustical and voice science considerations. The function of mathematics may be less evident here. For me, mathematical thinking underlies the use of an abstracted map of the voice to establish a common ground between singers and composers, creating a Rosetta Stone of abstract data points. More concretely, calculus and physics were needed during the programming process and for interpreting the Voice Range Profile (VRP). For the latter, I utilised mathematics to best assist singers and composers. By analysing numerous cases beforehand, I could create a fluent method that obscures the mathematics. Dedicated experience was needed in order to determine which parts are not required for improving communication.

That multidisciplinarity continues throughout this report: the development project is by nature a combination of different artistic and research-based fields. These theories and my personal observations and experiences provide a fruitful environment for the development of the Voice Map Method. Being structured and systematised, it allows composers and singers to communicate smoothly and thereby able to concentrate on the artistic process.

Introduction

The body of the thesis is divided into three parts: Background, Development, Discussion. In Part I, the methodologies and themes are introduced. The main methodology of creating the VMM is 'iterative development'. It is divided into three phases, each consisting of theory, programming and artistic testing, with each phase forming a starting point for the next one.

The field testing consists of executing the VMM with 22 singers and recordings. The artistic testing, the main section of this report, contains numerous concrete examples of how the VMM enhances communication and has a strong effect on artistic decisions.

The artistic tests relate to three operas: *Voice Box*, *Nomictic Solutions*, and *Voice is Voices*, each in its own phase of development.

The theoretical aspect of this development project is derived from numerous sources. The most abstract of these being communication theory, Keith Sawyer's (2006) shared creativity theory, and an analysis of the composer's praxis. Complementary to those are the voice studies and vocal pedagogy theories that introduce the vocal register or area, the singer's formant and vibrato, the voice range profile, and the Fach system. The literature is reviewed in the respective sections.

In Part II, the actual development process is fully described, including programming the Voice Map Analysis software and the testing process.

In Part III, the results and future research paths are discussed.

The VMA software technical structure and VMM manual are appended.

I

Background

Part I Background

The main methodological apparatus, 'iterative development', has three branches: (1) artistic tests, (2) theoretical components, and (3) phases of the Voice Map Method (VMM) development including technical testing. Each branch affects the subsequent branch. The requirements of the artistic process are considered in relation to the theory, which provides solutions that become incorporated in the VMM. Testing it in the artistic context starts the next cycle. This spiralling structure creates a virtuous circle[1] that forces the VMM to assume its final shape. This is comparable to general software development processes, especially Agile Development (2.2), but the analysis software is only part of the actual development target, the VMM.

Presented in Chapters 3-9 are the theories or concepts that play a special role in the VMM: collaboration and communication from the composer's point of view; vocal register (4),singer's formant (5.1), and vibrato (5.2) derived from voice studies; and Voice Range Profile (VRP) as an analytical tool (7). The Fach system has an integral function in the opera industry, but can cause serious misunderstandings for inexperienced composers, which the VMM can help prevent (6). The various applications of the VRP are presented in section 7.3, elucidating the need for the VMM.

[1] A virtuous circle being the opposite of a vicious circle.

1 Motivation

There is a lot of evidence of unsatisfactory communication between composers and singers. And a lot of it is merely anecdotal. Nevertheless, more structural communication deficiencies can be found, such as those coming from the educational system and social hierarchies. Chapter 1 provides descriptions of real cases that reveal the arc of successful and less successful communications. There's also a practical description of the Voice Map Method (VMM) that takes the accumulated information into account when creating an efficient strategy for adoption by inexperienced composers and others.

1.1 Composers and singers

To re-emphasise, the deep gaps in communication between singers and composers have been building, especially since the Second World War. There are very few written examples, some of which are covered in sections 3.2: Composer's education, and 6.2: Virtual soprano. To further elucidate, I present a collection of cases witnessed over time in different contexts. All the composers and singers included here are professionals or in the final stage of their studies. The singers were either purely classically trained or trained in a mixture of classical and other styles.

These singers are talented in their field; the difficulties described here are not the fault of the individuals but of the weaknesses in higher education and social structures. Hence, these case studies provide an appropriate starting point for my development project. The anonymity of the artists is maintained by leaving out or slightly altering the inessential details.

Case 1: Composing for a virtual soprano
The composer finished the composition for voice and a small ensemble of instruments. Although experienced in instrumental and electronic music, this was their first sizable vocal piece. The music was idiomatic for the instruments and the composer was well aware of their possibilities (i.e. the multiphonic fingering for alto flute). The vocal component, on the other hand, was written for 'a soprano'; the composer explained that they didn't want to limit themselves by writing too specifically for a particular singer. During the rehearsals, it was quickly deduced that the vocal part was unidiomatic and created a lot of unnecessary stress for the singer premiering the piece. The composer and singer were somewhat unsatisfied with the premiere and blamed each other.

Remarks: This is an archetypal communication problem and precisely what this project aims to alleviate. I have chosen to call this working method 'composing for a virtual soprano'. The inexperienced composer had a mental image of how the Fach system and human voice work, and composed the piece using that faulty and insufficient information as a basis. A composer writing a piece without knowing who will actually sing it, signifies to me a total lack of communication; one part (the composer) doesn't even acknowledge the existence of the other (the singer).

Solution: The inexperienced composer should have recognized their need to better understand the voice as well as the voice of the specific singer who would be premiering the piece. Tailor-made compositions would have ensured a successful premiere as well as further performances by singers with similar voices to that of the original singer. Music composed for a virtual soprano, on the other hand, tends to be unsatisfying for all concerned. Once the need for communication is accepted, the process can be effectively supported by the VMM.
This communicational deficiency is further analysed in Chapter 6, section 6.2: Virtual soprano.

Case 2: A soprano is a soprano
The composer took part in a workshop, writing a piece for an instrumental ensemble and a singer. This composer already had some experience of vocal music. They were informed that the singer has a soprano voice ranging all the way up to C6. The composer prepared for this work by listening to recordings of a second singer, another soprano, which should have been a useful reference. Both singers were experienced interpreters of contemporary vocal music, but the first singer was a lyric soprano and the second a lyric coloratura soprano. In a recording, the second singer sang the high C6 tone senza vibrato and pianissimo; the composer liked it and used something similar in the workshop composition. During the rehearsals it became evident that the first singer, the lyric soprano, couldn't produce

the tone as hoped, so the premiere was not satisfactory. Later on, a third singer, a lyric coloratura soprano, performed the piece and the tones turned out well. The composer assumed that the first singer wasn't a real soprano or that they had problems with their technique; that a 'true soprano' should have been able to do what the others did.

Remarks: The composer already had some understanding of the human voice but failed to see the subtle differences between the individual voices. Here, the vocal effect that inspired the composer is rare and is not easy for most sopranos to achieve. This composer wanted to understand the voice but was confused by the Fach, using it without sufficiently understanding it.

Solution: A short discussion before composing would have saved a lot of trouble. Had the composer better understood the possibilities of the specific voice, they would have been able to create something totally new instead of basing their music on pre-existing ideas that have limitations.
Proper use and limitations of the systems are discussed in Chapter 6: Fach system.

Case 3: Voice type in the context of the opera house
An experienced composer and vocal performer obtained a commission from an opera company. The vocal soloists for the production were chosen by the company and the composer didn't meet or communicate with them before the rehearsals. In official communications (i.e. contracts and marketing), the singers were only referenced very generally by voice type (bass, soprano, and so on). During the first rehearsals, the composer casually mentioned, as a side note, that the voices of the singers would be amplified throughout the piece and that they would be singing much of the time without vibrato or with very specific timbres. This turned out to be difficult for some of the singers, since they had rather dramatic voices and vibratos. A lot of rehearsal time was spent in achieving the right balance between the singers and instruments. Although the final result was successful, communications between the composer and singers were initially somewhat disrupted, since some of the singers felt that the use of vibrato was a personal thing that can't just be switched on and off like a light switch.

Remarks: The composer was very used to working with different voices, but didn't have much experience of working in the opera industry, with all the hidden information that the word 'soprano', etc. could carry. Communications between the composer and the institution were also flawed.

Solution: If the composer had informed the singers of the circumstances, the singers could have already trained these new skills before the official rehearsals. If the composer had been informed about the dramatic character of each particular voice, they could have considered this more advantageously in the piece. The composer could have also taken more time to communicate the delicate question of vibrato more discreetly beforehand rather than during the first rehearsals.
This Case is better contextualised in Chapter 3: Communication theories.

Case 4: Notating the vibrato
Here I was the composer, and already experienced in vocal music. I wrote a lengthy vocal piece and had familiarised myself with the singer's voice. The rehearsals began smoothly, but sometime later the singer wanted us to discuss the score. They didn't feel comfortable with the way I had notated the vibrato, with its rapid, often virtuosic changes between extremes (*senza* and *molto vibrato*). They felt it didn't reflect the vibrato in their vocal technique.

Remarks: It is useful to discuss the question of vibrato in detail, since it is personal to the singer and is highly dependent on the musical context, such as the register and the dynamic. Often, singers seem to feel that it is part of their body or identity, and finding their natural vibrato is an inevitable part of their studies.

Solution: For some of the musical sections, we agreed on mental images or colours (i.e. thin, or like a boy soprano) to create the effect I had originally notated as *senza vibrato.*
Different singers prefer different kinds of communication, different words and different notation. Some like to work very technically and prefer to have the vibrato written in a straightforward way, they tend to be the new music specialists. Singers with a more traditional background usually prefer a more poetic form of communication. This is highly individual and the musical results of both groups can be extremely successful.
See Chapter 6: Communication theories and section 5.2: Vibrato

Case 5: Voice is not part of the instrumentation
In an orchestration seminar for composition students, the work discussed was *Offrandes* (1921) by Edgard Varése (1883–1965) for chamber orchestra and soprano. During the analysis, the balance between the individual instruments and the registration of those instruments was discussed in detail, as always, but the vocal component was not mentioned until I enquired about it. The part was mainly written idiomatically for a lyric coloratura soprano voice, but some phrases seemed to

require a more dramatic voice. The professor of orchestration chose not to continue the discussion, apparently not finding the theme suitable for the seminar.

Remarks: At present, vocal music is not part of the study of orchestration in composition students' curricula, and maybe it shouldn't be. But then, where should it be? I didn't come across a single European programme on Western Art Music composition that provides a structured and systematic education for voice and vocal music. Only in some highly varying workshops did composers and singers collaborate to create new vocal music. A student might graduate from university as a composer without having had any formal studies on the principles of the human voice, or having spoken to a singer about their voice, or having composed any vocal music. The study of instruments and orchestration, however, are still obvious components of compositional studies.
This is discussed in detail in Chapter 3, section 3.4.: Composer's education.

Solution: The professor of orchestration probably wasn't wrong in thinking that voice types are too complex to be handled as a short detour. Also, most modern orchestration manuals don't mention the voice. Composing for voice is probably better learned as praxis, since the standardisation of instruments does not apply to singers' bodies. Structured workshops with theory and practical collaboration might be the best solution.
See Chapter 3, section 3.4: Composer's education; and Chapter 11, section 11.4: Further development.

The above cases are about the communication between composer and singer. Sometimes difficulties arise due to the use of the Fach system, not so much in the opera industry, where it is inbuilt, but in the context of contemporary music. Cases 6, 7, and 8 below, illustrate those kinds of difficulties.

Case 6: Looking for a singer in a sea of sopranos
Together with a team, I organised a university concert which was to include some vocal music by Morton Feldman (1926–1987) and we needed to find singers. The vocal parts were written for voice without any Voice type indicated, so when we approached the vocal classes for performers, we didn't mention any. As a result, few candidates came forward, since both the students and their professors thought the music wasn't suitable for them or that music without *Fach* isn't proper vocal music.

Remarks: Morton Feldman's vocal music is very specific, he often wrote for voice just as he did for instruments. On some occasions, the score only calls for 'voice', [*Voices and Cello* (1973) for two female voices and cello], but when necessary, it also specifies the voice types [*The O'Hara Songs* (1962) for bass-baritone, chimes, piano, violin, viola and cello].

Solution: I contacted the professors separately and explained the situation. The singers that performed the pieces had lyric voices and were, indeed, from different *Fächer*, one of them having been trained in jazz vocals. It is helpful to understand that the singers are accustomed to using the Fach system, although it may not be optimal for the inexperienced composer.
See Chapter 6: Fach system.

Case 7: Disguising the Fach
The Fach system can also create a lot of problems for the singers if they mainly perform contemporary or very early music. With the permission of the singer, this case isn't anonymised. It is further discussed in Chapter 10, section 10.2: *Nomictic Solutions*. For the Münchener Biennale, I was to compose an operatic role for Martina Koppelstetter. While studying her web page, I noticed she called herself a mezzo-soprano, and that she also had a remarkable repertoire of Baroque parts and contemporary premieres under her belt[2].
When we applied the VMM, it was clear that her voice was much deeper than that of a mezzo-soprano. Koppelstetter explained that although this label doesn't really feel natural, it is difficult to work in the opera industry as a contralto, thus the decision to call herself a mezzo-soprano.

Remark: It is somehow striking that Koppelstetter, who created an exceptionally good niche for herself, still has to disguise her voice type. This could also have wider consequences. Had I followed her written words, the role of the press officer in the opera *Nomictic Solutions* would have been marked as a mezzo-soprano and, later on, an opera company might have tried to recast a mezzo-soprano for this role — with catastrophic results.

Solution: After our discussion and once the production was finished, Koppelstetter decided to change the description of her voice on her web page (Martina Koppelstetter's web page, 2017 and 2022.) into *Altistin*, or contralto. The score of *Nomictic Solutions* doesn't name the *Fach* of the singers.

[2] Most of the music was composed either for her specific voice or before the development of the Fach system.

See Chapter 10, section 10.2: Artistic testing Phase II: Nomictic Solutions.

Case 8: A seasoned composer rewrites everything to surpass the Fach
György Kurtág's (1926–) first opera, *Samuel Beckett: Fin de partie* (2018), was highly awaited pieces by this acclaimed composer. Excitement was heightened by the numerous changes of its premiere date. Kurtág is known for his uncompromising attention to detail, which made the compositional process for this two-hour-long piece intensive (Woolfe 2018). In a short interview with musical assistant Sándor Szabolcs, I was informed that the Fach system is not nearly detailed enough for the composer's needs. At the beginning of the compositional process, he had written the opera for four singers of certain Fächer (presumably bass-baritone, baritone, contralto, and tenor buffo). After some years, the opera companies that were organising the premiere agreed on who the singers of the piece would be. Kurtág rewrote everything, this time specifically for the voices of Frode Olsen, Leigh Melrose, Hilary Summers and Leonardo Cortellazzi (Sándor Szabolcs, personal communication, 6.5.2019).

Remarks: György Kurtág's oeuvre maintains a wide range of vocal music and his composition for, say, a tenor buffo, was based on extensive experience of how the human voice works. Furthermore, whatever demands he would have decided to set for the voices, the opera companies surely would have been willing to find performers to fill them. And even still, the 92-year-old composer humbly decided to use the actual voices as the foundation of his composition.

Solution: This working method demonstrates the problems that arise from the opera industry's undue trust in the Fach system. For Kurtág, the composer's artistic decisions are stronger and deeper than the practical needs of the industry.
See Chapter 6, section 6.3: Composing for a particular singer.

1.2 Voice Map Method

The experiences referenced in the previous section motivated me to create the Voice Map Method (VMM). It is devised to help a classically trained opera singer and composer communicate with each other during the process of creating new vocal music. The needs of composers with little experience of vocal music are especially considered. This enables them to better understand the singing voice in general as well as the voice of this specific singer, although the latter is also applicable to all

composers. The VMM enhances communication throughout the creative process, but especially at the beginning stages. The VMM is briefly discussed here to give the reader enough information to proceed. Further details concerning the process can be found in the manual, Appendix 2.

First, the voice is measured in the Voice Map Analysis (VMA). This measurement is not any more demanding for the singer than a very thorough vocal warm-up using a microphone. During the process, the singer first names their vocal areas and then sings each tone, as softly and as loudly as possible but still within aesthetically acceptable parameters. These are recorded and analysed by the software. The results, charted on a graph (the Voice Map), illustrate certain aspects of the voice: the different areas, range, dynamic possibilities, and singer's formant. Thereafter, the singer and composer discuss the results, taking the List of Good Questions as their starting point. The Voice Map Analysis has a systematic nature, which makes it psychologically easier to go through the entire voice. The analysis proceeds and addresses each area without the singer or the composer having to make further choices. Voice is analysed in short sequences or individual tones, in order to provide a musically neutral context.[3] Approximately two hours is required to complete the VMM process.The communication enhanced by the method functions on many different levels. On the one hand, it includes a discussion between the singer and the composer; on the other hand, and more importantly, it involves the composer listening to the singer's voice. The composer observes the different timbres of the areas and the effort the tones require.

The VMM is designed as an aesthetically neutral tool, so as not to influence the composer's or singer's choice. It is purely up to each of them to decide how to employ the information gained through the VMM. The use of purely musical material, such

[3] The singer may choose the sequence they feel most comfortable with and in theory, even use of different scales is possible in future versions.

as existing compositions, would affect the artistic ideas aesthetically; they might, for example, cause the music to be composed along or against existing idioms. This could easily distract the composer from the singer's voice by concentrating too much on the 'music making' of the singer. Musicianship is an important part of the composer' input — a singer is never just a voice, but voice is the aspect that the composer has the least knowledge of and where the VMM can provide the most help. The singer needs to maintain control of their voice and be able to name their vocal areas, but other than that, their singing technique or style is not limited. To achieve the widest variation of range and dynamic in the analysis material, the singers who were selected to take part in the development and testing had all been classically trained. The underlying social structures which could potentially affect communications are discussed in chapter 8: From Voice Range Profile to Voice Map Analysis.

Case 9 [**hypothetical**]**: An experienced composer learns about a specific voice**
The composer already had considerable experience in working with different kinds of singers. They now wanted to create a piece for a singer who had been classically trained and was experienced in jazz. When using the VMM, the singer stated that their voice has three areas. Based on the VMM, the composer learned different things: that each area had complex natural colours, and that when the singer sang the highest notes of the second area, they had to use a lot of energy and their body tensed up. The singer mentioned that the notes in question were especially demanding for their voice, but slightly higher notes were easier even though they have a different timbre. The composer could then use this information, avoiding those difficult notes and applying them only for a specific effect. In addition, the natural timbre of each area could be used for compositional purposes.

Remarks: An inexperienced composer would have discovered other information about the voice, such as the use of vowels and text, areas, breathing, and so on. An experienced composer would already be aware of this information.

2 Methodology

This development project utilises methodologies that are different from those of classical research projects. The process can be described as 'iterative development' because it is based on iterating the material cyclically.

2.1 Iterative development

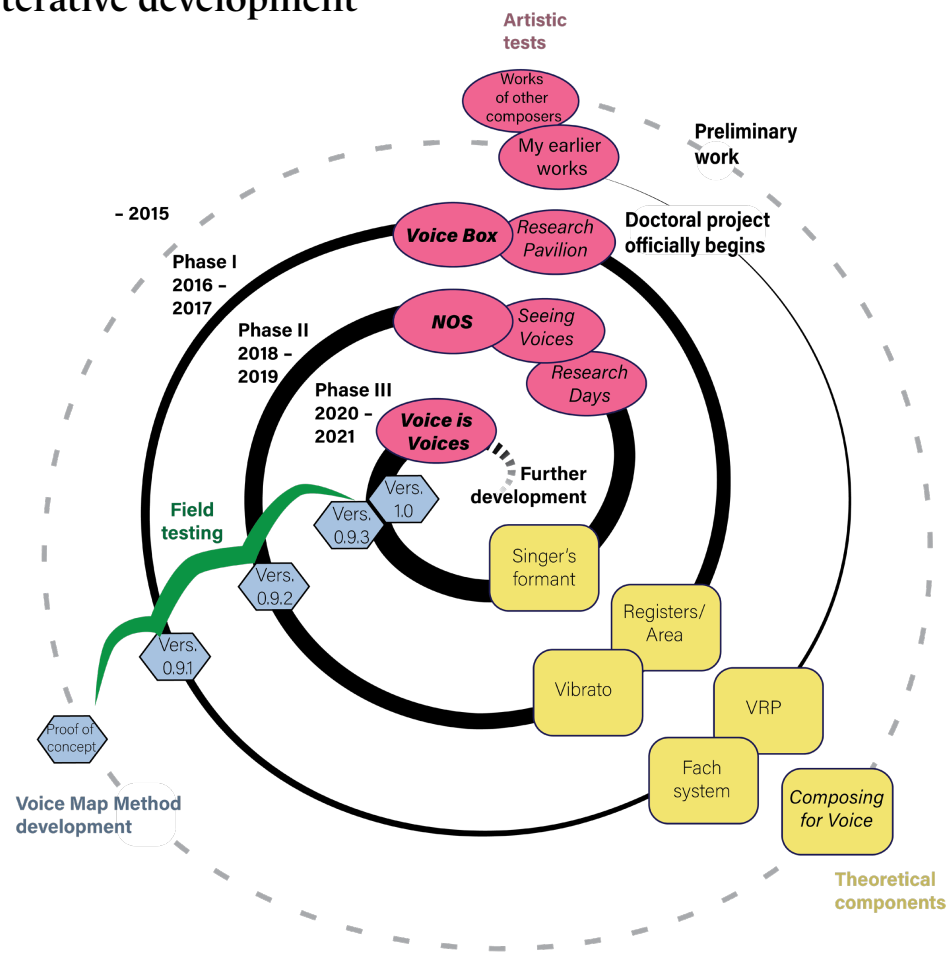


Figure 1. Spiral of the iterative development process

This spiral shows a circle of development, with the three branches being: artistic tests (red), theoretical components (yellow), and VMM development (blue). The

process recognises the challenge arising from the artistic work, paraphrasing it in the scientific context and then adding the solution to the subsequent version of the VMM. This is then used for the next, more ambitious cycle that creates new, more specific, detailed questions.

Artistic testing (red) comprises of musical works contained in the project portfolio (*Voice Box, NOS,* and *Voice is Voices*), as well as independent academic tests that were inspired and created using the VMM but were not evaluated by the jury (the lecture and presentation at the Venice Research Pavilion, *Seeing Voices* in Darmstadt, and a lecture and demonstration at the SibA Research Days in Helsinki). I was already motivated before the development process officially started, based on the experience gained from my own artistic work and the projects I followed closely.
See chapter 10: Artistic testing.

The theoretical components (in yellow) consist mainly of vocal pedagogy concepts and voice studies, and can be categorised into four themes: Voice Range Profile, vibrato, vocal register, and singer's formant. The Fach system remains integral to the opera industry; hence, it also forms part of the classical training of vocalists. This became a revealing but often challenging reference point during the study. Preliminary written sources included *Composing for Voice* (Parker and Huesca, 2018), which provided some initial ideas that supported my own notions regarding the right direction to pursue. *Komponieren f*ür Stimme (Mösch, 2017) revealed a fuller picture, allowing me to identify more precisely the occasions when the Fach system was functional and when it was limiting.
See chapters 4 to 6.

The phases of VMM (blue) development began with informal testing, by marking down the singer's registers and dynamics, then going to the first functional version (0.9.1) that was used to help compose the *Voice Box*, and on to the published version

(1.0). This is connected with artistic testing and field testing. The latter is an important and time-consuming segment that included 22 singers. The field testing had two main functions: to make sure the software worked with different voices, and that the technical set-up was practical. Each version of the VMM and the technical testing also included the instructions given to the singer in the analysis situation. In creating the VMM, I had to answer a myriad of small but significant questions, such as: what should the distance between the singer and the microphone be, how long should each note be sung, should there be a legato between the notes, what vowel should it be, and so forth.

See chapter 9, Technical Testing.

2.2 Tool versus method

The complete VMM includes:

- VMA software
- VMA instructions, how the software is used and how the resulting Voice Map should be interpreted
- List of Good Questions, which also gives structure to the artistic process by deepening communications over the course of time

Although the Voice Map Analysis software is a prominent component, it only forms one aspect of the whole process.

The philosophy underlying these components implies certain justified presuppositions about the development project. New vocal music is enhanced by the composer learning about the human voice (for inexperienced composers) and about the particular singer's voice (for all composers), as well as by effective communication

and collaboration between the composer and the singer.

Here, the term 'tool' means "a device used in the performance of a task" (Merriam-Webster online 'Tool'). The tools are the VMA and VMA software. The method is "a systematic procedure, technique, or mode of inquiry employed by or proper to a particular discipline or art" (Merriam-Webster online, 'Method'), and here it applies to the VMM. Tools can exist as independent physical items or software, whereas methods often require different tools and training to implement. I refer to three cases, ranging from an autonomous, straightforward tool to a sophisticated method: the clock on a mobile phone, Google Docs software, and the Rorschach inkblot test.

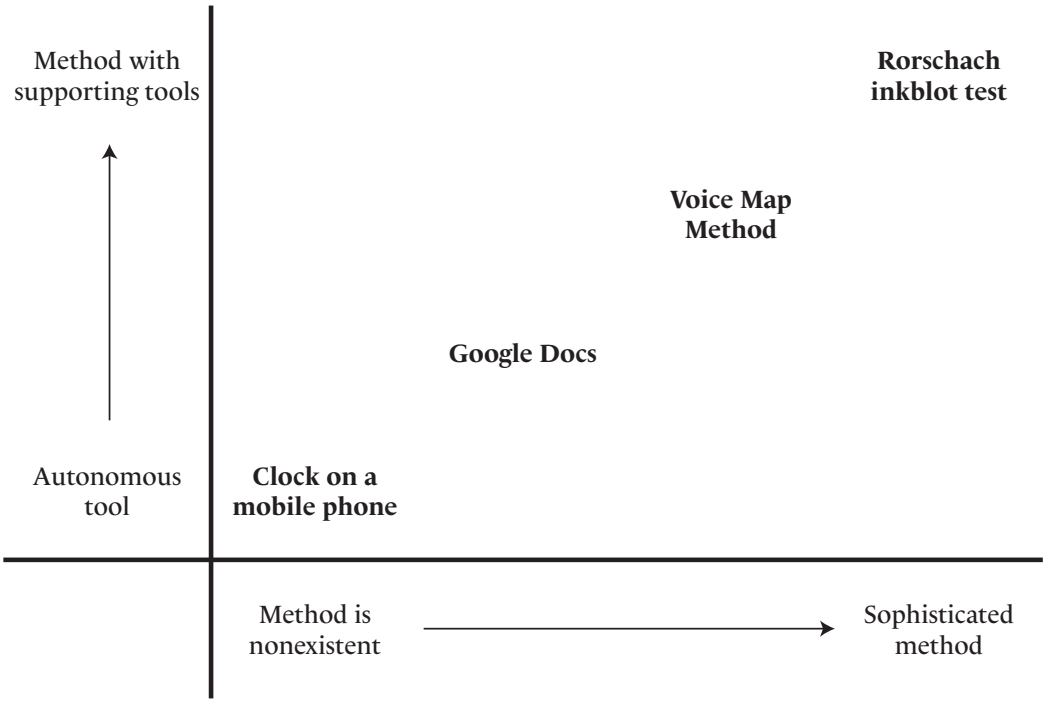


Table 1. Relationship between tool and method

The clock as an autonomous tool

The clock on a mobile phone is a small piece of software. It is designed to be so intuitive that mobile phone users don't realise that they are interacting with software.

The clock is an autonomous tool on a mobile platform and doesn't require any training or understanding, apart from knowing how to tell the time.

Google Docs as a tool serves different methods

In many ways, Google Docs is similar to other word processing software, the most novel feature being the possibility for people to work online simultaneously. Given the limits of word processing, the program can be used for a love letter to a research article. Some technical decisions might elicit certain approaches, but an application that is used by so many people needs to be easy to use and adaptable to different writing styles. Very little training is needed to use a word processor, and when mastered, the software is barely noticeable (Hamburger, 2013 theverge.com).

The Rorschach inkblot test — a method supported by a tool

Swiss psychiatrist Hermann Rorschach (1885–1922) had his patients play a game of free association, Klecksography. He noticed that the answers given by the participants could be used to form a diagnosis. He tested the hypothesis statistically, and as part of the process created a tool: ten carefully-selected plates containing random inkblots (Weiner and Greene, 2017, 312–313). Although the name of the test is famous for these iconic images, the actual method lies somewhere else; namely, in the elaborate system of recording different aspects of the person's means of communication, and then analysing them. The test was designed for use by highly trained medical specialists, which makes it quite different from the aforementioned tools (Ibid., 316–368).

The process of using the VMM is much closer to that of the Rorschach test than that of the clock. Randomly experimenting with the VMA software could probably create some surprising or inspiring results, but the VMM, when applied with a solid understanding of what is happening and why, goes deeper than this. At a metaphorical level, the theme of interpretation is significant for the Rorschach test and the VMM.

The test data needs to be analysed before it can be used. The data is collected in different formats, and its organisation is systematic and straightforward. The VMM is designed to be read by composers and singers, who come to the analysis equipped with a very special set of skills. I have taken these into account in the design of the application, with supplementary information provided in the manual.

Although this division between tool and method should not be underestimated, the structure of the VMM development process parallels that of the software development processes, especially the principles of Agile Development and Lean Architecture, two trends in software development.

Agility comes from quickly reacting to ideas, potentialities and problems that are met in the process, using collective planning and keeping the documentation as light as possible. The goal is not to provide generalised solutions but ones that function in this situation (Coplien and Bjønvig, 2010, 6–8). Usually, processes like this should, in the early stages, focus on designing an overall system architecture and develop functional demos (Ibid. Sommerville 2016, 168). Over the years, the term 'agility' has come to mean many things, and somewhat paradoxically, this documentation-minimising principle has been a subject of multitude academic writings (Koi-Akrofi, et al., 2019).

This sits well with my development project and with the principles of the VMM, all of which concern collaboration and communication. In the analysis situation, the singers often informed me as to whether or not the introduction was clear and the tasks comfortable. Also, one of the items in the List of Good Questions is "Can you recognise your voice in the Voice Map Analysis?". It is far more constructive to let the VMM assist the singer and composer in communicating, rather than to

assign absolute values that wouldn't necessarily help them communicate.[4] The early development project was strongly dependent on creating demos, often rough ones, that could be easily tested on the singers.

For academic purposes, detailed documentation was needed, which is not very agile. Also, some later phases of programming the software were slower than hoped and some agility was lost during production. (ibid., 5; Coplien and Bjørnvig, 2010).

Lean Architecture can be described in economic terms, whereby "the primary focus is the enterprise value stream" (Coplien and Bjørnvig, 2010, 1–4). Production is effective and inexpensive when the focus is on the final product. The different steps are then completed on time, not having to wait for the other parts to be prepared and for the production documentation to catch up. One of the key elements of Lean Architecture is involving people from all layers, regardless of hierarchy, especially at the beginning of the process.

In the case of VMM development, the need for Lean Architecture principles didn't come from the demands of stockholders but from the reality of a grant-financed doctoral project. Effective time management, in particular, was evident in the first iteration. Creating the first functional version of the VMA software, analysing Mia Heikkinen's voice, and proceeding onto the artistic project of *Voice Box*, took less than eight months.

'All hands on deck' adequately describes this mode of production. Composer-programmer Hadas Pe'ery was the other half of the core team. Designing the software architecture and user interface were accomplished with equal effort, but Pe'ery did the lion's share of programming. The roles were mixed and the hierarchies flat: I was

[4] Areas are a good example of this. A singer giving poetic names to seven different areas of their voice is much more inspiring for the composer than factual names based on those from singing lessons.

the main developer and technical and artistic tester. As Pe'ery is a trained composer, it was fitting that she should do the micro testing and comment on the practicality of the information while programming. Also, the singers who took part in the analysis were involved in different aspects. They gave feedback on the practical part of the analysis process, provided auditory data for the technical tests, and commented on the matters they thought important for effective communication.

2.3 Secondary methodologies

Due to the interdisciplinary nature of the work, adaptations of numerous other methods were applied over the course of this study.

Methodologies of the natural sciences and clinical research

The nature of the VMA software makes these methods necessary. The software analyses, categorises and stores audio data digitally. The program was initially based on the Voice Range Profile (VRP), so it had to be enhanced with statistical methods such as those that are usually used for creating and analysing a VRP in the context of the voice studies (see Chapter 7). Part of this involved understanding the systems that voice scientists use, in order to validate the analysis situation clinically and academically. My interdisciplinary background provided me with techniques that allowed me to readily distinguish the necessary and unnecessary parts of those statistical methods for the purposes of the VMM. This work wasn't as much about creating new mathematical systems as about streamlining the existing ones to achieve the final VMA software.

See Chapter 5: Singer's formant; Chapter 6: Voice Range Profile; Chapter 7: Other existing applications; and Chapter 8: Programming.

Communication analysis

Communication is one of the fundamental themes of this study, and therefore requires some kind of methodological apparatus. An explicit discourse analysis based on questionnaires or following communications during the artistic process, would not have been achievable in the context of this study. Instead, I have examined the cases found in the literature and those I've witnessed myself. One of the most striking problems was that inexperienced composers and singers didn't communicate at all. Often, misconceptions about the Fach system and the human voice lay behind these situations.

Some of the more successful communication strategies are reflected in Keith Sawyer's (2006) theories of collaborative creativity that represent a more abstract level of collaboration in art.

See Chapter 3: Communication and collaboration.

Autoethnography

The final and most crucial part of evaluating the effectiveness of the VMM lies in the artistic testing. Utilising some autoethnographic methods allowed me to assemble the discussions, the use of the VMM, and the compositional phases, as well as to critically analyse them. Autoethnography emphasises personal experience, familiarity with the theme, and the value of insider knowledge (Ellis and Adams, 2014, 254–76).

Qualitative methods

The different areas of field research have also affected this study in other ways. The List of Good Questions can be seen as a discussional form of a 'semi-structured interview,' a qualitative method; it has a well-defined purpose and reveals the participants' interpretations, not just the theoretical facts. Specifically, it borrows attributes from the constructionists, whereby the singer and composer create a new artistic

understanding of the voice. It also incorporates 'transformative concepts', in which the composer's understanding of the voice should change, and in many instances the singer adopts a new point of view (Brinkman and Levy, 2014, 282-283).

2.3 Ethical considerations

This study raises some ethical questions that can't be answered by just addressing the ordinary considerations of a software development project or of artistic research. In technical testing, a large number of people use the software and can be fully anonymised in the documentation, i.e. given certain homogenous or heterogenous parameters.[5] This is especially crucial when publishing something that could damage the persons involved, professionally or otherwise. Simultaneously, the artists have an unconditional right to the authorship of their creative work. It would be ethically problematic to hide the identity of the performing singers, not to mention unrealisable.

My solution was to keep the singers who participated in the field testing pseudonymised, and only transmit the information that was necessary to prove the analysis data was correct and the instructions for the singers worked. The assigned pseudonyms are S.1, S.2, and so on. The singers' voices are briefly described but without threatening their anonymity. All singers were informed of the process in advance and of how the results would be applied.

The singers who performed in the artistic tests were named in this study and retained the right to veto any aspect of the text throughout the project. In addition, they had read the report, especially the parts concerning themselves, prior to its publication, in case there were any objections at the final stage. Because of their role as artistic

[5] For example, to test a program that nurses will use in their work, the test group could have different levels of experience in using computers but they would all be nurses.

creators, I also include here the names of the singers in the opera *Voice is Voice*s, in the group Inner Voices, who have a dual function. The first is to tell the story of their experiences as a classically-trained singer in gender transitioning. The second is to create a semi-improvised vocal part for the opera.

Data management and data storage were executed within the limits of possibility, in accordance with the Data Protection policy of the University of Arts Helsinki (Internet resource: Data protection at Uniarts Helsinki).

3 Communication and collaboration

To understand the contextual purpose of the VMM, three aspects need to be considered: the dialectical theories necessary to understanding communication (3.1); the description of the composer's praxis and locating its effect on the process (3.2); and the analysis of collaborative creativity as a means of creating a theoretical explanation for the results (3.3). Review of the voice and vocal music in composition education further defines the requirements of the VMM (3.4).

3.1 Communication theory

In this study, communication is defined as the intentional interaction of information exchange between composers and singers. Presented here is a special case of interpersonal communication that has been extensively studied over the past 50 years. Charles R. Berger (2005) collected some of the resulting theories, which were published in a historical review article.

Berger referred to the rapid changes of interest in the field of interpersonal-communication research between the 1960s and 2005. The research foci can be divided into six distinct categories:

1. Verbal and nonverbal adjustments made during face-to-face interaction
2. The process of producing the message
3. Uncertainty as an organising construct
4. Aspects of deceptive communication
5. Dialectical theories
6. Comparisons between face-to-face and computer-mediated social interaction

(Berger, 2005, 415-416)

These provide a different and potentially illuminating context for the discourse between composer and singer, and the fundamental postulates of the dialectical theories resonate particularly well in this study.

Researchers in this group claim that the communicators always take a contradictory stance: autonomy–connection, predictability–novelty, and openness–closedness. These combinations change constantly, such that no system state can ever be revisited. This renders the communicator a social reactor, whose choices constrain their future options. Fundamentally, any phenomenon can only be understood in relation to other phenomena, rather than as an absolute (Ibid., 427-428). One part of this group of dialectical theories is termed 'relational dialectics perspective'. It states:

> *[The] social interaction entails the fusion of participants' perspectives while maintaining their individual perspectives. According to this account, self-consciousness arises out of interactions with others, and the forces of unity and differences involved in dialogue potentiate an indeterminate process in which the self is in a perpetual state of flux.*
> (Ibid., 428)

Dialectics does not provide a set of propositions or predictions; rather, it could be seen as a metatheoretical perspective with certain assumptions about communication (Ibid., 427). For further discussion on this theoretical approach see Baxter and Montgomery, 1996 or Montgomery and Baxter, 1998.

The following cases comprise of two hypothetical scenarios that were constructed and analysed based on this theoretical point of view.

> **Case 10 [hypothetical]: Trusting the score to adequately communicate**
> A student of composition needed to write a vocal piece for inclusion in their final portfolio. They felt intimidated by the singers, not having had any experience of working with them. From the student's viewpoint, singers work in a totally foreign field. Thus, the student decided to write the piece for a soprano, thinking that it would be general enough and therefore easier to find a performer. No singers were consulted.

Remarks: Communications were already defective at the start, due to the composer's emotional state and the social structures that caused them to avoid losing face.

Case 10 (cont.)**:**
Shortly before the premiere, the student finally summoned the courage to ask a singing student to perform in the concert. They agreed, assuming there would be a discussion with the composer beforehand, possibly including some kind of workshopping. Due to poor scheduling this did not occur, and the composer merely sent the singer the score, with hardly any explanation. The singer felt uncertain because of the unfamiliar notation. They didn't want to ask the composer, as they felt they should already have been familiar with the notation.

Remarks: The singer's insecurities were now blocking communications, and the connection was never properly established. They failed to see that a musical score is a form of communication and that, in the end, it's the composer's task to make it understandable, or at least to assist with the learning process, but the singer isn't just a passive object in the process. Effective communication is more crucial than concerns about social status.

Case 10 (cont.)**:** During rehearsals, the situation turned the other way. The composer felt insecure because for them it was something new. In addition, this singer was given high status among the musicians. The singer compensated for their insecurities concerning the notation by telling the composer that the vocal part was written unidiomatically; the singer would need to sing for a long time in their difficult *passaggio* area. The composer indicated that in a certain recording, another soprano had performed something very similar so maybe the student wasn't a soprano after all.

Remarks: The insecurities and misconceptions had a lot of time to accumulate, because of the earlier obstacles. The hierarchies changed; rather than creating a balance, this made the division worse. With more effective communication, the singer could have tried to find time to discuss these problems, and the composer might have realised that 'soprano' is actually a vague term.

The steps for altering the direction of communication in order to prevent it from spiralling downwards don't need to be devastatingly big, and they can support the creative process in many ways.

Case 11 [hypothetical]: VMM enhances communication
During a conservatory concert, a singing student heard an instrumental piece by a young composer and asked them if they would like to compose something for their particular voice. The inexperienced composer had never been interested in vocal music and felt uncertain about this prospect, but the interest expressed by a professional musician made them feel appreciated. The composer and singer met to discuss this and decided to go ahead, applying the VMM.

Remarks: The hierarchies and emotions were in continual flux here, but at least communications had started.

Case 11 (cont.)**:**
The VMM begins with the VMA. So, to undertake this, both parties had to step outside their comfort zone. The singer had done some extra training to equalise their voice and didn't want to call attention to their registers or areas. They decided to explain this to the composer. The two of them talked about the different timbres, which the composer could then listen to during the analysis process. The singer experimented with different vowels and the composer noticed something that sounded like overtone singing. Together, they figured out how this could work effectively and how to notate it.

Remarks: Both artists showed courage by admitting that they needed to learn more, and that only through collaboration could the information be gathered and transformed. The VMM supported this by lending a systematic structure to the process. The decision to go further was informed by the system. They started to create a common vocabulary, which supported their collaboration.

Case 11 (cont.):
The composer had an idea for a section of the piece that required the singer to apply their passaggio area. The two of them met to discuss how to use this in a manner that is practical for the voice but also supports the composer's idea.

Remarks: Communications are now flowing. The VMM has provided the artists with a good basis to proceed, having established some common ground and vocabulary. Also, the singer became aware that the composer had a good understanding of their voice. The composer made certain demands of the singer's voice, knowing well how much energy this will cost the singer. The singer understood the intent and was now more willing to experiment with their voice.

Chapter 8 includes an analysis of some communication asymmetries that exist in the VRP and which, as a consequence, could also be part of the VMM. The conclusion is that by including some balancing aspects (i.e. the singer naming their own areas and deciding the order of areas to be analysed) in the VMA and enhancing the dialogue with the List of Good Questions, this problem is minimised.

3.2 The composer's praxis

To contextualise the need for effective communications while composing, it is necessary to create a view of the composer's work. There is no lack of literature on musical analyses and there are also plenty of biographies, but not much has been written about the practical side or the working process as a whole.

Particularly notable is researcher Ulla Pohjannoro (2020; Pohjannoro and Rousi, 2018). She analysed case studies to reveal the more abstract structures of the composers' work. These provide interesting details about the process, although I haven't quite found the practical or general aspect that would allow it to connect here.

Tasos Zembylas and Martin Niederauer take a more comprehensive approach in *Composing Processes and Artistic Agency: Tacit Knowledge in Composing* (2018). The duo combined a strong, mostly sociological framework, along with case studies. 31 composers documented their artistic process. Karlheinz Essl's Herbecks *Versprechen* (2014) and Marko Ciciliani's *Lips&arsAssNoseBoobs (Gloomy Sunday)* (2014) compositional processes were analysed in detail. This study offers a solid theoretical apparatus for understanding the artistic process, though at times it remains a bit abstract and the actual contextualisation gets lost. For example, the writers explain the professional composer's means of studying instruments in order to write for them, but don't mention that their training included the study of instruments. Curiously, the monograph doesn't ever allude to vocal music, although in Ciciliani's piece,

the instrumentalists also sing. Nevertheless, this would appear to be the most comprehensive study of the reality of present-day composers.

All composers who were interviewed work almost exclusively on commission. Thus, it is usually known from early-on who will be premiering the piece (Zembylas and Niederauer, 2018, 15). In this context, the idea of composing for a virtual soprano (see section 6.2) is not only impractical but also atypical, and therefore inexperienced composers probably shouldn't learn it. The performers also provide creative impulses for many of the composers.

> *[The composers] let themselves be inspired by [the musicians'] specific way of handling their instruments and by the associated sound possibilities of the ensemble, as well as its willingness to experiment. The musicians' preferences, specific abilities and particularities can thus be discussed during the progress of creation and taken into account while composing. [...] Research into the ensemble forms the composer's provisional assumptions and orientation.* (Ibid., 24-25)

These examples specifically relate to the composer meeting the musicians who will perform in the premiere, those for whom the piece is composed. Zembylas and Niederauer position this in the table "The creative processes of composing", under "Peers and non-peers":

Material objects	Parameters and resources
• Musical instruments • Computers and technical apparatus • Writing materials	• Commission and instructions • Place of creation and performance • Working and living conditions
The creative process of composing	
Immaterial objects	**Peers and non-peers**
• Theoretical aesthetic discourses and considerations • Algorithms • Systems of musical notation	• Audience • Composers • Instrumentalists • Sound engineers and software developers

Table 2 . "The topography of composing work" (Ibid., 14)

Later on, the writers analyse in detail the forms of knowledge that shape the composing agency. Their empirical material suggests that composition is fundamentally learned through doing, with the rules and connotations only being created afterwards (Ibid., 82). This experience could also refer to sensory perception: "it sounds right" or "it feels right". Once again, the examples are of technical equipment and instruments, mainly the piano and violin (Ibid., 80–110). It is not mentioned whether or not the composers sense in their bodies how it is to sing the part, or if they would feel right about a certain vocal timbre.

My own experience supports this. Going through the extreme areas of the voice in

the VMA has led to striking sensory perceptions. I could hear the general timbre, but could also visually and acoustically experience the toll it takes on the body: face and body become agitated and breathing becomes heavier. To some extent, I could empathise with the toll it had taken on the singer. "Composers try out things using their own bodily implementation of experiences. This common body enables composers to anticipate the body-perspective of musicians whilst they are composing" (Ibid., 101). The VMM enhances this experience, since the differences in our voices makes it difficult to try.

3.3 Collaborative creativity

Communication is the first step in any collaboration. What is the positive effect of collaborating on the composition? Section 6.3: Composing for a particular singer provides plentiful evidence of successful and often-played vocal pieces that, if not composed in elemental collaboration, are at least composed for a singer and not for Fach. However, it doesn't tell us about the actual structure that lies behind that success.

The fundamental advantages of collaboration in creative and artistic processes are widely studied, but here we are concentrating on Keith Sawyer's (1999, 2003 2006, 2008, 2011) writings. Sawyer has a multidisciplinary background in computer science, jazz piano and psychology. He has researched creativity, learning, and collaboration in contexts such as schools, business teams, jazz, and theatre improvisation.

In the field of music education, Sawyer is a strong believer in collaboration. Applying his knowledge of social psychology and ethnography, he has created a theoretical structure and offers recommendations on how music education can be supported through collaboration (Sawyer, 2008). Group creativity has three defining characteristics: improvisation, collaboration, and emergence. Using case studies from

music and theatre, he shows that structure and improvisation are always present in these kinds of processes and that they support each other (Sawyer, 2006).

The idea of collaboration as a source of creativity, can solely be studied as a form of field observation. Sawyer (2011) has also compared these findings with cognitive neuroscience, electroencephalography (EEG), positron emission tomography (PET), and functional magnetic resonance imaging (fMRI), which all require strict laboratory conditions and hence do not invite realistic creative collaboration.

He often uses the idea of emergence (e.g. Sawyer, 1999), a concept of contemporary cognitive science. Emergent systems are complex, dynamic systems that display behaviours that can only be predicted with a full and complete knowledge of the component units of the system. Creativity emerges from complex individual actions that themselves are not creative. This is also one part of the collaborative aspect of creativity.

Sawyer notes that, traditionally, artistic communication is seen to take place exclusively between the artist and their audience. By creating a theory of intersubjectivity, achieved through communication, he argues that this and numerous other kinds of communication also take place between the artists themselves, such as in a musical ensemble. Complicated and rich processes especially occur in a live situation. He uses linguistic theories to describe this type of music making (Sawyer, 2003, 86-89).

The composer's creativity within a collaboration does not have a long history. Even now, we often choose the narrative of a singular person having spontaneously created a finished piece, as opposed to the idea of artists communicating with each other as part of the creative process (see also Zembylas and Niederauer, 2018, 111-151 and Sawyer, 2003).

3.4 Composer's education

To further understand the requirements of the VMM, we need to analyse the structures that already exist for teaching vocal music in the universities. The VMM should be based on the prior knowledge of most of the least experienced composers. Additionally, the VMM should support the array of pedagogical methods,such as short workshops, that include working with a singer.

Unfortunately, this complex theme can only be briefly analysed here, and must be done by limiting the geographical scope. In combining a manageable sample size and utilising my own experience, I have researched the curricula at the German universities that offer a Bachelor's and Master's degree in composition, altogether fourteen institutions. This overview has been broadened to include the further analysis of orchestration manuals, including German and English publications, thereby offering an aesthetic and temporal spectrum. Some examples may be missing but the study paints a representative picture of the general situation in Europe, and to some extent, the world.

Discussed here is the German system of training composers in music based on the classical European tradition. It is arguably especially representative because it is so pluralistic – there is no nationwide curriculum. Still, music and composition education has a long history. To my knowledge, the role of vocal music and voice has not been studied; in fact, any analysis of the composer's education has been scarce. Composer and educator Moritz Eggert possesses a solid understanding of the field. He has been working as a professor of composition at the Hochschule für Musik und Theater München since 2010, and now heads the German Composers Association, Deutscher Komponistenverband (since 2020).

To the question, "How is the study of the human voice and vocal music organised in composition studies in Germany?" Eggert answers: "It is everyone's own decision as

to whether or not these are included in the study. The students must, nevertheless, sing in a choir at German universities (usually for four semesters)." Further study options might include conducting a choir or accompanying the singers.

Because a national curriculum does not exist, the professors wield great power within the individual universities. Eggert states that it is imaginable – yet highly unlikely – to complete a Master's degree in composition without having composed for voice at all. He isn't aware of any systematic structures of teaching vocal music in a way that is analogous to orchestration education. Eggert mentions that most professors organise different projects for their students, including vocal music; these could be art song, music theatre and opera[6] (Moritz Eggert, personal email in German, translation by the writer, 19.7.2021).

> *- Wie sind Lehre der Stimme und Vokalmusik im deutschen Kompositionsunterricht organisiert?*
>
> Das wäre jeder/m Lehrer/in selbst überlassen, ob dies Teil des Unterrichts ist. Studierende müssen aber an den meisten Hochschulen in Deutschland zwingend im Chor mitsingen (normalerweise 4 Semester lang), und im Bachelor- und Masterstudium könnte es Wahlpflichtfächer geben, die mit Vokalmusik zu tun haben, z. B. Chorleitung oder Liedbegleitung)."
>
> *- Gibt es systematische Strukturen als Teil der Studiengänge, zum Beispiel vergleichbar mit Instrumentenkunde?*
>
> Ich würde sagen nein.
>
> *- Welche Rolle haben Stimme und Vokalmusik überhaupt im Kompositionsunterricht? Ist es möglich, Bachelor oder sogar Master-Abschluss zu machen, ohne Zeugnis von Kenntnissen zur Vokalmusik?*
>
> Es ist rein theoretisch möglich, in Deutschland einen Masterabschluss zu machen, ohne eine einzige Vokalkomposition geschrieben zu haben. Das ist aber meiner

[6] Eggert uses the word 'music theatre' as an alternative, since some students find 'opera' to be historically burdened.

> Ansicht nach sehr, sehr selten. Die meisten Professor:innen die ich kenne, machen regelmäßig Klassenabende oder Projekte, die in irgendeiner Form mit Vokalmusik zu tun haben, zum Beispiel Liedkompositionen, Musiktheater, Oper. Die Studierenden, die ich unterrichte, interessieren sich alle sehr für Vokalmusik und schreiben viele Kompositionen mit Gesang. Wir haben auch immer wieder Workshops mit Sänger:innen, auch was fortgeschrittene Vokaltechniken angeht.
> (Moritz Eggert, personal email in German, 19.7.2021)

Before proceeding, some of the terminology needs to be explained. The study subject 'orchestration' in the Anglo-Saxon tradition is divided into two separate subjects at most German universities: 'Instrumentenkunde', the study of instruments, and 'die Instrumentation',[7] how instruments are used in music. The former is a more theoretical field, usually learned from a combination of lectures, manuals, and presentations. Die Instrumentation includes the analysing of orchestral music scores and mimicking these styles through different exercises, to finally gain craftsmanship in the field.

All Bachelor's curricula at German universities list mandatory Instrumentenkunde and die Instrumentation[8] lessons. None of the programmes thematises composing for the voice of a trained singer at the same level. Some include mandatory projects for either instrumental, electronic or vocal music. Most universities also require the student to sing in a choir, and some offer singing lessons to composers. This information is summarised in Table 3.

[7] Grammatically, the German term 'Instrumentation' would be sufficient, but I use 'die Instrumentation' to avoid any confusion with the English word 'instrumentation', "the particular instruments used in a piece of music" (Oxford languages, 'instrumentation').

[8] Mannheim only mentions Instrumentenkunde and Stuttgart only die Instrumentation.

School name	Instrumentenkunde	Die Instrumentation	Project	Choir	Vocal training of the composer	Further remarks	Source
Hochschule für Musik Carl Maria von Weber Dresden	yes, also in Master's	yes, also in Master's	vocal music mentioned as one option	no	studying singing is mentioned as one of the optional solo instruments	-	www.hfmdd.de
Universität der Künste Berlin	yes	yes	not mentioned	yes	seminar 'Imagination - Bewegung -Stimme'	the online curriculum was insufficient	www.udk-berlin.de
Hochschule für Musik und Theater Rostock (hmt)	yes	yes	vocal music mentioned as one option	yes	mandatory singing lessons	-	www.hmt-rostock.de
Hochschule für Musik, Theater und Medien Hannover (HMTMH)	yes	yes	not mentioned	yes	not mentioned	-	www.hmtm-hannover.de
Hochschule für Musik Detmold	Yes	yes	not mentioned	no	Studying singing is mentioned as one of the optional solo instruments	seminar 'Musikalische Akustik und Medienkunde' mentions the acoustics of the voice	www.hfm-detmold.de
Hochschule für Musik und Darstellende Kunst Frankfurt a. M.	yes	yes	not mentioned	yes	not mentioned	"Practical experiences in vocal and instrumental works [...] will be made possible."	www.hfmdk-frankfurt.info
Hochschule für Musik Saar (University of Music)	yes	yes	not mentioned	1 of the 3 options	not mentioned	-	www.hfm.saarland.de
Staatliche Hochschule für Musik und Darstellende Kunst Mannheim	yes	no	not mentioned	yes	Stimmkunde I+II	-	www.muho-mannheim.de
Staatliche Hochschule für Musik und Darstellende Kunst Stuttgart	no	yes	not mentioned	no	not mentioned	-	www.hmdk-stuttgart.de
Hochschule für Musik Karlsruhe	yes	yes	not mentioned	1 of the 3 options	not mentioned	-	www.hfm-karlsruhe.de
Hochschule für Musik und Theater München	yes	yes	not mentioned	yes	not mentioned	-	website.musikhochschule-muenchen.de
Hochschule für Musik Würzburg	yes	yes	not mentioned	yes	mandatory singing lessons		www.hfm-wuerzburg.de
Hochschule für Musik Franz Liszt Weimar	yes	yes	not mentioned	1 of the 3 options	not mentioned	Bachelor's in Instrumental Composition	www.hfm-weimar.de

Table 3. Composition curricula at German music universities

This data was collected from the study guides (Studienordnung) on the universities' websites. Naturally, information on Instrumentenkunde, die Instrumentation, and choirs was abundant. Searches were made using the German words for 'human voice', Stimme, and 'vocal', Vokal. Any mention of vocal music and voice were thereby found and categorised. A university might hold regular vocal music workshops, but without stating this on the website. Still, none of these universities presented a vocal music composition component that features in the official curriculum. It should be mentioned that although the various curricula contain a certain level of freedom, they have been criticised for being normative and somewhat dated. (Jeßulat 2015, Walshe 2017, Vlitakis 2015)

If vocal music isn't mentioned separately in the documentation, maybe it is being taught as part of *Instrumentenkunde* or *die Instrumentation.* According to Eggert, the professors have a lot of freedom, so it is more difficult to obtain information about what actually happens in the classroom. The content of a seminar might be described in the curriculum, but it isn't very detailed. And none of the professors mention the word voice or vocal. To study this in detail would involve a combination of interviews with the professors and following the day-to-day teaching.

A rough understanding, however, can be gained from the instrumentation manuals, serving as a good secondary source. They describe, to some extent, the trends of *die Instrumentation*, although the content of the books and the teaching aren't identical. The most popular manuals begin by giving information about all instruments in the form of lists (*Instrumentenkunde*), and then showing, via examples and possibly tasks, how these are used (*die Instrumentation*). I have chosen 13 books based on my own experience and the online curricula. The list includes some true classics, often referred to only by the author's name ('Berlioz', 'Rimsky-Korsakov', 'Piston', and 'Adler') and four new books published since 2004.

Table 4. Comparing orchestration manuals

Title	Author	Publication	Solo Voice	Chorus	Register	Fach	Singer's formant	Remarks
Treatise on instrumentation	Hector Berlioz and Richard Strauss	1855/1905	Yes	Yes	Three registers	Soprano, Mezzo-soprano, Contralto, Tenor, Baritone, and Bass	Implied	The operatic voice is a very special case and each singer should be studied separately. Geographical differences make it problematic to use the Fach system.
Principles of Orchestration	Nikolay Rimsky-Korsakov	1922	Yes	Yes	Three registers, vary from singer to another	Soprano, Mezzo-soprano, Contralto, Tenor, Baritone, and Bass	Implied (Mentions very dramatic voice types)	"A composer should be able to rely upon flexible and equal voices without having to trouble himself as to the abilities or defects of individual singers. In these days a part is seldom written for a particular artist[.]" (133)
Orchestration	Cecil Forsyth	1935	No	No	-	-	-	-
The Technique of Orchestration	Kent Kennan, Donald Grantham	1952	No	No	-	-	-	-
Orchestration	Walter Piston	1955	No	No	-	-		-
The Study of Orchestration	Samuel Adler	1982	No	No	-	-	-	-
Instrumentation in der Musik des 20. Jahrhunderts: Akustik - Instrumente - Zusammenwirken	Walter Gieseler, Luca Lombardi, and Rolf D. Weyer	1985	Yes	Yes				The voice does not feature in the list of instruments, rather as a special case, analysed on the basis of phonetics, semantics, and a mixture of the two.
Handbuch der Musikinstrumentenkunde	Erich Valentin	1986	No	No	-	-	-	-
Instrumenten-Brevier: Handbuch zu Fragen des Gebrauchs der Instrumente	Hans Kunitz	1982; 2002	No	No	-	-	-	-
Instrumentation: Geschichte und Wandel des Orchesterklanges	Peter Jost	2004	No	No	-	-	-	-
Handbuch der Instrumentationspraxis	Ertug˘rul Sevsay	2005	No	No	-	-	-	Although Sevsay mentions that orchestration also deals with chamber and vocal music, it is not included in the book.
The Cambridge Guide to Orchestration	Ertug˘rul Sevsay	2013	No	No	-	-	-	-
Contemporary Orchestration	R. J. Miller	2015	Yes	Yes	-	only for choir: SI, SII, AI, AII, TI, TII, BI, and BII	-	This mostly concerns choirs and vocal ensembles. The voices are individual, even within the same Fach. Getting to know the particular vocalist is by far preferable.

As can be seen in Table 4, vocal music is seldom included in orchestration manuals. Only three books explain how the voice functions and how it can be used: two early ones, Berlioz and Strauss (1905) and Rimsky-Korsakov (1922), and a more recent one by Miller (2015). They all discuss the choral and solo voice rather well, and Berlioz and Strauss specifically mention the vocal registers. Most importantly, they all note that a solo voice is such a special case that a consultation with the singer is always required.

Another notable publication is *Instrumentation in der Musik des 20. Jahrhunderts: Akustik - Instrumente - Zusammenwirken* (Orchestration in the Music of the 20th century: Acoustics - Instruments - Collaboration), which takes a scientific stance. Here, the voice is not included in the list of instruments but is a special case at the end. The authors want to distance themselves from any musical instances where text and music are directly bound together, only commenting on the phonetic or semantic effects created by the voice. While this approach provides some novel ideas, it does not provide enough practical tools for a composer to use in working with classically trained singers. (Gieseler, et al., 1985, 237)

A further hint of the practical work being done at the universities can be found in the article 'Im Spannungsfeld zwischen Handwerksregel und Klangvorstellung: Instrumentation als Hochschullehrgang' (Arnecke, 2014), which describes *die Instrumentation* seminars at Hochschule für Musik und Theater Hamburg and at Hochschule für Musik Franz Liszt Weimar. The voice is not mentioned at all, which may be because Arnecke doesn't see it as instrumentation, or because it didn't come up in the pieces that are discussed.[9]

To summarise, vocal music is being taught in a highly varied manner, often through

[9] The chosen examples didn't include voice, but does this fact actually make them representative of the lack of vocal music in *die Instrumentation*?

projects or workshops that are not formally specified. Although these cases are from Germany, there is no reason to expect the situation to be drastically different elsewhere. Orchestration literature and my incidental research into UK and US university curricula have not provided any counterexamples. Nevertheless, additional studies that include interviews and a broader geographic scope are desired.

Lisa Fonrhammar, a soprano, teaches at Universität Mozarteum Salzburg and at Hochschule für Musik Leipzig. She has occasionally held workshops for singers and composers on collaboratively creating new vocal music.

When this manuscript was at the final stage, I was informed that Osnat Netzer (DePaul University, Chicago) and Renée Favand-See (Portland State University, Oregon) have been holding workshops that seem to be on par with this research; for example, by emphasising the importance of composing for a specific singer (Osnat Netzer, personal communication, 27.7.2022)

In theory, a project or workshop provides a good context for learning about voice. As the manuals remind us, studying the voice from a book is difficult, since voices are so individual. In an optimal situation, communication between composing and singing students would be fluent, and both parties would learn by doing. Nonetheless, this approach is not without its flaws.

On the one hand, the theoretical aspect of the human voice isn't sufficient. To only understand one voice in a project might prove to be too limiting in the future. A workshop can combine the general idea and examples from the repertoire with the practical understanding of a specific voice. On the other hand, if workshops and projects only take place sporadically and vary from project to project, the student's chances of learning about voice are based on chance. An unlucky composer might have timed their one-off workshop for 2020 and Covid-19 might have erased the theme of voice from their education altogether. How the composers learn about orchestration

is much more structured. It would be unimaginable to earn a Bachelor's degree in composition without undertaking time-consuming studies in *Instrumentation* and *die Instrumentenkunde*. This may sound theoretical, but it has yielded very concrete results. It would be unthinkable for a trained composer to be unable to name the open strings of a viola. Simultaneously, an unofficial discussion with composers from European universities shows that the majority have never acknowledged vocal registers in their studies. This was also the case with me. Luckily, universities tend to provide a platform for the student to get to know their own voice, but the relationship between contemporary composition education and vocal music remains a complicated theme, with the aesthetic, historical and psychological aspects entangled.

In summary, a composer applying the VMM might well have a rather limited understanding of voice.[10] The Method needs to be functional in the hands of a composer who has next to no understanding of the voice. In addition, it needs to provide different kinds of information. The VMM is intended to teach the composer about voice in general, as well as about the specific voice, while also conveying new knowledge to well-trained composers.

Setting up these requirements for the VMM opened up a new avenue. If teaching vocal music to composers is so firmly based on projects and workshops, a system that supports this type of communication and makes it more efficient – possibly also in the classroom – would definitely be welcome.

[10] In particular, a composer with a simplified and biassed interpretation of voice types may be ineffective in communicating with singers. See Chapter 6, Fach system.

4. Vocal register and vocal area

The vocal register is one of the research topics undertaken in logopedics, and also a central aspect of classical singing the bel canto technique. The VMA uses an analogous term 'area' (4.1 and 4.2). In some contexts, differences in timbre are equalised away, while in others they may serve as aesthetic tools (4.3).

4.1 Definitions

The term 'vocal register' describes the natural phenomenon that can easily be observed when a person without vocal training sings very high and very low tones; they have different timbres. Adjacent pitches sound similar, but at a certain point the quality changes. More such breaks can also occur. An example of this is when a deep voice rises from low to high and then suddenly switches, sounding lighter and more airy. Pitches having the same timbre and produced using the same technique belong to one 'vocal register'. The overlap of two registers is called *passaggio* (plural *passaggi*) or 'break'. This way, a note may be sung as part of one register or as part of another. Voice scientist Manuel García has supplied a more formal definition. Although somewhat dated, it is still relevant and widely used.

> *By the word register, we understand a series of consecutive and homogenous tones going from low to high, produced by the development of the same mechanical principle, whose nature differs essentially from another series of tones equally consecutive and homogenous produced by another mechanical principle.*
> (García, 1847, xli)

In the subsequent sections, I explain why this phenomenon is essential to a vocal composer. This is also shown in the VMM process. When beginning the VMA, the singer makes a list of their areas and names them. This lends a fundamental structure to the process, since the analysis is done area by area. But before doing that, the

dilemma must be articulated. The inexperienced composer should be aware of the phenomenon of registers. However, it is best to avoid weighing down the test situation with historical terminology or forcing the singer to use terms they don't consider their own.

As a solution, I adopted a new term, expanding slightly on the definition of vocal register. In the context of the VMA and VMM, the term 'vocal area', or simply 'area', describes a phenomenon similar to register, but with three amendments:

1. The 'mechanical principle' is judged to be the same or different, according to the singer's physical sensation.

2. The 'nature of the voice' is defined by the aural observations of the composer and the singer in the test situation.

3. Changing either the 'mechanical principle' or 'nature of the voice' is sufficient[11].

My definition is as follows:

In the VMM, the singer's 'vocal area' is a series of consecutive tones ranging from low to high, in which the singer feels like the tones are produced using the same mechanical principle, and which have the same audible timbre. These differ from other series, or areas, of tones that are produced using another mechanical principle or have another timbre. The singer's range is divided into different vocal areas and these may overlap.

In practice, these minor alterations have shown many advantages. Singers can experience the areas more freely in the analysis situation, not just in regard to what they have learned about the registers. It is easier to talk about the vocal areas even when they are somewhat obscure. For example, overtone singing is not often

[11] García did not specify this in his definition.

described as a register, but it would certainly be an area. Some vocal pedagogies don't consider male falsetto (Laryngeal mechanism **M2**),[12] vocal fry (Laryngeal mechanism **M0**) or whistle register (Laryngeal mechanism **M3**) to be registers at all, since they don't fit the aesthetic paradigm.

Usually a greater number of areas provides the composer with a more precise understanding of the vocal material. Occasionally, the timbre within what was thought to be one area changes so much that it proves better to refine the division of areas.

4.2 Different theories

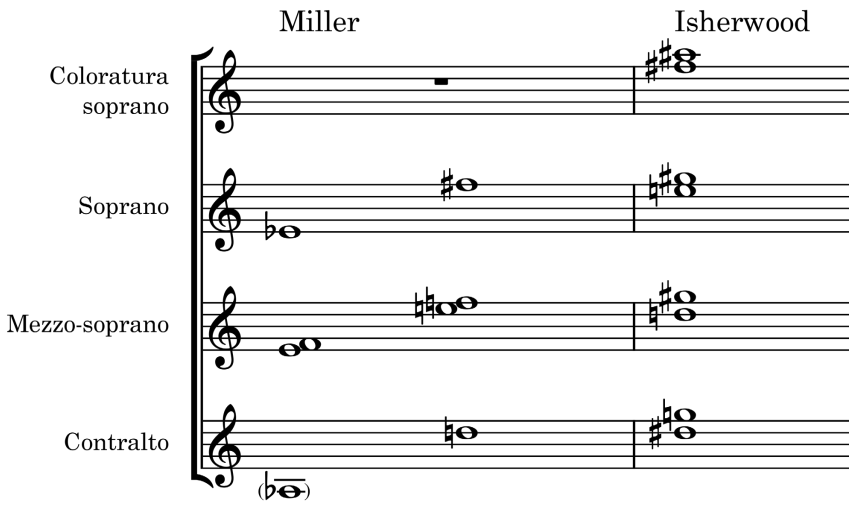
In section 6.2, I argue that the Fach system is not the most advantageous starting point for communications between an inexperienced composer and a singer, but it is worth mentioning that the passaggi are one aspect of determining the Fach of the voice (Miller, 2000, 25; Cotton, 2007). Miller (1996, 134-135) and Isherwood (2013, 135) state the following passaggio areas for female voices:

Author	Fach	Lower passaggio	Upper passaggio
Miller (1996)	Soprano	Eb 4	F# 5
	Mezzo-soprano	E4 (F4)	E5 (F5)
	Contralto	(Ab4)	D5
Isherwood (2013)	Coloratura soprano		F#5–A#5
	Soprano		E5–G#5
	Mezzo-soprano		D5–F#5
	Contralto soprano		D#5–G5

Table 5. Passaggio areas of female voices according to Miller and Isherwood

[12] The laryngeal mechanisms and the role of registers are further discussed in the next subsection.

Example 1. Passaggio areas of female voices according to Miller and Isherwood



These two examples are relatively recent and numerous different and contradictory ones that are older can be found. For a historical review, refer to the chapter 'Registers: Some Tough Breaks' in James Stark's well-studied book *Bel Canto - A history of Vocal Pedagogy* (1999). The lists should not be seen as anything more than generalisations, as the precise information can only be achieved by analysing the specific voice. Curiously, when field-testing the VMA, it came to light that even the coloratura sopranos didn't have identical *passaggi* (see Chapter 10).

One of the primary questions concerning registers relates to quantity. The human voice is divided into different registers, but how many are there and which of them can be used artistically?

The latest theories use the more developed analysis methods to answer this question.

For voice scientists, one of the main sources of obtaining new information is to analyse the mechanism of the larynx. This is achieved through the use of a laryngoscope, which enables viewing during singing. García invented this method in 1854 but it has developed considerably since then. The different laryngeal mechanisms can be

used to determine the different registers. The various ways the larynx can function are numbered **M0**, **M1**, **M2** and **M3**. Some vocal pedagogues also find a register between **M1** and **M2** (Heinrich, 2006).

In Table 6, I present the terms Henrich has collected for male and female voices. For some of the registers, she also mentions average frequency limits, but for the sake of clarity, I have omitted them here.

Laryngeal mechanism	Name	Remarks
M3	bell, flute, whistle, *flageolet*	Rare, not used in performing classical repertoire today.
M2	*falsetto*, loft, female head, upper,	Especially the female voice may be divided into lower, middle, upper-middle and upper register
(**M1** or **M2**)	mid, middle, mixed voice, *voix mixte*	An area that the singers use to smooth the transition between the two registers of different laryngeal mechanisms. Technically, the laryngeal mechanism is always **M1** (for males) or **M2** (for females).
M1	modal, chest, male head, belting	
M0	pulse, vocal fry, *Strohbass*	Easy to produce, but rarely used in classical music.

Table 6. Contemporary theory of registers (Henrich, 2006)

It is intriguing to compare the **M0 – M3** theory with the results gained by the VMA during the development process. The majority of singers said that indeed they possessed three registers that appeared to be similar to **M1**, **M2**. After these, the

most frequent candidate was a mixture of **M1** and **M2**, which can also be found in Table 6. None of the classically trained coloratura sopranos could sing in the whistle register, **M3**, when analysed, and none of them mentioned vocal fry, **M0**.

Nonetheless, there were also distinct exceptions regarding the number of areas and terminologies. Two of the singers decided to use their own names for their areas. For sure, the composer's expectations and also the mode of listening is different for the 'golden', 'ohm' or 'red' area, from the 'modal register' area. Therefore, the VMM was able to provide new and precise information about this specific singer and their voice, supplanting the existing theory.

The VMM is supported by the voice-study theories. For example, the singer might not mention the vocal fry register, which is not used in the classical repertoire but may well be an interesting tool for a contemporary composer. On the other hand, there are many contemporary techniques that are not included in the theory behind **M0** to **M3** registers.

4.3 Equalisation

Classically-trained singers and composers have different and often contradictory approaches to registers: singers tend to want to hide them, inexperienced composers don't tend to know about them and often bump into them by accident, and experienced composers can thematisise them in their compositions.

One of the main aspects of the *bel canto* technique is 'equalisation'; the *passaggi* are not noticeable, and all the registers have a similar timbre (Stark, 1999, 189). Stark writes that even the human voice, which is often considered to be a perfect musical instrument, has faults. "The most obvious of these imperfections, and the most difficult one to disguise, is the presence of discrete vocal *registers* [...]" (Ibid., italics

in original). In my experience, extensive training of equalisation has made singers reluctant to hint at the registers in any way. Often at the beginning of the VMA, the singer might mention that the registers or areas do not sound different. Still, after the analysis or the potential composition, they are happy with the result: the areas are naturally different, after all. Only in one case out of 22 did it feel that the change from one area to another was continuous or inaudible.[13] The VMA is based on the assumption that the voice is divided into areas. In the rare instances where the role of the areas is minimal, the areas have no functionality in the VMA either but still help to structure the analysis process.

As most inexperienced composers are not aware of the registers, they often compose against them. An example of this is when a long section uses the passaggio tones of the singer or continuously jumps just slightly above and below them. In this situation, the singer has to use more energy than usual to equalise the tones, which can cause a lot of stress. If the composer wishes the tones to sound homogenous, it is often wiser to transpose them to below or above the break. Contrarily, in some situations, the composer is specifically looking for these spontaneous changes. In those instances, it may be wise to communicate this to the singer so that they don't read it as an unidiomatic problem that needs to be solved. Making an informed decision to break the rule is fundamentally different than not knowing that the rule exists.

As a composer of vocal music, I see equalisation as an ideal that can never be fully achieved. This study negotiates between the extremes of hiding and celebrating nonhomogeneity. The VMM is intended to give the composer enough information about the areas of the voice, but the composer always maintains the option not to use it in their composition.

[13] The singer in this case is Kajsa Dahlbäck, performing in *Voice is Voices*, and the analysis is further discussed in section 11.3.

The legato lines are a fundamental aspect of the classical opera repertoire and of the *bel canto* technique (Stark, 1999, 189). These lines can falter if the timbre or technical mechanism of the voice also changes, so they are connected with the singer's technique in the *passaggio*. In contemporary music, continuous lines no longer have a dominant role, nor have they disappeared. For instance, most roles in the operas of Wolfgang Rihm and Kaija Saariaho, contain long lines that require legato technique and arguably require a voice that is mostly equalised.

All in all, contemporary music includes a lot of material where the whole range from one extreme to the other needs to be equalised, but there are also cases where a dramatic change of timbre is the main musical idea. One could argue that the soprano part in György Ligeti's *Requiem* is an example of the former, and in the opera *Le Grand Macabre,* the very same composer wrote the part of Chief of the Secret Police, an example of the latter. Both are sung by coloratura sopranos.

4.4 Function in vocal music

How, then, can a composer use the vocal registers as a compositional tool? General solutions do not apply; it is much better to work with the precise registers of the singer who premieres the piece. To compose for the virtual soprano's registers seldom works for any performer, entailing more work for no gain.

In order to link the examples (see below) to the singers' more classical *bel canto* training, I refer to an instance from the core repertoire of *Così fan tutte* (1790).

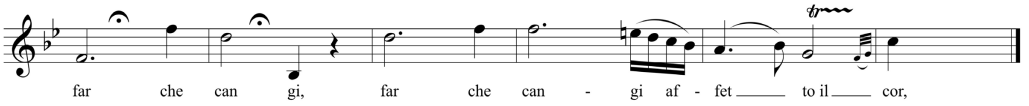
McCoyd and Halstead write at length about equalisation, while also admitting its paradoxical nature in the actual repertoire:

Of course, some music is written to highlight these changes; Fiordiligi's aria "Come scoglio" would be much less dramatic were the huge leaps from high to low all sung

in the same register! (McCoy and Halstead, 2012, 144)

Barker and Huesca (2018, 55) also refer to 'Come Scoglio' in their book *Composing for Voice*. Some of the leaps can be seen in Example 2. In this aria, Fiordiligi claims that she and her sister cannot be moved: "Come scoglio immoto resta, Contra i venti, e la tempesta" [Like a rock staying still, against the winds and storm] (De Ponte, 1790). The main plot line of the opera is that, in the end, the emotional turmoil has thoroughly ridiculed this statement.

Example 2. W. A. Mozart *Così fan tutte*, aria "Come scoglio" measures 42–47



It could be argued that the vocal performance works simultaneously on at least three levels:

The melody and the words represent the "winds and storm", the outside forces that try to make the women lose their balance.

Equalisation and the singing technique represent the promise of motionlessness. As with the control and homogeneity of the voice, the emotions shall withstand testing.

Underlying the performance is the performer's physical body. The voice and the body may be harnessed, but the natural registers exist nonetheless and will win in the end

The music was strongly connected with the voice of the performer and not just the composer's abstract musical idea. The composer worked extensively with the singers, helping them learn new material and achieve a better technique, so he was well aware of the general principles of the voice (e.g. Mahling, 1996). Moreover, he composed the piece for a particular singer. Adriana Ferrarese del Bene premiered the role of Fiordiligi in *Cosí fan tutte*, and 'Come scoglio' was destined to be a striking

solo number. This was in 1790 in Vienna, Austria; but already in 1789, Mozart had composed new arias for del Bene in the revival of *La Nozze di Figaro*. He apparently didn't much like del Bene, yet fully realised the nuanced abilities of her voice (Brown, 1995, 159-161).

According to Brown, del Bene was famous for her strong passagework (singing with an equalised voice around the *passaggi*) and what he calls a powerful "lower register".[14] Both Mozart and Antonio Salieri (1750 – 825) composed arias for her, and piece after piece, the material was becoming more complex and the leaps and ranges wider. But the leaps also "left her prone to mockery". Often her head bobbed up and down with the melody. She was a mediocre actor, but maybe the technical demands left some of her emotions unhidden (Brown, 1995, 159-161).

There may be some mockery in this aria too — perhaps Mozart actually wanted to see the singer's head move in a comical way — but he also created music that has survived time in an exceptional manner. Regardless of his opinion of the singer's qualities, Mozart followed his own aesthetic principle: "[...] I like an aria to fit a singer as perfectly as a well-made suit of clothes." (Mozart et al., 1966, 497).

This attitude was in no way an exception at the time. "Operatic roles often turned on a singer's characteristic features: the outer limits of the vocal range, the weight of the voice, the *tessitura* and the specific subset of favourite figurations…" (Gidwitz, 1996, 202).

In section 4.3 I have painted a picture of inexperienced composers writing music counter to the vocal registers, because they do not know them. Only composers deeply involved in vocal music can avoid or even use these phenomena to their advantage. In a major part of vocal music, this actually seems to be the performer's experience.

[14] Here, Brown may be speaking of the actual chest register or simply the general lower area of the voice. This is yet another example of the perplexity that exists in the terminology of the registers.

But when composers specifically decide to stretch to the more experimental parts of the voice (the 'extended technique'), they tend to play it safe and use the vocal registers a bit too conservatively.

The most notable example is probably when there's a quick oscillation between different registers, as mentioned by Hanna Aurbacher-Liska in her book *Die Stimme in der neuen Musik,* which contains new singing techniques and their notation. She writes about a trill with a relatively big range from one register to another.[15] "This is the yodel, and typical in many cultures, but it's also used by contemporary composers, like Mauricio Kagel (Aurbacher-Liska, 2003, 84, translation by the author,)."

Nicholas Isherwood's *The Techniques of Singing* (2013) matches Aurbacher-Liska's viewpoint in many ways, but he also notes the more theoretical aspects. Isherwood writes: "Some composers deliberately exploit the potentially huge timbral difference between chest and head voice for females. Giancinto Scelsi uses this in works such as his *Canti del Capricorno.*" Isherwood also references the yodel in Jacques Demierre's *Bleu* (1991).[16]

In his book *The 21st-Century Voice,* Michael Edward Edgerton mentions his own pieces, *Anaphora* (2001) and *A Marriage of Shadows* (2008), as well as Edwin London's *Psalm of These Days* (1977–80) and Sainkho Namtchylak's *Night Birds* (1991). He analyses the latter using a spectrogram of the recorded performance. Applying the same method, he demonstrates the striking timbral differences in a recording by Japanese singer Kinshi Tsuruta. The composer himself has written that he was inspired by "the timbral exploration [-] from South Indian Carnatic music". Furthermore, Mauricio Rodriquez does not identify any exact pitches in his *Voix* (2005), but the changes

[15] Ausbacher-Liska mentions that these registers should be 'Bruststimme' and 'Kopfstimme', chest and head voices.

[16] According to Isherwood, "male yodelling occurs between middle voice and falsetto, whereas female yodelling goes from chest voice to head voice" (2013, 122-123).

between the registers are meticulously notated (Edgerton, 2015, 36-40).

Still another question remains: how well do composers understand the possibilities of these areas for the specific voice they are writing for? The vocal fry can exhibit different dynamics and potentially different pitches, but the composers often use it to achieve a soft and low effect. The male falsetto voice, on the other hand, could also be used at relatively low pitches, rather than as a trick that is employed when the singer can't reach the high notes with any other technique. The VMM would support the composer who tries to utilise these methods with more nuance.

The concept of the 'vocal area' is a fundamental part of the VMM. The VMA is completed one area after another, and understanding the areas is an initial step. As mentioned, singers are highly skillful at equalising their voices, but the natural structure of the voice still provides the background for all vocal music. As the composer is the person creating the work, they can decide to compose for these natural areas or against them, but at least the decision is taken knowingly.

5. Vocal characteristics

Another cornerstone of the *bel canto* technique is the singer's formant, the ring, core or *squillo* that allows the classically trained opera singer's voice to be heard through the sound of the orchestra. Here, a somewhat technical approach to voice studies is needed. Ultimately, this proves to be a fruitful addition to the VMA, revealing veiled information about balance (5.1). Another characteristic of a classically trained voice is the vibrato, which is also a key consideration in the VMM (5.2).

5.1 Singer's formant

The singer's formant (also called 'singing formant', Fs, or F_S) describes the carrying quality or metallic ring in the voice of a classically trained singer that makes it audible through an orchestra even if the instruments have a louder dynamic.

This can be measured and observed in the spectrum of the voice as a peak at around 3 kHz[17] (see figure 2). In a neutral speaking-voice or in the sung tones of untrained singers, the Fs doesn't appear or is weak. The term 'singer's formant' is used by contemporary voice scientists and most vocal pedagogues, but historically, the singer's formant is also referred to as 'head resonance', 'placement in the mask' (Sundberg, 1987, 118-119), 'clear tinkling of little bells', 'ring' (Stark 1999, 50), 'squillo', 'ping', or 'core'. Fs has been technically studied and theoreticized by voice scientists for decades already (e.g. Bartholomew, 1934), but voice scientist Johan Sundberg has created what is probably the most comprehensive theoretical corpus and measurements concerning the formant. Sundberg's definition is more technical:

The singer's formant is a prominent spectrum envelope peak near 3 kHz that

[17] This approximates tone #F7, 2960.0 Hz but the values could range from 2.3 to 3.8 KHz, which is almost from D7 to Bb7.

appears in voiced sounds sung by classically trained bass, baritone, tenor, and alto singers' voices. It makes the voice easier to hear in the presence of a loud orchestral accompaniment. (Sundberg, 2001, 176-186)

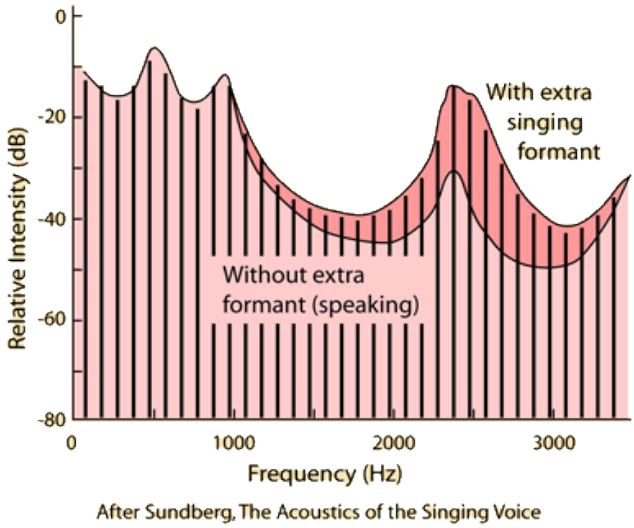


Figure 2. Singing Formant's Origin, (Sundberg, 1977, 89)

To use the VMM, there's no deeper understanding of vocal formants needed, but for those who are interested, the scientific details can be found in Sundberg's book *The Science of the Singing Voice* (1987), where he used the term 'singing formant'. Furthermore, I do not go into how the singers actually produce this vocal quality with their body. Rather, I describe how Fs functions and how it could be a useful tool for composers. In Sundberg's early and often quoted study from 1977, he uses the voice of singer Jussi Björkling to illustrate the Fs. In the graph below, figure 3, he illustrates the distribution of the energy from three different sources: the sound of the orchestra (black), ordinary speech (grey), and the combined sound of the singer and the orchestra (orange).

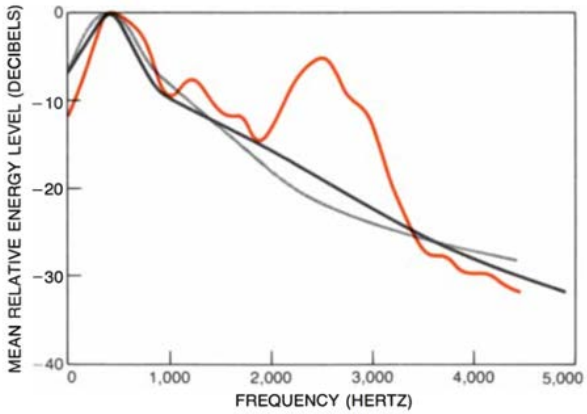


Figure 3. Singing Formant's Utility (Sundberg, 1977, 89),

Sundberg explains:

> *The distribution is very similar for speech and the orchestra at all frequencies; it is the singer's voice that produces the peak in the [orange] curve between 2,000 and 3,000 hertz. In that frequency region, a singer's voice is loud enough, compared with an orchestra's sound, to be discerned.*
> (Sundberg, 1977, 89)

The peak occurs at around 3 kHz, which has two advantages. Firstly, the sound energy in the orchestra peaks at 450 Hz (Stark, 1999, 50) and declines at the higher pitches, so Fs sounds are above the energy peak. Secondly, 3 kHz is optimal for human hearing. Because of our anatomy, we hear frequencies in this range better than any other (Hunter and Titze, 2005).

Recognising the Fs aurally is not at all trivial; this parameter is not as intuitive as loudness or pitch. Noticing and analysing the Fs continues to be the work of vocal pedagogues and singers. It is said to give the voice a metallic, silvery, resonating or biting sound. The VMM relays the Fs level for each tone in each area, but also this part of analysis is only a starting point for the conversation. Analysing the Fs is especially difficult, as it doesn't have a set scale, like dynamic or pitch, and the amount of Fs also varies greatly depending on the general dynamic of the sound, the vowel used,

or the vibrato[18] and the musical context. These issues are discussed in chapter 3.4.

Why, then, should we invest energy in analysing such a complicated part of the voice? Many of the problems encountered by inexperienced composers are related to the unrealistic dynamics and the balance between voice and instruments. The analysis methods in phases I and II that do not concern the singer's formant show the dynamic possibilities of the voice, thus solving the usual situation where a composer requires the dramatic voice to produce very high notes with a soft dynamic. Still remaining are the instances where light, high voices cannot be heard through an orchestra in the lower tones of their vocal range. The latter is partly a question of dynamic. If the singer can only produce the tone very softly (according to the VMA), it probably won't be heard if there are instruments playing loudly. This is, nonetheless, not fully accurate. A strong Fs could change the balance.

During the field testing of the analysis, I found the Fs only in tones with an apparent vibrato. In the lyric and dramatic soprano voices that were analysed, the Fs were strongest in the middle and higher parts of the ambitus. This makes sense, since in the classical repertoire the two highest or second to highest registers (respectively) are the ones these singers will mostly be using, and there they will also need the Fs.

Before leaving the subject of the Fs, there are two side notes worth mentioning. The first concerns the higher voices. Sundberg claims to have found it in male singers and contraltos (1995).[19] Later on, Weiss (2001) came to the conclusion that the sopranos might possess it, but it might function differently than it does with the lower voices. Lee and others (2008) found it in the voices of tenors, baritones, sopranos and mezzo-sopranos. Also, the classically trained coloratura soprano and

[18] The Fs is connected to a strong vibrato, which complicates the analysis of the pitch.

[19] Sundberg never thematises the use of a voice type or Fach, and he uses the terms: soprano, mezzo soprano, alto (not the English contralto), tenor, baritone and bass. For him, it is a question of an anatomical voice type, not Fach.

contemporary music expert Sarah Maria Sun says that she is very aware of the Fs and of where she emphasises it (Sarah Maria Sun, personal communication, 23.11.2018). Coincidentally, Kajsa Dahlbäck, one of the singers in *Voice is Voices*, actually analysed the singer's formant in her own voice for her Master's thesis (Dahlbäck, 2005).

Secondly, the terminology still fluctuates. Saruahn (2017) finds the 'singer's formant' problematic: technically, it isn't a formant at all, but a cluster of formants, as Sundberg (2003) also mentions. Saruahn is more troubled by the word 'singer', since this phenomenon has been found solely in Western classical opera. It could best be called 'Western opera singer's formant cluster'. I find the critique justified but have decided to stay with the widely accepted term.

To summarise: the voice of a classically trained singer contains a tingling quality which makes it more audible over the orchestra. This effect is optimal for its purpose, since we can hear the 3 kHz area especially well and, in addition, the sound of the orchestra has a lower energy. The VMM outlines the strength of Fs in each of the singer's areas and gives the composer a new tool for considering the matter of balance in vocal composition.

The singer's formant maximums are indicated in the Voice Map and should be taken into consideration when the dynamics of the Voice Map are being read. The singer's formant can strongly enhance the audibility of a voice that has soft dynamics, and it can alter the balance between the singer and the instrument.

5.2 Vibrato

In this study the vibrato is defined as pulsation of pitch that can be combined with similar pulsations in dynamic and timbre. The pitch oscillation can be as large as two semitones and the rate is between five and eight pulsations per second. Vibrato

is mainly a result of training, with some personal variation. In addition, the singer can control this rate, to a certain extent, which is useful for aesthetic purposes. The vibrato is considered something that most opera singers learn naturally. In fact, it is actually energy-consuming to avoid the vibrato when singing 'straight' tones *senza vibrato*. Although vibrato is somewhat present in all classical music, it also carries a certain musical aesthetic that can enrich the tone and support expressiveness (Stark, 1999, 121-146).

Use of vibrato in vocal music is a somewhat complicated issue. At least until the baroque period, singers used a narrower form of vibrato. In some contemporary music, the composer indicates the use of different kinds of vibratos. Still, in nearly all situations, the choice is left to the performer. This is also true of the majority of vocal styles that are not based on Western classical music.

In regard to the VMM, the vibrato can challenge the detection of pitch by the software. However, as from VMA software version 0.9.2, there is a component that takes the vibrato into account.

6. Fach system

The *bel canto* technique is also related to the German Fach system (6.1). Historically, the Fach system has been shown to be a tool that the opera industry cannot exist without. However, it has its limitations, particularly when used in the context of contemporary music. Inexperienced composers possess a superficial understanding of voice, which results in a naive and limited appreciation of voice types (6.2: Virtual soprano). Also, many of the most experienced vocal composers still opt to compose for a specific singer.

6.1 Definitions and literature

The German word *Fach* can be translated as compartment, discipline, or subject (of study or of expertise). By extension, *Stimmfach* can be translated as 'vocal category' or 'voice type'. The Fach system is a construction that helps the international opera industry cast singers more effectively by dividing them into different voice categories. For the purposes of the system, each operatic role and each singer should fit into one category, or in some cases, very few categories. Often 'voice type' refers to an anatomical fact, a way to divide the vocal cords into four to six categories, whereas 'Fach' is an artistic construction that mainly applies to opera singers. For questions concerning the relationship between these two, see Cotton (2007) and Koehler (2004).

The German Fach system is the most widely used and probably the most sophisticated, but there are also Italian, French, Russian, English and other versions and variations. One very concrete manifestation of the Fach system is the *Handbuch der Oper* (Kloiber, et al, 2002), often called the Kloiber (after Rudolf Kloiber). In its list of more than 1,000 roles, it states which voice type should perform each and how big the role is,[20]

[20] *große Solopartie*, *mittlere Solopartie* and *kleine Solopartie*, for large, medium and small solo parts, respectively.

which can have a direct impact on the singer's fee. *Handbuch der Oper* divides the singers into no fewer than 25 different voice types in two main categories.

Seriöse Fächer [serious types of Fach]: *lyrischer Sopran*, *jugendlich-dramatischer Sopran*, *dramatischer Koloratursopran*, *dramatischer Sopran*, *dramatischer Mezzosopran, dramatischer Alt, tiefer Alt (Kontra-Alt), lyrischer Tenor, jugendlicher Heldentenor, Heldentenor, lyrischer Bariton, Kavalierbariton, Heldenbariton (bisweilen auch Hoher Baß), seriöser Baß.*

Spiel- und Charakterfächer [acting or character type]: *lyrischer Koloratursopran*, *Spielsopran* (*Soubrette*) or *Charaktersopran, Spielalt (lyrischer Mezzosopran)*, *Spieltenor, Charaktertenor, Spielbariton, Charakterbariton, Spielbaß (Baßbuffo), Charakterbaß (Baßbariton)* and *Schwerer Spielbaß (Schwerer Baßbuffo)* (Kloiber, et al, 2002, 898).

Figure 4. Handbuch der Oper, 2016 version

Historically, the voice type and Fach originate from the terminology used for the different parts of choral polyphony. Only in the 16th century were these names first used to describe a soloist. At this point, the voice type, such as 'alto' or 'bass', is determined purely and practically by the range of the singer's voice (Seedorf, 2019, 34). In the 18th century, the division into four voice types — soprano, contralto (alto),

tenor, and bass — was still fixed, but descriptive prefixes were often used. Mezzo-soprano and baritone emerged into general use quite late, in the 19th century (Ibid., 34, 253). By then, opera had transformed from a local luxury item into a product for the middle classes. In his provocatively-titled article 'Opera Industry', Roger Parker notes the rapid growth of interest in opera:

> *Towards the end of the eighteenth century, regular operatic performances could be seen through much of Europe, even as far afield as Russia. Fifty years later, though, the genre had become a well-nigh global phenomenon, perhaps the earliest example of 'world music'.* (Parker, 2001, 88)

This global phenomenon needed structures that could guarantee the availability and quality of the singers. Over the course of time, this became associated with the German Fach system, as it now stands.

The system itself is complicated, but there is also a lot of confusion in regard to translations into other languages and aesthetical systems. In English, contralto is a low female[21] voice that sings solo. When the material is sung by a boy or a falsettist (a male voice), the common term is alto. Alto also applies to singers of a choir of any gender. In German, the term *Alt* or *Altistin* (feminine form of Alt) is used in all situations, and most other languages follow this system. On the other hand, according to the *Handbuch der Oper*, there is a special voice type, *tiefer Alt*, which can also be referred to as *Kontra-alt*.

Another indication, from a list of many, is *baryton Martin*, a high lyric baritone needed in some French repertoires. J.B. Steane questions, rather provocatively, whether non-French singers should be referred to by this term, since it is so strongly connected with the French school (Steane, 2002, Grove Music Online: 'Baryton Martin').

[21] In section 6, the terms male and female are only used to categorise the voice types, and are not related to the gender of the singer. Martin Grotjahn (2005) disccusses the theme of 'Stimmgeschlechter', 'vocal gender' or 'vocal sex'.

Because this heavily loaded system still can't categorise all voices, some singers are said to represent a *Zwischenfach* [in-between voice type], usually possessing some aspects of soprano and mezzo-soprano.[22]

The task of finding the right Fach for the singer or the role in classical opera is convoluted and will not be discussed here. However, the following aspects are considered when deciding the Fach: timbre, ambitus, tessitura (the ambitus that is most natural and comfortable for the voice), agility or skills in singing legato lines, and the general habitus of the singer (Miller, 1996, 19-202; Cotton, 2007; social implication Koehler, 2004). Calculating these parameters is a complex undertaking, which doesn't always work out. In some situations, the timbre and ambitus fall into a different voice-type category. It can also be problematic, when the singer doesn't look the part or does not fit the stereotype of that particular voice type, unfortunately this is still the case today.

One of the focal points of this project is to create a VMM that assists the inexperienced composer in working around the Fach system. It can also be useful for all composers to understand certain aspects of it — not in order to compose for a virtual soprano but to help to communicate with the singer or to make it easier to understand the existing vocal literature. Some of the essential points are listed here.

The inadequacy of standard terminology

Soprano, mezzo, contralto, tenor, baritone and bass are very crude terms to describe operatic voices. In the instrument family, the category of 'soprano' would be analogous to the 'woodwind'. The precise Fach (as indicated in *Handbuch der Oper*), such as *lyrische Koloratursopran* would be analogous to 'alto flute'. The vast differences in

[22] Singers like this are sometimes called Falcons, in memory of Cornélie Falcon (1812 – 1897), who is considered to be the first known example of this voice type. In a way, Falcon has since become the new voice type, and the term Zwischenfach is somewhat paradoxical.

aesthetic style and background of the singers should be kept in mind, regardless of them possessing precisely the same voice type. In section 10.3, I demonstrate how these partly minute differences can be used as musical material. The four soloists in the opera *Voice is Voices* all identify as coloratura sopranos, while still possessing different kinds of voices.

The indication 'for a soprano voice' in the score provides a lot of leeway and might confuse the reader. In this context, 'soprano' might indicate an anatomical division of voice types, or then a vague parent category of the actual Fac (Cotton, 2007, 1-3). To really use the Fach system professionally requires years of experience.

Coloratura voices

A very high, light, agile voice type is often seen as the ideal by contemporary composers, as they are able to ask the singer to use the extremes of their voice, sometimes without vibrato. The popularity of this aesthetic lays stress on the distinction between coloratura soprano and non-coloratura soprano (such as lyric soprano). The former has an ambitus and tessitura, which is somewhat higher, but there is also a difference in terms of agility. Historically, all voice types were trained extensively in coloratura,[23] or ornamentation, but as orchestras have grown in size and volume, it has become necessary for most voice types to concentrate on creating a sound that has projection and is hence less agile.

Dramatic voices

This brings us to another aspect, which applies to all the main categories, which is to determine how dramatic or lyric the voice is. Projection, or the penetrative quality that can be heard through an orchestra, is quintessential to the more dramatic voice

[23] By way of example, French bass-baritone Edouard Gassier (Forbes, 2002, Grove Music Online "Gassier, Edouard") and American bass singer Samuel Ramey are noted for their exceptional coloratura technique (Jander and Harris, 2001, Grove Music Online 'Coloratura').

types. This comes with a noticeable vibrato as well as a louder voice. It is especially striking in the high to middle range of the voice, but can be found in the lower ranges of very dramatic voices too. In contrast, lighter and more lyric voices can be highly flexible and agile. Dramatic voice types tend to have bigger vibratos, since the penetrative aspect is connected to the singer's formant (see Chapter 5: Vocal characteristics), which is itself connected to the vibrato. As a general rule, lyric voices are limited in their dynamic possibilities in the lower range and in a heavily-orchestrated context, whereas more dramatic voices are limited in their agility and possibly softer dynamics in the higher range. A good example of this is seen in case 2, In section 1.1, a composer had listened to the voice of a lyric coloratura soprano and then composed a piece for a lyric soprano using the earlier experience as a model. This proved to be a fundamental mistake, as it made the collaboration very unsatisfying and also affected future communications with other artists. This problem wouldn't have occurred if from the beginning, the composer had worked with a specific singer instead of a voice type.

Also, although the term would indicate otherwise, the most common soprano voice, lyric soprano, usually has quite some projective power, since that power is a considerable part of the singer's professional studies. The combination of a mid-sized orchestra and a lyric soprano is one of the most archetypal in the opera industry, and as such, the singer needs to master these kinds of situations with ease. Still, all voices need to possess some agility, singer's formant, coloratura-like ornamentation, the only difference being in the balance (Miller, 2000, 56).

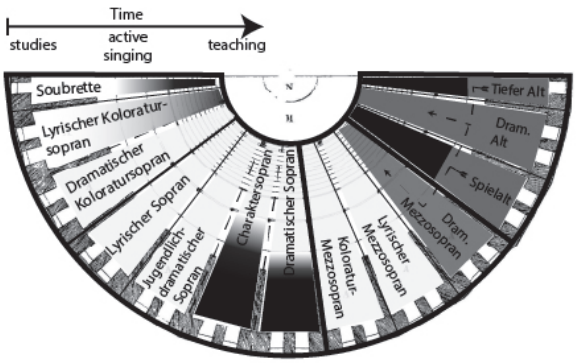
This compact introduction demonstrates that the Fach system plays a significant role in the opera industry. However, the people who use it — singers, teachers, casting agents, and heads of opera companies and festivals — have professional training and years of experience in how to apply it in practice. When untrained composers misuse this terminology, they create confusion and can damage the artistic work. There

is no shortage of literature concerning voice types and Fach. A recently compiled bibliography provides many further references (Nelson, 2020), also includes various vocal pedagogical aspects.

6.2 Typical problems for the inexperienced composer

Figure 5 displays the female voice types in the *Handbuch der Oper*. The graph demonstrates the singers' potential career paths throughout their lifetime, moving from the periphery to the centre of the semicircle or from students to professional singers and to teachers. The shape of the graph is inspired by Michael Foucault's concept of the Panopticon.[24]

Figure 5. A professional interpretation of certain female voices in the Fach system



The figure shows that the various voice types develop differently over the course of time. Very light voices, such as *soubrette*, may need to end singing earlier than others. Dramatic voice types, such as *dramatischer Sopran*, on the other hand, are sometimes only able to start their career when they are older (Miller, 2000, 175-181; and Fuchs, 1985, 146-147). As shown in the figure, sometimes extremely low female voices, *tiefer*

[24] In future studies, I aim to research the idea of the Fach system in the context of Foucault's theories.

Alt, have to disguise themselves as other voice types, such as *dramatischer Mezzosopran*, to give them better opportunities in the opera industry (see section 1.1, Case 7).

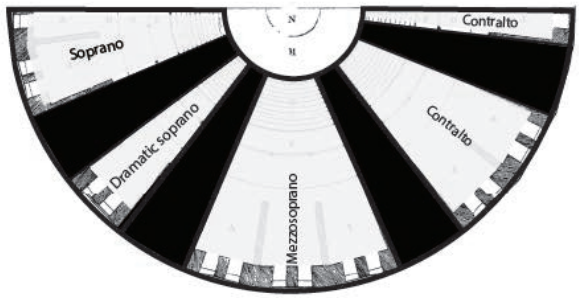


Figure 6. Inexperienced composer's interpretation of all female voices in the Fach system

In figure 6, I have imagined how an inexperienced composer might see the Fach system if it were drawn as in figure 5. This is an amalgam of many real-life misinterpretations I have observed during my career. When comparing figures 5 and 6, it can be seen that the inexperienced composer does not even recognise the existence of certain categories and the terminology is mixed up. The term 'soprano' is applied to a very light and agile voice type, which would be called *soubrette* or *lyrischer Koloratursopran* in the opera industry. There, a lyric soprano is considered to have a neutral or light voice, but this composer interprets it to be rather dramatic, since it has a recognisable vibrato and can be heard through a medium-sized orchestra. Most likely, an inexperienced composer is only used to working with smaller ensembles.

The distinction between mezzos and sopranos is not apparent and many of the more dramatic voice types are fully absent from the mental map. Inexperienced composers wouldn't intuitively compose for these voices and would not be aware that a soprano might possess that kind of voice. This structure doesn't have any temporal function either.

A composer's faulty mental reconstruction is probably based on the experiences and memories of those who sing a lot of contemporary music. Because of this, composers only experience a limited aspect of operatic voices. In this regard, the Fach system is transformed into a wrong model and, in turn, encourages the composer to neglect to communicate with the actual singer. They have the illusion of how a soprano voice functions so they don't have to consider how the human voice functions. If they were to have a discussion with a singer, they could learn a lot about the voice as an instrument, including breathing and registers. This mental image is too limited, certainly, but it can also be completely wrong.

I call this fallacious fantasy voice type or character a 'virtual soprano'. Analogous to this are the 'virtual bass' or 'virtual lyric coloratura soprano'. A composer who doesn't know the voice well thinks that having heard a lot of music, including some vocal music, they know how the voice and voice type functions. They don't notice that the Fach system contains rich and complicated structures and categories with a lot of implied aesthetical knowledge. Possibly one part of the problem is that they are rigorously trained in classical instruments that are often interchangeable: every viola is roughly the same, all clarinets of the same type and produced by the same hand function similarly. Unfortunately, they haven't studied voice in nearly the same level of detail, and the voice is anything but standard.

In the hands of an inexperienced composer the Fach system can cause misunderstandings and prove very problematic, even hazardous.

6.3 Composing for a particular singer

Although the Fach system can become problematic in the hands of an inexperienced composer, there is hope. A solution would be a compositional procedure that has been tested exhaustively and has helped to create most of the successful vocal music

from the 17th century to the present day.

The process is straightforward: the composer meets with the singer and they have an active discussion. This allows the composer to get to know the singer's voice and then compose for that voice. After the rehearsals and the performance, the composer receives direct feedback by listening to and talking with the performer, and is then better equipped to compose for all voices in future. Later on, other singers may perform the same piece.

For all composers, this provides illuminating information about a specific voice, but for inexperienced composers, it additionally provides a general understanding of how all voices function.

Vocal performers of contemporary music seem to favour meeting and communicating with the composer. In their book *Composing for Voice*, Barker and Huesca (2018) strongly argue for composers to work in this way. Their thesis is supported by numerouis vocalists such as **Sarah Leonard**, **Frances Lynch**, and **Jane Manning.** In discussions with me, the singers **Sarah Maria Sun** (personal communication, 25.10.2017) and **Lisa Fornhammar** (personal communication, 22.7.2021) were in accord.

Analogically, many composers would have had the option to compose using the Fach system, but decided differently. They had in mind the specific singer and their voice as they composed, although that person was only one of several booked to sing the piece. For example, according to Kaija Saariaho: "[...] it can be an advantage when you know the particular voice for which you are composing" (Mösch, 2017, 363-364, translation by the author).[25] In the projects Saariaho describes, the pieces were composed for the person not for the Fach, although it is clear from the beginning

[25] "Es kann zudem von Vorteil sein, wenn man eine bestimmte Stimme kennt und dann für sie komponiert."

that the parts would be sung by many different people who would be cast on the basis of their Fach, all in the context of the opera industry.

This is a telling counterexample of a common and unfortunate misunderstanding: that the vocal piece composed for a certain person would not be performed in future. Or, more tragically, that composing for the virtual soprano would somehow guarantee that many different singers would or could perform the piece. A vast majority of operatic roles performed today were originally composed for a particular singer or, in some instances, by a composer who had gained an understanding of the Fach by working with particular singers. Paradoxically, some pieces from the classical repertoire were composed to manifest the singer's unique skills; for example, W.A. Mozart rewrote arias for specific singers such as Aloysia Weber (Mahling, 1996), as did George Frideric Handel (Hunter, 2015, 214). In our time, this virtuosic music is sung by thousands of singers daily in opera houses around the world.

The following is a collection of works or composers that have maintained a position in the core repertoire. The descriptions indicate that composing for the specific singer has been the standard for centuries, and although the tradition has since been questioned, many notable contemporary composers are still in favour of it. These examples are taken from opera and larger-scale musical theatre.

The person who is often thought to have composed one of the first operas that has survived is **Claudio Monteverdi** (1567–1643), with *L'Orfeo* (1607). Not only did he study singing, he also worked as a choir and vocal teacher. The vocal parts in his operas were strongly influenced by the developing skills of the local virtuoso singer (Oxford Music online: 'Monteverdi').

In the 17th and 18th centuries, the period that gave birth to bel canto, most composers had some kind of singing training. In fact, many Italian composers at that time performed as singers (Lucie Manén, 1974, 11, as quoted in Barker and Huesca, 2018,

19). Even in the expensive art of opera, a composer would never have started to compose anything until they knew exactly who would be performing it (Ibid., 8). This is especially true for **Georg Friedrich Händel** (1685–1759), who wrote and rewrote much of his music for specific singers (Hunter, 2015, 214).

In the classical period, **W.A. Mozart** (1756–1791) is especially known for working as a vocal teacher and was thus able to create some dramatically new inventions for the voice and he also sang publicly as a child (Mahling, 1996). His use of particular singers' registers is discussed in section 4.3. At this point, the budding Fach system was also too vague to be used as effectively as it is now.

Ludwig van Beethoven (1770–1827) had a somewhat complicated relationship with his singers in his only opera *Fidelio* (1805). Anna Midler, the first Leonore, was said to have a voice dramatic enough for the role; nevertheless, she found Beethoven's music unsingable and required it to be simplified (Robinson, 1996, 145-146). Beethoven knew the singers but just didn't care, demonstrating the tendency of a romantic genius to make his own rules.

Gioachino Rossini (1792–1868) composed very specifically in response to the requests of the singers, also creating different versions of the arias for the different singers (Celletti 1991, 158, 163-16).

Giuseppe Verdi (1813–1901) usually worked with specific singers, and became famous for his outrageous demands on them, especially tenors, such as Enrico Tamberlik (Pleasants, 1967, 170-172).

Richard Wagner (1813–1883) had his own approach: while working as a conductor he became aware of the sad state of the singers and decided to compose regardless of them; the scores often had to wait for years to premiere. One of his successful collaborations was with Wilhelmine Schröder-Devrient who Wagner had conducted

before writing some central roles for her, including Senta in *Der fliegende Holländer* (1843). For Wagner, her skills as an actress were probably more important than the beauty of her voice (Glümer et al, 2009).

By the end of the 19th century, the Fach system had found its elaborated form and was in wide use. This allowed **Giacomo Puccini** (1858–1924) to write some of his operas before the casting was decided (Rosselli, 1992, 202).

Arnold Schönberg (1874–1951) worked as a conductor from early-on in his career. When composing *Pierrot Lunaire* (1912), he was well acquainted with the voice of actress Albertine Zehme, who commissioned the piece and sang in the premiere. He had also conducted many melodramas, the style that inspired this piece (Byron, 2006).

After the Second World War, the evolution of music picked up pace. This marked a change in vocal composition too, as the demands on singers were new, surprising and harsh. Serialism questioned the emotional aspect of singing, the meaning of the text, legato lines, and indeed the melodies; there was very little space for the *bel canto* technique (Griffiths, 1995, 34-56, 90). Opera, especially, became an absolute taboo, that is, until Ligeti (1923–2006) composed *Le Grand Macabre* (1975–76), a piece he labels "anti-anti-opera" (Ibid., 191).

The revolution might have been too drastic for many of the singers and vocal pedagogues. While some indicated the problematic requirements of the voice and vocal technique, many of the composers reacted by being more strict in their choices, seeing the voice as one of the instruments. Some of the earliest examples of difficulties in communication are from this era (e.g. Barker and Huesca, 2018). It is tempting to presume that the schism born here is somehow related to the communication deficiencies that have motivated this study.

For some of the more contemporary composers I mainly refer to the book *Komponieren für Stimme* [Composing for Voice] (Mösch, 2017), which provides an insight into the composition of vocal music. Mösch interviewed composers about their processes in working with vocal music, and many of them have composed for particular voices.

Helmut Lachenmann (1935–) is best known for his *musique concrète instrumentale*, which uses the extremes of the instruments systematically and with sophistication. Also, when working with voice, he searches for new possibilities. I interviewed him briefly about *temA* (1968) for flute, voice and cello (Helmut Lachenmann, personal communication, Berlin, 17.11.2018). Lachenmann composed the piece for **Hanna Aurbacher**. He already knew her voice somewhat and didn't want to disturb her, so he experimented mostly with his own voice: how the breathing works, how the vowels can be used compositionally, and so on. By experimenting with the vocal material in the piece within his own body, he was able to reorganise the material and create the composition. This work is one of the first compositions by Lachenmann that is still performed. In his later works, he was compelled to keep the possibilities more open. The opera *Das Mädchen mit den Schwefelhölzern* (1988-1996) involves a huge orchestra, a choir and vocal soloists. When asked, Lachenmann admitted he applied the understanding of the human voice he had collected so far, in different pieces, and then composed for a Fach. Due to the many forces needed to stage this opera, it could only be performed in an opera house, and therefore according to its rules (i.e. using the Fach), with no room for experimentation Ibid.).

Aribert Reimann (1936–) had gained a lot of experience with singers and singing during his childhood. When he was composing the opera *Troades* (1986), he was looking for a certain kind of voice that could be seen in the context of the Fach system, but also beyond that: "At the time, I was working on the singing recitals with mezzo-soprano **Doris Soffel**, and the role [of Kassandra] was tailor-made for her" (Mösch, 2017, 348-353, translation by the author).

Peter Eötvös (1944–) has worked with singers since childhood. Still, after composing many large-scale operas for international opera companies, he cannot begin the compositional process before he knows which singing voices he is writing for. He mentions composing portraits that connect the possibilities of the voice to the role (Mösch, 2017, 321).

John Adams (1947–) is the first blatant contemporary counterexample. This widely performed opera composer says that the characters in his operas are indeed archetypes, or Fach caricatures: for example, Mao Zedong's wife in *Nixon in China* (1987) is an obvious coloratura soprano in the style of *Königin der Nacht* (Ibid., 305).

Wolfgand Rihm (1952–) has composed music for voice throughout his entire youth. He listened to concerts by **Erika Margraf,** especially, and composed his op. 1 for her. Today he is known for his virtuosic use of voice and for operas such as *Hamletmaschine* (1983—1986), but his fundamental understanding of the voice dates from that time (Ibid., 354-360).

Kaija Saariaho (1952–) began her career as a composer by working intensively with the soprano **Anu Komsi**, recording her voice for electronic works (e.g. *La Dame à la Licorne*, 1993). Over her career, Saariaho has also written a lot of vocal chamber music for Komsi (e.g. *Leino Songs,* 2007, commissioned by Komsi). Later on, she collaborated with **Dawn Upshaw** in the compositional process for *Château de l'âme* (1996*),* her first piece for singer and orchestra. Subsequently, based on that experience, she wrote her first and highly successful opera *L'Amour de loin* (2000) with Upshaw as one of the soloists. Soprano **Karita Mattila**, on the other hand, inspired the title role in the opera *Émilie* (2008). And in *Only the Sound Remains* (2015), the voice of **Philippe Jaroussky** was live-manipulated using software that was specifically optimised for his voice (ibid., 361–365). Evidently, Saariaho composes her vocal music for a specific singer. The use of the voice is different for the different performers.

Chaya Czernowin (1957–) has an intense and complicated relationship with the human voice and works with very particular performers and singers. In 1996, while at Akademie Schloss Solitude, she was able to experiment with the multifaceted singer, performer and composer **Ute Wassermann**, who showed Czernowin many of the potentialities of the voice (lecture "On Recent Pieces", Darmstadt, 01.08.2016). She also studied the voice of **Frauke Aulbert** extensively before composing for it in the opera *Heart Chamber* (2019) (lecture, Universität der Künste Berlin, 28.11.2019).[26] On the other hand, she finds it problematic that the voice almost automatically brings with itself the personality and identity of the singer (lecture "On Recent Pieces", Darmstadt, 01.08.2016). Czernowin has tried to make the connection obscure through amplifying and thematizing the act of breathing (Mösch, 2017, 310-315). Although the musical qualities of a specific voice can be the starting point for a vocal composition, similar qualities can also make the voice personal, which clashes with Czernowin's aesthetic idea.

Nevertheless, from the 20th century to today, there are many examples proving that intense and lengthy collaboration is still attainable and extremely fruitful. Barker and Huesca mention, among other composer-singer duos, **Luciano Berio** (1925–2003) and **Cathy Berberian**; **Benjamin Britten** (1913–1976) and **Peter Pears**; and **Samuel Barber** (1910–1981) and **Leontyne Price** (Barker, 2004, 9). Berberian was also a composer and inspired many contemporary musical inventions. **John Cage** (1912–1992) articulates it nicely when he describes the birth of his piece *Aria*. He was "amused by Berberian's domestic vocal clowning," which he translated into a rapid and virtuosic change of styles in *Aria* (Berio et al, 1985, 60). Many of Luciano Berio's compositions were also based on improvised material by Berberian (Bosma, 1996).

[26] Interestingly, the score denotes 'vocal soloist' as soprano, contralto, countertenor and baritone, all of which perform on stage, but Aulbert belongs to the group of 'instrumental soloists' performing 'voice (high female)' (Czernowin, 2018).

Singer and conductor **Barbara Hannigan** has inspired numerous composers and, to date, has premiered 85 new works (barbarahannigan.com). To mention two very different pieces: she sang the role of Agnès in **George Benjamin**'s (1960–) highly successful opera *Written on Skin* in 2012. Benjamin states that he "... always writes with particular singers in mind, compiling a mental archive of each artist's strengths and weaknesses." (Mead, 2018, The New Yorker). Hannigan also premiered **Michel van der Aa**'s (1970 –) opera *One* (2002), which combined live performance with recorded material, placing value on Hannigan's appearance as well as her voice. As her voice matured, the recorded material differed more and more from her live performance. In this case, the composer and the performer decided to create something that could not be performed by anyone else in the future, including by Hannigan herself (vanderaa.net "One").

Experimental music theatre composer Georges Aperghis (1945–) has always worked intensively with his musicians, involving the kind of lengthy rehearsal processes common to a theatre director. His work with **Donatienne Michel-Dansac** served to inspire some of his finest works (Georges Aperghis, personal communication, Darmstadt 2016). At times, Aperghis's scores are often a bit sketch-like, since the work had been created together with the cast of the premiere.

Some composers have found a third option. Instead of composing for the Fach system or trying to get past it, they deconstruct it or critique it from within. The characters become caricatures of a Fach, playing the role of 'a soprano' or 'a tenor', complete with all the cliches: taking on the roles they usually sing but also the personalities they are supposed to be.[27] One example of this method would be **Tom Johnson**'s *Riemann-Oper* (1988) that uses **Hugo Riemann**'s *Musiklexikon* (first edition 1882) as a libretto. 'Aria' is used for an aria. The 'Lyrical tenor' is used in the tenor's number,

[27] Sometimes this even extends to referencing dated and more abstract layers, such as the fixed roles in commedia dell'arte (i.e. Pirrotta 1955).

as music allows them to play and fulfil our expectations of the role of the tenor (Gembris, 1988).

One tendency that has become more and more prevalent in recent years is that of vocal composers performing their own music. In pop music, the singer-songwriters are central to the style. Barker and Huesca (2018) list some 20th-century composers who use their own voice in the context of art-music genres: **Trevor Wishart**, **Meredith Monk**, and **Daryl Runswick**. The newer generation of singer/composers includes **Jennifer Walshe** and **Julia Mihály**. A composer using their own voice is able to use it with a precision that can't be achieved by any other composer. Still, this music can also be performed by other vocalists. For instance, pieces by Walshe are popular, although often demanding.

This chapter ends with the words of Martha Elliott. In her book *Singing in Style,* she goes through the historical styles, ending the book with a chapter called "Working with a living composer".[28] According to her, the composing processes that take place now are very similar to those that have always taken place:

> *Composers write for specific singers, but they frequently make changes for subsequent performances, recordings, publication, and other general purposes. Singers collaborate in the compositional process, grapple with the meaning of notation, and add their own idiosyncratic styles to a work.*
> (Elliott, 2006, 286)

[28] This chapter also provides the singer with a very practical description of how to perform contemporary music.

7 Voice Range Profile

The voice range profile (VRP), also known as the phonetogram[29] is a method that charts vocal intensity versus fundamental frequency (Schutte and Seidner, 1983). The graphic output is also called the VRP. It has a notable role in the development of Voice Map Analysis (VMA).

7.1 Definition and literature

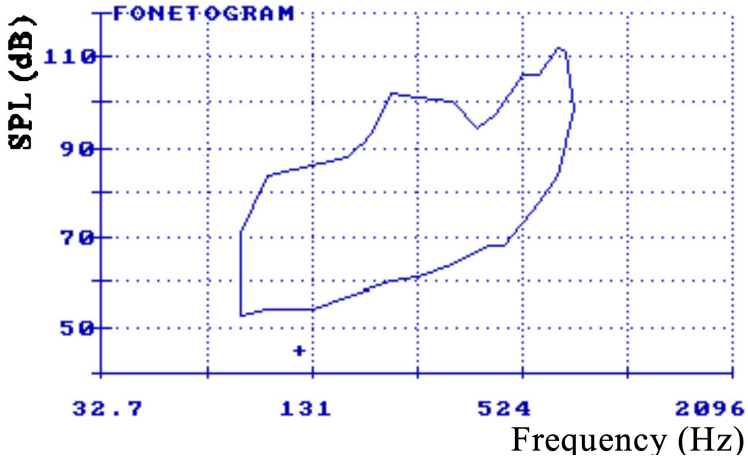
The VRP is executed as follows: the test subject, whether non-singer or singer, is positioned in a soundproof laboratory or studio with neutral acoustics. A microphone is placed 30 centimetres from the person's mouth. The test subject produces tones throughout their range. Depending on the testing system, they might need to sing step-by-step and hold each chromatic tone for a given period, which could be as long as several seconds. In some testing setups they can simply sing glissando from low to high, and in others, the program or the person leading the test can supply the tones, usually using a keyboard. The test subject sings through their range as softly as possible and as loudly as possible, using the vowel /a/. The verb 'singing' could have different interpretations here; a professional singer can apply their vocal technique, whereas a person with severe vocal difficulties might barely be able to produce pitches in the range of two semitones, only in very soft dynamics and with a very specific timbre. Hence, an analysis can determine the artistic possibilities or relate to spoken abilities. Sounds provide the data, which is analysed by the computer program.

The data points consist of the fundamental frequency and its associated maximum and minimum sound pressure levels. Frequency is expressed in Hertz (Hz), sometimes also overlaid with the musical pitch. The sound pressure level on the y-axis is shown

[29] Sometimes the software or hardware that is used to record the VRP is called phonetograph (Lamarche, 2009, xi). In this sense, VMA software is also a version of a phonetograph.

in decibels (dB), as seen in figure 7. The resulting graph will exhibit certain expected phenomena that a trained eye could easily read.[30] The practical protocol of the process has been described in 'Recommendation by the Union of European Phoniatricians (UEP): Standardising Voice Area Measurement/Phonetography' (Schutte and Seidner 1983), and a technical description by Sulter, et al. (1994) is given in 'A Structured Approach to Voice Range Profile (Phonetogram) Analysis', as well as by the the application providers (e.g. online resource Manual for Voice Profiler, Pabon, 2007).

Figure 7. Voice range profile (Sulter et al. 1994)



VRP was created and developed by vocal scientists to better obtain an overview of the voice through gathering numerical data. Its use can be divided into three categories: assessing information about an individual voice, investigating the influence of therapy or surgical intervention, and comparing the results of selected groups (Sulter, et al. 1994). If the VRP is carried out as part of a therapeutic process, this visual feedback can enable the patient to view their development. A comparison of the results can also be made statistically, such as by noting the VRP results of numerous patients before and after therapy (Lamarche, 2009, 25). The idea of analysing the dynamic

[30] These phenomena are further explained in the next section, and their involvement in the VMM is expanded upon in the section thereafter.

limits of the voice as a function of the pitch was first formulated by Wolf, et al. as early as 1935. Over the subsequent decades, the process became smoother, and since the 1990s, the data has been collected directly, by digital means. Creating VRPs more efficiently has proven to be of equal benefit to voice researchers and voice therapists. The historical review can be found in Lamarche (2009) and Sulter, et al. (1994).

The future direction might be to create software that can produce VRPs more quickly and reliably, or to combine the VRP information with alternative sound analyses (Pabon and Ternström, 2020). The number of studies using this method is substantial and even their meta-analysis has proved valuable. In conducting a systematic literature review, Printz et al. (2017) found a high level of reproductivity in the VRP as used by different researchers; repeating the test with the same subjects often yielded similar results. The reasons for the variability in the VRP of one person's voice have been analysed by Ternström and Pabon (2019).

To gain a better understanding of VRP-use as part of the therapeutic process, I consulted voice therapist Jaana Sellman. She uses the VRP in her work and mentions that, in modern therapy, the process is often rather informal. Many patients can barely achieve any pitches or emit sounds at all, so a question of F sharp or F is irrelevant. No external microphone is needed, since the importance of the procedure lies in its practicality. Often the internal microphone of a laptop is sufficient; it minimises the fear-factor that arises from the idea of testing or recording. The patient can also see the VRP on the screen while they are producing the sounds. This way, they are encouraged to surpass their previous results, which can have a therapeutic advantage (Jaana Sellman, personal communication, 31.8.2015).

The VRP should be carried out in a suitable place, in accordance with the 'Recommendations for the Creation of a Voice Acoustics Laboratory', as updated by its authors, Spielman, et al. (2007). It describes the technical and acoustical parameters

of a space, to guarantee neutral surroundings for analysing the human voice. This doesn't differ much from the basic qualities of the studio spaces in modern music universities.

7.2 Reading a VRP

As a research tool, the VRP is typically used to collect and organise statistical data and provide it in a format that is easy to read and also to compare. This section summarises the mathematical methods used for reading and comparing VRPs. (The subsequent chapter describes how these mathematical analysis methods are not necessary for users of the VMA.)

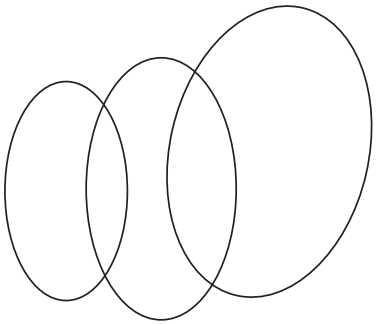
The frequencies and sound pressure levels are first analysed by the computer and then recorded in graphic format (see figure 7), making it easy for the researcher and test subject to read. The difficulty arises when these graphs need to be compared or analysed statistically. This comparison should take into account the vocal range as well as the dynamic of each pitch. Also, some qualities are more crucial to vocal communication than others.

Sulter, et al. (1994) mention three key features of a VRP: *general shape of the profile*, *closed area* and *speaking range dynamics*. These can be described by groups of parameters.

The **shape** of the profile can be approximated as a number of overlapping ovals, as seen in figure 8. In this attempt to quantify the graphs, the ovals could then be determined in reference to their main and secondary axes, rotation, and X and Y coordinates of a central point (Lamarche, 2009, 37). One factor concerning the shape is finding this intersection of points in the registers, which is related to the *passaggio* area in classical vocal pedagogy. The sloping intersections of these ovals are markers for register transitions. This method gives very rough results, and the

number of ovals or the precise method of their positioning has never been agreed upon. A similar issue concerns the method based on the Fourier descriptors, as found by Sulter (1996).

Figure 8. An abstraction of VRP with three registers



Hacki et al (1990) and Pabon, et al. (2011) have provided different statistical methods for comparing a group of VRPs and creating normative VRP data. These results can be helpful for masses of data, as is often the case in clinical studies, but they just depart further from describing one individual voice, as is the case in the VMM.

One strategy is to combine this kind of VRP data with a further analysis of the sound. Bloothooft, et al. (2001) created repeated register changes and used the crest as one of the factors in judging when the register change took place. These results were then compared with the VRP data.[31]

Sulter, et al. (1994), also analyse the methods of using a closed area and speaking-range dynamics, the two remaining features, to gain numeric data from the VRP. These methods are only briefly described here.

[31] The crest factor indicates how extreme the peaks are. Mathematically speaking, it is the ratio between maximum amplitude and RMS.

The VRP creates a **closed area**, the lowest pitch can be produced only with a very soft dynamic and the maximum phonation contour declines until it meets the minimum contour. Similarly, the highest tone can only be produced in a very restricted, often loud dynamic, so the minimum and maximum contours meet also at a rather high dynamic value. The closed area between these contours can be calculated as the so-called Riemann integral, which is the difference between the integral over the maximum contour (a) and the minimum contour (b), as indicated in figure 9. This area produces a numerical value that shows how much freedom the voice has in terms of dynamic and pitch (c).

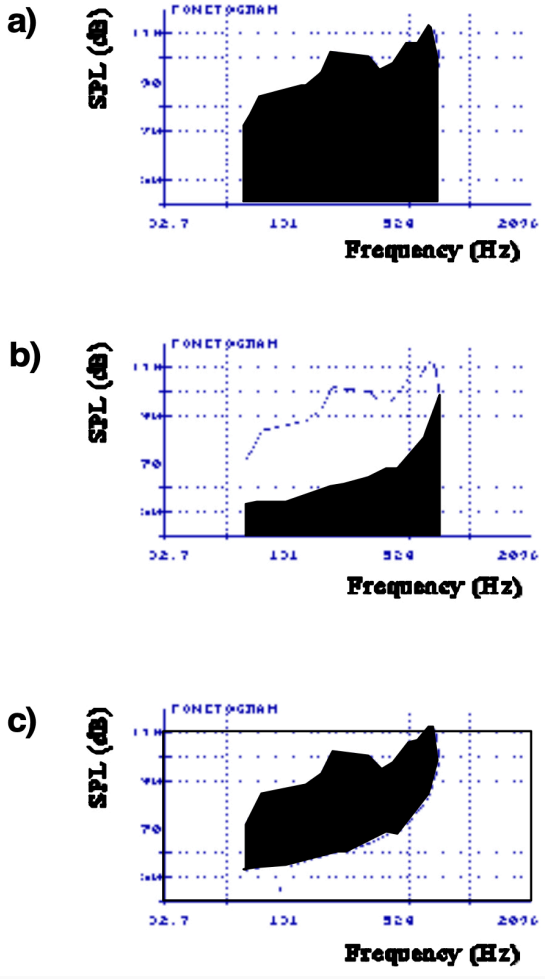


Figure 9. Counting the closed area as a difference of integrals: a) maximum contour, b) minimum contour, c) their difference. (Sulter, et al, 1994)

This area is indicated by an impractical unit of measurement (HzDb). To relate it to For practical purposes, the value is compared to the theoretical maximums of the human voice. Based on the publication 'Recommendation by the Union of European Phoniatricians' (Schutte and Seidner, 1983), the rectangle with corners 32.7 Hz — 40 dB, 32.7 Hz — 110 dB, 2096 Hz — 110 dB and 2096 Hz — 40 dB provides satisfactory results.[32] This rectangle is shown in figure 9, c. By dividing the closed area by the constant as calculated from the given rectangle, the result is an absolute value. Statistically, this value indicates what fraction of the theoretical possibilities the voice possesses. In this example, the value would be 0.238, meaning that roughly a quarter of the rectangle is covered by the closed area, a quarter of the possibilities of a maximal voice.

This kind of process is impractical for the singers, since their dynamic range is drastically different from that of an average person's speaking range. Theoretically, the areas of the different singers could be compared with each other, but it doesn't really help regarding communication.

Another way of creating numeric data is to concentrate on the frequencies and dynamics that are most imperative for speaking. These are called the **speaking range dynamic**s. Sulter, et al. (1994) provide this value only for four representative frequencies: (1) the mean speaking fundamental frequency[33] (mff), (2) mff minus three semitones, (3) mff plus six semitones, and (4) mff plus 12 semitones. The value of each point shows how well the different dynamic intensity values can be used, since being able to speak only very softly or loudly strongly limits communication. Not all dynamic values are equally important for vocal communication. 75dB is selected as the reference point, and on both sides of this, the intensity decreases to the

[32] This decision was partly based on what were considered to be the theoretical limits of the human voice, and partly on what was practical to measure using the machinery of the 1980s.
[33] The authors used an mff of 123 Hz for male subjects and mff of 220 Hz for female subjects.

decay of a natural logarithm. For example, the value of 55 dB has a distance of 20 dB from the reference point (75 dB — 55 dB = 20 dB). This value needs to be weighted, since the extreme values of dB are used less in speech. The natural logarithm of 20 is approximately 3.0. By adding together the weighted maximum and minimum values, we arrive at the weighted dynamic range of this frequency. Analogously, the weighted central position of that frequency can be calculated as the average of the minimum and maximum.

For the singing voice, the speaking range dynamics have limited use, since the importance of the specific dynamic parts are completely different than those of speaking.

7.3 Other existing applications

The VRP is fundamentally a way of visualising voice data. This data can be collected with the help of different software, some of which is designed for general vocal analysis (3.7.1) and some specifically for creating a VRP (3.7.2).

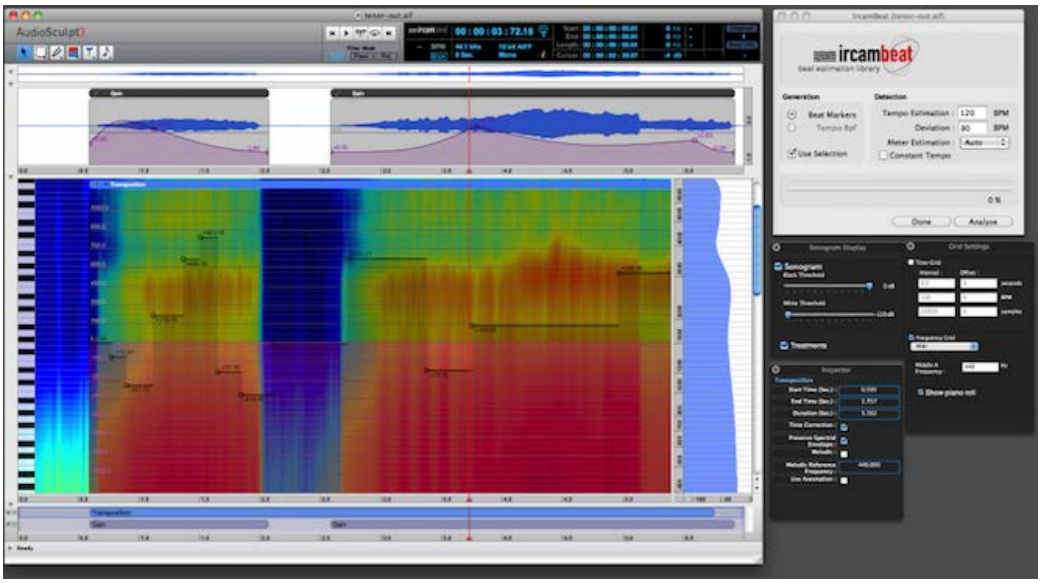
7.3.1 General vocal analysis

There is plenty of sound analysis software in a wide spectrum of usability and price categories that can be used for voice, and some of them show similar qualities as the VRP, such as the singer's formant. On the other hand, the software does not structure the data to render it helpful to a composer.

Praat software is free. It is used by some voice scientists to analyse the voice, especially the spoken voice. It can reveal specific formants in a short sound fragment in a reliable way, but the interface is cumbersome and doesn't invite analysing more lengthy sound files. It was used in this project for recognising the individual singer's formant (see section 9.3: Phase II).

On the other end of the spectrum is AudioSculpt. This software was developed at Ircam, an institute dedicated to the research of music and sound. AudioSculpt is rather easy to use, and provides effective tools for audio analysis and processing. Many of these tools can be used to provide very helpful and practical information about voice. It is the best software I have found for demonstrating the singer's formant visually. AudioSculpt is part of the Studio Forum program suite, which costs €200 per year (as of 2021) and is half-price for students. AudioSculpt does not provide tools for creating VRPs.

Figure 10. Screenshot of AudioSculpt (https://forum.ircam.fr/projects/detail/audiosculpt)



Ircam also produces many other tools, such as VoiceForger and Orchids, which provide interesting information and musical ideas about voice, especially from the composer's point of view. A somewhat older program, Chant, was originally created in the early 1980s for synthesising the human voice. It can reproduce the singer's formant and even mimic the effort of singing the tone. These two variables are also part of the VMM, but involve a real singer rather than a digital one (OM-Chant 2.0 User Manual, online).

Unfortunately, none of this software can be directly used for creating a VRP.

7.3.2 Existing applications for the VRP

The VRP is merely a structure for the collection and representation of the collected data. In the past, this was done by hand — the researcher followed the pitch using their ear or an acoustical tool, and the dynamic was controlled using a sound level metre. The data points were marked on paper (Schutte, et al., 1983). From the 1990s onward, the process was automated and done by computer.

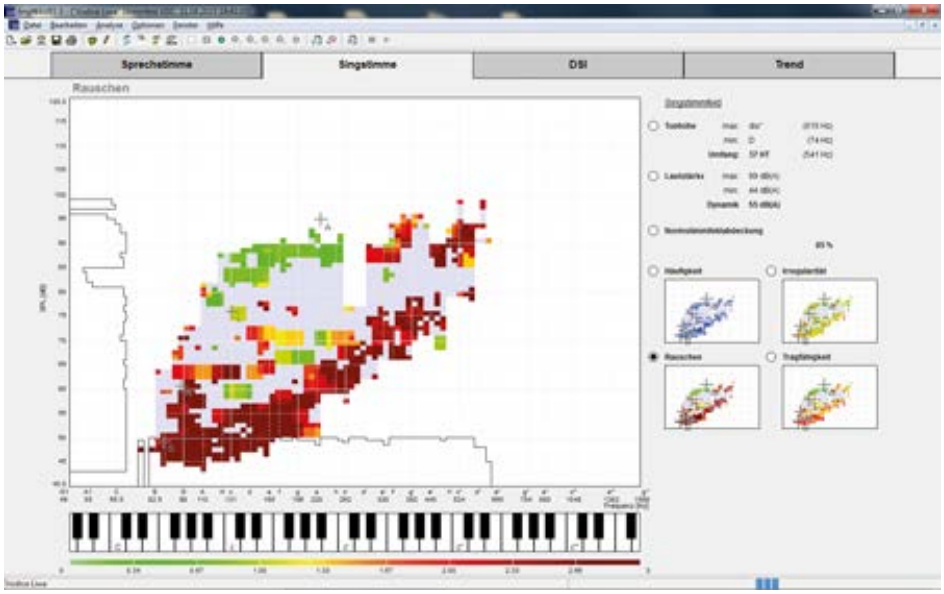
Since then, there have been several programs for making VRPs, but many of them have not been updated and so are mostly using out-dated technology and operating systems. Quite possibly, many of these were indeed created for one specific research project and were not designed to be used afterwards. The programs that still are more-or-less active and updated can be divided into two categories:

1) Open-source programs that are seldom updated. The whimsically named VRRRP!! seems to be the only software that could be called contemporary, and yet its last update was in 2008 (VRRRP!! Home page). Speech and language therapist Jaana Sellman (personal communication, 31.8.2015) mentioned that she uses this program for her patients when precise data is not needed. The other programs that exist are too old for practical purposes.

2) Extremely professional software designed for clinical and academic purposes. One such is lingWAVES Voice Diagnostic Centre (VDC) set by WEVOSYS. The screen capture in figure 11 shows the elegantly designed interface and some of the features, like the analysis of the singer's formant. Also Voice Profiler 5.0 by Alphatron Medical Systems provides many features for analysing the overtone structures of sound using 'spectral VRP'.

Figure 11. Screenshot of lingWAVES Voice Diagnostic Center (www.wevosys.de)

Both of these also provide hardware that includes a calibrated microphone. The



Voice Profiler can be used with a wearable harness, as well as a microphone distance stabiliser, which allows the test subject to move about while the distance between their mouth and the microphone remain unchanged. DiVAS Voice Diagnostics has a similar product; however, it aims more towards the medical market than the academic one.

All of this software and hardware is extremely expensive — the prices are not mentioned on the websites. Instead, the makers directly negotiate with the respective hospitals, universities, etc.

When this manuscript was at the final stages, I was informed of FonaDyn, free software originally conceived for analysing electroglottographic signals in a manner similar to that of the VRP (Ternström, 2022, The FonaDyn Handbook, online material). This software is capable of collecting and organising vocal data; in contrast to the VMM, it is even too much for a composer and a singer to use efficiently. It is, nonetheless,

an interesting tool for a person willing to go further into the analysis process.

Due to the technical limitations and economic realities, the applications mentioned here do not provide a realistic solution for inexperienced composers. There is a need for free software in order to use the VMM in a way that is practical for musicians.

II

Development

Part II Development

Developing, optimising and testing of the method were closely tied together. The step from VRP to VMA, described in Chapter 8. In Chapter 9, the process of Field testing, is described in three phases: vocal areas (9.1), vibrato (9.2), and the singer's formant (9.3). The VMM was tested with 22 classically trained singers. In six of these tests, the process was finalised and a composition was written. The artistic tests are analysed in detail in Chapter 10; they have been shown to produce the most profound evidence of the VMM's functionality. The resulting pieces are the operas *Voice Box* (10.1), *NOS* (10.2), *Voice is Voices* (10.3), along with independent academic tests (10.4).

8 From Voice Range Profile to Voice Map Analysis

The VRP provides essential data about the voice in a compact form, and the analysis protocol is well determined and tested. Still, extensive modification has been necessary in order for the VRP to develop into the VMA and to effectively aid in the communication between singers and composers.

The goal was to make a brand new method, based on the VRP, that is approachable and practical for use in the musical context. Also, the VMM always applies to a unique situation and functions as a starting point for the communication between two individuals, the singer and the composer.[34] The comparison is made within each VMA, especially between the different areas of one voice. Regarding the VRP, the results need to be reproducible and free of systematic errors, since they are used in relation to the other results. Frequent uses would be: collecting and analysing the statistical data from many different voices or observing how the results of one person's VRP has changed over the course of time as a result of their training or therapy (Sulter, et al., 1994).

This brings us to an important consideration. The VRP process maintains obvious social hierarchies. A therapist analysing a patient or a scientist studying a test subject's voice are both means of observing and being observed. The observer also already knows the process; they designate the test place (such as the laboratory) and control the equipment. In most instances, the observer is also the one applying the data resulting from the analysis, either for academic purposes or for supporting the therapeutic process. The person being observed may reap some personal benefits from the process, but the person using the data is usually the observer. How much of this structure remains in the VMM?

[34] In cases where there is more than one singer or, indeed, more than one composer, the individuals are treated separately and not as a group.

The imbalances can take form in different ways. Simply developing a method involves instructions and hence a power structure. By adhering to the instructions, the singer and composer gain tools for communicating more effectively and creating better vocal music.

Many of the problems specific to the VRP do not apply to the VMM: Both the singer and the composer know equally as much about the process, and the test could be executed in any neutral place. In addition, the singer decides about the areas of the voice and the order in which those are analysed. Most importantly, the Voice Map itself is used in a balanced way; it contributes to the communication between the two parties. Still, the fact remains that the composer is usually the one operating the computer and the singer's voice is the entity being observed.

General questions that arise during the process of creating new vocal music are described in 1.1 and 8.1. The VMM is a good solution for some of them, mainly because it lets the communication flow freely so that questions can be discussed before they develop into problems. At a minimum, the VMM takes care of the most basic level of imbalance: that of not communicating at all. As the virtual soprano could never apply the VMM, the composer and the actual singer are automatically brought together. Sections 9 and 10 describe in detail how the VMM provides a structure for gaining ample information during the analysis process, as well as a vocabulary for further discussion.

8. 1 VRP for singers

The question of using the VRP to assess singers is an old one. Lamarche (2009, 24) claims that the original concept was first created by Wolf and Sette (1935) and Wolf, et al. (1935) to track the maximum sound pressure level of 50 singers. In their doctoral theses, Lamarche (2009) and Lycke (2013) are trying to build a bridge between the VRP and the singing voice.

As significant as these studies are, they do not provide enough information for a composer. For instance, Lamarche only divides the female voices into sopranos and altos, which is a good starting point but hardly helpful to composers. Even still, studies like this prove that the VRP can indeed be used to analyse a singer's voice.

Further studies involving the VRPs of singers or singing students include: a study on vibrato (Thorpe, et al., 2004), timbre (Pabon and Ternström, 2020), and two studies that also analyse the pedagogical aspect of using the VRP to analyse the learning results of singing students (Pabon, et al., 2014 and Holmes-Bendixen, 2013).

Sometimes the difference between trained and untrained test subjects is emphasised by separating the terms 'physiological voice range profile' and 'performance voice range profile', or 'performance voice range profile'. The latter only takes into account the excerpts that the singer finds aesthetically acceptable (Lamarche, 2009). The VMA concentrates on the second category.

8.2 VRP for composers

The starting point of the VMM is clarity of communication. The process must be direct, effectively demonstrating the dynamic possibilities of the voice and its areas.

The VMM is about testing just one voice at a time, and a quick calibration of the equipment is adequate. The composer in the analysis situation can hear for themself how soft or loud the tones are. Further details of the dynamics of the different tones and areas in relation to one another can then be noted, as in the VRP situation. In this way, the composer notices the dynamic possibilities of the voice as a whole. The information regarding the absolute decibel level is not helpful. This is mainly because the VMMs of singers are never compared to each other.

I wanted to analyse the individual registers. According to the literature, this had

already been achieved using the VRP (e.g. Pabon and Ternström, 2020). To allow for a freer interpretation of the terminology here, the term 'area' is used in the context of the VMM (see section 4). The areas are indicated by the singers.

The software is provided with a virtual on-screen keyboard operated by the composer. Only the acceptable tones in the right register are included in the analysis. Data collected from sounds that fall outside of this category can be edited out. In a later phase, the singer's formant is indicated, unlike with the VRP.

The VMM is based on the assumption that the composer has a basic technical understanding of software usage. Both the software and the manual were designed to enable different kinds of composers and singersJOD to use this method.

The technical details of the software can be found in Appendix 1. A full description of the practical part of the process is in Appendix 2: Manual for Voice Map Method.

9 Field testing

The VMM was tested with 22 singers. These field tests helped to define the functionality of the VMA and optimise the process. Here, the singer's feedback was crucial.

Appendix 3 includes the full list of singers tested (pseudonymisation is applied). The majority have high or very high voices that could be categorised as soprano, nine of them as coloratura soprano. Almost all the singers had extensive experience in contemporary vocal music. Making a division between lyric and dramatic voice types was needed, since these groups were presumed to have different vibratos and different levels of singer's formant, which affects the analysis. Voice types such as soprano or baritone are used loosely to describe the vocal range, rather than the specific Fach.

9.1 Phase I: Vocal areas

09/2015 – 06/2017

Phase I consists mainly of creating the first functional version of VMA software (0.9.1), meaning the instructions for the singer, i.e. what and how they are to sing for the VMA. Earlier in my career, I had used an informal process for getting to know a singer's voice. It included going through aspects of the voice using scales, discussing the registers, and challenging parts of the voice. Essentially, the VMM is a new, structured and streamlined interpretation of this.

The very first preliminary experiment was done with S.1 and S.2. To prove the concept, I went through the extremes of the voice rather informally and recorded the results. This recording could then be used to recognise the area and, via audio analysis, provide some information about the dynamics.

These unstructured tests revealed the numerous questions that would need to be answered in order to adequately instruct the singers. The Voice Range Profile (Chapter 7) was instituted as a technical reference point at this stage. As the voice studies had already made use of the VRP, the same general information on procedure was also introduced in version 0.9.1 of the VMA software. The operating procedure involved the following aspects:

- The singer goes through their range as softly and as loudly as possible
- The singer sings the vowel sound /a/ (open front unrounded vowel, International Phonetic Alphabet)
- The singer holds each tone for one to two seconds
- The distance between the microphone and the mouth is fixed at 30 cm
- The software data (sound pressure level/pitch) is plotted on a graph

Maintaining the set distance between the microphone and the mouth was a difficult but crucial task. There are technical devices that enable a constant distance to be maintained, but this would have made the VMA too cumbersome. During the tests, I noticed that some singers had moved a centimetre or two, but there was no detectable difference in the analysis results.

Substantial adjustments to the VRP setup were needed when utilised by both a singer and a composer. These were the resulting changes:

- Redesign of the user interface and colour scheme used for the areas
- Adding of the visual programming language Max/MSP
- Interpretation of the sound-pressure level from the Zoom recorder
- Naming of their areas by the singer, at the beginning of the VMA

- The analysis is to be executed area-by-area,[35] with each area having its own colour on the graph
- Data is to be stored as a text file
- Monitoring of the software by the composer while the singer only sees the results between the recording segments
- Playing of the reference tones (for the singer) by the composer, using the keyboard
- Singer's use of moderate legato between the tones[36]
- Suggesting of the order of the notes and areas by the composer, with the singer able to request another option

The process of going through the vocal range area by area became evident during the tests with the first five to ten singers. A common choice was to start in the middle, then proceed to the bottom and finally, to the top; first singing the area softly and then loudly. A detailed description can be found in Appendix 2: Manual 1.3.2.

Following the visual display during the VRP process can be a motivator for the test subject, as part of a therapeutic process (Jaana Sellman, personal communication, 31.8.2015). In contrast, during the VMA, the benefit of observing the screen was not discernable. In the early tests, the screen was positioned so that the singers could view it, but they chose not to look at it while they were singing. As it was therefore deemed unhelpful and disconcerting, it was decided that they could read the results between going through the areas and study it thoroughly after the analysis.

[35] In the VRP, the entire voice is usually treated as one and the areas are then interpreted from the graph.
[36] When the phrases have too much portamento or glissando, the software cannot recognise the different tones.

The visual programming language Max/MSP[37] was chosen, since it is specifically designed for analysing and manipulating sound in real time. Many composers have also studied its use as part of their education in composition. This guaranteed that VMA software is readily usable.

The first proper version of VMA software was developed and tested in the opera *Voice Box* (see 10.1), where the singer's voice and areas were used in numerous ways as inspiration for the composition.

9.2 Phase II: Vibrato

08/2017 – 01/2018

The next phase included the artistic test *NOS*. For this opera, I analysed the voices of Martina Koppelstetter and Marie-Sophie Pollak (see Chapter 10, section 10.2), which were not pseudonymised here, as agreed with the singers. Firstly, a quick, partial analysis of Koppelstetter's voice was made, with a detailed analysis carried-out four months later. The second round proved that a casual and non-systematic analysis of her voice would not be sufficient. Only by going through the very extremes of it could I understand its specialness.

This practical experience made evident the following:

- Going through the voice systematically reveals the veiled aspects of the voice
- Part of the composer's task is to listen to the timbre of each area
- When the voice has a wide vibrato, this version of the software (0.9.1) cannot always recognise the pitch

[37] The language includes two components: Max processes Midi and MSP audio data. The third component, Jitter, controls video data and is not relevant for VMA software.

The systematic nature of the method serves as a psychological tool. It creates a structure for going through the various aspects of the voice that are not quite in the singer's comfort zone but that are still achievable and artistically fruitful. This has an advantage over the informal listening used previously.

To find a solution for the vibrato issue, a demonstration was organised: Hadas Pe'ery joined as a programmer during the analysis situation for S.4. The singer's voice was systematically evaluated, and they were asked to produce some tones with different vibratos. This way, we could better understand the limitations of version 0.9.1. We also used additional recording equipment (a second Zoom-recorder) to save the audio for further testing.

A new feature was added to the next version of the software (0.9.2) that takes the vibrato into account. Using this tool, the software accepts not only static tones but also tones with a certain cyclical nature. After some testing, a setup was formed to enable the composer to choose 'slow vibrato' (300 ms), 'fast vibrato' (100 ms), self-regulated vibrato, tempo, or none of these. The options were reliable and generated the best results for different vibratos. For some vibratos, however, the pitch may still have been analysed slightly incorrectly, but taking into account the rounding up, the offset was always less than 50 cents. This small inaccuracy, which occurs especially with voices where the vibrato varies from area to area, has still yielded satisfactory results for the VMA. Case 12 below demonstrates what happens when working with a voice that has moderately more demanding vibratos to analyse.

Case 12: A voice with different vibratos
S.22 had both dramatic and coloratura features in their voice. In the analysis situation, the different areas had different timbres and slightly different vibratos. Their vocal training was in the relatively early stages, so it is feasible that the differences between areas would diminish over time. In the analysis situation, the software's vibrato parameters had to be slightly altered from one area to another: for the area in the middle, the vibrato was quick; for the lowest area, the vibrato was

slower. On two occasions, for the very highest notes, the software marked the pitch a semitone too high due to the vibrato.
Remarks: This voice could be analysed systematically, as the minute miscalculations evened-out during the process.

03/2018 – 02/2019

A critical part of the testing was to analyse the voices of different kinds of singers. Up to this point, I was primarily running the software, and only partially present as a composer. Now that I had gained enough experience and become accustomed to the routine of using the software, I could distinguish the surprises that might occur and that would not harm the analysis process.

The most typical situations were these:

- The singer stated that there was no need to differentiate between the areas of their voice since it is so well equalised. In reality, the differences turned out to be fascinating, as well as inspirational for the composer
- In the first or second try, the program didn't recognise the pitch of one or two individual tones
- The singer got carried away and didn't remember that the tone should be as softly or sung in a specific area
- The very first time the microphone was switched on, the software created some seemingly random points.

After so much repetition, I had gained adequate experience of the above situations and could now put them into the proper context as minute digital occurrences that allow the analysis to continue.

S.5 and S.7 were the most experienced in working with a microphone and in adjusting their vibratos. With this skill, they illustrated that the vibrato function of the

software is precise enough, and when the singer has little vibrato, the results are remarkably exact and quick. In this respect, the singers didn't have to change their natural vibrato for the analysis.

Up until this point, the analysed sound had not been stored. Due to S.5's comments and the artistic test for Seeing Voices that uses Julia Mihály's recorded voice, the software was changed as follows:

- The sound recorded during the analysis is to be stored in a separate sound file
- The sound files can be used for subsequent analyses
- The sound files containing the maximum and minimum values are to be indexed in the text file

Here it also became evident that the software shouldn't play too great a role, as it forms only one part of the communications. Indeed, the step from the analysis to the discussion can be lengthy. After realising that I was fundamentally creating a method rather than just the software, I produced a more structured version of the List of Good Questions (the complete list is in Appendix 2: Manual, chapter 5). Consisting of individual questions directed towards the singer, this component of the VMM provides solid guidelines for open discussion.

The questions include the following themes:

- The singer's comments on whether the Voice Map is representative
- Special vocal and musical skills
- Particular vocal and musical limitations (textures or structures that require a lot of time to rehearse)
- What kind of possibilities and limitations do the areas present and how

demanding is it to use them

- Vowels and text in different parts of the voice
- How to continue structuring the project

The list emphasised the VMM's character as a holistic communication enhancement tool.

9.3 Phase III: Singer's formant

03/2019 – 03/2020

The VMM functioned well, and I was able to use it fluently. For the last phase of development, the question remained as to whether or not there were further audio analysis parameters that would serve as helpful and practical additions. Jitter and Shimmer were two candidates, since they describe the various irregularities in sound pressure and are relatively easy to analyse. It soon became evident that these irregularities do not yield much information about the voices of classically-trained singers. Furthermore, the composer's ears were a much more efficient tool for collecting timbral data than visual codes. Still, for understanding larger structures and relationships that consider the full range of the voice, visualisation — via a Voice Map — is stronger.

One aspect that wasn't evident from listening but strongly affected vocal performance, was the singer's formant (see section 5.1). It impacts the audibility of the voice, and is something that a composer would not be likely to hear in a singer's voice without being prompted to do so. The literature concerning the singer's formant rarely gives exact magnitudes; it describes the phenomenon and its origins but does not involve any measurements. This unknown territory was what I needed to explore. Many

different options were tried, and finally a satisfactory measurement method[38] was found and added to version 0.9.3:

- The singer's formant range is 3000 Hz – 3200 Hz, but the user can change it
- The sound to be analysed is divided into sinusoidal partials and only the dynamics of the partials in the range are collected
- The maximum dynamic values are shown on the graph using the same positions and colour-codes as for the rest of the VMA

The results gained are very easy to read and to incorporate in a discussion. In this reading, the singer's formant curves are analogous to the dynamic curves that we already know from the previous analysis. The analysis of the singer's formant only concerns a certain part of the sound spectrum. During the testing it became apparent that ranges larger than the default of 200 Hz provided data that was less clear. In the literature (i.e. Sundberg, 2001) the singer's formant is usually analysed relative to the main spectrum peak and is not absolute. In the testing phase, the relative method did not show a difference in the singer's formant for different voices, some of which evidently possessed it and some of which didn't. The absolute method was able to differentiate between voices and specific tones that would be audible over a large orchestra.

Testing the method was rather complicated and began with collecting the right sound material. For recording this material, I chose singers likely to have a strong singer's formant due to their dramatic voices. They were asked to sing certain notes in three modes:

[38] This idea was first suggested by Vesa Norilo.

1. *senza vibrato*
2. moderate vibrato but no singer's formant
3. with optimal singer's formant

The results were further analysed using Praat software, providing visual and numerical data in the sound file. If the auditive interpretation and Praat analysis both indicated a strong singer's formant, the sound file would be a valid reference.

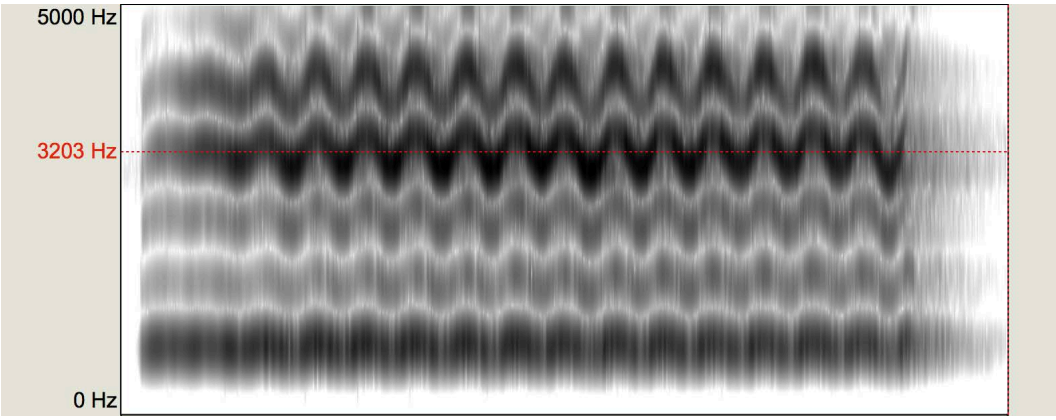


Figure 12. Sound waves of a vocal tone with a strong singer's formant, analysed using Praat software

Figure 12 shows a spectrogram drawn with Praat software, of the sung note G5 with an audibly strong singer's formant. The y-axis indicates the frequency scale (in Hz). The darker parts indicate higher intensity and the lighter parts lower intensity. The fundamental pitch of the tone can be seen at the bottom, with the waves indicating the vibrato of the tone. At around 3200 Hz and greater, another dark stripe appears, representing the singer's formant.

These reference files were then used to test and calibrate the singer's formant function of the VMA software. Calibration was successful when sounds such as that seen in figure 12 had a large value, whereas sounds that are equally loud but don't have the formant had a low value. Numeric data is not provided, the results are only visual.

03/2020 – 11/2019

Because of the limits I set at the beginning of the research project, most singers being tested had very high, lyric voices. For the last artistic component, *Voice is Voices* (section 10.3), all four soloists identified themselves as being coloratura sopranos. Limiting myself to these voice types was logical, since they are the most frequently heard voices in new vocal music. But unfortunately, they do not usually have a prominent singer's formant. It may have proved more fruitful to choose different voice types to analyse, but here the artistic argument was prioritised.

To reveal the benefits of the demonstration, I hereby compare[39] two of the voices. One of these is Annika Fuhrmann's voice, which is close to *Sprechgesang* and isn't dramatic. Kaisa Ranta's voice, on the other hand, has qualities associated with a dramatic coloratura soprano. Interestingly, apart from the singer's formant and the number of areas, their Voice Maps weren't drastically different.

Figures 13 and 14 compare the Praat analyses of Annika Fuhrmann and Kaisa Ranta singing the tone #D5. The long-term average spectrum (LTAS) allows us to observe the energy peaks of the sung note. For Fuhrmann, the individual overtones can be seen on the graph, with the dynamic drastically diminishing between them. For Ranta, there is an additional bulge at around 3 kHz. Ranta possesses an evident singer's formant.

[39] NB: the VMA was not initially designed for comparing voices.

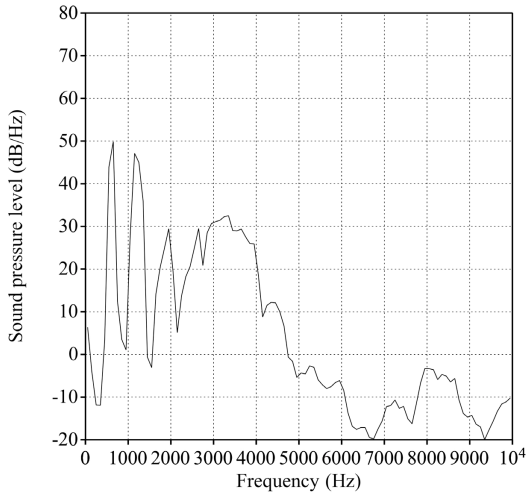


Figure 13. LTAS analysis of Annika Fuhrman's #D5 tone

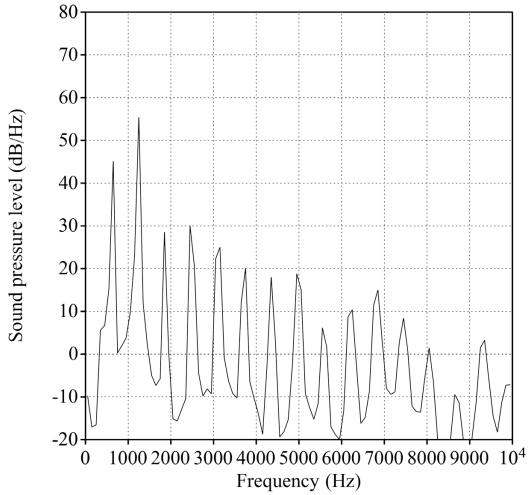


Figure 14. LTAS analysis of Kaisa Ranta's #D5 tone.

A comparison of their analogical areas according to the Voice Map reflects these results. A rather narrow frequency area, 3000 to 3200 Hz, is used. Higher parts of Fuhrmann's head area (D5 to A5) have some formants, but they are weak and uneven (see figure 15). For Ranta, the middle area (A#4 to A5) shows a continuous singer's formant (see figure 16).

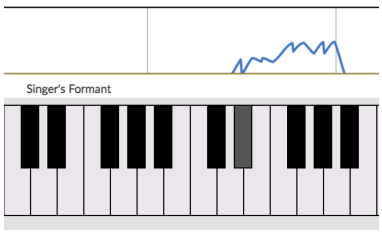


Figure 15. Fuhrmann's Voice Map: head register, singer's formant, from 3 to 3.2 kHz

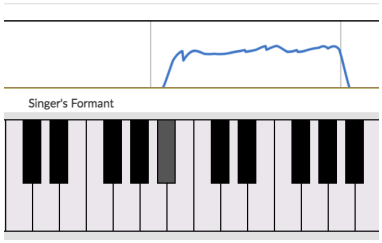


Figure 16. Ranta's Voice Map: middle register, singer's formant, from 3 to 3.2 kHz

At present, reading the singer's formant in the Voice Map requires some interpretation on the part of the composer. The composer should look for continuously strong values in the graph of the singer's formant, an auditive manifestation which indicates that the voice might possess a silvery tingle.

Another goal of this phase was to determine the quality and precision of the VMM. Although the method could be applied efficiently, did it function better than the intuitive method I was using prior to its development? Could the VMM provide much detailed information that couldn't have been gained by listening to the voices in a casual manner? This query was tested by composing for four voices, using their slight similarities and differences as a compositional tool. In section 10.4 there is a detailed description of how tailor-made vocal music for four singers was obtained through the VMM.

This indicates that the method is fluent and efficient, providing information that would be very difficult or impossible to collect without the VMM or a similar method.

08/2021 – 10/2021

The final three singers on the list succeed this development project. S.21 and S.23 are the lowest voices that were analysed; they both identify as baritones. In future studies, different voices as well as singers with completely different techniques will need to be analysed, especially for gaining more information concerning the singer's formant. This was also hinted at after the analysis of Marika Hölttä's voice, whose belting was one of the key components in *Voice is Voices* (section 10.4).

Version 0.9.3 still contains some minor technical bugs. These are due to having migrated from Max/MSP version 7.3.3, which was designed for a Mac that supports 32-bit software, to version 8.1.8, which supports 64-bit. These problems were resolved in the subsequent, first published version, 1.0.

10 Artistic Testing

The arc of field testing was covered in the previous chapter, but the final assessment of the method lies in the artistic verification described here. In the artistic doctoral portfolio there are three components: the operas *Voice Box* (2017) (section 10.1), *NOS* (2018) (section 10.2), and the installation-opera *Voice is Voices* (2021) (section 10.3). These illustrate in detail how, at the initial stage, the VMM features in the compositional process. Other, smaller-scale pieces that I composed ended up supporting the development (section 10.4).

10.1 Phase I: *Voice Box*

The opera *Voice Box* (2017) is the first artistic component in my doctoral studies. Its relationship with the VMM was straightforward. A functional version of the VMA software was created in 2016, and at the end of the year I analysed the voice of Mia Heikkinen, who was to be the soloist. I had already made plans for the composition, and was able to complete the score of the opera in March 2017, for the premiere in May. This part of the development project was definitely agile.

In Phase I, the Voice Map Analysis consisted of only the essentials, enough to show that the idea of using this method artistically could make sense. As described, the vocal part was idiomatic, partly due to the fluency of communications between myself and Heikkinen. In subsection 10.1.3 below, I describe the results of the VMA and how these affected the composition; in 10.1.2, I depict how the voice studies and the history of *bel canto* formed more than just the background of my composition process. In the end, *Voice Box* became a kaleidoscope of the Fach system, registers, and understanding the voice. It is essentially an opera comprising a series of five parodied lectures on the chosen aspects of vocal music composition. In this production, the 'communication' enhanced by the VMM ranged from the discussion to listening

to the timbres of the areas. These areas, with their ranges, timbres, and technical requirements became the motif of the opera and were used interdisciplinary, almost analogous to the tone row in serial music.

10.1.1 The Production of *Voice Box*

I wrote the piece for an ensemble that would allow enough freedom to make the production agile; this involved a singer, a flautist and a keyboard player.

The singer had to be classically trained and to identify as a coloratura soprano, someone who I had not worked with before and who could meet the vocal and theatrical demands of the piece. For years, I had planned to compose for **Mia Heikkinen**, but until then we hadn't found the right production. Luckily, she joined in enthusiastically and didn't mind having her voice analysed and discussed in an academic context. We agreed that she had the right to veto any of the material before it was published (see section 2.4: Ethical considerations). In addition, I gave all the performers the opportunity to comment on the artistic material (libretto, music, stage direction, etc.) via workshops. As a result, some corrections were made to Heikkinen's parts, mostly regarding timing and rests for the voice.

All performers played an essential role in the creation of the piece. **Jacintha Damström**, in addition to being a trained flautist, is also a singer and a professional circus artist. Her multidisciplinary skills brought a lot of humour and beauty to the performance. The third performer, **Maija Parko**, had just finished her doctoral studies on the embodiment of the pianist, and her personality and bodily presence shined in the performance. She delivered a short academic speech as part of Lecture 2.

Naturally, *Voice Box* would be created in my native artistic language of experimental music theatre. This multidisciplinary style could combine music, theatre, performance, and video art, for instance, on a constructional level that would not be obtainable

in a fully classical opera production with its hierarchical structures. *Voice Box* is interdisciplinary to the core: the composition affected the libretto and the on-stage video created melodies. This process is further discussed below.

I find composer-auteur Jennifer Walshe's description of the 'New Discipline' also quite accurate for experimental music theatre (Walshe, 2016, borealisfestival.no). According to her, New Discipline is a way of working by combining different art forms and requiring the artist to take broader responsibility. In *Voice Box*, that meant assigning the performers many different tasks (singing, playing, acting, dancing, lecturing, joggling, etc.). For me, it entailed composing the music, writing the libretto, using the VMA, and directing the opera.

Figure 17 Voice Box, Lecture 3: "Voice Map - YAY!" (photo Patrick Neumann)

The roles of composer and director greatly overlap, as is characteristic of experimental music theatre. For some of the sections here, I also composed for movement and directed melodies for the video. This way of working might appear egoistical, so a healthy dose of self-irony was needed to balance things out. I did not hide my many roles but used them as an artistic theme. In Lecture 3: "Voice Map - YAY!" I played the role of a TV-shop presenter selling the Voice Map, as can be seen in figure 17. This game of changing roles functioned in the opposite way too. As Mia Heikkinen

would be doing most of the talking in this piece, and as the piece comprises a series of lectures based on my research, I thought: why not give Heikkinen the role of professor M. H. (the name being a mixture of Miika Hyytiäinen and Mia Heikkinen)? Hence, I asked Heikkinen to make a brutal parody of my vocal mannerisms, clumsiness, and general forgetfulness. To complete the scenario, I asked her to wear a tartan jacket, an easily recognisable accessory that features in my professional image, see figure18. As contemporary, multidisciplinary and experimental as *Voice Box* is, it is still an opera with strong connections to the history of the art form. Structurally, the piece could be seen as a *Nummernoper* with recitativo and arioso parts, instrumental numbers, and vocal ensembles.

Figure 18. Voice Box, 'Prelude', (photo Patrick Neumann)

10.1.2 Results of the Voice Map Analysis[40]

Version 0.9.1 of the VMA software visualises two things:

1. How the voice is divided into different areas
2. The dynamic possibilities of each area

[40] Chapters 10.1.2 and 10.1.3 are based on the paper 'Genesis Helsinki', 2017: Creative Processes and Archives in Arts and Humanities.

Some tones may be performed as part of more than one area, in which case all the options are taken into account.

The result of the analysis can be seen in figure 19 below. Due to an unsuccessful calibration, some of the data points go beyond the area, but the numeric values of these points were still saved.

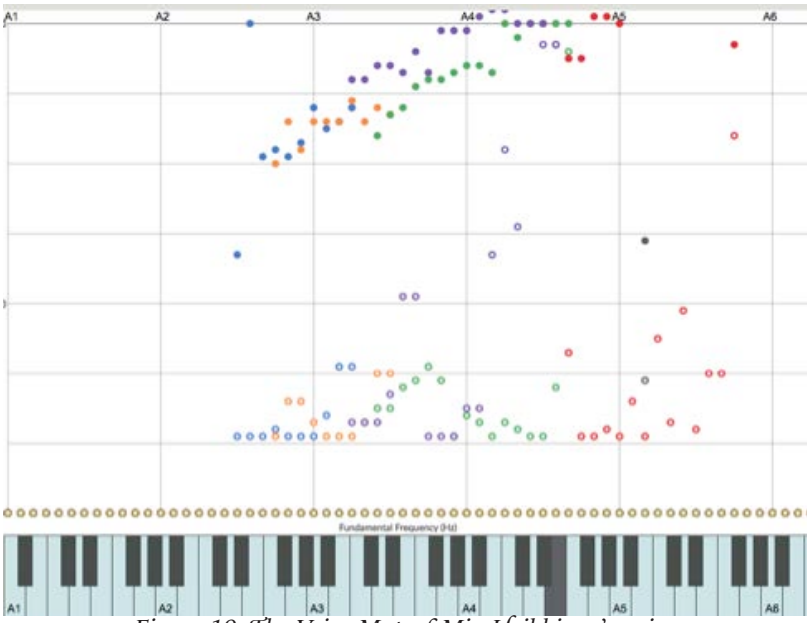


Figure 19. The Voice Map of Mia Heikkinen's voice

As always, the VMA begins with the singer indicating all their areas, naming them, and allocating a rough ambitus.

The following six areas were analysed, in the indicated colour.

- Chest (rinta): **Blue**
- Mixed chest (rintamiksi): **Orange**
- Belting: **Purple**
- Mixed head (päämiksi): **Green**
- Vocal fry: **Black**, only partial results were obtained
- Head (pää): **Red**

Most terms were suggested by Heikkinen herself, while I suggested the term and area 'vocal fry'. We used the Finnish terms where available, and I did the translations.

After the analysis, we discussed Heikkinen's voice. At this point, the List of Good Questions wasn't fully completed, but the informal discussion reflected the questions in the final list.

Much of the information gained from the analysis is difficult to formulate in words, namely aural data on the voice, a general experience of how easy or demanding the tones are to produce, and the feel of the building of the curves.[41] An interpretation that could be put into words is that in 2016 Heikkinen had a strong, somewhat direct, but not very dramatic voice. It was rather equalised, but she wasn't too afraid to experiment with some of its less classical aspects. Chest, mixed Chest, mixed Head, and Head areas were very virtuosic, with a pleasant timbre, but had some dynamic limitations that were typical of high and lyrical voice. The belting and vocal fry were more like effects that occur when shouting and speaking, respectively, rather than long melodic lines.

10.1.3 VMA as a device

The academic *raison d'être* of the opera *Voice Box* was to show that this early version of the VMA could support the communication between composer and singer and make the artistic process more efficient.

The VMA and Voice Map were used as a communication device, but also as a way of organising music and creating dramaturgy. The VMA supports the compositional process but the singer's gestures and documented sound and video also fulfil different

[41] Version 0.9.1 of the software needed a bit more interpretation, as the preciseness of the data left something to be desired. Through the different methods of analysing the pitch and considering the vibrato, later versions solved most of the problems.

functions as part of the final performance. These various uses, numbered from one to seven, extend from the compositional background to the abstract interpretation: 1. Communcational support, 2. Academic metafunction, 3. Vocal areas translated to instruments, 4. Musical dramaturgy, 5. Documentation as video material, 6. Musical abstraction, and 7. Scenic abstraction. It is worth noting that this kind of multidisciplinary work would normally be difficult or impossible to achieve in the production of a classical opera. Sound analysis material would have to be shared by the composer, video artist, librettist and director, at a very early stage of the work. Taking an artistic decision as a composer rather than as the creator of an academically-influenced libretto, I employed both the theoretical text and the VMA in a way that ties all the material together. The scientific literature and the structure of Heikkinen's voice affected the libretto, composition, scenic choices, and the structure of the piece. As explained in section 1.4, the VMM doesn't force the composer into taking any particular direction artistically, so this holistic approach was purely an artistic choice on my part.

1. Communicational support

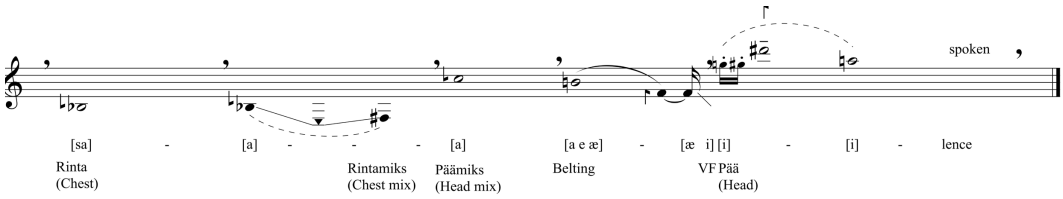
It is demanding to determine which aspects work or do not work due to the Voice Map, and which come from my experience of working with singers. When starting the composition process for the first time using the VMM, I was able to listen to the voice more systematically, which made communication both effective and thorough.

In version 0.9.1, we had to analyse some of the tones twice, and no precise pitches could be analysed for the vocal fry area. But even so, the whole analysis and discussion was finished in less than 90 minutes. When working informally on my earlier productions, with only my intuition as a guide, the duration would have been about the same. In that context, nevertheless, there would have been a real temptation to cut corners with the notes that are more demanding for the singer. This new, relentless method

provided structure and encouragement for thoroughly going through the singer's range. As a result, I learned fascinating details about the voice, especially in the lower areas that are not the forte of a coloratura soprano. On the other hand, the singer always makes the decision as to which tones they want to sing and which are outside their limits. This extensive analysis didn't feel too tiresome for any of the singers I analysed as part of the technical and artistic testing.

In the role of composer, I used the VMM to study Heikkinen's voice and its possibilities in order to better compose for it. The opening phrase with the word 'Silence!', demonstrates this with its remarkable ambitus of approximately three octaves, see Example 3. Exceptionally, for this phrase, I indicated which areas to use for each tone, incorporating all six areas.

Example 3. The first phrase of the opera *Voice Box*



Often, the use of wide skips at the extremes is not the most idiomatic way to write for voice. On the contrary, it's one the clichés of the unidiomatic style of inexperienced composers. Why, then, did I decide to begin the opera with such a red flag? In my experience, this kind of stretching-the-limits of the voice does indeed work, but only if there is healthy communication between composer and singer, and the composer understands what they are asking of the singer. Reaching between the top and bottom of the voice can create a deep schism, but in a production based on good understanding, it creates a strong, dramatic effect.

The composer must be aware that to write notes is to ask for the corresponding

bodily action involved in singing. The extremes of the voice are especially demanding for the body and shouldn't be assigned too lightly. For Mia Heikkinen, this opening phrase was demanding but doable. She understood that the beginning was composed to reveal her virtuosity in a decided way for dramatic purposes, and that the choice was based on an intimate knowledge of her voice.

This first, musically demanding phrase, contains all the melodic, rhythmic, harmonic and timbral ideas of the whole opera. In addition, different variations of this melody are used as a kind of jingle to indicate the beginning of each dramatic part. The areas of the singer and the act of making the analysis, become a musical motif that then creates data that could be used just as other music theatrical parameters, such as structure, colour or movement. These are explained in detail in the categorical sections 2 – 7 below. Listening to these timbres is a necessary part of the communication, as enhanced by the VMM.

Apart from the areas, the dynamic possibilities of the voice are the main component being analysed. This data was used in a less straightforward way. I studied the registers and the general dynamic levels provided by the Voice Map, learning them and trying to understand the curvature of the Map so deeply that it became intuitive.

2. Academic metafunction

The production of the opera proved hectic and inspiring, but I had to remind myself that the composition has both an artistic and an academic function, and I immediately became concerned about the lack of dynamic markings in my score. As a rule, I hadn't notated the dynamics for the singer's part, only certain ideas here and there. This was not planned. At the same time, I was pleased with the musical results, and during the rehearsal process we hardly had to talk about the singer's balance and dynamics. Following the production, I was happy to hear Heikkinen mention that she found it an exceptional piece because there weren't any questions

or concerns about dynamics. Clearly, the communications had succeeded.

This could be compared to more historic vocal music. Before the 19th century, composers were cautious about writing dynamics for the singers (Elliott, 2006, 6, 129). Maybe I had been able to create something similar. Using the orchestration and musical phrases to intuitively inform the singer as to which dynamics to use without the need for strict markings in the score.

This artistic project demonstrates that the VMM does indeed help the communication between singer and composer. The artistic jury agreed and the *Voice Box* became included in my portfolio.

3. Vocal areas translated to instruments

The areas of the singer's voice also affect the instrumental music in the opera. The keyboard solo in Lecture 3 is divided into discrete bands of pitch, as extensions to the registers of Heikkinen's voice.[42] The music composed for flute, on the other hand, uses similar musical ideas, but they are overlaid onto the natural registers of the flute.

4. Musical dramaturgy

The opera consists of a prelude and five spoof-lectures. Each of these lectures emphasises one of the singer's areas.

- Prelude: Chest
- Lecture 1 *Those Busy Virtual Sopranos*: Mixed chest
- Lecture 2 *Voice is Voices*: Mixed head
- Lecture 3 *Voice Map - YAY!*: Belting

[42] This method was inspired by Luciano Berio's Un re in ascolto, utilising a similar method for orchestra and baritone voice. The analysis is proffered by the keyboard player who uses this in her short speech in lecture 2 of *Voice Box*.

- Lecture 4 *Fach System - BOO!*: Vocal fry
- Lecture 5 *A Voice of One's Own*: Head

This is also the order in which they occur in the opening phrase (see Example 3: The first phrase of the opera *Voice Box*). I used different strategies to focus on specific areas. The tessitura ascends through the Prelude, Lecture 1, and Lecture 2. Lecture 3 uses belting in the form of shouts and cheering, whereas in Lecture 4, ordinary singing repeatedly fades into vocal fry. As mentioned, the last two areas do not form the core of Heikkinen's technique, so I used them more as an effect. Lecture 5 has a liberated coloratura part, showcasing the singer's head area.

5. Documentation as video material

The VMA situation was documented as a video during the project's development stage, but was put to artistic use in Lecture 3. The video formed a part of the visual and acoustic language of the piece, almost like documentary material, consisting of unedited, elementary scales or individual tones.

6. Musical abstraction

The recorded sound of the VMA is edited and played on a keyboard, as new musical material. As a result, the sound that inspired the composition becomes a new, digitalised instrument that has freed itself from the body of the singer.

7. Scenic abstraction

In the analysis situation, Heikkinen made spontaneous physical movements (figures 20 to 22), and the performers reenact these movements as choreography.

Figure 20. Screenshot from the video documentation of the analysis, 'Support' for low tones

Figure 21. Screenshot from the video documentation of the analysis, 'Lied hands' for middle tones

Figure 22. Screenshot from the video documentation of the analysis, 'Flamenco hands' for high tones

In the analysis situation, these movements served as Heikkinen's bodily support when producing the tones. In *Voice Box*, they freed themselves from the original purpose. When recording three areas, the singer spontaneously made three gestures that we later named *'Support'*,*'Lied hands'*, and '*Flamenco hands*'.

1. The gestures are on video but were edited to follow each other rhythmically.
2. The live performers mimicked the video and the movements.
3. In Lecture 3, the keyboard player produced the same tones and combined them with hand movements. Their initial function to support the singing had now disappeared. Rather, extra effort was required to simultaneously play and perform the gesture.
4. As a final abstraction, the gestures remained as isolated movements: an abstract choreography accompanying any kind of music.

In this way, the *Voice Box* echoes serial compositions: the motif derived from the vocal areas determines the melodic, timbral, structural and scenic parameters. As these methods create the light-hearted dancing and silliness of the spoof-lectures, you could argue that the *Voice Box* is actually a comic serial opera.

The experiences gained in *Voice Bo*x were encouraging. The project had potential. At this point, further understanding of the registers and areas was needed, and this material is collected in Chapter 10. In the original test situation, I recorded everything using a camera, but it would make more sense if the programme were to automatically save all the audio data. These were the aspects used in the next phase of the VMM and in composing the opera *NOS*, the second artistic test.

It was also evident that version 0.9.1 of the VMA software didn't recognise the pitches of the tone in an optimal way. This was greatly enhanced by programming the next component, which takes the vibrato into consideration. Unfortunately, this feature

was fully functional only slightly later, in *Seeing Voices*, as discussed in section 10.4.

10.2 Phase II: *NOS*

The second artistic component of this doctoral project is from the opera *Königliche Membranwerke, Nomictic Solutions,* or *NOS*, the third act, third scene, "From mythology to logistics". Only in 2017, when work on the opera had already started, was I advised to consider incorporating this in the project portfolio. *NOS* is a long, multidisciplinary piece with two composers, so it couldn't be included as a whole. But in this individual scene, the creative roles and the use of the VMM is clear and easy to analyse. Technical testing in phase II concentrated on solving problems concerning vibrato and on organising the recorded sound material in the analysis situation, for later use. A solution for the vibrato was only found after the premiere of *NOS*,[43] while the recorded sound material already had an important role. This test was an expedition to the areas of a very atypical voice full of wonder.

10.2.1 Production

The opera was commissioned by the City of Munich, premiering in 2018 at the Munich Biennale, a festival specialised in featuring music theatre. A team of four artists wrote the concept of the opera, and also brought their own artistic specialities. Video artist Babylonia Constantinides wrote the libretto, Anna Maria Münzner was responsible for the stage and costume design, and composers Nicolas Kuhn and myself created the music and sound design. The team collaborated for intensive periods from 2014 to 2018, allowing all four opinions to be heard equally. A lot of time was invested in creating small demos that helped us create a common artistic language.

[43] A version that includes different vibrato parameters (0.9.2) was used in my lecture performance Seeing Voices, premiered by Julia Mihály in Darmstädter Ferienkurse in 2018, a month after the premiere of *NOS* and a year after its final analysis.

The composers, in particular, had to develop their communication abilities almost to the point of telepathy. The music is a somewhat intuitive amalgam of different artistic personalities, whereby some discrete strategies for writing the score together were evolved. These could be grouped into four clusters:

- Writing the sections independently (i.e. musical numbers "Follow the horn" by Kuhn and "Don't follow the horn" by Hyytiäinen)
- Alternately writing different functional layers[44] of a number independently (i.e. musical number "Analysis")
- Alternately writing the short segments, a.k.a. the exquisite corpse method (i.e. musical number "Ladies and Gentlemen")
- Division of tasks, vocal and instrumental, with synchronisation decided jointly (i.e. musical number "From mythology to logistics")

The last example is a composition for Martina Koppelstetter. I analysed her voice twice using the VMA, first carrying out a preliminary test and then a full analysis. In composing the vocal part, I was not aware of the exact subtleties of the music Kuhn was writing for accordion and tuba. As these parts were combined in the end, it was somewhat unexpected that no significant changes were needed; this combination had a natural flow. This was possibly because we had worked together so intensively in the earlier phases.

The way *NOS* played out could be read as a classical dystopian sci-fi story, with the machine killing its maker. Moreover, its narrative is open and immersive. Nomictic Solutions is a company selling a new kind of surveillance system that analyses human voices in order to foretell any psychological problems or violent acts. Audiences are treated as potential customers for this futuristic system, but simultaneously as

[44] Such as structural harmony, musical dramaturgy and the compositional details.

potential spies or terrorists. The meeting takes place in different picturesque locations around Lake Starnberg, close to Munich. The beauty of the scenery is used to lure customers. The location is also carefully planned because the lake actually serves as what is termed wetware. The data is saved to a lake that has witnessed many historical events and is said to be 'nomictic', the lake water never changes or moves.[45] The duration of the JOD piece is 3 to 3.5 hours. Table 7 lists the opera's musical numbers.

Name and number	Activity	The character	Location	Dur.
0.	The audience travels by bus and on foot to Villa Waldberta, all in silence. Every individual agrees –in their own voice– to the NOS data policy.	-	Starnberg Nord → Villa	25'
I.1 Ladies and Gentlemen	The young CEO delivers a welcome speech using her many voices.	CEO	Villa Waldberta	10'
I.1 Follow the Horn	A sounding horn invites the audience to walk from the Villa to the bus.	Hornist	Villa Waldberta surrounds	15'
II.2 Scientist's video speech	During the bus journey, the scientist explains with accompanying musical *intermezzi.*	The Scientist	Villa → Possenhofen	20'

[45] 'Monomictic' is a term that describes lakes having layers of water that intermix only once a year. The word 'nomictic' was invented by the creative team.

II.2 "Kön-Oscar- Olik-Olik"	The CEO and the hornist guide the audience to the pier and communicate in coded language.	CEO and hornist	Walk: Possenhofen → pier	15'
II. 3 Don't Follow the Horn	The hornist plays while dancing into the water next to the pier.	Hornist	Pier Possenhofen	5'
III.1 Launch	After boarding onto the lower deck, the system is launched.	Senior Chief	Pier/ship's lower deck	5'
III.2	The Press Officer boards and takes the audience with her onto the upper deck. The officer seductively sings a philosophical text to allure them.	Senior Chief	Ship's lower deck	12'
III.3 "From Mythology to Logistics"	The Press Officer boards and takes the audience with her onto the upper deck. The officer seductively sings a philosophical text to allure them.	Press Officer	Ship's upper deck	20'
IV.2 "We moved the apparatus of the membranous	The Press Officer continues to explain while walking the audience back to the bus. In the evening darkness, the walk is like a dystopian pilgrimage or procession.	Press Officer	Pier → Possenhofen	15'
IV.2 Giving each person back their voice	On the return bus journey, the Press Officer hands the audience small gadgets. The voices emitted from the speakers are those they gave to NOS in the beginning.	Press Officer	Possenhofen → Starnberg Nord	27'

Table 7. The structure of the opera NOS

There are three live singers in the piece. Marie-Sophie Pollak performed the role of CEO in a very agile, high voice; the Senior Chief is interpreted by a more experienced

male singer, Eberhard Lorenz, in a relatively high voice; and the Press officer is Martina Koppelstetter, whose exceptionally deep voice I had analysed with the Voice Map Method. In number I.1, the female CEO's high voice becomes much deeper in nature. It is actually the recorded voice of Felix Schwandtken. In the video (II.2 and III.2), we see and hear the Scientist, performed by actor Caroline Ebner. The accordionist and hornist are present in almost every scene, with the two additional horns and tuba in accompaniment. There is also a local brass orchestra or Blaskapelle, Musikverein Eichenau, playing short phrases from the other side of the lake.

The creative team worked on the structure of the piece, but Babylonia Constantinides wrote the libretto, including the part under discussion here:

> *FROM MYTHOLOGY TO LOGISTICS*
>
> *From mythology to logistics, the curse of catastrophe*
> *will be transformed into irresistible progress.*
>
> *The tide of what has been, has receded from the bank of the present, and the future lies on the other side of the ocean.*
>
> *Navigating the vehicle of progress, we know everything that has happened and are able to predict what will be.*
>
> *Our system is intended to liberate vocal data from the power of the past and place it in the service of the present.*
>
> *The inversion of history is intertwined with our machinery of control.*
>
> *With conscious decisions, the perspective of the universe opens to objective necessity and unlimited ideology.*
>
> *Mythological mission is an expression of scientific interest.*
> *Liquid mind becomes the instrument of power.*
> *The measures on the ship shape reality irrevocably.*
> *You will recognise it as the engine of world history.*
> (Libretto of "From Mythology to Logistics", Constantinides, 2018)

The text is dense and layered. It is therefore challenging to add music and still retain its inherent meaning for the audience. I decided to confront this dilemma by letting the meaning become hidden, but in a way that makes dramatical sense. The Press Officer's stern message lounges behind two smokescreens. Effectively, the poetic and alluring words become deliberately entangled in the music. The vocal line concentrates so much on the phonemes that the individual words become rows of sounds, and the audience cannot register the existence of sentences. My intention was to instead communicate the hidden message physically, using our bodies or subconsciouses, the pitches of the singer's vocal areas, the colours of their voice as a compositional parameter without a metric pulse, letting the music breathe.

This is not the whole story, though. The *NOS* libretto appears in the programme booklet and can be read by the viewer. Furthermore, the Press Officer repeats parts of the same text in the following Act, but in a more understandable manner. Dramatically speaking, the audience experiences this speech first as a colourful musical number in a picturesque environment but only later starts to understand the words, and later still, the totalitarian and dystopian message behind them. The piece invites us into a future with full visual and auditory control, as punishment for something we might yet do.

I decided that the best way to emphasise individual phonemes and the physicality of the singer would be to steer away from classical notation. My arguments and methods are explained using graphic notation.

10.2.2 Graphic notation

In part III.3., "From mythology to logistics", I alternated between classical and graphic notational systems, as listed in Table 8.

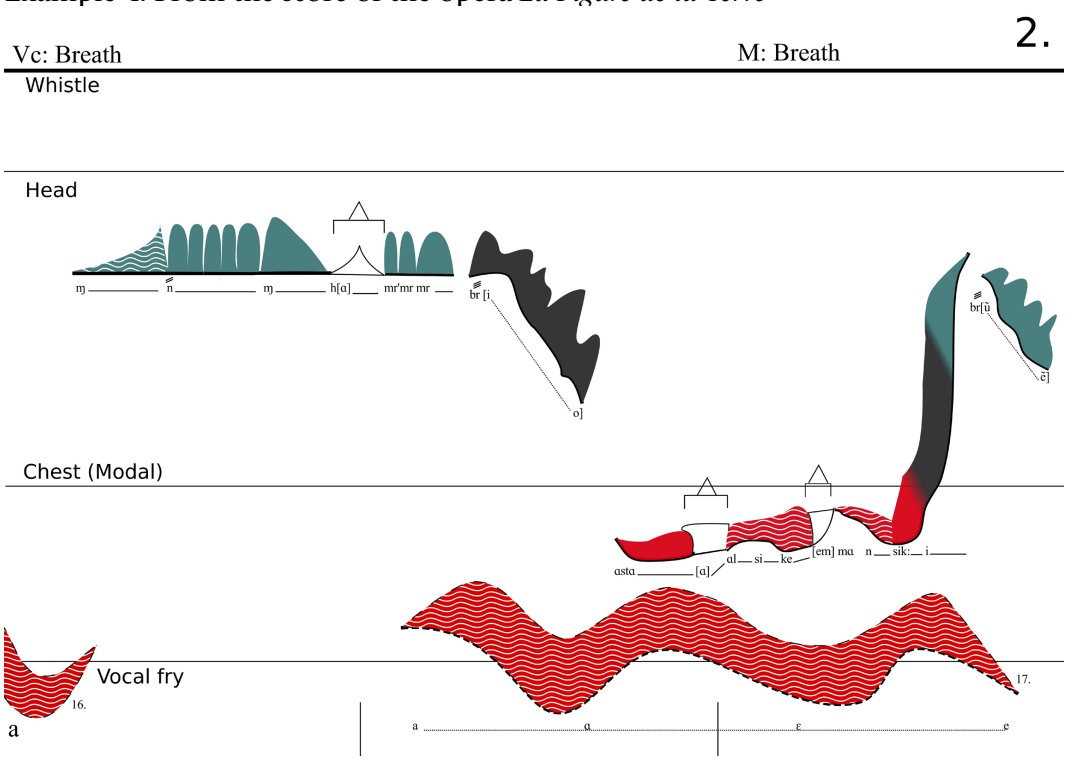
Name of the section	Activity	Notation	Page
"From Mythology"	The Press Officer comes aboard	Classical	49
"The tide of what has been"	The officer	Classical	50
"Navigating the vehicle of progression"	The officer	Graphic	53
"With conscious decision"	The officer invites the audience	Classical	
"Mythological mission"	The officer	Graphic	60
"W, ... we"	The officer	Classical	65

Table 8: Structure of part III.3. "From mythology to logistics"

I had used a version of the notation mentioned above in 2013, in the opera *La Figure de la Terr*e. The original inspiration for this was John Cage's Aria, which was composed around the registral and stylistical playfulness of singer Cathy Berberian (Berio et al, 1985, 60).

The evolution of the notation hasn't been radical, as the basic concept of range, pitch, dynamic, and use of colour remained roughly the same from 2013 to 2018 (see Examples 4 and 5 below). From years of experience, it has become evident that for the interpreter, this notation initially tends to elicit strong emotions but after a short period, the fluency of reading and the learning speed increase significantly. In most instances, the notation has been used for a singer, but it has also been successfully interpreted for violin (*Multiple Exposure*), clarinet (*Kaksinen*), and even for a chamber orchestra (*Autopsy for Schubert*).

Example 4: From the score of the opera *La Figure de la Terre*



The graphic score uses similar horizontal and vertical definitions as in classical notation. The x-axis indicates time. The performer starts reading from the left and continues to the right, at a steady pace. To sing one page should take approximately 30 seconds.

The y-axis indicates the pitch and dynamic simultaneously:

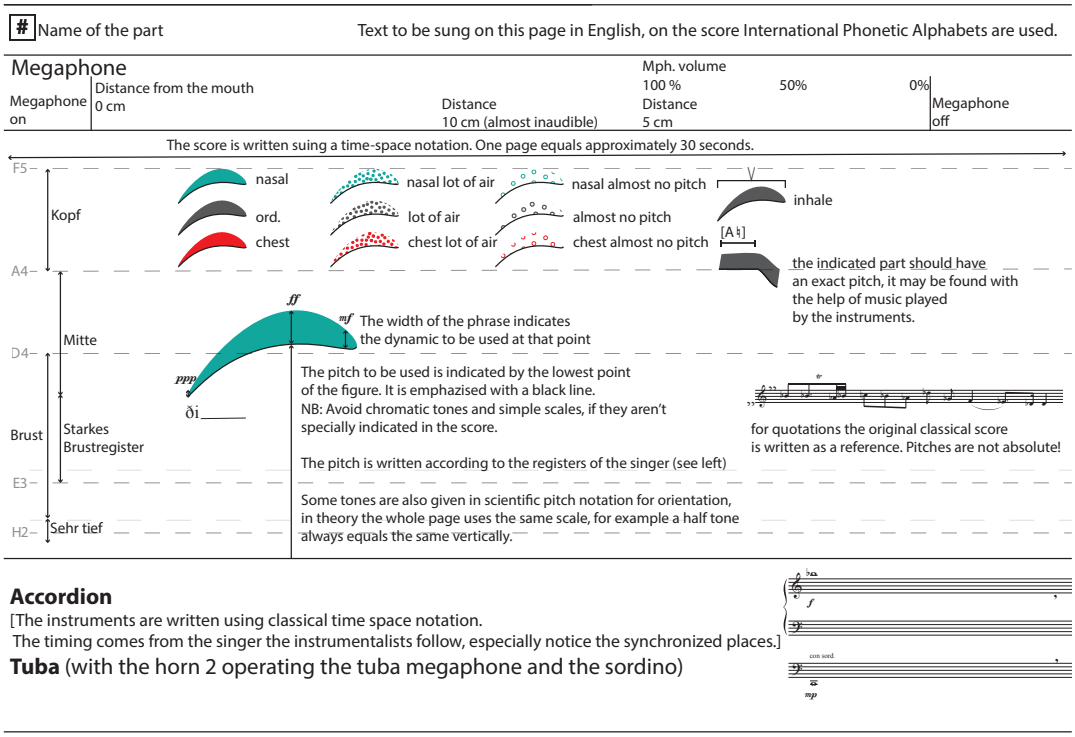
Each gesture has a darker base line, which indicates the pitch. It is written in relation to the areas of the singer's voice (for Koppelstetter: *Kopf*, *Mitte*, *Starkes Brustregister* and *Sehr tief*), indicated on the left-hand side of the page. The absolute tones (H2, E3, D4, A4, F5) assist coordination with the instrumentalists, but the register is the fundamental element, like the clef in classical notation. The pitches are divided equally; in the score, 2.13 cm on the y-axis equals a fifth. However, the physicality of

the performer and their interpretation ensure that absolute precision will always remain a hypothetical goal.

The coloured area above the dark line signifies the dynamic; the thicker it is, the louder it should be performed.

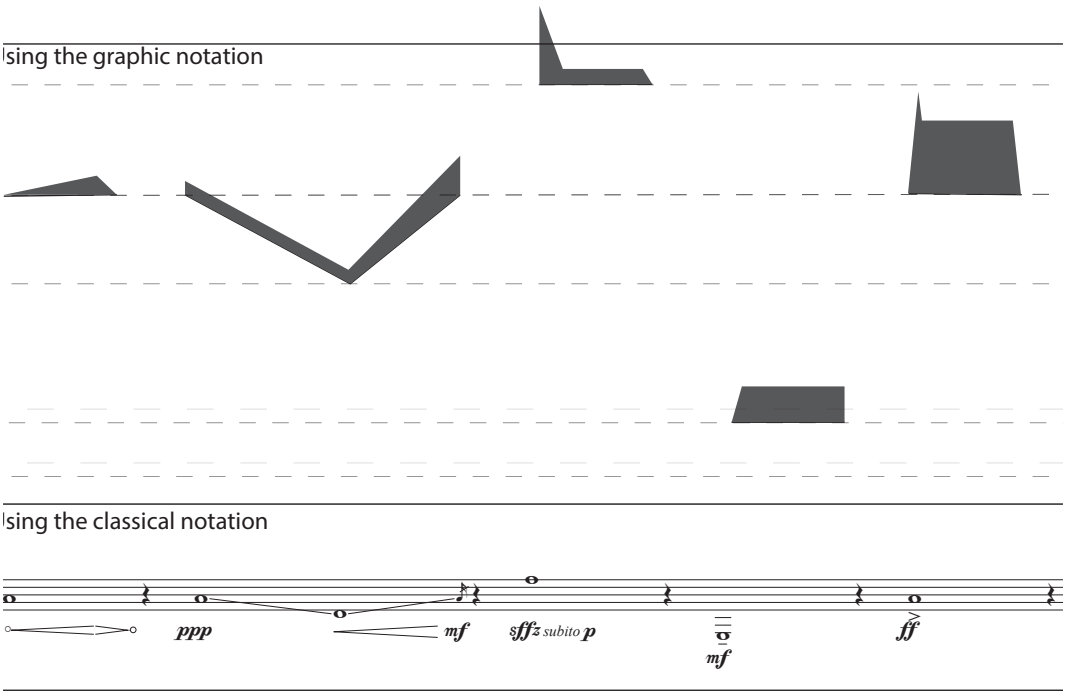
The other notational parameters, which are explained below in Example 5, include: (1) altered timbre (independent of the vocal area), (2) the use of a megaphone, and (3) the instrumentals.

Example 5. The page "Notation" The notation from the full score of *NOS*



Example 6 is like the Rosetta Stone, in which the same information is written using two notational systems. Some phrases are purely for explanatory purposes.

Example 6. The same music, written using graphic and classical notation



The question of interpretation is especially evident here. Different forms of graphic notation, such as that used by Cage, invites very open, almost improvisational use of the score. Sometimes this proves to be fruitful for the performer, but most of the time, performers prefer to commit to the score. In this case, Koppelstetter studied the score meticulously and was soon able to perform it almost exactly as written. From there on, she started to create her own interpretation, strongly encouraged by me.

I've found it crucial to make the graphic notation consistent. If the performer should want to make an interpretation using a ruler, they could always do so, but the performance is unlikely to sound very artistic. A computer could easily read and interpret the notation, but such a discussion must wait for another occasion.

10.2.3 The effect of the VMA on the composition

I used the Voice Map Analysis twice for Martina Koppelstetter. In August 2017 she visited Villa Waldberta, where the creative team was in residence, and I analysed her lowest register. It was impressive, as expected. She then sang different material within her repertoire[46] and we discussed the piece overall. I soon came to understand that this scene would be included in my doctoral project. However, it was also evident that by being too hasty in the first analysis, I couldn't be sure as to whether I understood her voice as well as I thought I had (a statement that would turn out to be correct). In early December, I visited her in Munich, taking all the time I needed for the full analysis, including a discussion on how well she thought she performed in the analysis and addressing the points in the List of Good Questions. All together, this took less than two hours.

The first, partial analysis had a useful function, because the creative team was present and were able to get an impression of how the VMA was executed. The physical gestures and the short musical phrases also provided artistic material for the creative team. This testing would later be recreated by the performers in part III, Phase 2, which uses similar elements when studying the voice of the Senior Chief. Of course, the VMA doesn't deal with the psyche the way the imaginary analysis in *NOS* is supposed to do.

The second, full VMA, on the other hand, was crucial. Only then could I understand Koppelstetter's voice in more detail. Through listening closely and trying to feel how the tones were produced, I was able to understand her very special vocal apparatus. Having worked with classically trained singers for years, I had obtained a solid, and maybe also a partially-fixed mindset about how voices work. Her vocal cords just didn't follow those rules, even though I was familiar with deep female voices,

[46] Material by Händel and some contemporary art songs.

having composed for them before.[47] It was still difficult to adjust my expectations to understand that for this female voice, C5 (above middle-C) was at the upper limits of the voice. At first I compared Koppelstetter's voice to a light, high male voice. Using this comparison, I could start to compose idiomatically, just for her. In order to provide a reference point, Mia Heikkinen, the soloist in the opera *Voice Box*, had roughly similar kinds of areas, but the highest tones of Koppelstetter's voice are slightly above Heikkinen's middle area. Here, an inexperienced composer might have found it even easier — my presuppositions derived from experience. Luckily, the VMA was practical in both situations.

When I carried out the full VMA, and went systematically through the tones that required a lot of energy from Koppelstetter, I was able to gain an understanding of the way the high tones affected her. I could see that her body worked harder and gradually became tenser; she used more air and the timbre was also different. Actually, this version of the VMA (0.9.2) had minor problems, possibly because of the vibrato, so we had to analyse some of her tones several times. That technical issue also came to serve as a datum for the opera: high tones, such as D#5, can be reached but should be visited only rarely, to obtain the most dramatic effect.

Koppelstetter's Voice Map is shown in figure 23, further below. This data, combined with aural information, such as the different timbres and the general feeling of the amount of energy needed to produce the tones, creates a complex system. Here are some remarks that also had a direct impact on my composition.

Koppelstetter considers that her voice consists of three areas: Chest, Middle and Head.[48] I split it even further:

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[47] For example, my pieces Dr. F + 1, with Tatjana Halttunen (2008), and Aikainen, with Tiina Sinkkonen as 'the third Norn' (2014).

[48] We communicate in German, so the terms she uses are 'Brust', 'Mittel' and 'Kopf'.

A2 to C3 was a really low, **uncontrollable area below the Chest**. I heard this as a rich timbral continuum, from an uncontrolled and almost inaudible A2 to a more stable C3.

C3 to C4 was the Chest. It was solid, and the sound quality and vibrato were classical but somehow personal and unique. The dynamic range was wide: tones as low as C3 sounded loud but still didn't possess the full 'cut' of some of the dramatic voices.[49]

Bb3 to C5 was the Middle. Here the timbre was more neutral and the dynamic range somewhat more limited. She was able to sing the tones under D4, only softer. Still, this area had more agility.

G4 to C5, was slightly different from the rest of the Middle. It had a stronger and more dramatic character. She could control it well, but with less agility. She didn't mention this division herself and when she transitioned to the following area, it wasn't always easy to discern.

G4 to D#5 was the Head. C#5 to D#5 was the loudest and most extreme part of her voice. The minimum dynamic increased dramatically and it felt like she used a lot of energy to produce these. The timbre was again in continuous flux, but the most striking thing was the expression of power and strength that was used to sing these tones. According to her, these and higher tones were still achievable, but only briefly and when well incorporated musically.

[49] Version 0.9.2 of the VMA software doesn't analyse the singer's formant. When the recorded material was used to make an analysis with the full Voice Map version, a moderate singer's formant was detected.

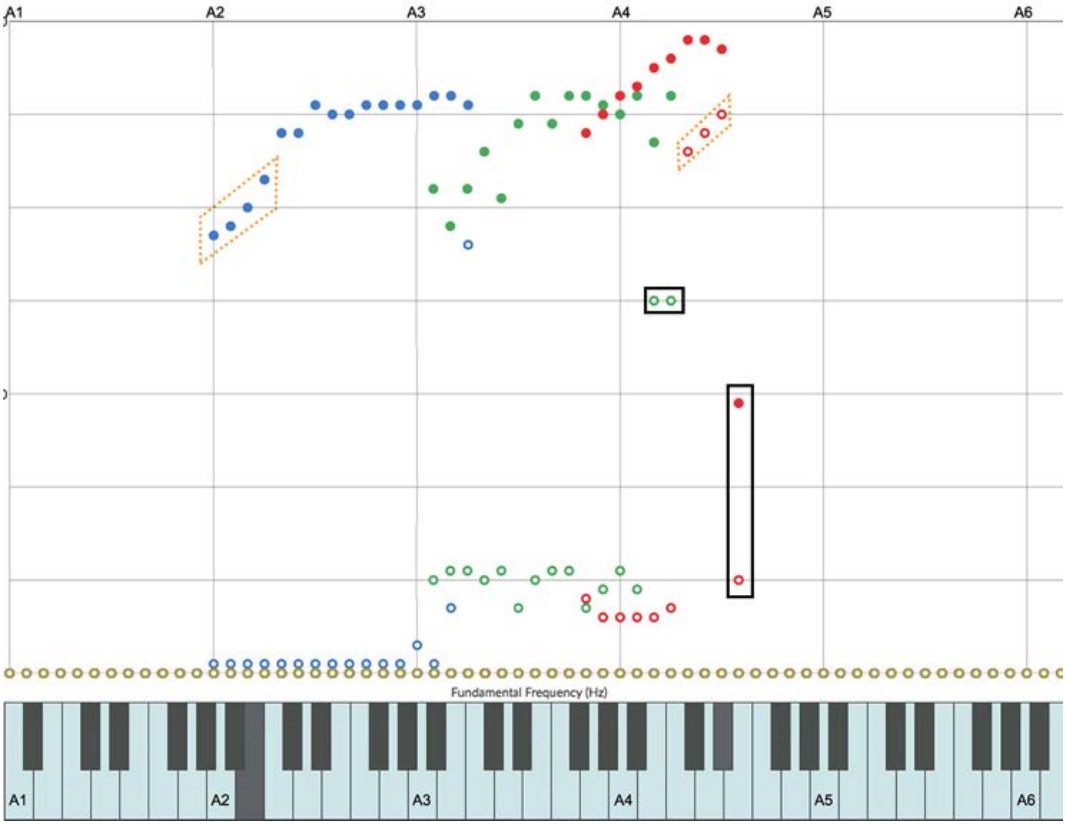


Figure 23. The Voice Map for Martina Koppelstetter

In figure 23, the Chest is marked in blue, the Middle in green and the Head in red. The orange dotted lines outline zones of special interest: A2 to C3 are separate from the rest of the Chest area. At around C#5 to D#5, the tones required a louder dynamic. The black rectangles indicate zones that were inaudible although plotted during the analysis, which I therefore consider to be inaccuracies in the actual analysis. In later versions of the VMA software, those can be edited out.

For technical reasons, the process was briefly paused between the analysis of the Chest area and the analysis of the other areas. Figure 23 is a combination of those two sets of data.

As the Voice Map indicates, the dynamic minimum of Koppelstetter's voice fell below

the measurable range almost everywhere. It couldn't be reliably differentiated from the general noise of the analysis equipment and situation. In the context of this performance, this meant that on the windy deck of the ship, with more background sounds, she could easily sing at an inaudible volume. These very soft dynamics do, nonetheless, include fascinating timbres, so we decided to use some amplification. For most of the opera, Koppelstetter was singing into a megaphone. For the cadenza-like part, there were even two of them, one carried by her and one by the hornist. The particular way the megaphone is used[50] is written into the score, but during the rehearsal process we decided to simplify this considerably so as not to miss out other musical details. The electronic quality of the sound and the image of a demagogue shouting into a megaphone, created yet another dimension to her speech.

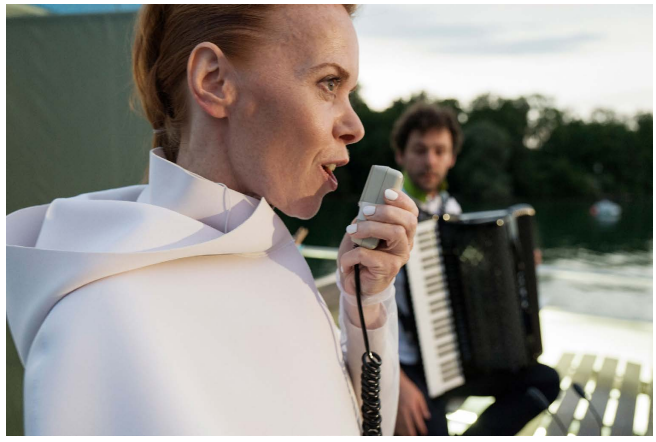


Figure 24. Koppelstetter singing on deck (photo Armin Smailovic)

The part "From Mythology to Logistics" served as my petri dish, a closed environment in which the details of the voice could come to light. At first I composed "From Mythology", "The Tide of What Has Been" and "Navigating the Vehicle of Progression" using only the information from the partial analysis. After the full analysis, I composed

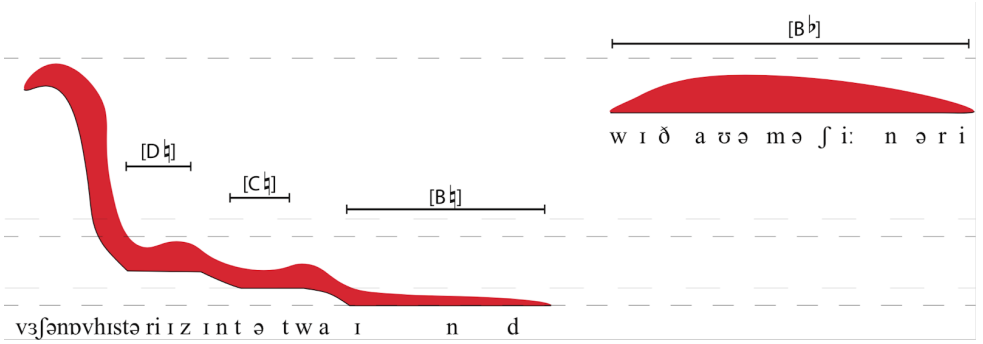
[50] These include: switching the megaphone on and off for a percussive effect, changing the volume mechanically, and altering the distance between the mouth and the microphone.

"With Conscious Decision", "Mythological mission", and "W, ... we", and made some corrections to the previous parts.

Inspecting the changes afterwards helps to show how the full analysis has enhanced the composition process. One small but aesthetically significant change was the use of *glissandi*. They are used throughout the final vocal part, and are small, often occurring in the lower region of Koppelstetter's voice. With these, I wanted to reveal the timbral worlds I had discovered. With only a few exceptions, the tone was constantly singing glissando or changing the dynamic or phoneme gradually. As a compositional tool, I wanted to use the timbral changes within each area. For instance, it was my intention to create a *Klangfarbenmelodie*, a melody of different timbres. To only use the natural timbres of the voice would be very demanding for many singers. For an athletic coloratura soprano with equalisation, I would probably have to compose huge leaps.[51] For Koppelstetter's voice, a glissando of a tritone could have the same effect.

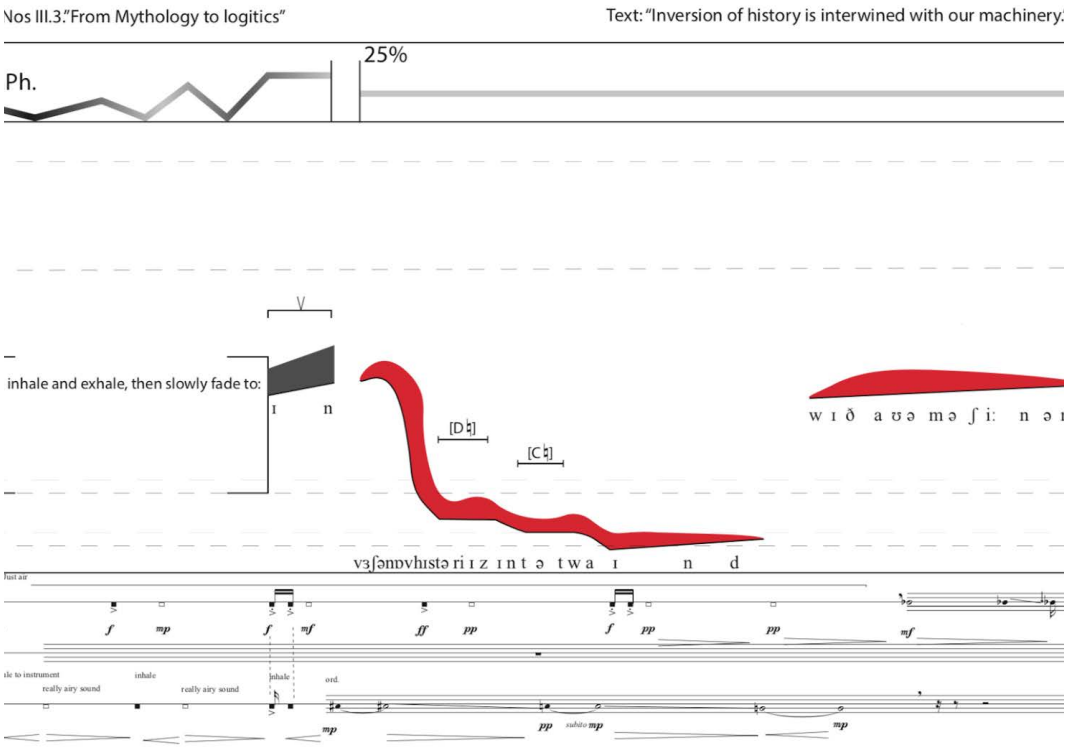
A small but revealing example can be found in the score on page 57. The text that is sung is: "[In]version of history is intertwined with our machinery of control". Examples 7 and 8 below, show the version composed before the analysis and the final version, in the musical context.

Example 7. Version composed before the analysis



[51] See also Fiordiligi's aria 'Come scoglio' in Così fan tutte discussed in section 4.4, or the opening phrase in Voice Box, subsection 10.1.3.

Example 8. The final version, in the musical context. The classical notation at the bottom of the page is for tuba and accordion.



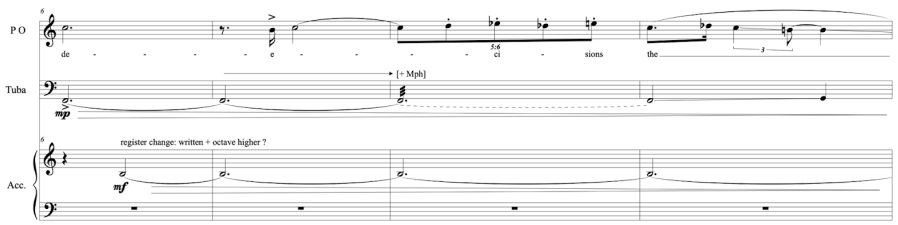
In the early version, Example 7, I composed the last syllable of the last word 'intertwined' as a static note, B2, while in the final version, Example 8, it's a glissando of roughly one semitone. A similar change occurs in the subsequent phrase "With our machinery", originally with a static tone, Bb3. In the original version I wanted this culmination to distinguish itself from the other material, as it is at the very lowest extremes of Koppelstetter's voice. By singing it as a slight ascending glissando, she could reveal the timbres that had intrigued me in the analysis situation. In this instance, these phrases are strongly connected, originally being a major seventh apart from one another. In the new version, Example 8, I added a similar glissando to each of them, to emphasise this similarity. The glissando needed to be small so that we could concentrate on the timbral changes that were happening. The only

tones I left static were D3 and C3, which involve a change in the phoneme.

This continuous flow of timbre matched the ambivalent message hidden in her words. The figure of the Press Officer is somehow ambiguous, emanating from the other side of the lake, in a voice that doesn't seem to fit any one area or gender. The extreme tones emphasise this confusing information, as the relatively low tones carry the energy usually required for much higher tones. The low tones that we would normally expect from a sizable male body come instead from a small and distinctly feminine body.

The tones above C#5 were only used for specific phrases. In 'From Mythology', a D5 (page 49, measure 3); and in 'With conscious decisions', Eb5 and E5 (page 58, measure 8, see example 9). These create a strength that then dissolves into subtler and maybe even seductive colours in the deeper tones. They are only used in musical sections that are individual, almost boisterous. In the graphic parts, the melody only rarely goes above A4, and the lower extremes are explored, emphasising the body and the timbres.

Example 9. Measures 6 to 9 with the second culmination point



10.3 Phase III: *Voice is Voices*

Voice is Voices is the third and last part of the artistic portfolio. Here I tested the functionality of the vibrato reading, to discern any differences between voices of the same Fach, and to study the singer's formant in a high female voice.

This is a sound-installation-opera with a duration of 52 minutes. The singers, four coloratura sopranos, represent four different corners of a Fach. In addition, there were two string players, and by overlaying the recordings, the effect was often orchestral and grandiose. In this loose, post-narrative piece, the voices were made to collide with each other to create combinations and contexts that had never existed before.

10.3.1 Four coloratura sopranos

It is only possible to understand the piece by knowing the singers; the dramatic arc is essentially based on their voices and personalities. From the outset, I wanted to find four singers who had classical vocal training and identified as coloratura sopranos. I found these characteristics in Kajsa Dahlbäck, Annika Fuhrmann, Marika Hölttä, and Kaisa Ranta. They are also trained in a wide spectrum of aesthetical styles (such as early music, new music and folk music) and of technical skills (such as dramatic lower register or belting). Through the use of the VMM, I learned to understand these particular voices. On the one hand, I wanted to put the VMM to a final test. On the other hand, I wanted to show that the Fach system casually excludes many voices and can simultaneously be too imprecise in dividing voice types. I composed *Voice is Voices* for these singers, knowing how different and much duller a piece for interchangeable coloratura sopranos would have been otherwise.

Kajsa Dahlbäck is probably best known as an interpreter of early music and for her work as an artistic director, researcher and lecturer. Analysing her voice revealed how exceptionally well equalised it is. I could not hear the register change, and there was a smooth transition over the entire range. In every other VMA I have carried out, it has been justifiable to interpret the voice as a collection of areas, but for Dahlbäck, the areas were only a technical parameter of the software. According to my testing and listening, her voice tends to be on the light side and often has a speech-like quality. The agile ornamentation characteristic of 17th and 18th century music

are especially well suited to her and come easily. She has substantial experience in leading and conducting music, so could handle solo parts that require more artistic decision-making than usual.

Annika Fuhrmann is the only one of these singers I had worked with previously. She sang in *Aikainen* (2014) and in *Pierrot Lunaire und drei Schattenträume* (2011), which combines my music with Schönberg's. Nevertheless, these collaborations had taken place more than five years ago, and I expected that Fuhrmann's voice would have changed somewhat since then. Also, she would now be working in a completely different context, singing alongside more classical singers. Fuhrmann's vocal style could best be described as vocal performance, with many experimental techniques coming naturally to her. *Sprechgesang* and theatrical expressionism describe her artistry. Maybe one reason it is so striking is that her areas have somewhat different timbres, lending her voice many diverse characteristics. From our earlier collaboration, I knew that she was swift to learn new music, already fluent in following my graphic notation, and a fearless improviser. In *Aikainen,* she also had to conduct some rather complex contemporary music while singing, so that could always be an option here too.

I first met **Marika Hölttä** in a workshop I held in 2018, where we also carried out a partial VMM. She had potential, with her pleasant coloraturas and maybe something else bubbling underneath. Hölttä mentioned that she also likes to sing pop and jazz, but we didn't properly address these techniques. When I cast Hölttä, I was seeking this extra dimension, and welcomed her eagerness to reach for new solutions. In this second and more profound VMA, which took place in 2019, the results were dramatically different. She had acquired fascinating upper areas in her

voice, but her belting technique was solid and exceptionally wide.[52] Her interest in mixing various styles opened up new artistic possibilities. Somehow it became part of her role that many things were new and her voice could react to them in fresh and unexpected ways.

Kaisa Ranta is, in essence, closest to the classical era in her repertoire and in her voice. Although the singer's formant couldn't be fully tested in the analysis situation, her voice was the most dramatic of the four.[53] She had mentioned that trills and agile coloraturas were her speciality; they had a certain weight and momentum that the other singers could hardly reproduce. In my vision, Hölttä and Ranta soon became a duo, and the comparison was revealing: they had very similar voices, but at the same time, the temporality was different. Ranta evidently knew where her voice was and what it could do because she had already used it in so many different contexts.

When I composed for these four voices, sets of skills and personalities, I tried to create material that would optimise the qualities of each of their voices. I chose to make a distinction between 'four individuals' and a 'group of four'. It may be theoretical, but I believe it to be an influential psychological distinction. Members of a group are compared with each other based on fulfilling given criteria, whereas the evaluation of an individual singer acknowledges their singular talent.

An example that was continuously being suggested was the competition between the different versions of the Queen of the Night's aria in *The Magic Flute*. A contest over who sang this iconic coloratura-soprano number best was utterly uninteresting to me. Although I quote the aria in the guided improvisation in Scene III, it is never

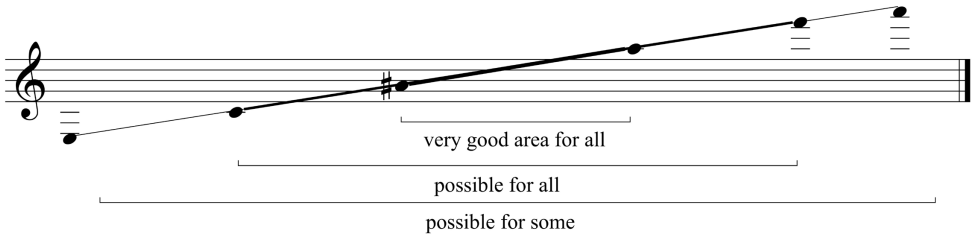
[52] It was unlikely that the voice itself, or the singer's technical skills, could change so much in such a short time. I assumed that the change was actually a combination of undergoing a full VMA, being asked the right questions, and Hölttä herself being better prepared, technically and psychologically.

[53] This was proven by another VMA being done later, using the saved audio files.

the high notes — the high F6s that make or break the coloratura sopranos. I didn't want the singers to have to prove anything.

The only exception I made to individualising the singers was to use the collective VMAs of the four voices to sketch the tessitura and overall range of vocal forces in the form of a musical score, as in Example 9.

Example 9. The collective tessitura and range of all four singers



10.3.2 Structure of the piece

Voice is Voices consists of eight scenes. The dramaturgy creates a certain symmetrical arc, but the personality of the piece and the real action grow from the voices shimmering in different contexts, alone and assembled. The libretto was written and collected by **Henriikka Tavi** and myself.

This piece is an audio installation. The audience experiences the actions only through their ears, like in a radio play. The sole visual components are the subtitles projected on screens in front of the audience.

I	I Recognition of Voice: meditative fairytale solo by Dahlbäck	
II	II Coloratura Identification: warm-up sung by all the singer (backstage)	
III	III Voices of Birds: choral prelude to die Fögel sung by all the singers (stage)	
IV	IV Bird Sisters and their Secret Language: duet in invented language by Hölttä and Ranta (imaginary nest)	
V	V Voices of Mad Love: postlude of mad scene quotes by all the singers (on stage)	
VI	VI Applause: mutterings by all the singers (on stage)	Parts VI to VIII overlap
VII	VII Voices of Gender: madrigal on gender by Fuhrmann (on stage)	
VIII	VIII Singing Myself: interview of all the singers, with an instrumental postlude (backstage)	

Table 9. The structure of Voice is Voices

The drama opens gently, with some kind of mother-figure inviting us into a hypnotic, fairy tale reality. The stories are told in different languages, becoming more and more entangled, and reality changes. (**Recognition of Voice**)

We realise that we are backstage in a theatre and four singers (coloratura sopranos) are preparing for a performance. The piece is called *Die Vögel*, a dramatic and somewhat bombastic opera based on Alfred Hitchcock's *The Birds*. (**Coloratura Identification**)

This imaginary opera-within-an-opera creates contrast in the music, as the personal intimacy of *Voice is Voices* has nothing to do with the gargantuan film remake: the prelude in *Die Vögel* introduces the singers and their numerous copies, creating dense, swarming nests of abstract birdsong. (**Voices of Birds**)

We do not experience this 'grand opera' any further because the focus is now on one, seemingly random, element: a lonely tree on stage. We listen to the story of two sisters living in that tree. The children had become lost and were raised by a mother bird, eventually creating a bird-like language of their own. (**Bird Sisters and their Secret Language**)

We do not hear how their story ends because at that moment, the finale of *Die Vögel* begins. The coloratura sopranos are on stage once again, but the mood has changed. They quote mad scenes from romantic-era operas, but in a relaxed, demonstratively non-neurotic way. (**Voices of Mad Love**)

Die Vögel ends, and during a round of ecstatic applause, the singers whisper to each other. But one of them stays silent and is left behind as the others proceed backstage. (**Applause**)

The singular singer reflects on the different demands the opera industry makes, based on one's sex and gender: you would have to be four different personalities and bodies simultaneously, yet none of them is really you. That singer imagines these aspects and the four singers start to sing alongside each other, eventually finding some kind of harmony. The one singer is then able to join the others backstage. This scene is based on interviews of transgender opera singers. (**Voices of Gender**)

The final vocal performance is the most personal of all: each singer gives a short interview, speaking outside of their performative role about their own experience of the process. (**Singing Myself**)

Before explaining in detail how each of these parts functioned as a laboratory of voices, I shall explain a little about the musical material. Since the singers possess a unique mixture of aesthetic styles, it felt natural to show each of them in their original environment or to have them sing existing material. I decided to treat it

more as dogma: Scenes I to VI are almost exclusively composed out of quotes from existing material. How intensively I have manipulated these found musical objects varies. In most cases, the material is obscure and abstract, but some relatively long and easily recognisable quotes from arias are also included. As the last two scenes represent the world we live in now (thematising gender and allowing the performers themselves to be active commentators), the quotes were sparse. The music of this 'reality' is still being composed and therefore cannot be quoted yet.

The only instruments in *Voice is Voices* are the viola da gamba played by **Louna Hosia**, and the modern cello played by **Pinja Nuñes**. Since the piece only exists as an audio installation, the sound could be edited. The balance between musicians was mostly created live in the recording situation, but layers from different recordings were added in afterwards.

10.3.3 Use of the VMM

The VMM was used to identify the minute similarities and differences in the voices. These could then be used in numerous ways and contexts.

In *Voice is Voices,* two solos and one duet concentrated specifically on individual performers. In Scene I, I tapped into the qualities of Kajsa Dahlbäck's voice and personality. The scene feels very close and intimate, creating a meditative safe space. Experienced in historically informed performance, she could use her voice in a speech-like manner, still managing some complex ornamentation. The libretto consists of collected fairy tales in their original language, providing geographical ideas for Dahlbäck to react to. As I could trust her skill in managing larger formats, I let her create the dramatic arc together with the gamba. To add to the hypnotic nature of the scene, I had repeating instrumental and vocal patterns running under this long fairy tale. They could be *passacaglia* lines or abstract, descending figures. One of them was a version of the so-called Shepard tone (Shepard, 1964). This auditory illusion

only functions if the sound has a very neutral and non-changing timbre, a quality I had discovered in Dahlbäck's voice.

The duet in Scene IV is a study of the two most similar voices in the group, those of Marika Hölttä and Kaisa Ranta. For this scene, created together with librettist Tavi, we evolved a new language that contains aspects of existing languages, bird songs, and mathematics. The rhythm, consonants, vowels, and pitch constructions were all critical aspects of that language. Much of the sung material was rather abstract, vocalese-like repetition of certain tones in a way that didn't sound quite human but was not purely natural for birds either. In these sections, I distinguished between the voices, focusing on the minute differences and similarities in order to highlight the particularities of each voice. Over the course of the scene, the youthful characters grow older and their differences start to appear. When groups of notes begin transforming into jumps and then melodies, the musicality of the performers becomes evident and their personalities emerge. This was underlined by tailor-made cadenzas: belting for Hölttä and trills for Ranta.

In Scene VII, Annika Fuhrmann was able to demonstrate her full emotional and vocal range. Inspired by the colourful areas of her voice, I could imagine shaping the different dramatic characteristics. This division also stemmed from the text, which is based on interviews by classically-trained singers whose life collided with the opera industry by being transgender. Tavi edited those texts, and in the final version, I could recognise four different approaches:

- Studying the voice after sex-reassignment therapies using technical terminology – a Pierrot-like character with a light German accent
- Controlling and manipulating the voice electronically, making it one's own – a straight, neutral voice that is electronically manipulated
- Needing to be heard and changing the structures – an empathetic spoken voice with Fuhrmann's natural Finnish accent

- Describing the part of voice, the physicality, and the transition, whether intimate, transcendental or bodily, and that can only be described poetically – voice art concentrating on the timbres, areas and body, and going beyond words and meaning (expressed using graphic notation)

In addition, five ensemble scenes show the singers in these different musical contexts:

Scene II shows them singing the same thing and nonchalantly drifting into their material (this part was conducted by Fuhrmann, which brought about some of the most complex tempo changes in the piece).

Scene III contrasts with everything else, as the music was composed explicitly for the Fach and not for the voice; the music in the narrative is in the realm of a fictional composer operating in the opera industry; the singers are manipulated as a group and forced to follow given lines, regardless of the areas of their voices.

Scene V uses homogenous source material (the so-called mad scenes of early 19th century operas) for all singers, with their individual styles now more present; this scene also provides one of the best options for studying the singer's formant artistically; Kaisa Ranta's voice is masked by instrumental material that could have made her voice inaudible, but the singer's formant alters the situation.

Scene VI provides the singers with similar material, stylistically related to Luigi Berio's *Sequenza III* (heavily based on Cathy Berberian's improvisations) and Georges Aperghis's *Recitations*; here the parts were recorded individually, so any musical relationships that existed in the previous scene make space for their individual personalities.

Scene VIII shows the singers as themselves, this time completely leaving out the aspect of vocal technique, speaking only their own words and opinions.

Within and in-between these large-scale structures, I used different compositional techniques to further shape the nature of the piece and to emphasise its character. The singers go through different musical processes during the full 52-minutes of the opera, which are woven into other musical material. These processes showcase the differences and similarities between the voices.

10.4 Independent academic tests

The core of VMM artistic testing concentrated on three large-scale operas: *Voice Box*, *NOS*, and *Voice is Voices*, as discussed in the previous three sections. These pieces comprise the portfolio of the doctoral project, and were evaluated by the artistic jury. The other three pieces, described in the following section, were not subjected to this process. Still, they played an essential role in gaining additional information concerning the usability and utility of the VMM. These artistic works included partly analysing the voice live in front of an audience, putting pressure on the singer for the purpose of making the VMA more effective. The pieces performed in Venice, Darmstadt, and Helsinki formed the artistic component by means of a lecture or discussion.

10.4.1 Research Pavilion, Venice

The first performance took place at the Research Pavilion, organised by the University of Arts Helsinki in collaboration with other European institutes and in the context of the 2017 Venice Biennale. The pavilion served as the stage for performances, lectures, and discussions.

My performance combined a talk and a demonstration with singer **Eleonora Claps**, along with video material from the opera *Voice Box*. A central feature, which the audience also appeared to find the most impressive, was analysing one of the areas of

Claps's voice live. I briefly commented on the analysis results and then continued to compose a miniature. Some aspects of her voice could be put into words, while others affected the composition intuitively. The audience could follow the documentation of the opera and my composing process simultaneously on screen. After roughly 10 minutes, the piece was ready, and Claps performed it *prima vista*. The end discussion included her feedback. Claps was happy with the music, and our artistic discussion and collaboration have continued.[54]

The performance took place about one year after the first version of the VMM (0.9.1) was created, so its development was still at a fairly early stage. This testing is part of Phase I, where the main focus was just to show that the general concept works and that the VMM could enhance communication. The performance in the Research Pavilion provided further positive evidence.

10.4.2 *Seeing Voices,* Darmstadt Summer Course

I suggested a performative piece to Julia Mihály, which would also include a live analysis and composition. She agreed, and found the idea so valuable that she incorporated it into her concert *[trigger me]* in Darmstadt (2018), where she was a performer as well as a tutor.

Seeing Voices has three short parts performed at the beginning, middle and end of the concert. The first part includes a description of the VMM and of parts of the VMA we carried out earlier, ending with the live analysis of one of the areas. In the second part, Mihály and I discuss the analysis results and simultaneously compose short vocal pieces. We did this using overhead projectors and transparencies that already

[54] Eleonora Claps's voice was not wholly unfamiliar to me. We had collaborated in a workshop at the Darmstadt Summer Course in 2016, working on my piece Phenomenological Notation. Because of the installation-nature of that work, I was unable to learn her voice fully — that opportunity came later, in Venice.

had her areas printed on them. In the last section, she sang the graphic scores we had composed, accompanied by a piece that consisted of the sound files of her analysis.

One day before the premiere, we shared an observation that analysing the voice live was actually unlikely to bring much to the performance, and would be dramatically and technically clumsy to achieve. It would have been a real challenge to add a computer into the setup for just a few minutes. The VMA itself would have been easy to do, technically, as a recent analysis showed that Mihály's voice was straightforward to analyse. She is a classically trained singer with vast experience in using her voice in different digital contexts, and finds it effortless to achieve the optimal amount of vibrato and legato.

The performance was successful. There were exciting discussions about it right after the concert and in the open space I gave some days later during the summer course. The composers and singers found the theme important and worthy of further study. The second part of *Seeing Voices* also formed part of the testing. In front of the audience, we discussed some of the themes in the List of Good Questions, and Mihály also had the opportunity to criticise the method. To my question, "Can you see your voice in the analysis?", she answered that it was definitely one way to see her voice.

Chronologically, this component took place in Phase II. The VMA was already functioning and the main focus was to analyse the voice fluently and take the vibrato into account. Because Mihály's voice was so malleable, the question of vibrato was not relevant. She did, nevertheless, provide crucial feedback to the List of Good Questions.

10.4.3 Research Days, Sibelius Academy

The third component was a lecture and a demonstration, much like the first one, but it had equally balanced assignments (like the second component). In spring 2019, in Helsinki, I gave a speech together with Lisa Fornhammar, a singer, researcher and university teacher. This lecture-performance had two functions — as an academic talk at SibA Research Days, but also as a practical demonstration for students, conveyed during a workshop taking place at the same time. This workshop was devised for composition and singing students at Sibelius Academy, and was about composing and performing new vocal music. The lecture included some inspiring theoretical and philosophical aspects of higher music education. Still, we wanted to provide some more concrete elements. Since we are a composer and singer, why not show communication and collaboration in action?

Analogous to the previous cases, I had analysed part of Fornhammar's voice earlier and then continued with one area in front of an audience. For this, I combined some pre-composed material with live composition. In this case, the singer's role as a commentator was more active .

This last component was also part of Phase II. Fornhammar was able to use different kinds of vibratos, which version 0.9.2 of the VMA software was able to read.

III

Conclusions

Part III Conclusions

11 Discussion

A defining decision of the study was to limit my focus to dealing with the most crucial questions. The doctoral project has provided a context for using and developing the Voice Map Method, technically and artistically, in order to gain a full picture of its functionality. However, there is space for further development and for finding different means of using the VMM. The software is open source.

11.1 Functionality of the VMM

The field testing discussed in Chapter 9 shows that the Voice Map Analysis software is safe to use and provides reliable data that enhances the creation of vocal music.

The artistic testing, involving the three operas and three further pieces, demonstrates how the information was used in real situations for composing new vocal music. The testing process was successful for all the pieces. In *Voice is Voices*, the results were especially striking: as a composer, I was able to hear the differences and similarities of four different voices and use them as a compositional starting point. The artistic results, as stated by the artistic committee, along with the singers' feedback[55] testify to achieving a more effective level of communication.

To test the functionality, all the key information concerning the voices of these singers was gained through the VMM. This proves that it can function as a communication tool for other composers too. The VMM made communication more fruitful, fluent and precise. And due to the systematic nature of the method, I could also be sure that I had gone through the whole voice.

[55] In *Voice is Voices*, this feedback was included in the piece in the form of video interviews.

11.2 Deficiencies in the Fach system

It would be easy to misinterpret the VMM as being a replacement for the Fach system.[56] Especially in *Voice is Voices*, where I demonstrated how the differences between singers can be crucial to the composer, even when they belong to the same *Fach*. Getting rid of the Fach system is not my mission. Rather, my goal is to understand the context in which the Fach system is necessary, as well as those in which it is misunderstood or misused.

The Fach system has been a part of opera and the opera industry in different forms for centuries, and its usefulness extends into the global world. Although finding the right Fach can be complicated and stressful for the singing student (pedagogical aspect: Miller, 1996; and Cotton, 2007; social implications: Koehler, 2004; technical aspect: Johnson and Kempster, 2011), it is part of becoming a professional opera singer. Moreover, the judgments laid down in the manuals, such as *Handbuch der Oper* (Kloiberet et. al. 2002), may at times feel arbitrary, and the system can feel like a construction that has little to do with music. Still, I am convinced that in most cases, the trained and experienced personnel of opera companies and festivals use the system wisely. It is merely a starting point of creating a cast, a complex process that is a form of art in itself. The Fach system doesn't harness the art, it just helps to organise it.

It is, nonetheless, only for opera professionals. For inexperienced composers, the situation is quite different. As I have shown in section 3.4, the teaching of vocal music and of voice varies greatly in composition curricula. Although some workshops may provide the right information, it is probable that a newly-graduated composer has a naive understanding of the Fach system and not much more information about

[56] The harsh and ironic words uttered by the fictional character Professor M. H. in the first artistic component, *Voice Box*, probably didn't help.

voice, such as the registers and the use of text. In this respect, the Fach system can cause a block in communication between the inexperienced composer and a singer. One common scenario is where the composer has created a biassed understanding of the voice types and communicates with the singer in a way that clashes with an opera professional's understanding. When the composer calls for a 'soprano', they may in fact mean a 'lyric coloratura-soprano' or a singing voice that doesn't exist at all.

It appears that the optimal way for an inexperienced composer to create their first pieces is to get to know a specific singer and their voice, later extending their knowledge based on this experience. In doing so, an understanding of the fine nuances of the Fach system is not needed.

11.3 Limitations of the VMM

This development project and testing was carried out with classically trained singers, whereby coloratura sopranos formed the main test group. Concentrating on this group is justified by the high number of contemporary vocal music pieces written for agile, lyric, and high voices. Nicholas Isherwood (2013, 117) even calls these new music specialists another voice type: contralto soprano.

Based on both technical and artistic testing, the VMM is also suitable for collaboration with other voice types. The testing of the male voices was barely undertaken here, but there is no reason it wouldn't work satisfactorily. Singers trained mainly in other styles, such as jazz, folk or pop music, were not analysed. The VMA is designed with the assumption that the singer has good control over their voice, especially its areas. Since no testing was done in those other groups, it is difficult to fully predict the kinds of questions that would arise, but it is likely that the dynamic range would be narrower and the singer's formant rarer. It is reasonable to assume that communications would also be enhanced in these cases. Some of the analysed

singers had a wider technical background and sang some of the areas using a non-classical technique, such as belting.

11.4 Further development

Further testing is still required. Especially the testing of different voice types and of other kinds of voices and singers in other musical styles. It was only touched on here, although with promising results.

The functionality of the VMA software has been optimised in this development project, but the question of vibrato and especially the analysis of the singer's formant could benefit from more extensive development. At present, these two aspects set the highest demands on the composer who employs the VMA.

This testing phase was based on the work of only one composer: myself. It has allowed me to precisely articulate my manner and motivation for using the VMM. In the VMM, the data is collected systematically rather than intuitively. The various steps involved in the VMM and the philosophy behind the method are devised to ensure that the prerequisites are minimal and the process itself easy to follow. I used the VMM to enhance communications in a similar way to that of an inexperienced composer, with positive results. On at least two occasions, the VMM was even able to correct my presupposition that a non-inexperienced composer would not have had. I'm referring to Martina Koppelstetter's atypically low voice (see 10.2) and Kajsa Dahlbäck's exceptionally well-equalised voice (see 10.3).

However, it still requires lengthy testing in collaboration with music universities, in order to absolutely determine its practical application. The framework of an artistic doctoral project does not lend itself to testing with numerous inexperienced students. I've executed the part of the development relating to obtaining a specific

understanding between a composer and a vocal artist, and now hope to proceed to the next, more scientific and statistical stage. This must include exhaustive testing with inexperienced composers and singers from different backgrounds. It has received much interest.

Because the VMA software is published as open source, its development can continue to happen independently. I plan to take on the task of managing the feedback and suggestions for the next few years.

11.5 Pedagogical possibilities

The pedagogical possibilities for composer-singer pairings are numerous. The VMM is beneficial for use in music schools and universities, as it is able to optimise workshops and projects, helping them to run more smoothly and efficiently. For inexperienced composers, this is especially meaningful because these workshops are prevalent in vocal music education. For these purposes, I would propose holding workshops that consist of three parts: basic theory of the human voice, well-chosen practical examples from the repertoire, and, as the main learning experience, close collaboration and experimentation with a singer, with the support of VMA. Based on my findings, I would argue that this kind of close teamwork should be a mandatory part of a composer's education in the way that it is for that of orchestration (see section 3.4).

In addition, other pedagogical uses can be distinguished. Some vocal pedagogues use the Voice Range Profile with their students, to obtain a new standpoint on their voices. Similarly, when I was testing the VMM with the singers, some of them mentioned that it enhanced the development of their vocal skills. For example, Marika Hölttä, in the opera *Voice is Voices*, said she found a completely new range and technique for belting, which she is now using in her warm ups. This way, it might also be informative to carry out the VMA on the same singer multiple times

throughout their careers or studies, in order for them to follow their development.

This realisation indicates that using the VMM might well give singers new ideas regarding their personal training, a positive and somewhat surprising side effect of the VMM.

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Voice Profiler, developer Alphatron Medical Systems. Current version 5.0

VRRRP!!, developer Christian Herbst. Current version 1.006 (from year 2008, only for Windows)

APPENDIX 1: Structure of the VMA software

Creating the VMA software was a collaboration between myself and composer/sound-artist Hadas Pe'ery. I was responsible for setting up the process, requirements and goals, and artistic testing. Pe'ery programmed the software. We both participated in the design of the interface as well as the technical tests. Pe'ery mainly worked with the recorded material and I interacted directly with the singers. The software uses Max/MSP visual programming language, which is based on modules.

Technically, the VMA software assesses four sets of values:

- Frequency – MIDI notes or musical pitches (affected by the vibrato)
- Duration – milliseconds
- Dynamic – amplitude of the tone
- Partials – sinusoidal components of the tone

Parameters established by the user of the software:

- Name and range of the areas
- Type of vibrato (quick, slow, or freely determined)

Parameters that the user can adjust if needed (default values in brackets):

- Noise gate (-70 dB)
- Frequency centre range of singer's formant (300 Hz to 3200 Hz)
- Minimum duration of the tone (300 ms)
- Microphone input gain (0 dB)

The software collects this specific data:

- The vocal areas and their ranges (text file **Areas**)
- All maximum and minimum dynamic values of each tone in each area
    - As a list, organised by area (text file **Max/Min**)
    - As a graph, each area is indicated in the respective colour; maximum values are shown with infilled circles and minimum values with hollow circles (in the upper graph)
- All maximum dynamic values of the tone's sinusoidal components in the range of the singer's formant
    - As a list (included in the text file **Max/Min**)
    - As a graph, each area indicated in the respective colour, shown as a continuous slope (in the lower graph)
    - Two text lists, **Areas** and **Max/Min** are stored in the software and the user can choose whether or not to save them as files.
- Recording of the sound used for the analysis
    - Every time **MIC ON/OFF** is activated, the recording starts or stops, creating a new AIFF file, indicated by the name of the area and a running number
    - The name of the sound file includes the specific maximum and minimum values (in the text file **Max/Min**)

Two related Max software modules, or patches, were utilised for the audio analysis: **fiddle~** and **analyzer~**, both based on the Fast Fourier Transform (FFT) convolution in the frequency domain. **fiddle~** is an patcht created by Puckette, it estimates the pitch and amplitude of an incoming sound (**fiddle~** patch documentation). Tristan Jehan developed this object further for more complex analysis, this object is called **analyzer~** (Jehan, 2001 **analyzer~** patch documentation). It is able to transform a complex tone into a group of sinusoidal components or partials (Puckette et al, 1998). This process facilitates the timbral analysis of a tone but is also an interpretation of it.

fiddle~ was used to collect the pitch and amplitude of the sung tone. The setup for most values for this object was determined by trial and error (e.g. window size, 2048 samples) or was trivial (e.g. number of voices, 1). Choosing the vibrato value was slightly more complicated. The final default values are: deviation, 0.5 halftones; duration, 50 ms. The latter indicates how long the pitch should be held within the threshold in order for the central value to be accepted; a large value indicates a slow vibrato. It can be altered by the user. **fiddle~** gives as the output the pitch and the amplitude. The pitch, indicated in MIDI tones, was rounded up to the nearest halftone. The amplitude values were used to obtain dB values. The collected information averaged 10 bits of data for every 50 ms.

To eliminate extraneous noises, only tones with a dynamic above the noise gate were analysed. Sounds that didn't maintain the same semitone for longer than the minimum duration were also excluded. As a default, the noise gate value was set at -60 dB and the minimum duration at 300 ms or 0.3 seconds.

- The software duly combines this information:
- If the value was louder than the noise gate, then the pitch was analysed
- When the pitch changed, the timer was restarted

- If the duration of the previous pitch was longer than the given minimum, the dynamic and pitch were both analysed.
- If the above values were louder than the previous maximum or softer than the previous minimum, in relation to this specific tone, then the value in the list was adjusted
    - The default value was set at -70 dB
- The file name of the recording was updated in the text file **AreaMax/Min**

To collect the singer's formant data, the **analyzer~** was used in a similar manner. It is an adapted and more powerful version of **fiddle~**, the main difference being that the amplitudes are indicated on a scale that's more practical for our purposes.

The setup for **analyzer~** was analogous to that of **fiddle~**. A buffer size of 1024 samples was sufficient. A higher value might have created latency and wouldn't have been beneficial, since the pitch was already analysed in **fiddle~**. The number of peaks was 10, as explained below. The outputs are the values for the sine component: the order number, frequency and amplitude.

These values were used to find the singer's formant: high energy values in the tonal components at a frequency of approximately 3000 Hz (see section 5. Singer's formant).

Only component numbers 3—10 are needed, as they are the ones that fall into the range of 2500 to 3500 Hz. If the first or second component reaches this area, the sung pitch would have to be so high that the singer's formant cannot be produced. On the other hand, components higher than the tenth are far beyond this range, and in most cases, beyond normal hearing range. The default of the singer's formant range in the VMA software is more limited: 3000 to 3200 Hz, although the user can adapt the value.

The software is programmed to combine this information in a sensible way:

- If the frequencies of the components are within the given singer's formant range, their amplitude is analysed
- If, using **fiddle~,** an acceptable value results, then the amplitude, or dynamic of the partial is further processed
- The maximum value is noted in the text file **AreaMax/Min** and in the lower graph

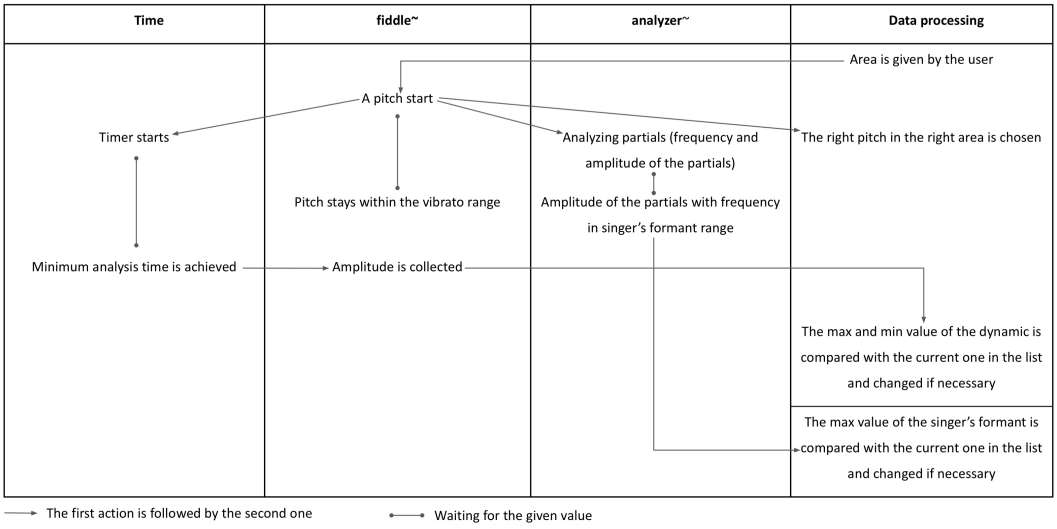

Table 10. Flow chart of the VMA software

APPENDIX 2: Manual for Voice Map Method Manual

Contents

This is a short, practical introduction to the Voice Map Method, VMM — a device for enhancing communication between composer and singer.

The method was created and tested as part of a doctoral project. For the theoretical background, see the project report: miika.info/VMM

Some information in this manual is provided via links to short videos. The full list of videos can be found here: miika.info/VMM/videomanual

1 What is the VMM?

The VMM is an assessment system that helps a classically trained opera singer and composer better communicate with each other during the process of creating new vocal music. The needs of composers with little experience of vocal music are especially considered. The VMM enhances communication during the creative process, especially at the beginning stages.

The voice is measured in the first step, the Voice Map Analysis (VMA). VMA software is a Max/MSP standalone patch. This measurement requires work from the singer, comparable to a very thorough vocal warm-up in front of a microphone. The full range of the singer's voice is studied, and most pitches are sung more than once. The output, charted on a graph (a.k.a. the Voice Map), illustrates certain aspects of the voice: the different areas, range, dynamic possibilities, and singer's formant. Thereafter, the singer and composer discuss these results, taking the List of Good Questions as their starting point. Two hours or less is normally required to complete the VMM process.

VMM process:

- Voice Map Analysis
    - Preparation
    - Naming the areas
    - Soundcheck
    - Measurement
    - Interpretation
- List of Good Questions

1.1 Who should use the VMM?

The VMM has been created to aid communication between singers and composers. Only singers who understand their vocal registers and have a good control of their voice can undertake the VMA, which is a fundamental part of the VMM. In the context of the VMM, the registers are called 'areas' (refer to the report, section 1.3: Areas, for further details). All singers participating in the testing phase were classically trained.

Through the systematic use of this method, the composer is able to gain an understanding of the functionality of the voice in general, and above all, of how the voice of a specific singer functions.

1.2 How can the VMM help the user?

Each area of the singer's voice is evaluated systematically using the VMA, whereby the composer hears each tone sung as softly as possible and as loudly as possible. Dynamic values of each tone are automatically shown in graph form, making it easier to discuss specific points, such as the extremes of the singer's range, or pitches that might be produced as part of more than one area. Although the VMM identifies the extremes of the voice, it doesn't encourage exploiting them.

The VM also informs the composer of the so-called singer's formant (i.e., ring, twang, *squillo*), an indicator of the voice's ability to be heard through the sound of the orchestra.

These communications help to engender an understanding of what the composer requires from the singer as well as how to compose efficiently for their voice. To demonstrate the practical use of the VMA, some theoretical, experience-based examples are provided here below.

1.3 Areas

The word 'area' can be used as a synonym of 'register' but at the same time, it can be understood more loosely as something the singer feels in their voice.

The range of the voice is divided into different areas. This division is based on the vocal mechanism – the physical sensation of singing and the timbre of the voice. When the tones are similar in both, they belong to one and the same area.

Before the singer enters into the analysis situation, they should write down the names and approximate ranges of their vocal areas. The exact pitches will then be checked during the analysis. The vocal areas will likely overlap.

Example 1: Being aware of the areas
The composer has a concept of a vocal piece consisting of two contradicting sections. In the first section, the voice changes timbre quickly, whereas in the second section, glissando lines with a very homogenous timbre are sung. Via the VMM, the natural areas of the singer's voice are identified, and from the discussion that follows, the composer can find out how the singer feels about using those areas. In the final composition, the timbral changes comprise a mixture of areas and some extended techniques. Most glissandi are sung in the range of one area. These decisions allow the singer to use the physical aspects of their voice efficiently and concentrate on the few places that come less naturally.

When another singer wants to perform the piece, the piece is transposed and the new singer's voice functions similarly in this new range.

2 The VMA Software and Accessories

This section introduces the technical equipment and processes involved in the VMA.

Video 1: Technical set-up and preparation: miika.info/VMM/videomanual1

2.1 Equipment

Zoom H4n Pro or Zoom H6 recorder

Testing was done on a Zoom device, which is deemed by many composers and other musicians to provide adequate quality. Thus, all the calibrations and instructions given in this manual relate to this device, but there are no technical reasons that prevent the use of similar recorders or microphones. Before beginning the testing, make sure that the device is updated and fully functional.

Mini USB to USB cable, 2 m or longer

The device needs to be connected to the computer so that it can be used as the audio interface.

Microphone stand

This should be at least 1.8 m tall, and you should be able to fix the Zoom to it.

Computer, with 300 MB of free space

Typically, audio files use less than 100 MB. Max/MSP software is not needed since the VMA software functions as standalone.

[Testing for this project was done with a 2015 MacBook Pro.]

Headphones for the singer

Closed-back headphones are preferable. They are used to enable the singer to hear the reference tones, so average audio quality is sufficient. The cable should be long enough to allow the singer to be positioned 50 cm from the microphone.

A silent space

It is essential that the testing space is reserved for private use during this analysis session, preferably for two hours. Noise coming from outside may disturb the singer

and also affect the program. The rehearsal rooms at universities often prove too noisy, but a standard soundproof room will do. The composer and the computer used for the analysis can be placed in the same space as the singer.

Optional:

Headphones and a splitter plug-in for the composer

With headphones, the composer can hear the reference tones exactly as the singer hears them. This may in some instances (such as when there is a strong vibrato) help the composer connect the sung tones to absolute pitches, but it can also hinder the listening to the actual timbre of the voice.

MIDI keyboard and USB cable

The reference tones can be played by clicking on the screen of the computer running the VMA software, but also by way of an external keyboard.

2.2 Voice Map Analysis software

The functionalities and components of the VMA software can be seen in figure 1.

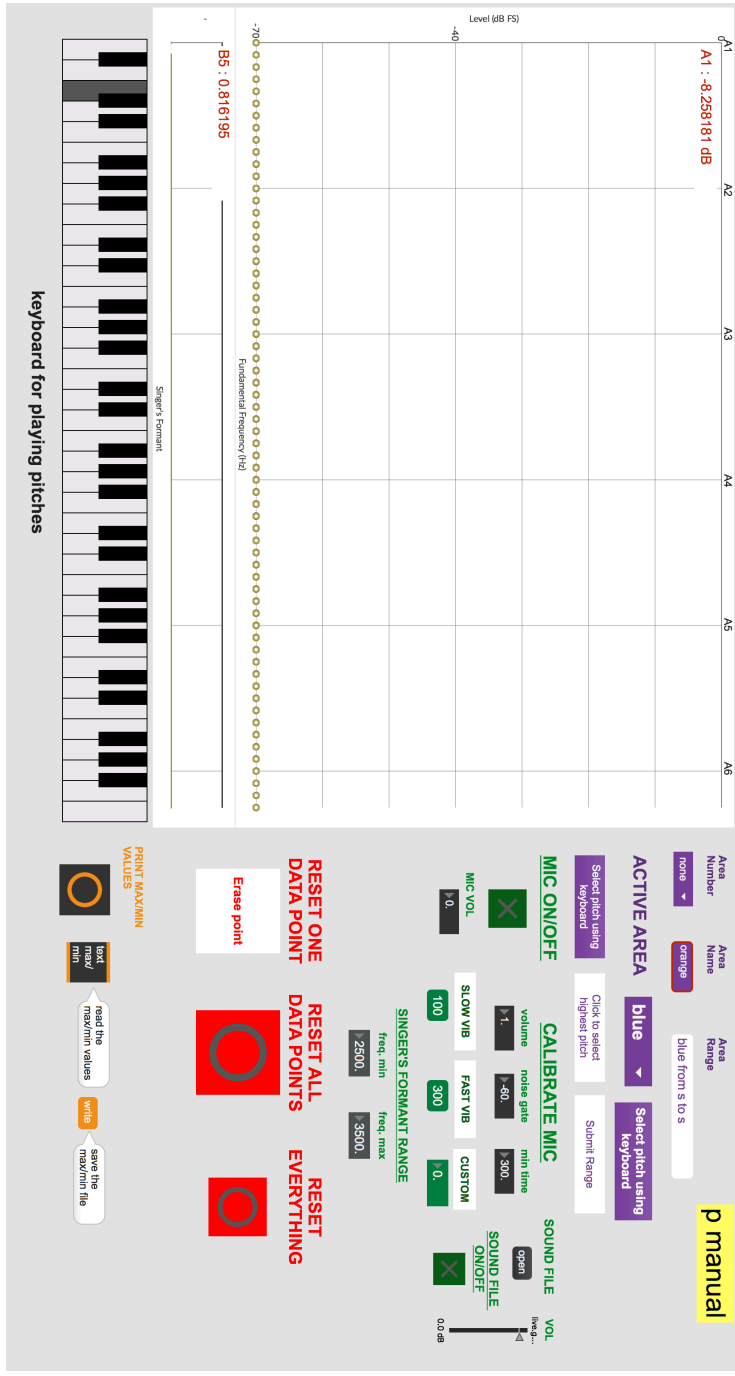

Figure 1. Components of the VMA software

2.3 Preparations

The voice measurement process should be clutter-free, in order for the singer to be able to concentrate on singing and the composer on listening. Therefore, a well-planned technical setup is crucial.

- Open the VMA software, a standalone patch for Max/MSP
- Connect the Zoom audio device to the computer via the cable; Zoom should start automatically
- In Zoom, select **Audio I/F**, **48 kHz** and then **Connect**; now you can use the audio device as an audio interface
- *For H4N*: On the side of the Zoom device is the **Rec level** button — use it to set the recording level at level 20 (practical in most analysis situations)
- *For H6:* On the Zoom device are volume knobs. Choose the one for the right stereo pair and set the recording level at 4 (practical in most analysis situations)
- In Mac OSX, go to **System preferences**, choose **Sound**, **Voice in**, and from the list, choose **H4** or **H6**; now the computer is using the audio device for sound input
- Open the VMA patch, a Max/MSP window opens; choose **Options** and **Audio status** then choose **Input device**, **H4** or **H6;** in the same window, click **Audio on/off**: Max/MSP uses the audio device for audio input, and the default **Audio** setting is **on**.

2.3. 1 Input of areas in the program

Video 2: Setting up the areas: miika.info/VMM/videomanual2

The areas of the singer's voice need to be set manually. This can be done by either the composer or the singer.

- In the menu, select **Choose Area to Add**. Start by choosing **Area 1**
- Type the name of this area into the corresponding field, choose **Area name**
- From the **Active Area**, choose the area you just named. You may have to click twice.
- Select **Click to define area range**. Two new options appear
- Select **Click to select lowest pitch**, then click on the lowest pitch of this area using the keyboard located at the bottom left of the screen. For reference, each A and the respective octave are indicated in the graph with scientific pitch notation, A4 is 440 Hz
- Select **Click to select highest pitch**, then click on the highest pitch of this area using the same keyboard
- Click on **Submit Range**. The range should now be indicated in the field **Area Range**
- Repeat for all the other areas

2.4 Soundcheck

The singer is positioned 50 cm from the audio device and sings the allocated tones as loudly as possible. As they sing these tones, the composer needs to keep an eye on the Current Vol., which should not be higher than -5 dB. Adjust the volume as you wish, but if it is set lower than this, the VMA might not be fully comparable with another singer's values. Note: adjustments to the volume should not be done mid-analysis.

3 Measurement

Video 3: Measurement: miika.info/VMM/videomanual3

It is advisable for the composer to run the application. Another person can also do this, in which case the composer can just listen to the voice and make notes.

Before starting, the singer should do a light warm-up to be sure that the VMA relays a representative image of their voice, and also to check that they can sing at the extremes of their voice in a healthy way.

As part of the analysis, the program automatically saves all the sounds. These may be helpful for the composer to reference afterwards. Before doing any actual measurements, the singer and composer should agree as to how the sound files can be used, whether they want these files to be saved permanently, how they are saved after the analysis, and for how long.

These AIFF files are designated with **area name** and **file number**. For example, the third recording of the area 'chest' would be chest3.aiff. A new file and file number is always created when the microphone is turned on, by pressing **MIC ON/OFF**.

The composer has the possibility to listen to the audio files after the VMA has been completed. Sound files can also be used to create a new Voice Map. To do so, open the first file by pressing **OPEN SF**, then **SOUND FILE ON/OFF**. Then go through all the sound files in the same way. For sound files, **SF VOL** is used instead of **MIC VOL**.

When all the areas are analysed, the Voice Map is ready and can be discussed. The Voice Map can be manually saved as a screenshot. The data can also be saved as a list: click **Read Max/Min** then **write** to save it as a text file. The software does not save these files automatically.

3.1 Singing

The singer should take a comfortable position facing the audio device, such that the distance between the device and their mouth is 50 cm. As it can be difficult to maintain this distance, it should be checked between measurement cycles.

The Voice Map shows how softly and how loudly each tone of each area can be sung. This is usually done by singing the scales, as indicated in 3.1.1. Using scales has proven to be a more natural way for the singer to proceed; furthermore, the data obtained is more reliable when the tones are sung numerous times.

The singer should sing vowel /a/ as per the International Phonetic Alphabet. This is an open front, unrounded vowel sound. At the extremes of the full ambitus, the vowel may change somewhat.

Each tone should be sung for roughly two seconds. The required length of the tone can be adjusted in the software, but shorter values often yield less satisfactory results and should only be used if really needed, such as for extremely high tones.

Typical order of a cycle:

- Singer and composer agree on which area to analyse and whether it will first be sung softly or loudly
- Area is chosen (**Active Area**)
- Singer indicates they are ready to start
- Composer gives the reference tones (a scale of three to five tones) using the on-screen keyboard or a physical keyboard, playing each tone for about two seconds
- Composer switches on microphone (**MIC ON/OFF**)
- Singer sings the tones at a similar tempo and with moderate legato

- Reference tones (within the area) and singing are repeated
- When appropriate, one of these options may be taken:
    - Singer signals they want to make a correction or repeat something
    - Singer or composer signals that they need to discuss how to proceed
    - Composer signals they have finished the area and may proceed to another
- Composer switches off microphone

In this manner, all the tones of the area are analysed as softly and as loudly as possible (but not necessarily in this order).

The composer observes the screen and can ask for any of the tones to be reanalysed. Sometimes, because of the vibrato or technical issues, the software may leave holes in the graph, which clearly do not represent the auditive reality.

Do not feel discouraged if the first few cycles aren't successful and need to be repeated, which could happen if the tones were sung too briefly or with too much legato between tones, for instance.

The singer should use their ordinary singing voice. Making the voice sound very breathy and noisy would not generate representative results and therefore should not be used in the VMA.

The program is provided with a setup for slow, fast, and adjustable vibrato (**SLOW VIB**, **FAST VIB**, and **CUSTOM**). Once one of those is activated, the software expects the tone to vibrate between tones at the given speed. A slow vibrato (100 pulses per second) is typical for a large and dramatic voice. A fast vibrato (300 pulses per second) is more characteristic of somewhat lighter voices. Moreover,

for many lighter voices that are trained in contemporary music, a full analysis could be completed without any vibrato adjustment. If the composer and singer are uncertain about which option to choose, they might try testing this with different tones to see which set can identify a test tone most reliably. The speed of the vibrato may also be tailored using the **CUSTOM** button, if the given options do not yield satisfactory results. Where the vibratos are rather wide, the software sometimes misinterprets the tone, reading it as the next chromatic tone. In most cases, this does not disturb the analysis, especially when it is done using scales.

3.1.1 Scales

In the testing phase, the most satisfying results usually come when the area is gone through using a sequence of two ascending and two descending whole tones, repeating this phrase a half-step higher, as in figure 2.

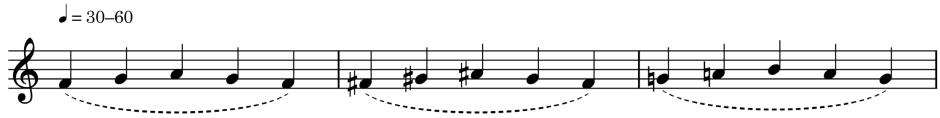

Figure 2. Using whole tones to go through the area

Sometimes the sequence can be transposed chromatically downwards instead of upwards.

At the extremes of the range, especially for the very high tones, it is often easier to sing chromatic scales upwards, as in figure 3.

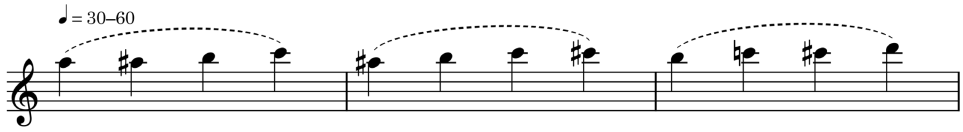

Figure 3. Using chromatic steps to go through the extremes of the area

If some of the tones are audible but the point does not appear on the graph, this

phrase should simply be sung again. Usually, going through the area using diatonic scales as seen in figures 2 and 3, yields good values across the full range, and the missing tones in the graph can then be sung individually.

While singing a sequence or a scale, the singer may use some legato, but if it goes too close to a *portamento*, the program will not be able to analyse the individual tones.

If the singer notices that the last tone they sang was not aesthetically solid, or if they notice that they sang a tone in a different area, the analysis should be briefly paused and the points on the graph referring to these tones should be erased (see section 3.2). The composer can also remark on differences in timbre.

3.1.2 Whole voice

Different voices function differently, so singers' preferences vary in terms of how to proceed within their vocal range. The following suggestions are based on the experiences of testing.

The area in the middle, or middle to low, is analysed first, thereafter continuing to the lower area(s), and from there ascending all the way to the highest area or areas, going through all of them .

For singing each tone of one specific area, two systems are equally popular: 1) going from low to high, and 2) starting in the middle of the area, going down and then all the way up.

Regarding the loudness of the voice, it is usually preferable to first sing as softly as possible and then as loudly as possible. But for the highest areas, it may be easier to sing loudly and then softer, but this sometimes yields unsatisfactory results.. If the singer finds that the very highest notes are only obtainable when

sung very loudly or the lowest notes extremely softly, then no minimum or maximum values need to be analysed.

The singer should always decide the order, as long as all the areas are gone through systematically.

Example 2 [hypothetical]: Analysing the four areas of the voice
(NB: The voice may also have more or fewer areas than four)

- Soundcheck
- Second lowest area
    - In the first cycle, the singer sings the tones too quickly and the software cannot recognise the tone
    - In the second cycle, the singer uses a very airy sound that doesn't represent their actual voice
- In the third cycle, the singer begins softly from the middle of the area, using a sequence of whole tones, first descending and then ascending. The softest tones can be produced so softly that they fall under the noise gate. This would be equivalent to the singer singing *niente.*
    - The highest tone feels different to the singer; it was already part of the higher register and gets erased from the graph
    - The loudest tones are sung ascending and then descending
- Lowest area
    - The softest tones are analysed from the middle of the area — first ascending and only then descending to the lower extreme

- As the loudest tones are analysed, the dynamic is almost identical to the softest tones; this phenomenon is common to all voices and it is quite natural that the contours meet at the lowest pitch, since it can only be produced very softly
- As the voice gets louder, the vibrato also widens; the software interprets some of the tones to be a halftone too high, but since all the tones are gone through with the whole tone sequences, these tones also eventually receive the right data

- Second highest area

    - The soft tones cannot be produced as softly as before
    - During the process, the software does not give any value to one tone in the middle of the area, although it is audibly present and part of the sung sequence
    - The cycle is restarted and the composer only gives the singer this missing tone to sing, which usually solves the problem
    - In the higher range, the singer needs to adjust the vowel somewhat, it is not precisely an /a/ anymore; this is for anatomical reasons only and does not adversely affect the analysis

- Highest area

    - The singer can produce the tones of this extreme area only in forte dynamics
    - Only loudly sung notes are analysed and the singer and composer discuss the limited dynamic range

3.2 Editing the graph

Sometimes a wrong tone or dynamic value needs to be deleted from the graph. This kind of error could be the result of background noise or the singer producing a note that is clearly in a different area, or other such causes. In this situation, pause the analysis cycle. Click **Erase point**, and select the pitch with the unwanted data using the keyboard. After this, you can choose to **Erase maximum value**, **Erase minimum value**, **Erase formant**, or **Erase all**. Then the analysis cycle can proceed.

4 Interpretation of the Voice Map

Video 4: Interpretation of the Voice Map: miika.info/VMM/videomanual4

The Voice Map is divided into two graphs, separated by a horizontal line. Together these graphs contain all the VMA data. The upper graph displays the full dynamic of the voice. The lower graph displays the singer's formant.[57] The x-axis indicates the musical pitch, and the y-axis indicates the dynamic (in dB) or the amount of singer's formant. The on-screen keyboard serves as a reference for reading the pitch.

All data points that belong to the same area are the same colour. On the upper graph, each tone has two dB values: the maximum level is indicated with a filled-in circle, and the minimum with a hollow circle. The tones outside the singer's range have a default value of -70 dB, which is seen on the x-axis (bottom of the graph).

The singer's formant appears as a solid line on the lower graph, where the same colour coding applies.

[57] Technically, the maximum dynamic from the range of the singer's formant.

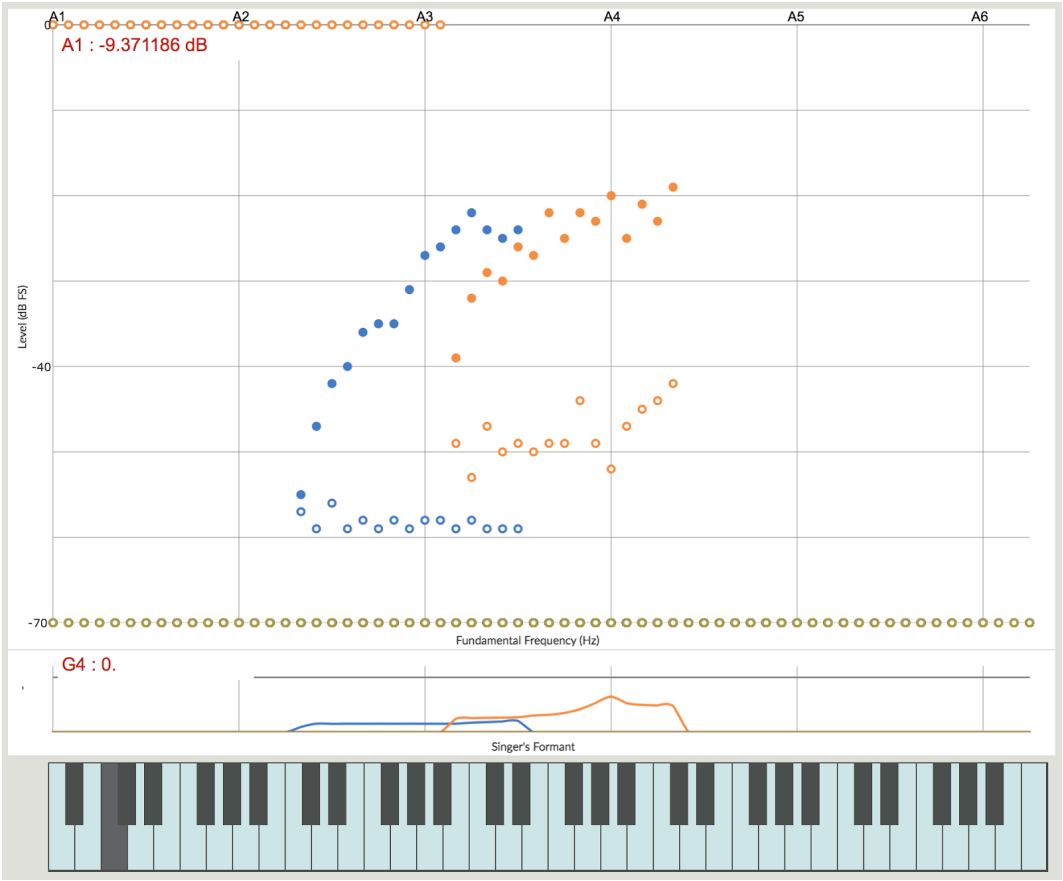

Figure 4 . Theoretical example of the Voice Map with two areas

These values give a good basic understanding of the voice, providing common ground for further discussion.

The composer should pay attention to the following aspects:

- For each area
    - Connecting each area with the memory of the timbre that was heard
    - General shapes of the contours

    - Comparison between the various maximum values
    - Addressing the minimum values similarly
    - -70 dB, the theoretical minimum value, indicates that the tone was not analysed
    - -60 dB is roughly the threshold of the background noise; tones with this dynamic can be considered niente

- Connection between the areas

    - Overlapping
    - Width of the areas

- For the singer's formant

    - Tones with moderately loud dynamics and a loud singer's formant can typically be heard through a larger orchestra than would be the case for tones with a soft singer's formant

Although the values are theoretically exact, the measurements relate to human beings and a person's voice alters slightly from day to day. However, the graph gives a very good idea of how the voice works, and changes of a few decibels are not significant.

Figure 4 is a theoretical example of a graph with two areas: blue and orange. The following information can be gleaned from it.

> **Example 3 [hypothetical]: Interpreting the graph in figure 4**
> The blue area ranges from C#3 to D#4. The minimum values of these tones are very low, close to the threshold of software analysis. The tones are going to be soft enough for practical purposes. For this area, the very first tones can only be sung softly, but from F3 onwards, the dynamic possibilities are rather open. The singer's formant does not make the voice more audible in the blue area.

The orange area has a range of B3 to C#5. This area needs a bit more energy, so the singer cannot sing it quite as softly as the blue area but still rather softly. Importantly, the minimum values get louder for tones A#4 to C#5. C#5, when sung as softly as possible (orange area), is approximately as loud as D#3 sung as loudly as possible (blue area). The maximum values of the orange area start from modest, at the bottom, and rise somewhat at the top of the area. The maximum is somewhat louder than the loudest maximum values of the blue area. Here, the singer's formant starts to have an effect. The dynamic maximum of A4 is only a little louder than C4, but A4 has a much more apparent singer's formant. This means that if a singer should sing a long tone accompanied by a chamber orchestra, the A4 would probably be audible, and C4 possibly not.

The tones that are part of more than one area are particularly interesting. In this case, B3 to D#4. This so-called passaggio is usually not very comfortable for singers and they need to learn how to mask the transition. From the composer's point of view, this can also be an opportunity: if these tones are reached from below, they are probably sung within the blue area and have its timbre. If the tones are reached from above, they can have the timbre of the orange area. In this case, the dynamic range of the blue area is much broader in the passaggio. If the composer wants to create a melody that ends with a C4 being sung loudly, the melody should preferably reach it from below rather than ascend to it.

The composer should always hold a discussion with the singer before composing for special parts of their voice, such as how to achieve very high and low tones, or tones that are part of more than one area. It should also be remembered that the VMA provides information on the limits of the voice in a closed analysis situation, and each analysis produces the tones only briefly and possibly just once. Usually the analysis situation informs the composer of how tiresome the tones are to produce. This should nevertheless be discussed in further detail during the next step, the List of Good Questions.

5 List of Good Questions

The VMA and the Voice Map serve as a starting point for communication. They provide auditory and visual information that help the singer and composer identify certain phenomena and talk about it. The questions are based on info obtained from literature and on the experience of the participants. The questions are directed at the singer, but should be seen as themes that invite open dialogue. Questions 1-8 stem from the Voice Map, continuing to the more general aspects of the voice, and eventually to the more holistic artistry of the singer.

Questions to address immediately after the analysis:

1. Can you see yourself in the Voice Map? What aspects of your voice does it accurately represent and what is not shown? Was the way your voice sounds today representative of what it typically sounds like?
2. The Voice Map emphasises the extremes of the voice. What pitches and dynamics do you consider to be:
   a) the main part of your voice (*tessitura*)
   b) the extremes of your voice that are usable occasionally and briefly
   c) very unreliable and only usable on special occasions, such as in recordings
3. The analysis was done with the vowel /a/. How does the text change at the extremes of your voice? What part of your range is optimal for text production and what part makes the text understandable? What kind of vowels would help to produce the tones at the extremes of your voice?
4. Are there some parts or points (pitch and dynamic) that are especially difficult or tiring for your voice, for example the *passaggi*?
5. Are there some parts of your voice or certain vocal effects (experimental singing techniques, laughter, tongue click, etc.) that you find especially interesting and would like to develop further?

6. What kinds of musical textures and performative styles are you especially used to and find easy to learn and produce? These might entail very long legato lines, fast coloraturas or jumps, passages with demanding intervals such as microtones, or extreme physicality and performance skills on stage
7. What musical textures and performative styles are least comfortable or demand a lot of time and energy to achieve?
8. How would you like to continue the artistic process? [This question is for the singer and the composer]

Questions to address during the artistic process:

It is highly recommended that the composer and singer meet after the analysis situation and before the first performance. Before the second of these meetings, the composer should re-read their notes about the voice and preferably listen to the recordings created by the VMA software, as these might aid the composition process.

The remaining questions relate to a situation whereby the composer already has some material that can be tried out with the singer and there is still time to make changes.

9. How does it feel to sing the material? Is it tiring for the voice? Does it need to have more pauses? How do you find the length of the piece?
10. Are there any specific sections where the text, dynamic, pitch, and phrasing could be improved to become more idiomatic or better suited to the composer's musical or dramatic idea? (Of course, the dramatic concept sometimes requires the music to be unidiomatic)
11. How shall we proceed from here?

This manual is for use in applying the full VMM, but the List of Good Questions alone

could also prove a useful as a starting point for communication, after which another such system would be required if the composer is to obtain a good understanding of the timbre and demands of different parts of the singer's voice.

6 Safe use of the program

To ensure the safety and comfort of the singers, it is advisable to follow these instructions.

6.1 Vocal health

The VMA requires the singer to sing at the extremes of their dynamic and pitch ranges. The analysis should not be done if the singer feels that their voice is not completely healthy. If the normal functionality of the voice changes, the analysis should immediately be halted. The VMM has been tested with classically trained opera singers, so to utilise it with other people, such as but not limited to untrained singers, may cause unforeseeable problems.

The VMM is devised to enhance the process of creating vocal music that fits the singer. For many reasons, the results may still be unsatisfactory and the singer and the composer should keep on communicating during the composition process and before the performance. With all vocal music, including music composed using the VMM, the singer should be aware of how it could affect and strain their voice.

During the testing phase, none of the singers mentioned that the VMA had caused excessive stress to them or to their voice. Many of the singers mentioned that they discovered new and inspiring aspects of their voice. According to the feedback on compositions created during the testing phase (*Voice Box*, *NOS*, and

Voice is Voices), they are very idiomatic for the singers who premiered them. This is also the goal of the process.

6.2 Data storage

The program saves all the audio that was used to make the analysis. It is saved in the form of audio files in a folder automatically created at the beginning of the VMA process. Before the analysis, the composer and singer must decide:

- whether they both agree to save the analysis files
- how the recordings, numeric data and screenshots are saved
- whether the recordings are destroyed afterwards, and if so, when?

7 Legal disclaimer

Legal disclaimer: Miika Hyytiäinen and the University of Arts, Helsinki are not responsible for any damage caused by the VMA or for the performance of a composition created using the VMA. Due to the limited and very specific test group, the VMA should not be used for medical diagnosis or as a tool for creating a Voice Range Profile.

Miika Hyytiäinen and the University of Arts, Helsinki are not responsible for inadequate use or storage of any of the data that is collected by the VMA software.

APPENDIX 3
List of singers taking part in the field testing

	Time	Description of the voice	Role in the development	Discussion with the singer
S.1	9/2015	mezzosoprano, dramatic	Preliminary experiment, not structured, sounds recorded, but not analysed live	Many remarks on the phases of the analytical process, especially length of the tone, use of vibrato, and vowels
S.2	12/2015	mezzo-soprano, lyric	Preliminary proof of idea, recorded and the SPL was observed	More a free discussion of all the possibilities
S.3	12/2016	soprano, lyric	The first analysis with the phase one VMA, some technical problems with the pitch recognition.	General remarks on the communication between singer and composer, based on singer's earlier unfortunate experiences
S.4	12/2016	coloratura soprano, lyric	Different areas are well documented, pitch recognition is acceptable	Discussion about the different areas
S.6	8/2017	contralto, lyric	a demonstration of the analysis process, not a full analysis	Discussion of the Fach and different aesthetichs (i.g. contemporary and Baroque),
S.7	8/2017	coloratura soprano, lyric	a demonstration of the analysis process, not a full analysis	Making a full analysis didn't seem interesting for the team at this point.
S.6 (again)	12/217	contralto, lyric	Full analysis, some technical difficulties with the extreme ranges, the voice turned out to have more areas than what they thought	A full analysis was required after all, since the voice was so escpetion. Only through long discussion and intense listening the dimensions of the voice became evident
S.8	1/2018	coloratura soprano, lyric	Programmer Pe'ery observed the analysis, solving the problem vibrato provides to the analysis	Use of different vibratos and extreme areas

S.9	3/2018	coloratura soprano, lyric	Making the analysis process more fluent	The young singer seemed very comfortable and her lyric voice was easy to analyse, they saw her voice in a new way, although the sopranoest areas weren't fully analysed
S.10	3/2018	soprano, dramatic	Making the analysis process more fluent in a technically limited situation	Discussion of the acoustic limitations of the space, singer could continue, although there were breaks in the analysis session
S.11	4/2018	soprano, lyric	Partly public lecture performance, technical focal point was the vibrato	Singer could very easily change her vibrato, which made the analysis fluent and quick. They commented in the lecture performance "It is one interpretation of my voice."
S.12	11/2018	mezzo-soprano, lyric	Making the analysis process more fluent	The young singer seemed to learn a lot about the areas and the dynamic range of her voice
S.13	2/2019	coloratura soprano, lyric	Making the analysis process more fluent	Singer is very experienced in VRP, thet asked for more fluentness in the process and recommended recording the sound for later use
S.14	3/2019	soprano, dramatic	Making the analysis process more fluent	Singer has a good understanding of their areas and made the discussion effective
S.10 (again)	4/2019	soprano, dramatic	Recording some sounds with different levels of singer's formant to be test material	When meeting with S.6 again, there was a discussion of how balance and singer's formant are related
S.15	6/2019	soprano, dramatic	Recording some sounds with different levels of singer's formant to be test material	Surprising level of singer's formant was evident, S.9 used provided very poetic names for her areas
S.16	6/2019	soprano, very dramatic	Recording some sounds with different levels of singer's formant to be test material	Singer's formant was very evident, but it seemed to be sopranoer than the theory would suggest

S.14 (again)	3/2020	soprano, dramatic	Recording some sounds with different levels of singer's formant to be test material	Virtuosic use of different kinds of functions (such as amount of singer's formant) seem to be an important part of their training
S.17	9/2020	coloratura soprano, rather dramatic	Full analysis and collecting material for singer's formant	Singer's voice was closest to what you could call 'Dramatischer Koloratursopran'
S.9 (again)	9/2020	coloratura soprano, lyric	Full analysis and collecting material for singer's formant	In this second, more comprehensive analysis, S.9 could demonstrate her sopranoer areas and also belting, she was also herself surprised of the extended possibilities it has in the areas
S.18	10/2020	coloratura soprano, lyric	Full analysis and collecting material for singer's formant	At times it was difficult for the singer to remember to stay in a specific area and they trusted maybe too much on my ears
S.19	11/2020	coloratura soprano, lyric	Full analysis and collecting material for singer's formant	Singer had a very analytical understanding of their voice and could give very specific information about it. Their voice is most clearly equalised of all the voices I tested, in this case, the division to areas was actually a technical requirement and didn't tell about the voice
S.20	08/2021	baritone, rather dramatic	Testing the final version of the VMM for a low voice	This was the first really low voice to be analyzed and the process went smootly. Some surprising new parts of the 'falsetto area' (M3) were found.
S.21	9/2021	soprano, rather dramatic	Testing the functionality of the final version, with different vibrati	This voice was surprising, because the areas seemed to have different characters and vibrati. Also extremely high pitches were recorded and it would be difficult to position the singer to the Fach system.
S.22	10/2021	baritone, rather lyric	Testing the final version of the VMM for a low voice	The singer used very poetic language when descriping their areas. They couldn't name the ranges, but using the names and roughly the ranges mentioned in the literature was succesful.

A composer and a singer creating new vocal music can often meet challenges in communication. This report introduces a solution called the Voice Map Method, in which various aspects of the singer's voice are visualised. The accompanying manual fully describes this computer-aided process. In parallel, composers and readers alike are able to deepen their theoretical understanding of different voice types, vocal registers, and the use of voice in contemporary music. The live compositional processes studied here demonstrate that the method inspires new musical ideas.

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